

**PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOURS AMONG COLOMBIAN
CHILDREN AND YOUTH:
PREVALENCE, CORRELATES AND INTERNATIONAL COMPARISONS**

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Abstract

In the context of epidemiological transitions in Latin American countries evidence is scarce. In Colombia, despite a broad policy framework for healthy lifestyles promotion, surveillance of movement behaviours including physical activity and sedentary behaviours has been limited. Therefore, this thesis aims to: a) Describe indicators of physical activity and sedentary behaviours among Colombian children and adolescents; b) determine the factors associated with meeting physical activity guidelines, engaging in active play, using active transportation and spending excessive recreational screen time among Colombian children and adolescents; and c) draw international comparisons of physical activity and sedentary behaviour indicators. To accomplish this, cross-sectional data from the National Survey of Nutrition in Colombia 2015-2016 and the Global Matrix of Physical Activity in Children and Youth 3.0 were analyzed. This dissertation compiles five research manuscripts prepared and submitted for publication in peer-reviewed scientific journals. Paper one describes physical activity indicators and correlates among Colombian children and found that a low proportion of children and adolescents in Colombia are physically active, with a consistently lower prevalence among females across all age groups. Paper two depicts the national situation of active transportation to school, indicating a non-negligible prevalence of this behaviour and several correlates to guide the design of strategies to promote walking and biking to school in Colombia. Paper three focused on recreational screen time and its correlates and found a high prevalence of excessive recreational screen time that increases with age. Paper four puts Colombian data in global context with nine other countries with a similar human development index participating in the Global Matrix 3.0 initiative. This study compared grades of behavioural and sources of influence indicators and

found similarly low performance across countries. In paper five a latent profile analysis approach was used to build active transportation profiles that contribute to understand active commuting to school across 49 countries from the Global Matrix 3.0. This dissertation helps fill gaps in knowledge in Colombia, and middle-income countries more broadly, providing national estimates of physical activity and sedentary behaviours of children aged 3-17 years for the first time in the surveillance history of the country.

Preface

This dissertation was developed as part of the requirements for the Doctorate in Philosophy degree in Epidemiology at the University of Ottawa. However, the seed of interest in investigating the current situation of physical activity and sedentary behaviours among Colombian children was planted and rooted some years before starting my doctoral studies.

Between 2012 and 2017, I had the privilege to start my path in research at the Group of Epidemiology at Universidad de los Andes in my country of origin, Colombia. During this time and under the exceptional mentorship of Dr. Olga Lucia Sarmiento, I had the opportunity to work in inspiring international, national and local research projects in public health and epidemiology. Two specific experiences should be highlighted as precursors of this dissertation.

On one side, since 2014, I coordinated the development of the first Report Card on Physical Activity in Colombian children and adolescents. This experience allowed me to identify the main research gaps in child physical activity surveillance in Colombia, and to join the Active Healthy Kids Global Alliance (AHKGA), a network of enthusiastic and committed researchers and practitioners with the mission to *power the movement to get kids moving*. As part of this endeavor, I have been part of the three versions of the Global Matrix initiative, one of the two sources of data used for this dissertation.

On the other side, I had the opportunity to join the research advisory and design team for the 2015 National Survey of Nutrition (ENSIN), which was the other main source of data for the analyses presented in this thesis. As part of this experience, I took part in the process to propose indicators and instruments to fill surveillance gaps, to train the data collection staff and to travel all around my country supervising the fieldwork to measure physical activity in the Colombian

population between 3 and 64 years of age. Both experiences were enriched by the guidance and mentorship of my current supervisor, Dr. Mark Tremblay. Therefore, this dissertation contributes to fill the gaps identified since the first Report Card on Physical Activity in Colombia in 2014, using the data we collected in the 2015 version of ENSIN with the expectation to explore the potential of epidemiology to guide a country's policy agenda, and therefore, to contribute to improve the health of its population.

Several approvals were obtained in the process of writing this dissertation. First, the ENSIN protocol was approved in Colombia by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (file number 2-2015, February 26, 2015). Then, the Ministry of Health from Colombia approved the secondary analyses of the ENSIN database and granted access to the dataset. And third, the secondary data analyses were approved by the University of Ottawa (file number H-06-19-3564) according to university policies. This work, as well as my doctoral studies, were possible thanks to the financial support received from the University of Ottawa and Ontario Government through the Ontario Trillium Scholarship.

Overall, I conceived the dissertation content and structure with the valuable guidance of my thesis advisory committee. I conducted the analyses and drafted each of the manuscripts that integrate this dissertation and received substantial contributions from my co-authors, which are detailed in each of the manuscripts.

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I would like to express my gratitude to the people who were part of this journey, and who, directly and indirectly, have contributed to the academic and personal growth resulting from the development of this doctoral dissertation.

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Thanks to my family and close friends for being patient, for the understanding when my research had to be the priority and for believing in my skills. I want to thank especially my mom, dad and sister. You inspired me to follow the path of public health as a way to contribute to society and you showed me that there is a lot to do for our country. Thanks for the endless love to accept the distance and the lack of time for most of this journey. Mamita, thanks for teaching me with your example the importance of being responsible in every aspect of life. Your strength and energy have fueled permanently along this path. Papin, thanks for teaching me about social justice, the base for our mission in public health. And Nanita, you have always been a role model to me. You showed me the power of science to help the most vulnerable populations, thanks for your unconditional support during this journey. Thanks to my love, Teto, I feel so lucky to have counted on you in the last but hardest part of this endeavor. You made the days brighter and smoother with your caring support, patience, and your beautiful music. Duni!

And finally, my sincere thanks also go to the co-authors of each of the papers included in this dissertation, as well as to the research staff from ENSIN survey. Thanks to the team of nutritionists, my colleagues, who collected the data used for this analysis, in a professional and careful way to allow the survey to have data of the best quality.

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List of Abbreviations

AHKGA: Active Healthy Kids Global Alliance

AIC: Akaike information criterion

ANOVA: Analysis of Variance

BLRT: Bootstrapped likelihood ratio test

BMI: Body Mass Index

C-MAFYCS: Measurement of Physical Activity and Sedentary Behaviours Questionnaire

CI: Confidence interval

ENSIN: National Survey of Nutrition in Colombia

GAM: Generalized Additive Models

GNI: Gross National Income

HBSC: Health Behaviour in School-Aged Children Survey

HDI: Human Development Index

LPA: Latent Profile Analysis

MVPA: Moderate- to Vigorous-intensity Physical Activity

METS: Metabolic Equivalents

NCD: Non-Communicable Disease

NIK: Neighborhood Impact on Kids Survey

P: Prevalence

PA: Physical Activity

PE: Physical Education

PR: Prevalence ratio

PSU: Primary Sampling Units

RST: Recreational screen-time

SABIC: Sample-adjusted Bayesian information criterion

SE: Standard error

SSU: Secondary Sampling Units

SVY: Survey module

TSU: Tertiary Sampling Units

UNICEF: United Nations Children's Fund

WHO: World Health Organization

YRBSS: Youth Risk Behaviour Surveillance System

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Chapter 1: Introduction

Rationale

Latin American countries are experiencing rapid urbanization and socio-economic changes that have led to demographic, epidemiological and nutritional transitions.¹ These transitions are reflected in a rapidly aging population, changes in the patterns of mortality and morbidity, a decline in infectious diseases and increases in non-communicable diseases (NCD),^{1,2} and changes in lifestyle characterized by decreased physical activity and increased sedentary behaviours and consumption of energy dense processed foods.³ Currently, Latin America has the highest prevalence of physical inactivity among adults at the global level⁴ and has reached a concerning prevalence of 20% to 25% for overweight or obesity among children and youth,^{5,6} and both of these are important risk factors for NCDs.

Specifically in Colombia, the average age of the population has increased rapidly in the last 70 years, indicating a rapid aging process compared to more developed countries.⁷ Between 1990 and 2016 the population grew by 42% and it is estimated that almost 80% of the Colombian population live in urban areas now.⁸ Thanks to public health initiatives, a considerable decrease in mortality rates has been observed, together with a shift in the main causes of mortality, away from nutritional deficiencies and infectious diseases towards NCDs.⁹ Coexisting with the consequences of infectious and deficiency-related diseases, NCDs now represent the main burden of disease.¹⁰ The prevalence of overweight among children has increased by 25% between 2005 and 2010.¹¹ For the same period of time, lifestyle-related behaviours, like recreational screen time among school-aged children has increased¹² but the evidence on physical activity patterns among Colombian children and youth is limited.¹³

Another important transition with effects on the development of the country is the current peace process. In 2016 a peace agreement was signed, ending more than five decades of armed conflict between the government and guerrilla forces in Colombia.¹⁴ This agreement led to a social transition towards a better integration and greater development of the population segments traditionally affected by the conflict, and mostly those living in rural areas.¹⁴ As part of the peace process, the implementation of actions for the promotion of health and the prevention of risk behaviours are expected, with the corresponding impacts on health indicators.^a

In the context of the aforementioned transitions, physical activity and sedentary behaviours are important factors susceptible to change as a result of demographic changes and economic growth and development, and may contribute to the expected shifts in health patterns.¹⁵ Specifically, the greater use of motorized transportation and technology may lead to a decrease in active transportation and leisure time physical activity and increased sedentary recreational pursuits.^{16,17} A brief description of these lifestyle behaviours is provided in the second chapter of this dissertation.

Statement of problem

In response to the global increase in NCDs, physical activity promotion and the reduction of sedentary behaviours have been broadly recognized as priority actions for disease prevention.¹⁸ Multiple calls to action for nations have been released, such as the Global Strategy on Diet, Physical Activity and Health¹⁹ and more recently, the Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World.²⁰ The latter highlights the importance of physical activity promotion for all age groups, in multiple settings, and provides guidance on

^a At the time that the writing of this dissertation started, the implementation of the Colombian Peace Process was promising and leading to foreseeable desired transitions. However, by the time that this dissertation was concluded the implementation of the agreement has been limited as well as the expected impacts on health.

feasible policy actions to increase physical activity and reduce sedentary behaviours.²⁰ This plan established the specific target to reduce by 15% (relative to present levels) the global prevalence of physical inactivity in adults and youth by 2030.²⁰

In addition to these global initiatives, Colombia has a broad policy framework for the promotion of physical activity. Specifically, Colombia's National Constitution recognizes physical activity, recreation and sports as a right of all citizens and establishes their promotion and funding as a state responsibility.^{12,21} As a result, physical activity is present in multiple laws from diverse sectors. For example, the Obesity-Law (Law 1355/2009) defines obesity and NCDs as priorities for public health and recognizes physical activity promotion as one of the crucial measures for their prevention.²² Similarly, physical activity is present in the recently launched Law 1811 of 2016, which promotes cycling and walking as main modes of transport at the national level.²³ Further, specific Ten-Year plans from the Sports and Health sectors also include concrete goals related to increasing physical activity opportunities for children and youth. For example, the Ten-Year plan of Public Health aims to create opportunities at schools for providing at least 300 minutes of physical activity per week by 2021.²⁴ Regarding sedentary behaviours and screen time regulation, the actions to date in Colombia have been limited.¹³

As evidenced in the first and second Report Cards on Physical Activity for Children and Youth in Colombia, despite the broad number of policies and plans to promote physical activity in Colombia, the evidence about the effectiveness of these policies is very limited and there seems to be a gap between written policies and specific actions.^{12,13} Also, the lack of data about the current situation of physical activity among children and youth makes it more difficult to follow-up on the success of the strategies and actions being implemented.

In Colombia, the main source of national data regarding physical activity and sedentary behaviours is the National Survey of Nutrition (ENSIN). This survey is recognized as the main source of data to inform the physical activity goals of public policies and plans. ENSIN has been conducted since 2005, with a five-year frequency. In response to the national gaps in physical activity surveillance, the most recent ENSIN 2015-2016 represents a unique opportunity to estimate physical activity levels for the first time, at the national level, for preschoolers, school-aged children and youth. This version of the survey provides the opportunity to examine the current situation of physical activity in the country and understand the relation between physical activity indicator, sedentary behaviours and multiple variables at the individual, family, community and environmental level. Also, the analysis of these indicators can contribute to informing future assessments of the advancement towards the specific goals in physical activity promotion and in the context of the epidemiologic and nutrition transition.

Objectives

The overall purpose of this thesis was to analyze the prevalence, patterns and correlates of physical activity and sedentary behaviours among Colombian children in the context of the epidemiological transition.

The specific aims were to:

- a) Describe indicators of physical activity and sedentary behaviours and determine their prevalence among Colombian children and youth (3-17 years).
- b) Within a socio-ecological framework, determine the factors associated with meeting physical activity guidelines, engaging in active play, using active transportation and

spending excessive time in sedentary behaviours among Colombian children and adolescents.

- c) Draw international comparisons of physical activity and sedentary behaviour indicators.

Hypotheses

The main hypotheses of this dissertation were that consistent with the global crisis of physical inactivity, 1) the prevalence of active behaviours would be low, while sedentary behaviours would be highly prevalent among Colombian children and adolescents; 2) individual, household and environmental level characteristics (e.g. sex, socioeconomic status, car availability) would be associated with active and sedentary behaviours; and 3) the physical activity and sedentary behaviours situation in Colombia would resemble the situation in other middle-income and Latin American countries.

Conceptual framework

Considering that physical activity and sedentary behaviours are individual behaviours that could be enhanced or hindered by multiple factors at different levels,^{25,26} the development of this thesis was guided by a socio-ecological model of health behaviours. This approach recognizes the relevance of environmental and policy contexts of behaviours, taking into account the social and psychological influences, leading to the consideration of multiple factors of influence for specific behaviours.²⁷ This is a particularly useful approach to understand the factors associated with physical activity and sedentary behaviours, and to provide useful insights to guide the development of comprehensive public health interventions with the aim to facilitate behaviour change. With the purpose of identifying relevant factors associated with the physical activity levels and sedentary behaviours among Colombian children, socio-ecological models such as the one proposed by Sallis et al. for active living (Figure 1),²⁵ and the one proposed by Owen et al.

for sedentary behaviours (Figure 2)²⁶ guided the analysis plan and the selection of variables for the present dissertation.

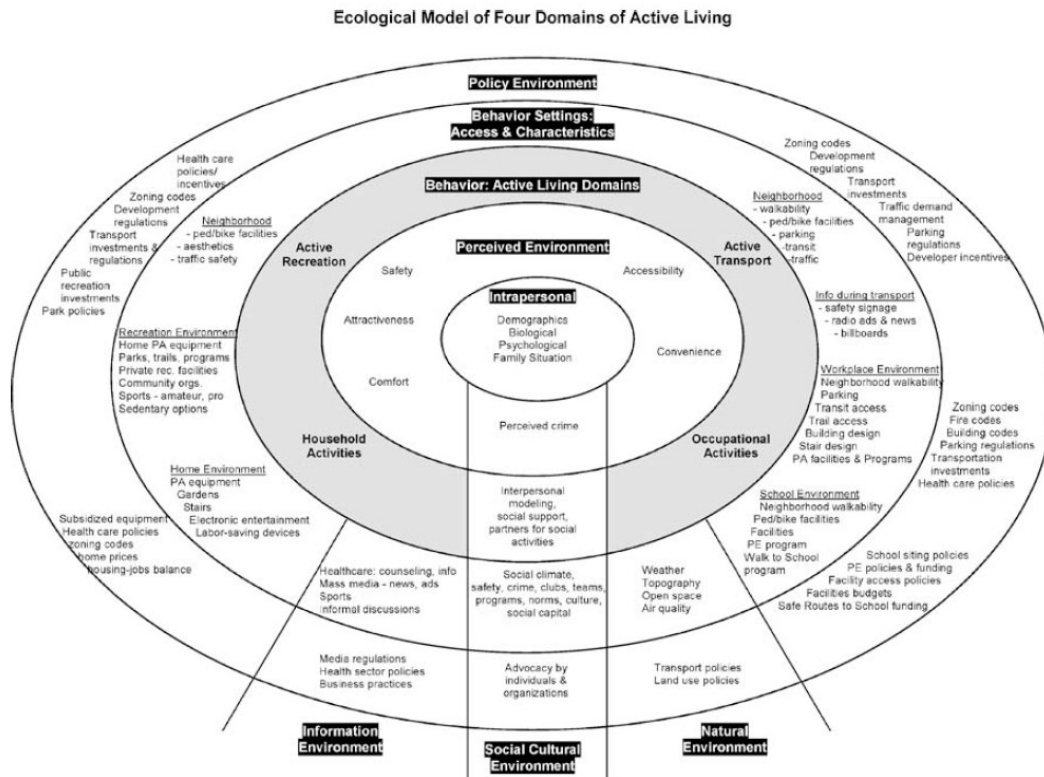


Figure 1. Ecological model of four domains of active living. Figure published in the Annual Review of Public Health 2006; 27:297-322, Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. Copyright Annual Reviews (2006).²⁵ Reproduced with permission.

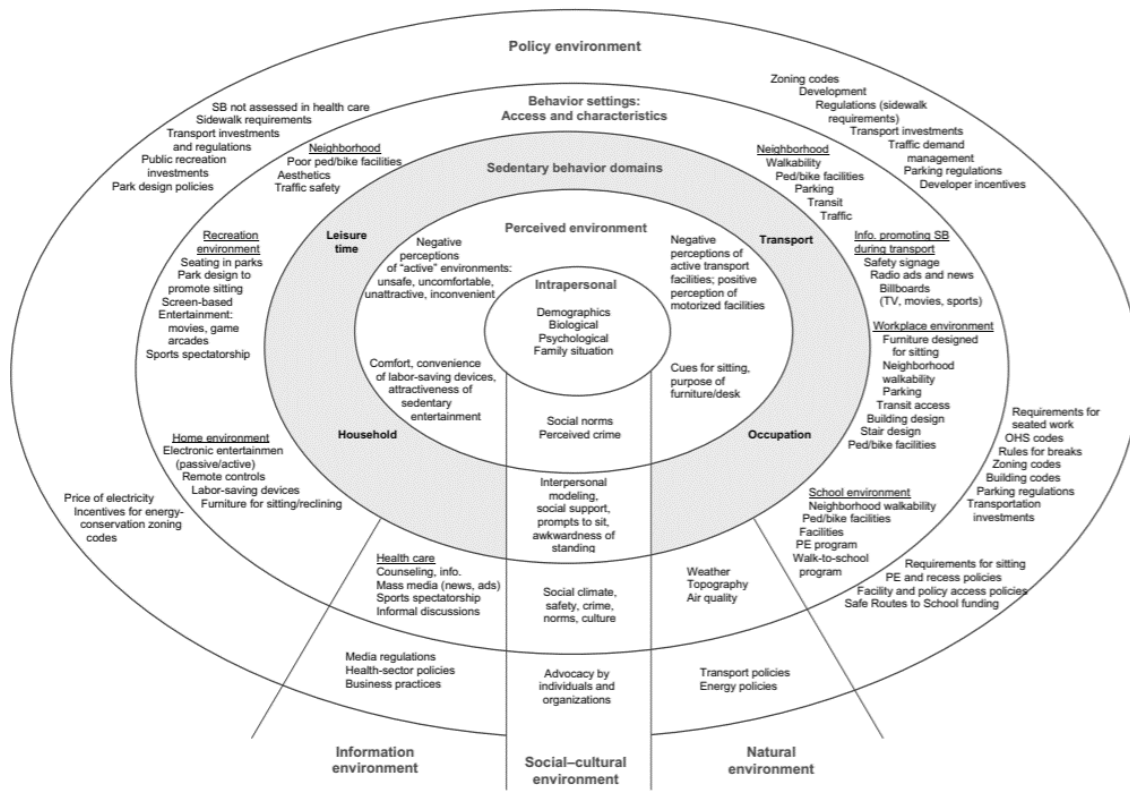


Figure 2. Ecological model of four domains of sedentary behaviour. Figure published in the American Journal of Preventive Medicine, 41(2): 189-196, Owen N, Sugiyama T, Eakin EE, Gardiner PA, Tremblay MS, Sallis JF. Adults' sedentary behavior determinants and interventions. Copyright Elsevier (2011).²⁶ Reproduced with permission.

Thesis organization

This thesis was developed as an article-based thesis and is organized following the guidelines provided by the School of Epidemiology and Public Health at the University of Ottawa. **Chapter 1** provides the introduction to the thesis, describing the context and rationale for conducting this research. The main key concepts studied in this thesis, the conceptual framework, as well as the epidemiological and social contexts are described in this section. **Chapter 2** compiles a review

of the literature of relevance for the development of this thesis. **Chapter 3** presents a general description of the overall methodology of the thesis. However, each manuscript had a specific methodology described in more detail in each of the following chapters. **Chapters 4 to 6** present the manuscripts focused on the prevalence and correlates of physical activity, active transportation, and sedentary behaviours, respectively. **Chapter 7** presents a comparison of physical activity and sedentary behaviour indicators among countries with a high human development index, and **Chapter 8** presents a global comparison of active transportation among children and youth. Finally, **Chapter 9** provides a comprehensive discussion and interpretation of the findings of this thesis and concludes the thesis with recommendations for future research and for practice and policy.

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Chapter 2: Review of the Literature

Physical activity among children and adolescents

Among children and adolescents, the practice of moderate- to vigorous-intensity physical activity (MVPA) has been consistently associated with physical health indicators such as favourable measures of adiposity, cardiometabolic biomarkers, physical fitness and bone health.¹ Evidence also suggests favourable associations of physical activity with indicators of mental and developmental health, like quality of life and well-being, motor skill development and psychological distress.¹ Furthermore, the benefits of physical activity reach other dimensions including cognitive function. A recent meta-analysis reported positive effects of physical activity on executive function, attention and academic performance in children.²

In order to provide guidance on the dose-response relationship between the practice of physical activity and its benefits for health, specific guidelines detailing the amount, frequency, duration, intensity and type of physical activity have been developed.^{3,4} These guidelines are evidence-based and specific by age groups. Some high-income countries like Canada^{4,5} and the United States⁶ have developed specific national guidelines, but the availability of similar public health documents for low- and middle-income countries is limited. Therefore, countries like Colombia have adopted the World Health Organization (WHO) Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children Under 5 Years of Age for preschoolers⁷ and the WHO Guidelines on Physical Activity and Sedentary Behaviour for the population aged five years and older.³ These guidelines include the following recommendations: children under five years should spend “at least 180 minutes in a variety of physical activities spread throughout the day, of which at least 60 minutes is MVPA.”⁷ For children and adolescents between 5 and 17 years, “at least an average of 60 minutes per day of moderate- to vigorous-intensity, mostly aerobic,

physical activity, across the week”. Also, “vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated at least 3 days a week”.³

These guidelines can be met through different activities, including active play, sports, transportation, recreation, and physical education. In the context of economic growth and lifestyle transitions, active play and active transportation are particularly susceptible to decrease, and their study and follow-up is very pertinent. Active play is an essential component of child development⁸ that provides an opportunity to learn and be physically active.⁹ Active play can also foster and improve motor function, creativity, decision-making, problem-solving and social skills.⁹ Active transportation represents an opportunity to engage in regular physical activity on a daily basis,¹⁰ and is associated with higher levels of physical activity, lower measures of adiposity, and higher cardiorespiratory fitness.^{11–13}

Sedentary Behaviours among children and adolescents

Sedentary behaviours are defined as any waking behaviour characterized by an energy expenditure of ≤ 1.5 metabolic equivalents, while in a sitting, reclining or lying posture,¹⁴ and spending excessive time in these behaviours has been associated with detrimental effects on health.¹⁵ Sedentary behaviours are among the indicators that have experienced notable changes in recent decades, with behavioural patterns shifting from active lifestyles to more sedentary habits, starting at early ages.^{16,17} Among sedentary behaviours, the most studied domain is screen time, commonly defined as watching TV, playing video games, and using computers, smartphones or tablets for recreational purposes. Excessive screen time has been associated with unfavourable measures of body composition, higher cardiometabolic risk, and lower fitness in children.¹⁵ In addition, unfavourable measurements on prosocial behaviour and self-esteem have been observed among children and youth who engage in excessive screen time.¹⁵ An increase in

daily time spent in these behaviours contributes to energy imbalance, increasing the risk of overweight and obesity beginning in the early stages of life.^{18,19}

Based on the evidence of detrimental effects of excessive screen time, countries like Australia²⁰⁻²² and Canada^{4,23}, as well as the American Academy of Pediatrics^{24,25} have developed specific guidelines to encourage healthy growth and development and to manage the time spent in these behaviours. More recently, the WHO also released guidelines on sedentary behaviours for the population under 5 years and between 5 and 17 years of age.^{3,7} In Colombia, specific national guidelines are not available, but the Canadian screen time guidelines are adopted for surveillance purposes for the population between 3 and 17 years. These guidelines established the following recommendations: for children 3-4 years, sedentary screen time should be limited to no more than one hour per day;²³ for children between 5 and 17 years, no more than 2 hours per day of recreational screen time is recommended.⁴

National surveillance of physical activity as a strategy to advance physical activity promotion

Physical activity surveillance, defined as the integration of collection, analysis, and interpretation of physical activity data to assess physical activity engagement, trends, and priorities,²⁶ is a pivotal component of physical activity promotion. In 2018, the WHO released the *Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World*, which provides guidance on specific actions for the creation of opportunities and environments for more active populations.²⁷ This plan establishes four strategic objectives and 20 specific policy actions to achieve them from a systems-based approach.²⁷ The four objectives are: 1) to create active societies, 2) to create active environments, 3) to create active people, and 4) to create active systems. The final goal with these objectives is to reduce the global prevalence of physical

inactivity in adults and adolescents by 15% by 2030. One of the specific actions proposed to achieve this goal is to “enhance data systems and capabilities at the national and, where appropriate, subnational levels, to support: regular population surveillance of physical activity and sedentary behaviour, across all ages and multiple domains; development and testing of new digital technologies to strengthen surveillance systems; development of monitoring systems of wider sociocultural and environmental determinants of physical inactivity; and regular multisectoral monitoring and reporting on policy implementation to ensure accountability and inform policy and practice”.²⁷ National population surveys, such as ENSIN, are important sources of data that could contribute to this action. In this context, a brief description of the relevance and potential of population health surveys is provided below.

Population health surveys

Population health surveys are a valuable source of information in epidemiology and public health. These surveys provide self-reported and directly measured data of health and sociodemographic variables that allow for the estimation of the incidence and prevalence of diseases, the occurrence of health-related behaviours, and the exposure to risk factors, among other indicators.²⁸ One of the advantages of using survey data is that, with the appropriate methodological approach that takes into account the nature of the study, survey data can provide relevant health indicators representative of a specific population.²⁸ Also, health surveys conducted in the household setting provide information on outcomes and determinants from the household and individual level, allowing detection of undiagnosed conditions or variables that are not necessarily documented by administrative registries.²⁹ This is particularly relevant in low- and middle-income countries, where access to health services is more limited than in higher-income countries.³⁰ Therefore, health surveys are a reliable source of data that provide

health information for the general public to inform the design of strategies and policies, and can be used to monitor policies and actions in public health when data are collected periodically.^{30,31}

Health surveys have been historically conducted to measure and monitor health outcomes and health determinants in low-, middle- and high-income countries. There are several examples of how survey data have influenced important decisions in policymaking. In the United States, the second National Health and Nutrition Examination Survey provided national data on blood lead levels that demonstrated an association between the removal of lead from gasoline and a decline in blood lead levels.³² This evidence supported the decision to remove completely the lead content from gasoline. In Mexico, data from the National Health and Nutrition Survey (ENSANUT) has informed multiple policies for the prevention of overweight and obesity, such as the National Strategy for the Prevention of Overweight, Obesity and Diabetes, Daily Dietary Guidelines, Guidelines for the sale and distribution of food and beverages in elementary schools, and the implementation of the tax on sweetened beverages.³³

In Colombia, ENSIN is a household-based population survey that has been conducted every five years since 2005, assessing relevant variables mainly for nutrition public policies. With its most recent version (2015-2016), ENSIN aimed to analyze the food and nutrition situation of the Colombian population within a social determinants of health framework, as an input for the design, follow-up, and adjustment of public policies on food and nutrition security.³⁴ With this purpose in mind, secondary analyses of ENSIN data have the potential to further guide national policies on health and nutrition. Specifically, the data on physical activity, collected for the first time for children and adolescents, can help to establish goals for the policies and strategies aimed at promoting physical activity. It can also fill research gaps identified in the global surveillance of physical activity, such as the lack of surveillance in children under 10 years of age, the

surveillance of physical activity in vulnerable groups such as ethnic minorities and rural communities, and it provides a first point in time for future trends analysis to monitor progress in physical activity promotion.²⁶

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Chapter 3: Methodology

Study setting

Colombia is an upper-middle income country, located in the northwest of South America. Administratively, Colombia is divided into 32 departments and one capital district (Bogotá), and each of these departments is subdivided into municipalities. Departments are territorial entities with administrative autonomy and mediation responsibilities between the Nation and the municipal governments.¹ According to the most recent population census, Colombia has 45.5 million inhabitants, of which 34% are children and youth under 18 years of age.² As in other middle-income countries, Colombia has experienced rapid urbanization, and currently 77% of the population lives in urban zones.² Colombia is among the top countries with the highest inequalities in the distribution of income in the region and in the world.³ Despite a decrease in poverty, there are significant and concerning inequalities between departments, and the human development index⁴ varies notably within Colombia.⁵

Study design

This thesis employs analyses of cross-sectional data from two sources: the ENSIN 2015-2016⁶ and the Global Matrix of Physical Activity in Children and Youth 3.0.⁷ These databases were used for separate analyses and are described separately in the following paragraphs.

ENSIN is a national population survey, representative of urban and rural areas, from 6 regions, 12 sub-regions and 32 departments of Colombia. This survey was designed within the Master Sample for Household Studies in Health, which is part of the National System of Population Health Surveys, of the Ministry of Health and Social Protection of Colombia.⁸ The Master Sample was designed to guarantee a comprehensive and complementary approach to health studies at the household level, with similar representativeness to other studies of the National

System. The Master Sample used a stratified, multistage probability cluster sampling procedure. The Primary Sampling Units (PSU) were municipalities with more than 7,500 inhabitants, and the municipalities with smaller populations were merged with other close municipalities from the same department and with similar socioeconomic characteristics. The Secondary Sampling Units (SSU) were selected after stratifying by area (urban vs. rural). In urban areas the SSU were groups of adjacent blocks from the same census tract with a minimum of 96 households. In rural areas the census tract usually had more than 100 households.⁸ The Tertiary Sampling Units (TSU) were segments with an average of 12 adjacent households. From this Master Sample, a probabilistic sample of segments was defined for ENSIN 2015, and from that sample, all the households had a probability of inclusion of 1, therefore, all were included in the sample (more than 50,000 households). All the households were included in the demographic, anthropometric and food security survey components. For the physical activity component, a probabilistic sub-sample was calculated based on the required samples per region and age group. The sub-sample for this analysis includes 2,864 preschoolers (3-5 years), 5,333 school-aged children (6-12 years) and 6,773 youth (13-17 years).

The Global Matrix of Physical Activity in Children and Youth 3.0 is an initiative that brought together physical activity leaders from 49 countries around the world.⁷ The countries involved in this initiative engaged in the development of national Report Cards on Physical Activity,⁹ which summarized the best and most updated surveillance data available for ten specific indicators related to physical activity among children: Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviours, Physical Fitness, Family and Peers, School, Community and Environment, and Government. Each of these

indicators was graded in every country following a harmonized and standardized process,⁷ which allowed the compilation of a matrix of 490 grades, based on the best available evidence.

Measurement and description of the main variables for analysis

For ENSIN, data were collected between December 2015 and November 2016, by trained nutritionists equipped with computer-assisted personal interview technology, specifically designed for the survey. The data collection was conducted at the household setting. For preschoolers and school-aged children, the survey was completed by a parent or a main caregiver of the child. For youth, the responses were self-reported to the interviewer. The questionnaires used in ENSIN were developed based on the Measurement of Physical Activity and Sedentary Behaviours (C-MAFYCS) Questionnaire,¹⁰ the U.S. Youth Risk Behaviour Surveillance System (YRBSS),¹¹ the Canadian component for active transportation of the 2009/2010 Health Behaviour in School-Aged Children (HBSC) survey¹² and the Neighborhood Impact on Kids (NIK) survey.¹³ Among these instruments, no validity or reliability studies have been conducted in the Colombian population, except for C-MAFYCS for which reliability was assessed with acceptable results.¹⁰

Dependent Variables

- Physical activity: Physical activity was defined as any bodily movement produced by skeletal muscles that results in energy expenditure.¹⁴ For the analyses conducted in this thesis, a dichotomous variable to indicate compliance with physical activity guidelines was created. For pre-school children, physical activity was assessed using the C-MAFYCS questionnaire and for school-aged children and youth, physical activity indicators were assessed with questions adapted from the YRBSS. For pre-schoolers, items 1, 3, and 7 to 13 in the Pre-school children-Physical Activity Questionnaire for

ENSIN (Appendix 1) were used to assess compliance with the physical activity guidelines.^{15,16} For school-aged children and youth, compliance with guidelines was determined based on item 2 in the School-aged children (Appendix 2) and Youth Physical Activity Questionnaires (Appendix 3), respectively.

- Sedentary behaviours: Sedentary behaviours are defined as any waking behaviour characterized by an energy expenditure of ≤ 1.5 metabolic equivalents, while in a sitting, reclining or lying posture,¹⁷ and for ENSIN were assessed as recreational screen time during weekdays and weekend days. Among preschoolers, questions from the C-MAFYCS questionnaire were used, and among school-aged children and youth questions from the YRBSS were used to assess compliance with the Canadian screen time guidelines.^{18,19} For pre-schoolers, items 14, 15, and 16 in the Pre-school children-Physical Activity Questionnaire for ENSIN (Appendix 1) informed this indicator. For school-aged children and youth, compliance of guidelines was determined based on items 4 to 7 in the School-aged children (Appendix 2) and Youth Physical Activity Questionnaires (Appendix 3), respectively.
- Active play: For ENSIN, active play was defined as play-related activities that require a higher effort, increase the heart rate, and cause participants to breathe hard and sweat.²⁰ This variable was measured only among preschoolers and the activities reported included only those conducted out of the school or childcare setting. Active play was assessed with questions from the C-MAFYCS questionnaire. The total time in active play-related activities was obtained from items 5, 6, and 9 to 13 in the Pre-school children-Physical Activity Questionnaire for ENSIN (Appendix 1).

- Active transport to school: Active transport is defined as the use of any active mode (e.g., walking, biking, skating or riding a scooter) for the journeys to or from school. For preschool children, active transportation was measured with questions from the C-MAFYCS questionnaire, and for school-aged children and youth, the Canadian component of the HBSC was used. This indicator was estimated using items 1 and 3 from Appendix 1 for preschoolers, and items 9 to 12 from Appendices 2 and 3 for school-aged children and youth, respectively.

Independent Variables

The independent variables included sociodemographic indicators including sex, age, wealth quintiles, area (urban vs. rural) and highest parental education level; anthropometric indicators (body mass index (BMI)); and physical activity-related variables such as availability of electronic devices, parks and programs, and counseling in physical activity. The sociodemographic variables were measured in the Household Questionnaire of ENSIN.⁶ The wealth index was calculated based on asset ownership, availability of public utilities and the materials used for housing construction,²¹ using a principal component analysis approach. BMI was calculated based on objectively measured weight and height. Availability of electronic devices and parks were measured with questions adapted from the NIK survey,¹³ and the availability of programs and counseling for physical activity were measured with questions specifically designed for ENSIN. Other variables such as parental physical activity and sedentary behaviours, disability, car ownership, food consumption in front of screens, among others, were considered according to their relevance for each individual manuscript.

For the Global Matrix 3.0 each country used the most updated data available to inform the following indicators, according to the benchmarks established by the Active Healthy Kids Global Alliance:⁷

Table 1. Global Matrix 3.0 indicators and benchmarks

Indicator	Benchmarks
Overall physical activity	Percent of children and youth who meet the Global Recommendations on Physical Activity for Health, which recommend that children and youth accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity per day on average. Or percentage of children and youth meeting the guidelines on at least 4 days a week (when an average cannot be estimated).
Organized sport and physical activity	Percent of children and youth who participate in organized sport and/or physical activity programs.
Active play	Percent of children and youth who engage in unstructured/unorganized active play at any intensity for more than 2 hours a day. Percent of children and youth who report being outdoors for more than 2 hours a day.
Active transportation	Percent of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend's house).
Sedentary behaviours	Percent of children and youth who meet the Canadian Sedentary Behaviour Guidelines (5- to 17-year-olds: no more than two hours of recreational screen time per day). Note: the Guidelines currently provide a time limit recommendation for screen-related pursuits, but not for non-screen-related pursuits.
Physical fitness	Average percentile achieved on certain physical fitness indicators based on the normative values published by Tomkinson et al. ²²
Family and peers	Percent of family members (e.g., parents, guardians) who facilitate physical activity and sport opportunities for their children (e.g., volunteering, coaching, driving, paying for membership fees and equipment). Percent of parents who meet the Global Recommendations on Physical Activity for Health, which recommend that adults accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical

Indicator	Benchmarks
	activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity.
	Percent of family members (e.g., parents, guardians) who are physically active with their kids.
	Percent of children and youth with friends and peers who encourage and support them to be physically active.
	Percent of children and youth who encourage and support their friends and peers to be physically active.
School	Percent of schools with active school policies (e.g., daily Physical Education (PE), daily physical activity, recess, “everyone plays” approach, bike racks at school, traffic calming on school property, outdoor time).
	Percent of schools where the majority ($\geq 80\%$) of students are taught by a PE specialist. % of schools where the majority ($\geq 80\%$) of students are offered the mandated amount of PE (for the given state/territory/region/country).
	Percent of schools that offer physical activity opportunities (excluding PE) to the majority ($> 80\%$) of their students.
	Percent of parents who report their children and youth have access to physical activity opportunities at school in addition to PE classes.
	Percent of schools with students who have regular access to facilities and equipment that support physical activity (e.g., gymnasium, outdoor playgrounds, sporting fields, multi-purpose space for physical activity, equipment in good condition).
Community and environment	Percent of children or parents who perceive their community/ municipality is doing a good job at promoting physical activity (e.g., variety, location, cost, quality).
	Percent of communities/municipalities that report they have policies promoting physical activity.
	Percent of communities/municipalities that report they have infrastructure (e.g., sidewalks, trails, paths, bike lanes) specifically geared toward promoting physical activity.
	Percent of children or parents who report having facilities, programs, parks and playgrounds available to them in their community.

Indicator	Benchmarks
Government	Percent of children or parents who report living in a safe neighborhood where they can be physically active.
	Percent of children or parents who report having well-maintained facilities, parks and playgrounds in their community that are safe to use.
	Evidence of leadership and commitment in providing physical activity opportunities for all children and youth.
	Allocated funds and resources for the implementation of physical activity promotion strategies and initiatives for all children and youth.
	Demonstrated progress through the key stages of public policy making (i.e., policy agenda, policy formation, policy implementation, policy evaluation and decisions about the future).

Analyses

The statistical analyses were specific for each of the proposed manuscripts. For the analyses using the ENSIN database, overall and stratified population-weighted prevalence estimates for physical activity, sedentary behaviours, active play and active transportation were calculated and differences among groups (females vs. males, rural vs. urban, wealth index quintiles) were assessed. Group differences were determined using unpaired t-tests (2 groups, e.g., sex differences); and Chi-square tests for categorical variables. Factors associated with physical activity, active transportation to school and recreational screen time at the individual, household and community level were determined using Poisson regression bivariate and multivariable models with robust variance. Variables with a marginally significant association in the bivariate models ($p < 0.10$) were included in the multivariable models. All analyses were conducted with appropriate weighting and adjustment for the sampling design and missing data. The analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) and STATA 15.1

(StataCorp, College Station, TX, USA) software, using the survey (SVY) module for complex samples to take into account the characteristics of the study design and the sample weights.

For the Global Matrix 3.0, descriptive statistics were estimated for each indicator based on the grades provided in the country Report Cards. Different scores were estimated to facilitate comparisons among countries and correlations between indicators were explored using Spearman's rank order correlation coefficients. Estimates of the prevalence of active transportation were calculated at the global level and by groups of countries according to the Human Development Index (HDI). Additionally, a latent profile analysis (LPA) was performed to identify groups of countries that share patterns according to their grades for active transportation, HDI and Gini index. LPA was conducted using R (version 3.4.1, The R Foundation for Statistical Computing, Vienna, Austria) and the tidyLPA package.²³

Ethical considerations

The Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health granted local ethical approval. Approval for secondary data analyses was obtained from the University of Ottawa in accordance with university policies (Appendix 4). Global Matrix data were all available in the public domain.

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Chapter 4: Prevalence and Correlates of Meeting Physical Activity Guidelines Among Colombian Children and Adolescents

Manuscript 1: Prevalence and correlates of meeting physical activity guidelines among Colombian children and adolescents

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Article preface

This article presents the national prevalence of meeting physical activity guidelines and identifies correlates of meeting physical activity guidelines among Colombian preschoolers, school-aged children and adolescents, therefore, it addresses the first and second objective of this dissertation, to describe indicators of physical activity and sedentary behaviours and determine their prevalence among Colombian children and youth (3-17 years), and to determine the factors associated with meeting physical activity guidelines, engaging in active play, using active transportation and spending excessive time in sedentary behaviours among Colombian children and youth, within a socioecological framework. SAG, OLS and MST conceived the idea of the manuscript. SAG drafted the manuscript, and all co-authors reviewed and approved the manuscript. The data used for these analyses required obtaining informed consent before conducting the survey. The survey obtained local ethics approval granted by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015; February 26, 2015). The University of Ottawa granted approval for secondary data analyses (file number H-06-19-3564). The published manuscript can be found in Appendix 5.

Abstract

Background: Global estimates have shown that a small proportion of children and adolescents are physically active. However, the evidence on physical activity among Colombian children and adolescents is limited. The objective of this study was to describe the prevalence and correlates of meeting physical activity guidelines among Colombian children and adolescents.

Methods: Data were collected as part of the National Survey of Nutrition 2015. A national sample of 16,612 children and adolescents (3-17 years) was included. Prevalence estimates of meeting physical activity and active play guidelines were calculated, and Poisson regression models were conducted to identify correlates of physical activity.

Results: A low proportion of Colombian children and adolescents met the physical activity guidelines. Low engagement in active play was observed among preschoolers. Correlates varied by age group. Female sex was a consistent negative correlate of meeting physical activity guidelines across all age groups.

Conclusions: Urgent actions are needed to promote active play and physical activity among Colombian children and adolescents. The correlates identified in our study can help inform the development of actions to overcome the disparities and provide opportunities for children to achieve their full potential for healthy growth and development.

Key words: surveillance, school-aged children, preschool, active play

Introduction

Regular physical activity (PA) is one of the most important behaviour for health promotion and disease prevention.¹ Among preschoolers, PA is associated with improved motor and cognitive development, better psychosocial and metabolic health, and favourable fitness and bone health.² Similarly, in school-aged children and adolescents, PA is favourably associated with adiposity, cardiometabolic risk factors, physical fitness, bone health, well-being, motor skills development and psychological health.³ To obtain these benefits, the World Health Organization (WHO) recommends that children between three and four years of age should accumulate a daily minimum of 180 minutes in physical activities of any intensity, of which at least 60 minutes

should be moderate- to vigorous- intensity physical activity (MVPA).⁴ For children and adolescents between five and 17 years of age, the WHO recommends the accumulation of a minimum of 60 minutes of MVPA daily.⁵

Despite the multiple benefits of regular PA, the proportion of children and adolescents meeting the guidelines is small. According to the Global Matrix 3.0 of Report Card grades on PA, the proportion of children and adolescents meeting the guidelines is between 27% and 33%.⁶ A pooled analysis of data from 1.6 million students found that 81% of adolescents around the world do not achieve the recommended amount of PA.⁷ A study on Latin American and Caribbean children and adolescents reported that only 15% met the PA guidelines.⁸

Considering the important benefits of PA for health, and in response to the high prevalence of physical inactivity, the WHO launched the Global Action Plan on Physical Activity 2018-2030.⁹ This plan established a target of a 15% relative reduction in physical inactivity among adolescents and adults by 2030 and provides guidance on how to achieve this target.⁹ One of the main actions proposed is having reliable surveillance systems that provide quality data on multiple domains of PA and its sociocultural and environmental determinants, across all ages.⁹

In Colombia, PA and recreation are social rights, essential for the improvement of quality of life and an indicator of social and human development.¹⁰ For this reason, multiple policies and strategies, like the WHO Global Action Plan, have been adopted to advance PA promotion, specifically for children and youth populations.¹¹ Following the WHO suggested actions, improved surveillance of PA in Colombia is desirable. The evidence on PA of Colombian children and adolescents has been limited and comes mainly from regional or local studies.¹² The National Survey of Nutrition (ENSIN), in its most recent version (2015), provides nationally

representative data on the PA of children and adolescents for the first time in the country's history. ENSIN provides rich contextual data and provides a unique opportunity to understand PA levels and correlates in Colombia. Using ENSIN data, this paper aims to describe the prevalence of PA among Colombian children and adolescents (3-17 years), and explore the factors associated with meeting PA guidelines within a socio-ecological framework.

Methods

Study setting

Colombia is an upper-middle income country, located in the northwest of South America. Geographically, Colombia is grouped into six regions: Orinoquia-Amazonia, Atlantic, Central, Eastern, Pacific, and Capital District.¹³ With a Gini index of 50.4, Colombia is among the countries with the highest income inequalities in the world.¹⁴ Colombia is classified as a country with a high Human Development Index (HDI) (0.761).¹⁵ However, the HDI varies considerably across the country.¹⁶ According to the 2018 population census, Colombia has 45.5 million inhabitants, of which 34% are children and adolescents under 18 years of age.¹⁷

Study design and participants

This study analyzed cross-sectional data from the ENSIN 2015 survey,¹³ a national population survey, representative of urban and rural areas of Colombia, with a stratified, multistage probability cluster sampling design. The survey, administered by the Colombian Institute of Family Welfare, was conducted at the household level and comprised different components. All selected households were included in the demographic and anthropometric components. For the PA component, a probabilistic sub-sample was identified based on the required samples per

region and age group. The sub-sample for this analysis included 4,507 preschoolers (3-5 years), 5,336 school-aged children (6-12 years), and 6,769 adolescents (13-17 years).

Data Collection

Data were collected by trained nutritionists equipped with computer-assisted personal interview technology, specifically designed for the survey. For preschoolers (3 to 5 years) and school-aged children (6 to 12 years), a parent or the primary caregiver of the child responded to the interview. For adolescents (13 to 17 years), the responses were self-reported to the interviewer. Data were collected in the household setting, between December 2015 and November 2016, and released in June 2019.

Informed consent was obtained before conducting the survey. For children and adolescents <18 years of age, parents or legal guardians provided their consent, and children between 12 and 17 years also provided informed assent. Local ethics approval to conduct the survey was granted by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015, February 26, 2015). Approval for secondary data analyses was obtained from the University of Ottawa (Canada) (file number H-06-19-3564).

Dependent variables

PA was self-reported or proxy-reported in response to different questions according to age group. For pre-school children, PA was assessed using the Questionnaire for the Measurement of Physical Activity and Sedentary Behaviours in preschool to fourth grade children (C-MAFYCS), which assesses PA out of school or day care institutions among preschoolers to 10-year olds. This questionnaire has a moderate internal consistency for PA and high reproducibility mainly

for walking to school, and organized sports.¹⁸ For school-aged children and adolescents, PA was assessed with a question adapted from the U.S. Youth Risk Behaviour Surveillance System (YRBSS).¹⁹ Details on the questions, response options and variables used in the analysis are provided in Table 1. For the analyses presented in this paper, dichotomous variables to indicate meeting/not meeting PA guidelines were created (Table 1). As sensitivity analyses, cut-offs of five and six days of MVPA were also examined for school-aged children and adolescents. Meeting muscle strengthening recommendations for school-aged children and adolescents was explored descriptively.

Considering the importance of active play for the health and development of younger children, active play involvement was explored among preschoolers. Two variables to assess active play were created, based on the benchmarks proposed by the Active Healthy Kids Global Alliance,⁶ engagement in unstructured active play and involvement in outdoor play (Table 1).

Covariates

The covariates for this analysis were selected among the available variables in the database and taking into account the socio-ecological framework of PA,²⁰ therefore these variables belong to different levels of influence. For the individual level, sociodemographic (age, ethnicity) and biologic variables (sex and body mass index (BMI)) were included. Sociodemographic variables were measured in the Household Questionnaire of ENSIN.¹³ Ethnicity was assessed with a self-determination question described in Table 1. Ethnicity was reported by the household main respondent. Despite being one of the main social conditions considered in the survey, ENSIN was not designed to be representative by ethnicity. Weight and height were measured objectively (Table 1). BMI was calculated based on the direct measures of weight and height, and categorized using the WHO growth standards and reference tables (Table 1).^{21,22}

For the household level, wealth index, area, the availability of TV in the child's bedroom and video games devices at home, and maternal adherence to PA guidelines were included.

Availability of devices was assessed with questions adapted from the Neighborhood Impact on Kids (NIK) survey²³ and maternal PA was assessed with the International Physical Activity Questionnaire (IPAQ).²⁴ For the school level, the number of days with Physical Education classes was assessed, only for adolescents. At the community level, the availability and perceived safety of parks was assessed with questions adapted from the NIK survey,²³ and counseling on PA by health providers was assessed with a specific question designed for ENSIN (Table 1). For the natural environment level, the geographic region where children and adolescents lived was included. For the policy level, participation in organized sports, organized activity groups, Ciclovías (Open Street programs in Colombia)²⁵ and PA programs was assessed among adolescents (Table 1).

Statistical Analysis

Descriptive statistics of the sample, and overall and stratified population-weighted prevalence estimates for PA and active play were calculated. Group differences were determined with Chi-square tests. To estimate the factors associated with PA, prevalence ratios (PR) were determined using Poisson regression models with robust variance. Bivariate models were conducted with each of the selected covariates. Multivariable models included the variables that showed at least marginally significant associations ($p < 0.10$) in the bivariate models and were adjusted for age and sex. The variables with p -values < 0.05 were considered correlates of PA indicators. Given that all the variables were obtained at the household level, a multilevel modelling approach was not used. The analyses were conducted using STATA 14.0 (StataCorp, College Station, TX, USA) with the survey (SVY) module for complex samples to take into account the

characteristics of the study design, sample weights and missing data. This module accounts for the clustering of the data.

Table 1. Description of the dependent variables and covariates included in the analyses of meeting physical activity guidelines and its factors associated among Colombian children and adolescents.

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Meeting physical activity (PA) guidelines among preschoolers	Questionnaire for the Measurement of Physical Activity and Sedentary Behaviours in preschool to fourth grade children (C-MAFYCS)	-During the last 7 days, did (name of the child) walk to go FROM home to school? How much time did he/she spend? (for each day) - During the last 7 days, did (...) walk to go BACK FROM school to home? How much time did he/she spend? (for each day) - Last week, did (...) practice any organized sport? How much time did he/she spend? (for each day) - Last week, did (...) walk out of school? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play with a ball? How much time did he/she spend? (for each day) - Last week, out of school, did (...) ride a bike, roller blades, skateboard, scooter? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play or swim in the pool, river, lake, lagoon, ocean or brook? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play at the park? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play with friends, neighbors or relatives? How much time did he/she spend? (for each day)	The total time in all activities per weekdays and weekend days was estimated in minutes, and an average of minutes of PA per day was calculated. A dichotomous variable to indicate if the preschooler met PA guidelines was created, using a cut-off of 180 minutes of PA per day including at least 60 minutes of energetic play for preschool children.
Meeting PA guidelines among school aged children	U.S. Youth Risk Behaviour Surveillance System (YRBSS)	During the last week (past 7 days), on how many days was (name of the child) physically active for at least 60 minutes per day? (Add up all the time (...) spent in any kind of PA that increased his/her heart rate and made him/her breathe hard some of the time.) Number of days _____	A dichotomous variable to indicate if the child met PA guidelines was created, using a cut-off of seven days of moderate-to-vigorous intensity PA (MVPA). Sensitivity analyses were conducted with cut-offs of five and six days of MVPA.
Meeting PA guidelines among adolescents	YRBSS	During the last week (past 7 days), on how many days were you physically active for at least 60 minutes per day? (Add up all the time you spent in any kind of PA that increased your heart rate and made you breathe hard some of the time.) Number of days _____	A dichotomous variable to indicate if the adolescent met PA guidelines was created, using a cut-off of seven days of MVPA.

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Meeting muscle strengthening recommendations among school aged children and adolescents	YRBSS	During the last week (past 7 days), how many days did (name of the child)/ you do exercises to strengthen or tone his/her/your muscles, such as squats, sit-ups, push-ups, weight lifting, cheerleading, monkey bars or mountain hiking? Number of days _____	Sensitivity analyses were conducted with cut-offs of five and six days of MVPA. A dichotomous variable to indicate if the child or adolescent met muscle strengthening recommendations was created, using a cut-off of three days per week of muscular strengthening activities.
Unstructured play among preschoolers	C-MAFYCS	- Last week, out of school, did (...) play with a ball? How much time did he/she spend? (for each day) - Last week, out of school, did (...) ride a bike, roller blades, skateboard, scooter? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play or swim in the pool, river, lake, lagoon, ocean or brook? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play at the park? How much time did he/she spend? (for each day) - Last week, out of school, did (...) play with friends, neighbors or relatives? How much time did he/she spend? (for each day) - Last week, did (...) play outside the house? How much time did he/she spend? (for each day)	The total time in play activities per weekdays and weekend days was estimated in minutes, and an average of minutes of play per day was calculated. A dichotomous variable to indicate the engagement in unstructured play was created, using a cut-off of 120 minutes per day.
Outdoor play among preschoolers	C-MAFYCS		The total time playing outdoors was obtained for weekdays and weekend days and the average of minutes of outdoor play per day was calculated. A dichotomous variable indicating the involvement in outdoor play was created, using a cut off of 120 minutes per day.
Sex	Household Questionnaire of the National Survey of Nutrition in Colombia (ENSIN)	Parent or self-report: male or female	Dichotomous variable: male or female
Age	Household Questionnaire of ENSIN	How old is (...)?/ How old are you?	Continuous and categorical variables were included in the analyses: 3 and 4 vs. 5 years old, 6 to 9 years old vs. 10 to 12 years old, and 13 to 15 years old vs. 16 to 17 years old.

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Ethnicity	Household Questionnaire of ENSIN	According with your culture, town or physical characteristics, (...) is or recognize himself/herself as: -Indigenous -Gipsy/Rom -Raizal of the archipelago -Palenquero from San Basilio -Black, mulatto, Afro-colombian, Afro-descendant -None of the mentioned above.	Categories were grouped and a new categorical variable was created with the following categories: Afro-Colombian vs. Indigenous vs. No ethnic identity reported.
Weight	Directly measured in kilograms using portable SECA 874 scales (Seca, Hamburg, Germany) after outer clothing and shoes were removed	Not applicable	Used as a continuous variable for the estimation of the body mass index.
Height	Directly measured in centimeters with ShorrBoard stadiometers (Shorr Productions, Olney, MD) with the participants standing, with the head in the Frankfort plane, and five contact points of the body with the stadiometer: heels, calves, buttocks, shoulder blades and head.	Not applicable	Used as a continuous variable for the estimation of the body mass index.
Body mass index (BMI)	Calculated based on the direct measures of weight and height	Not applicable	The continuous variable was categorized using the WHO growth standards and reference tables. For children under 5 years of age BMI was categorized as no excess (BMI z-score $\leq +2$) vs. overweight (BMI z-score $>+2$ to $\leq +3$) vs. obesity (BMI z-score $>+3$). For children and adolescents between 5 and 17 years of age BMI was categorized as no

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Wealth index	Household Questionnaire of ENSIN	Wealth index was calculated based on asset ownership, availability of public utilities and the materials used for housing construction using a principal component analysis approach.	excess (BMI z-score $\leq +1$) vs. overweight (BMI z-score $>+1$ to $\leq +2$) vs. obesity (BMI z-score $>+2$). Wealth index was categorized into quartiles for the analyses.
Area	Household Questionnaire of ENSIN	Parent or self-report of the area where the household is located: municipal center vs. population centre vs. scattered rural.	Area categories were grouped into two categories: urban (municipal centers) and rural (population centers and scattered rural). Dichotomous variable: yes or no
TV availability in the child's bedroom Videogames availability in the child's bedroom	Neighborhood Impact on Kids (NIK) survey NIK survey	Does (...) have a TV in his/her room? / Do you have a TV in your room? Yes vs. No Does (...) have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)? / Do you have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)? Yes vs. No	Dichotomous variable: yes or no Dichotomous variable: yes or no
Maternal adherence to PA guidelines	International Physical Activity Questionnaire (IPAQ)	Transport and leisure time domains of the IPAQ questionnaire on its long version.	Total minutes of physical activity on each domain were calculated and a dichotomous variable to indicate adherence to PA guidelines was created, using a cut off of 150 minutes of moderate to vigorous activity per week.
Physical Education frequency among adolescents	Adapted from YRBSS	In the last week you were in school (last 7 days), on how many days did you go to physical education (PE) classes? Number of days _____	The continuous variable was categorized into three categories: No class in the last week vs. One day vs. Two or more days
Parks availability	Adapted from NIK survey	Are there any parks, green spaces, recreation facilities or sports facilities in your neighborhood, where (...) / you can play? Yes vs. No	Dichotomous variable: yes or no
Safety perception of parks	Adapted from NIK survey	Is it safe for (...) / you to play at the park in your neighborhood? Yes vs. No	Dichotomous variable: yes or no
Counseling on PA by health providers	Designed for ENSIN	During the last 12 months, did any doctor or health professional recommend (...) / you to start or continue exercising, doing any PA or playing sports? Yes vs. No	Dichotomous variable: yes or no
Geographic region	Household Questionnaire of ENSIN	Parent or self-report of the department where the household is located.	The reported departments were categorized into the following regions according to their

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Participation in organized activities and programs among school-aged children	Designed for ENSIN	During the LAST WEEK (past 7 days), did (...) do any of these activities? Read all the response options and check all that apply a ☐ Sports teams (soccer, basketball, volleyball, etc.)? b ☐ Organized groups (dance, martial arts, etc.)? c ☐ Attend Ciclovía (when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes)? w ☐ None of these	geographical location: Orinoquia-Amazonia vs. Atlantic vs. Central vs. Eastern vs. Pacific vs. Capital District Dichotomous variables were created for each response category to ascertain the participation in organized activities and programs: -Sports clubs (Yes vs. No) -Organized groups (Yes vs. No) -Ciclovías (Yes vs. No)
Participation in organized activities and programs among adolescents	Designed for ENSIN	In the last month, did you participate in any of the following PA programs: a) Ciclovías? (when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes); b) PA classes? (e.g. aerobics classes, rumba, stretching, yoga, etc.); c) PA programs at school?; d) Sports clubs?; e) Organized groups? (dance, martial arts, etc.)	Dichotomous variables were created for each response category to ascertain the participation in organized activities and programs: -Ciclovías (Yes vs. No) -PA classes (Yes vs. No) -PA programs at school (Yes vs. No) -Sports clubs (Yes vs. No) -Organized groups (Yes vs. No)
Frequency of participation in programs and organized activities among adolescents	Designed for ENSIN	How often have you had participated in this/these program(s)? <i>If the adolescent has participated in more than one program, sum the total participation</i> ☐ Once per month ☐ Twice per month ☐ Three times per month ☐ Four times per month or more	A categorical variable with the four response options was used for the analyses.

BMI: body mass index, C-MAFYCS: Questionnaire for the Measurement of Physical Activity and Sedentary Behaviours in preschool to fourth grade children,

ENSIN the National Survey of Nutrition in Colombia, IPAQ: International Questionnaire of Physical Activity, MVPA: Moderate-to-vigorous intensity physical activity, NIK: Neighborhood Impact on Kids survey, PA: Physical activity, WHO: World Health Organization, YRBSS: U.S. Youth Risk Behavior Surveillance System.

Results

Characteristics of the sample are presented in Tables 2 and 3. Respondents with missing data on the main variables of interest were excluded. Approximately 48% of the samples for the three age groups were females. The mean age was 4.0 years (SD=0.8), 8.9 years (SD=2.0), and 14.9 years (SD=1.4) for preschoolers, children, and adolescents, respectively. Over 80% of the sample did not recognize themselves as Afro-Colombian or Indigenous, so were categorized as other. Statistically significant differences were observed between males and females. Among preschoolers, males had a higher prevalence of overweight and obesity than females. For school-aged children, higher participation in sport clubs was observed among males, while females had a higher participation in organized activities. Among adolescents, females had a higher prevalence of overweight and obesity. Male adolescents reported a higher availability of parks in their neighborhood and higher safety perceptions than females. A higher proportion of females reported receiving PA counseling by health professionals and there were differences by sex in the participation in programs (Table 3).

Physical activity prevalence

Preschool children

Table 4 presents the results of PA and play among preschoolers according to the socio-ecological framework selected variables. The overall prevalence of meeting PA guidelines among preschoolers was 24.4% with a higher prevalence among males (Figure 1). Regarding unstructured play, 31.3% of preschoolers were involved in more than 2 hours per day, with higher participation among males. Approximately 10.9% of preschoolers played outdoors for more than 2 hours per day.

Table 2. Sociodemographic characteristics of 4507 preschool children from Colombia. ENSIN 2015.

Sociodemographic variables	Preschool children									
	Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	p-value
Sex										
Female	2197	48.5	1.21		NA			NA		
Male	2310	51.6	1.21		NA			NA		
Age (years)										
3-4	3002	70.2	1.03	1517	70.5	1.46	1485	69.8	1.35	0.736
5	1505	29.8	1.03	793	29.5	1.46	712	30.2	1.35	
Ethnicity										
Afro-colombian	441	9.1	0.78	222	8.2	0.81	219	10.0	1.11	0.170
Indigenous	481	4.7	0.63	246	4.5	0.70	235	4.9	0.71	
Other	3547	86.2	0.84	1821	87.3	0.94	1726	85.1	1.17	
BMI categorization										
No excess ^b	3860	89.0	0.76	1936	86.6	1.22	1924	91.5	0.82	0.002
Overweight	375	8.4	0.69	218	10.1	1.14	157	6.6	0.72	
Obesity	130	2.6	0.33	82	3.3	0.51	48	1.9	0.40	
Wealth Quartiles										
First	2374	41.1	1.31	1198	40.3	1.58	1176	42.0	1.89	0.650
Second	1086	26.3	1.18	575	27.6	1.50	511	24.9	1.56	
Third	713	20.3	1.22	365	19.6	1.34	348	21.0	2.04	
Fourth	334	12.4	1.01	172	12.5	1.35	162	12.2	1.35	
Area										
Urban	3208	72.4	1.20	1631	71.8	1.47	1577	72.9	1.71	0.593
Rural	1293	27.6	1.20	675	28.2	1.47	618	27.1	1.71	
TV available at the child's bedroom										
Yes	1734	42.3	1.15	906	44.3	1.58	828	40.1	1.55	0.057
No	2767	57.7	1.15	1400	55.7	1.58	1367	59.9	1.55	
Video games devices availability										
Yes	554	14.0	0.84	295	13.7	1.12	259	14.2	1.32	0.788
No	3947	86.0	0.84	2011	86.3	1.12	1936	85.8	1.32	
Maternal physical activity ^c										
Meeting WHO guidelines	378	41.2	2.61	188	38.6	3.61	190	44.3	3.74	0.288
Not meeting WHO guidelines	489	58.8	2.61	253	61.4	3.61	236	55.7	3.74	
Parks availability in the neighborhood										
Yes	2376	55.4	1.37	1273	56.9	1.70	1103	53.8	1.94	0.187
No	2125	44.6	1.37	1033	43.1	1.70	1092	46.3	1.94	
Safety perception ^d										
Is safe to play in the park	1793	75.7	1.57	977	77.3	1.97	816	74.0	2.22	0.233
Is not safe to play in the park	583	24.3	1.57	296	22.7	1.97	287	26.0	2.22	
Counseling on physical activity										
Yes	641	14.7	0.80	329	15.0	1.10	312	14.3	1.10	0.621

Table 2. Sociodemographic characteristics of 4507 preschool children from Colombia. ENSIN 2015.

Sociodemographic variables	Preschool children									
	Total sample			Males			Females			p-value
	n ^a	%	SE	n	%	SE	n	%	SE	
No	3860	85.3	0.80	1977	85.0	1.10	1883	85.7	1.10	
Geographic region										
Atlantic	935	24.4	1.03	491	25.0	1.26	444	23.8	1.44	0.814
Eastern	799	17.0	1.24	401	16.2	1.41	398	17.8	1.61	
Orinoquia-Amazonia	775	3.9	0.27	395	3.8	0.53	380	4.0	0.47	
Capital District	318	14.0	1.30	161	14.2	1.45	157	13.7	2.14	
Central	970	24.2	0.93	498	24.9	1.34	472	23.5	1.35	
Pacific	710	16.5	0.70	364	15.8	0.94	346	17.2	1.17	

a The total sample size for preschoolers was 4507 children. However the following variables had missing values: ethnicity=38, BMI=142, area, TV availability, video games availability, parks availability and counseling on physical activity=6.

b No excess category groups children with thinness, risk of thinness and normal BMI.

c The variable maternal physical activity is available only for the dyads of children and mothers selected for the physical activity component of the survey, therefore the sample sizes are smaller.

d Safety perception was assessed only among those who reported having a park in their neighborhood.

