

Socioeconomic Inequality of Obesity in Canada

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[Abstract] The purpose of this paper is to compare the degree of income-related health inequality among decomposed Canadian population groups using different inequality indices. It has been statistically proved that problems of obesity and overweight are prevalent in Canada. In order to better measure income-related inequality of obesity among Canadian, this paper will not only target adults