Table 3. Sociodemographic characteristics of 12105 children and adolescents from Colombia. ENSIN 2015

Sociodemographic variables	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	P-value	n ^b	%	SE	n	%	SE	n	%	SE	P-value
Sex																				
Female	2558	48.1	1.12		NA			NA		NA	3330	48.2	0.93		NA			NA		NA
Male	2778	51.9	1.12		NA			NA			3439	51.8	0.93		NA			NA		
Ethnicity																				
Afro-colombian	452	9.8	0.93	233	9.6	1.09	219	10.1	1.06	0.842	575	9.1	0.91	334	9.4	1.13	241	8.7	0.96	0.176
Indigenous	671	5.9	0.78	333	5.7	1.23	338	6.1	1.06		653	4.4	0.78	262	3.9	0.78	391	5.0	0.89	
Other	4168	84.3	1.11	2192	84.8	1.48	1976	83.8	1.39		5487	86.5	0.80	2814	86.7	0.99	2673	86.3	1.00	
BMI categorization																				
No excess ^c	3895	74.1	1.16	2019	72.9	1.60	1876	75.4	1.51	0.528	5235	81.9	0.75	2806	85.1	0.96	2429	78.6	1.11	<0.001
Overweight	883	17.9	0.84	450	18.5	1.28	433	17.2	1.21		958	13.8	0.65	342	11.3	0.88	616	16.4	0.96	
Obesity	374	8.0	0.76	219	8.6	1.03	155	7.4	1.10		300	4.3	0.40	129	3.7	0.45	171	5.0	0.63	
Wealth Quartiles																				
First	2868	39.2	1.56	1479	39.0	2.06	1389	39.4	1.78	0.620	3414	37.9	1.29	1730	38.5	1.63	1684	37.3	1.49	0.767
Second	1290	25.6	1.19	709	25.8	1.49	581	25.3	1.64		1572	23.3	0.96	805	23.5	1.19	767	23.0	1.21	
Third	763	19.7	1.03	382	18.7	1.35	381	20.7	1.44		1123	21.3	0.92	570	21.1	1.36	553	21.5	1.24	
Fourth	415	15.6	1.16	208	16.4	1.58	207	14.7	1.35		660	17.5	1.09	334	16.9	1.36	326	18.2	1.41	
Area																				
Urban	4016	73.7	1.35	2087	74.0	1.77	1929	73.4	1.57	0.782	4922	73.9	1.27	2406	73.5	1.49	2516	74.4	1.44	0.535
Rural	1317	26.3	1.35	690	26.0	1.77	627	25.6	1.57		1842	26.1	1.27	1029	26.5	1.49	813	25.6	1.44	
TV available at the child's bedroom																				
Yes	1807	39.6	1.32	921	39.0	1.79	886	40.3	1.76	0.601	2411	41.4	1.06	1241	41.6	1.46	1170	41.3	1.42	0.883
No	3525	60.4	1.32	1855	61.0	1.79	1670	59.7	1.76		4352	58.6	1.06	2193	58.5	1.46	2159	58.7	1.42	
Video games devices availability																				
Yes	1452	33.7	1.28	782	35.2	1.85	670	32.0	1.70	0.208	3901	62.1	1.03	1970	61.6	1.37	1931	62.7	1.30	0.507
No	3881	66.3	1.28	1995	64.8	1.85	1886	68.0	1.70		2863	37.9	1.03	1465	38.4	1.37	1398	37.3	1.30	
Maternal physical activity ^d																				
Meeting WHO guidelines	512	48.9	2.15	258	51.1	3.30	254	46.8	3.35	0.408	366	50.3	2.78	185	49.1	3.20	181	51.5	4.19	0.630
Not meeting WHO guidelines	590	51.1	2.15	295	49.0	3.30	295	53.2	3.35		486	49.7	2.78	240	50.9	3.20	246	48.5	4.19	

Table 3. Sociodemographic characteristics of 12105 children and adolescents from Colombia. ENSIN 2015

Sociodemographic variables	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	P-value	n ^b	%	SE	n	%	SE	n	%	SE	P-value
Physical Education Classes ^e																				
No class in the last week		NA			NA			NA		NA	803	18.6	0.88	364	17.2	1.26	439	20.1	1.22	0.007
One day		NA			NA			NA			2737	61.1	1.24	1442	64.8	1.70	1295	57.3	1.67	
Two or more days		NA			NA			NA			1054	20.3	1.14	493	18.0	1.37	561	22.6	1.68	
Parks availability in the neighborhood																				
Yes	3121	61.4	1.54	1650	62.6	1.89	1471	60.1	1.90	0.263	4285	67.1	1.12	2261	69.4	1.28	2024	64.5	1.43	0.002
No	2212	38.6	1.54	1127	37.4	1.89	1085	39.9	1.90		2479	32.9	1.12	1174	30.6	1.28	1305	35.5	1.43	
Safety perception ^f																				
Is safe to play in the park	2371	72.1	1.58	1271	72.7	2.12	1100	71.4	2.14	0.652	3195	72.6	1.21	1783	77.4	1.59	1412	67.2	1.79	<0.001
Is not safe to play in the park	750	27.9	1.58	379	27.3	2.12	371	28.6	2.14		1090	27.4	1.21	478	22.6	1.59	612	32.8	1.79	
Counseling on physical activity																				
Yes	890	18.6	0.96	466	18.3	1.27	424	19.0	1.38	0.687	1166	18.8	0.76	511	16.0	0.94	655	21.8	1.18	<0.001
No	4443	81.4	0.96	2311	81.7	1.27	2132	81.0	1.38		5598	81.2	0.76	2924	84.0	0.94	2674	78.3	1.18	
Geographic region																				
Atlantic	786	23.5	1.54	418	23.4	2.05	368	23.6	1.66	0.740	1370	24.0	1.03	808	24.7	1.33	562	23.2	1.23	0.815
Eastern	809	17.9	1.88	409	17.1	2.05	400	18.7	1.90		1181	18.0	1.53	619	17.6	1.54	562	18.4	1.77	
Orinoquia-Amazonia	1560	3.3	0.24	802	3.2	0.32	758	3.4	0.25		1249	3.0	0.19	441	3.0	0.30	808	3.0	0.25	
Capital District	368	14.5	1.40	193	14.2	1.85	175	14.9	1.60		410	13.2	1.18	229	13.6	1.61	181	12.7	1.28	
Central	1195	24.4	1.23	631	25.4	1.69	564	23.2	1.30		1678	24.6	0.88	849	24.2	1.15	829	25.1	1.20	
Pacific	618	16.5	0.93	325	16.7	1.19	293	16.2	1.21		881	17.3	0.81	493	17.0	0.98	388	17.7	1.13	
Participation in organized activities and programs ^g																				
Ciclovias ^h																				
Yes	83	2.0	0.45	51	1.9	0.41	32	2.0	0.84	0.925	477	15.8	1.17	292	21.0	1.83	185	10.1	1.13	<0.001
No	5250	98.0	0.45	2726	98.1	0.41	2524	98.0	0.84		3038	84.3	1.17	1447	79.0	1.83	1591	89.9	1.13	
Community physical activity programs (e.g. aerobics)																				
Yes		NA			NA			NA		NA	808	20.4	1.20	300	16.4	1.35	508	23.9	1.77	0.001

Table 3. Sociodemographic characteristics of 12105 children and adolescents from Colombia. ENSIN 2015

Sociodemographic variables	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	P-value	n ^b	%	SE	n	%	SE	n	%	SE	P-value
No		NA			NA			NA			2873	79.6	1.20	1384	83.6	1.35	1489	76.1	1.77	
Physical activity programs at school																				
Yes		NA			NA			NA		NA	1921	47.8	1.29	1016	50.2	1.70	905	45.4	1.87	0.054
No		NA			NA			NA			2045	52.2	1.29	951	49.8	1.70	1094	54.6	1.87	
Sport Clubs																				
Yes	2237	41.7	1.18	1477	54.3	1.75	760	28.1	1.50	<0.001	1125	28.5	1.19	780	38.5	1.74	345	16.7	1.28	<0.001
No	3096	58.3	1.18	1300	45.7	1.75	1796	72.0	1.50		2709	71.6	1.19	1266	61.5	1.74	1443	83.3	1.28	
Organized groups (dance, martial arts, etc)																				
Yes	484	8.3	0.69	171	5.4	0.73	313	11.4	1.13	<0.001	728	19.7	1.17	258	15.7	1.48	470	23.1	1.70	0.002
No	4849	91.7	0.69	2606	94.6	0.73	2243	88.6	1.13		2810	80.3	1.17	1332	84.3	1.48	1478	76.9	1.70	
Frequency of participation in programs and organized activities ⁱ																				
Once per month		NA			NA			NA			738	22.4	1.28	348	20.6	1.68	390	24.6	1.85	
Twice per month		NA			NA			NA			449	14.3	0.95	217	13.8	1.37	232	14.9	1.33	
Three times per month		NA			NA			NA		NA	298	8.9	0.79	164	8.8	0.98	134	9.0	1.17	0.242
Four times per month or more		NA			NA			NA			1665	54.4	1.56	935	56.8	2.19	730	51.5	2.19	

a The total sample size for school-aged children was 5336 children. However, the following variables had missing values: ethnicity=45, BMI=184, TV availability=4, area, videogames availability, parks availability, counseling on physical activity and participation in Ciclovias, sport clubs and organized groups=3.

b The total sample size for adolescents was 6769. However, the following variables had missing values: ethnicity=54, BMI=276, TV availability=6, area, videogames availability, parks availability, counseling on physical activity=5.

c No excess category groups children with thinness, risk of thinness and normal BMI.

d The variable maternal physical activity is available only for the dyads of children and mothers selected for the physical activity component of the survey, therefore the sample sizes are smaller.

e The frequency of Physical Education classes was assessed only among school-attending adolescents, for this reason the sample size is smaller.

f Safety perception was assessed only among those who reported having a park in their neighborhood.

g Participation in organized activities and programs was assessed only among school-age children and adolescents who reported knowing those programs

h Ciclovias are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

i The frequency of participation in programs was assessed only among those adolescents who reported participating in at least one of the programs and activities listed.

School-aged children

Overall, 31.1% of school-aged children met the PA guidelines, with a higher prevalence among males (35.8%) (Figure 1) and several differences by sociodemographic and PA relevant variables (Table 5). When the vigorous activities and muscle strengthening recommendations were considered, the prevalence estimate decreased to 3.1%, and sex differences remained (Figure 1). The sensitivity analyses showed that when five- and six-day cut-off were used the prevalence increased to 36.9% and 32.5%, respectively.

Adolescents

Among adolescents, 13.4% met the PA guidelines with higher levels among males (18.8%) (Figure 1). Other significant differences were observed between groups (Table 5). When vigorous activities and muscle strengthening recommendations were considered, the prevalence estimate decreased to 4.8% and a significant difference between males and females remained (Figure 1). The sensitivity analysis showed that when five- and six-day cut-off were used the prevalence increased to 20.5% and 15.7%, respectively.

Table 4. Prevalence of meeting physical activity guidelines and play engagement among preschool children from Colombia.

Sociodemographic and PA relevant variables	Preschool children											
	Meeting 180 minutes of any intensity PA + 60 minutes of energetic play				More than 2 hours of unstructured play per day				More than 2 hours of outdoors play per day			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Total	24.4	(22.2-26.7)	1.125		31.5	(29.3-33.8)	1.126		10.9	(9.5-12.6)	0.7785	
Sex												
Female	19.9	(17.3-22.8)	1.388	<0.001	26.6	(23.9-29.5)	1.400	<0.001	10.4	(8.4-12.8)	1.088	0.448
Male	28.6	(25.5-31.9)	1.587		36.1	(32.9-39.4)	1.624		11.5	(9.6-13.6)	1.010	
Age (years)												
3-4	24.8	(22.1-27.8)	1.415	0.492	31.9	(29.1-34.8)	1.422	0.519	11.5	(9.7-13.6)	0.983	0.156
5	23.3	(19.9-27.0)	1.774		30.4	(27.1-34.1)	1.753		9.6	(7.9-11.7)	0.953	
Ethnicity												
Afro-colombian	31.3	(25.3-38.0)	3.184	0.058	44.2	(37.5-51.2)	3.459	<0.001	21.5	(16.1-28.2)	3.015	<0.001
Indigenous	20.6	(13.6-30.0)	4.102		25.1	(18.2-33.5)	3.860		16.0	(10.2-24.3)	3.504	
Other	23.9	(21.5-26.5)	1.248		30.5	(28.1-33.1)	1.250		9.5	(8.0-11.3)	0.820	
BMI categorization												
No excess ^a	24.7	(22.3-27.2)	1.210	0.975	31.5	(29.2-34.0)	1.207	0.598	11.4	(9.8-13.3)	0.869	0.133
Overweight	25.2	(18.9-32.7)	3.462		35.2	(27.8-43.5)	3.974		9.6	(6.5-14.0)	1.837	
Obesity	25.8	(15.8-39.1)	5.867		30.5	(20.1-43.3)	5.870		5.0	(2.0-12.1)	2.281	
Wealth Quartiles												
First (poorest)	23.4	(20.5-26.5)	1.509	0.070	29.6	(26.7-32.8)	1.545	0.346	16.6	(14.1-19.5)	1.342	<0.001
Second	25.2	(20.9-30.1)	2.301		33.7	(29.2-38.5)	2.323		7.4	(5.1-10.4)	1.304	
Third	20.9	(16.9-25.5)	2.145		30.1	(25.7-35.0)	2.347		5.1	(3.4-7.6)	1.018	
Fourth (wealthiest)	31.8	(23.9-40.9)	4.287		35.0	(27.4-43.5)	4.049		9.2	(5.0-16.3)	2.740	
Area												
Urban	25.2	(22.6-28.1)	1.361	0.217	33.1	(30.4-36.0)	1.391	0.021	8.6	(7.1-10.5)	0.848	<0.001
Rural	22.2	(18.5-26.4)	1.969		27.2	(23.4-31.3)	1.967		17.0	(14.0-20.4)	1.595	
TV available at the child's bedroom												
Yes	22.5	(19.4-25.9)	1.611	0.116	30.3	(27.1-33.8)	1.684	0.360	7.9	(6.3-9.8)	0.872	<0.001
No	25.8	(23.0-28.8)	1.435		32.4	(29.5-35.4)	1.466		13.2	(11.1-15.6)	1.122	

Table 4. Prevalence of meeting physical activity guidelines and play engagement among preschool children from Colombia.

Sociodemographic and PA relevant variables	Preschool children											
	Meeting 180 minutes of any intensity PA + 60 minutes of energetic play				More than 2 hours of unstructured play per day				More than 2 hours of outdoors play per day			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Video games devices availability												
Yes	27.7	(21.4-35.1)	3.439	0.284	38.8	(31.2-44.9)	3.451	0.048	9.3	(5.7-14.7)	2.196	0.443
No	23.9	(21.5-26.3)	1.203		30.5	(28.1-33.0)	1.222		11.2	(9.7-13.0)	0.827	
Maternal physical activity												
Meeting WHO guidelines	25.2	(17.5-34.9)	4.302	0.836	30.2	(22.2-39.5)	4.288	0.869	8.3	(5.4-12.5)	1.714	0.285
Not meeting WHO guidelines	24.1	(18.0-31.5)	3.333		31.1	(24.5-38.5)	3.452		11.5	(7.1-18.2)	2.667	
Parks availability in the neighborhood												
Yes	26.7	(23.6-29.9)	1.566	0.020	34.2	(31.1-37.4)	1.583	0.009	9.1	(7.3-11.3)	0.993	0.006
No	21.6	(18.8-24.7)	1.487		28.2	(25.1-31.4)	1.572		13.3	(11.1-15.8)	1.163	
Safety perception^b												
Is safe to play in the park	28.0	(24.8-31.5)	1.666	0.201	36.2	(32.8-39.6)	1.689	0.058	8.4	(6.4-10.9)	1.110	0.252
Is not safe to play in the park	22.5	(15.9-30.8)	3.718		28.0	(21.3-36.0)	3.679		11.0	(7.5-16.0)	2.107	
Counseling on physical activity												
Yes	23.3	(18.0-29.5)	2.898	0.680	35.4	(29.7-41.6)	2.988	0.161	7.9	(5.2-11.6)	1.569	0.074
No	24.6	(22.2-27.2)	1.240		30.8	(28.4-33.4)	1.249		11.5	(9.9-13.3)	0.860	
Geographic region												
Atlantic	26.4	(22.6-30.5)	1.977	0.489	34.4	(30.3-38.8)	2.125	0.296	14.5	(11.4-18.4)	1.739	0.018
Eastern	25.3	(20.2-31.1)	2.738		29.7	(25.0-35.0)	2.506		9.1	(5.8-13.9)	1.978	
Orinoquia-Amazonia	15.7	(9.5-25.0)	3.855		20.8	(13.8-30.2)	4.080		9.9	(6.4-15.2)	2.158	
Capital District	26.4	(19.0-35.5)	4.167		29.5	(21.9-38.5)	4.168		5.1	(2.2-11.5)	2.123	
Central	22.8	(19.1-27.0)	1.98		32.7	(28.5-37.1)	2.150		10.4	(8.1-13.2)	1.267	
Pacific	23.2	(18.3-29.0)	2.67		31.3	(26.5-36.7)	2.559		13.5	(10.1-17.8)	1.905	

a No excess category groups children with thinness, risk of thinness and normal BMI.

b Safety perception was assessed only among those who reported having a park in their neighborhood.

Table 5. Prevalence of meeting physical activity guidelines among Colombian school-aged children and adolescents.

Sociodemographic and PA relevant variables	School aged children								Adolescents							
	Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities				Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Total	31.1	(28.4-34.0)	1.398		3.1	(2.5-3.8)	0.343		13.4	(12.0-15.0)	0.753		4.8	(4.0-5.7)	0.434	
Sex																
Female	26.0	(22.9-29.4)	1.621	<0.001	2.4	(1.7-3.3)	0.401	0.050	7.6	(6.1-9.6)	0.871	<0.001	2.1	(1.5-2.8)	0.334	<0.001
Male	35.8	(32.1-39.7)	1.911		3.7	(2.8-5.0)	0.541		18.8	(16.7-21.0)	1.084		7.3	(5.9-9.0)	0.750	
Ethnicity																
Afro-colombian	45.2	(37.6-53.0)	3.893	<0.001	5.3	(2.9-9.3)	1.538	0.062	17.1	(12.0-23.8)	2.944	0.231	5.8	(3.7-9.1)	1.316	0.228
Indigenous	47.6	(35.2-60.4)	6.414		2.2	(1.0-4.9)	0.897		12.9	(8.5-19.0)	2.590		2.6	(1.4-4.9)	0.841	
Other	28.3	(25.5-31.2)	1.414		2.8	(2.2-3.6)	0.335		13.1	(11.7-14.6)	0.744		4.8	(3.9-5.8)	0.484	
BMI categorization																
No excess ^a	33.3	(30.4-36.3)	1.477	0.001	3.0	(2.3-3.9)	0.402	0.641	14.4	(12.7-16.3)	0.904	0.003	5.0	(4.1-6.2)	0.512	0.337
Overweight	27.0	(22.3-32.4)	2.518		3.1	(2.0-4.8)	0.678		8.4	(6.3-11.1)	1.192		3.8	(2.3-6.0)	0.887	
Obesity	18.6	(12.5-26.7)	3.534		2.1	(1.0-4.4)	0.759		12.7	(8.1-19.4)	2.781		6.8	(3.4-13.1)	2.286	
Wealth Quartiles																
First (poorest)	38.5	(34.2-43.0)	2.215	<0.001	3.2	(2.3-4.5)	0.551	0.940	15.4	(12.9-18.4)	1.375	0.019	3.7	(2.8-4.8)	0.507	0.241
Second	26.5	(22.3-31.1)	2.194		2.8	(1.8-4.3)	0.599		15.3	(12.6-18.4)	1.472		5.9	(3.9-8.7)	1.181	
Third	24.8	(20.5-29.8)	2.327		3.0	(1.9-4.5)	0.643		10.4	(8.2-13.1)	1.237		5.5	(3.9-7.8)	0.977	
Fourth (wealthiest)	28.1	(22.0-35.1)	3.297		3.3	(1.7-6.6)	1.148		10.2	(6.9-14.8)	1.940		4.8	(2.9-7.8)	1.166	
Area																
Urban	29.4	(26.4-32.6)	1.549	0.028	2.9	(2.2-3.8)	0.394	0.391	13.1	(11.5-14.8)	0.818	0.372	5.5	(4.5-6.7)	0.550	0.005
Rural	35.9	(30.8-41.4)	2.661		3.6	(2.4-5.4)	0.734		14.4	(11.8-17.6)	1.449		2.9	(1.9-4.3)	0.574	
TV available at the child's bedroom																
Yes	24.5	(21.5-27.7)	1.552	<0.001	2.5	(1.7-3.7)	0.500	0.173	12.2	(10.3-14.4)	1.030	0.155	5.1	(3.9-6.7)	0.708	0.529

Table 5. Prevalence of meeting physical activity guidelines among Colombian school-aged children and adolescents.

Sociodemographic and PA relevant variables	School aged children								Adolescents							
	Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities				Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
No	35.5	(31.8-39.3)	1.859		3.5	(2.7-4.5)	0.452		14.3	(12.3-16.4)	1.021		4.5	(3.5-5.8)	0.563	
Video games devices availability																
Yes	25.9	(22.1-30.0)	1.961	0.003	2.8	(1.8-4.3)	0.593	0.595	12.7	(11.0-14.5)	0.873	0.175	5.8	(4.7-7.2)	0.636	0.001
No	33.8	(30.4-37.3)	1.709		3.2	(1.5-4.2)	0.420		14.6	(12.3-17.2)	1.233		3.1	(2.3-4.1)	0.447	
Maternal physical activity																
Meeting WHO guidelines	24.8	(18.9-31.7)	3.169	0.921	4.3	(2.1-8.5)	1.492	0.468	16.2	(9.1-27.1)	4.415	0.773	5.3	(2.4-11.3)	2.030	0.612
Not meeting WHO guidelines	24.3	(18.9-30.7)	2.935		3.1	(1.8-5.3)	0.826		14.5	(8.7-23.1)	3.521		7.4	(2.7-18.3)	3.511	
Physical Education Classes ^b																
No class in the last week		NA				NA			12.6	(9.5-16.4)	1.707		5.6	(3.3-9.4)	1.455	
One day		NA				NA			13.2	(11.1-15.6)	1.131	0.952	4.9	(3.6-6.6)	0.727	0.849
Two or more days		NA				NA			12.9	(10.2-16.2)	1.488		5.2	(3.6-7.6)	0.976	
Parks availability in the neighborhood																
Yes	28.5	(25.6-31.7)	1.516	0.006	3.3	(2.5-4.4)	0.466	0.315	14.2	(12.5-16.1)	0.887	0.079	5.7	(4.7-7.1)	0.603	<0.001
No	35.2	(31.0-39.6)	2.143		2.7	(1.9-3.8)	0.469		11.8	(9.8-14.2)	1.116		2.8	(2.0-3.9)	0.452	
Safety perception ^c																
Is safe to play in the park	30.3	(27.2-33.6)	1.605	0.046	3.7	(2.7-5.0)	0.567	0.180	14.9	(13.0-17.1)	1.031	0.200	6.2	(5.0-7.6)	0.661	0.369
Is not safe to play in the park	24.0	(19.0-29.9)	2.724		2.4	(1.3-4.3)	0.725		12.2	(9.1-16.1)	1.732		4.6	(2.5-8.4)	1.394	
Counseling on physical activity																
Yes	25.2	(20.8-30.1)	2.317	0.009	4.3	(2.8-6.7)	0.942	0.087	14.0	(10.6-18.3)	1.918	0.734	6.1	(4.3-8.6)	1.062	0.118
No	32.5	(29.5-35.6)	1.547		2.8	(2.1-3.6)	0.363		13.3	(11.7-15.0)	0.807		4.5	(3.6-5.5)	0.468	
Geographic region																

Table 5. Prevalence of meeting physical activity guidelines among Colombian school-aged children and adolescents.

Sociodemographic and PA relevant variables	School aged children								Adolescents							
	Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities				Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Atlantic	42.2	(36.0-48.5)	3.138	<0.001	2.7	(1.8-4.0)	0.538	0.450	14.6	(12.1-17.5)	1.363	0.678	4.5	(3.2-6.2)	0.724	0.758
Eastern	24.1	(19.9-28.9)	2.244		2.9	(1.8-4.8)	0.732		12.8	(9.9-16.4)	1.621		5.2	(3.7-7.3)	0.900	
Orinoquia- Amazonia	40.7	(34.9-46.7)	2.960		5.4	(3.9-7.5)	0.894		15.6	(11.9-20.3)	2.109		7.8	(5.0-12.1)	1.752	
Capital District	19.4	(14.0-26.2)	3.057		3.7	(1.9-7.1)	1.221		13.7	(9.3-19.7)	2.593		4.8	(2.2-10.1)	1.841	
Central	28.4	(23.7-33.5)	2.445		2.4	(1.5-3.7)	0.524		11.6	(9.5-14.2)	1.171		4.2	(3.0-5.9)	0.723	
Pacific	35.4	(27.7-43.9)	4.071		3.8	(2.0-6.9)	1.158		14.4	(10.2-19.8)	2.383		5.0	(3.1-7.8)	1.143	
Participation in organized activities and programs																
Ciclovias ^d																
Yes	29.4	(15.1-49.2)	8.771	0.843	1.3	(0.3-5.2)	0.911	0.207	17.7	(12.7-24.1)	2.829	0.070	11.2	(6.7-18.1)	2.777	0.004
No	31.1	(28.4-34.0)	1.410		3.1	(2.5-3.9)	0.349		12.6	(10.7-14.8)	1.017		4.9	(3.9-6.1)	0.559	
Community physical activity programs (e.g. aerobics)																
Yes		NA				NA			10.0	(7.4-13.3)	1.440	0.028	5.1	(3.4-7.6)	1.030	0.643
No		NA				NA			14.3	(12.2-16.7)	1.115		5.7	(4.4-7.4)	0.742	
Physical activity programs at school																
Yes		NA				NA			15.8	(13.5-18.6)	1.271	0.005	6.5	(4.9-8.5)	0.886	0.023
No		NA				NA			11.3	(9.4-13.5)	1.022		4.1	(3.1-5.5)	0.595	
Sport Clubs																
Yes	32.1	(28.5-36.0)	1.878	0.404	4.8	(3.5-6.4)	0.707	<0.001 ¹	20.0	(16.6-23.9)	1.825	0.002	11.1	(8.5-14.5)	1.513	<0.001
No	30.4	(27.3-33.7)	1.603		1.9	(1.4-2.6)	0.298		13.1	(10.9-15.7)	1.192		4.6	(3.4-6.3)	0.728	
Organized groups																
Yes	22.3	(16.8-29.0)	3.051	0.006	1.9	(1.0-3.7)	0.643	0.158	13.8	(10.3-18.2)	1.969	0.732	6.5	(4.0-10.5)	1.566	0.332

Table 5. Prevalence of meeting physical activity guidelines among Colombian school-aged children and adolescents.

Sociodemographic and PA relevant variables	School aged children								Adolescents							
	Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities				Meeting 60 minutes of MVPA daily				Meeting 60 minutes of MVPA daily + 3 days of vigorous activities			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
No	31.9	(29.1-34.8)	1.438		3.2	(2.5-4.0)	0.370		13.0	(11.0-15.2)	1.045		5.0	(3.9-6.4)	0.615	
Frequency of participation in programs and organized activities																
Once per month		NA				NA			13.4	(8.9-19.6)	2.643		7.1	(3.4-14.2)	2.545	
Twice per month		NA				NA			11.4	(7.9-16.2)	2.039		3.8	(2.0-7.3)	1.245	
Three times per month		NA				NA			10.3	(6.7-15.7)	2.207	0.024	3.7	(1.8-7.4)	1.303	0.107
Four times per month or more		NA				NA			18.5	(15.8-21.5)	1.421		9.1	(7.1-11.5)	1.072	

a No excess category groups children with thinness, risk of thinness and normal BMI.

b The frequency of Physical Education classes was assessed only among school-attending adolescents

c Safety perception was assessed only among those who reported having a park in their neighborhood.

d Ciclovias are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

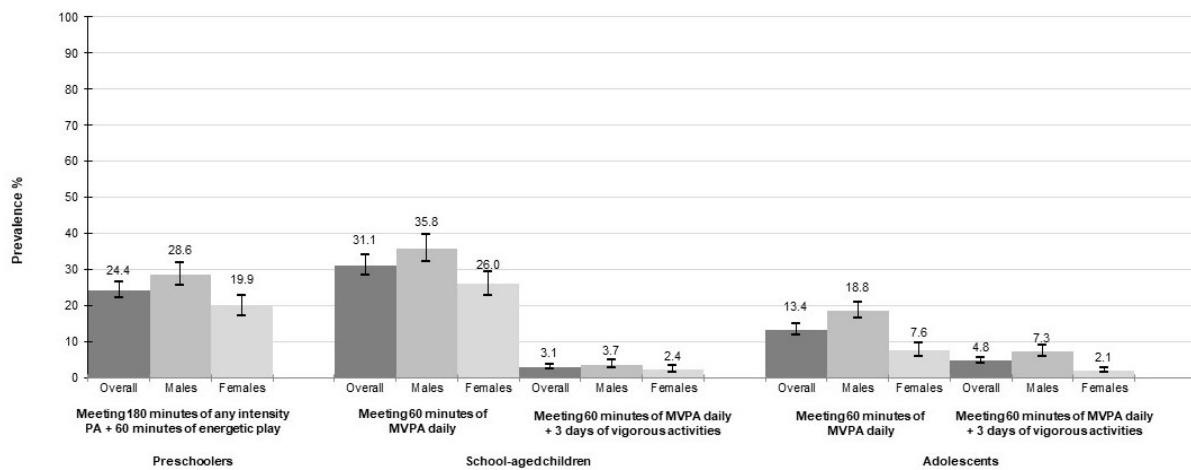


Figure 1. Prevalence estimates of meeting physical activity guidelines among Colombian children by sex ENSIN 2015. Data are shown as mean values (%) and 95% confidence intervals. PA, physical activity; MVPA, moderate-to-vigorous physical activity. Vigorous activities correspond to activities that strengthen muscle and bone.

Correlates of physical activity indicators

Meeting PA guidelines among preschoolers

According to the bivariate analyses, female sex, lower socioeconomic status, and TV availability in the bedroom were negatively associated with meeting PA guidelines. Afro-Colombian ethnicity and park availability were positively associated with meeting the PA guidelines. Multivariable analyses showed preschool females were less likely to meet the PA guidelines compared to males (PR=0.70, $p < 0.001$), as well as preschoolers in the third wealth quartile compared to the wealthiest (PR=0.66, $p = 0.016$). Afro-Colombian preschoolers were more likely to meet the PA guidelines compared to those that did not report ethnic identity (PR=1.36, $p = 0.011$), and preschoolers who had parks in their neighborhood were more likely to be active than those who did not have any (PR=1.23, $p = 0.026$) (Figure 2a).

Unstructured play among preschoolers

According to the bivariate models, female sex, living in rural areas, lower socioeconomic status, and living in the Orinoquia-Amazonia region were negatively associated with achieving 2 hours of unstructured play per day. Afro-Colombian ethnicity, video games devices availability, and having a park in the neighborhood were positively associated with unstructured play.

According to the multivariable analysis, preschool females were less likely to engage in unstructured play compared to males (PR=0.74, $p<0.001$), Afro-Colombian preschoolers were more likely to participate in unstructured play than those that did not report ethnic identity (PR=1.54, $p<0.001$), and preschoolers who had parks in their neighborhood were more likely to spend more than two hours of unstructured play per day than their counterparts (PR=1.22, $p=0.009$) (Figure 2b).

Outdoor play among preschoolers

The bivariate models showed negative associations for outdoor play with female sex, obesity and TV availability in the bedroom. Positive associations were observed with Afro-Colombian and indigenous ethnicity, lower socioeconomic status, living in a rural area, parks availability, safety perception, not receiving counseling in PA, and living in the Atlantic and Pacific regions. According to the multivariable analysis, Afro-Colombian preschoolers were more likely to engage in two daily hours of outdoor play compared to preschoolers who did not report ethnic identity (PR=1.86, $p=0.001$) (Figure 2c).

Meeting PA guidelines among school-aged children

The bivariate models showed negative associations with female sex, overweight and obesity, TV availability in the child's bedroom, parks availability and involvement in organized activities. Positive associations were found with younger age, Afro-Colombian and indigenous

ethnicity, lower socioeconomic status, video games devices availability, parks availability, safety perception, and living in the Atlantic, Orinoquia-Amazonia, Central or Pacific region. According to the multivariable analysis females were less likely to meet the PA guidelines than males (PR=0.74, $p<0.001$), and children with obesity were less likely to meet the guidelines than their counterparts (PR=0.60, $p=0.007$). Likewise, children who had a TV in their bedroom were less likely to be active than those who did not (PR=0.83, $p=0.014$). In contrast, younger children (6 to 9 years old) were more likely to meet the PA guidelines than their older counterparts (PR=1.67, $p<0.001$), Afro-Colombian children were more likely to be active than those who did not report an ethnic identity (PR=1.42, $p=0.001$), and children from the Atlantic (PR=1.75, $p=0.003$), and Amazonia-Orinoquia region (PR=1.87, $p=0.001$) had an increased likelihood of being active than those from the Capital district (Figure 3).

Meeting PA guidelines among adolescents

According to the bivariate models, negative associations were observed for female sex, overweight, TV and video games devices availability, and participation in community programs. Positive associations were found for the first and second wealth quartiles, parks availability, participation in Ciclovías, school programs and sports clubs, as well as the participation in programs four times per month or more. Given that the program related variables were available only for a subsample, two multivariable models were conducted. In the first multivariable model, all the variables associated in the bivariate models were included except the program related ones. The first model showed that females were less likely to meet PA guidelines than males (PR=0.42, $p<0.001$) and adolescents with overweight were less likely to be active than their counterparts (PR=0.67, $p=0.011$). Also, adolescents who reported having a park in their neighborhood were more likely to meet the PA guidelines, compared to those who did not have a

park (PR=1.27, p=0.020) (Figure 4a). The second multivariable model included the same variables as the first one, plus all the program variables that were significant in the bivariate models. This model showed that females were less like to be active than males (PR=0.52, p=0.010), while adolescents in the two lowest quartiles of the wealth index were more likely to meet the guidelines than their counterparts in the wealthiest quartile (PR=3.66, p=0.001 and PR=3.37, p=0.004, for the first and second quartiles, respectively). The adolescents who participated in programs four or more times per month were more likely to meet PA guidelines than those who participated only once per month (PR=2.15, p=0.014) (Figure 4b).

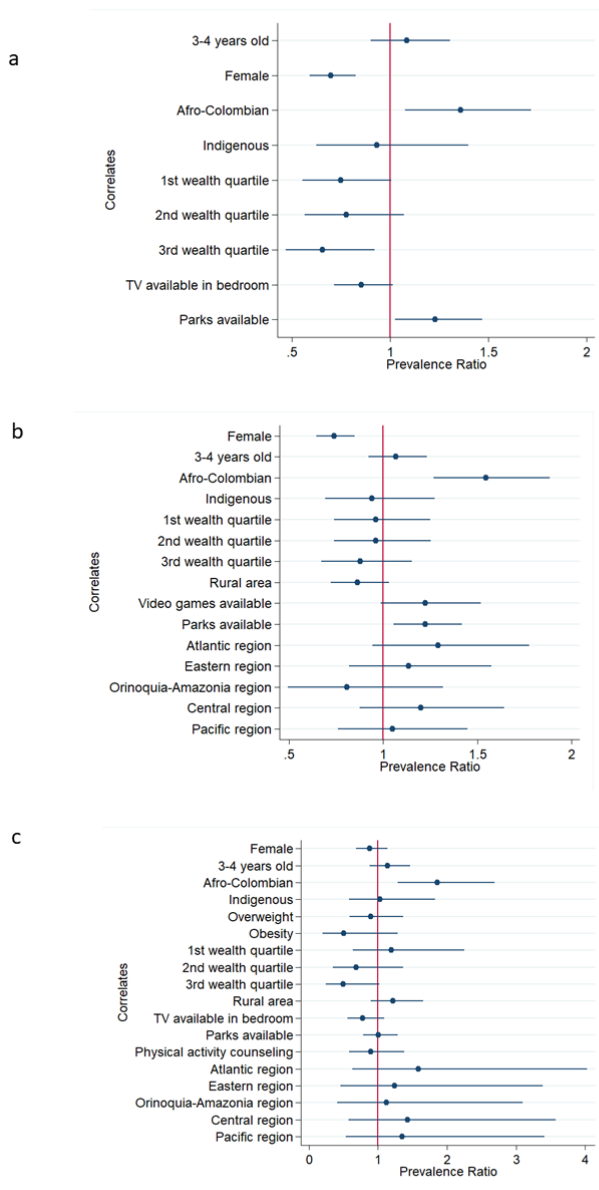


Figure 2. Prevalence ratios and 95% confidence intervals of correlates of physical activity indicators among Colombian preschool children. a) Correlates of meeting physical activity guidelines. Meeting guidelines is defined as engaging in at least 180 minutes of physical activity per day including at least 60 minutes of energetic play. b) Correlates of more than two hours of unstructured play per day. c) Correlates of more than two hours of outdoors play per day.

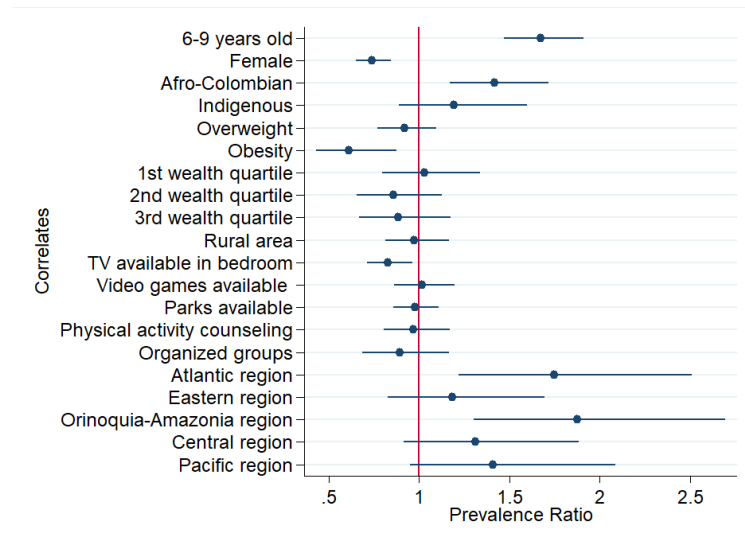


Figure 3. Prevalence ratios and 95% confidence intervals of correlates of meeting physical activity guidelines among Colombian school-aged children. Meeting guidelines was defined as engaging in at least 60 minutes of moderate- to vigorous-intensity physical activity per day seven days per week.

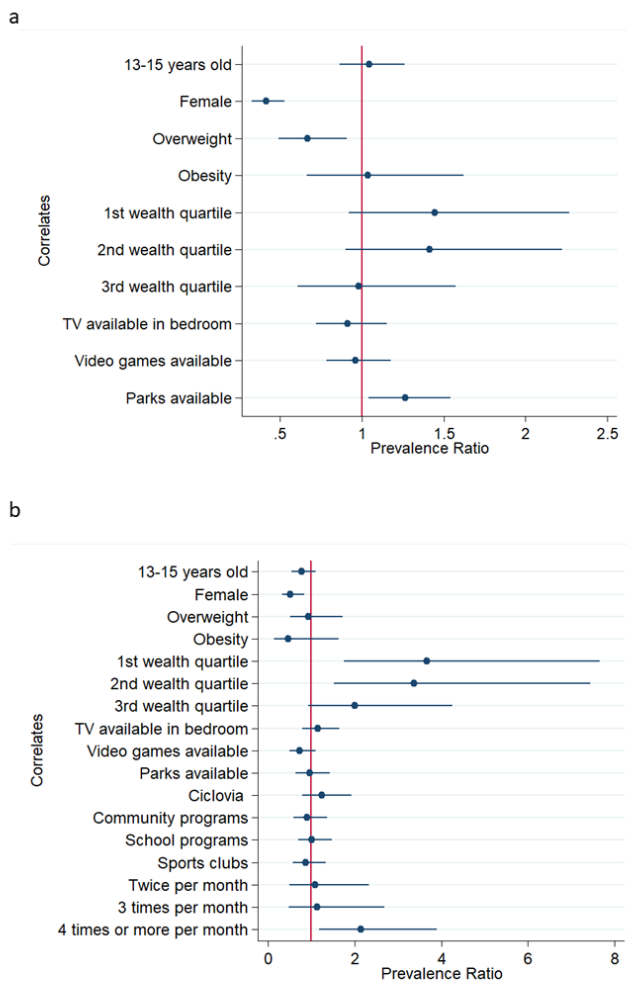


Figure 4. Prevalence ratios and 95% confidence intervals of correlates of meeting physical activity guidelines among Colombian adolescents. Meeting guidelines was defined as engaging in at least 60 minutes of moderate- to vigorous-intensity physical activity per day seven days per week. a) First multivariable model; b) Second multivariable model including program participation variables.

Discussion

Our results show that the prevalence of meeting PA guidelines among Colombian children and adolescents is low and decreases across age groups. The differences by sex were consistent across all age groups indicating that females are less active than males, and steep decreases in the prevalence of meeting PA guidelines were observed when the recommendation for vigorous and strengthening activities were taken into account. Several variables from the individual, household, community, and environmental levels were identified as correlates of PA indicators and are discussed below.

Among preschoolers, the low estimates are concerning considering the importance of PA and play from early ages for the development of cognitive, social, physical and emotional skills.^{26–29} Also, it is important to highlight that sex differences of approximately nine percentage points were observed in PA and unstructured play, indicating a clear inequity for females, since these are likely to be socially shaped differences, and therefore, unfair and avoidable. In the context of the scarce evidence on preschool adherence to the current PA guidelines, our results are notably lower than results from Canada, Australia and Finland, where 61.8% to 94.3% preschoolers met PA guidelines.^{30–33} However, it should be noted that those estimates were based on accelerometry measures, while ours were based on information reported by parents, who tend to under-report PA, especially for young children.³⁴ Estimates based on proxy-reported PA in Canadian preschoolers have shown an adherence to PA guidelines of 38%, still higher than our findings.³⁵ No comparable evidence was found from Latin American countries, probably because evidence in early years children using the recently released guidelines is just emerging.

Our results for school-aged children and adolescents are similar to the global and regional estimates.^{6–8} A third of school-aged children and only 13% of adolescents met the global

recommendations on PA for health.⁵ This means that the large majority of Colombian children and adolescents are not enjoying the health benefits associated to the practice of regular PA, and this situation is worse among females. The results of the sensitivity analyses showed similar patterns and cause for concern when the cut-off points were five and six days per week. This could be indicative of the limitation of the question used to assess PA, which inquires about frequency of PA instead of duration. The differences that we observed in the prevalence of meeting PA guidelines across age groups do not follow the patterns reported previously suggesting that the decline in MVPA happened around the age of school entry or around 7 years of age.^{36,37} This could be related to two factors. First, a methodological reason, since preschool PA was assessed with a different questionnaire than school-aged and adolescents' PA. And second, preschool and school-aged variables were reported by a proxy, while adolescents' PA was self-reported. However, the steep decline observed specifically among adolescents is consistent with previous literature that has reported PA declines in the transition to adolescence.^{38,39}

Correlates at the individual level

Our results showed that female sex, age, Afro-Colombian ethnicity, and BMI were associated with PA indicators among Colombian children and adolescents. However, the direction of the associations varied, and the correlates varied according to the age group. Female sex was a consistent negative correlate for all age groups and indicators, except for outdoor play. Sex is the most consistent correlate in the literature for all age groups^{40,41} and in light of our results is indicative of the need to create policies and programs with a differential approach that provide opportunities for girls to be active since early years. Age was identified as a correlate only for school-aged children, indicating that younger children were more likely to be active. This is also

consistent with the literature⁴⁰ and suggests the need to consider the age of the target population for PA programs, and to design strategies that maintain or even increase children's participation in active behaviours as they get older. The positive association of Afro-Colombian ethnicity with PA and unstructured play among preschool and school-aged children could be indicative of cultural differences that influence the activities in which young children spend their time. For example, traditional games or dance-related activities belonging to the Afro-Colombian culture can contribute to explain the observed difference. Also, the higher involvement in PA can be related to poverty conditions prevalent among Afro-Colombian populations. Unfortunately, there is a lack of research on PA with an ethnic-minority focus in Colombia that would help to better understand this association. Regarding BMI, our findings show that school-aged children with obesity and adolescents with overweight were less likely to be active. This association needs to be considered in the design of PA strategies in the context of the increase in overweight and obesity that Colombia is experiencing.

Correlates at the household level

Socioeconomic status and the availability of TV in the child's bedroom were significant correlates of PA at the household level. Among preschoolers, children in the lower wealth quartiles were less likely to be active than the wealthiest. This association was opposite for adolescents. In contrast with our findings, previous literature reported no association between socioeconomic status and PA in young children^{41–43} and positive associations for adolescents in the wealthiest groups.⁴⁰ We hypothesize that our findings for preschool children can be related to greater opportunities for being active out of school or in daycare centers for the wealthiest families. These findings should be considered to improve the actions within the Early Childhood Public Policy to promote the adequate development of the most vulnerable populations. For

adolescents, our results can be related to the necessity of involving other domains of PA, such as transport or occupational activities, which are more prevalent among lower socioeconomic levels, as well as a higher involvement in sedentary activities among the wealthiest groups. These results highlight the need to reach the wealthiest adolescents with activities that encourage them to be more active, as well as continue promoting PA among lower socioeconomic groups. The negative association between TV availability in the bedroom and PA among school-aged children is consistent with evidence from the United States and Brazil,^{44,45} and suggests the need to advise parents to avoid having TVs in children's bedrooms.

Correlates at the community level

The availability of parks in the neighborhood was a positive correlate of PA and unstructured play among preschool children and adolescents. Despite the inconsistent evidence in this field,⁴⁶ our results support positive associations previously reported,⁴⁷ and suggest that parks represent a viable approach for promoting daily PA. It is interesting to observe the lack of association with PA counseling across age groups. This suggests that the scarce counselling efforts are not related to a greater proportion of children or adolescents meeting PA guidelines and needs to be improved. This is especially relevant considering that among those who received PA counseling there are greater proportions of individuals who are less likely to meet PA recommendations, such as females, children and adolescents with overweight or obesity, and children and adolescents in the highest wealth quartile.

Correlates at the environmental and policy level

At the environmental level, living in the Orinoquia-Amazonia and Atlantic regions were positive correlates of meeting PA guidelines among school-aged children. In these regions meeting PA guidelines was approximately 10 percentage points higher than the national estimates. These

regions are composed mostly of departments (administrative units) with middle HDI, which are lower than the national estimate. As it has been observed in other contexts, those social development conditions can be related to a higher involvement in active behaviours, probably by necessity.⁴⁸ In these contexts the high prevalence of meeting PA guidelines needs to be preserved, providing safe and enjoyable opportunities for being active. At the policy level, frequent attendance (four times per month or more) in PA programs was a positive correlate of PA among adolescents. This result is very relevant for the policy agenda of the country. Colombia has implemented PA programs such as Ciclovías,²⁵ community PA programs (e.g., the National Program of Healthy Life Habits),⁴⁹ organized sports programs (e.g., Supérate)⁵⁰ and PA programs at schools, but the evaluation of their impact among children and adolescents has been limited.²⁵ Despite the lack of evaluation, the positive association of the frequent participation in programs supports the maintenance and promotion of regular PA programs for Colombian young people.

Policy implications

ENSIN data are the most comprehensive nationally representative data on PA for Colombia and the best available evidence that could serve as baseline data to assess the 15% relative reduction in physical inactivity established by the WHO.⁹ Based on our findings, we highlight the following messages that can help to strengthen public policies on PA, childhood development and education, among others: 1) public policies in Colombia should recognize and promote play and specifically outdoor play as a key component of healthy child development; 2) inequities by sex and socioeconomic level in PA need to be addressed beginning with the early years through policies with differential approaches that allow the targeting of the most vulnerable populations; 3) programs to promote PA should include strategies to involve children with overweight or

obesity, empowering them to participate and avoiding segregation or marginalization; 4) urban planning policies should take into account the importance of safe parks availability and community programs in public spaces (e.g., streets, parks) for PA and health; and 5) PA programs should be offered on a sustained and regular basis to have a better impact on children and adolescents compliance of PA guidelines.

Strengths and limitations

The main strength of this study is the use of a nationally representative sample for a wide age range of children, which ensures the generalizability of our results to the Colombian population of children and youth. Also, the use of standardized measurement instruments reduces the risk of bias. Key limitations include the cross-sectional nature of the survey that does not allow causal inferences from our findings. Second, the use of self- and proxy-report variables to ascertain meeting PA guidelines could be affected by social desirability bias or by under- or over-estimations because of a recall bias. Third, some of the questionnaires used in ENSIN were adapted from studies in other settings but their validity for Colombian context has not been evaluated.

Conclusion

The majority of Colombian children and adolescents are insufficiently active. Urgent actions are needed to maintain and hopefully increase the involvement in active play and PA. These actions can be guided by the correlates identified in our study, to overcome disparities and provide opportunities for children to achieve their full potential for healthy growth and development.

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Chapter 5: Prevalence and Correlates of Active Transportation to School Among Colombian Children and Adolescents

Manuscript 2: Prevalence and correlates of active transportation to school among Colombian children and adolescents

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Article preface

This article presents the national prevalence of active transportation to and from school among Colombian children and adolescents and identifies correlates of engaging in active transportation to school. This manuscript addresses the first and second objective of this dissertation, to

describe indicators of physical activity and sedentary behaviours and determine their prevalence among Colombian children and youth (3-17 years), and to determine the factors associated with meeting physical activity guidelines, engaging in active play, using active transportation and spending excessive time in sedentary behaviours among Colombian children and youth, within a socioecological framework. SAG, OLS and MST conceived the idea of the manuscript. SAG drafted the manuscript, and all co-authors reviewed and approved the manuscript. The data used for these analyses required obtaining informed consent before conducting the survey. The survey obtained local ethics approval granted by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015; February 26, 2015). The University of Ottawa granted approval for secondary data analyses (file number H-06-19-3564). The submitted manuscript is presented in this chapter. The acceptance confirmation can be found in Appendix 6.

Abstract

Background: In Colombia, active transportation has been assessed in multiple local and regional studies, but national data on active transportation are scarce. This paper aims to describe the prevalence and factors associated with active transportation to/from school among Colombian children and adolescents.

Methods: We analyzed nationally representative data from the National Survey of Nutrition 2015, with a sample of 11,466 children and adolescents aged between 3 and 17 years.

Descriptive statistics were calculated, and prevalence ratios (PR) were estimated using Poisson regression multivariable models with robust variance.

Results: Approximately 70% of Colombian children and adolescents reported engaging in active transportation to/from school over the last week. There were no differences by sex among pre-schoolers nor school-aged children. Fewer adolescent females than males used active transportation. Pre-schoolers and school-aged children living in Bogota were more likely to report active transport than children from other regions (PR for other regions ranged between 0.59 to 0.86). School-aged children and adolescents with a lower wealth index were more likely to use active transportation than their counterparts (PR= 1.32 and 1.22, respectively).

Conclusions: The wealthiest children and adolescents, adolescents from rural areas and female adolescents should be a focus for future interventions. Actions need to be implemented to improve the involvement in active transportation to/from school in Colombia.

Keywords: surveillance, walking, cycling, adolescents, preschoolers

Introduction

In Colombia, according to the most recent survey of nutrition, in 2015, only 24.4% of pre-schoolers, 31.1% of school aged children and 13.4% of adolescents achieved the recommended amount of daily physical activity for health.¹ Consequently, the majority of Colombian children were not enjoying the holistic health benefits of being active and could be predisposed to the adverse health effects of physical inactivity. In this context, active transportation to and from school is a regular and sustainable direct source of physical activity,² which makes it a promising strategy to increase physical activity levels. Therefore, active transportation was recently recognized as one of the top investments that work for physical activity promotion.³

Active transportation is associated with multiple health benefits, mainly explained by the increase in physical activity levels when engaged in cycling or walking.² Favourable

cardiometabolic indicators,^{4,5} better cardiorespiratory fitness,^{6,7} lower adiposity⁸ and better mental health outcomes^{9,10} have been associated with the use of active modes of transportation to/from school. In addition, shifting from motorized modes to active transportation can help to reduce congestion and air pollution, and contribute to create more sustainable and equitable cities.^{11,12}

Considering the benefits of engaging in active transportation, it is relevant to examine the national situation of this behaviour to guide the formulation of policies that support walking and cycling promotion. In Colombia, previous evidence from local studies showed considerable variation in active transportation engagement among children, ranging from 49.7% to 73.3%.^{8,13,14} However, the methods of assessment varied between studies. There were differences in measurement methods with some reporting active transportation at least once a week and others reporting the usual mode. Also, differences in the study design led to some studies including regional or local samples making it difficult to make generalizations to the overall country. To inform the national situation of active transportation and contribute to the understanding of active transportation to/from school as a source of physical activity among children, the most recent version of the National Survey of Nutrition (ENSIN 2015) assessed the involvement in active transportation to and from school for the first time in Colombia. This paper aims to describe the prevalence of active transportation to/from school among Colombian children and adolescents (3-17 years), and explore the factors associated with engaging in active transportation within a socio-ecological framework.

Methods

Study design and participants

This study analyzed cross-sectional data from ENSIN 2015,¹ a nationally representative survey conducted in urban and rural areas of Colombia. ENSIN 2015 aimed to analyze the food and nutritional situation of the Colombian population within a social determinants framework, to guide the design, follow-up, and adjustment of public policies in food and nutrition security. The survey employed a stratified, multistage probability cluster sampling design. This survey was designed within the Master Sample for Household Studies in Health, which is part of the National System of Population Health Surveys, of the Ministry of Health and Social Protection of Colombia.¹⁵ From this Master Sample, a probabilistic sample of segments was defined for ENSIN 2015, where all the households had a probability of inclusion of 1, therefore, all were included in the sample (more than 50,000 households). All the households were included in the demographic, anthropometric and food security components of ENSIN. The active transportation data analyzed in this study were from a probabilistic sub-sample, calculated based on the required samples per region and age group, that completed the physical activity module of the survey. Only individuals who attended school in the week previous to the survey were eligible for the active transportation module because the active transportation questions inquired about the mode of transport to and from school in the last week previous to the survey. The sub-sample for this analysis included 2,867 preschoolers (3-5 years), 4,005 school-aged children (6-12 years), and 4,594 adolescents (13-17 years).

Data collection

Data were collected in the household setting by trained nutritionists who administered the physical activity component of the survey. Data were collected electronically in data collection

system specifically designed for the survey. For preschoolers and school-aged children, a parent or the primary caregiver of the child responded to the interview. Adolescents self-reported their responses to the interviewer. Data were collected between December 2015 and November 2016.

The study was approved by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015, February 26, 2015). The University of Ottawa granted ethical approval for secondary data analyses (Canada) (file number H-06-19-3564). Parents provided signed informed consent prior to conducting the survey. Children between 12 and 17 years also provided informed assent.

Dependent variables

Responses to active transportation questions were proxy-reported for preschoolers and school-age children, and self-reported by adolescents. For pre-school children, active transportation was assessed with the Questionnaire for the Measurement of Physical Activity and Sedentary Behaviors in preschool to fourth grade children (C-MAFYCS). This questionnaire showed good reproducibility for walking to school ($\kappa=0.80$).¹⁶ Engagement in active transportation among preschoolers was ascertained with the questions: “During the last 7 days, did (name of the child) walk to go from home to school? How much time did he/she spend? (for each day)” and “during the last 7 days, did (...) walk to go back from school to home? How much time did he/she spend? (for each day)”. Children who walked in any of the trips were categorized as active travelers. Dichotomous variables to indicate the engagement in active transportation (active vs. non active) were created for the trip home to school, school to home and for them combined. For school-aged children and adolescents, active transportation was assessed with questions adapted from the Canadian component of the 2009–2010 Health Behavior in School-aged Children Study.¹⁷ Travel mode was ascertained with the questions “In the last week you were in school,

the main part of your journey to school was by” and “In the last week you were in school, the main part of your journey from school to home was by”. Response options were walking; riding a bicycle, roller blades, skateboard or scooter; bus or public transportation; car; motorcycle; or others. Children who reported walking, or riding a bicycle, rollerblades, skateboard or scooter were categorized as active travelers. A dichotomous variable to indicate the engagement in active transportation (active vs. non-active) was created for the trip home to school, school to home, and for them combined (at least one time per day in the trip from home to school and/or school to home). Only the combined variable is presented in the tables and results.

Covariates

Considering the socio-ecological framework of physical activity,¹⁸ variables at different levels of influence were selected as covariates. For the individual level, sex (female vs. male), age, and ethnicity (Afro-Colombian vs. indigenous vs. other ethnic identity) were assessed in the Household Questionnaire of ENSIN.¹ Weight and height were directly measured by trained interviewers according to standardized procedures. Weight was measured with a portable Seca 874 scale (Seca, Hamburg, Germany), after outer clothing, accessories and shoes were removed. Height was measured with portable Shorr board stadiometers (Olney, MD, USA) with the individual's head in the Frankfort Plane and the weight evenly distributed on both sides. Body mass index (BMI) was calculated based on the objective measures of weight and height, categorized according to the WHO growth standards and reference tables.^{19,20} For children under 5 years of age BMI was classified as no excess (BMI z score $\leq +2$) vs overweight (BMI z score $>+2$ to $\leq +3$) vs obesity (BMI z score $>+3$). For children and adolescents between 5 and 17 years of age BMI was classified as no excess (BMI z score $\leq +1$) vs overweight (BMI z score $>+1$ to $\leq +2$) vs obesity (BMI z score $>+2$). Also at the individual level, participation (yes vs. no) in

organized activity groups and Ciclovías (Open Street programs in Colombia) ²¹ was assessed among school aged children and adolescents, and physical activity programs in the school and community, as well as organized sports participation were assessed only among adolescents.

For the household level, wealth index, area of residence, bicycle availability and car availability in the household were included and measured with the Household Questionnaire of ENSIN.¹ The wealth index is a composite measure that was estimated with a principal component analysis and harmonized approach in order to make it comparable to the wealth index of the previous version of the survey. Wealth index is estimated based on assets ownership, public services availability and housing construction materials.¹ Wealth index was categorized into quartiles, with the first quartile grouping the lowest socioeconomic level, and the fourth grouping the wealthiest. Bicycle and car availability (yes vs. no) were assessed with the following question “Which of the following services or goods in use does this household own” and the options “bicycle” and “private car for home use” were among the response options.

At the community level, the availability of parks in the neighbourhood (yes vs. no) and their perceived safety (safe vs. not safe) was assessed with questions adapted from the Neighborhood Impact on Kids (NIK) survey.²² At the natural environment level, we included the geographic region (Orinoquia-Amazonia vs. Atlantic vs. Central vs. Eastern vs. Pacific vs. Capital District) where children and adolescents lived at the time of the survey, which was ascertained from the identification data at the beginning of the survey.

Statistical analysis

Descriptive statistics of sociodemographic, household, environmental, policy and active transportation-related variables were estimated to characterize the sample. The overall and

stratified population-weighted prevalence of active transportation to/from school were calculated. Statistically significant differences between categories defined by sociodemographic and contextual variables (e.g females vs. males) were determined with Chi-square tests. Active transportation correlates were identified based on prevalence ratios (PR) estimated using Poisson regression models with robust variance. Each of the covariates were included in bivariate models, and those with a p-value of at least 0.10 were also included in multivariable models that included the other potential correlates as well as sex. The variables with p-values ≤ 0.05 in the multivariable models were considered correlates of active transportation to/from school. All the analyses were conducted using STATA 14.0 (StataCorp, College Station, TX, USA) with the survey (SVY) module for complex samples to take into account the clustering of the data and the characteristics of the study design, sample weights and missing data.

Results

Table 1 shows the descriptive characteristics of the sample by age group. The sample was comprised of 52% males and the mean age was 4.1 ± 0.8 years for pre-schoolers, 8.9 ± 2.0 years for school-aged children, and 14.8 ± 1.4 years for adolescents. Over 80% of the sample reported other ethnic identity. Over 70% of the sample lived in urban areas, approximately 40% of households had bicycles available and only 12 to 13% of the households had a car available. Among active travellers, 76.6% to 84.9% spent 15 minutes or less on their trip to school, and 67.3% to 81.9% spent 15 minutes or less on their trip from school to home (Table 1).

Table 1. Sociodemographic characteristics of 11466 children and adolescents from Colombia. ENSIN 2015

Sociodemographic and contextual variables	Pre-school children			School-age children			Adolescents		
	n ^a	%	SE	n ^b	%	SE	n ^c	%	SE
Sex									
Female	1401	48.7	1.44	1914	48.0	1.20	2295	48.7	1.18
Male	1466	51.3	1.44	2091	52.1	1.20	2299	51.3	1.18
Age average (SD)	4.06 (0.79)			8.96 (1.99)			14.82 (1.37)		
Ethnicity									
Afro-colombian	298	8.8	0.77	346	9.8	1.11	374	8.7	0.86
Indigenous	226	3.2	0.45	429	4.3	0.74	401	4.0	0.89
Other	2318	88.0	0.86	3199	85.9	1.23	3784	87.3	0.94
BMI categorization									
No excess ^d	2429	88.1	0.99	2924	73.8	1.34	3583	81.5	0.91
Overweight	258	9.2	0.95	677	18.3	0.99	648	13.9	0.79
Obesity	93	2.8	0.40	281	7.9	0.83	202	4.6	0.52
Wealth Quartiles									
First (poorest)	1282	34.5	1.38	2080	37.5	1.66	2145	34.9	1.33
Second	784	27.9	1.29	1027	27.0	1.35	1111	23.9	1.06
Third	542	22.9	1.40	580	19.7	1.12	850	22.6	1.09
Fourth (wealthiest)	259	14.8	1.37	318	15.9	1.30	488	18.7	1.30
Area									
Urban	2217	79.0	1.09	3014	74.5	1.43	3390	75.6	1.30
Rural	647	21.1	1.09	991	25.5	1.43	1204	21.9	1.30
Parks availability in the neighbourhood									
Yes	1575	57.0	1.54	2313	61.5	1.64	2942	67.7	1.28
No	1289	43.0	1.54	1692	38.5	1.64	1652	32.3	1.28
Safety perception ^e									
Is safe to play in the park	1176	75.2	1.70	1729	71.0	1.71	2158	71.2	1.49
Is not safe to play in the park	399	24.8	1.70	584	29.0	1.71	784	28.9	1.49
Geographic region									

Table 1. Sociodemographic characteristics of 11466 children and adolescents from Colombia. ENSIN 2015

Sociodemographic and contextual variables	Pre-school children			School-age children			Adolescents		
	n^a	%	SE	n^b	%	SE	n^c	%	SE
Atlantic	646	26.2	1.24	571	22.6	1.70	963	24.6	1.14
Eastern	496	16.2	1.51	613	18.6	1.93	805	18.5	1.53
Orinoquia-Amazonia	407	2.8	0.18	1138	3.2	0.26	810	2.8	0.19
Capital District	218	13.8	1.33	272	14.0	1.47	278	13.0	1.34
Central	629	25.1	1.20	913	24.1	1.46	1143	23.7	1.00
Pacific	471	15.8	0.86	498	17.5	1.08	595	17.4	0.96
Bicycle availability at home									
Yes	1213	45.4	1.54	1677	46.6	1.47	1845	44.0	1.28
No	1654	54.6	1.54	2328	53.4	1.47	2749	56.0	1.28
Car availability at home									
Yes	260	12.3	1.29	374	13.5	1.28	412	13.4	1.15
No	2607	87.7	1.29	3631	86.5	1.28	4182	86.6	1.15
Travel time to school among active travellers and non-active travellers									
Less than 5 minutes		NA		837	19.7	1.31	692	14.2	0.87
5 to 15 minutes		NA		2307	56.6	1.39	2483	53.6	1.12
16 to 30 minutes		NA		669	18.0	1.02	1027	22.8	0.94
31 to 60 minutes		NA		143	4.5	0.63	293	7.2	0.67
More than 60 minutes		NA		49	1.2	0.27	99	2.3	0.40
Travel time from school among active travellers and non-active travellers									
Less than 5 minutes		NA		750	18.1	1.13	550	11.7	0.86
5 to 15 minutes		NA		2162	52.4	1.41	2262	48.7	1.18
16 to 30 minutes		NA		819	22.3	1.17	1265	27.6	1.05
31 to 60 minutes		NA		208	5.6	0.66	381	8.8	0.71
More than 60 minutes		NA		66	1.6	0.28	136	3.3	0.49

Table 1. Sociodemographic characteristics of 11466 children and adolescents from Colombia. ENSIN 2015

Sociodemographic and contextual variables	Pre-school children			School-age children			Adolescents		
	n ^a	%	SE	n ^b	%	SE	n ^c	%	SE
Travel time to school among active travellers									
Less than 5 minutes	247	13.0	1.16	637	22.3	1.65	599	18.2	1.12
5 to 15 minutes	1327	71.9	1.56	1733	58.5	1.68	1853	58.4	1.31
16 to 30 minutes	255	12.8	1.06	426	15.8	1.09	589	18.3	1.02
31 to 60 minutes	37	1.8	0.36	82	2.8	0.44	123	3.8	0.50
More than 60 minutes	19	0.6	0.16	26	0.7	0.23	46	1.2	0.26
Travel time from school among active travellers									
Less than 5 minutes	243	12.6	1.18	559	20.2	1.40	467	14.2	1.00
5 to 15 minutes	1291	69.4	1.64	1607	53.6	1.69	1672	53.1	1.40
16 to 30 minutes	291	15.4	1.23	565	21.1	1.32	808	24.6	1.22
31 to 60 minutes	44	2.1	0.38	135	4.0	0.55	194	6.0	0.60
More than 60 minutes	21	0.6	0.15	38	1.1	0.26	69	2.2	0.43

Abbreviations: BMI, body mass index; ENSIN, the National Survey of Nutrition in Colombia; NA, not applicable.

a The total sample size for pre-schoolers was 2867 children. However, the following variables had missing values: ethnicity=25, BMI=87, area and parks availability=3.

b The total sample size for school-aged children was 4005. However, the following variables had missing values: ethnicity=31, and BMI=123.

c The total sample size for adolescents was 4594. However, the following variables had missing values: ethnicity=35, and BMI=161.

d No excess category groups children with thinness, risk of thinness and normal BMI.

e Safety perception was assessed only among those who reported having a park in their neighbourhood.

Approximately 73% of pre-schoolers, 74% school-aged children and 69% of adolescents engaged in active transportation to or from school. There was no difference by sex in the engagement in active transportation among pre-schoolers nor school-aged children. However, female adolescents had a lower prevalence of active transportation than males (64.9% vs. 72.4%, $p=0.001$) (Table 2). Differences by ethnic group were observed only among school-aged children, indicating that Afro-Colombian and Indigenous children had a higher engagement in active modes of transport than their counterparts (Table 2). There were no differences observed according to BMI nor activity program attendance. There were differences by wealth index across all age groups, indicating that individuals at the lower wealth quartiles had a higher prevalence of active transportation than those in the fourth quartile (72.8% vs. 64% among preschoolers, 78.7% vs. 54.1% among school-aged children, and 65.1% vs 59.3 among adolescents) (Table 2). There were no differences by area of residence among pre-schoolers nor school-aged children. However, adolescents who lived in urban areas had a higher prevalence of active transportation than those living in rural areas (73.2% vs. 55.2%, $p<0.001$). Pre-schoolers who had a park in their neighbourhood had a higher engagement in active transportation than those who did not (75.6% vs. 69.9% $p=0.033$) (Table 2). There were differences in the prevalence of active transportation between geographic regions for pre-schoolers and school-aged children, with the Capital District and the Pacific region having the highest prevalence (88.6% and 82.5% in the Capital district for preschoolers and school-aged children, respectively, and 76.1% and 80.1% in the Pacific region for preschoolers and school-aged children, respectively) (Table 2).

Table 2. Prevalence of active transportation to school among 11466 children and adolescents from Colombia.

Sociodemographic and contextual variables	Pre-school children				School age children				Adolescents			
	Active transportation to or from school				Active transportation to or from school				Active transportation to or from school			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Total	73.2	(70.3-75.9)	1.379		73.8	(71.2-76.3)	1.273		68.8	(66.1-71.3)	1.285	
Sex												
Female	73.2	(69.3-76.9)	1.892	0.970	73.9	(70.2-77.2)	1.762	0.979	64.9	(61.5-68.2)	1.688	0.001
Male	73.1	(69.2-76.8)	1.888		73.8	(70.1-77.2)	1.777		72.4	(69.1-75.5)	1.600	
Ethnicity												
Afro-colombian	72.4	(65.5-78.3)	3.200	0.726	83.7	(77.5-88.3)	2.687	0.001	72.9	(64.9-79.6)	3.678	0.305
Indigenous	76.8	(68.1-83.7)	3.899		83.5	(73.8-90.1)	4.036		63.3	(53.2-72.4)	4.865	
Other	73.2	(70.0-76.1)	1.539		72.2	(69.2-75.0)	1.443		68.7	(65.8-71.5)	1.409	
BMI categorization												
No excess ^a	74.4	(71.4-77.1)	1.423	0.436	75.5	(72.6-78.2)	1.398	0.157	69.5	(66.5-72.3)	1.452	0.218
Overweight	71.2	(60.2-80.2)	5.058		71.6	(64.9-77.5)	3.145		67.2	(60.9-73.0)	3.029	
Obesity	66.0	(51.6-78.0)	6.732		67.6	(57.4-76.4)	4.800		60.4	(48.6-71.1)	5.709	
Participation in organized activities and programs^b												
Ciclovias ^c												
Yes	NA	NA	NA	NA	78.7	(59.5-90.3)	7.710	0.551	70.9	(62.0-78.4)	4.079	0.531
No	NA	NA	NA		73.7	(71.1-76.2)	1.275		68.2	(64.8-71.3)	1.611	
Community physical activity programs (e.g., aerobics)												
Yes	NA	NA	NA	NA	NA	NA	NA	NA	63.7	(54.8-71.7)	4.232	0.112
No	NA	NA	NA		NA	NA	NA		70.7	(67.4-73.8)	1.599	

Table 2. Prevalence of active transportation to school among 11466 children and adolescents from Colombia.

Sociodemographic and contextual variables	Pre-school children				School age children				Adolescents			
	Active transportation to or from school				Active transportation to or from school				Active transportation to or from school			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Physical activity programs at school												
Yes	NA	NA	NA	NA	NA	NA	NA	NA	66.4	(61.8-70.8)	2.247	0.532
No	NA	NA	NA		NA	NA	NA		68.2	(64.2-72.0)	1.942	
Sport Clubs												
Yes	NA	NA	NA	NA	71.9	(68.1-75.5)	1.863	0.163	71.9	(66.7-76.5)	2.457	0.395
No	NA	NA	NA		75.3	(71.9-78.5)	1.648		69.3	(65.7-72.7)	1.736	
Organized groups (dance, martial arts, etc)												
Yes	NA	NA	NA	NA	69.3	(61.3-76.3)	3.770	0.184	64.5	(56.9-71.4)	3.652	0.155
No	NA	NA	NA		74.3	(71.6-76.9)	1.322		69.9	(66.6-73.1)	1.625	
Wealth Quartiles												
First (poorest)	72.8	(68.9-76.5)	1.902	0.048	78.7	(75.4-81.7)	1.561	<0.001	65.1	(61.2-68.8)	1.907	<0.001
Second	76.4	(71.8-80.4)	2.151		77.9	(73.7-81.6)	1.972		77.5	(73.4-81.1)	1.906	
Third	75.8	(69.4-81.2)	2.942		74.7	(69.2-79.6)	2.598		73.1	(67.9-77.8)	2.458	
Fourth (wealthiest)	64.0	(53.5-73.3)	4.996		54.1	(45.6-62.3)	4.202		59.3	(51.2-67.0)	3.988	
Area												
Urban	73.3	(70.1-76.4)	1.576	0.793	73.3	(70.0-76.3)	1.569	0.382	73.2	(70.2-76.0)	1.449	<0.001
Rural	72.5	(66.6-77.7)	2.773		75.5	(71.4-79.2)	1.945		55.2	(50.3-60.1)	2.446	
Parks availability in the neighbourhood												
Yes	75.6	(71.7-79.2)	1.897	0.033	74.8	(71.0-78.2)	1.774	0.341	69.9	(66.6-73.1)	1.608	0.127
No	69.9	(66.0-73.5)	1.890		72.3	(68.6-75.7)	1.768		66.4	(62.7-69.9)	1.805	
Safety perception ^d												

Table 2. Prevalence of active transportation to school among 11466 children and adolescents from Colombia.

Sociodemographic and contextual variables	Pre-school children				School age children				Adolescents			
	Active transportation to or from school				Active transportation to or from school				Active transportation to or from school			
	P (%)	CI	SE	p	P (%)	CI	SE	p	P (%)	CI	SE	p
Is safe to play in the park	74.5	(69.5-78.9)	2.329	0.203	75.5	(71.3-79.2)	1.981	0.493	68.6	(64.9-72.1)	1.796	0.141
Is not safe to play in the park	79.1	(73.5-83.8)	2.565		73.0	(66.2-78.9)	3.162		73.1	(67.5-78.1)	2.651	
Geographic region												
Atlantic	70.2	(65.7-74.4)	2.182	<0.001	71.6	(65.9-76.7)	2.687	0.006	68.2	(63.3-72.7)	2.341	0.106
Eastern	67.9	(60.1-74.8)	3.696		69.5	(62.4-75.8)	3.369		62.8	(55.0-70.0)	3.763	
Orinoquia-Amazonia	54.4	(48.3-60.3)	3.013		72.6	(65.7-78.6)	3.238		75.7	(68.8-81.5)	3.172	
Capital District	88.6	(80.9-93.4)	3.066		82.5	(74.1-88.5)	3.587		75.1	(65.7-82.7)	4.265	
Central	71.5	(64.3-77.8)	3.387		69.8	(64.8-74.3)	2.372		67.9	(62.8-72.6)	2.442	
Pacific	76.1	(70.1-81.2)	2.763		80.1	(75.0-84.4)	2.358		71.3	(66.5-75.7)	2.295	

Abbreviations: BMI, body mass index; NA, not applicable.

a No excess category groups children with thinness, risk of thinness and normal BMI.

b Participation in organized activities and programs was assessed only among school-age children and adolescents who reported knowing those programs

c Ciclovías are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

d Safety perception was assessed only among those who reported having a park in their neighbourhood.

Correlates of active transportation to/from school

Correlates of active transportation varied by age group. Among pre-schoolers, the multivariable models found negative associations for car availability and for all the geographic regions compared to the Capital District, indicating that children who lived in a household with a car available (PR=0.78, 95%CI [0.7-0.9]), and those who lived in any region different from Bogota (PR by regions ranged between 0.59 and 0.84) were less likely to engage in active transportation to or from school (Figure 1). For school-aged children, wealth index, car availability and geographic region were associated with active transportation. These associations indicate that children from lower socioeconomic levels were more likely to engage in active transportation compared to those in the highest wealth quartile (PR=1.32, 95%CI [1.1-1.5]). Also, children who lived in any region other than the Capital District were less likely to engage in active modes of transport (PRs by regions ranged between 0.79 and 0.86), as well as those who lived in a household with car availability (PR=0.71, 95%CI [0.6-0.8]). (Figure 2). Among adolescents, significant associations were found for sex, wealth index, area of residence and car availability. Female adolescents were less likely to engage in active transportation than males (PR=0.9, 95%CI [0.8-0.9]), adolescents in the lower wealth quartiles were more likely to engage in active transportation (PR=1.22, 95%CI [1.1-1.4]), while those who lived in rural areas (PR=0.67, 95%CI [0.6-0.7]) and those who had a car available at home (PR=0.65, 95%CI [0.5-0.8]), were less likely (Figure 3). The prevalence ratios and 95% confidence intervals for these associations are presented in Table 3.

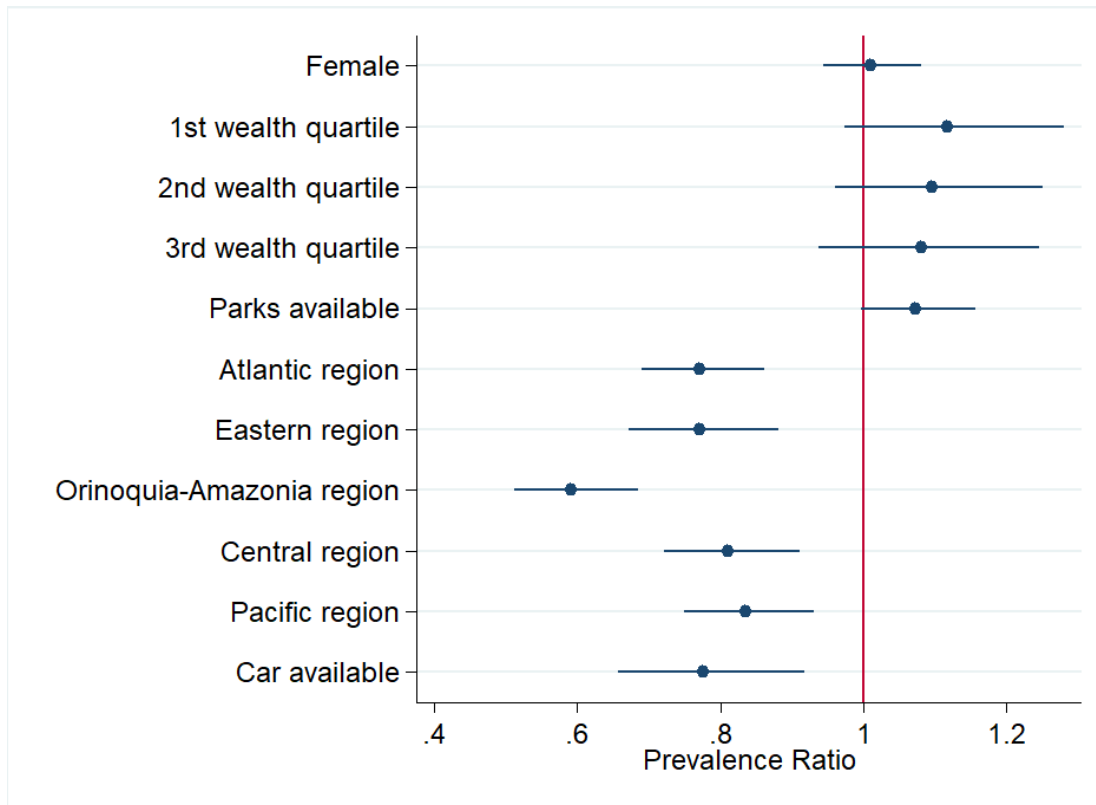


Figure 1. Prevalence ratios and 95% confidence intervals of correlates of active transportation to or from school among Colombian preschool children. Reference categories were male sex, 4th wealth quartile, no parks availability, Capital District region and no car availability.

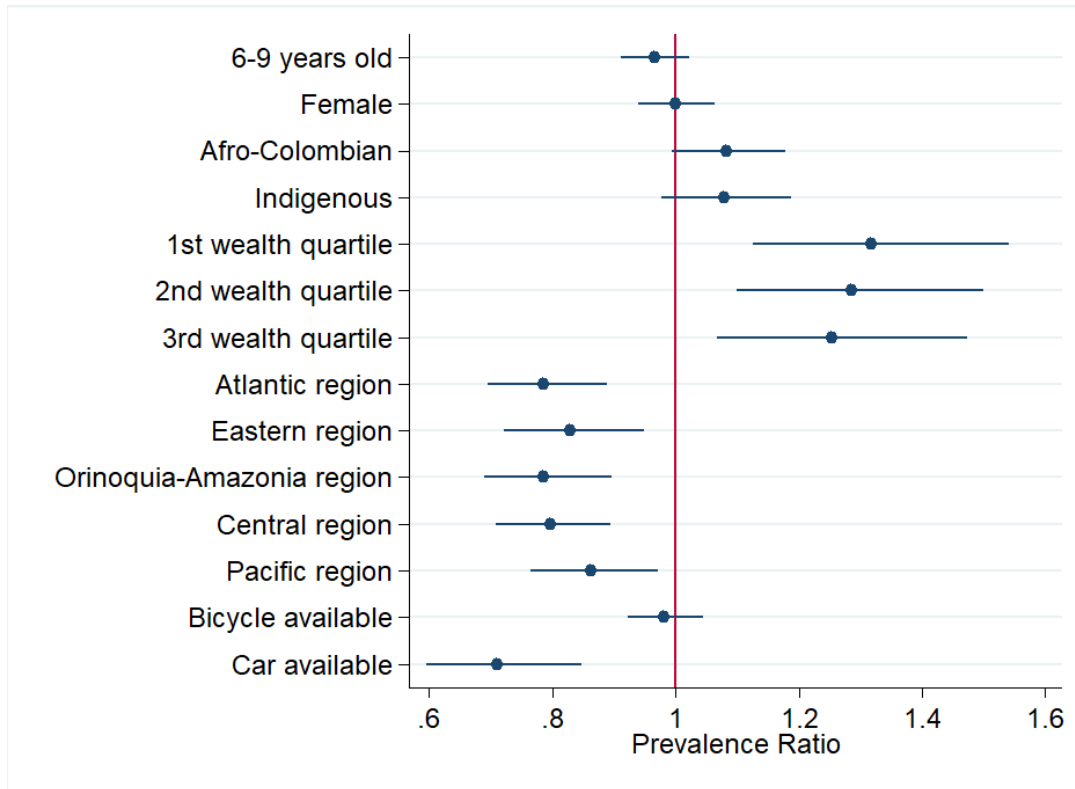


Figure 2. Prevalence ratios and 95% confidence intervals of correlates of active transportation to or from school among Colombian school-aged children. Reference categories were 10-12 years old, male sex, no ethnic identity, 4th wealth quartile, Capital District region, no bicycle availability and no car availability.

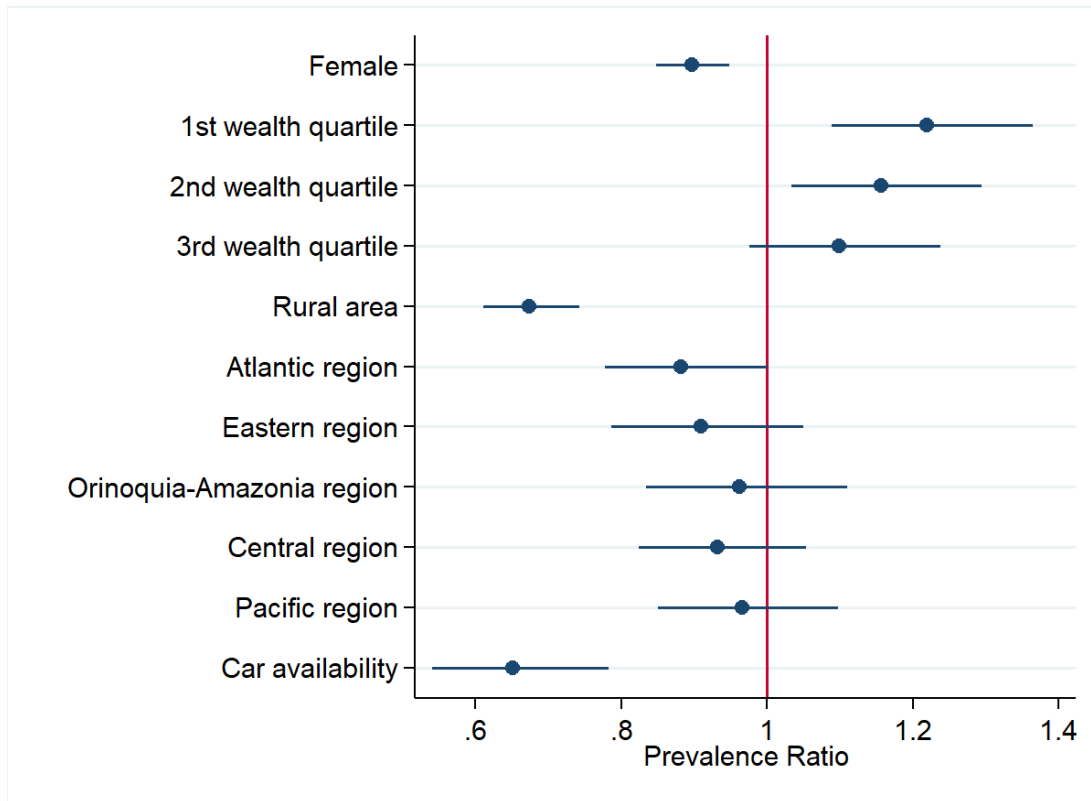


Figure 3. Prevalence ratios and 95% confidence intervals of correlates of active transportation to or from school among Colombian adolescents. Reference categories were male sex, 4th wealth quartile, urban area residence, Capital District region, and no car availability.

Table 3. Factors associated with engaging in active transportation to or from school among 11466 children and adolescents from Colombia

Sociodemographic and contextual variables^a	Pre-school children			School-aged children			Adolescents		
	PR^b	CI	p	PR^b	CI	p	PR^b	CI	p
Individual variables									
Sex									
Female	1.01	(0.9-1.1)	0.752	1.00	(0.9-1.1)	0.999	0.90	(0.8-0.9)	<0.001
Male	1.00			1.00			1.00		
Age									
3-4	-	-	-	NA	NA	NA	NA	NA	NA
5	-	-	-	NA	NA		NA	NA	
6-9	NA	NA	NA	0.96	(0.9-1.0)	0.217	NA	NA	NA
10-12	NA	NA	NA	1.00			NA	NA	
13-15	NA	NA	NA	NA	NA	NA	-	-	-
16-17	NA	NA	NA	NA	NA		-	-	-
Ethnicity									
Afro-colombian	-	-	-	1.08	(1.0-1.2)	0.069	-	-	-
Indigenous	-	-	-	1.08	(1.0-1.2)	0.128	-	-	-
Other	-			1.00			-	-	-
Household variables									
Wealth Quartiles									
First (poorest)	1.12	(1.0-1.3)	0.111	1.32	(1.1-1.5)	0.001	1.22	(1.1-1.4)	0.001
Second	1.10	(1.0-1.3)	0.167	1.28	(1.1-1.5)	0.002	1.16	(1.0-1.3)	0.012
Third	1.08	(0.9-1.2)	0.279	1.25	(1.1-1.5)	0.007	1.10	(1.0-1.2)	0.117
Fourth (wealthiest)	1.00			1.00			1.00		
Area									
Urban	-			-			1.00		-
Rural	-	-	-	-	-	-	0.67	(0.6-0.7)	<0.001
Bicycle Availability									
Yes	-	-	-	0.98	(0.9-1.0)	0.551	-	-	-
No	-			1.00			-		

Table 3. Factors associated with engaging in active transportation to or from school among 11466 children and adolescents from Colombia

Sociodemographic and contextual variables^a	Pre-school children			School-aged children			Adolescents		
	PR^b	CI	p	PR^b	CI	p	PR^b	CI	p
Car availability									
Yes	0.78	(0.7-0.9)	0.004	0.71	(0.6-0.8)	<0.001	0.65	(0.5-0.8)	<0.001
No	1.00			1.00			1.00		
Community variables									
Parks availability in the neighbourhood									
Yes	1.07	(1.0-1.2)	0.062	-	-	-	-	-	-
No	1.00			-			-		
Natural Environment									
Geographic region									
Atlantic	0.77	(0.7-0.9)	<0.001	0.79	(0.7-0.9)	<0.001	0.88	(0.8-1.0)	0.051
Eastern	0.77	(0.7-0.9)	<0.001	0.83	(0.7-0.9)	0.008	0.91	(0.8-1.1)	0.192
Orinoquia-Amazonia	0.59	(0.5-0.7)	<0.001	0.79	(0.7-0.9)	0.001	0.96	(0.8-1.1)	0.591
Capital District	1.00			1.00			1.00		
Central	0.81	(0.7-0.9)	0.001	0.80	(0.7-0.9)	<0.001	0.93	(0.8-1.1)	0.253
Pacific	0.84	(0.8-0.9)	0.002	0.86	(0.8-1.0)	0.015	0.97	(0.9-1.1)	0.590

Abbreviations: BMI, body mass index; NA, not applicable.

a Only variables with a marginally significant association in the bivariate models were included in multivariable models. BMI and programs participation are not reported in this table because of the lack of association in bivariate models.

b Prevalence ratio

Discussion

Our results show that active school transportation is a prevalent behaviour among Colombian children and adolescents and identified common and age-specific correlates of this behaviour. Approximately seven out of 10 children and adolescents in Colombia engage in active modes of transportation for their trip to/from school. Children and adolescents with a car in the household were less likely to report being involved in active transportation. Pre-schoolers and school age children living in the Capital city (Bogota) were more likely to report active transport, as well as school age children and adolescents with a lower wealth index. Additionally, we observed that female adolescents and adolescents living in rural areas were less likely to engage in active transportation to/from school.

Children who engaged in active transportation to school have been found to be more active than those who use passive modes.^{23,24} It has been estimated that active transportation provides about 10% of the recommended physical activity guidelines.²⁴ However, according to ENSIN data, the moderate involvement in active transportation among Colombian children and adolescents is not reflected in their prevalence of meeting physical activity recommendations, which is very low.¹ This suggests that in addition to maintaining active transportation to/from school, walking and cycling to other destinations should be promoted, especially among groups at higher risk of inactivity in Colombia, like females and adolescents. The low prevalence of physical activity despite the moderate engagement in active transportation could have different explanations. It could be related to the fact that the majority of active travellers have short trips to/from school; therefore, the contribution to daily physical activity time is small and not necessarily reflected in an adequate volume of moderate-to-vigorous physical activity. It is also possible that active transportation time is underestimated or not reported when parents and adolescents are asked

about their engagement in 60 minutes of moderate-to-vigorous physical activity, as observed in a previous study.²⁵ This could be the case specially among school age children and adolescents, who were asked: “During the last week, on how many days were you physically active for at least 60 minutes per day?”. This question used to ascertain the engagement in moderate-to-vigorous physical activity, did not specify any active transportation-related activities, and they may have not considered them in their response. Additionally, recall bias may have led to underestimate the physical activity related to active transportation, and also, short trips may have not been taken into account when reporting the engagement in moderate-to-vigorous physical activity.

The moderate prevalence of active transportation to/from school among Colombian children and adolescents is comparable to the prevalence observed in Denmark, Finland, South Korea and Nigeria, according to the data reported in the Global Matrix 3.0 initiative.^{26,27} However, the determinants of this relatively high prevalence of active transportation may be different as socioeconomic and environmental conditions differ between countries^{27,28} and this needs to be considered when designing interventions and policies. While the use of active modes of transportation is the normative choice in countries like Denmark and Finland, it could be a necessity in Colombia, Nigeria and other low- and middle-income countries.^{29,30} Other Latin American countries have similar prevalences, such as Venezuela, where more than 60% of children walk or bike to school.³¹ In countries like Mexico, Brazil and Uruguay this prevalence is around 50%.^{32–34} However, there are also countries with a very low prevalence of active transportation to school in the region, like Chile, where only 15% of children walk or bike to school.³⁵ In the particular case of Colombia, there are also supporting policies such as Law 1811

of 2016 that supports the use of active modes of transportation across the country ³⁶ and most of the children in urban areas attend schools within walkable distances.

We identified several significant correlates of active school transportation and they differed by age group. Our findings on the associations with car availability and wealth index are consistent with the main correlates reported in a systematic review on environmental correlates of active transportation ³⁷ and support the “need-based framework” proposed by previous studies to understand the influence of socioeconomic status on the decisions about transport modes.^{8,38} This framework postulates that the engagement in active transportation is likely driven by the absence of other alternatives and is the result of a necessity ³⁸ as suggested by the gradient in the association with wealth index and by the low rate of car ownership in the sample.

According to our findings, pre-schoolers and school age children from Bogota were more likely to engage in active transportation. This can be related to the fact that Bogota has a higher density (which can minimize distance between home and school) and likely has more appropriate infrastructure and conditions for active transportation than other regions of the country. In Bogota, approximately 90% of children attending public schools live within a walkable distance from school. ³⁹ Also, Bogota has implemented active commuting programs such as Al Colegio en Bici to promote cycling among children who attend public schools since 2013 ⁴⁰ and Ciempies to promote walking to school since 2016.⁴¹ Similarly, adolescents living in rural areas were less likely to engage in active modes of transport. This could be related to the lower density of rural areas and greater distance to schools, which have been observed as common correlates in other studies.^{37,42} In the Colombian context, it is likely that these conditions led adolescents to prefer motorized alternatives such as moto-taxis (motorcycles that transport passengers for a low cost).

Finally, it is interesting to observe that there are no sex differences in the engagement in active transportation among pre-schoolers and school-aged children, but there are disparities by gender indicating that females were less likely to report active transportation among adolescents. These results align with the findings of a previous study conducted in Canada, that shows that the gap in active transportation between males and females gets wider as age increases.⁴³ The mechanisms that explain this difference between males and females are not clear. We hypothesize that this disparity can be influenced by safety conditions and parental concerns about the potential risks for females in the journey to/from school, which are more relevant in countries where cycling for transportation is not the norm, as observed in previous literature.^{44,45} These correlates contribute to the understanding of active transportation participation to/from school in Colombia, but other relevant variables such as distance and safety should be addressed in future studies.

Actions to promote the use of active modes of transportation to/from school should be put in place across the country to prevent a decrease in the prevalence of walking and cycling. Based on our results, we propose the following recommendations that can guide the policy agenda for physical activity and active transportation promotion in Colombia: 1) Considering that active travel is the result of necessity in many Colombian households, adequate infrastructure and safety conditions need to be provided to prevent a shift to motorized modes of transportation as the socioeconomic situation of the population improves. 2) Specific actions directed to the wealthiest children and adolescents, as well as to their families, are needed to address social norms and position active modes as a healthy and sustainable alternative to go to school. 3) National and regional strategies can be guided by the experience of promising interventions and initiatives carried out in the Capital District (e.g., Al Colegio en Bici). 4) Multi-modal

alternatives that include an active mode for a portion of the trip should be considered when planning school transport initiatives in the rural areas of Colombia. 5) Strategies that engage and empower females in the use of active modes should be put in place from early ages to avoid the gap observed among adolescents.

The main strength of this study is that it provides the first assessment of the mode of transport to/from school among a nationally representative sample of Colombian children and adolescents. However, there are limitations that should be considered when interpreting our results. First, the cross-sectional design of the study does not allow for causal inferences. Second, active transportation assessment could have been affected by recall bias, since it relied on parent- and self-report. Third, the active transportation component used was adapted for the survey and has been widely used in other contexts, but its validity for the Colombian context has not been previously evaluated. Fourth, the question used to assess active transportation engagement did not specify the frequency of this behaviour over the last week, therefore, the number of days that children and adolescents engaged in active transportation is not clear. Finally, relevant variables such as distance and safety could not be included in the models since they were not captured by ENSIN.

Conclusions

In Colombia, the majority of children and adolescents engage in active modes of transportation to/from school. Considering the potential of walking and cycling to school to increase physical activity levels, and that active transportation is one of the main contributors to habitual levels of physical activity in low- and middle-income countries,⁴⁶ active transportation to/from school needs to be preserved in Colombia among children, expanded where possible, and sustained along the lifespan. Strategies that target children and adolescents from the wealthiest households

to shift their transportation modes, and that provide safety and convenient conditions to maintain the behaviour in those that are already walking and cycling to school are needed. A special focus should be put on female adolescents in the design of programs and strategies to promote active transportation to/from school.

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Chapter 6: Prevalence and Correlates of Excessive Recreational Screen Time Among Colombian Children and Adolescents

Manuscript 3: Prevalence and correlates of excessive recreational screen time among Colombian children and adolescents

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Article preface: This article presents the national prevalence of excessive recreational screen time among Colombian children and adolescents and identifies correlates of having excessive recreational screen time. This manuscript addresses the first and second objective of the dissertation, to describe indicators of physical activity and sedentary behaviours and determine their prevalence among Colombian children and youth (3-17 years), and to determine the factors

associated with meeting physical activity guidelines, engaging in active play, using active transportation and spending excessive time in sedentary behaviours among Colombian children and youth, within a socioecological framework. SAG, and MST conceived the idea of the manuscript. SAG drafted the manuscript, and all co-authors reviewed and approved the manuscript. The data used for these analyses required obtaining informed consent before conducting the survey. The survey obtained local ethics approval granted by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015; February 26, 2015). The University of Ottawa granted approval for secondary data analyses (file number H-06-19-3564). The submitted manuscript is presented in this chapter. The submission confirmation can be found in Appendix 7.

Abstract

Objectives: Excessive recreational screen time (RST) is associated with detrimental effects for physical, psychological and cognitive development. This article aims to describe the prevalence of excessive RST among Colombian preschoolers, children and adolescents and explore its factors associated.

Methods: We analyzed data from the National Survey of Nutrition 2015. The sample included 4,503 preschoolers, 5,333 school-aged children and 6,623 adolescents. Poisson regression models with robust variance were conducted to estimate prevalence ratios and determine correlates of excessive RST.

Results: Fifty percent of preschoolers, 61% of school-aged children and 73% of adolescents in Colombia had excessive RST. Positive associations were observed with the availability of TV in

the child's bedroom, the availability of video games at home, and eating while using screens. A negative association with rural area was observed for all age groups.

Conclusions: The majority of Colombian children and adolescents have excessive RST. Younger preschoolers, older school-aged children, wealthiest children and those from urban areas should be targeted by interventions to decrease RST. These interventions should promote limiting the availability of electronic devices in children's bedrooms and not eating in front of screens.

Introduction

Sedentary behavior, defined by the Sedentary Behavior Research Network as “any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture”¹ has been identified as an important risk factor for poor health. Excessive time spent in sedentary behaviors, mainly recreational screen time (RST), has been associated with detrimental effects on health and development in children including unfavourable body composition, lower fitness, higher cardiometabolic risk scores, greater energy intake and poorer diet quality, lower measures of self-esteem and prosocial behaviors, lower quality of life and lower academic achievement.^{2–6} Concerningly, there is a large proportion of children and adolescents around the world who spend excessive time in sedentary pursuits, and may have a higher risk of those conditions.^{7,8}

The high prevalence of excessive sedentary time globally is likely a result of greater access to labor-saving technologies, motorized vehicles and screen-based entertainment which have led to a shift from active lifestyles to greater involvement in activities that require lower energy expenditure.^{6,9} In response to this situation, countries like Canada and Australia, and recently the World Health Organization, have developed public health guidelines to promote a reduction in

sedentary behaviors.^{10–12} These guidelines focus their message on the reduction of RST such as watching TV, playing videogames or using computers or tablets for non-school related purposes, as these are some of the main sedentary behaviors with important implications for health.⁶ Using the cut-off point of Australian and Canadian sedentary behavior guidelines for children and adolescents, global data indicate that the prevalence of meeting sedentary behavior guidelines ranges from 7% in Estonia and China to 85% in Bangladesh.^{7,13–15}

In Colombia, screen time has been included as a relevant indicator for nutrition surveillance since 2005,¹⁶ and its assessment has evolved over time. In the first version of the National Survey of Nutrition (ENSIN for its name in Spanish), screen time was assessed among 5 to 12 year-old children as TV viewing and videogame use.¹⁷ In the 2010 survey, the same indicator was included and extended to adolescents aged 13 to 17 years.¹⁸ For the most recent 2015 survey the indicator was modified to include time spent using other devices such as tablets, portable videogame devices and mobile phones for recreational purposes, and extended the population of interest to include preschool children in addition to the previously included age groups.

Therefore, this is the first study in Colombia and among the first in Latin America that examines engagement in excessive RST in a nationally representative sample of pre-schoolers, children and adolescents between 3 and 17 years old. This initial approach to a broader range of recreational screen-based activities in a national sample with a larger age range provides a unique opportunity to help inform public health policies that contribute to decrease sedentary behavior in Colombia. In this context, this paper aims to describe the prevalence of excessive RST among Colombian preschoolers, children and adolescents and explore the factors associated with excessive RST within a socio-ecological framework.

Methods

Study design and participants

We analyzed data from the sedentary behavior component of ENSIN 2015. ENSIN is a cross-sectional population health survey with national representativeness of urban and rural areas of Colombia.¹⁹ The sample of this survey was selected with a stratified, multistage probability cluster sampling design. The sub-sample for the sedentary behavior component included 4,503 preschoolers (3-5 years), 5,333 school-aged children (6-12 years) and 6,623 adolescents (13-17 years). The survey was administered by the Colombian Institute of Family Welfare.

Data collection

Data were collected by trained nutritionists in the household setting between December 2015 and November 2016. For preschoolers and school-aged children, one of the parents or the main caregiver responded to the survey, while adolescents self-reported their responses. Parents provided signed informed consent and children between 12 and 17 years provided informed assent before conducting the survey. The ENSIN protocol was approved by the Profamilia Institutional Review Board on Research involving Human Subjects and the Colombian National Institutes of Health (file number 2-2015, February 26, 2015). The secondary data analyses were approved by the University of Ottawa (file number H-06-19-3564).

Dependent variables

Among preschoolers, RST was assessed with the Questionnaire for the Measurement of Physical Activity and Sedentary Behaviors in preschool to fourth grade children (C-MAFYCS), which has low internal consistency for the sedentary behavior scale (Cronbach's $\alpha=0.31$) and moderate to good reproducibility mainly for items such as computer and videogame use (Kappa= 0.71 and 0.62, respectively).²⁰ Engagement in screen-based activities was assessed with three questions:

“During the last 7 days, did (name of the child) watch television, movies or videos in the TV? During the last 7 days, did (name of the child) play or listen to music in the computer? And during the last 7 days, did (name of the child) play with consoles such as X-Box, Play-Station, manual videogames such as Nintendo DS, etc., play with a cellphone, smartphone, iPad or other tablets?” Each of these questions was informed with the amount of time spent in each activity with the following questions: How much time did he/she spend on weekdays? And how much time did he/she spend on weekends? (for each day)”. The total time in all screen-based activities per weekdays and weekend days was estimated in minutes and the average screen time per day, per weekday and per weekend day was calculated. A dichotomous variable to indicate if the preschooler achieved excessive RST was calculated (excessive vs. not excessive RST).

Excessive RST was defined as engaging in more than one hour of RST per day among preschoolers under 5 years of age or more than two hours of RST per day among 5-year-olds, in accordance with the WHO and the Canadian sedentary behavior guidelines.^{10,21}

Among school-aged children and adolescents, RST was assessed with the following questions adapted from the U.S. Youth Risk Behavior Surveillance System (YRBSS):²² “On an average school day or weekday, how many hours did (name of the child)/you watch TV?; On an average school day or weekday, how many hours did (name of the child)/you play video games or use a computer for something that is not schoolwork?; On a weekend day, how many hours did (name of the child)/you watch TV? And, on a weekend day, how many hours did (...) play video games or use a computer for something that is not schoolwork?” The question inquiring about videogames and computer use included the following examples of devices and activities to consider: Xbox, PlayStation, iPod, iPad or other tablet, smartphone, cellphone, YouTube, Facebook or other social media and internet. The response options were: 1) Did not watch TV/

played videogames or used the computer, 2) less than 1 hour, 3) between 1 and 1:59 hour, 4) between 2 and 2:59 hours, 5) between 3 and 3:59 hours, 6) between 4 and 4:59 hours, and 7) 5 hours or more. A screen time score was calculated converting these categories as follows: 1 and 2 = 0 hour, 3 = 1 hour, 4 = 2 hours, 5 = 3 hours, 6 = 4 hours and 7 = 5 hours. With these values we calculated a weighted mean score of daily screen time, as previously estimated in other studies.²³ A dichotomous variable to indicate excessive RST was created using a cut-off of more than 2 hours of screen time, according to the sedentary behavior guidelines in the Canadian 24-hour movement guidelines.¹⁰

Potential Correlates

We selected variables that were potentially relevant for the analysis of RST at different levels according to the socio-ecological framework of sedentary behaviors.²⁴

Intrapersonal level

Sex (female vs. male), age, ethnicity (Afro-Colombian vs. Indigenous vs. Other ethnic identity), overweight (yes vs. no), physical activity program participation (yes vs. no), physical activity (meeting vs. not meeting the WHO physical activity guidelines), and food frequency consumption variables (yes vs. no) were included at the individual level. Sociodemographic variables (i.e., sex, age, ethnicity) were measured with the Household Questionnaire designed for ENSIN.¹⁹ Overweight (including obesity) was ascertained based on body mass index, calculated from objective measurements of height and weight, and categorized according to WHO growth standards and reference tables.^{25,26} Physical activity program participation (organized activities, sports clubs, and Ciclovías for school-aged children and adolescents, and programs at the school and community levels among adolescents) was assessed with questions designed for the Physical Activity and Sedentary Behavior Questionnaire for ENSIN.¹⁹ Physical activity was proxy-

reported (by parents or caregivers) for pre-schoolers and school-aged children and self-reported by adolescents. For pre-schoolers, physical activity was assessed with the C-MAFYCS questionnaire, and for school-aged children and adolescents it was assessed with a question adapted from the YRBSS. A dichotomous variable to indicate if the child/adolescent met the physical activity guidelines was created, using a cut-off of 180 min of physical activity per day with at least 60 min of energetic play for preschool children, and seven days of being active at least 60 min per day for school-age children.²⁷ More details on the physical activity assessment are described elsewhere.²⁸ Food consumption variables were measured with the Food Frequency Questionnaire designed for ENSIN¹⁹ and specific food groups were incorporated in the analysis including: charcuterie products, sodas, snacks and fried foods at least three times per week; fast food consumption at least once per week; and daily consumption of candy. We also assessed usual food consumption while using screens during the last month.

Household level

At the household level, we included wealth index, area of residence (urban vs. rural), and TV and video game device availability in the child's bedroom. Wealth index was estimated using principal components analysis and based on asset ownership and housing conditions, and then categorized into quartiles. TV and videogame availability were assessed with questions adapted from the Neighborhood Impact on Kids (NIK) survey.²⁹

Environmental and community level

At the community level we included parks availability in the neighbourhood and perceived safety in the parks, which were assessed with questions adapted from the NIK survey.²⁹ For the natural environment level, we included the geographic region where the children lived at the

time of the survey (Orinoquia-Amazonia vs. Atlantic vs. Central vs. Eastern vs. Pacific vs. Capital District).

Statistical analysis

Descriptive statistics (means, standard deviations, and frequencies) were estimated for demographic and contextual characteristics of the sample and chi-squared tests were conducted to determine differences between groups. Poisson regression models with robust variance were conducted to estimate prevalence ratios (PR) and determine correlates of excessive RST. Three types of models were run for each age group: 1) bivariate models with potential correlates, 2) multivariable model 1 included the variables available for the whole sample that showed at least marginally significant associations ($p < 0.10$) and were adjusted for age and sex and 3) multivariable model 2 included the food consumption and program participation variables that had p -values < 0.10 in the bivariate analyses and were conducted as a sub-analysis with a smaller sample size. Variables with p -values < 0.05 in the multivariable models were considered correlates of excessive RST. We used STATA 14.0 (StataCorp, College Station, TX, USA) for the analyses, with the survey (SVY) module for complex samples to take into account the clustering of data and the characteristics of the study design, sample weights and missing data.

Results

Sociodemographic characteristics of the sample and other descriptive statistics for this analysis are presented in supplementary tables 1 and 2. Approximately 48% of the sample for each age group were females. About 9% and 5% of the children and adolescents were Afro-Colombian or indigenous, respectively. Overweight prevalence was 11.0% for preschoolers, 25.8% among school-aged children, and 18.1% among adolescents. Male preschoolers had a higher prevalence of overweight compared to females, while female adolescents had a higher prevalence of

overweight compared to male adolescents. Low proportions of active children were observed across all age groups and were lower among females. More than 60% of preschoolers and school-aged children, and over 70% of adolescents reported eating in front of screens. Over 70% of children and adolescents lived in urban areas, about 40% had a TV available in their bedroom, and availability of video game devices ranged from 14% among preschoolers to more than 60% among adolescents (Supplementary tables 1 and 2).

Prevalence of excessive recreational screen-time

Table 1 presents the overall prevalence of excessive RST and the prevalence according to potentially relevant variables. We found that 50% of preschoolers, 61% of school-aged children and 73% of adolescents in Colombia had excessive RST (Table 1). This prevalence did not differ by sex. Among preschoolers, younger children (3-4 years) had a greater prevalence of excessive RST, while in school-aged children this prevalence was higher for older children (10-12 years). Indigenous preschoolers, children and adolescents had a lower prevalence of excessive RST. Among school-aged children, those with overweight or who were physically inactive, had greater prevalences of excessive RST.

The prevalence of excessive RST differed by socioeconomic status, with those in the third and fourth wealth quartiles having a higher prevalence across all age groups. Also, children and adolescents from urban areas, with TV in the bedroom, video-game devices available and those with park availability in the neighborhood had higher prevalence of excessive RST. According to geographic region, children and adolescents living in the capital district had a higher prevalence of excessive RST (Table 1).

**Table 1 Prevalence of excessive recreational screen-time among Colombian children and adolescents.
National Survey of Nutrition, Colombia 2015.**

Sociodemographic and other potentially relevant variables for screen-time	Preschool children ^a				School aged children ^b				Adolescents ^b			
	P (%)	CI	SE	P-value	P (%)	CI	SE	p-value	P (%)	CI	SE	P-value
Total	50.1	(47.5-52.7)	1.294		61.0	(58.4-63.6)	1.303		72.5	(70.5-74.4)	0.964	
Sex												
Female	50.5	(46.8-54.2)	1.856	0.74	60.2	(56.7-63.6)	1.724	0.52	73.0	(70.2-75.5)	1.332	0.636
Male	49.7	(46.4-53.1)	1.661		61.7	(58.1-65.2)	1.778		72.1	(69.2-74.7)	1.383	
Age												
3-4	56.4	(53.4-59.3)	1.494	<0.001	NA			NA	NA			NA
5	35.5	(31.6-39.5)	1.978		NA				NA			
6-9		NA		NA	57.2	(54.0-60.4)	1.597	<0.001	NA			NA
10-12		NA			66.4	(62.8-69.7)	1.723		NA			
13-15		NA		NA	NA			NA	72.5	(70.1-74.8)	1.176	0.972
13-17		NA			NA				72.5	(69.5-75.4)	1.458	
Ethnicity												
Afro-colombian	42.3	(35.4-49.5)	3.551	0.001	56.0	(49.6-62.1)	3.140	<0.001	73.5	(68.3-78.1)	2.449	<0.001
Indigenous	37.0	(29.2-45.6)	4.147		26.6	(18.3-36.9)	4.677		54.1	(47.0-61.1)	3.543	
No ethnic identity reported	51.6	(48.7-54.5)	1.443		63.9	(61.1-66.7)	1.396		73.3	(71.1-75.4)	1.079	
Overweight												
Yes	47.0	(39.6-54.6)	3.771	0.382	69.5	(65.0-73.6)	2.163	<0.001	75.8	(71.7-79.4)	1.935	0.153
No	50.6	(47.7-53.5)	1.443		58.1	(55.1-61.1)	1.505		72.4	(70.0-74.6)	1.143	
Physically active ^c												
Yes	51.1	(45.8-56.4)	2.653	0.646	54.1	(49.7-58.4)	2.188	<0.001	69.1	(63.8-74.0)	2.553	0.129
No	49.8	(47.0-52.6)	1.387		64.1	(61.1-67.0)	1.456		73.0	(71.0-75.0)	0.992	
Wealth Quartiles												
First (poorest)	36.7	(33.6-39.9)	1.564	<0.001	45.5	(41.8-49.2)	1.859	<0.001	61.5	(58.4-64.6)	1.542	<0.001
Second	57.2	(52.5-61.8)	2.333		65.8	(61.2-70.2)	2.245		74.0	(69.9-77.7)	1.949	
Third	62.0	(55.5-68.2)	3.206		74.2	(69.5-78.3)	2.219		84.4	(81.1-87.1)	1.498	
Fourth (wealthiest)	60.3	(51.7-68.4)	4.208		74.5	(68.3-81.6)	3.334		80.0	(73.9-85.0)	2.771	
Area												
Urban	56.0	(52.9-59.1)	1.553	<0.001	67.0	(64.1-69.8)	1.423	<0.001	77.2	(75.0-79.3)	1.077	<0.001
Rural	34.8	(30.6-39.1)	2.132		44.1	(40.0-48.2)	2.068		59.2	(55.2-63.1)	1.990	
TV available at the child's bedroom												
Yes	58.5	(54.8-62.0)	1.802	<0.001	71.5	(67.9-74.8)	1.709	<0.001	80.8	(78.0-83.2)	1.307	<0.001
No	44.1	(40.9-47.2)	1.578		54.1	(50.7-57.5)	1.697		66.6	(63.9-69.2)	1.334	
Video games devices availability												
Yes	67.1	(61.0-72.7)	2.925	<0.001	79.0	(75.2-82.3)	1.779	<0.001	81.6	(79.1-83.8)	1.160	<0.001
No	47.4	(44.8-50.0)	1.304		51.9	(48.9-54.8)	1.493		57.6	(54.5-60.6)	1.548	
Parks availability in the neighborhood												
Yes	57.0	(53.4-60.6)	1.805	<0.001	67.1	(63.8-70.3)	1.609	<0.001	75.3	(72.8-77.5)	1.180	<0.001

Sociodemographic and other potentially relevant variables for screen-time	Preschool children ^a				School aged children ^b				Adolescents ^b			
	P (%)	CI	SE	p-value	P (%)	CI	SE	p-value	P (%)	CI	SE	p-value
No	41.6	(38.2-45.2)	1.750		51.2	(47.6-54.9)	1.837		67.0	(64.1-69.7)	1.401	
Safety perception^d												
Is safe to play in the park	57.0	(52.7-61.1)	2.115	0.968	66.8	(63.1-70.3)	1.788	0.706	75.3	(72.6-77.9)	1.311	0.899
Is not safe to play in the park	57.1	(50.4-63.6)	3.336		68.0	(62.0-73.5)	2.893		75.0	(70.3-79.2)	2.231	
Geographic region												
Atlantic	39.8	(36.2-43.7)	1.881	<0.001	48.0	(42.3-53.8)	2.903	<0.001	65.8	(62.2-69.2)	1.736	0.001
Eastern	50.1	(44.0-56.2)	3.088		67.2	(62.1-71.8)	2.432		71.3	(65.4-76.5)	2.789	
Orinoquia-Amazonia	47.6	(35.8-59.6)	6.056		52.5	(47.3-57.7)	2.609		66.8	(60.7-72.5)	2.961	
Capital District	70.6	(61.8-78.0)	4.088		72.4	(63.9-79.5)	3.926		80.4	(71.1-87.2)	4.011	
Central	54.0	(49.0-59.0)	2.508		64.5	(60.0-68.8)	2.210		78.1	(75.2-80.8)	1.396	
Pacific	42.9	(37.9-48.1)	2.571		59.3	(53.2-65.2)	3.031		70.8	(66.1-75.1)	2.261	

Abbreviations: P, prevalence; CI, 95% confidence intervals; SE, standard error; NA, not applicable

a Excessive recreational screen-time in preschoolers was defined as engaging in more than one hour of screen time per day among children under 5 years of age or more than two hours of screen time per day among 5-year-olds

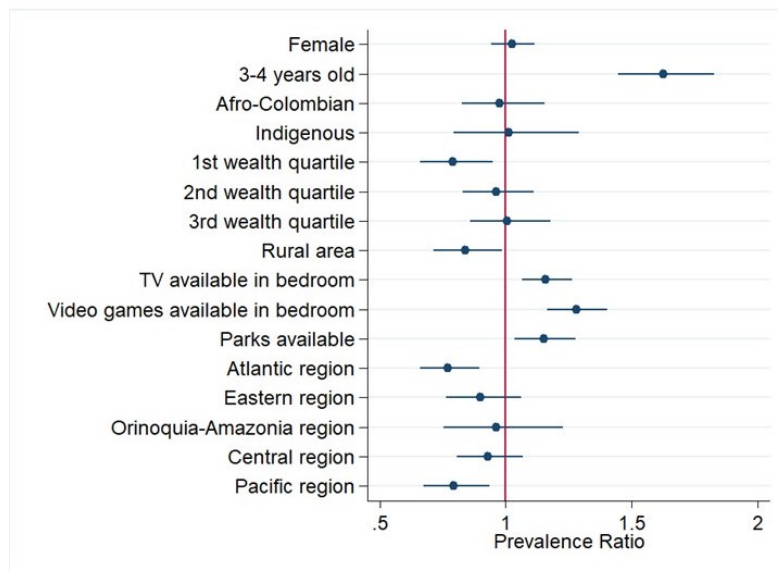
b Excessive recreational screen-time in school-aged children and adolescents was defined as engaging in more than 2 hours of screen time per day.

c Physically active is defined as meeting the WHO physical activity guidelines.

d Safety perception was assessed only among those who reported having a park in their neighborhood.

Correlates of excessive screen time among preschoolers

A



B

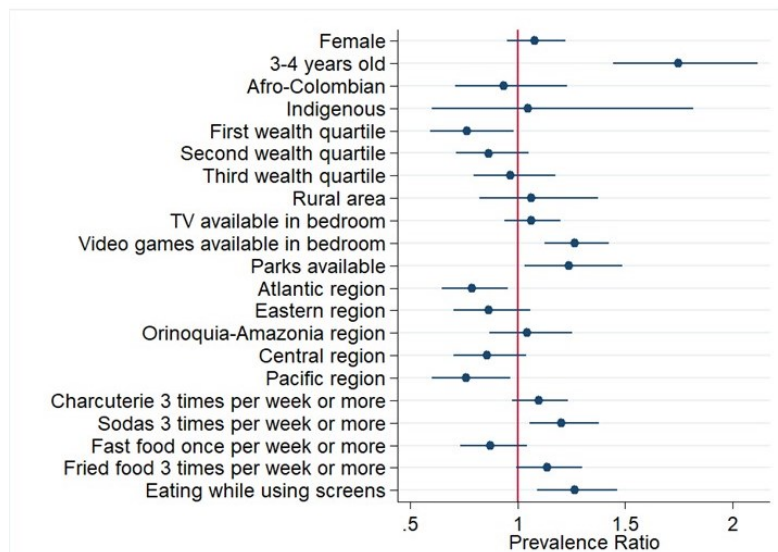


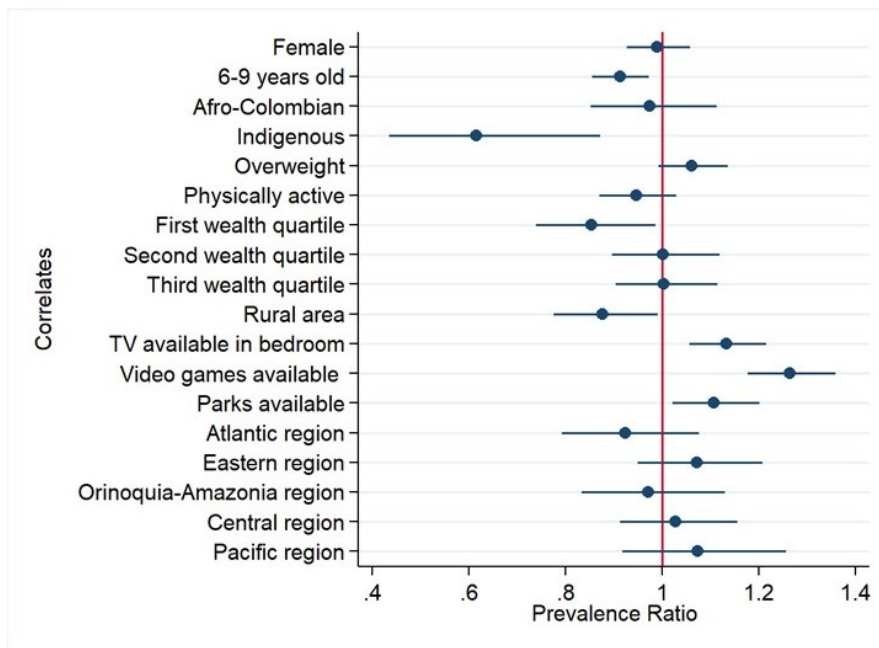
Figure 1 Prevalence ratios and 95% confidence intervals of correlates of spending excessive recreational screen-time among Colombian preschoolers in the National Survey of Nutrition, Colombia 2015. Excessive screen-time was defined as spending more than 1 one hour of screen-time per day among children under 5 years, and engaging in more than 2 hours of screen-time

per day among 5-year-olds. A) Multivariable model 1 (B) Multivariable model 2 including food consumption variables.

Figure 1 presents the correlates of excessive RST among preschoolers. According to multivariable model 1, younger preschoolers (3-4 year-olds), those with TV availability in their bedroom, video-game devices available, and those with parks available in their neighbourhood were more likely to have excessive RST compared to their counterparts. Also, preschoolers in the lowest wealth quartile, those living in rural areas, and those living in the Atlantic or Pacific region were less likely to have excessive RST (Figure 1a). According to multivariable model 2, soda consumption three or more times per week and eating while using screens were positively associated with having excessive RST (Figure 1b).

Correlates of excessive screen time among school-aged children

A



B

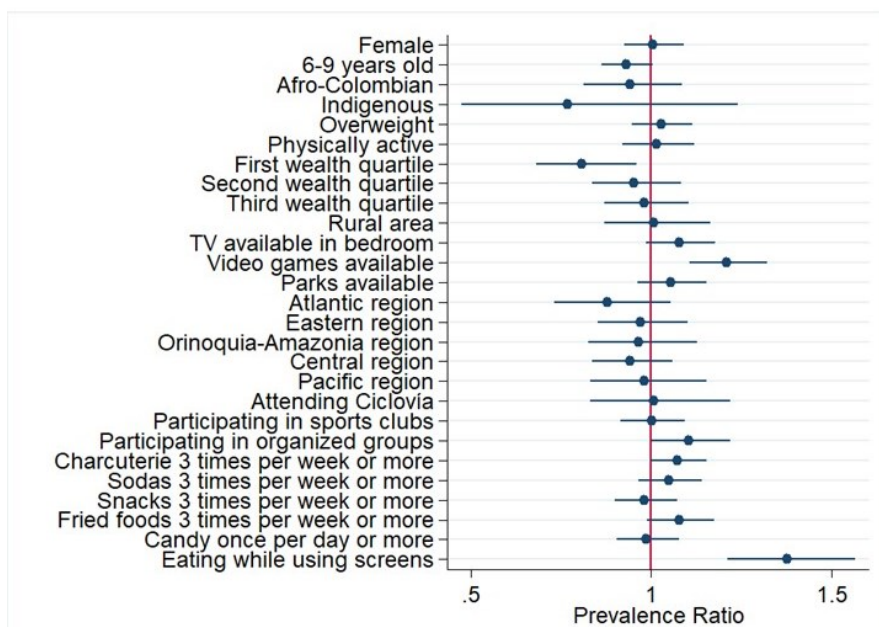


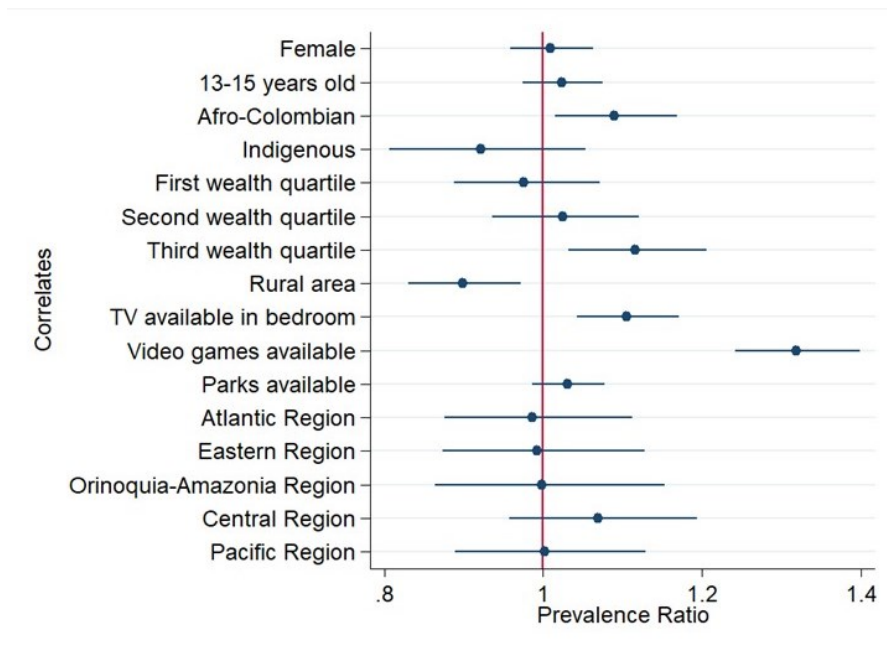
Figure 2 Prevalence ratios and 95% confidence intervals of correlates of spending excessive recreational screen-time among Colombian school-aged children in the National Survey of

Nutrition, Colombia 2015. Excessive screen-time was defined as spending more than 2 hours of screen-time per day. A) Multivariable model 1 (B) Multivariable model 2 including food consumption and program participation variables.

According to multivariable model 1, among school-aged children, those who had a TV in their bedroom or video-game device availability were more likely to have excessive RST. Younger age, Indigenous ethnicity, those in the lowest socioeconomic level, and those living in rural areas were less likely to have excessive RST (Figure 2a). According to multivariable model 2, there was a positive association with the usual consumption of foods in front of screens (Figure 2b).

Correlates of excessive screen time among adolescents

A



B

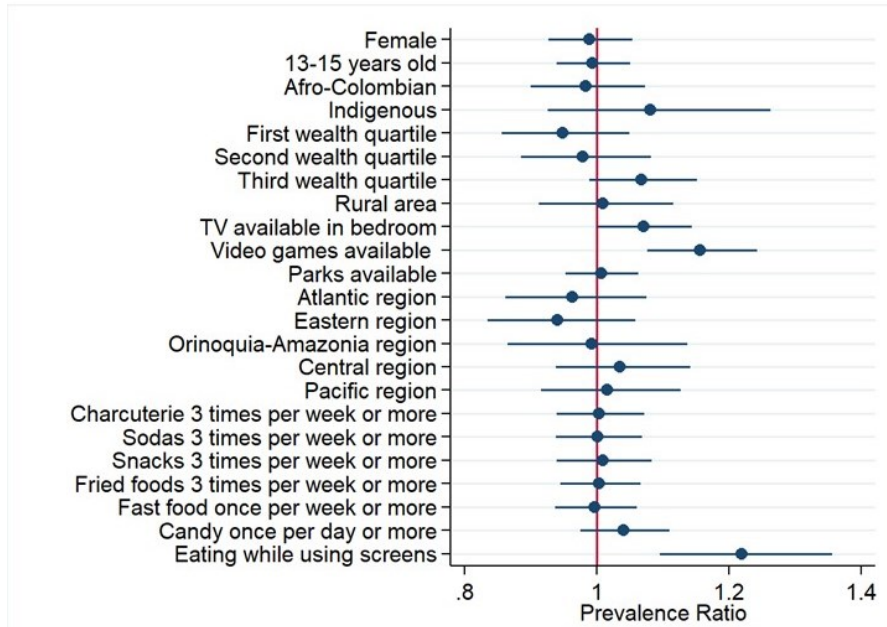


Figure 3 Prevalence ratios and 95% confidence intervals of correlates of spending excessive recreational screen-time among Colombian adolescents in the National Survey of Nutrition,

Colombia 2015. Excessive screen-time was defined as spending more than 2 hours of screen-time per day. A) Multivariable model 1 (B) Multivariable model 2 including food consumption variables.

According to multivariable model 1, Afro-Colombian adolescents, those in the third wealth index quartile and those who had TV available in their rooms or video-games available were more likely to have excessive RST than their counterparts. On the contrary, those living in rural areas were less likely to have excessive RST than their counterparts (Figure 3a). Program participation variables were not associated in the bivariate models and therefore were not included in model 2. According to multivariable model 2, adolescents who usually eat in front of screens were more likely to have excessive RST (Figure 3b).

Discussion

Our results indicate that a large proportion of Colombian children and adolescents have excessive RST and the prevalence increases with age. Approximately five out of every 10 preschoolers, six out of every 10 school-aged children, and seven out of every 10 adolescents had excessive RST. Correlates differed across age groups, but consistent positive associations were observed with the availability of TV in the child's bedroom, the availability of video games, and eating while using screens. Also, a negative association with rural area was observed for all age groups. Correlates at the intrapersonal, household and environmental levels are discussed below.

At the intrapersonal level RST correlates included age, ethnicity, consumption of energy dense foods and food intake while using screens. Younger preschoolers (3-4 years old) and older school-aged children (10-12 years old) were more likely to have excessive RST. Our findings for

school-aged children are consistent with other studies that have reported a positive association between age and screen time.^{30,31} However, among preschoolers, our results, which contribute to the limited studies on this population, showed an opposite association, which can be related to the fact that the sedentary behavior guidelines used as cut-offs in this analysis are stricter for younger children.³² It is important that public health messages consider this difference in the sedentary behavior guidelines according to age. The observed associations with ethnicity suggest that children belonging to Indigenous communities use screens less and this situation should be preserved. On the contrary, Afro-Colombian adolescents showed an increased likelihood of having excessive RST, which indicates that initiatives or programs to decrease sedentary behaviors should have a special focus on this population and further research is needed to better understand the drivers of this association. Our findings for food consumption are aligned with other studies, showing that children and adolescents with excessive RST have a greater consumption of energy dense foods and drinks³³ and tend to eat their meals while using screens.^{33,34} These associations are concerning considering that these obesogenic behaviors are present at a high proportion from early ages. Specific public health messaging for parents and children should be designed not only to reduce RST but also to avoid practices like eating while watching TV or other screens. The dietary guidelines of Brazil, for example, encourage sitting with the family to eat meals in an appropriate environment paying full attention to the act of eating and without engaging in another activity.³⁵

At the household level, living in a rural area and electronic devices availability emerged as consistent correlates across all age groups. The negative association with rural area was a common correlate^{17,36} that highlights the importance of focusing interventions on populations living in the continuously growing urban areas. The association of RST and sitting time with

devices availability has been previously reported, mainly for school-aged children and adolescents.^{36–38} In our study we observed that this is a relevant correlate from early age, which is a reason for concern considering that TV availability in the bedroom contributes to an obesogenic environment.³⁹ Future actions should take into account that having a TV in the bedroom and video-game availability are modifiable correlates, and removing them from children's bedrooms can contribute to limiting screen time, as demonstrated by Atkin et al. in a longitudinal study.⁴⁰ Our results also indicate that the wealthiest children and adolescents are more likely to have excessive RST than their poorer counterparts. This association was also reported in a systematic review and meta-analysis that found a positive relationship between socioeconomic level and excessive RST in adolescents from low-middle income countries, and opposite to the association observed in high income countries.⁴¹

At the environmental level, we did not find a statistically significant association of RST with the availability of physical activity programs. This result may indicate the need to have specific interventions aimed at reducing RST together with the already existing physical activity programs to have an impact on the children and adolescent's movement behaviors in Colombia. In this regard, it is important to highlight that there is a lack of policies and interventions to reduce screen time among Colombian children and adolescents, as previously reported by a group of experts in the Colombian Report Card of Physical Activity.⁴² We also observed a counter-intuitive positive association of excessive RST with parks availability. This finding could be related to safety conditions of the existing parks, as suggested by the non-statistically significant positive association between excessive RST and lack of safety perception observed in the bivariate analysis for preschoolers and school-aged children. In terms of geographic region, we also observed that preschoolers from the Atlantic and Pacific regions, and adolescents from

the Atlantic region were less likely to have excessive RST compared to their counterparts from Bogotá (the capital district). This could be probably influenced by differences in internet accessibility and cultural norms on the use of leisure time that should be further studied.

Our estimates seem higher than the prevalence of excessive RST reported in previous versions of the ENSIN survey.¹⁷ However, it is important to mention that our results may not be comparable, since different questionnaires have been used and the most recent version of ENSIN includes a wider range of screen-devices. In the global context, our results are similar to the engagement in RST reported by very high-income countries like Canada, Denmark, England and Qatar.⁷ Having a prevalence comparable to those observed in rich countries may be indicative of the lifestyle transition that low- and middle-income countries are experiencing and reinforces the urgent need to proactively implement actions to decrease risk behaviors such as excessive RST.⁴³ In the current context of the COVID-19 pandemic that has drastically changed the routine and movement behaviors of children and adolescents it would be expected that the observed estimates have largely increased, as observed in other countries.⁴⁴ This adds to the urgency for the design and implementation of strategies to reduce RST. These actions should align with the call made by the WHO-UNICEF- Lancet Commission to place children as the center of the Sustainable Development Goals. Specifically, greater regulation of advertising and commercial governance to protect children from the exposure to marketing of unhealthy products and harmful contents of videogames should be priorities for decision-makers.⁴⁵

Our results should be interpreted considering strengths and limitations of the study. The main strength is that our estimates inform the situation of RST for a nationally representative sample of 3- to 17-year-old individuals from Colombia, the broadest age range evaluated at the national level, to the best of our knowledge. Also, the survey data used for this analysis provides a wide

range of contextual covariates of relevance to understand the RST situation in Colombia. Limitations include the cross-sectional design of the survey, which does not allow to make causal inferences from our findings, and the use of self- and proxy-report of screen time engagement. Despite self-report being the most feasible method of assessment of RST for population surveys, it is important to recognize that this measure of screen time can be influenced by social desirability bias and recall bias and may lead to a certain degree of misclassification. Also, the questionnaire used to ascertain engagement in RST did not allow for a continuous variable of the total time engaged in RST.

In conclusion, the majority of Colombian children and adolescents have excessive RST and several correlates were identified that can be considered in the design of strategies to decrease these behaviors. The non-modifiable correlates identified in this study can guide interventions aimed at decreasing RST among children and youth, for target populations such as younger preschoolers, older school-aged children, children and adolescents from urban areas and the wealthiest children and adolescents. Significant modifiable correlates, such as availability of electronic devices, provide guidance for promising strategies that can be considered as part of a comprehensive initiative to reduce RST, such as public health campaigns to reduce the availability of TVs and electronic devices in children's bedrooms and not eating in front of the TV.

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Supplementary tables

Supplementary table 1 Sociodemographic and lifestyle characteristics of 4503 preschoolers from Colombia. National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	Preschool children								
	Total sample			Males			Females		
	n ^a	%	SE	n	%	SE	n	%	SE p-value
Sex									
Female	2195	48.5	1.21		NA			NA	
Male	2308	51.5	1.21		NA			NA	
Age (years)									
3-4	2998	70.1	1.03	1515	70.4	1.47	1483	69.8	1.35 0.746
5	1505	29.9	1.03	793	29.6	1.47	712	30.2	1.35
Ethnicity									
Afro-colombian	441	9.1	0.78	222	8.2	0.81	219	10.0	1.11 0.178
Indigenous	480	4.7	0.63	246	4.5	0.71	234	4.9	0.71
Other	3544	86.2	0.84	1819	87.3	0.94	1725	85.1	1.16
Overweight									
Yes	505	11.0	0.76	300	13.4	1.22	205	8.5	0.82 0.001
No	3856	89.0	0.76	1934	86.6	1.22	1922	91.5	0.82
Physically active ^b									
Yes	1075	24.4	1.1	635	28.6	1.6	440	19.92	1.39 <0.001
No	3428	75.6	1.1	1673	71.4	1.6	1755	80.08	1.39
Food intake ^c									
<i>Charcuterie 3 times per week or more</i>									
Yes	1077	34.8	1.49	557	35.4	1.83	520	34.2	2.10 0.625
No	1950	65.2	1.49	1012	64.6	1.83	938	65.8	2.10
<i>Sodas 3 times per week or more</i>									
Yes	1393	45.6	1.38	731	46.4	1.98	662	44.8	1.83 0.560
No	1780	54.4	1.38	888	53.6	1.98	892	55.2	1.83
<i>Snacks 3 times per week or more</i>									
Yes	1332	44.3	1.40	689	44.4	1.90	643	44.1	1.78 0.914
No	1908	55.8	1.40	956	55.6	1.90	952	55.9	1.78
<i>Fried foods 3 times per week or more</i>									
Yes	2008	53.4	1.24	1017	52.2	1.77	991	54.6	1.68 0.337
No	1751	46.6	1.24	908	47.8	1.77	843	45.5	1.68
<i>Fast food once per week or more</i>									
Yes	213	9.9	0.93	112	10.4	1.30	101	9.5	1.31 0.652
No	1599	90.1	0.93	804	89.6	1.30	795	90.5	1.31
<i>Candy once per day or more</i>									
Yes	1426	42.6	1.21	711	40.2	1.67	715	45.1	1.71 0.044
No	2168	57.4	1.21	1136	59.8	1.67	1032	54.9	1.71
<i>Usually eats while using screens</i>									
Yes	2463	62.5	1.27	1274	62.3	1.62	1189	62.7	1.84 0.860
No	1683	37.5	1.27	859	37.7	1.62	824	37.3	1.84
Wealth Quartiles									
First	2371	41.1	1.31	1197	40.4	1.58	1174	41.9	1.90 0.655
Second	1086	26.3	1.18	575	27.6	1.50	511	24.9	1.56
Third	713	20.3	1.22	365	19.6	1.34	348	21.0	2.04

Sociodemographic and other potentially relevant variables for screen-time	Preschool children								
	Total sample			Males			Females		
	n ^a	%	SE	n	%	SE	n	%	SE p-value
Fourth	333	12.3	1.01	171	12.4	1.35	162	12.2	1.35
Area									
Urban	3208	72.4	1.20	1631	71.8	1.47	1577	72.9	1.71 0.593
Rural	1293	27.6	1.20	675	28.2	1.47	618	27.1	1.71
TV available at the child's bedroom									
Yes	1734	42.3	1.15	906	44.3	1.58	828	40.1	1.55 0.057
No	2767	57.7	1.15	1400	55.7	1.58	1367	59.9	1.55
Video games devices availability									
Yes	554	14.0	0.84	295	13.7	1.12	259	14.2	1.32 0.788
No	3947	86.0	0.84	2011	86.3	1.12	1936	85.8	1.32
Parks availability in the neighborhood									
Yes	2376	55.4	1.37	1273	56.9	1.70	1103	53.8	1.94 0.187
No	2125	44.6	1.37	1033	43.1	1.70	1092	46.3	1.94
Safety perception ^d									
Is safe to play in the park	1793	75.7	1.57	977	77.3	1.97	816	74.0	2.22 0.233
Is not safe to play in the park	583	24.3	1.57	296	22.7	1.97	287	26.0	2.22
Geographic región									
Atlantic	932	24.4	1.03	490	25.0	1.26	442	23.7	1.44
Eastern	799	17.0	1.24	401	16.2	1.42	398	17.8	1.61
Orinoquia-Amazonia	775	3.9	0.27	395	3.9	0.53	380	4.0	0.47
Capital District	318	14.0	1.30	161	14.3	1.46	157	13.7	2.14
Central	969	24.2	0.93	497	24.9	1.35	472	23.5	1.34
Pacific	710	16.5	0.70	364	15.8	0.94	346	17.3	1.17

Abbreviations: n, sample size; SE, standard error; NA, not applicable

a The total sample size for preschoolers was 4503 children. However the following variables had missing values: ethnicity=38, BMI=142, area, TV availability, video games availability and parks availability =2.

b Physically active is defined as meeting the WHO physical activity guidelines using a cut-off of 180 min of physical activity per day with at least 60 min of energetic play.

c Food intake variables are available only for the sub-sample selected for the food intake component of the survey, therefore the sample sizes are smaller.

d Safety perception was assessed only among those who reported having a park in their neighborhood.

Supplementary table 2 Sociodemographic and lifestyle characteristics of 11956 children and adolescents from Colombia. National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	p-value	n ^b	%	SE	n	%	SE	n	%	SE	p-value
Sex																				
Female	2556	48.0	1.12		NA			NA		NA	3329	49.6	0.99		NA			NA		NA
Male	2777	52.0	1.12		NA			NA			3294	50.4	0.99		NA			NA		
Age (years)																				
6-9	3015	58.8	1.10	1535	58.1	1.47	1480	59.5	1.73	0.56		NA			NA			NA		NA
10-12	2318	41.2	1.10	1242	41.9	1.47	1076	40.5	1.73			NA			NA			NA		
13-15		NA			NA			NA		NA	4007	60.3	0.99	2009	59.0	1.45	1998	61.7	1.36	0.179
13-17		NA			NA			NA			2616	39.7	0.99	1285	41.0	1.45	1331	38.3	1.36	
Ethnicity																				
Afro-colombian	452	9.8	0.93	233	9.6	1.09	219	10.1	1.06	0.834	557	9.2	0.94	316	9.7	1.19	241	8.7	0.96	0.238
Indigenous	671	5.9	0.78	333	5.7	1.23	338	6.1	1.06		652	4.5	0.80	261	4.0	0.83	391	5.0	0.89	
Other	4165	84.3	1.11	2191	84.8	1.48	1974	83.8	1.39		5361	86.3	0.82	2689	86.3	1.05	2672	86.3	0.99	
Overweight																				
Yes	1255	25.8	1.15	668	27.1	1.60	587	24.5	1.51	0.221	1234	18.1	0.75	447	14.9	0.98	787	21.4	1.11	<0.001
No	3894	74.2	1.15	2019	73.0	1.60	1875	75.5	1.51		5120	81.9	0.75	2692	85.2	0.98	2428	78.6	1.11	
Participation in organized activities and programs ^c																				
Ciclovias ^d																				
Yes	83	2.0	0.45	51	1.9	0.410	32	2.0	0.84	0.925	459	15.4	1.15	274	20.7	1.86	185	10.1	1.13	<0.001
No	5250	98.0	0.45	2726	98.1	0.410	2524	98.0	0.84		2999	84.6	1.15	1408	79.3	1.86	1591	89.9	1.13	
Community physical activity programs (e.g. aerobics)																				
Yes		NA			NA			NA		NA	797	20.2	1.19	289	15.9	1.25	508	23.9	1.77	<0.001
No		NA			NA			NA			2840	79.8	1.19	1351	84.1	1.25	1489	76.1	1.77	
Physical activity programs at school																				

Supplementary table 2 Sociodemographic and lifestyle characteristics of 11956 children and adolescents from Colombia. National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	School aged children										Adolescents										
	Total sample			Males			Females				Total sample			Males			Females				
	n ^a	%	SE	n	%	SE	n	%	SE	p-value	n ^b	%	SE	n	%	SE	n	%	SE	p-value	
Yes	NA			NA			NA				NA	1889	47.9	1.29	984	50.5	1.68	905	45.4	1.87	<0.001
No	NA			NA			NA					2006	52.1	1.29	912	49.5	1.68	1094	54.6	1.87	
Sport Clubs																					
Yes	2237	41.7	1.18	1477	54.3	1.75	760	28.1	1.50	<0.001	1104	27.9	1.16	759	38.0	1.72	345	16.7	1.28	<0.001	
No	3096	58.3	1.18	1300	45.7	1.75	1796	72.0	1.50		2671	72.1	1.16	1228	62.0	1.72	1443	83.3	1.28		
Organized groups (dance, martial arts, etc)																					
Yes	484	8.3	0.69	171	5.4	0.73	313	11.4	1.13	<0.001	719	19.9	1.18	249	15.9	1.52	470	23.1	1.70	0.002	
No	4849	91.7	0.69	2606	94.6	0.73	2243	88.6	1.13		2778	80.1	1.18	1300	84.1	1.52	1478	76.9	1.70		
Physically active ^e																					
Yes	1722	31.1	1.40	1042	35.8	1.91	680	26.0	1.62	<0.001	848	13.3	0.76	605	18.8	1.12	243	7.6	0.87	<0.001	
No	3611	68.9	1.40	1735	64.2	1.91	1876	74.0	1.62		5775	86.8	0.76	2689	81.2	1.12	3086	92.4	0.87		
Food intake ^f																					
Charcuterie 3 times per week or more																					
Yes	1256	37.2	1.33	692	40.0	1.93	564	34.1	1.92	0.039	1878	39.3	1.08	966	40.7	1.63	912	37.8	1.52	0.212	
No	2422	62.9	1.33	1249	60.0	1.93	1173	65.9	1.92		3018	60.7	1.08	1527	59.3	1.63	1491	62.2	1.52		
Sodas 3 times per week or more																					
Yes	1965	51.5	1.64	997	51.8	2.07	968	51.1	2.15	0.791	3420	61.9	1.04	1832	65.5	1.29	1588	58.0	1.48	<0.001	
No	2045	48.5	1.64	1108	48.2	2.07	937	48.9	2.15		2159	38.1	1.04	1022	34.5	1.29	1137	42.0	1.47		
Snacks 3 times per week or more																					
Yes	1753	50.0	1.52	916	52.3	2.07	837	47.6	1.81	0.059	2527	49.5	1.18	1272	49.1	1.60	1255	49.9	1.54	0.706	
No	2194	50.0	1.52	1133	47.7	2.07	1061	52.4	1.81		2763	50.5	1.18	1365	50.9	1.60	1398	50.1	1.54		
Fried foods 3 times per week or more																					
Yes	2584	56.2	1.37	1378	56.9	1.96	1206	55.6	1.73	0.612	3766	60.0	1.09	1904	60.9	1.38	1862	59.0	1.49	0.333	
No	2029	43.8	1.37	1032	43.2	1.96	997	44.4	1.73		2370	40.0	1.09	1172	39.1	1.38	1198	41.0	1.49		

Supplementary table 2 Sociodemographic and lifestyle characteristics of 11956 children and adolescents from Colombia. National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	p-value	n ^b	%	SE	n	%	SE	n	%	SE	p-value
<i>Fast food once per week or more</i>																				
Yes	329	12.4	1.21	165	11.7	1.60	164	13.2	1.87	0.556	1041	25.1	1.14	553	26.1	1.60	488	24.1	1.46	0.337
No	2179	87.6	1.21	1126	88.3	1.60	1053	86.9	1.87		2986	74.9	1.14	1450	73.9	1.60	1536	75.9	1.46	
<i>Candy once per day or more</i>																				
Yes	2136	53.9	1.50	1064	52.7	2.01	1072	55.1	1.83	0.338	2692	51.3	1.24	1284	49.4	1.71	1408	53.2	1.60	0.091
No	2277	46.2	1.50	1233	47.3	2.01	1044	45.0	1.83		2786	48.7	1.24	1420	50.6	1.71	1366	46.8	1.60	
<i>Usually eats while using screens</i>																				
Yes	3208	68.3	1.24	1651	66.2	1.83	1557	70.6	1.62	0.074	4711	74.7	1.02	2353	74.2	1.22	2358	75.2	1.29	0.497
No	1808	31.7	1.24	969	33.8	1.83	839	29.4	1.62		1829	25.3	1.02	906	25.8	1.22	923	24.8	1.29	
Wealth Quartiles																				
First	2867	39.2	1.56	1479	39.0	2.06	1388	39.4	1.78	0.575	3342	38.1	1.31	1658	38.9	1.49	1684	37.3	1.71	0.673
Second	1289	25.6	1.20	708	25.8	1.49	581	25.4	1.64		1537	23.3	0.96	770	23.6	1.21	767	23.0	1.21	
Third	763	19.7	1.03	382	18.7	1.35	381	20.7	1.44		1097	21.2	0.94	545	20.9	1.27	552	21.5	1.24	
Fourth	414	15.5	1.14	208	16.4	1.59	206	14.5	1.34		647	17.5	1.11	321	16.7	1.39	326	18.2	1.41	
Area																				
Urban	4016	73.7	1.35	2087	74.0	1.77	1929	73.4	1.57	0.782	4816	73.8	1.29	2300	73.2	1.56	2516	74.4	1.44	0.436
Rural	1317	26.3	1.35	690	26.0	1.77	627	25.6	1.57		1807	26.2	1.29	994	26.8	1.57	813	25.6	1.44	
TV available at the child's bedroom																				
Yes	1807	39.6	1.32	921	39.0	1.79	886	40.3	1.76	0.601	2363	41.6	1.07	1193	42.0	1.50	1170	41.3	1.41	0.723
No	3525	60.4	1.32	1855	61.0	1.79	1670	59.7	1.76		4259	58.4	1.07	2100	58.0	1.50	2159	58.7	1.41	
Video games devices availability																				
Yes	1452	33.7	1.28	782	35.2	1.85	670	32.0	1.70	0.208	3835	62.2	1.01	1904	61.7	1.39	1931	62.7	1.30	0.552
No	3881	66.3	1.28	1995	64.8	1.85	1886	68.0	1.70		2788	37.8	1.01	1465	38.3	1.39	1398	37.3	1.30	
Parks availability in the neighborhood																				

Supplementary table 2 Sociodemographic and lifestyle characteristics of 11956 children and adolescents from Colombia. National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	School aged children										Adolescents									
	Total sample			Males			Females				Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	p-value	n ^b	%	SE	n	%	SE	n	%	SE	p-value
Yes	3121	61.4	1.54	1650	62.6	1.89	1471	60.1	1.90	0.263	4203	66.8	1.12	2179	69.1	1.32	2024	64.5	1.43	0.006
No	2212	38.6	1.54	1127	37.4	1.89	1085	39.9	1.90		2420	33.2	1.12	1115	30.9	1.32	1305	35.5	1.43	
Safety perception [#]																				
Is safe to play in the park	2371	72.1	1.58	1271	72.7	2.12	1100	71.4	2.14	0.652	3130	72.2	1.22	1718	76.9	1.64	1412	67.2	1.79	<0.001
Is not safe to play in the park	750	27.9	1.58	379	27.3	2.12	371	28.6	2.14		1073	27.8	1.22	461	23.2	1.64	612	32.8	1.79	
Geographic región																				
Atlantic	786	23.5	1.54	418	23.4	2.05	368	23.6	1.67	0.759	1340	24.4	1.06	778	25.6	1.43	562	23.2	1.23	0.682
Eastern	809	17.9	1.88	409	17.1	2.05	400	18.8	1.91		1149	18.0	1.57	587	17.7	1.63	562	18.4	1.77	
Orinoquia-Amazonia	1560	3.3	0.24	802	3.2	0.32	758	3.4	0.25		1248	3.1	0.20	440	3.2	0.32	808	3.0	0.25	
Capital District	367	14.5	1.39	193	14.2	1.85	174	14.7	1.60		382	12.3	1.12	202	11.9	1.64	180	12.7	1.27	
Central	1193	24.4	1.22	630	25.4	1.68	563	23.2	1.31		1636	24.4	0.90	807	23.7	1.26	829	25.1	1.19	
Pacific	618	16.5	0.93	325	16.7	1.19	293	16.2	1.22		868	17.8	0.83	480	17.8	1.04	388	17.7	1.13	

Abbreviations: n, sample size; SE, standard error; NA, not applicable

a The total sample size for school-aged children was 5333 children. However the following variables had missing values: ethnicity=45, BMI=184 and TV availability=1.

b The total sample size for adolescents was 6623. However the following variables had missing values: ethnicity=53, BMI=269, and TV availability=1.

c Participation in organized activities and programs was assessed only among school-age children and adolescents who reported knowing those programs

d Ciclovias are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

e Physically active is defined as meeting the WHO physical activity guidelines

f Food intake variables are available only for the sub-sample selected for the food intake component of the survey, therefore the sample sizes are smaller.

g Safety perception was assessed only among those who reported having a park in their neighborhood.

Supplementary table 3 Correlates of excessive recreational screen time among Colombian preschoolers.

National Survey of Nutrition, Colombia 2015.

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value
Sex						
Female	1.02	(0.9-1.1)	0.561	1.08	(0.9-1.2)	0.238
Male	1.00			1.00		
Age						
3-4	1.62	(1.4-1.8)	<0.001	1.75	(1.4-2.1)	<0.001
5	1.00			1.00		
Ethnicity						
Afro-colombian	0.98	(0.8-1.2)	0.781	0.93	(0.7-1.2)	0.619
Indigenous	1.01	(0.8-1.3)	0.929	1.05	(0.6-1.8)	0.869
No ethnic identity reported	1.00			1.00		
Food intake						
<i>Charcuterie 3 times per week or more</i>						
Yes	-	-	-	1.10	(1.0-1.2)	0.123
No	-			1.00		
<i>Sodas 3 times per week or more</i>						
Yes	-	-	-	1.20	(1.1-1.4)	0.008
No	-			1.00		
<i>Fried foods 3 times per week or more</i>						
Yes	-	-	-	1.14	(1.0-1.3)	0.059
No	-			1.00		
<i>Fast food once per week or more</i>						
Yes	-	-	-	0.87	(0.7-1.0)	0.136
No	-			1.00		
<i>Usually eats while using screens</i>						
Yes	-	-	-	1.26	(1.1-1.5)	0.003
No	-			1.00		
Wealth Quartiles						
First (poorest)	0.79	(0.7-0.9)	0.012	0.76	(0.6-1.0)	0.037
Second	0.96	(0.8-1.1)	0.585	0.87	(0.7-1.1)	0.140
Third	1.01	(0.9-1.2)	0.933	0.97	(0.8-1.2)	0.728
Fourth (wealthiest)	1.00			1.00		
Area						
Urban	1.00			1.00		
Rural	0.84	(0.7-1.0)	0.033	1.06	(0.8-1.4)	0.633

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value
TV available at the child's bedroom						
Yes	1.16	(1.1-1.3)	0.001	1.06	(0.9-1.2)	0.328
No	1.00			1.00		
Videogames available						
Yes	1.28	(1.2-1.4)	<0.001	1.27	(1.1-1.4)	<0.001
No	1.00			1.00		
Parks availability in the neighborhood						
Yes	1.15	(1.0-1.3)	0.009	1.24	(1.0-1.5)	0.023
No	1.00			1.00		
Geographic region						
Atlantic	0.77	(0.7-0.9)	0.001	0.79	(0.6-1.0)	0.017
Eastern	0.90	(0.8-1.1)	0.209	0.86	(0.7-1.1)	0.157
Orinoquia-Amazonia	0.96	(0.8-1.2)	0.746	1.04	(0.9-1.3)	0.649
Capital District	1.00			1.00		
Central	0.93	(0.8-1.1)	0.291	0.86	(0.7-1.0)	0.116
Pacific	0.79	(0.7-0.9)	0.006	0.76	(0.6-1.0)	0.025

Abbreviations: PR, prevalence ratio; CI, 95% confidence interval

a Model 1 included sex, age, ethnicity, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

b Model 2 included sex, age, ethnicity, food intake variables, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

Supplementary table 4 Correlates of excessive recreational screen time among Colombian school-aged children. National Survey of Nutrition, Colombia 2015.

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value
Sex						
Female	0.99	(0.9-1.1)	0.75	1.01	(0.9-1.1)	0.895
Male	1.00			1.00		
Age						
6-9	0.91	(0.9-1.0)	0.006	0.93	(0.9-1.0)	0.063
10-12	1.00			1.00		
Ethnicity						
Afro-colombian	0.97	(0.9-1.1)	0.693	0.94	(0.8-1.1)	0.396
Indigenous	0.62	(0.4-0.9)	0.007	0.77	(0.5-1.2)	0.273
No ethnic identity reported	1.00			1.00		
Overweight						
Yes	1.06	(1.0-1.1)	0.081	1.03	(0.9-1.1)	0.511
No	1.00		-	1.00		
Participation in organized activities and programs						
Ciclovias ^c						
Yes	-	-	-	1.01	(0.8-1.2)	0.936
No	-			1.00		
Sport Clubs						
Yes	-	-	-	1.00	(0.9-1.1)	0.985
No	-			1.00		
Organized groups (dance, martial arts, etc)						
Yes	-	-	-	1.10	(1.0-1.2)	0.051
No	-			1.00		
Physically active ^d						
Yes	0.95	(0.9-1.0)	0.189	1.02	(0.9-1.1)	0.744
No	1.00			1.00		
Food intake						
<i>Charcuterie 3 times per week or more</i>						
Yes	-	-	-	1.07	(1.0-1.2)	0.064
No	-			1.00		
<i>Sodas 3 times per week or more</i>						
Yes	-	-	-	1.05	(1.0-1.1)	0.253
No	-			1.00		
<i>Snacks 3 times per week or more</i>						

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value
Yes	-	-	-	0.98	(0.9-1.1)	0.675
No	-			1.00		
<i>Fried foods 3 times per week or more</i>						
Yes	-	-	-	1.08	(1.0-1.2)	0.083
No	-			1.00		
<i>Candy once per day or more</i>						
Yes	-	-	-	0.99	(0.9-1.1)	0.761
No	-			1.00		
<i>Usually eats while using screens</i>						
Yes	-	-	-	1.38	(1.2-1.6)	<0.001
No	-			1.00		
Wealth Quartiles						
First (poorest)	0.85	(0.7-1.0)	0.032	0.81	(0.7-1.0)	0.016
Second	1.00	(0.9-1.1)	0.990	0.95	(0.8-1.1)	0.452
Third	1.00	(0.9-1.1)	0.949	0.98	(0.9-1.1)	0.739
Fourth (wealthiest)	1.00			1.00		
Area						
Urban	1.00			1.00		
Rural	0.88	(0.8-1.0)	0.035	1.01	(0.9-1.2)	0.923
TV available at the child's bedroom						
Yes	1.13	(1.1-1.2)	0.001	1.08	(1.0-1.2)	0.098
No	1.00			1.00		
Videogames available						
Yes	1.26	(1.2-1.4)	<0.001	1.21	(1.1-1.3)	<0.001
No	1.00			1.00		
Parks availability in the neighborhood						
Yes	1.11	(1.0-1.2)	0.015	1.05	(1.0-1.2)	0.259
No	1.00			1.00		
Geographic region						
Atlantic	0.92	(0.8-1.1)	0.300	0.88	(0.7-1.1)	0.159
Eastern	1.07	(0.9-1.2)	0.257	0.97	(0.9-1.1)	0.630
Orinoquia-Amazonia	0.97	(0.8-1.1)	0.693	0.97	(0.8-1.1)	0.650
Capital District	1.00			1.00		
Central	1.03	(0.9-1.2)	0.651	0.94	(0.8-1.1)	0.316
Pacific	1.07	(0.9-1.3)	0.371	0.98	(0.8-1.2)	0.803

Abbreviations: PR, prevalence ratio; CI, 95% confidence interval

a Model 1 for school-aged children included sex, age, ethnicity, overweight, physical activity, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

b Model 2 for school-aged children included sex, age, ethnicity, overweight, participation in Ciclovías, sports clubs and organized groups, physical activity, food intake variables, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value

c Ciclovías are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

d Physically active is defined as meeting the WHO physical activity guidelines

Supplementary table 5 Correlates of recreational screen time among Colombian adolescents.

National Survey of Nutrition, Colombia 2015

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value

Sex

Female	1.01	(1.0-1.1)	0.721	0.98	(0.9-1.1)	0.714
Male	1.00			1.00		

Age

13-15	1.02	(1.0-1.1)	0.358	0.99	(0.9-1.0)	0.801
16-17	0.00			1.00		

Ethnicity

Afro-colombian	1.09	(1.0-1.2)	0.018	0.98	(0.9-1.1)	0.692
Indigenous	0.92	(0.8-1.1)	0.226	1.08	(0.9-1.3)	0.318
No ethnic identity reported	1.00			1.00		

Food intake

Charcuterie 3 times per week or more

Yes	-	-	-	1.00	(0.9-1.1)	0.919
No	-			1.00		

Sodas 3 times per week or more

Yes	-	-	-	1.00	(0.9-1.1)	0.974
No	-			1.00		

Snacks 3 times per week or more

Yes	-	-	-	1.01	(0.9-1.1)	0.815
No	-			1.00		

Fried foods 3 times per week or more

Yes	-	-	-	1.00	(0.9-1.1)	0.911
No	-			1.00		

Fast food once per week or more

Yes	-	-	-	1.00	(0.9-1.1)	0.922
No	-			1.00		

Candy once per day or more

Yes	-	-	-	1.04	(1.0-1.1)	0.227
No	-			1.00		

Usually eats while using screens

Yes				1.22	(1.1-1.4)	<0.001

Sociodemographic and other potentially relevant variables for screen-time	Model 1 ^a			Model 2 ^b		
	PR	CI	p-value	PR	CI	p-value
No				1.00		
Wealth Quartiles						
First (poorest)	0.98	(0.9-1.1)	0.599	0.95	(0.9-1.0)	0.294
Second	1.02	(0.9-1.1)	0.597	0.98	(0.9-1.1)	0.669
Third	1.12	(1.0-1.2)	0.007	1.07	(1.0-1.2)	0.094
Fourth (wealthiest)	1.00			1.00		
Area						
Urban	1.00			1.00		
Rural	0.90	(0.8-1.0)	0.008	1.01	(0.9-1.1)	0.860
TV available at the child's bedroom						
Yes	1.11	(1.0-1.2)	0.001	1.07	(1.0-1.1)	0.046
No	1.00			1.00		
Videogames available						
Yes	1.32	(1.2-1.4)	<0.001	1.16	(1.1-1.2)	<0.001
No	1.00			1.00		
Parks availability in the neighborhood						
Yes	1.03	(1.0-1.1)	0.168	1.01	(1.0-1.1)	0.827
No	1.00			1.00		
Geographic region						
Atlantic	0.99	(0.9-1.1)	0.825	0.96	(0.9-1.1)	0.493
Eastern	0.99	(0.9-1.1)	0.905	0.94	(0.8-1.1)	0.299
Orinoquia-Amazonia	1.00	(0.9-1.2)	0.980	0.99	(0.9-1.1)	0.903
Capital District	1.00			1.00		
Central	1.07	(1.0-1.2)	0.227	1.04	(0.9-1.1)	0.483
Pacific	1.00	(0.9-1.1)	0.976	1.02	(0.9-1.1)	0.760

Abbreviations: PR, prevalence ratio; CI, 95% confidence intervals

a Model 1 for adolescents included sex, age, ethnicity, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

b Model 2 for adolescents included sex, age, ethnicity, food intake variables, wealth index, area of residence, TV availability in the child's bedroom, video games available at home, parks availability in the neighbourhood and geographic region.

Chapter 7: Comparison of Physical Activity and Sedentary Behaviours Indicators Among Countries with a High Human Development Index

Manuscript 4: Report Card Grades on the Physical Activity of Children and Youth from 10 countries with high Human Development Index: Global Matrix 3.0

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Article preface

This article compares physical activity indicators in children and adolescents across ten countries with a high Human Development index that were involved in the Global Matrix 3.0 initiative.

This manuscript addresses the third objective of the dissertation, to draw international comparisons of physical activity and sedentary behaviour indicators. SAG, JDB and MST conceived the idea of the manuscript. SAG drafted the manuscript, and all co-authors reviewed and approved the manuscript. The University of Ottawa granted approval for secondary data analyses conducted in this study (file number H-06-19-3564). This article is now published in open access. The published manuscript can be found in Appendix 8.

Abstract

Background: The Global Matrix 3.0 brings together the Report Card grades for 10 physical activity indicators for children and youth from 49 countries. This article describes and compares the Global Matrix 3.0 findings among 10 countries with high Human Development Index (HDI).

Methods: Report Cards on physical activity indicators were developed by each country, following a harmonized process. Countries informed their Report Cards with the best and most recent evidence available. Indicators were graded using a common grading rubric and benchmarks established by the Active Healthy Kids Global Alliance. A database of grades from the countries was compiled, and letter grades were converted to numerical equivalents.

Descriptive statistics and scores for groups of indicators were calculated, and correlation analyses were conducted.

Results: Grades for the 10 countries clustered around “D”, ranging from “F” to “B+”. Active Transportation had the highest average grade (“C”), while Overall Physical Activity had the lowest average grade (“D-”). Low grades were observed for both behavioral and sources of influence indicators.

Conclusions: In the context of social and economical changes of high HDI countries, urgent actions to increase physical activity among children and youth are required. Surveillance and monitoring efforts are required to fill research gaps.

Introduction

Regular physical activity among children and youth (i.e., adolescents) has been consistently associated with decreased adiposity, healthy cardiometabolic biomarkers, improved physical fitness and better bone health, as well as with favorable psychological and cognitive health outcomes.¹ The public health potential of regular physical activity is particularly relevant in the current context in which more than 107 million children are obese worldwide.² Despite the broad evidence on the benefits of physical activity, globally, 80% of adolescents are not attaining the minimum recommendation of 60 minutes of daily moderate- to vigorous-intensity physical activity (MVPA) to achieve those benefits.³ A moderate decline in the cardiorespiratory fitness of children and adolescents has also been observed⁴ and excessive sedentary behaviours among children and youth are highly prevalent⁵⁻⁸

For many countries considered to have emerging economies, a shift towards reduced habitual physical activity is probable and related to broad social changes and economic growth.^{9,10}

Greater use of motorized transportation, shifts from rural to urban dwelling and increased use of technology that occur with economic growth may be contributing to decreased active

transportation and leisure time physical activity, and to increased sedentary recreational activities.^{11,12} Despite the rapidly rising burden of non-communicable diseases (NCDs) in middle income countries,¹³ there are competing priorities at the policy and structural levels,¹⁴ which can be reflected in lack of investments by governments to prevent NCDs.¹⁵ This is the context of several countries in Latin America, the Middle East, the Eastern Balkan region, and East Asia, regions in the midst of a physical activity¹⁶ and demographic transition.¹⁷

In response to the physical inactivity crisis and the increase in NCDs¹³ as unintended consequences of economic development, multilateral organizations have launched action plans and policy documents that support physical activity promotion as a key strategy. The Bangkok Declaration on Physical Activity for Global Health and Sustainable Development¹⁸, the Plan of Action for the Prevention of Obesity in Children and Adolescents¹⁹ (signed by all countries in Latin America), and the World Health Organization's (WHO) Global Action Plan on Physical Activity²⁰ are some of the recent policy documents that highlight the key role of physical activity in the prevention of NCDs globally.

As the global public health agenda fosters the implementation of policies and action plans to decrease the burden of physical inactivity, surveillance of physical activity, its related behaviours and relevant settings of influence for its promotion, is needed. In response to these needs, Active Healthy Kids Canada and subsequently the Active Healthy Kids Global Alliance (AHKGA) have led the harmonized development of country specific physical activity Report Cards, synthesizing the best available evidence on how a nation is doing in terms of promoting physical activity among children and youth since 2014.^{21,22} The countries involved in the Report Card initiative have graded common indicators related to physical activity in children and youth, using a common grading rubric and standardized benchmarks.²¹⁻²³ This international effort has been

consolidated in the creation of a “Global Matrix” of grades, which has compiled and compared grades across physical activity related indicators for 15, 38 and 49 countries in its first, second and third versions, respectively.^{21–23}

As the Global Matrix project has grown, greater representativeness of countries from different levels of development and different regions of the world has been achieved. This progress provides a unique opportunity to identify successes and challenges to improve physical activity levels among children and youth from countries with similar levels of development in various regions of the world. For this purpose, the 49 countries involved in the Global Matrix 3.0 were classified into three categories, based on their Human Development Index (HDI): low and medium, high, and very high HDI, following the cut-off points defined by the United Nations Development Programme. The HDI is a composite index that integrates life expectancy, years of schooling and gross national income per capita, as basic dimensions of human development.²⁴

The current article focuses on the group of countries with a high HDI, which are susceptible to the aforementioned consequences of economic growth. In this context it is important to document the current situation of physical activity related indicators and the priorities for research and advocacy to advance efforts to promote active living in children from these countries, and to study the variability in successes and challenges between countries with similar HDI. Therefore, the purpose of this article is to describe and compare the Global Matrix 3.0 findings for 10 physical activity indicators among 10 high HDI countries: Brazil, Bulgaria, China, Colombia, Ecuador, Lebanon, Mexico, Thailand, Uruguay and Venezuela.

Methods

Global Matrix involvement

Countries registered for the Global Matrix 3.0 project between April 2017 and January 2018 and paid a registration fee according to their HDI classification. Eleven high HDI countries registered and 10 fully participated. According to the mentorship model developed for the Global Matrix 3.0,²³ each country was assigned a mentor from the AHKGA network and from their geographical region, to guide the development of their Report Cards following a harmonized process.²⁵ Four of the high HDI countries developed their Report Cards for the first time (Bulgaria, Ecuador, Lebanon and Uruguay).

Report card development

Each country formed a working group of national and international experts on physical activity from the academic, private and government sectors, and research staff from the lead organization. These teams were in charged with: i) compiling and synthesizing the best available and most recent evidence for their country; and ii) assessing the available evidence for each indicator and assigning the corresponding grade based on the benchmarks and grading rubric established by the AHKGA (Table 1 and Table 2). The evidence was gathered from literature reviews comprising peer-reviewed published and unpublished data, surveys, governmental reports and policy documents, and in some cases, was complemented by experts on the team.

Indicators

The data gathered were summarized in 10 common indicators: Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviours, Physical Fitness, Family and Peers, School, Community and Environment, and Government. In order to harmonize the process, the AHKGA established benchmarks for each

indicator (Table 1) and a standardized grading rubric (Table 2). Every indicator was assigned a grade by the group of experts in each country. The ten countries submitted their grades with a detailed rationale supporting these, and a scientific committee from the AHKGA audited the submitted grades. Details about the development and findings of the Report Card for each individual country are provided in country-specific articles in this issue.^{26–35}

To facilitate comparisons across countries, the Global Matrix 3.0 only includes data for children between 5 and 17 years (school-aged children and youth in most countries), and data for the 10 common indicators; however, each country was free to include a wider age range and additional indicators on their individual Report Cards. It is worth noting that for some countries, the grades reported in the Global Matrix 3.0 may differ from the countries' Report Card, due to the inclusion of additional criteria on the grading scheme (e.g., changes over time or evidence of disparities) at the country level.

Statistical Analysis

A database of the grades for high HDI countries was compiled. For analysis purposes, letter grades were converted to numerical equivalents (Table 2). Descriptive statistics (average grade, standard deviation (SD)) were calculated for each indicator. To facilitate comparisons among countries and to draw more general conclusions about the indicator grades, an overall score (combining all the indicators) was computed along with scores for the behavioural indicators (Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviours) and the sources of influence indicators (Family and Peers, School, Community and Environment, and Government). For score calculations, incomplete grades were removed, and the scores were re-weighted accordingly. Based on the scores, countries were ranked by letter grade on scatterplots. Associations within indicators and between

indicators and sociodemographic indexes were then explored using Spearman's rank correlation coefficients. Strong correlations were defined as coefficients equal to or higher than 0.7 or -0.7.³⁶ Pairwise deletion was used to treat missing data (i.e., incomplete grades). All statistical analyses were performed using R version 3.4.1 (The R Foundation for Statistical Computing, Vienna, Austria). Several packages were loaded to extend base R including corrplot,³⁷ ggplot2,³⁸ UpSetR,³⁹ and VIM.⁴⁰

Qualitative assessment

A qualitative appraisal was also conducted to compare the methods used to assess the Overall Physical Activity indicator across countries. For this, we collected information on the main source of physical activity data used by each country, instruments used, data collection methods and sample size.

Table 1. Global Matrix 3.0 indicators and benchmarks used to guide the grade assignment process.

Indicator	Benchmarks
Overall Physical Activity	% of children and youth who meet the Global Recommendations on Physical Activity for Health, which recommend that children and youth accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity per day on average. Or percentage of children and youth meeting the guidelines on at least 4 days a week (when an average can not be estimated).
Organized Sport and Physical Activity	% of children and youth who participate in organized sport and/or physical activity programs.
Active Play	% of children and youth who engage in unstructured/unorganized active play at any intensity for more than 2hours a day.

Table 1. Global Matrix 3.0 indicators and benchmarks used to guide the grade assignment process.

Indicator	Benchmarks
	% of children and youth who report being outdoors for more than 2 hours a day.
Active Transportation	% of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend's house).
Sedentary behaviors	% of children and youth who meet the Canadian Sedentary Behavior Guidelines (5- to 17-year-olds: no more than two hours of recreational screen time per day). Note: the Guidelines currently provide a time limit recommendation for screen-related pursuits, but not for non-screen-related pursuits.
Physical Fitness	Average percentile achieved on certain physical fitness indicators based on the normative values published by Tomkinson et al. ⁶⁷
Family and Peers	% of family members (e.g., parents, guardians) who facilitate physical activity and sport opportunities for their children (e.g., volunteering, coaching, driving, paying for membership fees and equipment). % of parents who meet the Global Recommendations on Physical Activity for Health, which recommend that adults accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. % of family members (e.g., parents, guardians) who are physically active with their kids.

Table 1. Global Matrix 3.0 indicators and benchmarks used to guide the grade assignment process.

Indicator	Benchmarks
	% of children and youth with friends and peers who encourage and support them to be physically active. % of children and youth who encourage and support their friends and peers to be physically active.
School	% of schools with active school policies (e.g., daily Physical Education (PE), daily physical activity, recess, “everyone plays” approach, bike racks at school, traffic calming on school property, outdoor time). % of schools where the majority ($\geq 80\%$) of students are taught by a PE specialist. % of schools where the majority ($\geq 80\%$) of students are offered the mandated amount of PE (for the given state/territory/region/country). % of schools that offer physical activity opportunities (excluding PE) to the majority ($> 80\%$) of their students. % of parents who report their children and youth have access to physical activity opportunities at school in addition to PE classes. % of schools with students who have regular access to facilities and equipment that support physical activity (e.g., gymnasium, outdoor playgrounds, sporting fields, multi-purpose space for physical activity, equipment in good condition).
Community and Environment	% of children or parents who perceive their community/ municipality is doing a good job at promoting physical activity (e.g., variety, location, cost, quality). % of communities/municipalities that report they have policies promoting physical activity.

Table 1. Global Matrix 3.0 indicators and benchmarks used to guide the grade assignment process.

Indicator	Benchmarks
	% of communities/municipalities that report they have infrastructure (e.g., sidewalks, trails, paths, bike lanes) specifically geared toward promoting physical activity. % of children or parents who report having facilities, programs, parks and playgrounds available to them in their community. % of children or parents who report living in a safe neighbourhood where they can be physically active. % of children or parents who report having well-maintained facilities, parks and playgrounds in their community that are safe to use.
Government	Evidence of leadership and commitment in providing physical activity opportunities for all children and youth. Allocated funds and resources for the implementation of physical activity promotion strategies and initiatives for all children and youth. Demonstrated progress through the key stages of public policy making (i.e., policy agenda, policy formation, policy implementation, policy evaluation and decisions about the future).

Table 2. Global Matrix 3.0 grading rubric.

Grade	Interpretation	Numerical equivalents^a
A+	94% - 100%	15
A	We are succeeding with a large majority of children and youth (87% - 93%)	14
A-	80% - 86%	13
B+	74% - 79%	12
B	We are succeeding with well over half of children and youth (67% - 73%)	11
B-	60% - 66%	10
C+	54% - 59%	9
C	We are succeeding with about half of children and youth (47% - 53%)	8
C-	40% - 46%	7
D+	34% – 39%	6
D	We are succeeding with less than half but some children and youth (27% - 33%)	5
D-	20% - 26%	4
F	We are succeeding with very few children and youth (<20%)	2
INC	Incomplete – insufficient or inadequate information to assign a grade	

^a Letter grades were converted to numerical equivalents for analyses purposes.

Results

Table 3 presents sociodemographic characteristics to provide the context and comparison of countries included in this analysis. Among the included countries, the HDI ranged from 0.727 in Colombia to 0.795 in Uruguay. The country with the highest public health expenditure was Uruguay (6.1% of the GDP), whereas the country with the lowest expenditure was Venezuela

(1.5% of the GDP). The prevalence of stunting among children under 5 years ranged from 7.1% in Brazil to 25.2% in Ecuador. According to the Gini index, the country with the greatest income inequality was Brazil, while Lebanon had the lowest income inequality. The gender inequality index, which measures disparities between males and females on measures of reproductive health, empowerment and labour market participation,²⁴ was greatest in Brazil and lowest in China. Population density ranged from 20 inhabitants per km² in Uruguay, to 587 inhabitants per km² in Lebanon, and the percentage of urban population ranged from 34.4% in Thailand to 93.7% in Venezuela.

Table 3. Sociodemographic information of high HDI countries in the global matrix 3.0

Country	HDI²⁴	Life expectancy at birth²⁴	Expected years of schooling²⁴	Mean years of schooling²⁴	GNI per capita²⁴	Public Health Expenditure (% of GDP)²⁴	Stunting (% under 5 years)²⁴	Gini index⁶⁸	Gender Inequality Index²⁴	Population density (people per km2 of land area)⁶⁹	Urban Population (%)⁷⁰
Brazil	0.754	74.7	15.2	7.8	14,145	3.8	7.1	51.3	0.414	25	84.9
Bulgaria	0.794	74.3	15.0	10.8	16,261	4.6	8.8	37.4	0.223	66	73.7
China	0.738	76.0	13.5	7.6	13,345	3.1	9.4	42.2	0.164	147	51.9
Colombia	0.727	74.2	13.6	7.6	12,762	5.4	12.7	50.8	0.393	44	75.6
Ecuador	0.739	76.1	14.0	8.3	10,536	4.5	25.2	45.0	0.391	66	68.0
Lebanon	0.763	79.5	13.3	8.6	13,312	3.0	16.5	31.8	0.381	587	87.4
Mexico	0.762	77.0	13.3	8.6	16,383	3.3	13.6	43.4	0.345	66	78.4
Thailand	0.740	74.6	13.6	7.9	14,519	5.6	16.3	37.8	0.366	135	34.4
Uruguay	0.795	77.4	15.5	8.6	19,148	6.1	10.7	39.7	0.284	20	92.6
Venezuela	0.767	74.4	14.3	9.4	15,129	1.5	13.4	46.9	0.461	36	93.7

The consolidated country grades per indicator are presented in Table 4. Two countries (Brazil and China) assigned grades to all the indicators, while two other countries (Ecuador and Venezuela) did not assign a grade to five of the ten indicators. Twenty-five of the possible one hundred grades were graded as incomplete (INC). The most common indicators with INC grades due to insufficient evidence were Active Play (Colombia, Ecuador, Lebanon, Mexico, Uruguay, Venezuela), Physical Fitness (Bulgaria, Ecuador, Lebanon, Mexico, Thailand, Venezuela) and Family and Peers (Colombia, Lebanon, Mexico, Uruguay and Venezuela) (Tables 4 and 5). Only two indicators, Overall Physical Activity and Active Transportation were graded by all countries (Table 5).

Country grades ranged from “F” to “B+”, with most grades clustered around the “D” categories. The mean score for all indicators was equivalent to a “D+”, and the same letter grade equivalent was observed when mean scores were computed for indicators grouped by behaviours or sources of influence. Active Transportation was the indicator with the highest average grade across the countries (“C”), whereas Overall Physical Activity obtained the lowest average grade (“D-”).

Table 4. Grades assigned to core physical activity indicators among countries with a high Human Development Index

Country	PA	SP	AP	AT	SB	PF	FAM	SCH	COM	GOV
Brazil	D	C+	D+	C	D-	D	C-	C	C-	D+
Bulgaria	D+	C+	C+	B-	D	INC	D	C	C	INC
China	F	D-	D+	C+	F	D	D+	D+	F	F
Colombia	D+	C	INC	B	D+	D-	INC	D	B-	B
Ecuador	D	INC	INC	C-	C	INC	F	INC	D+	INC
Lebanon	D	F	INC	D	C-	INC	INC	D	INC	C+

Table 4. Grades assigned to core physical activity indicators among countries with a high Human Development Index

Country	PA	SP	AP	AT	SB	PF	FAM	SCH	COM	GOV
Mexico	D+	C	INC	C+	D-	INC	INC	D+	D+	C
Thailand	D-	C-	F	C	D-	INC	B	B	B-	B+
Uruguay	D	F	INC	C	C-	C-	INC	C-	INC	D
Venezuela	D	D	INC	B-	INC	INC	INC	INC	D-	F

Abbreviations: PA: Overall Physical Activity; SP: Organized Sport Participation; AP: Active Play; AT: Active Transportation; SB: Sedentary Behaviors; PF: Physical Fitness; FAM: Family and Peers; SCH: School; COM: Community and Environment; GOV: Government.

Table 5. Average grades and descriptive statistics by indicator or group of indicators among countries with a high Human Development Index.

Indicator	Grade count	Incomplete grades	Mean number grade	SD	Mean letter grade
Overall Physical Activity	10	0	4.9	1.2	D-
Organized Sport and Physical Activity	9	1	6.0	2.8	D+
Active Play	4	6	5.8	2.9	D
Active Transportation	10	0	8.5	1.7	C
Sedentary Behaviors	9	1	5.2	1.9	D
Physical Fitness	4	6	5.2	1.3	D
Family and Peers	5	5	6.2	3.3	D+

Table 5. Average grades and descriptive statistics by indicator or group of indicators among countries with a high Human Development Index.

Indicator	Grade count	Incomplete grades	Mean number grade	SD	Mean letter grade
School	8	2	7.0	2.0	C-
Community and Environment	8	2	6.6	2.8	D+
Government	8	2	6.9	3.8	D+
Behavioral indicators	10	0	6.4	1.2	D+
Sources of influence indicators	10	0	6.5	2.4	D+
All indicators	10	0	6.4	1.3	D+

Note: physical fitness was not included in the behavioral indicators cluster. There are no missing grades for the bottom three rows because these scores are adjusted for missing grades.

Regarding the overall score for all indicators, Thailand, Colombia and Bulgaria reported the highest scores, while China, Venezuela and Lebanon had the lowest (Figure 1). When the indicators were grouped, the score for behavioral indicators was higher in Bulgaria and Colombia whereas China, Lebanon and Thailand had the lowest scores. The highest score for sources of influence indicators was observed in Thailand while Venezuela, China and Ecuador had the lowest scores (Figures 2 and 3). Details on the country rankings for each indicator are provided in supplementary figures. The correlation matrix indicates significant strong positive correlations for Family and Peers with Government ($r=1.0$); Community and Environment with Government ($r=0.91$); and Community and Environment with public health expenditure ($r=0.93$). A significant strong negative correlation was found for Active Transportation and life expectancy ($r=-0.78$) (Table 6).

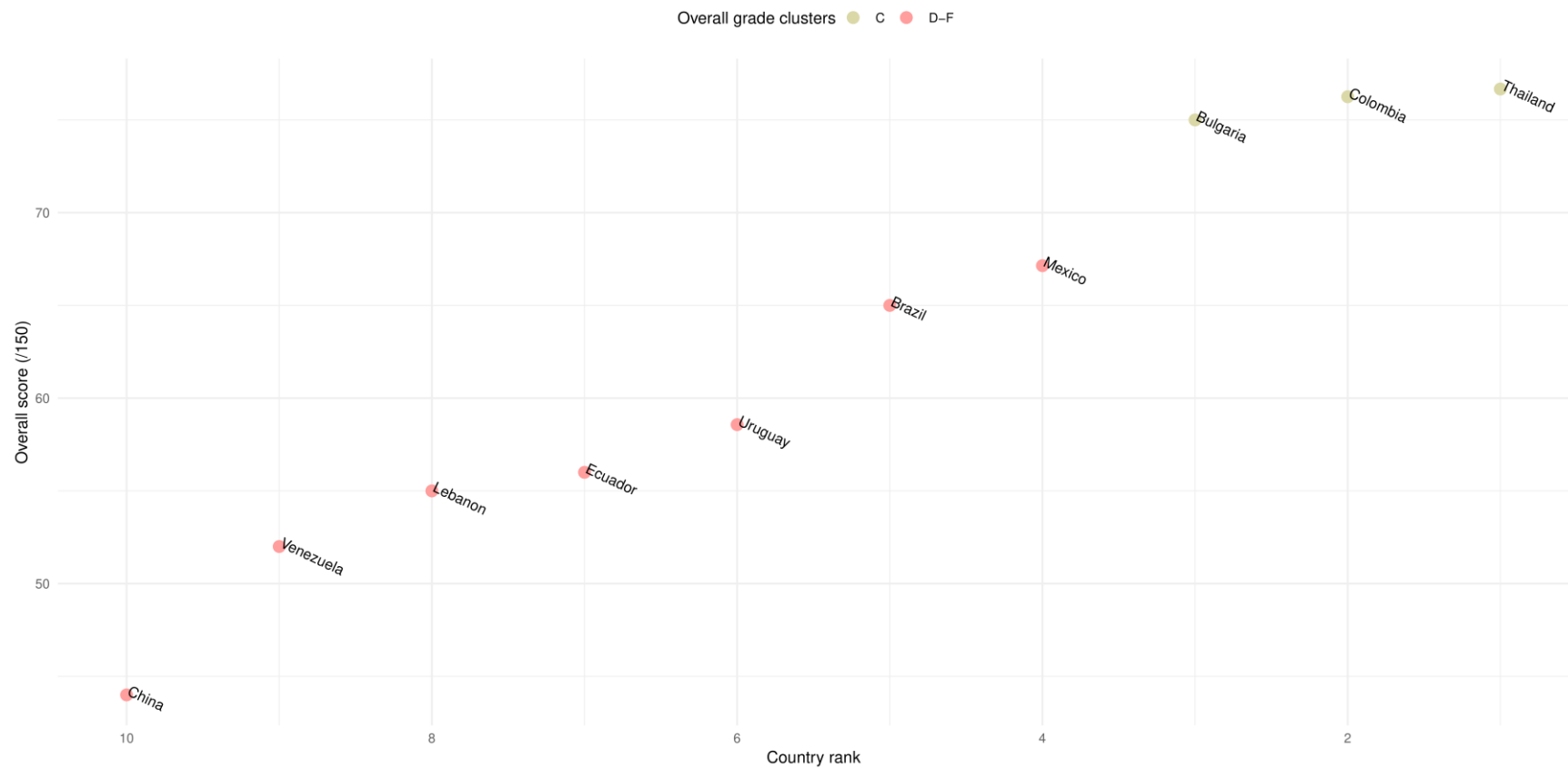


Figure 1. Scatterplot of the overall score estimated for the 10 core indicators in the Global Matrix 3.0

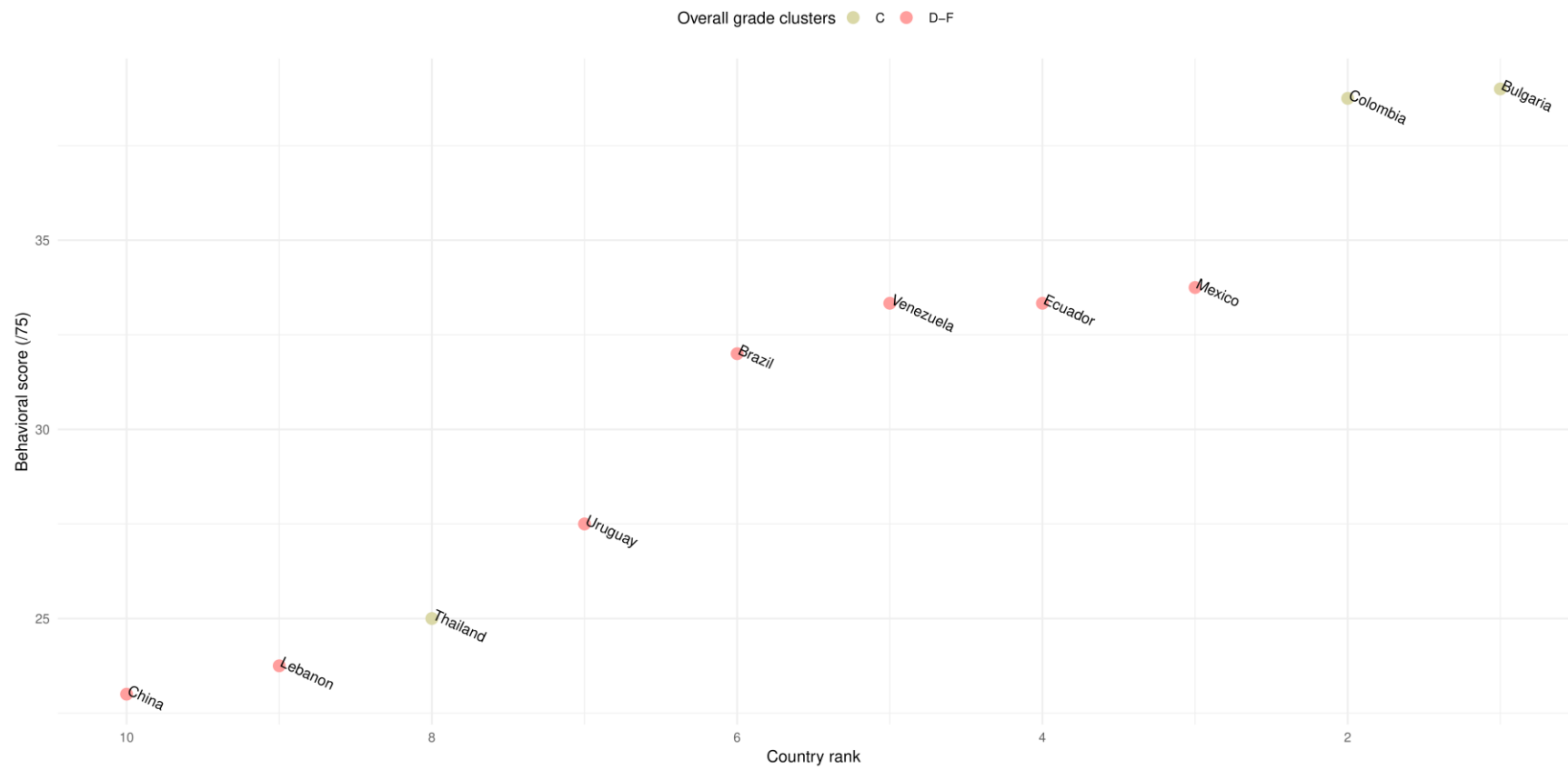


Figure 2. Scatterplot of the behavioral score across ten high-HDI countries in the Global Matrix 3.0.

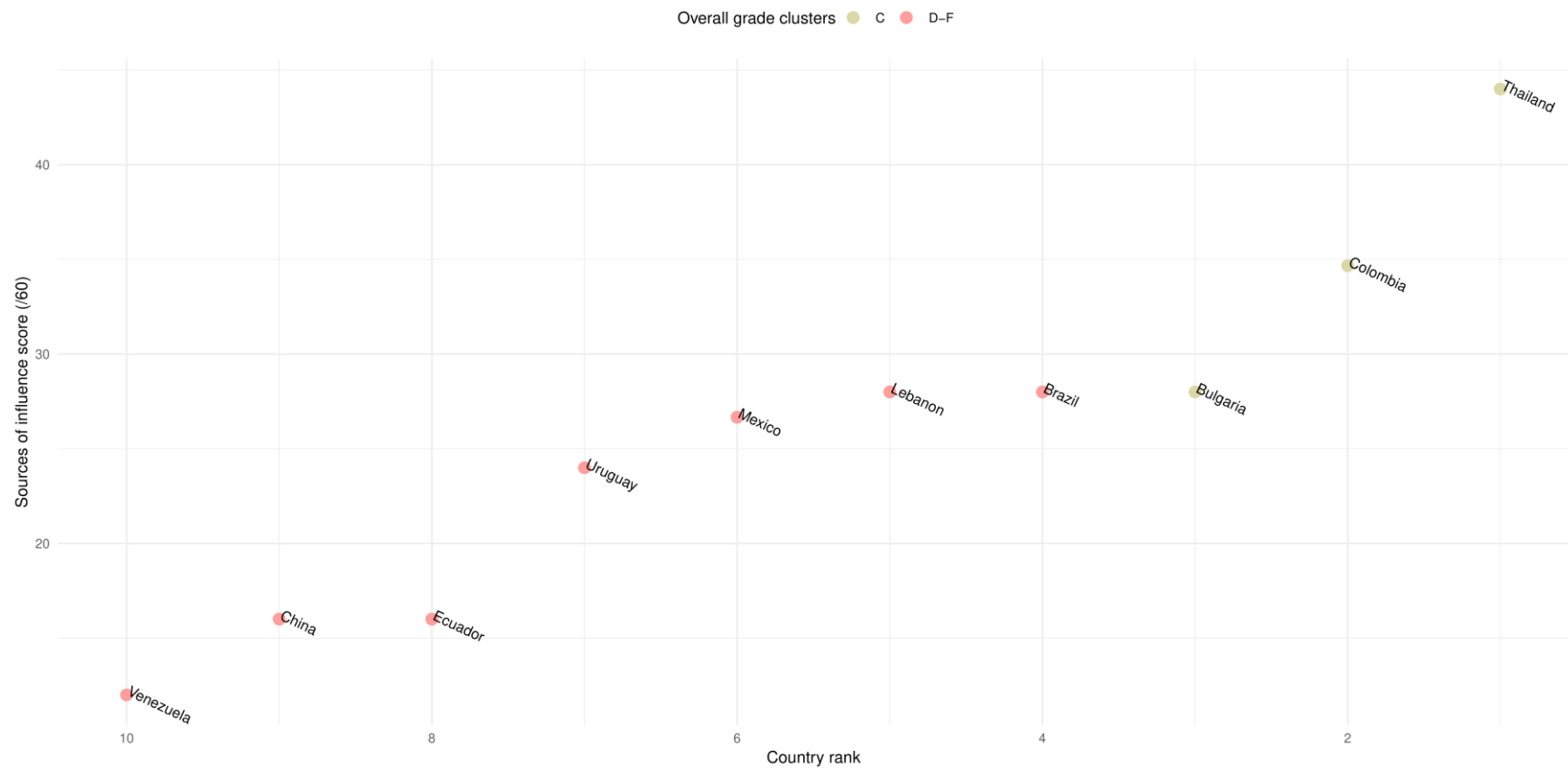


Figure 3. Scatterplot of the sources of influence score across ten high-HDI countries in the Global Matrix 3.0.

Table 6: Correlation Matrix (Spearman's rank correlation coefficients) of core indicators and sociodemographic indexes

Sociodemographic Index/Core indicator	Core Indicators								
	PA	SP	AP	AT	SB	FAM	SCH	COM	GOV
PA									
SP	0.53								
AP	0.63	0.50							
AT	0.46	0.45	0.83						
SB	0.28	-0.38	0.50	-0.44					
FAM	-0.46	-0.21	-0.95	0.05	-0.67				
SCH	-0.26	0.38	-0.50	-0.15	-0.36	0.63			
COM	0.38	0.51	-0.32	0.12	0.36	0.50	0.24		
GOV	0.28	0.29	-0.87	-0.22	0.24	1.00*	-0.04	0.91*	
Human Development Index	0.22	-0.21	0.63	-0.09	0.26	0.10	0.21	-0.10	-0.40
Life expectancy at birth	-0.26	-0.64	-0.32	-0.78*	0.33	-0.40	-0.29	-0.55	-0.13
Mean years of schooling	0.38	0.00	0.32	0.03	0.39	-0.50	0.23	-0.09	-0.23
GNI per capita	0.19	0.03	0.32	0.23	-0.31	0.40	0.55	-0.02	-0.35
Public Health Expenditure	0.13	0.16	-0.32	0.01	0.24	0.20	0.50	0.93*	0.43
Stunting	-0.10	-0.49	-0.63	-0.48	0.53	-0.30	-0.38	-0.01	0.56

Gini index	0.15	0.42	-0.32	0.33	-0.13	0.00	-0.06	-0.05	-0.24
Gender Inequality Index	0.13	0.15	-0.32	0.00	0.32	0.10	-0.12	0.12	0.11
Population density	-0.31	-0.23	-0.32	-0.28	-0.21	0.15	-0.24	-0.12	0.31
Urban population	0.28	-0.35	0.63	0.01	0.40	-0.30	-0.35	-0.21	-0.50

Abbreviations: PA: Physical Activity; SP: Organized Sport and Physical Activity; AP: Active Play; AT: Active Transportation; SB: Sedentary Behaviors; FAM: Family and Peers; SCH: School; COM: Community and Environment; GOV: Government.

Note: Correlation coefficients in bold show strong (negative or positive) relationships between a specific indicator and an index/indicator. Physical Fitness was removed from this analysis due to incomplete grades. Pairwise deletion was used to treat missing data. * Shows correlations that were statistically significant ($p < 0.05$).

The Overall Physical Activity indicator was informed by national health surveys in six countries (Brazil, Bulgaria, Colombia, Ecuador, Lebanon and Mexico), physical activity or health studies in three countries (China, Thailand and Venezuela), and by the Global School-based Student Health Survey in two countries (Lebanon and Uruguay). Most of these surveys and studies used self-reported methods to assess physical activity. Only Brazil reported studies with objective measures using accelerometers and pedometers. The sample size of the studies ranged between 156 youth in Venezuela and 242,259 children and youth in Brazil (Table 7).

Table 7. Methods implemented to assess the Overall Physical Activity Indicator across 10 high-HDI countries.

Country	Study or Survey	Method to assess PA	Questionnaire or device	Respondent	Sample
Brazil	National Survey of School Health - PeNSE, and 89 regional surveys.	Subjective and objective	Physical Activity Questionnaire for Older Children (PAQ-C) Physical Activity Questionnaire for Adolescents (PAQ-A) Physical Activity Questionnaire for Children and Adolescents Global School-based Student Health Survey (GSHS) Youth Risk Behaviour Survey (YRBSS) Good Health Questionnaire (Good Health) Physical Activity Questionnaire for Adolescents (QAFA) List of Physical Activities (LAF) Physical Activity Questionnaire (PAQ) Risk Behaviors in Catarinese Adolescents (COMCAP)	Self-reported	242,259 children and youth between 6 and 19 years

Table 7. Methods implemented to assess the Overall Physical Activity Indicator across 10 high-HDI countries.

Country	Study or Survey	Method to assess PA	Questionnaire or device	Respondent	Sample
			Previous Day Physical Activity Questionnaire (QUAFDA) International Physical Activity Questionnaire (IPAQ) Accelerometers Pedometers		
Bulgaria	Active Kids National Representative Survey 2016	Subjective	YRBSS Questionnaire	Self-reported	1014 children and youth between 6 and 18 years
China	Physical Activity and Fitness in China – The Youth Study (PAFCTYS)	Subjective	Health Behaviour in School-age Children Study (HBSC) Questionnaire	Self-reported	125,281 children and youth between 9 and 17 years

Table 7. Methods implemented to assess the Overall Physical Activity Indicator across 10 high-HDI countries.

Country	Study or Survey	Method to assess PA	Questionnaire or device	Respondent	Sample
Colombia	National Nutrition Survey ENSIN 2015	Subjective	YRBSS Questionnaire	6-12 years: reported by parents 13-17 years: self-reported	12,106 children and youth between 6 and 17 years old.
Ecuador	National Health and Nutrition Survey 2012	Subjective	Modified version of the IPAQ	Self-reported	10,910 Children and youth between 10 and 17 years old.
Lebanon	Lebanese-Food and Nutrition Security (L- FANUS) Study	Subjective	Modified version of the Children and Youth Physical Activity Questionnaire	Self-reported	1079 Children and youth between 5 and 17 years old.
	Global School- based Student	Subjective	GSHS Questionnaire	Self-reported	5,708 youth between 13 and 17 years

Table 7. Methods implemented to assess the Overall Physical Activity Indicator across 10 high-HDI countries.

Country	Study or Survey	Method to assess PA	Questionnaire or device	Respondent	Sample
	Health Survey (GSHS) 2017				
Mexico	National Health and Nutrition Survey ENSANUT 2016	Subjective	HBSC Questionnaire	Self-reported, with assistance from parents/tutors	1,843 children between 10 and 14 years old.
		Subjective	IPAQ short version	Self-reported	1,440 youth between 15 and 19 years old
Thailand	Thailand Physical Activity Surveillance System 2015- 2017	Subjective	Thailand Physical Activity Children Survey – Student Questionnaire and 24 hours clock	6-9 years old children: Self- reported, with assistance from parents/tutors	1, 287 children and youth between 6 and 17 years old.

Table 7. Methods implemented to assess the Overall Physical Activity Indicator across 10 high-HDI countries.

Country	Study or Survey	Method to assess PA	Questionnaire or device	Respondent	Sample
				10-17 years old pupils: self-reported	
Uruguay	Global School- based Student Health Survey 2012	Subjective	GSHS Questionnaire	Self-reported	3,524 youth between 13 and 15 years
Venezuela	Latin American Study of Nutrition and Health (ELANS)	Subjective	IPAQ	Self-reported	156 youth between 15 and 19 years

Discussion

This study aimed to describe and compare the Global Matrix 3.0 grades among 10 countries with high HDI. Findings indicate these countries have a lot to improve in providing opportunities for children and youth to change behaviours and be more active, as well as in assuring good quality physical activity surveillance. Grades for the 10 countries clustered around “D”, which indicates that these countries, at a similar stage of development, are at similar stages in the physical inactivity crisis.²⁰ This further highlights the urgent need to take tangible actions to increase physical activity among children and youth. Additionally, the Global Matrix 3.0 allowed to identify research gaps that should be addressed for the design and follow-up of initiatives to promote active living among children. In the context of the evidence available, a discussion of the findings for each indicator is presented below, followed by the interpretation of the findings by groups of indicators and the correlations observed.

Overall Physical Activity

Among the estimated average grades for the 10 countries, the Overall Physical Activity indicator had the lowest grade “D-”, indicating that less than one third of children and youth are enjoying the benefits of being regularly active. This is consistent with global reports,³ and with the results of the Global Matrix 2.0, in which 53% of the countries graded this indicator with a “D”.²²

Although Bulgaria, Colombia and Mexico graded this indicator higher (“D+”), the grades are still low. Compared to the Global Matrix 2.0, the grades remained the same for China, Thailand and Venezuela, decreased for Brazil (from “C-” to “D”) and Mexico (from “C” to “D+”), and increased for Colombia (“D” to “D+”). However, these latter changes are more likely to be the result of changes in the benchmarks, the inclusion of additional evidence, or the change in data collection methods, instead of an actual change in the behaviours.²⁹ The comparability of these

results among the 10 countries should be interpreted with caution, since, as observed in Table 7, there was important variation in the methods used to assess the Overall Physical Activity indicator. Objective methods were used only in Brazil, and all other countries used different questionnaires. At the same time, countries reported meeting different benchmarks, according to available weekly data. Brazil and Thailand reported the children meeting physical activity guidelines on average,^{26,33} and Colombia, Ecuador and Venezuela reported those meeting guidelines 4 days or more,^{29,30,35} which could be comparable, as observed in previous evidence.⁴¹ In contrast, China, Lebanon and Mexico reported children meeting the guidelines 7 days,^{28,31,32} Bulgaria reported 6 days²⁷ and Uruguay 5 or more.³⁴ These differences highlight the need of consensus in implementing common methods to assess compliance to physical activity guidelines, as well as providing access to raw data for researchers to be able to estimate common indicators. Also, the comparability of estimates for overall physical activity could be affected by the wide variation in the sample sizes of the surveys or studies that informed this indicator. Specifically, small sample sizes could be affecting the precision of the estimates.

Organized Sport and Physical Activity

According to the estimated average grade, approximately one of every three children and youth from high HDI countries in the Global Matrix 3.0 participated in organized sport and/or physical activity programs. These results are slightly lower than those observed for the Global Matrix 2.0.²² However, this is consistent with the fact that middle income countries like Colombia and Mexico had lower grades than high income countries in the Global Matrix 2.0. Among countries that participated in previous Global Matrices, an increase in the grades was observed for Mexico and China. In the case of Mexico, the latest version of the National Health and Nutrition Survey ENSANUT showed an increase in sports participation among girls and children from rural

areas.⁴² This change could be related to the implementation of programs to promote physical activity at the school level, such as *Muevete en 30 Escolar*.⁴² However, the impact of these programs in Mexico has not been evaluated, and a causal relationship cannot be established. In the case of China, the change in the grade could be related to the inclusion of national data compared to mainly Shanghai's data in the Global Matrix 2.0.^{9,28} The availability of data for countries that had INC grades in previous versions of the Global Matrix for this indicator could be considered an improvement in surveillance or in the methodology to gather the evidence, which is the case for Brazil^{26,43} and Venezuela.^{35,44}

Active Play

The average “D” grade for Active Play indicates that only around 30% of children and youth are involved in unstructured active play. This could be considered as a low engagement on a behaviour that could be relatively easier to promote than organized physical activity, from a public health perspective,⁴⁵ and that contributes to improved physical, emotional, social and cognitive development.⁴⁶ It is noteworthy that the frequency and time reported for these activities varied from one country to another, which makes it difficult to compare the situation between countries. Furthermore, the average grade was based on the data available for the four countries that graded this indicator (Brazil, Bulgaria, China, Thailand). The lack of data for more than half of the countries in this analysis, is an indication of the need to include active play and unstructured physical activity in the surveillance agenda of these countries.

Active Transportation

The Active Transportation indicator obtained the highest average grade (“C”), suggesting that around 50% of children and youth in the ten countries use some mode of active transportation to get to and from places. This prevalence is not negligible, and in the context of the physical

inactivity crisis, it is encouraging that at least half of the population of children and youth are enjoying the multiple benefits of active transportationⁿ⁴⁷⁻⁵⁰ on a regular basis. However, it is important to notice that for some of the countries in this analysis, as in other high HDI countries, the high prevalence of active transportation may be the result of a daily need instead of a choice.^{22,49,51} For this reason, the challenge with high HDI countries is to maintain these behaviors in the current context of rapid economic growth and increased access to motorized transportation.¹⁰ In countries like Brazil and China, trends analyses show important declines in active transportation,^{52,53} which are indicative of the urgency to design and implement strategies to make cycling and walking a desirable, safe, accessible and sustainable mode of transport for children and youth.

Sedentary Behaviors

The average grade for the Sedentary Behaviors indicator was “D” and suggests that in high HDI countries participating in the Global Matrix 3.0, only one third of children and youth engage in 2 or less hours of recreational screen time, meeting the Canadian Sedentary Behavior Guidelines.⁵⁴ This proportion is consistent with international estimates that indicate at least two thirds of the children in the International Children’s Accelerometry Database exceeded 2 hours of recreational screen time per day.⁵⁵ These findings are concerning given the associations of excessive screen time with reduced fitness, unfavourable body composition, lower scores for self-esteem and prosocial behavior.⁵⁶ In the current analysis, the proportion of children meeting the guidelines ranged from 7.1% in China²⁸ to 55.4% in Ecuador.³⁰ However, there are methodological differences that limit the comparability of these data. For example, China reported sedentary behaviors, including homework time²⁸, which could underestimate the proportion of children meeting the sedentary behavior guidelines, which are focused on recreational screen time.

Similarly, the behavior reported by Brazil in this indicator was watching television, which according to longitudinal international data seem to be decreasing in many countries, while other screen time-related behaviours are increasing.⁵⁷ Therefore, in order to improve comparability of data, standardization of methods and tools to measure sedentary behaviors is required.

Physical fitness

An average “D” grade was assigned to the Physical Fitness indicator, based on the grades available for Brazil, China, Colombia and Uruguay. This grade is difficult to interpret, given the differences in the information and samples reported for this indicator among countries. While Brazil reported data for cardiorespiratory fitness, muscular strength, endurance and flexibility,²⁶ China reported a physical fitness score estimated from 11 fitness indicators,²⁸ Uruguay reported cardiorespiratory fitness and handgrip strength,³⁴ and Colombia only reported handgrip strength.²⁹ Despite this limitation, the grades are consistent with previous evidence indicating low performance on physical fitness in South American countries.⁵⁸ Considering the potential of cardiorespiratory fitness as an indicator of current and future health,⁵⁹ and the high proportion of INC grades for this indicator, surveillance on fitness should be a priority in the research and health monitoring agenda for high HDI countries.

Family and peers

The average grade for this indicator was “D+”. Compared to other indicators, more variability is observed among the five countries that graded the influence of family and peers. The grades ranged from “F” in Ecuador, to “B” in Thailand. The low grade in Ecuador is based on the fact that only 11.6% of the adults in the households are meeting the Global Recommendations on Physical Activity for Health.³⁰ Higher grades and different benchmarks were reported in Brazil and Thailand, where more than 50% and 70% of family members, respectively, facilitated

physical activity and sport opportunities for their children through volunteering, coaching, driving or investing resources. Compared to the Global Matrix 2.0, the grades for this indicator remained the same for Brazil and Thailand.²² For China, the grade decreased as a reflection of the differences between the data for the national level and the data exclusively for Shanghai, reported in the Global Matrix 2.0.^{9,28} As in previous versions of the Global Matrix, research gaps for this indicator are evident across countries.^{21,22} The research network created around Global Matrix 3.0 could lead to opportunities to share methodologies and tools used by countries that are monitoring the influence of family and peers on physical activity of children and youth, with countries where this evidence is lacking.

School

Among the sources of influence indicators, the school environment obtained the highest average grade “C-”, ranging from “D” in Lebanon and Colombia, to “B” in Thailand. The low grades in Lebanon and Colombia are based on the report of physical education participation.^{29,31} In Colombia, 81.4% of children and adolescents reported attending physical education classes once per week. Though this proportion seems high, the rationale to assign a low grade was based on the fact that physical education is mandatory and almost 20% of school-attending children and youth did not report participation in the last week.²⁹ The high grade in Thailand is based on the fact that 70% of schools in Thailand provide their students access to facilities and equipment that support physical activity.³³ Comparing results between countries is challenging given the variety of information reported due to the complex nature of this indicator, and the variety of factors at school that can influence physical activity among children and youth.⁶⁰ However, the low grades for the behavioral indicators are indicative of the need for implementation of the available policies, as well as the importance of assuring the provisioning of high quality physical

education classes. International efforts, like the UNESCO core principles for quality physical education indicators⁶¹ could guide countries in the definition and monitoring of the quality of physical education.

Community and Environment

An average “D+” grade was estimated for the Community and Environment indicator. The grades ranged from “F” in China to “B-” in Colombia and Thailand. The low grades in China are based on the limited access to sports facilities, equipment and activities at the community level for children and youth (14.8%).²⁸ In contrast, Colombia and Thailand assigned a relatively high grade based on the fact that around 64% of children and youth reported having access to facilities, programs and parks to be physically active.^{29,33} Low grades in Mexico (“D+”) and Venezuela (“D-”) are mainly influenced by safety perceptions. In Mexico, according to the latest National Survey on Safety Perception, 74% of Mexican adults stopped allowing their children to go outside.³² Similarly, in Venezuela, 75.5% of adolescents consider insecurity as an obstacle for being physically active.³⁵ The evidence available for this indicator in high HDI countries in the Global Matrix is consistent with the findings of a review on built environment and physical activity in developing countries. This review highlighted that the evidence on the built environment in Latin America has focused on crime, traffic safety and availability of parks and open spaces, while the evidence from Middle Eastern countries and middle-income countries in Europe is limited.¹²

Government

A “D+” average grade was estimated for the Government indicator in high HDI countries. However, the grades ranged from “F” in China, to “B+” in Thailand. The failing grade in China is based on the low proportion of parents that reported being aware of the existence of national

policies to promote physical activity among children.²⁸ In the case of Thailand, the “B+” grade was based on the fact that 74.4% of policymakers reported that existing policies to promote physical activity are being implemented.³³ For example, since 2015, the “Teach Less Learn More” policy has been implemented in both primary and secondary schools nationwide in order to provide more opportunities for students to move outside of the classroom. While most of the countries in this group reported the existence of programs, national plans or policies, the implementation and impact of these initiatives are unknown.^{26,29,30,32}

Sources of influence and behavioural indicators

Previous versions of the Global Matrix showed higher grades for the sources of influence indicators, compared to the behavioural indicators.^{21,22} The findings from our analysis differ from those, given that there is no apparent difference among sources of influence and behavioural indicators, all of them have low average grades (D+), which suggests that besides the low engagement in active behaviours, the current opportunities provided by families, schools, communities and governments to engage in physical activity are limited. According to the estimated scores, Bulgaria is leading the behavioural indicators and Thailand leads the sources of influence. Bulgaria’s lead seems to be due to a relatively high participation in organized sports outside of school (56%), active play (55% of children involved in outdoor activities 3 or more days per week) and active transportation (64%).²⁷ In the case of Thailand, there is a high involvement of parents in facilitating physical activity for their children, high accessibility to school facilities to engage in physical activity and a high perception of access to supportive environments for being active.³³ At the same time, Thailand’s government has demonstrated commitment and leadership in implementing policies to promote physical activity among

children.³³ However, the low ranking of Thailand in the behavioral score suggests that the success in the sources of influence indicators is not yet reflected in improved behaviors.

The correlational analysis revealed statistically significant positive or negative correlations between sociodemographic factors and physical activity indicators, as well as within physical activity indicators. We found that as grades for Community and Environment indicator increased, grades for Government indicator and the yearly public health expenditure increased. These are intuitive correlations, considering the significant power of governments in the design of the built environment (sidewalks, walking and cycling trails, green space), the maintenance of infrastructure, and their role in the provision of resources for community programs that promote physical activity.⁶² An opposite pattern was observed between Active Transportation and life expectancy, indicating that as Active Transportation grades increased, life expectancy decreased. This may be related to the conditions in which active transportation is performed, considering that developing countries have the highest burden of road traffic accidents⁶³ and pedestrians and cyclists are more vulnerable. In Lebanon, for example, pedestrian deaths represented 40% of all reported road traffic deaths in 2013.⁶⁴ Evidence from China suggest that improvements in road safety conditions could lead to a gain in life expectancy.⁶⁵ Therefore, the promotion of active transportation in developing countries should include policies to improve road safety. Finally, the association observed between Family and Peers with Government should be interpreted with caution since only three countries graded both of the indicators. Missing data and the small sample size highlight the need to interpret these correlations with caution.

Gaps in knowledge

Evidence is limited to provide a comprehensive description of the Global Matrix 3.0 indicators among the 10 high HDI countries. Only Brazil and China had evidence available to grade all the

indicators. This suggests that these countries are leading the research development in physical activity in this group and their efforts in surveillance could guide other countries. As described by the Global Observatory of Physical Activity, these are the only middle-income countries in the top ten of scientific publications in the field.⁶⁶ One quarter of the total matrix of indicators could not receive a grade because of insufficient evidence. As observed in the previous versions of the Global Matrix,^{21,22} Active Play and Family and Peers remain the indicators where the evidence is lacking for most of the countries. These gaps point out the need for consensus on definitions and measures to assess these indicators. Physical fitness was included in the Global Matrix for the first time, and the absence of data for more than half of the high HDI countries supports the call to improve fitness surveillance among children and youth worldwide.⁵⁹

Some limitations should be taken into account for this analysis. First, we only included 10 high HDI countries out of the 55 total countries under this classification, so the representativeness of countries at this level of development is limited. Among these 10 countries, 60% belong to the Americas region, which could also limit the external validity of our results. Second, the sources of data, as well as the quality of the evidence varied widely between countries, which could limit the comparability of data. Third, the variability in sociodemographic variables suggests heterogeneity in this group of countries, which makes difficult to infer clear relationships between physical activity indicators and contextual variables at the group level. Fourth, there are important contextual differences between the countries that HDI might not capture at the moment of this research, like political and cultural dimensions, as well as disparities that can influence the determinants of physical activity. The absence of these dimensions can compromise the comparability of the overall physical activity scenario for all 10 countries. And fifth, there was a considerable amount of INC grades or missing data, which makes it difficult to

rank and compare the indicators among countries. However, this paper also has several strengths. It provides a comprehensive assessment of the physical activity evidence for children and youth from countries experiencing a physical activity transition, compiling the best available national data. The harmonized process to develop the individual report cards that informed the Global Matrix represents an advance in standardization and accountability in physical activity surveillance, as well as an important methodological effort to structure a global vision on physical activity of the young population. And finally, the leadership and commitment from researchers from every country participating, in each of the stages of the project, provide assurance of the inclusion of relevant and accurate information for each country.

Conclusion

This analysis of Global Matrix 3.0 grades shows that high HDI countries are lagging in both, physical activity behaviors and sources of influence indicators. The main challenge for high HDI countries is to provide opportunities to increase physical activity, in the context of concurrent social and economical changes occurring, appropriate for the stages of development that these countries are experiencing. This analysis identified the main gaps in physical activity surveillance and could guide future initiatives to define indicators and measures in a standardized manner. Filling the research gaps and involving more high HDI countries in future versions of the Global Matrix may provide a better understanding of the situation of physical activity among children in the context of a physical activity transition.

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Chapter 8: Global Comparison of Active Transportation Among Children And Youth

Manuscript 5: Profiles of Active Transportation among Children and Adolescents in the Global Matrix 3.0 Initiative: A 49-Country Comparison

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Article preface

This article compares the prevalence of active transportation across the 49 countries involved in the Global Matrix 3.0 initiative and identified a set of profiles based on the prevalence of active transportation and socioeconomic variables. This manuscript addresses the third objective of the

dissertation, to draw international comparisons of physical activity and sedentary behaviour indicators. SAG, JDB, SA and MST conceived the idea of the manuscript. SAG drafted the manuscript, and all co-authors reviewed and approved the manuscript. The University of Ottawa granted approval for secondary data analyses conducted in this study (file number H-06-19-3564). This article is now published in open access. The published version of the manuscript can be found in Appendix 9.

Abstract

This article aims to compare the prevalence of active transportation among children and adolescents from 49 countries at different levels of development. The data was extracted from the Report Cards on Physical Activity for Children and Youth from the 49 countries that participated in the Global Matrix 3.0 initiative. Descriptive statistics and a latent profile analysis with active transportation, Human Development Index and Gini index as latent variables were conducted. The global average grade was a “C”, indicating that countries are succeeding with about half of children and youth (47% - 53%). There is wide variability in the prevalence and in the definition of active transportation globally. Three different profiles of countries were identified based on active transportation grades, Human Development Index (HDI) and income inequalities. The first profile grouped very high HDI countries with low prevalence of active transport and low inequalities. The second profile grouped low and middle HDI countries with high prevalence of active transportation and higher inequalities. And the third profile was characterized by the relatively high prevalence of active transportation and more variability in the socioeconomic variables. Promising policies from countries under each profile were identified. A unified definition of active transportation and contextualized methods for its assessment are needed to advance in surveillance and practice.

Keywords: Cycling; walking; health promotion; policy; latent profile analysis; surveillance

Introduction

The world is experiencing a crisis of physical inactivity with almost 80% of adolescents not achieving the recommended 60 minutes of daily moderate to vigorous physical activity for health.¹ In this context, transportation, as a daily necessity to move from one place to another, represents a promising domain to promote the accumulation of physical activity in children and adolescents in a convenient and habitual manner.² Specifically, active transportation to/from school is an opportunity to integrate physical activity into children's and adolescent's routines.³

Active transportation comprises non-motorized travel modes like walking, cycling or riding a scooter, among others.⁴ The use of these active modes leads not only to health benefits such as greater levels of cardiorespiratory fitness^{3,5} and better cardiometabolic health indicators⁶ among children who actively commute, but also to other co-benefits, such as better mental health outcomes,^{7,8} greater interaction with their environment,⁹ and reduced transportation-related emissions and pollution.¹⁰ Despite these benefits, current evidence suggests that this behaviour is declining in many countries.¹¹

In the same way that physical inactivity prevalence varies widely across countries,¹ a wide variation in active transportation could be expected. These variations represent an opportunity to identify those countries that are succeeding with active transportation behaviours, and those that require action to increase active transportation or prevent a decline in this behaviour. However, to the best of our knowledge, the few international comparisons of data on active transportation among children and adolescents include mostly small groups of countries or the availability of national representative data is limited.^{11–13} Therefore, the Global Matrix 3.0 of Report Card

grades on physical activity among children and youth provides an opportunity to describe and examine the global situation of active transportation. For the first time, 49 countries from all continents reported data on an active transportation indicator at the national level.¹⁴ The aims of this study were to compare the prevalence of active transportation among children and adolescents from 49 countries participating in the Global Matrix 3.0, to identify a set of profiles to group the countries according to their prevalence of active transport and sociodemographic variables, and to discuss policies and practices implemented across different countries to increase active transportation.

Materials and Methods

The Global Matrix 3.0 was an international initiative released in 2018 and led by the Active Healthy Kids Global Alliance (AHKGA). This project brought together 513 researchers and physical activity leaders from 49 countries around the world.¹⁵ All the participating countries followed a harmonized process to develop Report Cards on the physical activity of children and youth. A detailed description of the countries' involvement and the process to develop the Report Cards has been published elsewhere and is briefly described here.¹⁴

In each country, National Report Card Committees gathered the best and most recent national surveillance data available up to 2018 to inform and grade ten specific indicators related to physical activity among children and adolescents: Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviours, Physical Fitness, Family and Peers, School, Community and Environment, and Government.¹⁴ The analyses presented in this paper are focused on the Active Transportation indicator.

According to the benchmarks proposed by AHKGA to harmonize and guide the development of the Report Cards, the Active Transportation indicator was described as the “percentage of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend’s house)”.¹⁴ Report card leaders were instructed to inform this indicator by the best, preferably nationally representative, data available for children and adolescents between five and 17 years, and a grade was assigned according to the prevalence following a common rubric established by the AHKGA (Table 1).

Table 1. Global Matrix 3.0 grading rubric.

Grade	Interpretation ^a	Numerical equivalents ^b
A+	94% - 100%	15
A	We are succeeding with a large majority of children and youth (87% - 93%)	14
A-	80% - 86%	13
B+	74% - 79%	12
B	We are succeeding with well over half of children and youth (67% - 73%)	11
B-	60% - 66%	10
C+	54% - 59%	9
C	We are succeeding with about half of children and youth (47% - 53%)	8
C-	40% - 46%	7
D+	34% – 39%	6
D	We are succeeding with less than half but some children and youth (27% - 33%)	5
D-	20% - 26%	4
F	We are succeeding with very few children and youth (<20%)	2
INC	Incomplete – insufficient or inadequate information to assign a grade	

^a For this article, the interpretation corresponds to the percentage of children and youth who use active transportation to get to and from places (eg, school, park, mall, friend’s house).

^b Letter grades were converted to numerical equivalents for analyses purposes.

The prevalence of active transportation reported by each country and the related details presented in each Report Card, including policies, practices, strategies to improve the grade and research gaps, were extracted from the Report Cards and from related publications in English, Spanish or French, including brief reports, posters and peer-reviewed articles. These publications were reviewed, and relevant information was summarized by two of the authors of this manuscript. Based on the grades provided, numerical equivalents were assigned (Table 1), and average estimates of the grades for active transportation were calculated at the global level and by groups of countries according to their level of development determined by the Human Development Index (HDI). The HDI is a composite index created by the United Nations Development Programme to rank countries based on key dimensions of human development such as education, life expectancy and gross national income per capita ¹⁶. HDI ranges from 0 to 1 and for the present analysis we used the continuous index and a categorical variable that classified countries in three categories: low and medium (HDI <0.70), high (HDI ≥0.70 to <0.80) and very high (HDI ≥0.80).¹⁶ It was included as a variable of interest in this analysis based on the variability in active transportation observed across HDI clusters in previous analysis of the Global Matrix.¹⁴ Also, the Gini index for each country was retrieved from the World Bank estimates. The Gini index provides a measure of inequality in income distribution. It ranges from 0 (perfect equality) to 100 (perfect inequality).¹⁷ The Gini index was included in this analysis considering previous international evidence that has shown that income inequality is a relevant variable related to physical activity levels and taking into account the importance of socioeconomic inequalities in transport as an essential activity for economic and social development.^{18,19}

A latent profile analysis (LPA) was conducted to identify groups or profiles of countries based on the numerical grades for active transportation and the two sociodemographic variables at the

country level, the HDI and the Gini index. LPA is a probability-based statistical procedure that allows to identify classes or profiles that group observations sharing similar patterns of the variables of interest.²⁰ The analysis was performed to look for the best model solution for one to five possible profiles. Models were compared to choose the solution with the best fit based on the Akaike information criterion (AIC), sample-adjusted Bayesian information criterion (SABIC) and the bootstrapped likelihood ratio test (BLRT) as indicators of model fit. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina, USA) and R (version 3.4.1; The R Foundation for Statistical Computing, Vienna, Austria). The tidyLPA package 21 was used for the LPA.

Results

A total of 47 countries (96%) in the Global Matrix 3.0 had sufficient evidence (determined by each country's National Report Card Committee) on active transportation to assign a grade. The grades ranged from "A-" in Japan, Nepal and Zimbabwe to "F" in Chile (Table 2). The global average for active transportation was "C". The average grade by HDI was "C+" for low to medium HDI countries, "C" for high HDI countries and "C-" for very high HDI countries, as previously reported by Aubert et al.¹⁴ The HDI of the included countries varied from 0.448 in Ethiopia to 0.985 in Jersey. According to the Gini index, the country with the most unequal distribution of income was South Africa with a Gini index of 63, while Slovenia had the lowest inequality score, with a Gini of 25.4 (Table 2).

Table 2. Active transportation grades and sociodemographic variables of the 49 countries participating in the Global Matrix 3.0.

Country	Active transport grade	Active transport numerical grade	Human Development Index (HDI) ^a	HDI classification	Gini index ^b
Australia	D+	6	0.939	Very high	34.7
Bangladesh	C-	7	0.579	Low to medium	32.4
Belgium (Flanders)	C+	9	0.896	Very high	27.7
Botswana	C	8	0.698	Low to medium	60.5
Brazil	C	8	0.754	High	51.3
Bulgaria	B-	10	0.794	High	37.4
Canada	D-	4	0.920	Very high	34.0
Chile	F	2	0.847	Very high	47.7
China	C+	9	0.738	High	42.2
Colombia	B	11	0.727	High	50.8
Czech Republic	C+	9	0.878	Very high	25.9
Denmark	B+	12	0.925	Very high	28.2
Ecuador	C-	7	0.739	High	45.0
England	C-	7	0.909	Very high	33.2
Estonia	D	5	0.865	Very high	32.7
Ethiopia	C	8	0.448	Low to medium	39.1
Finland	B+	12	0.895	Very high	27.1
France	C-	7	0.897	Very high	32.7
Germany	C-	7	0.926	Very high	31.7
Ghana	C+	9	0.579	Low to medium	42.4
Guernsey Channel Islands	D	5	0.975	Very high	40.0
Hong Kong	B+	12	0.917	Very high	N/A

Country	Active transport grade	Active transport numerical grade	Human Development Index (HDI) ^a	HDI classification	Gini index ^b
India	B-	10	0.624	Low to medium	35.1
Japan	A-	13	0.903	Very high	32.1
Jersey	D+	6	0.985	Very high	41.0
Lebanon	D	5	0.763	High	31.8
Lithuania	C-	7	0.848	Very high	37.4
Mexico	C+	9	0.762	High	43.4
Nepal	A-	13	0.558	Low to medium	32.8
Netherlands	B-	10	0.924	Very high	29.3
New Zealand	C-	7	0.915	Very high	N/A
Nigeria	B	11	0.527	Low to medium	43.0
Poland	C	8	0.855	Very high	31.8
Portugal	C-	7	0.843	Very high	35.5
Qatar	N/A	N/A	0.856	Very high	N/A
Scotland	C	8	0.909	Very high	33.2
Slovenia	C	8	0.890	Very high	25.4
South Africa	C	8	0.666	Low to medium	63.0
South Korea	B+	12	0.901	Very high	31.6
Spain	B-	10	0.884	Very high	36.2
Sweden	C	8	0.913	Very high	29.2
Taiwan	C-	7	0.885	Very high	33.6
Thailand	C	8	0.740	High	37.8
United Arab Emirates	INC	N/A	0.840	Very high	N/A
United States	D-	4	0.920	Very high	41.5
Uruguay	C	8	0.795	High	39.7
Venezuela	B-	10	0.767	High	46.9

Country	Active transport grade	Active transport numerical grade	Human Development Index (HDI) ^a	HDI classification	Gini index ^b
Wales	D+	6	0.909	Very high	33.2
Zimbabwe	A-	13	0.516	Low to medium	43.2
Global average	C	8.29	NA	NA	NA
Low to medium HDI countries	C+	9.67	NA	NA	NA
High HDI countries	C	8.5	NA	NA	NA
Very high HDI countries	C-	7.78	NA	NA	NA

^a Data at the national level from the United Nations Development Programme ¹⁶

^b Data at the national level from the World Bank ¹⁷

Abbreviations: HDI, Human Development Index; INC, Incomplete, N/A, Not available; NA, Not Applicable.

Table 3 presents the prevalence and rationales behind the grades for each country, as well as the sources and characteristics of the information reported. Active transportation among children and adolescents varied between 15% in Chile and 86% in Japan and Nepal. Among the countries that assigned a grade for active transportation, 83% (n= 39) did not provide details of the prevalence stratified by sex. In the majority (62%) of countries that reported data by sex, the prevalence of active transportation was slightly higher for males. More than half of the countries (65%) reported data for both children and adolescents, however, the age groups included varied from one country to another. Most countries (87%) only included data on school trips, and only two countries (Ecuador and the United States) clearly reported active transportation to other destinations. Regarding the direction of the trips, about half of the countries (49%) reported active transportation to and from school or other destinations. In more than half of the countries

(65%), the frequency of active transportation reported was not clear. The most common frequencies reported were “daily” (n= 3), “typically” or “usually” (n= 3) and “on a regular basis” (n= 2). Regarding the source of information, 64% (n=30) of the countries used data from surveys and studies with national representativeness, 8.5% (n=4) used local studies, and 19% (n=9) used both local and national studies. International surveys such as the Global School-Based Student Health Survey (GSHS)²² and the Health Behaviour of School-aged Children (HBSC)²³ were among the sources of information in 7 countries.

Table 3. Rationale for grades and information reported on active transportation by 49 countries involved in the Global Matrix 3.0.

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
A-	Japan	86% of students used active transportation to school from home.	Not reported	6-17 years	To school	On a regular basis	The National Sports-Life Survey of Young People (SSF), 2015 ²⁴	3
A-	Nepal	86% of children and youth of 15-20 years used active transportation to get to and from places.	Not reported	15-20 years	Not specified	Not clear	Physical Activity Level and Associated Factors Among Higher Secondary School Students in Banke, Nepal: A Cross-Sectional Study, 2013 ²⁵	2
A-	Zimbabwe	Over 80% of children and adolescents used active transport to and from school, with variation between provinces as well as between rural and urban areas.	82% of girls and 79% of boys engaged in active transport to and from school	8-16 years	To and from School	Not clear	The Zimbabwe Baseline ²⁶ and Global school-based health survey (GSHS) Zimbabwe 2003 ²⁷	2
B+	Denmark	78% of children and adolescents reported cycling, walking, or using children's scooters as transport (e.g. to school) at least two times per week.	Not reported	7-15 years	To school	At least two times per week	Danish Sports Habits Study 2016 ²⁸	3

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
B+	Finland	77% of children and adolescents actively commuted to school, on foot or by bike.	9 years old 79% of boys, 81% of girls 11 years old 85% of boys, 81% of girls 13 years old 80% of boys, 77% of girls 15 years old 59% of boys, 63% of girls	9-15 years	To school	Not clear	National Physical Activity Behaviour Study for Children and Adolescents 2016 (LIITU) ²⁹	3
B+	Hong Kong	80% of the adolescent males and 77% of the adolescent females actively travelled to school at least once per week. 52% of primary school children used active travel to/from school at least 5 times per week.	80% adolescent males and 77% adolescent females	Primary and secondary	To and from school	At least 5 times per week and at least once per week.	Understanding Children's Activity and Nutrition (UCAN) study, 2011-2012 ³⁰	3
B+	South Korea	79.4% of children and adolescents reported walking or cycling to/from places, with an average duration of 39 minutes per day.	84.3% of boys and 73.8% of girls took active modes of transport.	12-17 years	Not specified	Not clear	Korea National Health and Nutrition Examination Survey, 2016 ³¹	3

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
B	Colombia	71.7% of children and adolescents in Colombia reported walking or biking as their main mode of transport to or from school in the previous week.	Not reported	6-17 years	To and from school	Main mode during the last 7 days	National Survey of Nutrition (ENSIN) 2015 ³²	3
B	Nigeria	The majority (61% to 80%) of Nigerian children and adolescents engage in some form of active transportation, mostly walking to and from school.	Not reported	5-13 years	To and from school	Not clear	2 different studies on rural and urban populations in Nigeria, conducted in 2011 ³³ and 2013 ³⁴ .	2
B-	Bulgaria	64% of children and youth reported walking, biking, or skating, etc. to go to school and back.	Not reported	Not specified	To and from school	Not clear	Bulgarian Active Kids survey, 2016 ³⁵	3
B-	India	Approximately 65% of children/adolescents (weighted average) reported walking or cycling to school on a regular basis.	Not reported	5-17 years	To school	On a regular basis	7 different studies at the national and local level conducted between 2005 and 2018 ^{12,13,36-40}	2
B-	Netherlands	90% of the adolescents commute actively to school. 36% of the children commute actively to school	Not reported	Not specified	To school	At least three days per week	Lifestyle monitor National Survey, 2017 ⁴¹	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
B-	Spain	55% and 56.9% of children between 6 and 9 years old walked to and from school, respectively. In Catalonia, 61.3% of children between 3 to 14 years old walked to and from school.	Not reported	3-14 years	To and from school	Not clear	Food, Physical Activity, Child development and Obesity study (ALADINO) 2011 ⁴² , and the Catalan Health Survey (ESCA) 2016 ⁴³	3
B-	Venezuela	63% of adolescents might walk at least 10 min to move from one place to another.	Not reported	Not specified	Not specified	Not clear	Venezuelan Study of Nutrition and Health ⁴⁴	3
C+	Belgium (Flanders)	55.5% of parents of 6-to 9-year old children reported that their child uses active transportation, and 58.9% of 10- to 17-year-old adolescents reported to mainly use active transportation to travel to school.	Not reported	6 to 9 and 10 to 17	To school	Not clear	Belgian National Food Consumption Survey 2014 ⁴⁵	1
C+	China	56.3% of Chinese children (aged 6-18 years) reported going to and from school by walk or bicycle.	Not reported	9 to 17 years	To and from school	Daily	Physical Activity and Fitness in China - The Youth Study (PAFCTYS), 2016 ⁴⁶	3

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C+	Czech Republic	On average, 57% (weighted mean: 59%) of children and adolescents reported using active transport to get to and from school.	Not reported	9-17 years	To and from school	Not clear	Health Behaviour in School-aged Children Study (HBSC)2006, 2010, and 2014 ⁴⁷ and International Physical Activity and Environment Network Study (IPEN), 2013-2015 ⁴⁸	1
C+	Ghana	About 54% of children and youth especially those in the rural areas walk to school and back home covering about 2km.	Not reported	Not specified	To and from school	Not clear	Not specified	2
C+	Mexico	54.8% of children 3 years and older walked to school and 1.5% rode bicycles. 69% of 10-14-year olds walked or rode a bicycle to school.	Not reported	3 years and older	To school	Not clear	Intercensal Survey of the National Institute of Statistics and Geography (INEGI), 2015 ⁴⁹ and the National Health and Nutrition Survey 2016 (ENSANUT) ⁵⁰	3

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C	Botswana	49% of 13-15-year olds walked or rode a bike to and from school at least one day during the past 7 days.	Not reported	13-15	To and from school	At least one of the last 7 days	2005 Botswana School-based Student Health Survey (GSHS) ¹³	3
C	Brazil	55.0% of children and youth in Brazil used active transportation to get to and from school.	Not reported	6 to 21	To and from school	Not clear	18 different national and regional studies conducted between 2008 and 2017 ⁵¹	3
C	Ethiopia	Approximately 48% of children and youth (31% in urban and 65% rural) walked to and from school.	Not reported	Not specified	To and from school	Not clear	Experts' opinion	2
C	Poland	47.4% of 10- to 17-year-olds reported walking to school and 52.3% walking from school. 5.5% and 5.2% travel to and from school by bicycle, respectively. 41% and 5% of lower-secondary students walk and cycle to school, respectively. While 36% and 3% of upper-secondary school students walk and cycle to school, respectively.	Not reported	10-19 years	To and from school	Not clear	Study of Physical Activity of School Children Aged 9–17 by the Institute of Mother and Child, 2013 ⁵² and the All-Poland survey of physical activity and sedentary lifestyles for middle school, high school and university students, 2011 ⁵³	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C	Scotland	51 and 52% of school age children and adolescents, respectively, actively commuted to school (walking, cycling, skating or using scooter).	Not reported	4-18 years	To school	Not clear	Hands up Scotland Survey (HUS) 2016, ⁵⁴ Transport and Travel in Scotland (TATiS) 2016 ⁵⁵	1
C	Slovenia	Almost 49 % of children commute actively to and from school and additional 12 % commute actively from school only.	52% of boys and 50% of girls commute actively to school	5-15 years	To and from school	Not clear	Analysis of Children's Development in Slovenia study (ACDSi) 2013-16 ^{56,57}	1
C	South Africa	63% of school-aged children walk to school. 81% of children and adolescents in Cape Town walk to school without adult supervision in low-income settings, and 61% of parents reported concerns about their children safety.	Not reported	6-15 years	To school	Not clear	General Household Survey, 2013 ⁵⁸ and two local studies conducted in Cape Town, 2016 ^{59,60}	3
C	Sweden	48% and 57% of children and adolescents used active transportation to and from school in the winter and summer months, respectively.	Not reported	6-15 years	To and from school	Not clear	Children's Routes to School Survey 2015-16 ⁶¹	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C	Thailand	53.4% children and adolescents used active transportation (walking, cycling, using a wheelchair, in-line skating or skateboarding) to get to and from places.	54.7% of girls and 52.4% of boys used active transportation	6-17 years	Not specified	Not clear	Thailand Physical Activity Children Survey (TPACS) 2015 ⁶²	3
C	Uruguay	51.2% of adolescents between 13 and 15 years old went to the school walking or bicycling 4 or more days per week.	Not reported	13-15 years	To school	4 or more days per week	Global School-Based Student Health Survey (GSHS)2012 ⁶³	3
C-	Bangladesh	41.1% students aged 13-17 years used active transport to commute to or from school at all seven days prior to the survey.	Not reported	13-17 years	To and from school	Last 7 days	Bangladesh School-based Student Health Survey (GSHS), 2014 ⁶⁴	2
C-	Ecuador	42.7% of 5-17 years-old children reported going to school or work by foot or bike.	Boys: 42% Girls: 41%	5-17 years	To school, work or other destinations	Not clear	Not specified	3
C-	England	On average, 42.5% of children and adolescents used active modes of transport to school everyday.	Not reported	5- 16 years	To school	Every day	National Travel Survey 2016, ⁶⁵ Health Survey for England 2015 ⁶⁶ and Walking and Cycling Statistics 2016 ⁶⁷	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C-	France	44% of the 3-10 years olds and 43 % of the 11-14 years old used active transportation to go to school according to the National Study of Individual Nutritional Consumption 2014-2015. And 41% of the 6-10-year olds reported using active transportation to school according to the Health Study of the Environment, Biosurveillance, Physical Activity, and Nutrition 2015.	Not reported	3 - 14 years	To school	Not clear	National Study of Individual Nutritional Consumption (INCA) 2014-2015 ⁶⁸ and the Health Study of the Environment, Biosurveillance, Physical Activity and Nutrition (ESTEBAN) 2015 ⁶⁹	1
C-	Germany	Approximately 40% of the children and adolescents commute actively to school.	Not reported	Not specified	To school	Not clear	Not specified	1
C-	Lithuania	45% of 7–8 aged children used active transport to school and 57.9 %. used active transport from school to home. 84 % of children and adolescents (11-13 year) walked to/from school. 12% of youths and adolescents (15-24 year) reported to engage regularly in cycling from one point to another.	Not reported	7-24 years	To and from school	Not clear	4 different studies and one special report Eurobarometer on Sport and Physical Activity, between 2012 and 2017 ⁷⁰⁻⁷⁴ .	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
C-	New Zealand	45% of children and adolescents aged 5-14 years usually used active transport to school according to the the NZ Health Survey, 43% of children and youth aged 5-17-year olds usually used active transport to and from school according to the Active NZ Survey. 30% of children aged 5-12 years and 31% of adolescents aged 13-17 years used active transport to school according to the Health and Lifestyles Survey and the NZ Household Travel Survey, respectively. 24% of 6-year olds in a longitudinal cohort study usually used active transport to get to and from school.	Not reported	5-17 years	To and from school	Not clear	New Zealand Health Survey 2016/2017 ⁷⁵ , Active NZ Survey 2018 ⁷⁶ , Health and Lifestyles Survey 2016 ⁷⁷ , NZ Household Travel Survey 2015-2018 ⁷⁸ , and the Growing Up in New Zealand study 2010 ⁷⁹ .	1
C-	Portugal	A study with urban school-aged children showed that 45% of participants commuted actively to and from school. Another study in the countryside region found that 30% of the participants (aged 7 to 8 years) commuted either by foot or cycling on a regular	Not reported	7-8 years and 15-24 years	To and from school	Not clear	A study in public schools from the Porto area ⁸⁰ and the Health Study of the Child Population of the Alentejo Region, 2012 ⁸¹	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
		basis during school days (ARSA 2012).						
C-	Taiwan***	33-46% of children and adolescents reported walking or cycling to school most of the days	Not reported	7-18 years	To school	Most of the days	Student Participation in Physical Activity Survey, 2015 ⁸² and Health Behaviour Survey in Junior High School Students, 2016 ⁸³	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
D+	Australia	National data shows that 43% of 12-17 y olds usually travel to/from school using active transport, other state and regional studies shows that 37% of primary students and 36% of secondary students use active transport as their usual mode to get to school.	Not reported	12-17 years	To school	Usual mode - each week (Usual defined as at least 5 trips out of 10 or on at least 2.5 school days)	National Secondary Students Diet and Activity Survey 2012-2013 ⁸⁴ , ACT Year 6 Physical Activity and Nutrition Survey 2015 ⁸⁵ , Child Population Health Survey ⁸⁶ , Queensland Child Preventive Health Survey 2018 ⁸⁷ , NSW School Physical Activity and Nutrition Survey 2015 ⁸⁸ , Victorian Child Health and Wellbeing survey 2016 ⁸⁹ .	1
D+	Jersey**	37% of 10-15-year olds traveled to school by active modes.	Not reported	10-15 years	To school	Not clear	Health Related Behaviour Questionnaire 2014 ⁹⁰	1
D+	Wales	44% primary school children and 34% secondary school pupils traveled actively to school. In another survey, 33.8% and 36.1% of children	Not reported	11-16 years	To and from school	Not clear	National Survey for Wales (2016-17) ⁹¹ and The Health Behaviour of School-aged	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
		and young people aged 11-16 years walked/cycled to and from school, respectively.					Children (HBSC)/School Health Research Network (SHRN) Survey 2017 ⁹²	
D	Estonia	The percentage of use of active transport varied between 36-56%. Specifically, 35% of children walked to school and back home, while 14% of children rode a bike to go to school. The grading process took into account the number of subjects, age range and used methodology of different studies.	Not reported	7-17 years	To and from school	Not clear	Children's Physical Activity Study 2015 and Schools in Motion Survey 2018 ⁹³	1
D	Guernsey Channel Islands*	On average, 31% of children and adolescents reported active travel (walking, bicycle or scooter) to school on the day of the survey (43% of primary school pupils and 25% of secondary pupils.	Not reported	Primary and secondary (grades 6, 8 and 10)	To school	On the day of the survey	Guernsey Young People Survey 2016-2017 ⁹⁴	1
D	Lebanon	36.8% of Lebanese adolescents between the ages	Not reported	13-17 years	To school	Not clear	Global School-Based Student	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
		of 13 and 18 reported walking or biking to school.					Health Survey 2016 (GSHS) ⁹⁵	
D-	Canada	21% of 5- to 19-year-olds in Canada typically use active modes of transportation (e.g., walk, bike), and 16% use a combination of active and inactive modes of transportation to travel to and from school (2014-16 CANPLAY, CFLRI).	Not reported	5 to 19	To and from school	Typical use	Kids CANPLAY 2014-2016 ⁹⁶	1
D-	United States	38% of adolescents walked or used a bicycle for at least 10 minutes continuously once or more in a typical week to get to and from places, and 23% of youth actively commuted 5-7 days per week.	45% of boys and 32% of girls reported any active transportation in a typical week	12-19 years	To and from multiple places	5 to 7 days on a typical week	National Health and Nutrition Examination Survey (NHANES 2015-16) ⁹⁷	1
F	Chile	15% of children and youth (weighted average) rode a bike or walked to and from school (ranging from 0.29% to 32.2% in different samples and regions).	Not reported	Not specified	To and from school	Not clear	National Survey of Quality of life 2015-2016 (ENCAVI) ⁹⁸ , Survey of Urban Quality of Life Perception 2015 (EPCVU) ⁹⁹ , a cross-sectional	1

Grade	Country	Rationale	Gender	Age	Destination and direction	Frequency	Source of information and year	Profile
							study of seventh grade students in the Maule region 2014 ¹⁰⁰ , and a cross-sectional study in Valparaiso 2017 ¹⁰¹	
INC	United Arab Emirates	There was no current data available to grade this indicator.	NA	NA	NA	NA	NA	1
N/A	Qatar	Active transportation indicator is excluded from the report according to stakeholders' group recommendation. This indicator is still not applicable in Qatar due to unsafe roads and the hot climate during most times of the year.	N/A	N/A	N/A	N/A	N/A	1

Abbreviations: INC, Incomplete; NA, Not Applicable

The best LPA model grouped the Global Matrix 3.0 countries into three profiles according to the grades for active transportation, the HDI and the Gini index. The three-profile model had the best fit statistics according to the criteria proposed by Nylund et al. for model selection.¹⁰² The preferred model showed the lowest values for the AIC (359.8), SABIC (331.1) and the BLRT (24.8), and a significant p value for the BLRT (p=0.041). Table 4 shows the descriptive statistics for the latent variables among the three profiles identified. In profile 1 (n=25) 72% of the countries had active transportation grades below “C”, 96% of the countries had a very high HDI, and 72% had relatively low Gini indices (below 40). In profile 2 (n=7), 85% of the countries had active transportation grades equal to or greater than “C”, all of them had a low to medium HDI and 43% had Gini indices above 40. In profile 3 (n=17), 94% of the countries had active transportation grades equal to or greater than “C”, 53% had a high HDI and 35% had a very high HDI, and 47% had Gini indices above 40. For countries with missing values in any of the variables of interest, the LPA assigned a profile based on the values available for the remaining variables. Figure 1 presents a plot of the scaled data for the three profiles.

Table 4. Descriptive statistics of the latent variables by country profile.

Profile (% of countries)	Active Transportation Grade				Human Development Index				Gini Index			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
1 n=25 (51%)	6.08	2.55	0.00	10.00	0.89	0.05	0.763	0.985	33.78	5.29	25.44	47.70
2 n=7 (14.3%)	10.14	2.34	7.00	13.00	0.55	0.06	0.448	0.624	38.29	4.81	32.40	43.20
3 n=17 (34.7%)	9.82	1.88	7.00	13.00	0.80	0.09	0.666	0.925	42.08	10.58	27.10	63.0

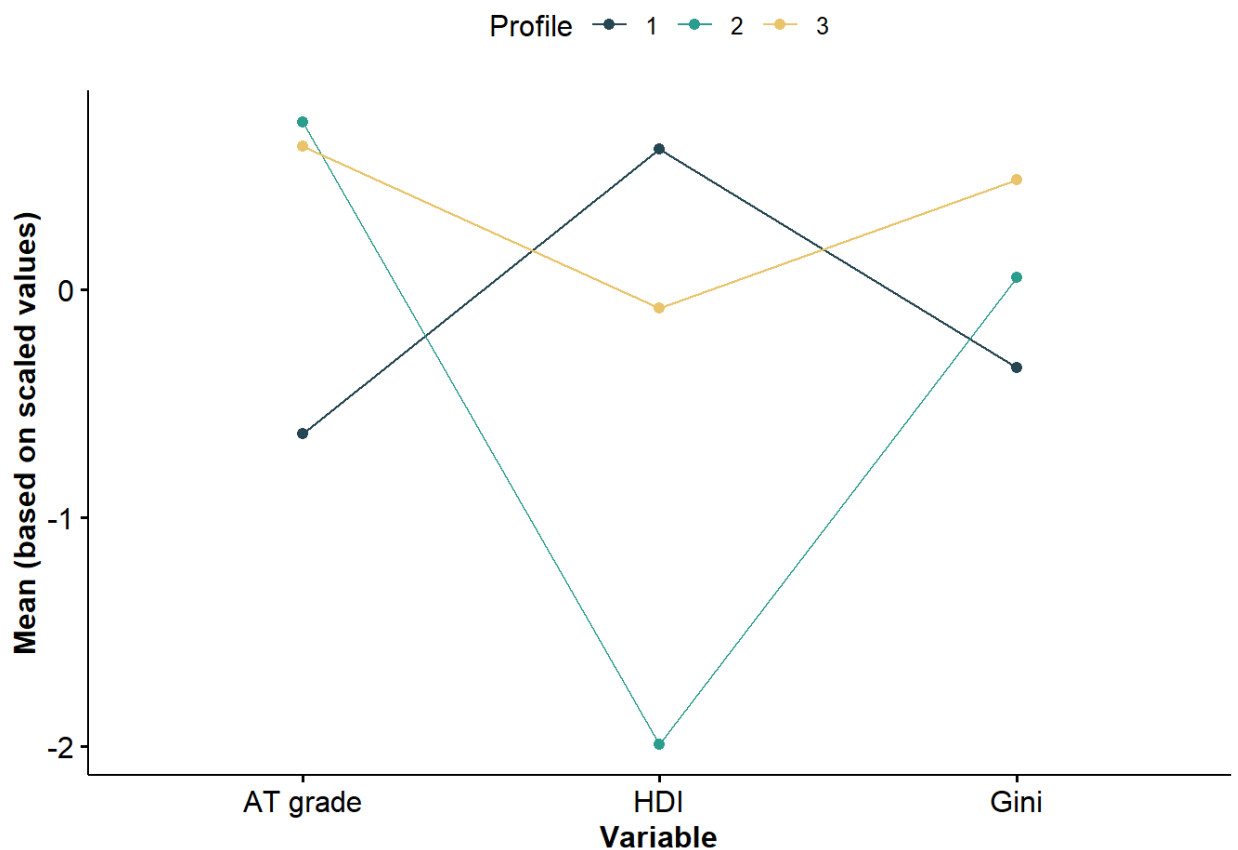


Figure 1. Country profiles for active transportation and sociodemographic variables of countries in the Global Matrix 3.0. ^a The range of values for the active transportation grade, Human Development Index and the Gini index varied notably between variables, therefore they were converted to z-scores to be expressed in the same range of values and to ease their graphic depiction.

The availability of details related to active transportation in the report cards, beyond the reported prevalence, varied across countries. Table 5 summarizes the information provided by countries in terms of practices and policies, strategies proposed to improve the grades and research gaps identified by expert groups in each country. Twenty-four countries provided at least one of these details. The policies and practices identified by the expert groups included school siting policies, transport policies that prioritize active modes of commuting, walking challenges and special events, and multi-component programs that comprise educational strategies, enforcement of regulation to improve traffic safety, and providing

infrastructure and resources at several levels (children, teachers, schools and communities). The most common topics in the strategies proposed to improve the grades were improving safety conditions, providing supportive infrastructure, developing informational and education strategies, and involving parents, schools and communities in the promotion of active transportation. Several research gaps were identified, but the most frequent across countries was the need to study active transportation to destinations other than school (Table 5).

Table 5. Policies and practices, strategies to improve the grade and research gaps in active transportation identified in the Global Matrix 3.0.

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
A-	Japan	3	Since 1953 Japan has a "walking to school practice" resulting from the implementation of the article 49 of the School Education Act, which regulates the siting of public schools in urban areas of Japan. This article establishes that the commuting distances are 4km for elementary schools and 6km for junior high schools. Based on these, the boards of education must ensure that children attend to schools located within those distances to allow children to walk to school ^{14,103,104} .	Not reported	Research on active transportation to destinations other than schools (e.g. going shopping, going to the park, sports clubs or cram schools) ¹⁰⁴ .
A-	Zimbabwe	2	Not reported	1. Through public health messages to highlight the benefits of active transportation and reduce the prestige/status symbol associated with motorized transportation. 2. Implementing policies that encourage and provide safe and walkable neighborhoods and bike lanes, etc. ¹⁰⁵	There is a need of data reporting the time invested in active transportation and distance to and from school, as well as research data on the correlates of active transportation, and more recent data is required. ¹⁰⁵
B+	Finland	3	Not reported	Not reported	There is no comparable published data available about active school commutes for upper secondary students when the distance between home and

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
					school is less than 5km. More information is needed about active transportation to other destinations. ¹⁰⁶
B+	Hong Kong	3	The high density of Hong Kong could be one of the factors facilitating active transportation to school. Since most districts in Hong Kong are highly self-contained, children can attend schools located at walkable distance from their home. ^{107,108}	1. Encouraging active travel to destinations other than school may provide additional health benefits for children and adolescents. 2. Promoting cycling to and from school and other destinations in districts with a bicycle track.^{107,108}	Data about active transportation to destinations other than school, as well as the relationship between active transportation, physical activity and health-related outcomes. Also, data on the duration of active travel trips is required. ^{107,108}
B	Colombia	3	In Bogota, the capital city of Colombia, the program “Bike to school” is implemented in public schools to promote cycling as a sustainable mode of transportation to school and other destinations in the city. The program was created in order to address the barriers to access to education and to decrease the dropout rates. Bike to school program includes the following strategies: a) bicycle loan, b) workshops on skills and abilities to ride a bicycle, c) basic mechanics and road safety education, d) participatory mapping of safe routes, e) daily trips from a meeting point to school with adult supervision, and f) extracurricular activities to develop	1. Improving safety conditions and infrastructure to keep promoting and maintaining active transportation as a desirable behaviour since early ages. ¹⁰⁹	Not reported

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
			responsible behaviours in the roads and to visit other destinations of interest in the city.^{109,110} Another promising practice to encourage walking and cycling, but with recreational purposes, are the Open Streets programs, or Ciclovias. Colombia currently has 67 of these programs that close main roads to motorized vehicles and open them for leisure activities on Sundays and holidays.^{109,111} Walking and cycling are the main activities performed by children who attend Ciclovía in Bogota.¹¹² Also, Colombia has a specific law to support the use of bicycles as the main mode of transport at the national level (Law 1811 of 2016). This law establishes the responsibility of public transportation systems to allow multi-modal trips through the provision of bike-supporting infrastructure, and encourages schools to implement programs to promote cycling.¹¹³		
B	Nigeria	2	The National Transport Policy in Nigeria is under review with the aim to strengthen the inclusion of non-motorized transport infrastructure and to create better non-motorized transport options for urban residents. This review is the result of a workshop on streets design led by the Federal Ministry of Transport in 2017 and is a good example of the concerted efforts to improve the conditions for active transportation in Nigeria.^{114,115} Another example is the Non-Motorized Transport Policy developed in Lagos, which aims to prioritize walking, cycling and public transportation as the main modes of	Not reported	Not reported

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
			transport. ¹¹⁴ This policy specifically address active transportation to school through two strategies: a) public awareness through the creation of a curriculum about road safety and benefits of active transportation for primary and secondary school students. And b) regulations that include the creation of route plans for students to go to school, and the implementation of access and safety measures such as speed limits, traffic calming infrastructure and school zone signaling. ¹¹⁶		
C+	Ghana	2	The Community Day Senior High Schools, built in various districts in Ghana, seem to be encouraging active transportation to school. The students who attend to this schools usually walk to and from school everyday, some of them covering more than two kilometers. ¹¹⁷	Not reported	Not reported
C+	Mexico	3	Not reported	1. Promoting active transportation among Mexican children and adolescents. 2. Communities and governments should provide appropriate safety conditions on streets, sidewalks and neighborhoods to promote walking and cycling among children and adolescents.¹¹⁸	Data on all age groups and stratified by age group and sex is desirable for future surveys. ¹¹⁸
C	Brazil	3	Not reported	Local authorities should be encouraged to create a monitoring system to generate standardized and detailed	Data on time invested in active transportation, the distance to the school

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
				reports on active transportation to school to support planning and evaluation of public policies. ¹¹⁹	and other environmental and mobility-related factors such as bike paths, traffic and conditions of the city is lacking. ⁵¹
C	Ethiopia	2	Not reported	1. Building sidewalks to encourage active transportation in all cities in Ethiopia. 2. Encouraging and supporting children and adolescents to travel to and from school through active transportation.¹²⁰	Active transportation specific studies in Ethiopia are required. ¹²⁰
C	Scotland	1	Not reported	Not reported	No data available on active commuting to and from places other than school. ¹²¹
C	Sweden	1	A national cycling strategy has been adopted in Sweden to improve safety and increase cycling. ¹²² The strategy aims to increase cycling through five action lines: a) creating more bicycle-friendly municipalities, b) focusing on various types of cyclists (where children are highlighted as a population of interest), c) giving higher priority to bicycle traffic in community planning, d) building more functional and user-friendly cycling infrastructure and e) strengthening research and innovation on cycling. ¹²³	Not reported.	Not reported.

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
C	Uruguay	3	Not reported	Creating policies to encourage the creation of cycle lanes and safe sidewalks.	Data on active transportation in a wider age range and to locations other than school.
C-	Ecuador	3	Not reported	Reinforcing programs aiming to promote active transportation. ¹²⁴	Not reported
C-	France	1	Not reported	Not reported	Research is needed on the characteristics of active transportation of children and adolescents (frequency, mode, distance covered) and on the potential barriers to this in order to develop effective promotion program. ¹²⁵
C-	Lithuania	1	Not reported	1. Promoting and facilitating safe active transport to get to school and other destinations. 2. Prioritizing active transportation promotion as a key factor at schools and communities. 3. Involving parents, schools, community and policy makers	1. Research on the prevalence and trends of active transport in Lithuania, considering the most popular modes of active transportation used to get to/from different points or destinations (e.g., parks, shops, sport fields) among children and

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
				in the promotion of active transportation. ⁷⁰	adolescents as well as studying the role of active transport in achieving recommended levels of physical activity. 2. Research on health and social benefits of active transportation is needed. 3. Evaluating the impact of the cycling paths and interventions at the school, community and municipality levels. 4. Examining the potential moderators and mediators of active transport behaviour change to help refine interventions.⁷⁰
C-	New Zealand	1	Not reported.	Strategies to encourage active travel to school are needed, especially for girls, younger children, and older adolescents. ¹²⁶ This strategies should have a multi-sectoral y culturally appropriate approach, including urban	Nationally representative data on active transportation to school and other destinations that is comparable between

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
				planning, initiatives at the school and community level, social marketing campaigns and family support. ¹²⁷	countries and across time is desirable. ¹²⁷
C-	Taiwan***	1	Not reported	Local governments and schools should work together to create a safe and convenient environment for active transportation. ¹²⁸	Research on the contribution of active transportation to overall physical activity in children and adolescents, and about motivations and barriers for active transportation is needed. ¹²⁸
D+	Australia	1	The Australian Capital Territory has implemented the Ride or Walk to School program since 2012 aiming to build the capacity of primary schools to support and promote active travel to and from school. The program was designed with a participatory approach including students and different stakeholders. The strategies of the program include: a) resources for teachers and students, b) provision of bikes and helmets, c) safe routes maps, d) workshops to increase skills, and e) four annual active travel events. This program was expanded to high schools since 2016.¹²⁹ In Western Australia, the Department of Transport implemented the program “Your Move Schools”. This is a community-focused program that promotes active and sustainable transportation providing: a) teaching resources, b)	1. Encouraging families to active commute at least part of the way, promoting the use of park and walk/ride/scoot zones away from school grounds to reduce traffic. 2. Creating and promoting safe routes to schools and engage schools to promote their use. 3. Creating greater awareness of actual distances between home and school and the travel time for active modes. 4. Highlighting the benefit of students travelling to school carrying their school bags as an opportunity to be active	1. Nationally representative data for primary and secondary students. 2. Data on the use of active transportation to other destinations. 3. Data on the use of multi-modal transport combining active transport with public transport. 4. Research about how far families and children are willing to travel using active transportation.¹²⁹

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
			expert advice and c)access to funding (up to \$5,000 AUD) to promote active transportation through bike education workshops, wayfinding, bike supporting infrastructure like bike shelters, bike repair stations, bike skills tracks and bicycle parkings.¹²⁹ In the Northern Territory, the Nightcliff Walk and Wheel initiative is aimed at encouraging students to walk and cycle to school. This is a local project in two dense suburbs lead by principals and parents from four schools. The project has a focus on roads safety for children and has implemented activities such as the Ride2School days, increasing cycling to school.¹²⁹	while carrying a load, which could contribute to improve their muscular fitness. ¹²⁹	
D+	Wales	1	The report card mentioned the following initiatives led by charities to promote active travel to school: 1. Active Journeys – Sustrans School active travel program promotes active transportation through different actions like: a) providing support to schools to develop active travel plans, b) delivering activities and lessons, c) offering free incentives to promote active travel, d) providing resources and online travel challenges for the school community, and e) rewarding schools with the School Mark award for achieving excellence in active and sustainable travel.¹³⁰ 2. Living Streets Walking initiatives: This charity has two main strategies for schools, the WOW Year-Round Walk to School challenge and the Five-Days Walking challenge. Both of these aim	Not reported	More research is needed on how children and young people travel to other places including shops, parks and friends' or relatives' houses. ¹³²

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
			to engage primary and secondary students to walk to school encouraging them with an interactive travel tracker and the provision of incentives at the end of the challenge. This charity also encourages the celebration of the Walk to School Week in May every year. ¹³¹		
D	Guernsey Channel Islands*		Guernsey has an integrated transport strategy in place that promotes active travel with the aim of having a positive impact on the environment and the population's health. ¹³³ The On-island Integrated Transport Strategy aims to encourage active travel, followed by the use of public transport and to reduce the use of private motor vehicles. This strategy was initially planned to progressively advance to a taxation policy for high emission vehicles to support the promotion of active travel. However, there are other actions in this strategy aimed at increasing active travel to school, such as: a) bikeability training at primary schools, b) increasing the investments in walking and cycling infrastructure to improve safety for active commuters, c) revising the speed limits to enhance the safety of vulnerable populations using active travel, and d) developing and implementing travel plans for schools. ¹³⁴	Through the implementation of the integrated transport initiative that supports active travel. ¹³³	Not reported.
D	Lebanon	1	Not reported	Not reported	Nationally representative samples for children and adolescents and on all active transportation means are required to gain a

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
					better understanding of this indicator. ^{135,136}
D-	Canada	1	In Ontario, the Minister of Education expanded the funding for initiatives that improve the cognitive, physical, social and emotional well-being of students. Specifically walking school buses and biking-to-school programs have benefited from this increase in the funding.¹³⁷ These initiatives are part of the Ontario Active School Travel program (formerly Active & Safe Routes to School) which comprise five components: a) education activities to foster the skills, confidence, and awareness such as workshops and route mapping. b) Encouragement activities to inspire students, parents and school staff to try active travel modes. For example, walk and wheel seasonal events or walking school buses. c) Engineering actions to create safe and accessible school sites, neighbourhoods and routes to school, such as school siting, signaling, parking restrictions, crosswalk improvements or crossing guards. d) Enforcement of traffic policies to improve safety around schools. And e) evaluations to measure the measure success, and demonstrate impact of the actions.¹³⁸ In 2017, three organizations in Canada (Canada Bikes, Green Communities Canada and the National Active and Safe Routes to School	1. Creating a culture of active transportation, to make active transportation the norm. 2. Establishing lower speed limits in school areas. 3. Implementing traffic-calming devices (e.g., speed bumps/humps, chicanes, narrower intersections) to enhance compliance with speed limits, mainly in low-income areas, where more children engage in active transportation. 4. Hiring more crossing guards at busy intersections near schools. 5. Considering more progressive policies for low-income areas, to access to funding for active transportation interventions. 6. Considering children's	1. Research on active transportation to destinations such as parks, stores, recreation facilities and other places. 2. Studies on children's preferences for cycling and how to harness them in interventions. 3. More research is needed on how to facilitate children's independent mobility. 4. More research is needed on the use of mixed modes of transportation to and from destinations.¹³⁷

Grade	Country	Profile	Policies/practices	How to improve the grade	Gaps
			Working Group) created an active transportation alliance to advocate for the adoption and funding of a national active transportation strategy. ¹³⁷ However, this strategy is not yet in place.	active transportation when planning schools and recreation facilities. 7. Encouraging schools to implement “drop-off spots” from which driven children could safely walk to school in groups. ¹³⁷	
D-	United States	1	Safe Routes to School is a movement with initiatives at the regional, state and local levels that aims to promote walking and bicycling to school, improving safety, health and physical activity levels. Actions at the local level incorporate the six E’s integrated approach: a) education through the provision of training in skills and knowledge to walk and bicycle safely and teaching the benefits of active transportation. b) Encouragement to motivate children to travel actively through events and activities. c) Engineering to improve streets and neighborhoods in order o make them more convenient for walking and bicycling. d) Enforcement of safety regulation. e) Evaluation of the success and opportunities to improve the initiatives in place. And f) equity to ensure that the program benefits all demographic groups. Actions at the regional and state level are focused on finding funding and ensuring the proper use of the resources invested in the program. At the federal level, the Safe Routes Partnership advocates for policy and funding support and provides expert help, ideas and resources for the leaders at all levels. ¹³⁹	1. Investing in infrastructure, programs, and policies that promote active transportation to and from school. 2. Allocating funding to provide and improve infrastructure to encourage active transportation (e.g., sidewalks, crosswalks, bike lanes, trails, etc.). 3. Encouraging children at home to use active transportation to school and other neighborhood locations. 4. Investing in infrastructure and policies such as Safe Routes to School and walking school buses. 5. Informing parents (at all income levels) about the benefits of active transportation. ¹⁴⁰	1. The study of locations where children and adolescents walk and bike, duration and distance of trips as well as the main reasons for not engaging in active transportation. 2. Surveillance systems should include children under 12 years old. ¹⁴⁰

Discussion

Our results suggest that about half of children and adolescents use active modes of transportation to get to and from places, mainly to and/or from school. However, a pooled estimate of the global prevalence of active transportation cannot be calculated from the Global Matrix 3.0 data for reasons that will be discussed below. Despite the clear gradient in average grades according to HDI that has been discussed in previous publications,^{141–143} our results show variability within HDI groups and the LPA allowed us to examine the clustering of this sample of countries according to three variables of interest (active transportation grades, level of development and income inequality).

Comparability of data

There was wide variability between countries in the prevalence of active transportation, and high involvement in this behaviour was reported across countries with very different socioeconomic contexts (e.g. Japan, Zimbabwe, Nepal, Denmark and Finland). However, the data reported by the countries presented in Table 3 show important methodological differences that should be accounted for when comparing the prevalence of active transportation between countries. One of the issues that can affect the comparability of data is the difference in the frequency of use of active transportation reported by the countries. Depending on the cut-point used to define children as active travelers, the prevalence will vary widely, and the use of active transportation can be overestimated or underestimated. Similarly, the prevalence may vary depending on the direction of active transportation assessed since different modes can be used to go to and from school. As observed in previous comparisons of surveillance systems measuring active transportation, the prevalence of active transportation varies greatly according to the construct assessed.¹⁴⁴ In the group of countries included in this analysis, the frequencies reported varied

from daily to at least twice per week. Even when the source of information was the same survey (e.g. the GSHS across countries), different frequencies were reported.^{136,145–147} Regarding the construct assessed, the destination for active transportation is also relevant. Despite the broad definition of active transportation in the Global Matrix 3.0 benchmarks,¹⁴ most of the evidence available on active transportation in children is focused on the journeys to and from school, as observed in this analysis and in previous literature.¹⁴⁸ Only Ecuador and the United States reported the use of active transportation to other destinations, which could suggest an underestimation of the involvement in active transportation in other countries since trips to places such as parks and other people's homes are also relevant opportunities to engage in this behaviour.¹⁴⁹ These findings point to a need for the development of harmonized and contextualized measurements. Our results are consistent with the findings reported by Herrador-Colmenero et al. in a systematic review, in which the formulation of a standardized question is proposed to overcome the heterogeneity in measures to assess active transportation.¹⁵⁰ Based on these insights, initiatives like the Global Matrix and organizations like the AHKGA can contribute to the improvement of surveillance systems for the evaluation of active transportation among children.

The Global Matrix initiative aims to better understand the global variation of certain physical activity indicators.¹⁴ Specifically, active transportation is one of the most strategic indicators in the Global Matrix 3.0 to contribute to this aim, due to the low amount of INC grades, and the good dispersion of grades across countries.¹⁴ However, the availability of transportation-relevant contextual variables at the country level to understand these variations was limited. Therefore, the LPA provides an exploratory approach to identify subgroups that share similar patterns of variables,^{20,151} and provides a unique opportunity to identify the ways in which countries in the

Global Matrix 3.0 cluster, according to the grades for active transportation and contextual variables. The identified profiles can be useful for the discussion of the different contexts in which active transportation needs to be maintained or increased. A description of the three profiles is provided below.

Country profiles for active transportation and sociodemographic variables

Profile 1 included mainly countries with a very high HDI and low income inequality, mostly with a reported prevalence of active transportation under 50%. Mainly, countries from North America, Europe and Oceania were grouped in this profile. While the countries with the lowest prevalence of active transportation were classified in this group (Chile, the United States and Canada), it also included some countries with non-negligible prevalence of active transportation such as the Netherlands, Belgium and the Czech Republic. This means that although all of these countries have a similar development level, there are other relevant factors influencing active travel among children. First, some of these are countries where long distances between destinations and the perceived convenience of driving may undermine opportunities for active travel.^{101,152–154} Second, urban planning and policies that have prioritized people instead of cars, as well as supportive infrastructure have made active modes a convenient and safe alternative to commute.^{155,156} Interventions in countries under this profile should aim to increase active transportation addressing the issues of distance and convenience, attempting to discourage the use of motorized vehicles for short trips, and trying to shift the social norms to consider active modes the default option for commuting as it occurs in many European countries. A useful example among the policies reported in the Report Cards is the National Cycling Policy from Sweden, which aims to prioritize cycling in the community and municipalities planning.¹²³

Profile 2 grouped mostly countries with high prevalence of active transportation, low to medium HDI and higher income inequalities. In most of these countries, access to motorized vehicles is limited, and active travel is happening despite multiple safety concerns^{157,158} and the lack of supportive infrastructure.¹⁴³ Therefore, for many families, active transportation is likely to reflect necessity rather than choice.¹⁵⁹ Also, many of the countries in this group report important differences between children from rural and urban areas.^{117,120,145} As suggested by a previous systematic review on active transportation in Africa, these differences could be indicative of the physical activity transition that these countries are experiencing.^{157,160} In this context, for the countries classified in this profile, preserving active travel while providing improved safety and infrastructure conditions should be a priority. It is important to design strategies to avoid the unintended consequences that economic growth can have on the mode of transport for children and adolescents. A good example of the approaches needed in countries under this profile is the Non-Motorized Transport Policy from Lagos, Nigeria. This policy aims to prioritize active modes of transportation over motorized options, communicating the benefits and importance of active transportation, as well as improving safety conditions for students using active modes to go to school.¹¹⁶

Profile 3 had more variability in terms of HDI and income inequality, however, the relatively high prevalence of active transportation was a main feature in common between this group of countries. Some of the most successful countries in active transportation are grouped under this profile. However, the conditions in which it is happening are very different. There are countries such as Finland, Denmark, Japan, South Korea and Hong Kong where the use of active modes is supported by the design of compact cities, school siting policies that ensure that children attend to schools located at a walkable distance from home, and supportive infrastructure and

regulations.^{103,104,108,141,155,161} These factors have made walking and cycling safe options for the daily commuting. Conversely, there are countries like Colombia, Brazil, Mexico, Venezuela and South Africa, where active transportation is prevalent despite safety concerns, the lack of supportive infrastructure and regulations and is likely to be a necessity-driven behaviour.^{51,59,60,162–165} Similarly to profile 2, almost half of the countries in this profile have a relatively high Gini coefficient. However, this profile also includes countries with very low inequality, such as Finland and Denmark. Income inequality has been previously documented as a negative correlate of physical activity and organized sports involvement.^{14,19} Notwithstanding, the high prevalence of active transportation in both equal and unequal societies are consistent with literature that suggest that active transportation modes could be an opportunity to bridge the inequities in transportation 18 as well as in other domains of physical activity. Due to the diversity of contexts found in this profile, different approaches are needed to promote or maintain active travel. School siting policies that take into account the proximity between schools and children's homes, like those implemented in Japan and Hong Kong,^{103,104,107} can be useful for growing cities. Also, multi-component strategies, such as the Bike to school program in Colombia are a good reference for countries that aim to provide access, skills, and support to bike to school in safe conditions.¹¹⁰ Furthermore, Ciclovias or Open Streets programs are a good model for countries where active transportation to school is already prevalent and aim to increase walking and cycling to other destinations in the leisure time.^{112,166}

Regarding the strategies to improve active transportation, it is concerning to find that major correlates of active transportation such as distance and the perceived convenience of driving are not mentioned among the strategies proposed by the Report Card teams. Future versions of the Report Cards, as tools to communicate evidence to stakeholders, should take these important

factors into consideration in order to advocate for active transportation addressing its most important drivers.

Our results can contribute to the call for measures of conditions related to all children wellbeing made by a recent commission sponsored by the WHO, UNICEF and The Lancet. This commission identified that inequities and climate change are undermining children's right to a healthy environment in both, the poorest and wealthiest countries.¹⁶⁷ Given that the transportation sector accounts for almost 25% of global greenhouse gas emissions,¹⁶⁸ local, regional, and national policymakers and practitioners should implement interventions that support children's active transportation in all socioeconomic contexts.

Strengths and limitations of the study

Strengths of this study include the availability of active transportation data from 47 countries from all continents, and the harmonized selection of the best available evidence in each country. Our analyses contributed with a diverse context perspective to the emerging evidence on international comparisons of active transportation, which has focused on specific groups of countries in previous studies.^{169,170} Although most countries reported nationally representative data on active transportation, in some countries, the best available evidence consisted of local data. The main limitations of the study were the diversity in the quality of the data reported, and the broad benchmark proposed for active transportation in the Global Matrix 3.0, which led to variations in the definition of active transportation across countries. The important amount of missing data in the Community and Environment indicator (26%) and the heterogeneity of the data reported across countries did not allow to include it as a variable of interest in the LPA, despite its relevance for active transportation. For example, including data on average distances for active transportation by country in future studies could strengthen the model and enrich the

profiling of countries as distance is one of the most consistent predictors of active transportation. Also, since we analyzed aggregated data at the country level, a sample size of 47 is small and has limited power for the LPA. This could partly explain the heterogeneity observed in the profiles, mainly in profile 1. Regarding the policies and practices reviewed, there was also heterogeneity in the information reported across countries. Future versions of the Global Matrix can strengthen the guidance on desirable information to report in this regard, such as the inclusion of active transportation to school in National Education Acts or their equivalents in each country. The sample included in this study represents approximately 25% of the total countries in the world. The inclusion of a larger sample of countries in future studies could provide a clearer picture of profiles according to active transportation and sociodemographic variables.

Conclusions

This work allowed for a deeper exploration of the active transportation information reported by all the countries participating in the Global Matrix 3.0. Based on our findings, we identified the need to standardize definitions of active transportation to be able to make more meaningful comparisons. The LPA conducted allows for the inference that countries belonging to a specific profile have a greater probability of sharing certain characteristics among them compared to the countries belonging to other profiles. Given the variation by geographic region and even HDI, this approach is useful for identification of more meaningful groupings that can facilitate the cross-fertilization of efforts to promote active transportation, and therefore, to “power the movement to get kids moving”, as is intended by the Global Matrix initiative.¹⁷¹ The Active Healthy Kids Global Alliance can contribute to improving active travel surveillance providing guidance to countries involved in future versions of the Global Matrix. A more comprehensive approach to active transportation surveillance that considers duration, distance, frequency,

direction, other destinations than school and the contribution of active transportation to school to overall active transportation, could improve the understanding of this behaviour and its potential to increase overall physical activity.

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Chapter 9: General Discussion

Miquel Porta, in *The Dictionary of Epidemiology*, defines Epidemiology as “the study of the occurrence and distribution of health-related events, states, and processes in specified populations, including the study of the determinants influencing such processes, and the application of this knowledge to control relevant health problems”.¹ Aligned with this definition, this dissertation, developed as part of the requirements for the Doctorate in Philosophy degree in Epidemiology, analyzed the prevalence, patterns and correlates of physical activity and sedentary behaviours among Colombian children and adolescents. In this case, physical activity and sedentary behaviour indicators were the health-related events of interest. These behaviours were studied using surveillance data with descriptive and analytical approaches to understand the occurrence (in terms of prevalence), distribution (by relevant sociodemographic variables) and factors associated with engagement in these behaviours. A socio-ecological framework of health behaviours² was employed as the conceptual framework to understand the influence of contextual variables with the physical activity and sedentary behaviour indicators studied in this thesis. Also, several recommendations for practice and research were formulated in order to use the obtained knowledge to guide public health actions.

To accomplish the main objective of this thesis, three specific aims were proposed: first, to determine the prevalence of physical activity and sedentary behaviour indicators; second, to identify the factors associated with those indicators within a socio-ecological framework; and third, to draw international comparisons of the Colombian situation of physical activity and sedentary behaviour indicators. Five analyses were proposed and one research paper was developed for each of these analyses. The first three papers analyzed nationally representative data from the National Survey of Nutrition in Colombia. The last two manuscripts analyzed data

from the Global Matrix of Physical Activity in Children and Youth initiative. The first manuscript was focused on the prevalence of children and youth meeting physical activity guidelines and related correlates. The second paper examined the prevalence of active transportation to/from school and associated factors. The third paper described the prevalence and correlates of engaging in excessive recreational screen time. The fourth paper compared physical activity and sedentary behaviour indicators across ten countries with a similar human development index. Finally, the fifth paper compared active transportation data across the 49 countries in the Global Matrix 3.0 initiative. This chapter provides a summary and integrated discussion of the results obtained from the five analyses conducted, interprets the findings in the context of current literature and discusses the contributions of this dissertation to knowledge and practice, as well as future directions in research.

Summary of key results

Prevalence of physical activity and sedentary behaviour indicators

Overall, the results obtained in the first three manuscripts (Chapters 4 to 6) indicate that a low proportion of Colombian preschoolers, school-aged children and adolescents engaged in sufficient MVPA to meet the WHO physical activity guidelines for health.³⁻⁵ However, there is a potential to increase physical activity in the transport domain, as suggested by a moderate involvement in walking or cycling to/from school (Chapter 5). Nonetheless, actions are required to decrease the highly prevalent excessive recreational screen time since early ages.

Among preschoolers, only a quarter of Colombian children between 3 and 5 years were active, and of concern, only a third of this population engaged in unstructured play and 10% played outdoors for at least two hours per day.³ Adding to these concerns, half of the preschooler population were excessively exposed to recreational screen time (Chapter 6). However, it is

promising that 73% of children between 3 and 5 years of age walked or cycled to/from kindergarten or school (Chapter 5); this involvement should be increased or at least maintained.

In school-aged children, just a third of this population was active,³ with 74% engaged in active transportation to/from school (Chapter 5), and over 60% had excessive recreational screen time (Chapter 6). These estimates contribute to inform the context in which the increase in overweight is happening. Particularly in this population, the prevalence of overweight increased from 18.8% in 2010 to 24.4% in 2015 according to ENSIN data.⁶

Our results for the adolescent population are of great concern. Only 13% of the Colombian adolescents were active,³ with a slightly lower involvement in active transportation (68.8%) than other age groups (Chapter 5), and more than 70% of adolescents reported excessive recreational screen time (Chapter 6). These findings suggest that the physical inactivity and sedentary lifestyle problem is getting more evident with increasing age and supports the need to implement actions from early ages to prevent the detrimental effects of physical inactivity and sedentary behaviours later in life.⁷⁻¹⁰

Patterns and correlates of physical activity and sedentary behaviour indicators

The movement behaviour patterns observed included statistically significant differences by sex, ethnicity, body mass index, area of residence, wealth index and geographic region among other contextual variables. One of the most consistent patterns was the difference by sex observed in physical activity indicators, which indicates a concerning inequity for females, consistent with the global and regional situation reported elsewhere.¹¹ Active transportation differences by sex were evident only for adolescents. Another pattern of interest in the context of epidemiological transitions and socioeconomic development is the pattern observed by wealth index. We found

that children and adolescents in the first (lowest) wealth quartiles were more active and engaged in active transportation more frequently than higher wealth quartiles, while preschoolers, school-aged children and adolescents from the wealthiest quartile had a higher prevalence of excessive recreational screen time. These findings suggest that Colombia is in an early stage of the lifestyle transitions, in which, the wealthiest populations are at a greater risk of obesogenic environments and behaviours.¹² Although a different methodological approach is needed to demonstrate the hypothesis of an epidemiological/lifestyle transition, these findings coincide with the patterns observed in other low- and middle-income countries, and is opposite to the associations observed in high-income countries.¹³ Documenting these patterns can contribute evidence to plan timely actions to avoid the expected shift according to the epidemiological/lifestyle transitions in which the most vulnerable populations are at a higher risk of unhealthy behaviours.¹²

Some of the observed patterns were confirmed by the Poisson regressions for the correlates analyses, in which statistical associations remained after adjusting for age, sex and other relevant variables. We could observe correlates at the individual (sex, age, ethnicity, overweight or obesity), household (wealth index, devices and car availability), community (parks and programs) and environmental (geographic region) levels, confirming that as proposed in the socio-ecological models of health behaviours, multiple factors at different levels influence active and sedentary behaviours.² These identified correlates help to understand the difference in the engagement in active and sedentary behaviours among Colombian children, and can guide interventions to increase physical activity and decrease recreational screen time, thereby promoting healthy growth and development.

International comparisons

Another important contribution of epidemiology is the study of differences in health-related events between populations, especially in the case of global health issues,¹⁴ like the global crisis of physical inactivity.¹⁵ These comparisons help to understand different patterns in health behaviours and to learn from other contexts' experiences to address the health issue under study. The last two manuscripts (Chapters 7 and 8) used data from the Global Matrix 3.0 initiative to draw international comparisons.^{16,17} Manuscript number four compared 10 common physical activity indicators between countries with a similar HDI level (Chapter 7). And the fifth manuscript focused on active transportation and proposed a set of profiles to classify countries according to the prevalence of active transportation and contextual variables (Chapter 8). As described in the methodology (Chapter 3), the Global Matrix project follows a harmonized methodology to grade common indicators related to physical activity and sedentary behaviours.¹⁸ This approach helps to overcome the challenges of comparability of data collected from multiple sources and with different methodologies. In this initiative, countries reported their best available evidence to inform a set of standardized benchmarks using a harmonized grading framework.¹⁸ The comparison between ten countries with a high human development index found that this group of countries had low performance for both individual-level behavioural indicators and indicators of sources of influence, which can be translated into low engagement in active behaviours and a limited offer of opportunities for being active at different levels. This comparison also found that from this group, Brazil and China can be considered leaders in surveillance since their surveillance systems allowed them to inform all the indicators assessed in the Report Cards. Their experience could guide surveillance efforts in other countries with a similar development level.

As part of the analysis of patterns and combining it with international comparisons, the fifth manuscript used latent profile analyses as an exploratory approach to group countries sharing patterns of active transportation and socioeconomic variables. This analysis allowed us to group the 49 countries participating in the Global Matrix 3.0, under three different profiles: profile one grouped countries with very high human development index, low inequality and moderate to low prevalences of active transportation.¹⁷ Profile two grouped countries with low to medium human development index, high inequalities and high prevalences of active transportation.¹⁷ And profile three had more variability, grouping countries with high to very high human development index, low to high inequalities and moderate to high prevalences of active transportation.¹⁷ In this manuscript we attempted to go one step further than making raw comparisons between countries. We tried to identify groups in which meaningful comparisons could be made and that could contribute to advance the interchange of lessons to promote active transportation among children.

Summary of limitations and strengths

Some limitations of the analyses presented in this dissertation need to be taken into account. First, ENSIN data come from a cross-sectional survey, as does most of the data reported in the Global Matrix 3.0. The nature of those data precludes making inferences of causation. In addition, given that ENSIN indicators were measured for the first time among 3 to 17 year-old Colombians, it was not possible demonstrate evidence of a transition due to the lack of trends data that provide evidence of a transition in the studied lifestyles. Second, all the data included were self-reported or proxy-reported by children's parents or caregivers, which implies a risk of social desirability and recall bias that could have affected our estimations. Third, the validity and reliability of the questionnaires used in ENSIN, for school-aged children and adolescents, have

not been previously assessed in the Colombian context. And fourth, not all the data reported by the Global Matrix 3.0 countries were perfectly comparable. Different methodologies were used to measure the variables reported across countries, and different definitions of some constructs were observed.

However, there are several strengths that should be highlighted. First, the use of a large and nationally representative sample in the ENSIN analyses allowed for the production of informative indicators that can be generalized to the Colombian population of children and adolescents for the first time. Second, ENSIN was designed within a social determinants of health framework, which allowed for the inclusion of several key contextual variables to enrich the analysis. Third, a strength was the use of a database of harmonized grades from 49 countries that covered all inhabited continents and different levels of development and were informed by the best available evidence recognized by experts in physical activity from each country.

Thesis contributions to knowledge and practice

In a country where economic resources and policy evaluations are limited, periodic surveillance data can contribute to the monitoring of physical activity and sedentary behaviour indicators and the follow-up of the established targets adopted to promote more active and healthier lifestyles, like the Global Action Plan target to reduce physical inactivity prevalence by 15%.¹⁹ The analyses conducted in this dissertation respond to the need to increase reliable surveillance on physical activity indicators and its determinants in children and adolescents in an upper-middle-income country, as stated by the WHO in the Global Action Plan on Physical Activity 2018-2030.¹⁹ The study of physical behaviours in the early years contributes to the call made in a recent systematic review on physical activity and sedentary behaviour indicators in preschoolers from South America.²⁰ In this review, the authors recommend further research with large and

representative samples from countries other than Argentina, Brazil and Chile to enrich the evidence on early years populations in the continent.²⁰ This dissertation also adds relevant evidence for the slightly greater but also emerging body of evidence for school-aged children and adolescents.

The research from this thesis also contributed to the strengthening of capabilities to support population surveillance of physical activity and sedentary behaviours, in this case among children and adolescents, and especially in Colombia. This aligns with the specific actions proposed by the WHO to achieve strategic objective four of the Global Action Plan on Physical Activity that aims to create active systems.¹⁹ In this particular case, the use of survey data from the National Survey of Nutrition can strengthen the surveillance system in Colombia and motivate the continuous monitoring of physical activity and sedentary behaviour indicators in the country. As it was described in the introduction of this thesis and throughout the different manuscripts, many of the indicators assessed in these analyses were available for the first time in the country, and to the best of our knowledge, it is the best available evidence with national representativeness. In this context, it is crucial for the surveillance system that these data are used, analyzed, and communicated.

Recommendations and future directions

Future studies in Colombia should incorporate an ethnic minority focus to deepen the cultural norms in the use of time and drivers of movement behaviours of indigenous and Afro-Colombian children and adolescents. This could contribute to have a better understanding of the associations observed in this dissertation. Also, the national surveillance of physical activity and sedentary behaviours in Colombia needs to be maintained and strengthened if possible. The continuous surveillance of these indicators will facilitate trend analyses that will provide valuable

information of possible shifts or transitions in the patterns observed, adding evidence to the epidemiological transition literature. The addition of sleep surveillance to allow an integrated approach of movement behaviours is recommended to understand the combination of movement behaviours throughout the day.²¹ Our results also demonstrate the need to advance in improving the global harmonization of validated tools to assess physical activity and sedentary behaviour indicators to facilitate comparisons between countries. Future versions of ENSIN and the Global Matrix initiative can be improved by taking into account the limitations and recommendations discussed in Chapters 4 to 8. Also, recommendations to improve the opportunities for children and adolescents to be active and decrease sedentary behaviours are provided in each of the manuscripts that are integrated in this dissertation. Those recommendations are even more relevant nowadays in the current context of the coronavirus disease 2019 (COVID-19) pandemic, in which the observed problems of physical inactivity and excessive sedentary behaviour have been probably magnified.²²

Conclusions

Considering the disease and economic burden of physical inactivity,²³ the promotion of healthy lifestyles should be a priority action in public health, and for this purpose, the study of physical activity and sedentary behaviour indicators among the youngest population is crucial to better design programs and establish feasible goals. This dissertation adds to the scarce evidence on movement behaviours among children and adolescents from Latin America, a traditionally under-represented region in the global surveillance of physical activity and sedentary behaviours. It showed that Colombian children and adolescents have a low prevalence of meeting physical activity guidelines, a moderate prevalence of engaging in active transportation to school and a concerning high prevalence of excessive recreational screen time. This dissertation also

provided insights on relevant contextual variables that influence positively and negatively the engagement in active and sedentary behaviours. The identified correlates are expected to support the design of actions to promote active behaviours and decrease recreational screen time in Colombia and other countries with similar socioeconomic and politic environments. Also, the international comparisons conducted provided evidence on the urgency of implementing actions to improve healthy childhood movement behaviours around the world.

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Appendices

Appendix 1. Physical Activity and Sedentary Behaviours Questionnaire (Translated) for Pre-school Children (3-5 years old)

A. During the last week, did (name of the child) go to the care center, kindergarten or school?

1 ☐ Yes

2 ☐ No → Skip to question 5

“The information that you will provide below, corresponds to the activities that (name of the child) did during the LAST 7 DAYS OUT of the school setting. This section refers to activities that need a higher effort, increase the heart beats, make breathe harder and sometimes sweat; for example: walking, running, playing with a ball or practising any sport.”

Example #1 (For the interviewer)

1. During the last 7 days, did (name of the child) walk to go FROM home to school?	1 ☐ Yes → 2 ☐ No	1a. How much time did he/she spend? <table border="1"> <tr> <th></th> <th>Monday</th> <th>Tuesday</th> <th>Wednesday</th> <th>Thursday</th> <th>Friday</th> </tr> <tr> <td>Hours</td> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>Mins</td> <td>4</td> <td>5</td> <td>0</td> <td>0</td> <td>1</td> </tr> </table>		Monday	Tuesday	Wednesday	Thursday	Friday	Hours	0	0	0	1	0	Mins	4	5	0	0	1									
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Hours	0	0	0	1	0																								
Mins	4	5	0	0	1																								
2. Last week, did (...) walk out of school?	1 ☐ Yes → 2 ☐ No	2a. How much time did he/she spend on weekdays? <table border="1"> <tr> <th></th> <th>Mon</th> <th>Tue</th> <th>Wed</th> <th>Thu</th> <th>Fri</th> </tr> <tr> <td>Hours</td> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>Mins</td> <td>4</td> <td>5</td> <td>0</td> <td>0</td> <td>1</td> </tr> </table> 2b. How much time did he/she spend on weekend days? <table border="1"> <tr> <th></th> <th>Sat</th> <th>Sun</th> </tr> <tr> <td>Hours</td> <td>0</td> <td>0</td> </tr> <tr> <td>Mins</td> <td>4</td> <td>5</td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours	0	0	0	1	0	Mins	4	5	0	0	1		Sat	Sun	Hours	0	0	Mins	4	5
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1. During the last 7 days, did (name of the child) walk to go FROM home to school?	1 ☐ Yes → 2 ☐ No	1a. How much time did he/she spend? <table border="1"> <tr> <th></th> <th>Monday</th> <th>Tuesday</th> <th>Wednesday</th> <th>Thursday</th> <th>Friday</th> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		Monday	Tuesday	Wednesday	Thursday	Friday	Hours						Mins					
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2. During the last 7 days, did (...) use any motorized vehicle (car, taxi, motorcycle, bus) to go FROM home to school?	1 ☐ Yes → 2 ☐ No	2a. How much time did he/she spend? <table border="1"> <tr> <th></th> <th>Monday</th> <th>Tuesday</th> <th>Wednesday</th> <th>Thursday</th> <th>Friday</th> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		Monday	Tuesday	Wednesday	Thursday	Friday	Hours						Mins					
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3. During the last 7 days, did (...) walk to go BACK FROM school to home?	1 ☐ Yes → 2 ☐ No	3a. How much time did he/she spend?										
			Monday	Tuesday	Wednesday	Thursday	Friday					
		Hours										
		Mins										
4. During the last 7 days, did (...) use any motorized vehicle (car, taxi, motorcycle, bus) to go BACK FROM school to home?	1 ☐ Yes → 2 ☐ No	4a. How much time did he/she spend?										
			Monday	Tuesday	Wednesday	Thursday	Friday					
		Hours										
		Mins										

“Now I will ask you about the activities that (...) did inside and outside the house, during the last week.”

5. Last week, did (...) play inside the house?	1 ☐ Yes → 2 ☐ No	5a. How much time did he/she spend on weekdays?										
			Mon	Tue	Wed	Thu	Fri					
		Hours										
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6. Last week, did (...) play outside the house? (This question refers to outdoor play)	1 ☐ Yes → 2 ☐ No	5b. How much time did he/she spend on weekend days?										
			Sat	Sun								
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		Mins										
7. Last week, did (...) practice any organized sport? (Teams of basketball, soccer, swimming, roller blading, cheerleading, cycling, etc.)	1 ☐ Yes → 2 ☐ No	6a. How much time did he/she spend on weekdays?										
			Mon	Tue	Wed	Thu	Fri					
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		Mins										
8. Last week, did (...) walk out of school?	1 ☐ Yes → 2 ☐ No	7a. How much time did he/she spend on weekdays?										
			Mon	Tue	Wed	Thu	Fri					
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		8a. How much time did he/she spend on weekdays?										
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		8b. How much time did he/she spend on weekend days?										
			Sat	Sun								
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9. Last week, out of school, did (...) play with a ball?	1 ☐ Yes → 2 ☐ No	9a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> 9b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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10. Last week, out of school, did (...) ride a bike, roller blades, skateboard, scooter?	1 ☐ Yes → 2 ☐ No	10a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> 10b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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11. Last week, out of school, did (...) play or swim in the pool, river, lake, lagoon, ocean or brook?	1 ☐ Yes → 2 ☐ No	11a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> 11b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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12. Last week, out of school, did (...) play at the park?	1 ☐ Yes → 2 ☐ No	12a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> 12b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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13. Last week, out of school, did (...) play with friends, neighbors or relatives?	1 ☐ Yes → 2 ☐ No	13a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table> 13b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td> <td></td> </tr> <tr> <td>Mins</td> <td></td> <td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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SEDENTARY BEHAVIOURS

“The information that you will provide below, corresponds to the activities that (name of the child) did during the LAST 7 DAYS OUT of the school setting.”

Sedentary behaviours are those that require minimum or none movement and need low effort, for example: watching TV, reading a book, playing with the smartphone or tablet, using the computer, among others.

14. During the last 7 days, did (...) watch television, movies or videos in the TV?	1 ☐ Yes → 2 ☐ No	14a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td><td></td><td></td><td></td> </tr> </table> 14b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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15. During the last 7 days, did (...) play or listen to music in the computer?	1 ☐ Yes → 2 ☐ No	15a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td><td></td><td></td><td></td> </tr> </table> 15b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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16. During the last 7 days, did (...) play with consoles such as X-Box, Play-Station, manual videogames such as Nintendo DS, etc., play with a cellphone, smartphone, iPad or other tablets?	1 ☐ Yes → 2 ☐ No	16a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td><td></td><td></td><td></td> </tr> </table> 16b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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17. During the last 7 days, did (...) take a nap or sleep during the day?	1 ☐ Yes → 2 ☐ No	17a. How much time did he/she spend on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td><td></td><td></td><td></td> </tr> </table> 17b. How much time did he/she spend on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td> </tr> </table>		Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours			Mins		
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18. During the last 7 days, how long did (...) sleep during the night? <i>In case the caregiver can not count the number of hours per day, ask what time does (...) go to bed and what time does he/she wake up. Based on that information, estimate and register the time for each day.</i>	18a. How much time did he/she sleep on weekdays? <table border="1"> <tr> <td></td> <td>Mon</td> <td>Tue</td> <td>Wed</td> <td>Thu</td> <td>Fri</td> </tr> <tr> <td>Hours</td> <td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>Mins</td> <td></td><td></td><td></td><td></td><td></td> </tr> </table> 18b. How much time did he/she sleep on weekend days? <table border="1"> <tr> <td></td> <td>Sat</td> <td>Sun</td> </tr> <tr> <td>Hours</td> <td></td><td></td> </tr> </table>			Mon	Tue	Wed	Thu	Fri	Hours						Mins							Sat	Sun	Hours					
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ELECTRONIC DEVICES

“Please indicate if (name of the child) has the following electronic devices”

19. Does (...) have a TV in his/her room?	1 ☐ Yes 2 ☐ No
20. Does (...) have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)?	1 ☐ Yes 2 ☐ No

PARKS

21. Are there any parks, green spaces, recreation facilities or sports facilities in your neighborhood, where (...) can play?	1 ☐ Yes 2 ☐ No
22. Is it safe for (...) to play at the park in your neighborhood? (under supervision)	1 ☐ Yes 2 ☐ No

23. During the last 12 months, did any doctor or health professional recommended (...) to start or continue exercising, doing any physical activity or playing sports?	1 ☐ Yes 2 ☐ No 3 ☐ The child did not go to the doctor in the last 12 months.

Appendix 2. Physical Activity and Sedentary Behaviours Questionnaire (Translated) for School-aged Children (6-12 years old)

Grip Strength measure														
1. Dominant side 1 ☐ Right 2 ☐ Left 3 ☐ Both	<i>Remember that the difference between measures should not exceed 10% between measure 1 and measure 2. If the difference is higher than 10% a third measure should be registered.</i>	1b. ☐ The measure was not taken Notes: 												
	<table border="1"> <thead> <tr> <th>1a. Measure</th> <th>Right</th> <th>Left</th> </tr> </thead> <tbody> <tr> <td>Measure 1</td> <td>.</td> <td>.</td> </tr> <tr> <td>Measure 2</td> <td>.</td> <td>.</td> </tr> <tr> <td>Measure 3</td> <td>.</td> <td>.</td> </tr> </tbody> </table>	1a. Measure	Right	Left	Measure 1	.	.	Measure 2	.	.	Measure 3	.	.	
1a. Measure	Right	Left												
Measure 1	.	.												
Measure 2	.	.												
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2. During the last week (past 7 days), on how many days was (name of the child) physically active for at least 60 minutes per day? (Add up all the time (...) spent in any kind of physical activity that increased his/her heart rate and made him/her breathe hard some of the time.)	Number of days: _____
3. During the last week (past 7 days), how many days did (...) do exercises to strengthen or tone his/her muscles, such as squats, sit-ups, push-ups, weight lifting, cheerleading, monkey bars or mountain hiking?	Number of days: _____

SEDENTARY BEHAVIOURS

For the following questions, please tell me about what (...) did last week:

4. On an average SCHOOL DAY or WEEKDAY, how many hours did (...) watch TV? 1 ☐ (...) did not watch TV on an average school day 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
5. On an average SCHOOL DAY or WEEKDAY, how many hours did (...) play video games or use a computer for something that is NOT SCHOOL WORK? (Count time spent using Xbox, PlayStation, iPod, iPad or other tablet, smartphone, cellphone, Youtube, Facebook or other social media and internet.) 1 ☐ (...) did not play video or computer games or use a computer for something that is not school work 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
6. On a WEEKEND DAY, how many hours did (...) watch TV? 1 ☐ (...) did not watch TV on weekend days 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours

5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
7. On a WEEKEND DAY, how many hours did (...) play video games or use a computer for something that is NOT SCHOOL WORK? <i>(Count time spent using Xbox, PlayStation, iPod, iPad or other tablet, smartphone, cellphone, Youtube, Facebook or other social media and internet.)</i> 1 ☐ (...) did not play video or computer games or use a computer for something that is not school work 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day

8. During the LAST WEEK (past 7 days), did (...) do any of these activities? <i>Read all the response options and check all that apply</i> a ☐ Sports teams (soccer, basketball, volleyball, etc.)? b ☐ Organized groups (dance, martial arts, etc.)? c ☐ Attend Ciclovía (when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes)? w ☐ None of these

A. During the last week, did (...) go to the school or any education institution?

1 ☐ Yes → *Continue*

2 ☐ No → *Skip to question 13*

TRANSPORT

9. In the last week (...) attended school (last 7 days), the MAIN part of her/his journey TO SCHOOL was by: 1 ☐ Walking? 2 ☐ Bicycle, roller-blade, skateboard or scooter? 3 ☐ Bus, public transportation? 4 ☐ Car? 5 ☐ Motorcycle? -1 ☐ Other? _____
10. In the last week (...) attended school (last 7 days) school, HOW LONG did it take (...) to travel FROM HOME TO SCHOOL? 1 ☐ Less than 5 minutes 2 ☐ Between 5 and 15 minutes 3 ☐ Between 16 and 30 minutes 4 ☐ Between 31 minutes and 1 hour 5 ☐ More than 1 hour
11. In the last week (...) attended school (last 7 days), the MAIN part of her/his journey FROM SCHOOL to home was by: 1 ☐ Walking? 2 ☐ Bicycle, roller-blade, skateboard or scooter? 3 ☐ Bus, public transportation? 4 ☐ Car? 5 ☐ Motorcycle? -1 ☐ Other? _____
12. In the last week (...) attended school (last 7 days) school, HOW LONG did it take (...) to travel FROM SCHOOL TO HOME?

1 ☐ Less than 5 minutes 2 ☐ Between 5 and 15 minutes 3 ☐ Between 16 and 30 minutes 4 ☐ Between 31 minutes and 1 hour 5 ☐ More than 1 hour

ELECTRONIC DEVICES

“Please indicate if (name of the child) has the following electronic devices”

13. Does (...) have a TV in his/her room?	1 ☐ Yes 2 ☐ No
14. Does (...) have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)?	1 ☐ Yes 2 ☐ No

PARKS

15. Are there any parks, green spaces, recreation facilities or sports facilities in your neighborhood, where (...) can play?	1 ☐ Yes 2 ☐ No → <i>Skip to question 17</i>
16. Is it safe for (...) to play at the park in your neighborhood? (under supervision)	1 ☐ Yes 2 ☐ No

17. During the last 12 months, did any doctor or health professional recommended (...) to start or continue exercising, doing any physical activity or playing sports?	1 ☐ Yes 2 ☐ No 3 ☐ The child did not go to the doctor in the last 12 months.

Appendix 3. Physical Activity and Sedentary Behaviours Questionnaire (Translated) for Youth (13-17 years old)

Grip Strength measure														
1. Dominant side 1 ☐ Right 2 ☐ Left 3 ☐ Both	<i>Remember that the difference between measures should not exceed 10% between measure 1 and measure 2. If the difference is higher than 10% a third measure should be registered.</i>	1b. ☐ The measure was not taken Notes: 												
	<table border="1"> <thead> <tr> <th>1a. Measure</th> <th>Right</th> <th>Left</th> </tr> </thead> <tbody> <tr> <td>Measure 1</td> <td>.</td> <td>.</td> </tr> <tr> <td>Measure 2</td> <td>.</td> <td>.</td> </tr> <tr> <td>Measure 3</td> <td>.</td> <td>.</td> </tr> </tbody> </table>	1a. Measure	Right	Left	Measure 1	.	.	Measure 2	.	.	Measure 3	.	.	
1a. Measure	Right	Left												
Measure 1	.	.												
Measure 2	.	.												
Measure 3	.	.												

2. During the last week (past 7 days), on how many days were you physically active for at least 60 minutes per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)	Number of days: _____
3. During the last week (past 7 days), how many days did you do exercises to strengthen or tone your muscles, such as squats, sit-ups, push-ups, weight lifting, cheerleading, monkey bars or mountain hiking?	Number of days: _____

SEDENTARY BEHAVIOURS

For the following questions, please tell me about what you did last week:

4. On an average SCHOOL DAY or WEEKDAY, how many hours did you watch TV? 1 ☐ I did not watch TV on an average school day 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
5. On an average SCHOOL DAY or WEEKDAY, how many hours did you play video games or use a computer for something that is NOT SCHOOL WORK? (Count time spent using Xbox, PlayStation, iPod, iPad or other tablet, smartphone, cellphone, Youtube, Facebook or other social media and internet.) 1 ☐ I did not play video or computer games or use a computer for something that is not school work 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
6. On a WEEKEND DAY, how many hours did you watch TV? 1 ☐ I did not watch TV on weekend days 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours

4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day
7. On a WEEKEND DAY, how many hours did you play video games or use a computer for something that is NOT SCHOOL WORK? (Count time spent using Xbox, PlayStation, iPod, iPad or other tablet, smartphone, cellphone, Youtube, Facebook or other social media and internet.) 1 ☐ I did not play video or computer games or use a computer for something that is not school work 2 ☐ Less than 1 hour per day 3 ☐ Between 1:00 and 1:59 hours 4 ☐ Between 2:00 and 2:59 hours 5 ☐ Between 3:00 and 3:59 hours 6 ☐ Between 4:00 and 4:59 hours 7 ☐ 5 or more hours per day

B. During the last week, did you go to the school or any education institution?

1 ☐ Yes → *Continue*

2 ☐ No → *Skip to question 13*

8. In the last week you were in school (last 7 days), on how many days did you go to physical education (PE) classes?	Number of days: _____

TRANSPORT

9. In the last week you attended school (last 7 days), the MAIN part of your journey TO SCHOOL was by: 1 ☐ Walking? 2 ☐ Bicycle, roller-blade, skateboard or scooter? 3 ☐ Bus, public transportation? 4 ☐ Car? 5 ☐ Motorcycle? -1 ☐ Other? _____
10. In the last week you attended school (last 7 days) school, HOW LONG did it take you to travel FROM HOME TO SCHOOL? 1 ☐ Less than 5 minutes 2 ☐ Between 5 and 15 minutes 3 ☐ Between 16 and 30 minutes 4 ☐ Between 31 minutes and 1 hour 5 ☐ More than 1 hour
11. In the last week you attended school (last 7 days), the MAIN part of your journey FROM SCHOOL to home was by: 1 ☐ Walking? 2 ☐ Bicycle, roller-blade, skateboard or scooter? 3 ☐ Bus, public transportation? 4 ☐ Car? 5 ☐ Motorcycle? -1 ☐ Other? _____
12. In the last week you attended school (last 7 days) school, HOW LONG did it take you to travel FROM SCHOOL TO HOME? 1 ☐ Less than 5 minutes 2 ☐ Between 5 and 15 minutes 3 ☐ Between 16 and 30 minutes 4 ☐ Between 31 minutes and 1 hour

5 ☐ More than 1 hour

ELECTRONIC DEVICES

“Please indicate if you have the following electronic devices”

13. Do you have a TV in your room?	1 ☐ Yes 2 ☐ No
14. Do you have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)?	1 ☐ Yes 2 ☐ No

PARKS

15. Are there any parks, green spaces, recreation facilities or sports facilities in your neighborhood, where you can play?	1 ☐ Yes 2 ☐ No → <i>Skip to question 17</i>
16. Is it safe for you to play at the park in your neighborhood?	1 ☐ Yes 2 ☐ No

17. During the last 12 months, did any doctor or health professional recommended (...) to start or continue exercising, doing any physical activity or playing sports?	1 ☐ Yes 2 ☐ No 3 ☐ The child did not go to the doctor in the last 12 months.

PROGRAMS

18. Which of the following physical activity programs promoted in your city or municipality do you know or have heard about: <i>(Check all the options that apply. If the response is “No” for all the options, proceed to the Body Self-Perception component)</i>		
1. Ciclovías? <i>(when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes)</i> 2. Physical activity classes? <i>(e.g. aerobics classes, rumba, stretching, yoga, etc.)</i> 3. Physical activity programs at school? 4. Sports clubs? 5. Organized groups? <i>(dance, martial arts, etc.)</i>	Yes 1 ☐	No 2 ☐
19. In the last month, did you participate in any of the following physical activity programs: <i>(Ask only about the programs referred by the adolescent in the previous question. Check all the options that apply. If the response is “No” for all the options, proceed to the Body Self-Perception component)</i>		
1. Ciclovías? <i>(when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes)</i> 2. Physical activity classes? <i>(e.g. aerobics classes, rumba, stretching, yoga, etc.)</i> 3. Physical activity programs at school? 4. Sports clubs? 5. Organized groups? <i>(dance, martial arts, etc.)</i>	Yes 1 ☐	No 2 ☐
20. How often have you had participated in this/these program(s)? <i>If the adolescent has participated in more than one program, sum the total participation</i> 1 ☐ Once per month 2 ☐ Twice per month 3 ☐ Three times per month 4 ☐ Four times per month or more		

Appendix 4. University of Ottawa Ethics Approval

19/06/2019

Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number

H-06-19-3564

Titre du projet / Project Title

Physical activity and sedentary behaviours among Colombian children and youth: Patterns, correlates and international comparisons

Type de projet / Project Type

Thèse de doctorat / Doctoral thesis

Statut du projet / Project Status

Approuvé / Approved

Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)

19/06/2019

Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)

18/06/2020

Équipe de recherche / Research Team

Chercheur /
Researcher

Affiliation

Role

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Département d'épidémiologie et santé publique / Department of Epidemiology and Public Health

Chercheur Principal / Principal Investigator

Mark TREMBLAY

Département de pédiatrie / Department of Paediatrics

Superviseur / Supervisor

Conditions spéciales ou commentaires / Special conditions or comments

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Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout événement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completed four weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Riana MARCOTTE

Responsable d'éthique en recherche / Protocol Officer

Pour/For Daniel LAGAREC Président(e) du/ Chair of the Comité d'éthique de la recherche en sciences sociales et humanités / Social Sciences and Humanities Research Ethics Board

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Appendix 5. Published version of Manuscript 1 Prevalence and Correlates of Meeting Physical Activity Guidelines Among Colombian Children and Adolescents

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ORIGINAL RESEARCH

Prevalence and Correlates of Meeting Physical Activity Guidelines Among Colombian Children and Adolescents

Silvia A. González, Olga L. Sarmiento, Peter T. Katzmarzyk, Jean-Philippe Chaput, Diana M. Camargo-Lemos, and Mark S. Tremblay

Background: Global estimates have shown that a small proportion of children and adolescents are physically active. However, the evidence on physical activity (PA) among Colombian children and adolescents is limited. The objective of this study was to describe the prevalence and correlates of meeting PA guidelines among Colombian children and adolescents. **Methods:** Data were collected as part of the National Survey of Nutrition 2015. A national sample of 16,612 children and adolescents (3–17 y) was included. Prevalence estimates of meeting PA and active play guidelines were calculated, and Poisson regression models were conducted to identify correlates of PA. **Results:** Low proportion of Colombian children and adolescents met the PA guidelines. Low engagement in active play was observed among preschoolers. Correlates varied by age group. Female sex was a consistent negative correlate of meeting PA guidelines across all age groups. **Conclusions:** Urgent actions are needed to promote active play and PA among Colombian children and adolescents. The correlates identified in our study can help inform the development of actions to overcome the disparities and provide opportunities for children to achieve their full potential for healthy growth and development.

Keywords: surveillance, school-aged children, preschool, active play

Regular physical activity (PA) is one of the most important behaviors for health promotion and disease prevention.¹ Among preschoolers, PA is associated with improved motor and cognitive development, better psychosocial and metabolic health, and favorable fitness and bone health.² Similarly, in school-aged children and adolescents, PA is favorably associated with adiposity, cardio-metabolic risk factors, physical fitness, bone health, well-being, motor skills development, and psychological health.³ To obtain these benefits, the World Health Organization (WHO) recommends that children between 3 and 4 years of age should accumulate a daily minimum of 180 minutes in PAs of any intensity, of which at least 60 minutes should be moderate- to vigorous-intensity PA (MVPA).⁴ For children and adolescents between 5 and 17 years of age, the WHO recommends the accumulation of a minimum of 60 minutes of MVPA daily.⁵

Despite the multiple benefits of regular PA, the proportion of children and adolescents meeting the guidelines is small. According to the Global Matrix 3.0 of Report Card grades on PA, the proportion of children and adolescents meeting the guidelines is between 27% and 33%.⁶ A pooled analysis of data from 1.6 million students found that 81% of adolescents around the world do not achieve the recommended amount of PA.⁷ A study on Latin American and Caribbean children and adolescents reported that only 15% met the PA guidelines.⁸

Considering the important benefits of PA for health, and in response to the high prevalence of physical inactivity, the WHO launched the Global Action Plan on Physical Activity 2018–2030.⁹ This plan established a target of a 15% relative reduction in physical inactivity among adolescents and adults by 2030 and provides guidance on how to achieve this target.⁹ One of the main actions proposed is having reliable surveillance systems that provide quality data on multiple domains of PA and its sociocultural and environmental determinants, across all ages.⁹

In Colombia, PA and recreation are social rights, essential for the improvement of quality of life, and an indicator of social and human development.¹⁰ For this reason, multiple policies and strategies, like the WHO Global Action Plan, have been adopted to advance PA promotion, specifically for children and youth populations.¹¹ Following the WHO suggested actions, improved surveillance of PA in Colombia is desirable. The evidence on PA of Colombian children and adolescents has been limited, and comes mainly from regional or local studies.¹² The National Survey of Nutrition (ENSIN), in its most recent version (2015), provides nationally representative data on the PA of children and adolescents for the first time in the country's history. ENSIN provides rich contextual data and provides a unique opportunity to understand PA levels and correlates in Colombia. Using ENSIN data, this paper aims to describe the prevalence of PA among Colombian children and adolescents (3–17 y) and to explore the factors associated with meeting PA guidelines within a socio-ecological framework.

Methods

Study Setting

Colombia is an upper middle-income country, located in the north-west of South America. Geographically, Colombia is grouped into 6 regions: Orinoquia-Amazonia, Atlantic, Central, Eastern, Pacific,

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and Capital District.¹³ With a Gini index of 50.4, Colombia is among the countries with the highest income inequalities in the world.¹⁴ Colombia is classified as a country with a high Human Development Index (0.761).¹⁵ However, the Human Development Index varies considerably across the country.¹⁶ According to the 2018 population census, Colombia has 45.5 million inhabitants, of which 34% are children and adolescents under 18 years of age.¹⁷

Study Design and Participants

This study analyzed cross-sectional data from the ENSIN 2015 survey,¹³ a national population survey, representative of urban and rural areas of Colombia, with a stratified, multistage probability cluster sampling design. The survey, administered by the Colombian Institute of Family Welfare, was conducted at the household level and comprised different components. All selected households were included in the demographic and anthropometric components. For the PA component, a probabilistic subsample was identified based on the required samples per region and age group. The subsample for this analysis included 4507 preschoolers (3–5 y), 5336 school-aged children (6–12 y), and 6769 adolescents (13–17 y).

Data Collection

Data were collected by trained nutritionists equipped with computer-assisted personal interview technology, specifically designed for the survey. For preschoolers (3–5 y) and school-aged children (6–12 y), a parent or the primary caregiver of the child responded to the interview. For adolescents (13–17 y), the responses were self-reported to the interviewer. Data were collected in the household setting, between December 2015 and November 2016, and released in June 2019.

Informed consent was obtained before conducting the survey. For children and adolescents <18 years of age, parents or legal guardians provided their consent, and children between 12 and 17 years also provided informed assent. Local ethics approval to conduct the survey was granted by the *Profamilia* Institutional Review Board on Research Involving Human Subjects and the Colombian National Institutes of Health (reference number 2-2015; February 26, 2015). Approval for secondary data analyses was obtained from the University of Ottawa (Canada; file number H-06-19-3564).

Dependent Variables

The PA was self-reported or proxy reported in response to different questions according to age group. For preschool children, PA was assessed using the Questionnaire for the Measurement of PA and Sedentary Behaviors in preschool to fourth-grade children, which assesses PA out of school or day-care institutions among preschoolers to 10 year olds. This questionnaire has a moderate internal consistency for PA and high reproducibility mainly for walking to school and organized sports.¹⁸ For school-aged children and adolescents, PA was assessed with a question adapted from the US Youth Risk Behavior Surveillance System.¹⁹ Details on the questions, response options, and variables used in the analysis are provided in Table 1. For the analyses presented in this paper, dichotomous variables to indicate meeting/not meeting PA guidelines were created (Table 1). As sensitivity analyses, cutoffs of 5 and 6 days of MVPA were also examined for school-aged children and adolescents. Meeting muscle-strengthening recommendations for school-aged children and adolescents was explored descriptively.

Considering the importance of active play for the health and development of younger children, active play involvement was explored among preschoolers. Two variables to assess active play were created, based on the benchmarks proposed by the Active Healthy Kids Global Alliance,⁶ engagement in unstructured active play and involvement in outdoor play (Table 1).

Covariates

The covariates for this analysis were selected among the available variables in the database and taking into account the socioecological framework of PA²⁰; therefore, these variables belong to different levels of influence. For the individual level, sociodemographic (age and ethnicity) and biologic variables (sex and body mass index [BMI]) were included. Sociodemographic variables were measured in the Household Questionnaire of ENSIN.¹³ Ethnicity was assessed with a self-determination question described in Table 1. Ethnicity was reported by the household main respondent. Despite being one of the main social conditions considered in the survey, ENSIN was not designed to be representative by ethnicity. Weight and height were measured objectively (Table 1). BMI was calculated based on the direct measures of weight and height and categorized using the WHO growth standards and reference tables (Table 1).^{21,22}

For the household level, wealth index, area, the availability of TV in the child's bedroom and video games devices at home, and maternal adherence to PA guidelines were included. Availability of devices was assessed with questions adapted from the Neighborhood Impact on Kids survey,²³ and maternal PA was assessed with the International PA Questionnaire.²⁴ For the school level, the number of days with physical education classes was assessed, only for adolescents. At the community level, the availability and perceived safety of parks was assessed with questions adapted from the Neighborhood Impact on Kids survey,²³ and counseling on PA by health providers was assessed with a specific question designed for ENSIN (Table 1). For the natural environment level, the geographic region where children and adolescents lived was included. For the policy level, participation in organized sports, organized activity groups, Ciclovías (Open Street programs in Colombia),²⁵ and PA programs was assessed among adolescents (Table 1).

Statistical Analysis

Descriptive statistics of the sample and overall and stratified population-weighted prevalence estimates for PA and active play were calculated. Group differences were determined with chi-square tests. To estimate the factors associated with PA, prevalence ratios (PRs) were determined using Poisson regression models with robust variance. Bivariate models were conducted with each of the selected covariates. Multivariable models included the variables that showed at least marginally significant associations ($P < .10$) in the bivariate models and were adjusted for age and sex. The variables with P values $< .05$ were considered correlates of PA indicators. Given that all the variables were obtained at the household level, a multilevel modeling approach was not used. The analyses were conducted using STATA (version 14.0; StataCorp, College Station, TX) with the survey (SVY) module for complex samples to take into account the characteristics of the study design, sample weights, and missing data. This module accounts for the clustering of the data.

Table 1 Description of the Dependent Variables and Covariates Included in the Analyses of Meeting PA Guidelines and its Factors Associated Among Colombian Children and Adolescents

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Meeting PA guidelines among preschoolers	C-MAFYCS	– During the last 7 days, did (name of the child) walk to go FROM home to school? How much time did he/she spend? (for each day) – During the last 7 days, did (...) walk to go BACK FROM school to home? How much time did he/she spend? (for each day) – Last week, did (...) practice any organized sport? How much time did he/she spend? (for each day) – Last week, did (...) walk out of school? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play with a ball? How much time did he/she spend? (for each day) – Last week, out of school, did (...) ride a bike, roller blades, skateboard, scooter? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play or swim in the pool, river, lake, lagoon, ocean or brook? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play at the park? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play with friends, neighbors or relatives? How much time did he/she spend? (for each day)	The total time in all activities per weekdays and weekend days was estimated in minutes, and an average of minutes of PA per day was calculated. A dichotomous variable to indicate if the preschooler met PA guidelines was created, using a cutoff of 180 min of PA per day including at least 60 min of energetic play for preschool children.
Meeting PA guidelines among school-aged children	YRBSS	During the last week (past 7 days), on how many days was (name of the child) physically active for at least 60 minutes per day? (Add up all the time [...] spent in any kind of PA that increased his/her heart rate and made him/her breathe hard some of the time.) Number of days _____	A dichotomous variable to indicate if the child met PA guidelines was created, using a cutoff of 7 d of MVPA. Sensitivity analyses were conducted with cutoffs of 5 and 6 d of MVPA.
Meeting PA guidelines among adolescents	YRBSS	During the last week (past 7 days), on how many days were you physically active for at least 60 minutes per day? (Add up all the time you spent in any kind of PA that increased your heart rate and made you breathe hard some of the time.) Number of days _____	A dichotomous variable to indicate if the adolescent met PA guidelines was created, using a cutoff of 7 d of MVPA. Sensitivity analyses were conducted with cutoffs of 5 and 6 d of MVPA.
Meeting muscle-strengthening recommendations among school-aged children and adolescents	YRBSS	During the last week (past 7 days), how many days did (name of the child)/ you do exercises to strengthen or tone his/her/your muscles, such as squats, sit-ups, push-ups, weight lifting, cheerleading, monkey bars or mountain hiking? Number of days _____	A dichotomous variable to indicate if the child or adolescent met muscle-strengthening recommendations was created, using a cutoff of 3 d/wk of muscular-strengthening activities.
Unstructured play among preschoolers	C-MAFYCS	– Last week, out of school, did (...) play with a ball? How much time did he/she spend? (for each day) – Last week, out of school, did (...) ride a bike, roller blades, skateboard, scooter? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play or swim in the pool, river, lake, lagoon, ocean or brook? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play at the park? How much time did he/she spend? (for each day) – Last week, out of school, did (...) play with friends, neighbors or relatives? How much time did he/she spend? (for each day)	The total time in play activities per weekdays and weekend days was estimated in minutes, and an average of minutes of play per day was calculated. A dichotomous variable to indicate the engagement in unstructured play was created, using a cutoff of 120 min/d.

(continued)

Table 1 (continued)

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Outdoor play among preschoolers	C-MAFYCS	– Last week, did (...) play outside the house? How much time did he/she spend? (for each day)	The total time playing outdoors was obtained for weekdays and weekend days and the average of minutes of outdoor play per day was calculated. A dichotomous variable indicating the involvement in outdoor play was created, using a cutoff of 120 min/d.
Sex	Household Questionnaire of the ENSIN	Parent or self-report: male or female	Dichotomous variable: male or female
Age	Household Questionnaire of ENSIN	How old is (...)/? How old are you?	Continuous and categorical variables were included in the analyses: 3 and 4 vs 5 y old, 6–9 y old vs 10–12 y old, and 13–15 y old vs 16–17 y old.
Ethnicity	Household Questionnaire of ENSIN	According with your culture, town or physical characteristics, (...) is or recognize himself/ herself as: – Indigenous – Gipsy/Rom – Raizal of the archipelago – Palenquero from San Basilio – Black, mulatto, Afro-colombian, Afro-descendant – None of the mentioned above.	Categories were grouped and a new categorical variable was created with the following categories: Afro-Colombian vs Indigenous vs no ethnic identity reported.
Weight	Directly measured in kilograms using portable SECA 874 scales (Seca, Hamburg, Germany) after outer clothing and shoes were removed	Not applicable	Used as a continuous variable for the estimation of the BMI.
Height	Directly measured in centimeters with ShorrBoard stadiometers (Shorr Productions, Olney, MD) with the participants standing, with the head in the Frankfort plane, and 5 contact points of the body with the stadiometer: heels, calves, buttocks, shoulder blades, and head.	Not applicable	Used as a continuous variable for the estimation of the BMI.
BMI	Calculated based on the direct measures of weight and height	Not applicable	The continuous variable was categorized using the WHO growth standards and reference tables. For children under 5 y of age BMI was categorized as no excess (BMI z score $\leq +2$) vs overweight (BMI z score $>+2$ to $\leq +3$) vs obesity (BMI z score $>+3$). For children and adolescents between 5 and 17 y of age BMI was categorized as no excess (BMI z score $\leq +1$) vs overweight (BMI z score $>+1$ to $\leq +2$) vs obesity (BMI z score $>+2$).
Wealth index	Household Questionnaire of ENSIN	Wealth index was calculated based on asset ownership, availability of public utilities and the materials used for housing construction using a principal component analysis approach.	Wealth index was categorized into quartiles for the analyses.
Area	Household Questionnaire of ENSIN	Parent or self-report of the area where the household is located: municipal center vs. population centre vs. scattered rural.	Area categories were grouped into 2 categories: urban (municipal centers) and rural (population centers and scattered rural).
TV availability in the child's bedroom	NIK survey	Does (...) have a TV in his/her room?/ Do you have a TV in your room? Yes vs. No	Dichotomous variable: Yes or No

(continued)

Table 1 (continued)

Variable	Instrument	Question and response options	Variable processing and final variable used in the analysis
Video games availability in the child's bedroom	NIK survey	Does (...) have video games systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)?/Do you have videogames systems (Playstation, Xbox, cellphone, smartphone, iPod, iPad or other tablets, etc.)? Yes vs. No	Dichotomous variable: Yes or No
Maternal adherence to PA guidelines	IPAQ	Transport and leisure time domains of the IPAQ questionnaire on its long version.	Total minutes of PA on each domain were calculated and a dichotomous variable to indicate adherence to PA guidelines was created, using a cutoff of 150 min of moderate to vigorous activity per week.
PE frequency among adolescents	Adapted from YRBSS	In the last week you were in school (last 7 days), on how many days did you go to physical education (PE) classes? Number of days _____	The continuous variable was categorized into 3 categories: No class in the last week vs 1 day vs 2 or more days
Parks availability	Adapted from NIK survey	Are there any parks, green spaces, recreation facilities or sports facilities in your neighborhood, where (...) you can play? Yes vs. No	Dichotomous variable: Yes or No
Safety perception of parks	Adapted from NIK survey	Is it safe for (...) you to play at the park in your neighborhood? Yes vs. No	Dichotomous variable: Yes or No
Counseling on PA by health providers	Designed for ENSIN	During the last 12 months, did any doctor or health professional recommend (...) you to start or continue exercising, doing any PA or playing sports? Yes vs. No	Dichotomous variable: Yes or No
Geographic region	Household Questionnaire of ENSIN	Parent or self-report of the department where the household is located.	The reported departments were categorized into the following regions according to their geographical location: Orinoquia-Amazonia vs Atlantic vs Central vs Eastern vs Pacific vs Capital District
Participation in organized activities and programs among school-aged children	Designed for ENSIN	During the LAST WEEK (past 7 days), did (...) do any of these activities? Read all the response options and check all that apply ☐ Sports teams (soccer, basketball, volleyball, etc.)? ☐ Organized groups (dance, martial arts, etc.)? ☐ Attend Ciclovía (when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes)? ☐ None of these	Dichotomous variables were created for each response category to ascertain the participation in organized activities and programs: – Sports clubs (Yes vs No) – Organized groups (Yes vs No) – Ciclovías (Yes vs No)
Participation in organized activities and programs among adolescents	Designed for ENSIN	In the last month, did you participate in any of the following PA programs: a) Ciclovías? (when streets are closed to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes); b) PA classes? (e.g. aerobics classes, rumba, stretching, yoga, etc.); c) PA programs at school?; d) Sports clubs?; e) Organized groups? (dance, martial arts, etc.)	Dichotomous variables were created for each response category to ascertain the participation in organized activities and programs: – Ciclovías (Yes vs No) – PA classes (Yes vs No) – PA programs at school (Yes vs No) – Sports clubs (Yes vs No) – Organized groups (Yes vs No)
Frequency of participation in programs and organized activities among adolescents	Designed for ENSIN	How often have you had participated in this/these program(s)? <i>If the adolescent has participated in more than one program, sum the total participation</i> ☐ Once per month ☐ Twice per month ☐ Three times per month ☐ Four times per month or more	A categorical variable with the 4 response options was used for the analyses.

Abbreviations: BMI: body mass index; C-MAFYCS, Questionnaire for the Measurement of Physical Activity and Sedentary Behaviors in preschool to fourth-grade children; ENSIN, the National Survey of Nutrition in Colombia; IPAQ, International Questionnaire of Physical Activity; MVPA, moderate-to vigorous-intensity PA; NIK, Neighborhood Impact on Kids survey; PA, physical activity; PE, physical education; WHO, World Health Organization; YRBSS, US Youth Risk Behavior Surveillance System.

Results

Characteristics of the sample are presented in Tables 2 and 3. Respondents with missing data on the main variables of interest were excluded. Approximately 48% of the samples for the 3 age groups were females. The mean age was 4.0 years ($SD=0.8$), 8.9 years ($SD=2.0$), and 14.9 years ($SD=1.4$) for preschoolers, children, and adolescents, respectively. Over 80% of the sample did not recognize themselves as Afro-Colombian or Indigenous, so were categorized as other. Statistically significant differences were observed between males and females. Among preschoolers, males had a higher prevalence of overweight and obesity than females. For school-aged children, higher participation in sport clubs was observed among males, while females had a higher participation in organized activities. Among adolescents, females had a higher prevalence of overweight and obesity. Male adolescents reported a higher availability of parks in their neighborhood and higher safety perceptions than females. A higher proportion of females reported receiving PA counseling by health professionals, and there were differences by sex in the participation in programs (Table 3).

PA Prevalence

Preschool Children. Table 4 presents the results of PA and play among preschoolers according to the socio-ecological framework selected variables. The overall prevalence of meeting PA guidelines among preschoolers was 24.4% with a higher prevalence among males (Figure 1). Regarding unstructured play, 31.3% of preschoolers were involved in more than 2 hours per day, with higher participation among males. Approximately 10.9% of preschoolers played outdoors for more than 2 hours per day.

School-Aged Children. Overall, 31.1% of school-aged children met the PA guidelines, with a higher prevalence among males (35.8%; Figure 1) and several differences by sociodemographic and PA relevant variables (Table 5). When the vigorous activities and muscle-strengthening recommendations were considered, the prevalence estimate decreased to 3.1%, and sex differences remained (Figure 1). The sensitivity analyses showed that when 5- and 6-day cutoffs were used, the prevalence increased to 36.9% and 32.5%, respectively.

Adolescents. Among adolescents, 13.4% met the PA guidelines with higher levels among males (18.8%; Figure 1). Other significant differences were observed between groups (Table 5). When vigorous activities and muscle-strengthening recommendations were considered, the prevalence estimate decreased to 4.8% and a significant difference between males and females remained (Figure 1). The sensitivity analysis showed that when 5- and 6-day cutoffs were used, the prevalence increased to 20.5% and 15.7%, respectively.

Correlates of PA Indicators

Meeting PA Guidelines Among Preschoolers. According to the bivariate analyses, female sex, lower socioeconomic status, and TV availability in the bedroom were negatively associated with meeting PA guidelines. Afro-Colombian ethnicity and park availability were positively associated with meeting the PA guidelines. Multivariable analyses showed preschool females were less likely to meet the PA guidelines compared with males ($PR=0.70$, $P<.001$), as well as preschoolers in the third wealth quartile compared with the wealthiest ($PR=0.66$, $P=.016$). Afro-Colombian preschoolers were more likely to meet the PA guidelines compared with those

that did not report ethnic identity ($PR=1.36$, $P=.011$), and preschoolers who had parks in their neighborhood were more likely to be active than those who did not have any ($PR=1.23$, $P=.026$) (Figure 2A).

Unstructured Play Among Preschoolers. According to the bivariate models, female sex, living in rural areas, lower socioeconomic status, and living in the Orinoquia-Amazonia region were negatively associated with achieving 2 hours of unstructured play per day. Afro-Colombian ethnicity, video games devices availability, and having a park in the neighborhood were positively associated with unstructured play. According to the multivariable analysis, preschool females were less likely to engage in unstructured play compared with males ($PR=0.74$, $P<.001$). Afro-Colombian preschoolers were more likely to participate in unstructured play than those that did not report ethnic identity ($PR=1.54$, $P<.001$), and preschoolers who had parks in their neighborhood were more likely to spend more than 2 hours of unstructured play per day than their counterparts ($PR=1.22$, $P=.009$) (Figure 2B).

Outdoor Play Among Preschoolers. The bivariate models showed negative associations for outdoor play with female sex, obesity, and TV availability in the bedroom. Positive associations were observed with Afro-Colombian and indigenous ethnicity, lower socioeconomic status, living in a rural area, parks availability, safety perception, not receiving counseling in PA, and living in the Atlantic and Pacific regions. According to the multivariable analysis, Afro-Colombian preschoolers were more likely to engage in 2 daily hours of outdoor play compared with preschoolers who did not report ethnic identity ($PR=1.86$, $P=.001$; Figure 2C).

Meeting PA Guidelines Among School-Aged Children. The bivariate models showed negative associations with female sex, overweightness and obesity, TV availability in the child's bedroom, parks availability, and involvement in organized activities. Positive associations were found with younger age; Afro-Colombian and indigenous ethnicity; lower socioeconomic status; video games devices availability; parks availability; safety perception; and living in the Atlantic, Orinoquia-Amazonia, Central or Pacific region. According to the multivariable analysis, females were less likely to meet the PA guidelines than males ($PR=0.74$, $P<.001$), and children with obesity were less likely to meet the guidelines than their counterparts ($PR=0.60$, $P=.007$). Likewise, children who had a TV in their bedroom were less likely to be active than those who did not ($PR=0.83$, $P=.014$). In contrast, younger children (6–9 y old) were more likely to meet the PA guidelines than their older counterparts ($PR=1.67$, $P<.001$). Afro-Colombian children were more likely to be active than those who did not report an ethnic identity ($PR=1.42$, $P=.001$), and children from the Atlantic ($PR=1.75$, $P=.003$) and Amazonia-Orinoquia region ($PR=1.87$, $P=.001$) had an increased likelihood of being active than those from the Capital District (Figure 3).

Meeting PA Guidelines Among Adolescents. According to the bivariate models, negative associations were observed for female sex, overweightness, TV and video games devices availability, and participation in community programs. Positive associations were found for the first and second wealth quartiles, parks availability, and participation in Ciclovías, school programs, and sports clubs, as well as the participation in programs 4 times per month or more. Given that the program-related variables were available only for a subsample, 2 multivariable models were conducted. In the first multivariable model, all the variables associated in the bivariate

Table 2 Sociodemographic Characteristics of 4507 Preschool Children From Colombia—ENSIN 2015

Sociodemographic variables	Preschool children									P value
	Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	
Sex										
Female	2197	48.5	1.21		NA			NA		
Male	2310	51.6	1.21		NA			NA		
Age, y										
3–4	3002	70.2	1.03	1517	70.5	1.46	1485	69.8	1.35	.736
5	1505	29.8	1.03	793	29.5	1.46	712	30.2	1.35	
Ethnicity										
Afro-Colombian	441	9.1	0.78	222	8.2	0.81	219	10.0	1.11	.170
Indigenous	481	4.7	0.63	246	4.5	0.70	235	4.9	0.71	
Other	3547	86.2	0.84	1821	87.3	0.94	1726	85.1	1.17	
BMI categorization										
No excess ^b	3860	89.0	0.76	1936	86.6	1.22	1924	91.5	0.82	.002
Overweight	375	8.4	0.69	218	10.1	1.14	157	6.6	0.72	
Obesity	130	2.6	0.33	82	3.3	0.51	48	1.9	0.40	
Wealth quartiles										
First	2374	41.1	1.31	1198	40.3	1.58	1176	42.0	1.89	.650
Second	1086	26.3	1.18	575	27.6	1.50	511	24.9	1.56	
Third	713	20.3	1.22	365	19.6	1.34	348	21.0	2.04	
Fourth	334	12.4	1.01	172	12.5	1.35	162	12.2	1.35	
Area										
Urban	3208	72.4	1.20	1631	71.8	1.47	1577	72.9	1.71	.593
Rural	1293	27.6	1.20	675	28.2	1.47	618	27.1	1.71	
TV available at the child's bedroom										
Yes	1734	42.3	1.15	906	44.3	1.58	828	40.1	1.55	.057
No	2767	57.7	1.15	1400	55.7	1.58	1367	59.9	1.55	
Video games devices availability										
Yes	554	14.0	0.84	295	13.7	1.12	259	14.2	1.32	.788
No	3947	86.0	0.84	2011	86.3	1.12	1936	85.8	1.32	
Maternal PA ^c										
Meeting WHO guidelines	378	41.2	2.61	188	38.6	3.61	190	44.3	3.74	.288
Not meeting WHO guidelines	489	58.8	2.61	253	61.4	3.61	236	55.7	3.74	
Parks availability in the neighborhood										
Yes	2376	55.4	1.37	1273	56.9	1.70	1103	53.8	1.94	.187
No	2125	44.6	1.37	1033	43.1	1.70	1092	46.3	1.94	
Safety perception ^d										
Is safe to play in the park	1793	75.7	1.57	977	77.3	1.97	816	74.0	2.22	.233
Is not safe to play in the park	583	24.3	1.57	296	22.7	1.97	287	26.0	2.22	
Counseling on PA										
Yes	641	14.7	0.80	329	15.0	1.10	312	14.3	1.10	.621
No	3860	85.3	0.80	1977	85.0	1.10	1883	85.7	1.10	
Geographic region										
Atlantic	935	24.4	1.03	491	25.0	1.26	444	23.8	1.44	.814
Eastern	799	17.0	1.24	401	16.2	1.41	398	17.8	1.61	
Orinoquia-Amazonia	775	3.9	0.27	395	3.8	0.53	380	4.0	0.47	
Capital District	318	14.0	1.30	161	14.2	1.45	157	13.7	2.14	
Central	970	24.2	0.93	498	24.9	1.34	472	23.5	1.35	
Pacific	710	16.5	0.70	364	15.8	0.94	346	17.2	1.17	

Abbreviations: BMI, body mass index; NA, not applicable; PA, physical activity; WHO, World Health Organization.

^aThe total sample size for preschoolers was 4507 children. However, the following variables had missing values: ethnicity = 38; BMI = 142; area, TV availability, video games availability, parks availability, and counseling on PA = 6. ^bNo excess category groups children with thinness, risk of thinness and normal BMI. ^cThe variable maternal PA is available only for the dyads of children and mothers selected for the PA component of the survey; therefore, the sample sizes are smaller. ^dSafety perception was assessed only among those who reported having a park in their neighborhood.

Table 3 Sociodemographic Characteristics of 12,105 Children and Adolescents From Colombia—ENSIN 2015

Sociodemographic variables	School-aged children						Adolescents												
	Total sample			Males			Females			Total sample			Males			Females			
	n ^a	%	SE	n	%	SE	n	%	SE	n ^b	%	SE	n	%	SE	n	%	SE	
																			P value
Sex	2558	48.1	1.12		NA	NA	NA	NA	NA	3330	48.2	0.93		NA	NA	NA	NA	NA	
Female	2778	51.9	1.12		NA	NA	NA	NA	NA	3439	51.8	0.93		NA	NA	NA	NA	NA	
Ethnicity	452	9.8	0.93	233	9.6	1.09	219	10.1	1.06	842	9.1	0.91	334	9.4	1.13	241	8.7	0.96	
Afro-Colombian	671	5.9	0.78	333	5.7	1.23	338	6.1	1.06		653	4.4	0.78	262	3.9	0.78	391	5.0	0.89
Indigenous	4168	84.3	1.11	2192	84.8	1.48	1976	83.8	1.39		5487	86.5	0.80	2814	86.7	0.99	2673	86.3	1.00
Other	3895	74.1	1.16	2019	72.9	1.60	1876	75.4	1.51	.528	5235	81.9	0.75	2806	85.1	0.96	2429	78.6	1.11
BMI categorization	883	17.9	0.84	450	18.5	1.28	433	17.2	1.21		958	13.8	0.65	342	11.3	0.88	616	16.4	0.96
No excess ^c	374	8.0	0.76	219	8.6	1.03	155	7.4	1.10		300	4.3	0.40	129	3.7	0.45	171	5.0	0.63
Overweight	2868	39.2	1.56	1479	39.0	2.06	1389	39.4	1.78	.620	3414	37.9	1.29	1730	38.5	1.63	1684	37.3	1.49
Obesity	1290	25.6	1.19	709	25.8	1.49	581	25.3	1.64		1572	23.3	0.96	805	23.5	1.19	767	23.0	1.21
Wealth quantiles	763	19.7	1.03	382	18.7	1.35	381	20.7	1.44		1123	21.3	0.92	570	21.1	1.36	553	21.5	1.24
First	415	15.6	1.16	208	16.4	1.58	207	14.7	1.35		660	17.5	1.09	334	16.9	1.36	326	18.2	1.41
Second	4016	73.7	1.35	2087	74.0	1.77	1929	73.4	1.57	.782	4922	73.9	1.27	2406	73.5	1.49	2516	74.4	1.44
Third	1317	26.3	1.35	690	26.0	1.77	627	25.6	1.57		1842	26.1	1.27	1029	26.5	1.49	813	25.6	1.44
Fourth	1807	39.6	1.32	921	39.0	1.79	886	40.3	1.76	.601	2411	41.4	1.06	1241	41.6	1.46	1170	41.3	1.42
Area	3525	60.4	1.32	1855	61.0	1.79	1670	59.7	1.76		4352	58.6	1.06	2193	58.5	1.46	2159	58.7	1.42
Urban	1452	33.7	1.28	782	35.2	1.85	670	32.0	1.70	.208	3901	62.1	1.03	1970	61.6	1.37	1931	62.7	1.30
Rural	3881	66.3	1.28	1995	64.8	1.85	1886	68.0	1.70		2863	37.9	1.03	1465	38.4	1.37	1398	37.3	1.30
TV available at the child's bedroom	512	48.9	2.15	258	51.1	3.30	254	46.8	3.35	.408	366	50.3	2.78	185	49.1	3.20	181	51.5	4.19
Yes	590	51.1	2.15	295	49.0	3.30	295	53.2	3.35		486	49.7	2.78	240	50.9	3.20	246	48.5	4.19
No	1807	39.6	1.32	921	39.0	1.79	886	40.3	1.76	.601	2411	41.4	1.06	1241	41.6	1.46	1170	41.3	1.42
Video games devices availability	3525	60.4	1.32	1855	61.0	1.79	1670	59.7	1.76		4352	58.6	1.06	2193	58.5	1.46	2159	58.7	1.42
Yes	1452	33.7	1.28	782	35.2	1.85	670	32.0	1.70	.208	3901	62.1	1.03	1970	61.6	1.37	1931	62.7	1.30
No	3881	66.3	1.28	1995	64.8	1.85	1886	68.0	1.70		2863	37.9	1.03	1465	38.4	1.37	1398	37.3	1.30
Maternal PA ^d	512	48.9	2.15	258	51.1	3.30	254	46.8	3.35	.408	366	50.3	2.78	185	49.1	3.20	181	51.5	4.19
Meeting WHO guidelines	590	51.1	2.15	295	49.0	3.30	295	53.2	3.35		486	49.7	2.78	240	50.9	3.20	246	48.5	4.19
Not meeting WHO guidelines																			
PPE classes ^e																			
No class in the last week																			
One day																			
Two or more days																			
Parks availability in the neighborhood																			
Yes	3121	61.4	1.54	1650	62.6	1.89	1471	60.1	1.90	.263	4285	67.1	1.12	2261	69.4	1.28	2024	64.5	1.43
No	2212	38.6	1.54	1127	37.4	1.89	1085	39.9	1.90		2479	32.9	1.12	1174	30.6	1.28	1305	35.5	1.43
Safety perception ^f																			
Is safe to play in the park	2371	72.1	1.58	1271	72.7	2.12	1100	71.4	2.14	.652	3195	72.6	1.21	1783	77.4	1.59	1412	67.2	1.79
Is not safe to play in the park	750	27.9	1.58	379	27.3	2.12	371	28.6	2.14		1090	27.4	1.21	478	22.6	1.59	612	32.8	1.79

Table 3 (continued)

Sociodemographic variables	School-aged children						Adolescents													
	Total sample			Males			Females			Total sample			Males			Females				
	n ^a	%	SE	n	%	SE	n	%	SE	n ^b	%	SE	n	%	SE	n	%	SE	P value	
Counseling on PA																				
Yes	890	18.6	0.96	466	18.3	1.27	424	19.0	1.38	.687	1166	18.8	0.76	511	16.0	0.94	655	21.8	1.18	<.001
No	4443	81.4	0.96	2311	81.7	1.27	2132	81.0	1.38		5598	81.2	0.76	2924	84.0	0.94	2674	78.3	1.18	
Geographic region																				
Atlantic	786	23.5	1.54	418	23.4	2.05	368	23.6	1.66	.740	1370	24.0	1.03	808	24.7	1.33	562	23.2	1.23	.815
Eastern	809	17.9	1.88	409	17.1	2.05	400	18.7	1.90		1181	18.0	1.53	619	17.6	1.54	562	18.4	1.77	
Orinoquia-Amazonia	1560	3.3	0.24	802	3.2	0.32	758	3.4	0.25		1249	3.0	0.19	441	3.0	0.30	808	3.0	0.25	
Capital District	368	14.5	1.40	193	14.2	1.85	175	14.9	1.60		410	13.2	1.18	229	13.6	1.61	181	12.7	1.28	
Central	1195	24.4	1.23	631	25.4	1.69	564	23.2	1.30		1678	24.6	0.88	849	24.2	1.15	829	25.1	1.20	
Pacific	618	16.5	0.93	325	16.7	1.19	293	16.2	1.21		881	17.3	0.81	493	17.0	0.98	388	17.7	1.13	
Participation in organized activities and programs ^c																				
Ciclovia ^b																				
Yes	83	2.0	0.45	51	1.9	0.41	32	2.0	0.84	.925	477	15.8	1.17	292	21.0	1.83	185	10.1	1.13	<.001
No	5250	98.0	0.45	2726	98.1	0.41	2524	98.0	0.84		3038	84.3	1.17	1447	79.0	1.83	1591	89.9	1.13	
Community PA programs (eg, aerobics)																				
Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	808	20.4	1.20	300	16.4	1.35	508	23.9	1.77	.001
No	NA	NA	NA	NA	NA	NA	NA	NA	NA		2873	79.6	1.20	1384	83.6	1.35	1489	76.1	1.77	
PA programs at school																				
Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1921	47.8	1.29	1016	50.2	1.70	905	45.4	1.87	.054
No	NA	NA	NA	NA	NA	NA	NA	NA	NA		2045	52.2	1.29	951	49.8	1.70	1094	54.6	1.87	
Sport clubs																				
Yes	2237	41.7	1.18	1477	54.3	1.75	760	28.1	1.50	<.001	1125	28.5	1.19	780	38.5	1.74	345	16.7	1.28	<.001
No	3096	58.3	1.18	1300	45.7	1.75	1796	72.0	1.50	2709	71.6	1.19	1266	61.5	1.74	1443	83.3	1.28		
Organized groups (dance, martial arts, etc)																				
Yes	484	8.3	0.69	171	5.4	0.73	313	11.4	1.13	<.001	728	19.7	1.17	258	15.7	1.48	470	23.1	1.70	.002
No	4849	91.7	0.69	2606	94.6	0.73	2243	88.6	1.13		2810	80.3	1.17	1332	84.3	1.48	1478	76.9	1.70	
Frequency of participation in programs and organized activities ^d																				
Once per month	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	738	22.4	1.28	348	20.6	1.68	390	24.6	1.85	.242
Twice per month	NA	NA	NA	NA	NA	NA	NA	NA	NA		449	14.3	0.95	217	13.8	1.37	232	14.9	1.33	
Three times per month	NA	NA	NA	NA	NA	NA	NA	NA	NA		298	8.9	0.79	164	8.8	0.98	134	9.0	1.17	
Four times per month or more	NA	NA	NA	NA	NA	NA	NA	NA	NA		1665	54.4	1.56	935	56.8	2.19	730	51.5	2.19	

Abbreviations: BMI, body mass index; NA, not applicable; PA, physical activity; PE, physical education; WHO, World Health Organization.

^aThe total sample size for school-aged children was 5336 children. However, the following variables had missing values: ethnicity = 45; BMI = 184; TV availability = 4; and area, video games availability, parks availability, counseling on PA and participation in Ciclovias, sport clubs, and organized groups = 3. ^bThe total sample size for adolescents was 6769. However, the following variables had missing values: ethnicity = 54; BMI = 276; TV availability = 6; and area, video games availability, parks availability, counseling on PA = 5. ^cNo excess category groups children with thinness, risk of thinness, and normal BMI. ^dThe variable maternal PA is available only for the dyads of children and mothers selected for the PA component of the survey, therefore the sample sizes are smaller. ^eThe frequency of PE classes was assessed only among school-attending adolescents, for this reason the sample size is smaller. ^fSafety perception was assessed only among those who reported having a park in their neighborhood. ^gParticipation in organized activities and programs was assessed only among school-aged children and adolescents who reported knowing those programs. ^hCiclovias are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes. The frequency of participation in programs was assessed only among those adolescents who reported participating in at least one of the programs and activities listed.

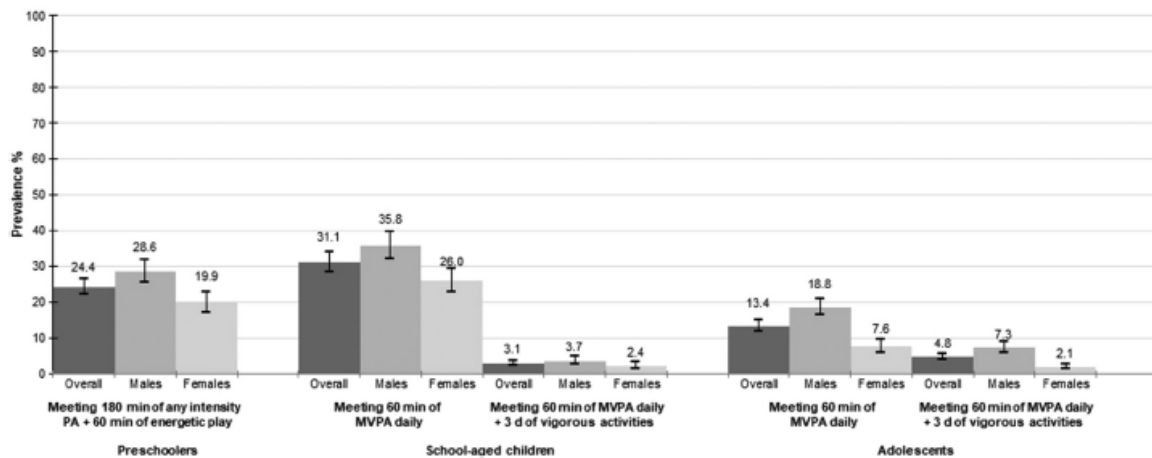


Figure 1 — Prevalence estimates of meeting PA guidelines among Colombian children by sex ENSIN 2015. Data are shown as mean values (in percentage) and 95% CIs. Vigorous activities correspond to activities that strengthen muscle and bone. ENSIN indicates the National Survey of Nutrition in Colombia; CI, confidence interval; MVPA, moderate- to vigorous-intensity PA; PA, physical activity.

models were included except the program-related ones. The first model showed that females were less likely to meet PA guidelines than males ($PR = 0.42$, $P < .001$), and adolescents who were overweight were less likely to be active than their counterparts ($PR = 0.67$, $P = .011$). Also, adolescents who reported having a park in their neighborhood were more likely to meet the PA guidelines, compared with those who did not have a park ($PR = 1.27$, $P = .020$; Figure 4A). The second multivariable model included the same variables as the first one, plus all the program variables that were significant in the bivariate models. This model showed that females were less likely to be active than males ($PR = 0.52$, $P = .010$), while adolescents in the 2 lowest quartiles of the wealth index were more likely to meet the guidelines than their counterparts in the wealthiest quartile ($PR = 3.66$, $P = .001$ and $PR = 3.37$, $P = .004$ for the first and second quartiles, respectively). The adolescents who participated in programs 4 or more times per month were more likely to meet PA guidelines than those who participated only once per month ($PR = 2.15$, $P = .014$; Figure 4B).

Discussion

Our results show that the prevalence of meeting PA guidelines among Colombian children and adolescents is low and decreases across age groups. The differences by sex were consistent across all age groups indicating that females are less active than males, and steep decreases in the prevalence of meeting PA guidelines were observed when the recommendation for vigorous and strengthening activities were taken into account. Several variables from the individual, household, community, and environmental levels were identified as correlates of PA indicators and are discussed below.

Among preschoolers, the low estimates are concerning considering the importance of PA and play from early ages for the development of cognitive, social, physical, and emotional skills.^{26–29} Also, it is important to highlight that sex differences of approximately 9 percentage points were observed in PA and unstructured play, indicating a clear inequity for females, as these are likely to be

socially shaped differences, and therefore, unfair and avoidable. In the context of the scarce evidence on preschool adherence to the current PA guidelines, our results are notably lower than results from Canada, Australia, and Finland, where 61.8% to 94.3% preschoolers met PA guidelines.^{30–33} However, it should be noted that those estimates were based on accelerometry measures, while ours were based on information reported by parents, who tend to under-report PA, especially for young children.³⁴ Estimates based on proxy-reported PA in Canadian preschoolers have shown an adherence to PA guidelines of 38%, still higher than our findings.³⁵ No comparable evidence was found from Latin American countries, probably because evidence in early years children using the recently released guidelines is just emerging.

Our results for school-aged children and adolescents are similar to the global and regional estimates.^{6–8} A third of school-aged children and only 13% of adolescents met the global recommendations on PA for health.⁵ This means that the large majority of Colombian children and adolescents are not enjoying the health benefits associated to the practice of regular PA, and this situation is worse among females. The results of the sensitivity analyses showed similar patterns and cause for concern when the cutoff points were 5 and 6 days per week. This could be indicative of the limitation of the question used to assess PA, which inquires about frequency of PA instead of duration. The differences that we observed in the prevalence of meeting PA guidelines across age groups do not follow the patterns reported previously suggesting that the decline in MVPA happened around the age of school entry or around 7 years of age.^{36,37} This could be related to 2 factors. First, a methodological reason, as preschool PA was assessed with a different questionnaire than school-aged and adolescents' PA. And second, preschool and school-aged variables were reported by a proxy, while adolescents' PA was self-reported. However, the steep decline observed specifically among adolescents is consistent with previous literature that has reported PA declines in the transition to adolescence.^{38,39}

Correlates at the Individual Level. Our results showed that female sex, age, Afro-Colombian ethnicity, and BMI were associated

Table 4 Prevalence of Meeting PA Guidelines and Play Engagement Among Preschool Children From Colombia

Sociodemographic and PA relevant variables	Preschool children											
	Meeting 180 min of any intensity PA + 60 min of energetic play				More than 2 h of unstructured play per day				More than 2 h of outdoors play per day			
	P (%)	CI	SE	P	P (%)	CI	SE	P	P (%)	CI	SE	P
Total	24.4	(22.2–26.7)	1.125		31.5	(29.3–33.8)	1.126		10.9	(9.5–12.6)	0.7785	
Sex												
Female	19.9	(17.3–22.8)	1.388	<.001	26.6	(23.9–29.5)	1.400	<.001	10.4	(8.4–12.8)	1.088	.448
Male	28.6	(25.5–31.9)	1.587		36.1	(32.9–39.4)	1.624		11.5	(9.6–13.6)	1.010	
Age, y												
3–4	24.8	(22.1–27.8)	1.415	.492	31.9	(29.1–34.8)	1.422	.519	11.5	(9.7–13.6)	0.983	.156
5	23.3	(19.9–27.0)	1.774		30.4	(27.1–34.1)	1.753		9.6	(7.9–11.7)	0.953	
Ethnicity												
Afro-Colombian	31.3	(25.3–38.0)	3.184	.058	44.2	(37.5–51.2)	3.459	<.001	21.5	(16.1–28.2)	3.015	<.001
Indigenous	20.6	(13.6–30.0)	4.102		25.1	(18.2–33.5)	3.860		16.0	(10.2–24.3)	3.504	
Other	23.9	(21.5–26.5)	1.248		30.5	(28.1–33.1)	1.250		9.5	(8.0–11.3)	0.820	
BMI categorization												
No excess ^a	24.7	(22.3–27.2)	1.210	.975	31.5	(29.2–34.0)	1.207	.598	11.4	(9.8–13.3)	0.869	.133
Overweight	25.2	(18.9–32.7)	3.462		35.2	(27.8–43.5)	3.974		9.6	(6.5–14.0)	1.837	
Obesity	25.8	(15.8–39.1)	5.867		30.5	(20.1–43.3)	5.870		5.0	(2.0–12.1)	2.281	
Wealth quartiles												
First (poorest)	23.4	(20.5–26.5)	1.509	.070	29.6	(26.7–32.8)	1.545	.346	16.6	(14.1–19.5)	1.342	<.001
Second	25.2	(20.9–30.1)	2.301		33.7	(29.2–38.5)	2.323		7.4	(5.1–10.4)	1.304	
Third	20.9	(16.9–25.5)	2.145		30.1	(25.7–35.0)	2.347		5.1	(3.4–7.6)	1.018	
Fourth (wealthiest)	31.8	(23.9–40.9)	4.287		35.0	(27.4–43.5)	4.049		9.2	(5.0–16.3)	2.740	
Area												
Urban	25.2	(22.6–28.1)	1.361	.217	33.1	(30.4–36.0)	1.391	.021	8.6	(7.1–10.5)	0.848	<.001
Rural	22.2	(18.5–26.4)	1.969		27.2	(23.4–31.3)	1.967		17.0	(14.0–20.4)	1.595	
TV available at the child's bedroom												
Yes	22.5	(19.4–25.9)	1.611	.116	30.3	(27.1–33.8)	1.684	.360	7.9	(6.3–9.8)	0.872	<.001
No	25.8	(23.0–28.8)	1.435		32.4	(29.5–35.4)	1.466		13.2	(11.1–15.6)	1.122	
Video games devices availability												
Yes	27.7	(21.4–35.1)	3.439	.284	38.8	(31.2–44.9)	3.451	.048	9.3	(5.7–14.7)	2.196	.443
No	23.9	(21.5–26.3)	1.203		30.5	(28.1–33.0)	1.222		11.2	(9.7–13.0)	0.827	
Maternal PA												
Meeting WHO guidelines	25.2	(17.5–34.9)	4.302	.836	30.2	(22.2–39.5)	4.288	.869	8.3	(5.4–12.5)	1.714	.285
Not meeting WHO guidelines	24.1	(18.0–31.5)	3.333		31.1	(24.5–38.5)	3.452		11.5	(7.1–18.2)	2.667	

(continued)

Table 4 (continued)

Sociodemographic and PA relevant variables	Preschool children											
	Meeting 180 min of any intensity PA + 60 min of energetic play				More than 2 h of unstructured play per day				More than 2 h of outdoors play per day			
	P (%)	CI	SE	P	P (%)	CI	SE	P	P (%)	CI	SE	P
Parks availability in the neighborhood												
Yes	26.7	(23.6–29.9)	1.566	.020	34.2	(31.1–37.4)	1.583	.009	9.1	(7.3–11.3)	0.993	.006
No	21.6	(18.8–24.7)	1.487		28.2	(25.1–31.4)	1.572		13.3	(11.1–15.8)	1.163	
Safety perception ^b												
Is safe to play in the park	28.0	(24.8–31.5)	1.666	.201	36.2	(32.8–39.6)	1.689	.058	8.4	(6.4–10.9)	1.110	.252
Is not safe to play in the park	22.5	(19.9–30.8)	3.718		28.0	(21.3–36.0)	3.679		11.0	(7.5–16.0)	2.107	
Counseling on PA												
Yes	23.3	(18.0–29.5)	2.898	.680	35.4	(29.7–41.6)	2.988	.161	7.9	(5.2–11.6)	1.569	.074
No	24.6	(22.2–27.2)	1.240		30.8	(28.4–33.4)	1.249		11.5	(9.9–13.3)	0.860	
Geographic region												
Atlantic	26.4	(22.6–30.5)	1.977	.489	34.4	(30.3–38.8)	2.125	.296	14.5	(11.4–18.4)	1.739	.018
Eastern	25.3	(20.2–31.1)	2.738		29.7	(25.0–35.0)	2.506		9.1	(5.8–13.9)	1.978	
Orinoquia-Amazonia	15.7	(9.5–25.0)	3.855		20.8	(13.8–30.2)	4.080		9.9	(6.4–15.2)	2.158	
Capital District	26.4	(19.0–35.5)	4.167		29.5	(21.9–38.5)	4.168		5.1	(2.2–11.5)	2.123	
Central	22.8	(19.1–27.0)	1.98		32.7	(28.5–37.1)	2.150		10.4	(8.1–13.2)	1.267	
Pacific	23.2	(18.3–29.0)	2.67		31.3	(26.5–36.7)	2.559		13.5	(10.1–17.8)	1.905	

Abbreviations: BMI, body mass index; CI, confidence interval; PA, physical activity; WHO, World Health Organization.

^aNo excess category groups children with thinness, risk of thinness, and normal BMI. ^bSafety perception was assessed only among those who reported having a park in their neighborhood.

Table 5 Prevalence of Meeting PA Guidelines Among Colombian School-Aged Children and Adolescents

Sociodemographic and PA relevant variables	School-aged children						Adolescents					
	Meeting 60 min of MVPA daily + 3 d of vigorous activities						Meeting 60 min of MVPA daily					
	P (%)	CI	SE	P	P (%)	CI	SE	P	P (%)	CI	SE	P
Total	31.1	(28.4–34.0)	1.398		3.1	(2.5–3.8)	0.343		13.4	(12.0–15.0)	0.753	4.8
Sex												
Female	26.0	(22.9–29.4)	1.621	<.001	2.4	(1.7–3.3)	0.401	.050	7.6	(6.1–9.6)	0.871	2.1
Male	35.8	(32.1–39.7)	1.911		3.7	(2.8–5.0)	0.541		18.8	(16.7–21.0)	1.084	7.3
Ethnicity												
Afro-Colombian	45.2	(37.6–53.0)	3.893	<.001	5.3	(2.9–9.3)	1.538	.062	17.1	(12.0–23.8)	2.944	5.8
Indigenous	47.6	(35.2–60.4)	6.414		2.2	(1.0–4.9)	0.897		12.9	(8.5–19.0)	2.590	2.6
Other	28.3	(25.5–31.2)	1.414		2.8	(2.2–3.6)	0.335		13.1	(11.7–14.6)	0.744	4.8
BMI categorization												
No excess ^a	33.3	(30.4–36.3)	1.477	.001	3.0	(2.3–3.9)	0.402	.641	14.4	(12.7–16.3)	0.904	.003
Overweight	27.0	(22.3–32.4)	2.518		3.1	(2.0–4.8)	0.678		8.4	(6.3–11.1)	1.192	3.8
Obesity	18.6	(12.5–26.7)	3.534		2.1	(1.0–4.4)	0.759		12.7	(8.1–19.4)	2.781	6.8
Wealth quartiles												
First (poorest)	38.5	(34.2–43.0)	2.215	<.001	3.2	(2.3–4.5)	0.551	.940	15.4	(12.9–18.4)	1.375	.019
Second	26.5	(22.3–31.1)	2.194		2.8	(1.8–4.3)	0.599		15.3	(12.6–18.4)	1.472	5.9
Third	24.8	(20.5–29.8)	2.327		3.0	(1.9–4.5)	0.643		10.4	(8.2–13.1)	1.237	5.5
Fourth (wealthiest)	28.1	(22.0–35.1)	3.297		3.3	(1.7–6.6)	1.148		10.2	(6.9–14.8)	1.940	4.8
Area												
Urban	29.4	(26.4–32.6)	1.549	.028	2.9	(2.2–3.8)	0.394	.391	13.1	(11.5–14.8)	0.818	.372
Rural	35.9	(30.8–41.4)	2.661		3.6	(2.4–5.4)	0.734		14.4	(11.8–17.6)	1.449	2.9
TV available at the child's bedroom												
Yes	24.5	(21.5–27.7)	1.552	<.001	2.5	(1.7–3.7)	0.500	.173	12.2	(10.3–14.4)	1.030	.155
No	35.5	(31.8–39.3)	1.859		3.5	(2.7–4.5)	0.452		14.3	(12.3–16.4)	1.021	4.5
Video games devices availability												
Yes	25.9	(22.1–30.0)	1.961	.003	2.8	(1.8–4.3)	0.593	.595	12.7	(11.0–14.5)	0.873	.175
No	33.8	(30.4–37.3)	1.709		3.2	(1.5–4.2)	0.420		14.6	(12.3–17.2)	1.233	3.1
Maternal PA												
Meeting WHO guidelines	24.8	(18.9–31.7)	3.169	.921	4.3	(2.1–8.5)	1.492	.468	16.2	(9.1–27.1)	4.415	.773
Not meeting WHO guidelines	24.3	(18.9–30.7)	2.935		3.1	(1.8–5.3)	0.826		14.5	(8.7–23.1)	3.521	7.4
PE classes ^b												
No class in the last week		NA					NA		12.6	(9.5–16.4)	1.707	.952
One day		NA					NA		13.2	(11.1–15.6)	1.131	4.9
Two or more days		NA					NA		12.9	(10.2–16.2)	1.488	5.2
Parks availability in the neighborhood												
Yes	28.5	(25.6–31.7)	1.516	.006	3.3	(2.5–4.4)	0.466	.315	14.2	(12.5–16.1)	0.887	.079
No	35.2	(31.0–39.6)	2.143		2.7	(1.9–3.8)	0.469		11.8	(9.8–14.2)	1.116	2.8

(continued)

Table 5 (continued)

Sociodemographic and PA relevant variables	School-aged children										Adolescents									
	Meeting 60 min of MVPA daily					Meeting 60 min of MVPA daily + 3 d of vigorous activities					Meeting 60 min of MVPA daily					Meeting 60 min of MVPA daily + 3 d of vigorous activities				
	P (%)	CI	SE	P		P (%)	CI	SE	P		P (%)	CI	SE	P		P (%)	CI	SE	P	
Safety perception ^c																				
Is safe to play in the park	30.3	(27.2–33.6)	1.605	.046		3.7	(2.7–5.0)	0.567	.180		14.9	(13.0–17.1)	1.031	.200		6.2	(5.0–7.6)	0.661	.369	
Is not safe to play in the park	24.0	(19.0–29.9)	2.724		2.4	(1.3–4.3)	0.725				12.2	(9.1–16.1)	1.732		4.6	(2.5–8.4)	1.394			
Counseling on PA																				
Yes	25.2	(20.8–30.1)	2.317	.009		4.3	(2.8–6.7)	0.942	.087		14.0	(10.6–18.3)	1.918	.734		6.1	(4.3–8.6)	1.062	.118	
No	32.5	(29.5–35.6)	1.547		2.8	(2.1–3.6)	0.363				13.3	(11.7–15.0)	0.807		4.5	(3.6–5.5)	0.468			
Geographic region																				
Atlantic	42.2	(36.0–48.5)	3.138	<.001		2.7	(1.8–4.0)	0.538	.450		14.6	(12.1–17.5)	1.363	.678		4.5	(3.2–6.2)	0.724	.758	
Eastern	24.1	(19.9–28.9)	2.244		2.9	(1.8–4.8)	0.732				12.8	(9.9–16.4)	1.621		5.2	(3.7–7.3)	0.900			
Orinoquia-Amazonia	40.7	(34.9–46.7)	2.960		5.4	(3.9–7.5)	0.894				15.6	(11.9–20.3)	2.109		7.8	(5.0–12.1)	1.752			
Capital District	19.4	(14.0–26.2)	3.057		3.7	(1.9–7.1)	1.221				13.7	(9.3–19.7)	2.593		4.8	(2.2–10.1)	1.841			
Central	28.4	(23.7–33.5)	2.445		2.4	(1.5–3.7)	0.524				11.6	(9.5–14.2)	1.171		4.2	(3.0–5.9)	0.723			
Pacific	35.4	(27.7–43.9)	4.071		3.8	(2.0–6.9)	1.158				14.4	(10.2–19.8)	2.383		5.0	(3.1–7.8)	1.143			
Participation in organized activities and programs																				
Cicloviás ^d																				
Yes	29.4	(15.1–49.2)	8.771	.843		1.3	(0.3–5.2)	0.911	.207		17.7	(12.7–24.1)	2.829	.070		11.2	(6.7–18.1)	2.777	.004	
No	31.1	(28.4–34.0)	1.410		3.1	(2.5–3.9)	0.349				12.6	(10.7–14.8)	1.017		4.9	(3.9–6.1)	0.559			
Community PA programs (eg, aerobics)																				
Yes		NA					NA				10.0	(7.4–13.3)	1.440	.028		5.1	(3.4–7.6)	1.030	.643	
No		NA					NA				14.3	(12.2–16.7)	1.115		5.7	(4.4–7.4)	0.742			
PA programs at school																				
Yes		NA					NA				15.8	(13.5–18.6)	1.271	.005		6.5	(4.9–8.5)	0.886	.023	
No		NA					NA				11.3	(9.4–13.5)	1.022		4.1	(3.1–5.5)	0.595			
Sport clubs																				
Yes	32.1	(28.5–36.0)	1.878	.404		4.8	(3.5–6.4)	0.707	<.001		20.0	(16.6–23.9)	1.825	.002		11.1	(8.5–14.5)	1.513	<.001	
No	30.4	(27.3–33.7)	1.603		1.9	(1.4–2.6)	0.298				13.1	(10.9–15.7)	1.192		4.6	(3.4–6.3)	0.728			
Organized groups																				
Yes	22.3	(16.8–29.0)	3.051	.006		1.9	(1.0–3.7)	0.643	.158		13.8	(10.3–18.2)	1.969	.732		6.5	(4.0–10.5)	1.566	.332	
No	31.9	(29.1–34.8)	1.438		3.2	(2.5–4.0)	0.370				13.0	(11.0–15.2)	1.045		5.0	(3.9–6.4)	0.615			
Frequency of participation in programs and organized activities																				
Once per month		NA					NA				13.4	(8.9–19.6)	2.643	.024		7.1	(3.4–14.2)	2.545	.107	
Twice per month		NA					NA				11.4	(7.9–16.2)	2.039		3.8	(2.0–7.3)	1.245			
Three times per month		NA					NA				10.3	(6.7–15.7)	2.207		3.7	(1.8–7.4)	1.303			
Four times per month or more		NA					NA				18.5	(15.8–21.5)	1.421		9.1	(7.1–11.5)	1.072			

Abbreviations: BMI, body mass index; CI, confidence interval; MVPA, moderate- to vigorous-intensity PA; NA, not applicable; PA, physical activity; PE, physical education; WHO, World Health Organization.
^aNo excess category groups children with thinness, risk of thinness, and normal BMI. ^bThe frequency of PE classes was assessed only among school-attending adolescents. ^cSafety perception was assessed only among those who reported having a park in their neighborhood. ^dCicloviás are defined as a program that closes the streets to motorized vehicles, usually Sundays and holidays, for recreational and exercise purposes.

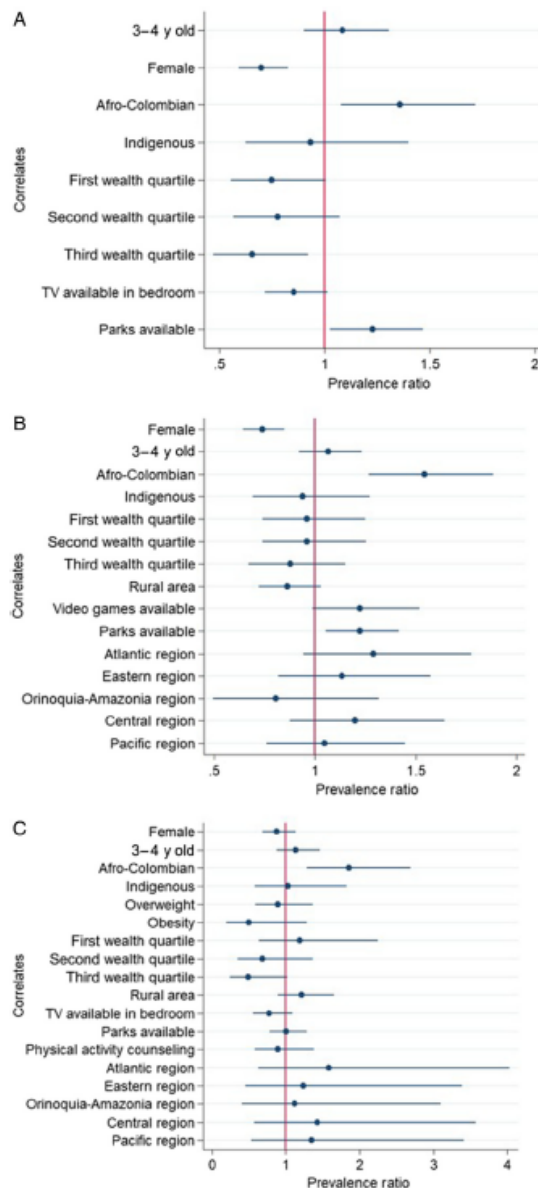


Figure 2 — PRs and 95% CIs of correlates of PA indicators among Colombian preschool children. (A) Correlates of meeting PA guidelines. Meeting guidelines is defined as engaging in at least 180 minutes of PA per day including at least 60 minutes of energetic play. (B) Correlates of more than 2 hours of unstructured play per day. (C) Correlates of more than 2 hours of outdoor play per day. CI indicates confidence interval; PA, physical activity; PRs, prevalence ratios.

with PA indicators among Colombian children and adolescents. However, the direction of the associations varied, and the correlates varied according to the age group. Female sex was a consistent negative correlate for all age groups and indicators, except for

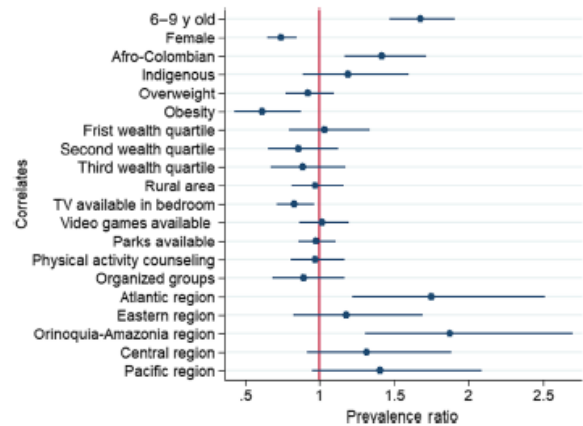


Figure 3 — PRs and 95% CIs of correlates of meeting PA guidelines among Colombian school-aged children. Meeting guidelines was defined as engaging in at least 60 minutes of MVPA per day 7 days per week. CI indicates confidence interval; MVPA, moderate- to vigorous-intensity PA; PA, physical activity; PRs, prevalence ratios.

outdoor play. Sex is the most consistent correlate in the literature for all age groups,^{40,41} and our results are indicative of the need to create policies and programs with a differential approach that provide opportunities for girls to be active since early years. Age was identified as a correlate only for school-aged children, indicating that younger children were more likely to be active. This is also consistent with the literature,⁴⁰ and suggests the need to consider the age of the target population for PA programs, and to design strategies that maintain or even increase children's participation in active behaviors as they get older. The positive association of Afro-Colombian ethnicity with PA and unstructured play among preschool and school-aged children could be indicative of cultural differences that influence the activities in which young children spend their time. For example, traditional games- or dance-related activities belonging to the Afro-Colombian culture can contribute to explain the observed difference. Also, the higher involvement in PA can be related to poverty conditions prevalent among Afro-Colombian populations. Unfortunately, there is a lack of research on PA with an ethnic-minority focus in Colombia that would help to better understand this association. Regarding BMI, our findings show that school-aged children with obesity and adolescents with overweightness were less likely to be active. This association needs to be considered in the design of PA strategies in the context of the increase in overweightness and obesity that Colombia is experiencing.

Correlates at the Household Level. Socioeconomic status and the availability of TV in the child's bedroom were significant correlates of PA at the household level. Among preschoolers, children in the lower wealth quartiles were less likely to be active than the wealthiest. This association was opposite for adolescents. In contrast with our findings, previous literature reported no association between socioeconomic status and PA in young children⁴¹⁻⁴³ and positive associations for adolescents in the wealthiest groups.⁴⁰ We hypothesize that our findings for preschool children can be related to greater opportunities for being active out of school or in day-care centers for the wealthiest families. These findings should be considered in order to improve the actions within the Early

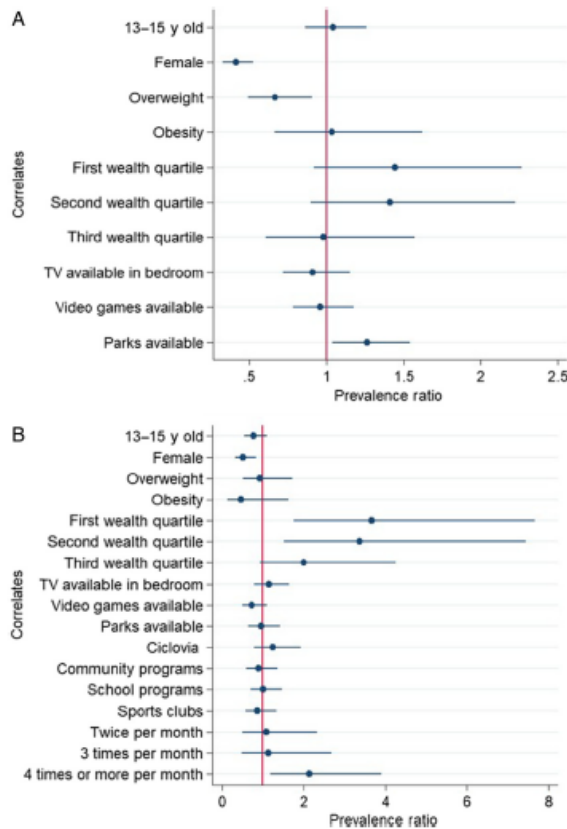


Figure 4 — PRs and 95% CIs of correlates of meeting PA guidelines among Colombian adolescents. Meeting guidelines was defined as engaging in at least 60 minutes of MVPA per day 7 days per week. (A) First multivariable model and (B) second multivariable model including program participation variables. CI indicates confidence interval; MVPA, moderate- to vigorous-intensity PA; PA, physical activity; PRs, prevalence ratios.

Childhood Public Policy to promote the adequate development of the most vulnerable populations. For adolescents, our results can be related to the necessity of involving other domains of PA, such as transport or occupational activities, which are more prevalent among lower socioeconomic levels, as well as a higher involvement in sedentary activities among the wealthiest groups. These results highlight the need to reach the wealthiest adolescents with activities that encourage them to be more active, as well as to continue promoting PA among lower socioeconomic groups. The negative association between TV availability in the bedroom and PA among school-aged children is consistent with evidence from the United States and Brazil^{44,45} and suggests the need to advise parents to avoid having TVs in children's bedrooms.

Correlates at the Community Level. The availability of parks in the neighborhood was a positive correlate of PA and unstructured play among preschool children and adolescents. Despite the inconsistent evidence in this field,⁴⁶ our results support positive associations previously reported⁴⁷ and suggest that parks represent a viable

approach for promoting daily PA. It is interesting to observe the lack of association with PA counseling across age groups. This suggests that the scarce counseling efforts are not related to a greater proportion of children or adolescents meeting PA guidelines and needs to be improved. This is especially relevant considering that among those who received PA counseling, there are greater proportions of individuals who are less likely to meet PA recommendations, such as females, children, and adolescents with overweightness or obesity, and children and adolescents in the highest wealth quartile.

Correlates at the Environmental and Policy Level. At the environmental level, living in the Orinoquia-Amazonia and Atlantic regions were positive correlates of meeting PA guidelines among school-aged children. In these regions, meeting PA guidelines was approximately 10 percentage points higher than the national estimates. These regions are composed mostly of departments (administrative units) with middle Human Development Index, which are lower than the national estimate. As it has been observed in other contexts, those social development conditions can be related to a higher involvement in active behaviors, probably by necessity.⁴⁸ In these contexts, the high prevalence of meeting PA guidelines needs to be preserved, providing safe and enjoyable opportunities for being active. At the policy level, frequent attendance (4 times per month or more) in PA programs was a positive correlate of PA among adolescents. This result is very relevant for the policy agenda of the country. Colombia has implemented PA programs such as Ciclovías,²⁵ community PA programs (eg, the National Program of Healthy Life Habits),⁴⁹ organized sports programs (eg, Supérate),⁵⁰ and PA programs at schools, but the evaluation of their impact among children and adolescents has been limited.²⁵ Despite the lack of evaluation, the positive association of the frequent participation in programs supports the maintenance and promotion of regular PA programs for Colombian young people.

Policy Implications. The ENSIN data are the most comprehensive nationally representative data on PA for Colombia and the best available evidence that could serve as baseline data to assess the 15% relative reduction in physical inactivity established by the WHO.⁹ Based on our findings, we highlight the following messages that can help to strengthen public policies on PA, childhood development, and education, among others: (1) public policies in Colombia should recognize and promote play and specifically outdoor play as a key component of healthy child development; (2) inequities by sex and socioeconomic level in PA need to be addressed beginning with the early years through policies with differential approaches that allow the targeting of the most vulnerable populations; (3) programs to promote PA should include strategies to involve children with overweightness or obesity, empowering them to participate and avoiding segregation or marginalization; (4) urban planning policies should take into account the importance of safe parks availability and community programs in public spaces (eg, streets, parks) for PA and health, and (5) PA programs should be offered on a sustained and regular basis to have a better impact on children's and adolescents' compliance with PA guidelines.

Strengths and Limitations

The main strength of this study is the use of a nationally representative sample for a wide age range of children, which ensures the generalizability of our results to the Colombian population of children and youth. Also, the use of standardized measurement

instruments reduces the risk of bias. Key limitations include the cross-sectional nature of the survey that does not allow causal inferences from our findings. Second, the use of self- and proxy-report variables to ascertain meeting PA guidelines could be affected by social desirability bias or by underestimations or overestimations because of a recall bias. Third, some of the questionnaires used in ENSIN were adapted from studies in other settings but their validity for Colombian context has not been evaluated.

Conclusions

The majority of Colombian children and adolescents are insufficiently active. Urgent actions are needed to maintain and hopefully increase the involvement in active play and PA. These actions can be guided by the correlates identified in our study, to overcome disparities and provide opportunities for children to achieve their full potential for healthy growth and development.

Acknowledgments

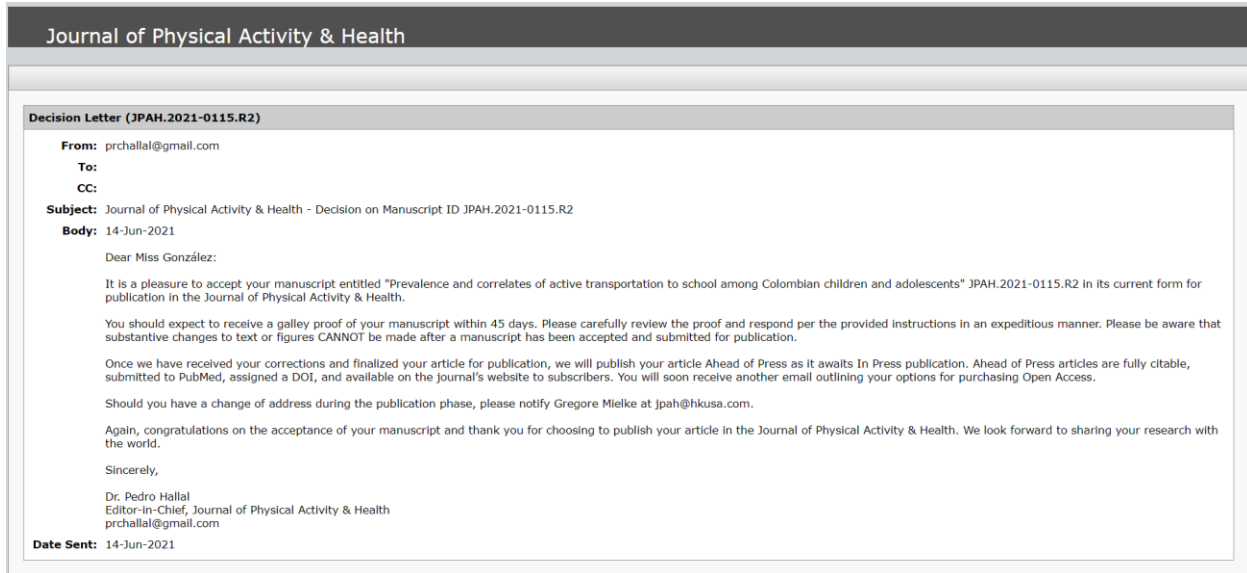
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Appendix 6. Manuscript 2 acceptance confirmation



Appendix 7. Manuscript 3 submission confirmation

6/9/2021

Mali - Silvia Gonzalez - Outlook

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-----MANUSCRIPT DETAILS-----

Manuscript title: Prevalence and correlates of excessive recreational screen time among Colombian children and adolescents

Manuscript ID: 1604217

Authors: Silvia A Gonzalez, Olga L Sarmiento, Alberto Florez-Pregonero, Peter T Katzmarzyk, Jean-Philippe Chaput and Mark S Tremblay

Journal: International Journal of Public Health

Article type: Original Article

Submitted on: 24 Apr 2021

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Appendix 8. Published version of Manuscript 4 Report Card Grades on the Physical Activity of Children and Youth From 10 Countries with High Human Development Index: Global Matrix 3.0

Journal of Physical Activity and Health, 2018, 15(Suppl 2), S284-S297
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ORIGINAL RESEARCH

Report Card Grades on the Physical Activity of Children and Youth From 10 Countries With High Human Development Index: Global Matrix 3.0

Silvia A. González, Joel D. Barnes, Patrick Abi Nader, Dolores Susana Andrade Tenesaca, Javier Brazo-Sayavera, Karla I. Galaviz, Marianella Herrera-Cuenca, Piyawat Katewongsa, Juan López-Taylor, Yang Liu, Bilyana Mileva, Angélica María Ochoa Avilés, Diego Augusto Santos Silva, Pairoj Saonuan, and Mark S. Tremblay

Background: The Global Matrix 3.0 brings together the Report Card grades for 10 physical activity indicators for children and youth from 49 countries. This study describes and compares the Global Matrix 3.0 findings among 10 countries with high Human Development Index. **Methods:** Report Cards on physical activity indicators were developed by each country following a harmonized process. Countries informed their Report Cards with the best and most recent evidence available. Indicators were graded using a common grading rubric and benchmarks established by the Active Healthy Kids Global Alliance. A database of grades from the countries was compiled, and letter grades were converted to numerical equivalents. Descriptive statistics and scores for groups of indicators were calculated, and correlation analyses were conducted. **Results:** Grades for the 10 countries clustered around “D” ranging from “F” to “B+.” Active Transportation had the highest average grade (“C”), whereas Overall Physical Activity had the lowest average grade (“D–”). Low grades were observed for both behavioral and sources of influence indicators. **Conclusions:** In the context of social and economical changes of high-Human Development Index countries, urgent actions to increase physical activity among children and youth are required. Surveillance and monitoring efforts are required to fill research gaps.

Keywords: advocacy, health promotion, international, policy

Regular physical activity among children and youth (ie, adolescents) has been consistently associated with decreased adiposity, healthy cardiometabolic biomarkers, improved physical

fitness, and better bone health, as well as with favorable psychological and cognitive health outcomes.¹ The public health potential of regular physical activity is particularly relevant in the current context in which more than 107 million children are obese worldwide.² Despite the broad evidence on the benefits of physical activity, globally, 80% of adolescents are not attaining the minimum recommendation of 60 minutes of daily moderate- to vigorous-intensity physical activity to achieve those benefits.³ A moderate decline in the cardiorespiratory fitness of children and adolescents has also been observed,⁴ and excessive sedentary behaviors among children and youth are highly prevalent.^{5–8}

For many countries considered to have emerging economies, a shift toward reduced habitual physical activity is probable and related to broad social changes and economic growth.^{9,10} Greater use of motorized transportation, shifts from rural to urban dwelling, and increased use of technology that occur with economic growth may be contributing to decreased active transportation and leisure-time physical activity and to increased sedentary recreational activities.^{1,11,12} Despite the rapidly rising burden of noncommunicable diseases (NCDs) in middle-income countries,¹³ there are competing priorities at the policy and structural levels,¹⁴ which can be reflected in lack of investments by governments to prevent NCDs.¹⁵ This is the context of several countries in Latin America, the Middle East, the Eastern Balkan region, and East Asia, regions in the midst of a physical activity¹⁶ and demographic transition.¹⁷

In response to the physical inactivity crisis and the increase in NCDs¹³ as unintended consequences of economic development, multilateral organizations have launched action plans and policy documents that support physical activity promotion as a key strategy. The Bangkok Declaration on Physical Activity for Global

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Health and Sustainable Development,¹⁸ the Plan of Action for the Prevention of Obesity in Children and Adolescents¹⁹ (signed by all countries in Latin America), and the World Health Organization's Global Action Plan on Physical Activity²⁰ are some of the recent policy documents that highlight the key role of physical activity in the prevention of NCDs globally.

As the global public health agenda fosters the implementation of policies and action plans to decrease the burden of physical inactivity, surveillance of physical activity, its related behaviors and relevant settings of influence for its promotion, is needed. In response to these needs, Active Healthy Kids Canada and subsequently the Active Healthy Kids Global Alliance (AHKGA) have led the harmonized development of country-specific physical activity Report Cards, synthesizing the best available evidence on how a nation is doing in terms of promoting physical activity among children and youth since 2014.^{21,22} The countries involved in the Report Card initiative have graded common indicators related to physical activity in children and youth using a common grading rubric and standardized benchmarks.^{21–23} This international effort has been consolidated in the creation of a “Global Matrix” of grades, which has compiled and compared grades across physical activity-related indicators for 15, 38, and 49 countries in its first, second, and third versions, respectively.^{21–23}

As the Global Matrix project has grown, greater representativeness of countries from different levels of development and different regions of the world has been achieved. This progress provides a unique opportunity to identify successes and challenges to improve physical activity levels among children and youth from countries with similar levels of development in various regions of the world. For this purpose, the 49 countries involved in the Global Matrix 3.0 were classified into 3 categories based on their Human Development Index (HDI): low and medium, high, and very high HDI, following the cutoff points defined by the United Nations Development Programme. The HDI is a composite index that integrates life expectancy, years of schooling, and gross national income per capita as basic dimensions of human development.²⁴

This study focuses on the group of countries with a high HDI, which are susceptible to the aforementioned consequences of economic growth. In this context, it is important to document the current situation of physical activity-related indicators and the priorities for research and advocacy to advance efforts to promote active living in children from these countries and to study the variability in successes and challenges between countries with similar HDI. Therefore, the purpose of this study is to describe and compare the Global Matrix 3.0 findings for 10 physical activity indicators among 10 high-HDI countries: Brazil, Bulgaria, China, Colombia, Ecuador, Lebanon, Mexico, Thailand, Uruguay, and Venezuela.

Methods

Global Matrix Involvement

Countries registered for the Global Matrix 3.0 project between April 2017 and January 2018 and paid a registration fee according to their HDI classification. Eleven high-HDI countries registered and 10 fully participated. According to the mentorship model developed for the Global Matrix 3.0,²³ each country was assigned a mentor from the AHKGA network and from their geographical region to guide the development of their Report Cards following a harmonized process.²⁵ Four of the high-HDI countries developed their Report Cards for the first time (Bulgaria, Ecuador, Lebanon, and Uruguay).

Report Card Development

Each country formed a working group of national and international experts on physical activity from the academic, private and government sectors, and research staff from the lead organization. These teams were in charged with (1) compiling and synthesizing the best available and most recent evidence for their country, and (2) assessing the available evidence for each indicator and assigning the corresponding grade based on the benchmarks and grading rubric established by the AHKGA (Tables 1 and 2). The evidence was gathered from literature reviews comprising peer-reviewed published and unpublished data, surveys, governmental reports, and policy documents and in some cases, was complemented by experts on the team.

Indicators

The data gathered were summarized in 10 common indicators: Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviors, Physical Fitness, Family and Peers, School, Community and Environment, and Government. To harmonize the process, the AHKGA established benchmarks for each indicator (Table 1) and a standardized grading rubric (Table 2). Every indicator was assigned a grade by the group of experts in each country. The 10 countries submitted their grades with a detailed rationale supporting these indicators, and a scientific committee from the AHKGA audited the submitted grades. Details about the development and findings of the Report Card for each individual country are provided in country-specific articles in this issue.^{27–36}

To facilitate comparisons across countries, the Global Matrix 3.0 only includes data for children between 5 and 17 years (school-aged children and youth in most countries) and data for the 10 common indicators; however, each country was free to include a wider age range and additional indicators on their individual Report Cards. It is worth noting that for some countries, the grades reported in the Global Matrix 3.0 may differ from the countries' Report Card, due to the inclusion of additional criteria on the grading scheme (eg, changes over time or evidence of disparities) at the country level.

Statistical Analysis

A database of the grades for high-HDI countries was compiled. For analysis purposes, letter grades were converted to numerical equivalents (Table 2). Descriptive statistics (average grade, SD) were calculated for each indicator. To facilitate comparisons among countries and to draw more general conclusions about the indicator grades, an overall score (combining all the indicators) was computed along with scores for the behavioral indicators (Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, and Sedentary Behaviors) and the sources of influence indicators (Family and Peers, School, Community and Environment, and Government). For score calculations, incomplete grades were removed and the scores were reweighted accordingly. Based on the scores, countries were ranked by letter grade on scatterplots. Associations within indicators and between indicators and sociodemographic indexes were then explored using Spearman's rank correlation coefficients. Strong correlations were defined as coefficients equal to or higher than .7 or $-.7$.³⁷ Pairwise deletion was used to treat missing data (ie, incomplete grades). All statistical analyses were performed using R (version 3.4.1; The R Foundation for Statistical Computing, Vienna, Austria). Several

Table 1 Global Matrix 3.0 Indicators and Benchmarks Used to Guide the Grade Assignment Process

Indicator	Benchmarks
Overall Physical Activity	Percentage of children and youth who meet the global recommendations on physical activity for health, which recommend that children and youth accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity per day on average. Or percentage of children and youth meeting the guidelines on at least 4 days a week (when an average cannot be estimated).
Organized Sport and Physical Activity	Percentage of children and youth who participate in organized sport and/or physical activity programs.
Active Play	Percentage of children and youth who engage in unstructured/unorganized active play at any intensity for more than 2 hours a day.
Active Transportation	Percentage of children and youth who report being outdoors for more than 2 hours a day.
Sedentary Behaviors	Percentage of children and youth who use active transportation to get to and from places (eg, school, park, mall, friend's house).
Physical Fitness	Percentage of children and youth who meet the Canadian Sedentary Behavior Guidelines (5- to 17-year-olds: no more than 2 hours of recreational screen time per day). Note: the guidelines currently provide a time limit recommendation for screen-related pursuits but not for non-screen-related pursuits.
Family and Peers	Average percentile achieved on certain physical fitness indicators based on the normative values published by Tomkinson et al. ²⁶
	Percentage of family members (eg, parents, guardians) who facilitate physical activity and sport opportunities for their children (eg, volunteering, coaching, driving, paying for membership fees and equipment).
	Percentage of parents who meet the Global Recommendations on Physical Activity for Health, which recommend that adults accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity.
	Percentage of family members (eg, parents, guardians) who are physically active with their kids.
	Percentage of children and youth with friends and peers who encourage and support them to be physically active.
	Percentage of children and youth who encourage and support their friends and peers to be physically active.
School	Percentage of schools with active school policies (eg, daily physical education, daily physical activity, recess, "everyone plays" approach, bike racks at school, traffic calming on school property, outdoor time).
	Percentage of schools where the majority (≥80%) of students are taught by a physical education specialist. Percentage of schools where the majority (≥80%) of students are offered the mandated amount of physical education (for the given state/territory/region/country).
	Percentage of schools that offer physical activity opportunities (excluding physical education) to the majority (>80%) of their students.
	Percentage of parents who report their children and youth have access to physical activity opportunities at school in addition to physical education classes.
	Percentage of schools with students who have regular access to facilities and equipment that support physical activity (eg, gymnasium, outdoor playgrounds, sporting fields, multipurpose space for physical activity, equipment in good condition).
Community and Environment	Percentage of children or parents who perceive their community/municipality is doing a good job at promoting physical activity (eg, variety, location, cost, quality).
	Percentage of communities/municipalities that report they have policies promoting physical activity.
	Percentage of communities/municipalities that report they have infrastructure (eg, sidewalks, trails, paths, bike lanes) specifically geared toward promoting physical activity.
	Percentage of children or parents who report having facilities, programs, parks, and playgrounds available to them in their community.
	Percentage of children or parents who report living in a safe neighborhood where they can be physically active.
	Percentage of children or parents who report having well-maintained facilities, parks, and playgrounds.
	Allocated funds and resources for the implementation of physical activity promotion strategies and initiatives for all children and youth.
	Demonstrated progress through the key stages of public policymaking (ie, policy agenda, policy formation, policy implementation, policy evaluation and decisions about the future).

Table 2 Global Matrix 3.0 Grading Rubric

Grade	Interpretation	Numerical equivalents ^a
A+	94%–100%	15
A	We are succeeding with a large majority of children and youth (87%–93%)	14
A–	80%–86%	13
B+	74%–79%	12
B	We are succeeding with well over half of children and youth (67%–73%)	11
B–	60%–66%	10
C+	54%–59%	9
C	We are succeeding with about half of children and youth (47%–53%)	8
C–	40%–46%	7
D+	34%–39%	6
D	We are succeeding with less than half but some children and youth (27%–33%)	5
D–	20%–26%	4
F	We are succeeding with very few children and youth (<20%)	2
INC	Incomplete—insufficient or inadequate information to assign a grade	

^aLetter grades were converted to numerical equivalents for analyses purposes.

packages were loaded to extend base R including *corplot*,³⁸ *ggplot2*,³⁹ *UpSetR*,⁴⁰ and *VIM*.⁴¹

Qualitative Assessment

A qualitative appraisal was also conducted to compare the methods used to assess the Overall Physical Activity indicator across countries. For this, we collected information on the main source of physical activity data used by each country, instruments used, data collection methods, and sample size.

Results

Table 3 presents sociodemographic characteristics to provide the context and comparison of countries included in this analysis. Among the included countries, the HDI ranged from 0.727 in Colombia to 0.795 in Uruguay. The country with the highest public health expenditure was Uruguay (6.1% of the GDP), whereas the country with the lowest expenditure was Venezuela (1.5% of the GDP). The prevalence of stunting among children less than 5 years ranged from 7.1% in Brazil to 25.2% in Ecuador. According to the Gini index, the country with the greatest income inequality was Brazil, whereas Lebanon had the lowest income inequality. The gender inequality index, which measures disparities between males and females on measures of reproductive health, empowerment and labor market participation,²⁴ was greatest in Brazil and lowest in China. Population density ranged from 20 inhabitants/km² in Uruguay to 587 inhabitants/km² in Lebanon, and the percentage of urban population ranged from 34.4% in Thailand to 93.7% in Venezuela.

The consolidated country grades per indicator are presented in Table 4. Two countries (Brazil and China) assigned grades to all the indicators, whereas 2 other countries (Ecuador and Venezuela)

did not assign a grade to 5 of the 10 indicators. About 25 of the possible 100 grades were graded as incomplete (INC). The most common indicators with INC grades due to insufficient evidence were Active Play (Colombia, Ecuador, Lebanon, Mexico, Uruguay, and Venezuela), Physical Fitness (Bulgaria, Ecuador, Lebanon, Mexico, Thailand, and Venezuela), and Family and Peers (Colombia, Lebanon, Mexico, Uruguay, and Venezuela) (Tables 4 and 5). Only 2 indicators, Overall Physical Activity and Active Transportation were graded by all countries (Table 5).

Country grades ranged from “F” to “B+”, with most grades clustered around the “D” categories. The mean score for all indicators was equivalent to a “D+”, and the same letter grade equivalent was observed when mean scores were computed for indicators grouped by behaviors or sources of influence. Active Transportation was the indicator with the highest average grade across the countries (“C”), whereas Overall Physical Activity obtained the lowest average grade (“D–”).

Regarding the overall score for all indicators, Thailand, Colombia, and Bulgaria reported the highest scores, whereas China, Venezuela, and Lebanon had the lowest scores (Figure 1). When the indicators were grouped, the score for behavioral indicators was higher in Bulgaria and Colombia, whereas China, Lebanon, and Thailand had the lowest scores. The highest score for sources of influence indicators was observed in Thailand, whereas Venezuela, China, and Ecuador had the lowest scores (Figures 2 and 3). Details on the country rankings for each indicator are provided in [Supplementary Material](#) [available online]. The correlation matrix indicates significant strong positive correlations for Family and Peers with Government ($r=1.0$), Community and Environment with Government ($r=.91$), and Community and Environment with public health expenditure ($r=.93$). A significant strong negative correlation was found for Active Transportation and life expectancy ($r=-.78$) (Table 6).

The Overall Physical Activity indicator was informed by national health surveys in 6 countries (Brazil, Bulgaria, Colombia, Ecuador, Lebanon, and Mexico), by physical activity or health studies in 3 countries (China, Thailand, and Venezuela), and by the Global School-based Student Health Survey in 2 countries (Lebanon and Uruguay). Most of these surveys and studies used self-reported methods to assess physical activity. Only Brazil reported studies with objective measures using accelerometers and pedometers. The sample size of the studies ranged between 156 youth in Venezuela and 242,259 children and youth in Brazil (Table 7).

Discussion

This study aimed to describe and compare the Global Matrix 3.0 grades among 10 countries with high HDI. Findings indicate these countries have a lot to improve in providing opportunities for children and youth to change behaviors and be more active, as well as in assuring high-quality physical activity surveillance. Grades for the 10 countries clustered around “D”, which indicates that these countries, at a similar stage of development, are at similar stages in the physical inactivity crisis.²⁰ This further highlights the urgent need to take tangible actions to increase physical activity among children and youth. In addition, the Global Matrix 3.0 allowed to identify research gaps that should be addressed for the design and follow-up of initiatives to promote active living among children. In the context of the evidence available, a discussion of the findings for each indicator is presented below, followed by the interpretation of the findings by groups of indicators and the correlations observed.

Table 3 Sociodemographic Information of High-HDI Countries in the Global Matrix 3.0

Country	HDI ²⁴	Life expectancy at birth ²⁴	Expected years of schooling ^{2,4}	Mean years of schooling ^{2,4}	GNI per capita ²⁴	Public health expenditure (% of GDP) ²⁴	Stunting (% under 5 years) ^{2,4}	Gini Index ⁴²	Gender Inequality Index ^{2,4}	Population density (people per km ² of land area) ⁴³	Urban population (%) ⁴⁴
Brazil	0.754	74.7	15.2	7.8	14,145	3.8	7.1	51.3	0.414	25	84.9
Bulgaria	0.794	74.3	15.0	10.8	16,261	4.6	8.8	37.4	0.223	66	73.7
China	0.738	76.0	13.5	7.6	13,345	3.1	9.4	42.2	0.164	147	51.9
Colombia	0.727	74.2	13.6	7.6	12,762	5.4	12.7	50.8	0.393	44	75.6
Ecuador	0.739	76.1	14.0	8.3	10,536	4.5	25.2	45.0	0.391	66	68.0
Lebanon	0.763	79.5	13.3	8.6	13,312	3.0	16.5	31.8	0.381	587	87.4
Mexico	0.762	77.0	13.3	8.6	16,383	3.3	13.6	43.4	0.345	66	78.4
Thailand	0.740	74.6	13.6	7.9	14,519	5.6	16.3	37.8	0.366	135	34.4
Uruguay	0.795	77.4	15.5	8.6	19,148	6.1	10.7	39.7	0.284	20	92.6
Venezuela	0.767	74.4	14.3	9.4	15,129	1.5	13.4	46.9	0.461	36	93.7

Abbreviations: HDI, Human Development Index; GNI, gross national income.

Table 4 Grades Assigned to Core Physical Activity Indicators Among Countries With a High HDI

Country	PA	SP	AP	AT	SB	PF	FAM	SCH	COM	GOV
Brazil	D	C+	D+	C	D-	D	C-	C	C-	D+
Bulgaria	D+	C+	C+	B-	D	INC	D	C	C	INC
China	F	D-	D+	C+	F	D	D+	D+	F	F
Colombia	D+	C	INC	B	D+	D-	INC	D	B-	B
Ecuador	D	INC	INC	C-	C	INC	F	INC	D+	INC
Lebanon	D	F	INC	D	C-	INC	INC	D	INC	C+
Mexico	D+	C	INC	C+	D-	INC	INC	D+	D+	C
Thailand	D-	C-	F	C	D-	INC	B	B	B-	B+
Uruguay	D	F	INC	C	C-	C-	INC	C-	INC	D
Venezuela	D	D	INC	B-	INC	INC	INC	INC	D-	F

Abbreviations: AP, Active Play; AT, Active Transportation; COM, Community and Environment; FAM, Family and Peers; GOV, Government; HDI, Human Development Index; INC, incomplete; PA, Overall Physical Activity; PF, Physical Fitness; SB, Sedentary Behaviors; SCH, School; SP, Organized Sport Participation.

Overall Physical Activity

Among the estimated average grades for the 10 countries, the Overall Physical Activity indicator had the lowest grade “D-”, indicating that less than one-third of children and youth are enjoying the benefits of being regularly active. This is consistent with global reports³ and with the results of the Global Matrix 2.0, in which 53% of the countries graded this indicator with a “D”.²² Although Bulgaria, Colombia, and Mexico graded this indicator higher (“D+”), the grades are still low. Compared with the Global Matrix 2.0, the grades remained the same for China, Thailand, and Venezuela, decreased for Brazil (from “C-” to “D”) and Mexico (from “C” to “D+”), and increased for Colombia (“D” to “D+”). However, these latter changes are more likely to be the result of changes in the benchmarks, the inclusion of additional evidence, or the change in data collection methods, instead of an actual change in the behaviors.³⁰ The comparability of these results among the 10 countries should be interpreted with caution because, as observed in Table 7, there was important variation in the methods used to assess the

Overall Physical Activity indicator. Objective methods were used only in Brazil, and all other countries used different questionnaires. At the same time, countries reported meeting different benchmarks, according to available weekly data. Brazil and Thailand reported the children meeting physical activity guidelines on average,^{27,34} and Colombia, Ecuador, and Venezuela reported those meeting guidelines 4 days or more,^{30,31,36} which could be comparable, as observed in previous evidence.⁴⁵ By contrast, China, Lebanon, and Mexico reported children meeting the guidelines 7 days,^{29,32,33} Bulgaria reported 6 days,²⁸ and Uruguay reported 5 days or more.³⁵ These differences highlight the need of consensus in implementing common methods to assess compliance with physical activity guidelines, as well as providing access to raw data for researchers to be able to estimate common indicators. In addition, the comparability of estimates for overall physical activity could be affected by the wide variation in the sample sizes of the surveys or studies that informed this indicator. Specifically, small sample sizes could be affecting the precision of the estimates.

Table 5 Average Grades and Descriptive Statistics by Indicator or Group of Indicators Among Countries With a High Human Development Index

Indicator	Grade count	Incomplete grades	Mean number grade	SD	Mean letter grade
Overall Physical Activity	10	0	4.9	1.2	D-
Organized Sport and Physical Activity	9	1	6.0	2.8	D+
Active Play	4	6	5.8	2.9	D
Active Transportation	10	0	8.5	1.7	C
Sedentary Behaviors	9	1	5.2	1.9	D
Physical Fitness	4	6	5.2	1.3	D
Family and Peers	5	5	6.2	3.3	D+
School	8	2	7.0	2.0	C-
Community and Environment	8	2	6.6	2.8	D+
Government	8	2	6.9	3.8	D+
Behavioral indicators	10	0	6.4	1.2	D+
Sources of influence indicators	10	0	6.5	2.4	D+
All indicators	10	0	6.4	1.3	D+

Note: Physical fitness was not included in the behavioral indicators cluster. There are no missing grades for the bottom 3 rows because these scores are adjusted for missing grades.

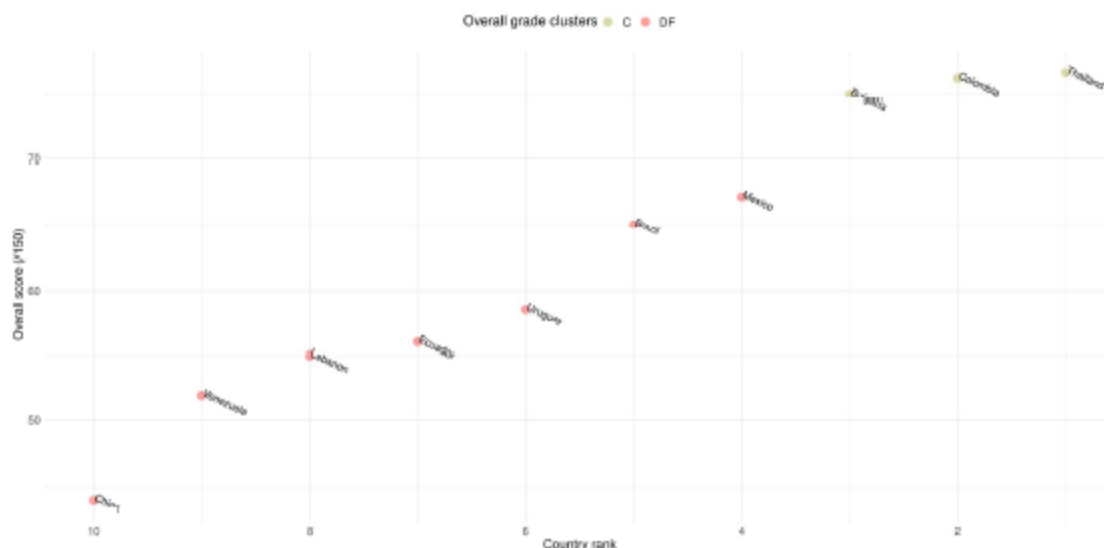


Figure 1 — Scatterplot of the overall score estimated for the 10 core indicators in the Global Matrix 3.0.

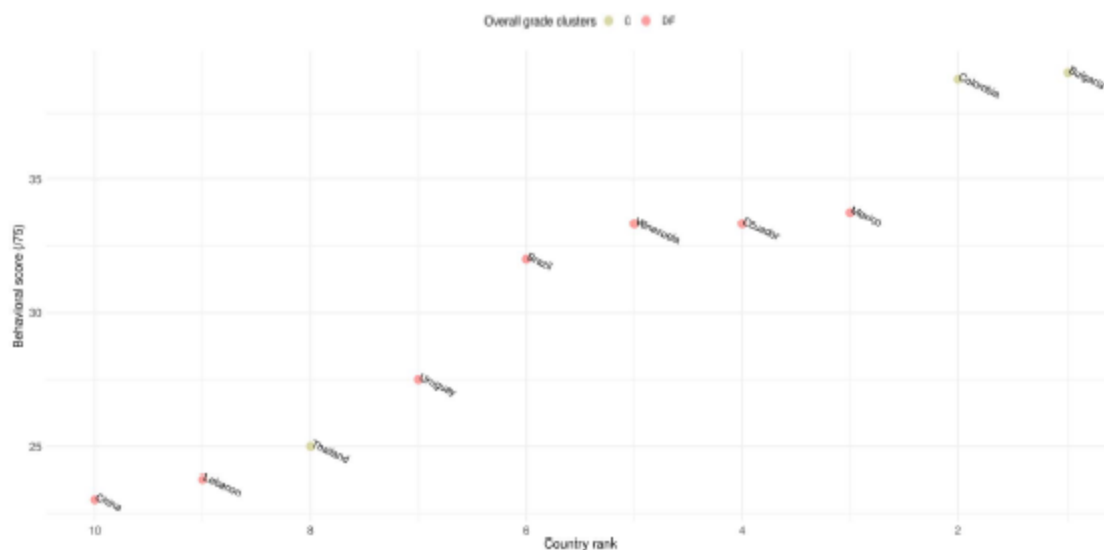


Figure 2 — Scatterplot of the behavioral score across 10 high-HDI countries in the Global Matrix 3.0.

Organized Sport and Physical Activity

According to the estimated average grade, approximately 1 of every 3 children and youth from high-HDI countries in the Global Matrix 3.0 participated in organized sport and/or physical activity programs. These results are slightly lower than those observed for the Global Matrix 2.0.²² However, this is consistent with the fact that middle-income countries, such as Colombia and Mexico, had lower grades than high-income countries in the Global Matrix 2.0. Among countries that participated in previous Global Matrices, an

increase in the grades was observed for Mexico and China. In the case of Mexico, the latest version of the National Health and Nutrition Survey ENSANUT showed an increase in sports participation among girls and children from rural areas.⁴⁶ This change could be related to the implementation of programs to promote physical activity at the school level, such as *Muevete en 30 Escolar*.⁴⁶ However, the impact of these programs in Mexico has not been evaluated and a causal relationship cannot be established. In the case of China, the change in the grade could be related to the inclusion of national data compared with mainly Shanghai's

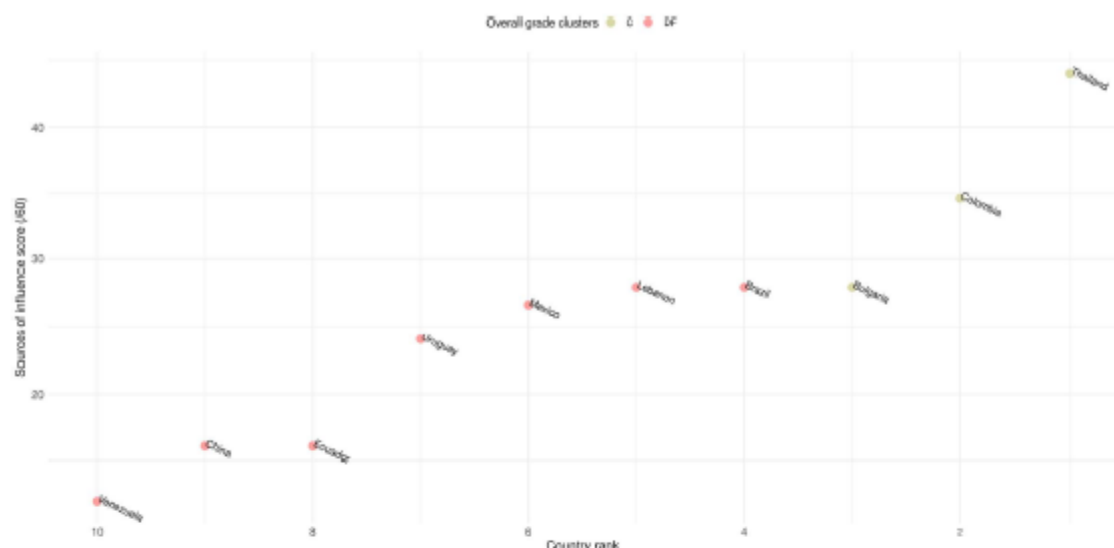


Figure 3 — Scatterplot of the sources of influence score across 10 high-HDI countries in the Global Matrix 3.0.

Table 6 Correlation Matrix (Spearman's Rank Correlation Coefficients) of Core Indicators and Sociodemographic Indexes

Sociodemographic Index/core indicator	Core Indicators								
	PA	SP	AP	AT	SB	FAM	SCH	COM	GOV
PA									
SP	.53								
AP	.63	.50							
AT	.46	.45	.83						
SB	.28	-.38	.50	-.44					
FAM	-.46	-.21	-.95	.05	-.67				
SCH	-.26	.38	-.50	-.15	-.36	.63			
COM	.38	.51	-.32	.12	.36	.50	.24		
GOV	.28	.29	-.87	-.22	.24	1.00*	-.04	.91*	
HDI	.22	-.21	.63	-.09	.26	.10	.21	-.10	-.40
Life expectancy at birth	-.26	-.64	-.32	-.78*	.33	-.40	-.29	-.55	-.13
Mean years of schooling	.38	.00	.32	.03	.39	-.50	.23	-.09	-.23
GNI per capita	.19	.03	.32	.23	-.31	.40	.55	-.02	-.35
Public Health Expenditure	.13	.16	-.32	.01	.24	.20	.50	.93*	.43
Stunting	-.10	-.49	-.63	-.48	.53	-.30	-.38	-.01	.56
Gini index	.15	.42	-.32	.33	-.13	.00	-.06	-.05	-.24
Gender Inequality Index	.13	.15	-.32	.00	.32	.10	-.12	.12	.11
Population density	-.31	-.23	-.32	-.28	-.21	.15	-.24	-.12	.31
Urban population	.28	-.35	.63	.01	.40	-.30	-.35	-.21	-.50

Abbreviations: AP, Active Play; AT, Active Transportation; COM, Community and Environment; FAM, Family and Peers; GNI, gross national income; GOV, Government; HDI, Human Development Index; PA, Physical Activity; SB, Sedentary Behaviors; SCH, School; SP, Organized Sport and Physical Activity. Note: Correlation coefficients in bold show strong (negative or positive) relationships between a specific indicator and an index/indicator. Physical Fitness was removed from this analysis due to incomplete grades. Pairwise deletion was used to treat missing data.

*Correlations that were statistically significant ($P < .05$).

Table 7 Methods Implemented to Assess the Overall Physical Activity Indicator Across 10 High-HDI Countries

Country	Study or survey	Method to assess physical activity		Questionnaire or device	Respondent	Sample
		Subjective	and objective			
Brazil	National Survey of School Health—PENSE and 89 regional surveys.	Subjective	and objective	Physical Activity Questionnaire for Older Children Physical Activity Questionnaire for Adolescents Global School-based Student Health Survey Youth Risk Behavior Survey Good Health Questionnaire (Good Health) Physical Activity Questionnaire for Adolescents List of Physical Activities Physical Activity Questionnaire Risk Behaviors in Adolescents from Santa Catarina Previous Day Physical Activity Questionnaire International Physical Activity Questionnaire Accelerometers Pedometers	Self-reported	242,259 children and youth between 6 and 19 y old
Bulgaria	Active Kids National Representative Survey 2016	Subjective		Youth Risk Behavior Survey Questionnaire	Self-reported	1014 children and youth between 6 and 18 y old
China	Physical Activity and Fitness in China—The Youth Study	Subjective		Health Behavior in School-age Children Study Questionnaire	Self-reported	125,281 children and youth between 9 and 17 y old
Colombia	National Nutrition Survey ENSIN 2015	Subjective		Youth Risk Behavior Survey Questionnaire	6–12 y: reported by parents 13–17 y: self-reported	12,106 children and youth between 6 and 17 y old
Ecuador	National Health and Nutrition Survey 2012	Subjective		Modified version of the International Physical Activity Questionnaire	Self-reported	10,910 children and youth between 10 and 17 y old
Lebanon	Lebanese-Food and Nutrition Security Study Global School-based Student Health Survey 2017	Subjective		Modified version of the Children and Youth Physical Activity Questionnaire Global School-based Student Health Survey Questionnaire	Self-reported	1079 children and youth between 5 and 17 y old
Mexico	National Health and Nutrition Survey ENSANUT 2016	Subjective		Health Behavior in School-age Children Study Questionnaire	Self-reported, with assistance from parents/tutors	5708 youth between 13 and 17 y old 1843 children between 10 and 14 y old
Thailand	Thailand Physical Activity Surveillance System 2015–2017	Subjective		International Physical Activity Questionnaire short version Thailand Physical Activity Children Survey—Student Questionnaire and 24-h clock	Self-reported 6–9 y-old children: self-reported, with assistance from parents/tutors 10–17 y-old pupils: self-reported	1440 youth between 15 and 19 y old 1287 children and youth between 6 and 17 y old
Uruguay	Global School-based Student Health Survey 2012	Subjective		Global School-based Student Health Survey Questionnaire	Self-reported	3524 youth between 13 and 15 y old
Venezuela	Latin American Study of Nutrition and Health	Subjective		International Physical Activity Questionnaire	Self-reported	156 youth between 15 and 19 y old

data in the Global Matrix 2.0.^{9,29} The availability of data for countries that had INC grades in previous versions of the Global Matrix for this indicator could be considered an improvement in surveillance or in the methodology to gather the evidence, which is the case for Brazil^{27,47} and Venezuela.^{36,48}

Active Play

The average “D” grade for Active Play indicates that only around 30% of children and youth are involved in unstructured active play. This could be considered as a low engagement with a behavior that could be relatively easier to promote than organized physical activity, from a public health perspective,⁴⁹ and that contributes to improved physical, emotional, social, and cognitive development.⁵⁰ It is worth noting that the frequency and time reported for these activities varied from 1 country to another, which makes it difficult to compare the situation between countries. Furthermore, the average grade was based on the data available for the 4 countries that graded this indicator (Brazil, Bulgaria, China, and Thailand). The lack of data for more than half of the countries in this analysis is an indication of the need to include active play and unstructured physical activity in the surveillance agenda of these countries.

Active Transportation

The Active Transportation indicator obtained the highest average grade (“C”) suggesting that around 50% of children and youth in the 10 countries use some mode of active transportation to get to and from places. This prevalence is not negligible, and in the context of the physical inactivity crisis, it is encouraging that at least half of the population of children and youth are enjoying the multiple benefits of active transportation^{51–54} on a regular basis. However, it is important to notice that for some of the countries in this analysis, as in other high-HDI countries, the high prevalence of active transportation may be the result of a daily need instead of a choice.^{22,53,55} For this reason, the challenge with high-HDI countries is to maintain these behaviors in the current context of rapid economic growth and increased access to motorized transportation.¹⁰ In countries such as Brazil and China, trends analyses show important declines in active transportation,^{56,57} which are indicative of the urgency to design and implement strategies to make cycling and walking a desirable, safe, accessible, and sustainable mode of transport for children and youth.

Sedentary Behaviors

The average grade for the Sedentary Behaviors indicator was “D” and suggests that in high-HDI countries participating in the Global Matrix 3.0, only one-third of children and youth engage in 2 or less hours of recreational screen time, meeting the Canadian Sedentary Behavior Guidelines.⁵⁸ This proportion is consistent with international estimates that indicate at least two-thirds of the children in the International Children’s Accelerometry Database exceeded 2 hours of recreational screen time per day.⁵⁹ These findings are concerning given the associations of excessive screen time with reduced fitness, unfavorable body composition, and lower scores for self-esteem and prosocial behavior.⁶⁰ In the current analysis, the proportion of children meeting the guidelines ranged from 7.1% in China²⁹ to 55.4% in Ecuador.³¹ However, there are methodological differences that limit the comparability of these data. For example, China reported sedentary behaviors, including homework time,²⁹ which could underestimate the proportion of children meeting the

sedentary behavior guidelines, which are focused on recreational screen time. Similarly, the behavior reported by Brazil in this indicator was watching television, which according to longitudinal international data seem to be decreasing in many countries, whereas other screen time-related behaviors are increasing.⁶¹ Therefore, to improve comparability of data, standardization of methods and tools to measure sedentary behaviors is required.

Physical Fitness

An average “D” grade was assigned to the Physical Fitness indicator based on the grades available for Brazil, China, Colombia, and Uruguay. This grade is difficult to interpret, given the differences in the information and samples reported for this indicator among countries. Although Brazil reported data for cardiorespiratory fitness, muscular strength, endurance and flexibility,²⁷ China reported a physical fitness score estimated from 11 fitness indicators,²⁹ Uruguay reported cardiorespiratory fitness and handgrip strength,³⁵ and Colombia only reported handgrip strength.³⁰ Despite this limitation, the grades are consistent with previous evidence indicating low performance on physical fitness in South American countries.⁶² Considering the potential of cardiorespiratory fitness as an indicator of current and future health,⁶³ and the high proportion of INC grades for this indicator, surveillance on fitness should be a priority in the research and health monitoring agenda for high-HDI countries.

Family and Peers

The average grade for this indicator was “D+”. Compared with other indicators, more variability is observed among the 5 countries that graded the influence of family and peers. The grades ranged from “F” in Ecuador, to “B” in Thailand. The low grade in Ecuador is based on the fact that only 11.6% of the adults in the households are meeting the Global Recommendations on Physical Activity for Health.³¹ Higher grades and different benchmarks were reported in Brazil and Thailand, where more than 50% and 70% of family members, respectively, facilitated physical activity and sport opportunities for their children through volunteering, coaching, driving, or investing resources. Compared with the Global Matrix 2.0, the grades for this indicator remained the same for Brazil and Thailand.²² For China, the grade decreased as a reflection of the differences between the data for the national level and the data exclusively for Shanghai, reported in the Global Matrix 2.0.^{9,29} As in previous versions of the Global Matrix, research gaps for this indicator are evident across countries.^{21,22} The research network created around the Global Matrix 3.0 could lead to opportunities to share methodologies and tools used by countries that are monitoring the influence of family and peers on physical activity of children and youth, with countries where this evidence is lacking.

School

Among the sources of influence indicators, the school environment obtained the highest average grade “C–”, ranging from “D” in Lebanon and Colombia to “B” in Thailand. The low grades in Lebanon and Colombia are based on the report of physical education participation.^{30,32} In Colombia, 81.4% of children and adolescents reported attending physical education classes once per week. Though this proportion seems high, the rationale to assign a low grade was based on the fact that physical education is mandatory and almost 20% of school-attending children and youth did not report participation in the last week.³⁰ The high grade in Thailand is

based on the fact that 70% of schools in Thailand provide their students access to facilities and equipment that support physical activity.³⁴ Comparing results between countries is challenging given the variety of information reported due to the complex nature of this indicator and the variety of factors at school that can influence physical activity among children and youth.⁶⁴ However, the low grades for the behavioral indicators are indicative of the need for implementation of the available policies, as well as the importance of assuring the provisioning of high-quality physical education classes. International efforts such as the UNESCO core principles for quality physical education indicators⁶⁵ could guide countries in the definition and monitoring of the quality of physical education.

Community and Environment

An average “D+” grade was estimated for the Community and Environment indicator. The grades ranged from “F” in China to “B–” in Colombia and Thailand. The low grades in China are based on the limited access to sports facilities, equipment, and activities at the community level for children and youth (14.8%).²⁹ By contrast, Colombia and Thailand assigned a relatively high grade based on the fact that around 64% of children and youth reported having access to facilities, programs, and parks to be physically active.^{30,34} Low grades in Mexico (“D+”) and Venezuela (“D–”) are mainly influenced by safety perceptions. In Mexico, according to the latest National Survey on Safety Perception, 74% of Mexican adults stopped allowing their children to go outside.³³ Similarly, in Venezuela, 75.5% of adolescents consider insecurity as an obstacle for being physically active.³⁶ The evidence available for this indicator in high-HDI countries in the Global Matrix is consistent with the findings of a review on built environment and physical activity in developing countries. This review highlighted that the evidence on the built environment in Latin America has focused on crime, traffic safety, and availability of parks and open spaces, while the evidence from Middle Eastern countries and middle-income countries in Europe is limited.¹²

Government

A “D+” average grade was estimated for the Government indicator in high-HDI countries. However, the grades ranged from “F” in China to “B+” in Thailand. The failing grade in China is based on the low proportion of parents that reported being aware of the existence of national policies to promote physical activity among children.²⁹ In the case of Thailand, the “B+” grade was based on the fact that 74.4% of policymakers reported that existing policies to promote physical activity are being implemented.³⁴ For example, since 2015, the “Teach Less Learn More” policy has been implemented in both primary and secondary schools nationwide to provide more opportunities for students to move outside of the classroom. Although most of the countries in this group reported the existence of programs, national plans, or policies, the implementation and impact of these initiatives are unknown.^{27,30,31,33}

Sources of Influence and Behavioral Indicators

Previous versions of the Global Matrix showed higher grades for the sources of influence indicators compared with the behavioral indicators.^{21,22} The findings from our analysis differ from those, given that there is no apparent difference among sources of influence and behavioral indicators, all of them have low average grades (D+), which suggests that beside the low engagement in active behaviors, the current opportunities provided by families,

schools, communities, and governments to engage in physical activity are limited. According to the estimated scores, Bulgaria is leading the behavioral indicators and Thailand leads the sources of influence. Bulgaria’s lead seems to be due to a relatively high participation in organized sports outside of school (56%), active play (55% of children involved in outdoor activities 3 or more days per week), and active transportation (64%).²⁸ In the case of Thailand, there is a high involvement of parents in facilitating physical activity for their children, high accessibility to school facilities to engage in physical activity, and a high perception of access to supportive environments for being active.³⁴ At the same time, Thailand’s government has demonstrated commitment and leadership in implementing policies to promote physical activity among children.³⁴ However, the low ranking of Thailand for the behavioral score suggests that the success in the sources of influence indicators is not yet reflected in improved behaviors.

The correlational analysis revealed statistically significant positive or negative correlations between sociodemographic factors and physical activity indicators, as well as within physical activity indicators. We found that as grades for Community and Environment indicator increased, grades for Government indicator and the yearly public health expenditure increased. These are intuitive correlations, considering the significant power of governments in the design of the built environment (sidewalks, walking and cycling trails, and green space), the maintenance of infrastructure, and their role in the provision of resources for community programs that promote physical activity.⁶⁶ An opposite pattern was observed between Active Transportation and life expectancy indicating that as Active Transportation grades increased, life expectancy decreased. This may be related to the conditions in which active transportation is performed, considering that developing countries have the highest burden of road traffic accidents⁶⁷ and pedestrians and cyclists are more vulnerable. In Lebanon, for example, pedestrian deaths represented 40% of all reported road traffic deaths in 2013.⁶⁸ Evidence from China suggest that improvements in road safety conditions could lead to a gain in life expectancy.⁶⁹ Therefore, the promotion of active transportation in developing countries should include policies to improve road safety. Finally, the association observed between Family and Peers with Government should be interpreted with caution as only 3 countries graded both of the indicators. Missing data and the small sample size highlight the need to interpret these correlations with caution.

Gaps in Knowledge

Evidence is limited to provide a comprehensive description of the Global Matrix 3.0 indicators among the 10 high-HDI countries. Only Brazil and China had evidence available to grade all the indicators. This suggests that these countries are leading the research development in physical activity in this group and their efforts in surveillance could guide other countries. As described by the Global Observatory of Physical Activity, these are the only middle-income countries in the top 10 of scientific publications in the field.⁷⁰ One quarter of the total matrix of indicators could not receive a grade because of insufficient evidence. As observed in the previous versions of the Global Matrix,^{21,22} Active Play and Family and Peers remain the indicators where the evidence is lacking for most of the countries. These gaps point out the need for consensus on definitions and measures to assess these indicators. Physical fitness was included in the Global Matrix for the first time, and the absence of data for more than half of the high-HDI countries supports the call to improve fitness surveillance among children and youth worldwide.⁶³

Some limitations should be taken into account for this analysis. First, we only included 10 high-HDI countries out of the 55 total countries under this classification, so the representativeness of countries at this level of development is limited. Among these 10 countries, 60% belong to the Americas region, which could also limit the external validity of our results. Second, the sources of data, as well as the quality of the evidence varied widely between countries, which could limit the comparability of data. Third, the variability in sociodemographic variables suggests heterogeneity in this group of countries, which makes difficult to infer clear relationships between physical activity indicators and contextual variables at the group level. Fourth, there are important contextual differences between the countries that HDI might not capture at the moment of this research, such as political and cultural dimensions, as well as disparities that can influence the determinants of physical activity. The absence of these dimensions can compromise the comparability of the overall physical activity scenario for all 10 countries. Fifth, there was a considerable amount of INC grades or missing data, which makes it difficult to rank and compare the indicators among countries. However, this paper also has several strengths. It provides a comprehensive assessment of the physical activity evidence for children and youth from countries experiencing a physical activity transition, compiling the best available national data. The harmonized process to develop the individual report cards that informed the Global Matrix represents an advance in standardization and accountability in physical activity surveillance, as well as an important methodological effort to structure a global vision on physical activity of the young population. Finally, the leadership and commitment from researchers from every country participating, in each of the stages of the project, provide assurance of the inclusion of relevant and accurate information for each country.

Conclusion

This analysis of Global Matrix 3.0 grades shows that high-HDI countries are lagging in both physical activity behaviors and sources of influence indicators. The main challenge for high-HDI countries is to provide opportunities to increase physical activity, in the context of concurrent social and economical changes occurring, appropriate for the stages of development that these countries are experiencing. This analysis identified the main gaps in physical activity surveillance and could guide future initiatives to define indicators and measures in a standardized manner. Filling the research gaps and involving more high-HDI countries in future versions of the Global Matrix may provide a better understanding of the situation of physical activity among children in the context of a physical activity transition.

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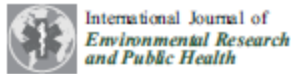
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Appendix 9. Published version of Manuscript 5 Profiles of Active Transportation among Children and Adolescents in the Global Matrix 3.0 Initiative: a 49-Country Comparison



Article

Profiles of Active Transportation among Children and Adolescents in the Global Matrix 3.0 Initiative: A 49-Country Comparison

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Abstract: This article aims to compare the prevalence of active transportation among children and adolescents from 49 countries at different levels of development. The data was extracted from the Report Cards on Physical Activity for Children and Youth from the 49 countries that participated in the Global Matrix 3.0 initiative. Descriptive statistics and a latent profile analysis with active transportation, Human Development Index and Gini index as latent variables were conducted. The global average grade was a “C”, indicating that countries are succeeding with about half of children and youth (47–53%). There is wide variability in the prevalence and in the definition of active transportation globally. Three different profiles of countries were identified based on active transportation grades, Human Development Index (HDI) and income inequalities. The first profile grouped very high HDI countries with low prevalence of active transport and low inequalities. The second profile grouped low and middle HDI countries with high prevalence of active transportation and higher inequalities. And the third profile was characterized by the relatively high prevalence of active transportation and more variability in the socioeconomic variables. Promising policies from countries under each profile were identified. A unified definition of active transportation and contextualized methods for its assessment are needed to advance in surveillance and practice.

Keywords: cycling; walking; health promotion; policy; latent profile analysis; surveillance

1. Introduction

The world is experiencing a crisis of physical inactivity with almost 80% of adolescents not achieving the recommended 60 min of daily moderate to vigorous physical activity for health [1]. In this context, transportation, as a daily necessity to move from one place to another, represents a promising domain to promote the accumulation of physical activity in children and adolescents in a convenient and habitual manner [2]. Specifically, active transportation to/from school is an opportunity to integrate physical activity into children's and adolescent's routines [3].

Active transportation comprises non-motorized travel modes like walking, cycling or riding a scooter, among others [4]. The use of these active modes leads not only to health benefits such as greater levels of cardiorespiratory fitness [3,5] and better cardiometabolic health indicators [6] among children who actively commute, but also to other co-benefits, such as better mental health

outcomes [7,8], greater interaction with their environment [9], and reduced transportation-related emissions and pollution [10]. Despite these benefits, current evidence suggests that this behaviour is declining in many countries [11].

In the same way that physical inactivity prevalence varies widely across countries [1], a wide variation in active transportation could be expected. These variations represent an opportunity to identify those countries that are succeeding with active transportation behaviours, and those that require action to increase active transportation or prevent a decline in this behaviour. However, to the best of our knowledge, the few international comparisons of data on active transportation among children and adolescents include mostly small groups of countries or the availability of national representative data is limited [11–13]. Therefore, the Global Matrix 3.0 of Report Card grades on physical activity among children and youth provides an opportunity to describe and examine the global situation of active transportation. For the first time, 49 countries from all continents reported data on an active transportation indicator at the national level [14]. The aims of this study were to compare the prevalence of active transportation among children and adolescents from 49 countries participating in the Global Matrix 3.0, to identify a set of profiles to group the countries according to their prevalence of active transport and sociodemographic variables, and to discuss policies and practices implemented across different countries to increase active transportation.

2. Materials and Methods

The Global Matrix 3.0 was an international initiative released in 2018 and led by the Active Healthy Kids Global Alliance (AHKGA). This project brought together 513 researchers and physical activity leaders from 49 countries around the world [15]. All the participating countries followed a harmonized process to develop Report Cards on the physical activity of children and youth. A detailed description of the countries' involvement and the process to develop the Report Cards has been published elsewhere and is briefly described here [14].

In each country, National Report Card Committees gathered the best and most recent national surveillance data available up to 2018 to inform and grade ten specific indicators related to physical activity among children and adolescents: Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behaviours, Physical Fitness, Family and Peers, School, Community and Environment, and Government [14]. The analyses presented in this paper are focused on the Active Transportation indicator.

According to the benchmarks proposed by AHKGA to harmonize and guide the development of the Report Cards, the Active Transportation indicator was described as the “percentage of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend’s house)” [14]. Report card leaders were instructed to inform this indicator by the best, preferably nationally representative, data available for children and adolescents between five and 17 years, and a grade was assigned according to the prevalence following a common rubric established by the AHKGA (Table 1).

The prevalence of active transportation reported by each country and the related details presented in each Report Card, including policies, practices, strategies to improve the grade and research gaps, were extracted from the Report Cards and from related publications in English, Spanish or French, including brief reports, posters and peer-reviewed articles. These publications were reviewed, and relevant information was summarized by two of the authors of this manuscript. Based on the grades provided, numerical equivalents were assigned (Table 1), and average estimates of the grades for active transportation were calculated at the global level and by groups of countries according to their level of development determined by the Human Development Index (HDI). The HDI is a composite index created by the United Nations Development Programme (New York, NY, USA) to rank countries based on key dimensions of human development such as education, life expectancy and gross national income per capita [16]. HDI ranges from 0 to 1 and for the present analysis we used the continuous index and a categorical variable that classified countries in three categories: low and

medium ($HDI < 0.70$), high ($HDI \geq 0.70$ to <0.80) and very high ($HDI \geq 0.80$) [16]. It was included as a variable of interest in this analysis based on the variability in active transportation observed across HDI clusters in previous analysis of the Global Matrix [14]. Also, the Gini index for each country was retrieved from the World Bank estimates. The Gini index provides a measure of inequality in income distribution. It ranges from 0 (perfect equality) to 100 (perfect inequality) [17]. The Gini index was included in this analysis considering previous international evidence that has shown that income inequality is a relevant variable related to physical activity levels and taking into account the importance of socioeconomic inequalities in transport as an essential activity for economic and social development [18,19].

Table 1. Global Matrix 3.0 grading rubric.

Grade	Interpretation ^a	Numerical Equivalents ^b
A+	94–100%	15
A	We are succeeding with a large majority of children and youth (87–93%)	14
A–	80–86%	13
B+	74–79%	12
B	We are succeeding with well over half of children and youth (67–73%)	11
B–	60–66%	10
C+	54–59%	9
C	We are succeeding with about half of children and youth (47–53%)	8
C–	40–46%	7
D+	34–39%	6
D	We are succeeding with less than half but some children and youth (27–33%)	5
D–	20–26%	4
F	We are succeeding with very few children and youth (<20%)	2
INC ^c	Incomplete—insufficient or inadequate information to assign a grade	

^a For this article, the interpretation corresponds to the percentage of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend's house). ^b Letter grades were converted to numerical equivalents for analyses purposes. ^c INC: Incomplete

A latent profile analysis (LPA) was conducted to identify groups or profiles of countries based on the numerical grades for active transportation and the two sociodemographic variables at the country level, the HDI and the Gini index. LPA is a probability-based statistical procedure that allows to identify classes or profiles that group observations sharing similar patterns of the variables of interest [20]. The analysis was performed to look for the best model solution for one to five possible profiles. Models were compared to choose the solution with the best fit based on the Akaike information criterion (AIC), sample-adjusted Bayesian information criterion (SABIC) and the bootstrapped likelihood ratio test (BLRT) as indicators of model fit. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA) and R (version 3.4.1, The R Foundation for Statistical Computing, Vienna, Austria). The tidyLPA package [21] was used for the LPA.

3. Results

A total of 47 countries (96%) in the Global Matrix 3.0 had sufficient evidence (determined by each country's National Report Card Committee) on active transportation to assign a grade. The grades ranged from "A–" in Japan, Nepal and Zimbabwe to "F" in Chile (Table 2). The global average for active transportation was "C". The average grade by HDI was "C+" for low to medium HDI countries, "C" for high HDI countries and "C–" for very high HDI countries, as previously reported by Aubert et al. [14]. The HDI of the included countries varied from 0.448 in Ethiopia to 0.985 in Jersey. According to the Gini index, the country with the most unequal distribution of income was South Africa with a Gini index of 63, while Slovenia had the lowest inequality score, with a Gini of 25.4 (Table 2).

Table 2. Active transportation grades and sociodemographic variables of the 49 countries participating in the Global Matrix 3.0.

Country	Active Transport Grade	Active Transport Numerical Grade	Human Development Index (HDI) ^a	HDI Classification	Gini Index ^b
Australia	D+	6	0.939	Very high	34.7
Bangladesh	C−	7	0.579	Low to medium	32.4
Belgium (Flanders)	C+	9	0.896	Very high	27.7
Botswana	C	8	0.698	Low to medium	60.5
Brazil	C	8	0.754	High	51.3
Bulgaria	B−	10	0.794	High	37.4
Canada	D−	4	0.920	Very high	34.0
Chile	F	2	0.847	Very high	47.7
China	C+	9	0.738	High	42.2
Colombia	B	11	0.727	High	50.8
Czech Republic	C+	9	0.878	Very high	25.9
Denmark	B+	12	0.925	Very high	28.2
Ecuador	C−	7	0.739	High	45.0
England	C−	7	0.909	Very high	33.2
Estonia	D	5	0.865	Very high	32.7
Ethiopia	C	8	0.448	Low to medium	39.1
Finland	B+	12	0.895	Very high	27.1
France	C−	7	0.897	Very high	32.7
Germany	C−	7	0.926	Very high	31.7
Ghana	C+	9	0.579	Low to medium	42.4
Guernsey Channel Islands	D	5	0.975	Very high	40.0
Hong Kong	B+	12	0.917	Very high	N/A
India	B−	10	0.624	Low to medium	35.1
Japan	A−	13	0.903	Very high	32.1
Jersey	D+	6	0.985	Very high	41.0
Lebanon	D	5	0.763	High	31.8
Lithuania	C−	7	0.848	Very high	37.4
Mexico	C+	9	0.762	High	43.4
Nepal	A−	13	0.558	Low to medium	32.8
Netherlands	B−	10	0.924	Very high	29.3
New Zealand	C−	7	0.915	Very high	N/A
Nigeria	B	11	0.527	Low to medium	43.0
Poland	C	8	0.855	Very high	31.8
Portugal	C−	7	0.843	Very high	35.5
Qatar	N/A	N/A	0.856	Very high	N/A
Scotland	C	8	0.909	Very high	33.2
Slovenia	C	8	0.890	Very high	25.4
South Africa	C	8	0.666	Low to medium	63.0
South Korea	B+	12	0.901	Very high	31.6
Spain	B−	10	0.884	Very high	36.2
Sweden	C	8	0.913	Very high	29.2
Taiwan	C−	7	0.885	Very high	33.6
Thailand	C	8	0.740	High	37.8
United Arab Emirates	INC	N/A	0.840	Very high	N/A
United States	D−	4	0.920	Very high	41.5

Table 2. Cont.

Country	Active Transport Grade	Active Transport Numerical Grade	Human Development Index (HDI) ^a	HDI Classification	Gini Index ^b
Uruguay	C	8	0.795	High	39.7
Venezuela	B+	10	0.767	High	46.9
Wales	D+	6	0.909	Very high	33.2
Zimbabwe	A+	13	0.516	Low to medium	43.2
Global average	C	8.29	NA	NA	NA
Low to medium HDI countries	C+	9.67	NA	NA	NA
High HDI countries	C	8.5	NA	NA	NA
Very high HDI countries	C+	7.78	NA	NA	NA

^a Data at the national level from the United Nations Development Programme [16]. ^b Data at the national level from the World Bank [17]. Abbreviations: HDI, Human Development Index; INC, Incomplete; N/A, Not available; NA, Not Applicable.

Table 3 presents the prevalence and rationales behind the grades for each country, as well as the sources and characteristics of the information reported. Active transportation among children and adolescents varied between 15% in Chile and 86% in Japan and Nepal. Among the countries that assigned a grade for active transportation, 83% ($n = 39$) did not provide details of the prevalence stratified by sex. In the majority (62%) of countries that reported data by sex, the prevalence of active transportation was slightly higher for males. More than half of the countries (65%) reported data for both children and adolescents, however, the age groups included varied from one country to another. Most countries (87%) only included data on school trips, and only two countries (Ecuador and the United States) clearly reported active transportation to other destinations. Regarding the direction of the trips, about half of the countries (49%) reported active transportation to and from school or other destinations. In more than half of the countries (65%), the frequency of active transportation reported was not clear. The most common frequencies reported were “daily” ($n = 3$), “typically” or “usually” ($n = 3$) and “on a regular basis” ($n = 2$). Regarding the source of information, 64% ($n = 30$) of the countries used data from surveys and studies with national representativeness, 8.5% ($n = 4$) used local studies, and 19% ($n = 9$) used both local and national studies. International surveys such as the Global School-Based Student Health Survey (GSHS) [22] and the Health Behaviour of School-aged Children (HBSC) [23] were among the sources of information in seven countries.

The best LPA model grouped the Global Matrix 3.0 countries into three profiles according to the grades for active transportation, the HDI and the Gini index. The three-profile model had the best fit statistics according to the criteria proposed by Nylund et al. for model selection [24]. The preferred model showed the lowest values for the AIC (359.8), SABIC (331.1) and the BLRT (24.8), and a significant p value for the BLRT ($p = 0.041$). Table 4 shows the descriptive statistics for the latent variables among the three profiles identified. In profile 1 ($n = 25$) 72% of the countries had active transportation grades below “C”, 96% of the countries had a very high HDI, and 72% had relatively low Gini indices (below 40). In profile 2 ($n = 7$), 85% of the countries had active transportation grades equal to or greater than “C”, all of them had a low to medium HDI and 43% had Gini indices above 40. In profile 3 ($n = 17$), 94% of the countries had active transportation grades equal to or greater than “C”, 53% had a high HDI and 35% had a very high HDI, and 47% had Gini indices above 40. For countries with missing values in any of the variables of interest, the LPA assigned a profile based on the values available for the remaining variables. Figure 1 presents a plot of the scaled data for the three profiles.

Table 3. Rationale for grades and information reported on active transportation by 49 countries involved in the Global Matrix 3.0.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
A–	Japan	86% of students used active transportation to school from home.	Not reported	6–17 years	To school	On a regular basis	The National Sports-Life Survey of Young People (SSF), 2015 [25]	3
A–	Nepal	86% of children and youth of 15–20 years used active transportation to get to and from places.	Not reported	15–20 years	Not specified	Not clear	Physical Activity Level and Associated Factors Among Higher Secondary School Students in Banke, Nepal: A Cross-Sectional Study, 2013 [26]	2
A–	Zimbabwe	Over 80% of children and adolescents used active transport to and from school, with variation between provinces as well as between rural and urban areas.	82% of girls and 79% of boys engaged in active transport to and from school	8–16 years	To and from School	Not clear	The Zimbabwe Baseline [27] and Global school-based health survey (GSHS) Zimbabwe 2003 [28]	2
B+	Denmark	78% of children and adolescents reported cycling, walking, or using children's scooters as transport (e.g., to school) at least two times per week.	Not reported	7–15 years	To school	At least two times per week	Danish Sports Habits Study 2016 [29]	3
B+	Finland	77% of children and adolescents actively commuted to school, on foot or by bike.	9 years old 79% of boys, 81% of girls 11 years old 85% of boys, 81% of girls 13 years old 80% of boys, 77% of girls 15 years old 59% of boys, 63% of girls	9–15 years	To school	Not clear	National Physical Activity Behaviour Study for Children and Adolescents 2016 (LIITU) [30]	3
B+	Hong Kong	80% of the adolescent males and 77% of the adolescent females actively travelled to school at least once per week. 52% of primary school children used active travel to/from school at least 5 times per week.	80% adolescent males and 77% adolescent females	Primary and secondary	To and from school	At least 5 times per week and at least once per week	Understanding Children's Activity and Nutrition (UCAN) study, 2011–2012 [31]	3
B+	South Korea	79.4% of children and adolescents reported walking or cycling to/from places, with an average duration of 39 min per day.	84.3% of boys and 73.8% of girls took active modes of transport	12–17 years	Not specified	Not clear	Korea National Health and Nutrition Examination Survey, 2016 [32]	3
B	Colombia	71.7% of children and adolescents in Colombia reported walking or biking as their main mode of transport to or from school in the previous week.	Not reported	6–17 years	To and from school	Main mode during the last 7 days	National Survey of Nutrition (ENSIN) 2015 [33]	3
B	Nigeria	The majority (61% to 80%) of Nigerian children and adolescents engage in some form of active transportation, mostly walking to and from school.	Not reported	5–13 years	To and from school	Not clear	2 different studies on rural and urban populations in Nigeria, conducted in 2011 [34] and 2013 [35]	2

Table 3. Cont.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
B–	Bulgaria	64% of children and youth reported walking, biking, or skating, etc. to go to school and back.	Not reported	Not specified	To and from school	Not clear	Bulgarian Active Kids survey, 2016 [36]	3
B–	India	Approximately 65% of children/adolescents (weighted average) reported walking or cycling to school on a regular basis.	Not reported	5–17 years	To school	On a regular basis	7 different studies at the national and local level conducted between 2005 and 2018 [12,13,37–41]	2
B–	Netherlands	90% of the adolescents commute actively to school. 36% of the children commute actively to school	Not reported	Not specified	To school	At least three days per week	Lifestyle monitor National Survey, 2017 [42]	1
B–	Spain	55% and 56.9% of children between 6 and 9 years old walked to and from school, respectively. In Catalonia, 61.3% of children between 3 to 14 years old walked to and from school.	Not reported	3–14 years	To and from school	Not clear	Food, Physical Activity, Child development and Obesity study (ALADINO) 2011 [43], and the Catalan Health Survey (ESCA) 2016 [44]	3
B–	Venezuela	63% of adolescents might walk at least 10 min to move from one place to another.	Not reported	Not specified	Not specified	Not clear	Venezuelan Study of Nutrition and Health [45]	3
C+	Belgium (Flanders)	55.5% of parents of 6-to 9-year old children reported that their child uses active transportation, and 58.9% of 10- to 17-year-olds adolescents reported to mainly use active transportation to travel to school.	Not reported	6 to 9 and 10 to 17	To school	Not clear	Belgian National Food Consumption Survey 2014 [46]	1
C+	China	56.3% of Chinese children (aged 6–18 years) reported going to and from school by walk or bicycle.	Not reported	9 to 17 years	To and from school	Daily	Physical Activity and Fitness in China—The Youth Study (PAFCTYS), 2016 [47]	3
C+	Czech Republic	On average, 57% (weighted mean: 59%) of children and adolescents reported using active transport to get to and from school.	Not reported	9–17 years	To and from school	Not clear	Health Behaviour in School-aged Children Study (HBSC) 2006, 2010, and 2014 [48] and International Physical Activity and Environment Network Study (IPEN), 2013–2015 [49]	1
C+	Ghana	About 54% of children and youth especially those in the rural areas walk to school and back home covering about 2 km.	Not reported	Not specified	To and from school	Not clear	Not specified	2
C+	Mexico	54.8% of children 3 years and older walked to school and 1.5% rode bicycles. 69% of 10–14-year-olds walked or rode a bicycle to school.	Not reported	3 years and older	To school	Not clear	Intercensal Survey of the National Institute of Statistics and Geography (INEGI), 2015 [50] and the National Health and Nutrition Survey 2016 (ENSANUT) [51]	3

Table 3. Cont.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
C	Botswana	49% of 13–15-year-olds walked or rode a bike to and from school at least one day during the past 7 days.	Not reported	13–15	To and from school	At least one of the last 7 days	2005 Botswana School-based Student Health Survey (GSHS) [13]	3
C	Brazil	55.0% of children and youth in Brazil used active transportation to get to and from school.	Not reported	6 to 21	To and from school	Not clear	18 different national and regional studies conducted between 2008 and 2017 [52]	3
C	Ethiopia	Approximately 48% of children and youth (31% in urban and 65% rural) walked to and from school.	Not reported	Not specified	To and from school	Not clear	Experts' opinion	2
C	Poland	47.4% of 10- to 17-year-olds reported walking to school and 52.3% walking from school. 5.5% and 5.2% travel to and from school by bicycle, respectively. 41% and 5% of lower-secondary students walk and cycle to school, respectively. While 36% and 3% of upper-secondary school students walk and cycle to school, respectively.	Not reported	10–19 years	To and from school	Not clear	Study of Physical Activity of School Children Aged 9–17 by the Institute of Mother and Child, 2013 [53] and the All-Poland survey of physical activity and sedentary lifestyles for middle school, high school and university students, 2011 [54]	1
C	Scotland	51% and 52% of school age children and adolescents, respectively, actively commuted to school (walking, cycling, skating or using scooter).	Not reported	4–18 years	To school	Not clear	Hands up Scotland Survey (HUS) 2016 [55], Transport and Travel in Scotland (TATIS) 2016 [56]	1
C	Slovenia	Almost 49% of children commute actively to and from school and additional 12% commute actively from school only.	52% of boys and 50% of girls commute actively to school	5–15 years	To and from school	Not clear	Analysis of Children's Development in Slovenia study (ACDSi) 2013–16 [57,58]	1
C	South Africa	63% of school-aged children walk to school. 81% of children and adolescents in Cape Town walk to school without adult supervision in low-income settings, and 61% of parents reported concerns about their children safety.	Not reported	6–15 years	To school	Not clear	General Household Survey, 2013 [59] and two local studies conducted in Cape Town, 2016 [60,61]	3
C	Sweden	48% and 57% of children and adolescents used active transportation to and from school in the winter and summer months, respectively.	Not reported	6–15 years	To and from school	Not clear	Children's Routes to School Survey 2015–16 [62]	1
C	Thailand	53.4% children and adolescents used active transportation (walking, cycling, using a wheelchair, in-line skating or skateboarding) to get to and from places.	54.7% of girls and 52.4% of boys used active transportation	6–17 years	Not specified	Not clear	Thailand Physical Activity Children Survey (TPACS) 2015 [63]	3
C	Uruguay	51.2% of adolescents between 13 and 15 years old went to the school walking or bicycling 4 or more days per week.	Not reported	13–15 years	To school	4 or more days per week	Global School-Based Student Health Survey (GSHS) 2012 [64]	3

Table 3. Cont.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
C–	Bangladesh	41.1% students aged 13–17 years used active transport to commute to or from school at all seven days prior to the survey.	Not reported	13–17 years	To and from school	Last 7 days	Bangladesh School-based Student Health Survey (GSHS), 2014 [65]	2
C–	Ecuador	42.7% of 5–17 years-old children reported going to school or work by foot or bike.	Boys: 42% Girls: 41%	5–17 years	To school, work or other destinations	Not clear	Not specified	3
C–	England	On average, 42.5% of children and adolescents used active modes of transport to school every day.	Not reported	5–16 years	To school	Every day	National Travel Survey 2016 [66], Health Survey for England 2015 [67] and Walking and Cycling Statistics 2016 [68]	1
C–	France	44% of the 3–10 years old and 43% of the 11–14 years old used active transportation to go to school according to the National Study of Individual Nutritional Consumption 2014–2015. And 41% of the 6–10-year-olds reported using active transportation to school according to the Health Study of the Environment, Biosurveillance, Physical Activity, and Nutrition 2015.	Not reported	3–14 years	To school	Not clear	National Study of Individual Nutritional Consumption (INCA) 2014–2015 [69] and the Health Study of the Environment, Biosurveillance, Physical Activity and Nutrition (ESTEBAN) 2015 [70]	1
C–	Germany	Approximately 40% of the children and adolescents commute actively to school.	Not reported	Not specified	To school	Not clear	Not specified	1
C–	Lithuania	45% of 7–8 aged children used active transport to school and 57.9% used active transport from school to home. 84% of children and adolescents (11–13 year) walked to/from school. 12% of youths and adolescents (15–24 year) reported to engage regularly in cycling from one point to another.	Not reported	7–24 years	To and from school	Not clear	4 different studies and one special report Eurobarometer on Sport and Physical Activity, between 2012 and 2017 [71–75]	1
C–	New Zealand	45% of children and adolescents aged 5–14 years usually used active transport to school according to the NZ Health Survey, 43% of children and youth aged 5–17-year-olds usually used active transport to and from school according to the Active NZ Survey. 30% of children aged 5–12 years and 31% of adolescents aged 13–17 years used active transport to school according to the Health and Lifestyles Survey and the NZ Household Travel Survey, respectively. 24% of 6-year-olds in a longitudinal cohort study usually used active transport to get to and from school.	Not reported	5–17 years	To and from school	Not clear	New Zealand Health Survey 2016/2017 [76], Active NZ Survey 2018 [77], Health and Lifestyles Survey 2016 [78], NZ Household Travel Survey 2015–2018 [79], and the Growing Up in New Zealand study 2010 [80]	1

Table 3. Cont.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
C−	Portugal	A study with urban school-aged children showed that 45% of participants commuted actively to and from school. Another study in the countryside region found that 30% of the participants (aged 7 to 8 years) commuted either by foot or cycling on a regular basis during school days (ARSA 2012).	Not reported	7–8 years and 15–24 years	To and from school	Not clear	A study in public schools from the Porto area [81] and the Health Study of the Child Population of the Alentejo Region, 2012 [82]	1
C−	Taiwan	33–46% of children and adolescents reported walking or cycling to school most of the days.	Not reported	7–18 years	To school	Most of the days	Student Participation in Physical Activity Survey, 2015 [83] and Health Behaviour Survey in Junior High School Students, 2016 [84]	1
D+	Australia	National data shows that 43% of 12–17 year-olds usually travel to/from school using active transport, other state and regional studies shows that 37% of primary students and 36% of secondary students use active transport as their usual mode to get to school.	Not reported	12–17 years	To school	Usual mode—each week (Usual defined as at least 5 trips out of 10 or on at least 2.5 school days)	National Secondary Students Diet and Activity Survey 2012–2013 [85], ACT Year 6 Physical Activity and Nutrition Survey 2015 [86], Child Population Health Survey [87], Queensland Child Preventive Health Survey 2018 [88], NSW School Physical Activity and Nutrition Survey 2015 [89], Victorian Child Health and Wellbeing survey 2016 [90]	1
D+	Jersey	37% of 10–15-year-olds traveled to school by active modes.	Not reported	10–15 years	To school	Not clear	Health Related Behaviour Questionnaire 2014 [91]	1
D+	Wales	44% primary school children and 34% secondary school pupils traveled actively to school. In another survey, 33.8% and 36.1% of children and young people aged 11–16 years walked/cycled to and from school, respectively.	Not reported	11–16 years	To and from school	Not clear	National Survey for Wales (2016–17) [92] and The Health Behaviour of School-aged Children (HBSC)/School Health Research Network (SHRN) Survey 2017 [93]	1
D	Estonia	The percentage of use of active transport varied between 36–56%. Specifically, 35% of children walked to school and back home, while 14% of children rode a bike to go to school. The grading process took into account the number of subjects, age range and used methodology of different studies.	Not reported	7–17 years	To and from school	Not clear	Children's Physical Activity Study 2015 and Schools in Motion Survey 2018 [94]	1
D	Guernsey Channel Islands	On average, 31% of children and adolescents reported active travel (walking, bicycle or scooter) to school on the day of the survey (43% of primary school pupils and 25% of secondary pupils).	Not reported	Primary and secondary (grades 6, 8 and 10)	To school	On the day of the survey	Guernsey Young People Survey 2016–2017 [95]	1

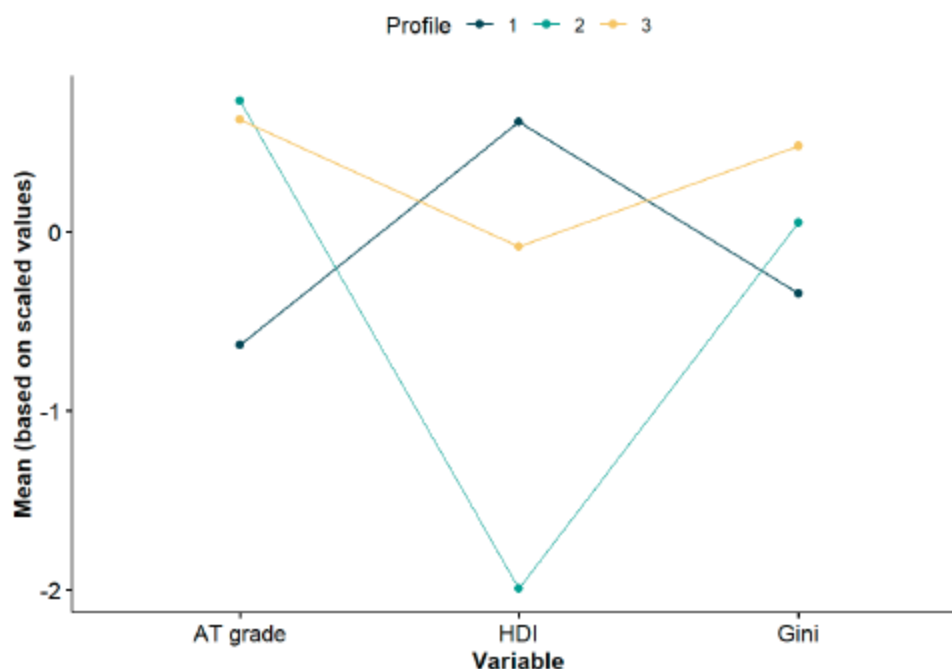
Table 3. Cont.

Grade	Country	Rationale	Gender	Age	Destination and Direction	Frequency	Source of Information and Year	Profile
D	Lebanon	36.8% of Lebanese adolescents between the ages of 13 and 18 reported walking or biking to school.	Not reported	13–17 years	To school	Not clear	Global School-Based Student Health Survey 2016 (GSHS) [96]	1
D–	Canada	21% of 5- to 19-year-olds in Canada typically use active modes of transportation (e.g., walk, bike), and 16% use a combination of active and inactive modes of transportation to travel to and from school (2014–16 CANPLAY, CFLRI).	Not reported	5 to 19	To and from school	Typical use	Kids CANPLAY 2014–2016 [97]	1
D–	United States	38% of adolescents walked or used a bicycle for at least 10 min continuously once or more in a typical week to get to and from places, and 23% of youth actively commuted 5–7 days per week.	45% of boys and 32% of girls reported any active transportation in a typical week	12–19 years	To and from multiple places	5 to 7 days on a typical week	National Health and Nutrition Examination Survey (NHANES 2015–16) [98]	1
F	Chile	15% of children and youth (weighted average) rode a bike or walked to and from school (ranging from 0.29% to 32.2% in different samples and regions).	Not reported	Not specified	To and from school	Not clear	National Survey of Quality of life 2015–2016 (ENCAVI) [99], Survey of Urban Quality of Life Perception 2015 (EPCVU) [100], a cross-sectional study of seventh grade students in the Maule region 2014 [101], and a cross-sectional study in Valparaiso 2017 [102]	1
INC	United Arab Emirates	There was no current data available to grade this indicator.	NA	NA	NA	NA	NA	1
N/A	Qatar	Active transportation indicator is excluded from the report according to stakeholders' group recommendation. This indicator is still not applicable in Qatar due to unsafe roads and the hot climate during most times of the year.	N/A	N/A	N/A	N/A	N/A	1

Abbreviations: INC, incomplete; NA, not applicable.

Table 4. Descriptive statistics of the latent variables by country profile.

Profile (% of Countries)	Active Transportation Grade				Human Development Index				Gini Index			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
1 <i>n</i> = 25 (51%)	6.08	2.55	0.00	10.00	0.89	0.05	0.763	0.985	33.78	5.29	25.44	47.70
2 <i>n</i> = 7 (14.3%)	10.14	2.34	7.00	13.00	0.55	0.06	0.448	0.624	38.29	4.81	32.40	43.20
3 <i>n</i> = 17 (34.7%)	9.82	1.88	7.00	13.00	0.80	0.09	0.666	0.925	42.08	10.58	27.10	63.0

**Figure 1.** Country profiles for active transportation and sociodemographic variables of countries in the Global Matrix 3.0. The range of values for the active transportation grade, Human Development Index and the Gini index varied notably between variables, therefore they were converted to z-scores to be expressed in the same range of values and to ease their graphic depiction.

The availability of details related to active transportation in the report cards, beyond the reported prevalence, varied across countries. Table 5 summarizes the information provided by countries in terms of practices and policies, strategies proposed to improve the grades and research gaps identified by expert groups in each country. Twenty-four countries provided at least one of these details. The policies and practices identified by the expert groups included school siting policies, transport policies that prioritize active modes of commuting, walking challenges and special events, and multi-component programs that comprise educational strategies, enforcement of regulation to improve traffic safety, and providing infrastructure and resources at several levels (children, teachers, schools and communities). The most common topics in the strategies proposed to improve the grades were improving safety conditions, providing supportive infrastructure, developing informational and education strategies, and involving parents, schools and communities in the promotion of active transportation. Several research gaps were identified, but the most frequent across countries was the need to study active transportation to destinations other than school (Table 5).

Table 5. Policies and practices, strategies to improve the grade and research gaps in active transportation identified in the Global Matrix 3.0.

Grade	Country	Profile	Policies/Practices	How to Improve the Grade	Gaps
A−	Japan	3	Since 1953 Japan has a “walking to school practice” resulting from the implementation of the article 49 of the School Education Act, which regulates the siting of public schools in urban areas of Japan. This article establishes that the commuting distances are 4 km for elementary schools and 6 km for junior high schools. Based on these, the boards of education must ensure that children attend to schools located within those distances to allow children to walk to school [14,103,104].	Not reported	Research on active transportation to destinations other than schools (e.g., going shopping, going to the park, sports clubs or cram schools) [104].
A−	Zimbabwe	2	Not reported	1. Through public health messages to highlight the benefits of active transportation and reduce the prestige/status symbol associated with motorized transportation. 2. Implementing policies that encourage and provide safe and walkable neighborhoods and bike lanes, etc. [105].	There is a need of data reporting the time invested in active transportation and distance to and from school, as well as research data on the correlates of active transportation, and more recent data is required [105].
B+	Finland	3	Not reported	Not reported	There is no comparable published data available about active school commutes for upper secondary students when the distance between home and school is less than 5 km. More information is needed about active transportation to other destinations [106].
B+	Hong Kong	3	The high density of Hong Kong could be one of the factors facilitating active transportation to school. Since most districts in Hong Kong are highly self-contained, children can attend schools located at walkable distance from their home [107,108].	1. Encouraging active travel to destinations other than school may provide additional health benefits for children and adolescents. 2. Promoting cycling to and from school and other destinations in districts with a bicycle track [107,108].	Data about active transportation to destinations other than school, as well as the relationship between active transportation, physical activity and health-related outcomes. Also, data on the duration of active travel trips is required [107,108].
B	Colombia	3	In Bogota, the capital city of Colombia, the program “Bike to school” is implemented in public schools to promote cycling as a sustainable mode of transportation to school and other destinations in the city. The program was created in order to address the barriers to access to education and to decrease the dropout rates. Bike to school program includes the following strategies: (a) bicycle loan, (b) workshops on skills and abilities to ride a bicycle, (c) basic mechanics and road safety education, (d) participatory mapping of safe routes, (e) daily trips from a meeting point to school with adult supervision, and (f) extracurricular activities to develop responsible behaviours in the roads and to visit other destinations of interest in the city [109,110]. Another promising practice to encourage walking and cycling, but with recreational purposes, are the Open Streets programs, or Ciclovias. Colombia currently has 67 of these programs that close main roads to motorized vehicles and open them for leisure activities on Sundays and holidays [109,111]. Walking and cycling are the main activities performed by children who attend Ciclovía in Bogota [112]. Also, Colombia has a specific law to support the use of bicycles as the main mode of transport at the national level (Law 1811 of 2016). This law establishes the responsibility of public transportation systems to allow multi-modal trips through the provision of bike-supporting infrastructure, and encourages schools to implement programs to promote cycling [113].	1. Improving safety conditions and infrastructure to keep promoting and maintaining active transportation as a desirable behaviour since early ages [109].	Not reported

Table 5. Cont.

Grade	Country	Profile	Policies/Practices	How to Improve the Grade	Gaps
B	Nigeria	2	The National Transport Policy in Nigeria is under review with the aim to strengthen the inclusion of non-motorized transport infrastructure and to create better non-motorized transport options for urban residents. This review is the result of a workshop on streets design led by the Federal Ministry of Transport in 2017 and is a good example of the concerted efforts to improve the conditions for active transportation in Nigeria [114,115]. Another example is the Non-Motorized Transport Policy developed in Lagos, which aims to prioritize walking, cycling and public transportation as the main modes of transport [114]. This policy specifically addresses active transportation to school through two strategies: (a) public awareness through the creation of a curriculum about road safety and benefits of active transportation for primary and secondary school students. And (b) regulations that include the creation of route plans for students to go to school, and the implementation of access and safety measures such as speed limits, traffic calming infrastructure and school zone signaling [116].	Not reported	Not reported
C+	Ghana	2	The Community Day Senior High Schools, built in various districts in Ghana, seem to be encouraging active transportation to school. The students who attend to this schools usually walk to and from school every day, some of them covering more than two kilometers [117].	Not reported	Not reported
C+	Mexico	3	Not reported	1. Promoting active transportation among Mexican children and adolescents. 2. Communities and governments should provide appropriate safety conditions on streets, sidewalks and neighborhoods to promote walking and cycling among children and adolescents [118].	Data on all age groups and stratified by age group and sex is desirable for future surveys [118].
C	Brazil	3	Not reported	Local authorities should be encouraged to create a monitoring system to generate standardized and detailed reports on active transportation to school to support planning and evaluation of public policies [119].	Data on time invested in active transportation, the distance to the school and other environmental and mobility-related factors such as bike paths, traffic and conditions of the city is lacking [52].
C	Ethiopia	2	Not reported	1. Building sidewalks to encourage active transportation in all cities in Ethiopia. 2. Encouraging and supporting children and adolescents to travel to and from school through active transportation [120].	Active transportation specific studies in Ethiopia are required [120].
C	Scotland	1	Not reported	Not reported	No data available on active commuting to and from places other than school [121].
C	Sweden	1	A national cycling strategy has been adopted in Sweden to improve safety and increase cycling [122]. The strategy aims to increase cycling through five action lines: (a) creating more bicycle-friendly municipalities, (b) focusing on various types of cyclists (where children are highlighted as a population of interest), (c) giving higher priority to bicycle traffic in community planning, (d) building more functional and user-friendly cycling infrastructure and (e) strengthening research an innovation on cycling [123].	Not reported	Not reported

Table 5. Cont.

Grade	Country	Profile	Policies/Practices	How to Improve the Grade	Gaps
C	Uruguay	3	Not reported	Creating policies to encourage the creation of cycle lanes and safe sidewalks.	Data on active transportation in a wider age range and to locations other than school.
C–	Ecuador	3	Not reported	Reinforcing programs aiming to promote active transportation [124].	Not reported
C–	France	1	Not reported	Not reported	Research is needed on the characteristics of active transportation of children and adolescents (frequency, mode, distance covered) and on the potential barriers to this in order to develop effective promotion program [125].
C–	Lithuania	1	Not reported	1. Promoting and facilitating safe active transport to get to school and other destinations. 2. Prioritizing active transportation promotion as a key factor at schools and communities. 3. Involving parents, schools, community and policy makers in the promotion of active transportation [71].	1. Research on the prevalence and trends of active transport in Lithuania, considering the most popular modes of active transportation used to get to/from different points or destinations (e.g., parks, shops, sport fields) among children and adolescents as well as studying the role of active transport in achieving recommended levels of physical activity. 2. Research on health and social benefits of active transportation is needed. 3. Evaluating the impact of the cycling paths and interventions at the school, community and municipality levels. 4. Examining the potential moderators and mediators of active transport behaviour change to help refine interventions [71].
C–	New Zealand	1	Not reported.	Strategies to encourage active travel to school are needed, especially for girls, younger children, and older adolescents [126]. This strategies should have a multi-sectoral y culturally appropriate approach, including urban planning, initiatives a the school and community level, social marketing campaigns and family support [127].	Nationally representative data on active transportation to school and other destinations that is comparable between countries and across time is desirable [127].
C–	Taiwan	1	Not reported	Local governments and schools should work together to create a safe and convenient environment for active transportation [128].	Research on the contribution of active transportation to overall physical activity in children and adolescents, and about motivations and barriers for active transportation is needed [128].

Table 5. Cont.

Grade	Country	Profile	Policies/Practices	How to Improve the Grade	Gaps
D+	Australia	1	The Australian Capital Territory has implemented the Ride or Walk to School program since 2012 aiming to build the capacity of primary schools to support and promote active travel to and from school. The program was designed with a participatory approach including students and different stakeholders. The strategies of the program include: (a) resources for teachers and students, (b) provision of bikes and helmets, (c) safe routes maps, (d) workshops to increase skills, and (e) four annual active travel events. This program was expanded to high schools since 2016 [129]. In Western Australia, the Department of Transport implemented the program “Your Move Schools”. This is a community-focused program that promotes active and sustainable transportation providing: (a) teaching resources, (b) expert advice and (c) access to funding (up to \$5000 AUD) to promote active transportation through bike education workshops, wayfinding, bike supporting infrastructure like bike shelters, bike repair stations, bike skills tracks and bicycle parkings [129].	1. Encouraging families to active commute at least part of the way, promoting the use of park and walk/ride/scoot zones away from school grounds to reduce traffic. 2. Creating and promoting safe routes to schools and engage schools to promote their use. 3. Creating greater awareness of actual distances between home and school and the travel time for active modes. 4. Highlighting the benefit of students travelling to school carrying their school bags as an opportunity to be active while carrying a load, which could contribute to improve their muscular fitness [129].	1. Nationally representative data for primary and secondary students. 2. Data on the use of active transportation to other destinations. 3. Data on the use of multi-modal transport combining active transport with public transport. 4. Research about how far families and children are willing to travel using active transportation [129].
			In the Northern Territory, the Nightcliff Walk and Wheel initiative is aimed at encouraging students to walk and cycle to school. This is a local project in two dense suburbs lead by principals and parents from four schools. The project has a focus on roads safety for children and has implemented activities such as the Ride2School days, increasing cycling to school [129].		
D+	Wales	1	The report card mentioned the following initiatives led by charities to promote active travel to school: 1. Active Journeys—Sustrans School active travel program promotes active transportation through different actions like: (a) providing support to schools to develop active travel plans, (b) delivering activities and lessons, (c) offering free incentives to promote active travel, (d) providing resources and online travel challenges for the school community, and (e) rewarding schools with the School Mark award for achieving excellence in active and sustainable travel [130]. 2. Living Streets Walking initiatives: This charity has two main strategies for schools, the WOW Year-Round Walk to School challenge and the Five-Days Walking challenge. Both of these aim to engage primary and secondary students to walk to school encouraging them with an interactive travel tracker and the provision of incentives at the end of the challenge. This charity also encourages the celebration of the Walk to School Week in May every year [131].	Not reported	More research is needed on how children and young people travel to other places including shops, parks and friends’ or relatives’ houses [132].
D	Guernsey Channel Islands		Guernsey has an integrated transport strategy in place that promotes active travel with the aim of having a positive impact on the environment and the population’s health [133]. The On-island Integrated Transport Strategy aims to encourage active travel, followed by the use of public transport and to reduce the use of private motor vehicles. This strategy was initially planned to progressively advance to a taxation policy for high emission vehicles to support the promotion of active travel. However, there are other actions in this strategy aimed at increasing active travel to school, such as: (a) Bikeability training at primary schools, (b) increasing the investments in walking and cycling infrastructure to improve safety for active commuters, (c) revising the speed limits to enhance the safety of vulnerable populations using active travel, and (d) developing and implementing travel plans for schools [134].	Through the implementation of the integrated transport initiative that supports active travel [133].	Not reported

Table 5. Cont.

Grade	Country	Profile	Policies/Practices	How to Improve the Grade	Gaps
D	Lebanon	1	Not reported	Not reported	Nationally representative samples for children and adolescents and on all active transportation means are required to gain a better understanding of this indicator [135,136].
D–	Canada	1	In Ontario, the Minister of Education expanded the funding for initiatives that improve the cognitive, physical, social and emotional well-being of students. Specifically walking school buses and biking-to-school programs have benefited from this increase in the funding [137]. These initiatives are part of the Ontario Active School Travel program (formerly Active & Safe Routes to School) which comprise five components: (a) education activities to foster the skills, confidence, and awareness such as workshops and route mapping. (b) Encouragement activities to inspire students, parents and school staff to try active travel modes. For example, walk and wheel seasonal events or walking school buses. (c) Engineering actions to create safe and accessible school sites, neighbourhoods and routes to school, such as school siting, signaling, parking restrictions, crosswalk improvements or crossing guards. (d) Enforcement of traffic policies to improve safety around schools. (e) Evaluations to measure the measure success, and demonstrate impact of the actions [138].	1. Creating a culture of active transportation, to make active transportation the norm. 2. Establishing lower speed limits in school areas. 3. Implementing traffic-calming devices (e.g., speed bumps/humps, chicanes, narrower intersections) to enhance compliance with speed limits, mainly in low-income areas, where more children engage in active transportation. 4. Hiring more crossing guards at busy intersections near schools. 5. Considering more progressive policies for low-income areas, to access to funding for active transportation interventions. 6. Considering children's active transportation when planning schools and recreation facilities.	1. Research on activetransportation to destinations such as parks, stores, recreation facilities and other places. 2. Studies on children's preferences for cycling and how to harness them in interventions. 3. More research is needed on how to facilitate children's independent mobility. 4. More research is needed on the use of mixed modes of transportation to and from destinations [137].
			In 2017, three organizations in Canada (Canada Bikes, Green Communities Canada and the National Active and Safe Routes to School Working Group) created an active transportation alliance to advocate for the adoption and funding of a national active transportation strategy [137]. However, this strategy is not yet in place.	7. Encouraging schools to implement "drop-off spots" from which driven children could safely walk to school in groups [137].	
D–	United States	1	Safe Routes to School is a movement with initiatives at the regional, state and local levels that aims to promote walking and bicycling to school, improving safety, health and physical activity levels. Actions at the local level incorporate the six E's integrated approach: (a) education through the provision of training in skills and knowledge to walk and bicycle safely and teaching the benefits of active transportation. (b) Encouragement to motivate children to travel actively through events and activities. (c) Engineering to improve streets and neighborhoods in order to make them more convenient for walking and bicycling. (d) Enforcement of safety regulation. (e) Evaluation of the success and opportunities to improve the initiatives in place. And (f) equity to ensure that the program benefits all demographic groups. Actions at the regional and state level are focused on finding funding and ensuring the proper use of the resources invested in the program. At the federal level, the Safe Routes Partnership advocates for policy and funding support and provides expert help, ideas and resources for the leaders at all levels [139].	1. Investing in infrastructure, programs, and policies that promote active transportation to and from school. 2. Allocating funding to provide and improve infrastructure to encourage active transportation (e.g., sidewalks, crosswalks, bike lanes, trails, etc.). 3. Encouraging children at home to use active transportation to school and other neighborhood locations. 4. Investing in infrastructure and policies such as Safe Routes to School and walking school buses. 5. Informing parents (at all income levels) about the benefits of active transportation [140].	1. The study of locations where children and adolescents walk and bike, duration and distance of trips as well as the main reasons for not engaging in active transportation. 2. Surveillance systems should include children under 12 years old [140].

4. Discussion

Our results suggest that about half of children and adolescents use active modes of transportation to get to and from places, mainly to and/or from school. However, a pooled estimate of the global prevalence of active transportation cannot be calculated from the Global Matrix 3.0 data for reasons that will be discussed below. Despite the clear gradient in average grades according to HDI that has been discussed in previous publications [141–143], our results show variability within HDI groups and the LPA allowed us to examine the clustering of this sample of countries according to three variables of interest (active transportation grades, level of development and income inequality).

4.1. Comparability of Data

There was wide variability between countries in the prevalence of active transportation, and high involvement in this behaviour was reported across countries with very different socioeconomic contexts (e.g., Japan, Zimbabwe, Nepal, Denmark and Finland). However, the data reported by the countries presented in Table 3 show important methodological differences that should be accounted for when comparing the prevalence of active transportation between countries. One of the issues that can affect the comparability of data is the difference in the frequency of use of active transportation reported by the countries. Depending on the cut-point used to define children as active travelers, the prevalence will vary widely, and the use of active transportation can be overestimated or underestimated. Similarly, the prevalence may vary depending on the direction of active transportation assessed since different modes can be used to go to and from school. As observed in previous comparisons of surveillance systems measuring active transportation, the prevalence of active transportation varies greatly according to the construct assessed [144]. In the group of countries included in this analysis, the frequencies reported varied from daily to at least twice per week. Even when the source of information was the same survey (e.g., the GSHS across countries), different frequencies were reported [136,145–147]. Regarding the construct assessed, the destination for active transportation is also relevant. Despite the broad definition of active transportation in the Global Matrix 3.0 benchmarks [14], most of the evidence available on active transportation in children is focused on the journeys to and from school, as observed in this analysis and in previous literature [148]. Only Ecuador and the United States reported the use of active transportation to other destinations, which could suggest an underestimation of the involvement in active transportation in other countries since trips to places such as parks and other people's homes are also relevant opportunities to engage in this behaviour [149]. These findings point to a need for the development of harmonized and contextualized measurements. Our results are consistent with the findings reported by Herrador-Colmenero et al. in a systematic review, in which the formulation of a standardized question is proposed to overcome the heterogeneity in measures to assess active transportation [150]. Based on these insights, initiatives like the Global Matrix and organizations like the AHKGA can contribute to the improvement of surveillance systems for the evaluation of active transportation among children.

The Global Matrix initiative aims to better understand the global variation of certain physical activity indicators [14]. Specifically, active transportation is one of the most strategic indicators in the Global Matrix 3.0 to contribute to this aim, due to the low amount of INC grades, and the good dispersion of grades across countries [14]. However, the availability of transportation-relevant contextual variables at the country level to understand these variations was limited. Therefore, the LPA provides an exploratory approach to identify subgroups that share similar patterns of variables [20,151], and provides a unique opportunity to identify the ways in which countries in the Global Matrix 3.0 cluster, according to the grades for active transportation and contextual variables. The identified profiles can be useful for the discussion of the different contexts in which active transportation needs to be maintained or increased. A description of the three profiles is provided below.

4.2. Country Profiles for Active Transportation and Sociodemographic Variables

Profile 1 included mainly countries with a very high HDI and low income inequality, mostly with a reported prevalence of active transportation under 50%. Mainly, countries from North America, Europe and Oceania were grouped in this profile. While the countries with the lowest prevalence of active transportation were classified in this group (Chile, the United States and Canada), it also included some countries with non-negligible prevalence of active transportation such as the Netherlands, Belgium and the Czech Republic. This means that although all of these countries have a similar development level, there are other relevant factors influencing active travel among children. First, some of these are countries where long distances between destinations and the perceived convenience of driving may undermine opportunities for active travel [102,152–154]. Second, urban planning and policies that have prioritized people instead of cars, as well as supportive infrastructure have made active modes a convenient and safe alternative to commute [155,156]. Interventions in countries under this profile should aim to increase active transportation addressing the issues of distance and convenience, attempting to discourage the use of motorized vehicles for short trips, and trying to shift the social norms to consider active modes the default option for commuting as it occurs in many European countries. A useful example among the policies reported in the Report Cards is the National Cycling Policy from Sweden, which aims to prioritize cycling in the community and municipalities planning [123].

Profile 2 grouped mostly countries with high prevalence of active transportation, low to medium HDI and higher income inequalities. In most of these countries, access to motorized vehicles is limited, and active travel is happening despite multiple safety concerns [157,158] and the lack of supportive infrastructure [143]. Therefore, for many families, active transportation is likely to reflect necessity rather than choice [159]. Also, many of the countries in this group report important differences between children from rural and urban areas [117,120,145]. As suggested by a previous systematic review on active transportation in Africa, these differences could be indicative of the physical activity transition that these countries are experiencing [157,160]. In this context, for the countries classified in this profile, preserving active travel while providing improved safety and infrastructure conditions should be a priority. It is important to design strategies to avoid the unintended consequences that economic growth can have on the mode of transport for children and adolescents. A good example of the approaches needed in countries under this profile is the Non-Motorized Transport Policy from Lagos, Nigeria. This policy aims to prioritize active modes of transportation over motorized options, communicating the benefits and importance of active transportation, as well as improving safety conditions for students using active modes to go to school [116].

Profile 3 had more variability in terms of HDI and income inequality, however, the relatively high prevalence of active transportation was a main feature in common between this group of countries. Some of the most successful countries in active transportation are grouped under this profile. However, the conditions in which it is happening are very different. There are countries such as Finland, Denmark, Japan, South Korea and Hong Kong where the use of active modes is supported by the design of compact cities, school siting policies that ensure that children attend to schools located at a walkable distance from home, and supportive infrastructure and regulations [103,104,108,141,155,161]. These factors have made walking and cycling safe options for the daily commuting. Conversely, there are countries like Colombia, Brazil, Mexico, Venezuela and South Africa, where active transportation is prevalent despite safety concerns, the lack of supportive infrastructure and regulations and is likely to be a necessity-driven behaviour [52,60,61,162–165]. Similarly to profile 2, almost half of the countries in this profile have a relatively high Gini coefficient. However, this profile also includes countries with very low inequality, such as Finland and Denmark. Income inequality has been previously documented as a negative correlate of physical activity and organized sports involvement [14,19]. Notwithstanding, the high prevalence of active transportation in both equal and unequal societies are consistent with literature that suggest that active transportation modes could be an opportunity to bridge the inequities in transportation [18] as well as in other domains of physical activity. Due

to the diversity of contexts found in this profile, different approaches are needed to promote or maintain active travel. School siting policies that take into account the proximity between schools and children's homes, like those implemented in Japan and Hong Kong [103,104,107], can be useful for growing cities. Also, multi-component strategies, such as the Bike to school program in Colombia are a good reference for countries that aim to provide access, skills, and support to bike to school in safe conditions [110]. Furthermore, Ciclovías or Open Streets programs are a good model for countries where active transportation to school is already prevalent and aim to increase walking and cycling to other destinations in the leisure time [112,166].

Regarding the strategies to improve active transportation, it is concerning to find that major correlates of active transportation such as distance and the perceived convenience of driving are not mentioned among the strategies proposed by the Report Card teams. Future versions of the Report Cards, as tools to communicate evidence to stakeholders, should take these important factors into consideration in order to advocate for active transportation addressing its most important drivers.

Our results can contribute to the call for measures of conditions related to all children wellbeing made by a recent commission sponsored by the WHO, UNICEF and The Lancet. This commission identified that inequities and climate change are undermining children's right to a healthy environment in both, the poorest and wealthiest countries [167]. Given that the transportation sector accounts for almost 25% of global greenhouse gas emissions [168], local, regional, and national policymakers and practitioners should implement interventions that support children's active transportation in all socioeconomic contexts.

4.3. Strengths and Limitations of the Study

Strengths of this study include the availability of active transportation data from 47 countries from all continents, and the harmonized selection of the best available evidence in each country. Our analyses contributed with a diverse context perspective to the emerging evidence on international comparisons of active transportation, which has focused on specific groups of countries in previous studies [169,170]. Although most countries reported nationally representative data on active transportation, in some countries, the best available evidence consisted of local data. The main limitations of the study were the diversity in the quality of the data reported, and the broad benchmark proposed for active transportation in the Global Matrix 3.0, which led to variations in the definition of active transportation across countries. The important amount of missing data in the Community and Environment indicator (26%) and the heterogeneity of the data reported across countries did not allow to include it as a variable of interest in the LPA, despite its relevance for active transportation. For example, including data on average distances for active transportation by country in future studies could strengthen the model and enrich the profiling of countries as distance is one of the most consistent predictors of active transportation. Also, since we analyzed aggregated data at the country level, a sample size of 47 is small and has limited power for the LPA. This could partly explain the heterogeneity observed in the profiles, mainly in profile 1. Regarding the policies and practices reviewed, there was also heterogeneity in the information reported across countries. Future versions of the Global Matrix can strengthen the guidance on desirable information to report in this regard, such as the inclusion of active transportation to school in National Education Acts or their equivalents in each country. The sample included in this study represents approximately 25% of the total countries in the world. The inclusion of a larger sample of countries in future studies could provide a clearer picture of profiles according to active transportation and sociodemographic variables.

5. Conclusions

This work allowed for a deeper exploration of the active transportation information reported by all the countries participating in the Global Matrix 3.0. Based on our findings, we identified the need to standardize definitions of active transportation to be able to make more meaningful comparisons. The LPA conducted allows for the inference that countries belonging to a specific profile have a

greater probability of sharing certain characteristics among them compared to the countries belonging to other profiles. Given the variation by geographic region and even HDI, this approach is useful for identification of more meaningful groupings that can facilitate the cross-fertilization of efforts to promote active transportation, and therefore, to “power the movement to get kids moving”, as is intended by the Global Matrix initiative [171]. The Active Healthy Kids Global Alliance can contribute to improving active travel surveillance providing guidance to countries involved in future versions of the Global Matrix. A more comprehensive approach to active transportation surveillance that considers duration, distance, frequency, direction, other destinations than school and the contribution of active transportation to school to overall active transportation, could improve the understanding of this behaviour and its potential to increase overall physical activity.

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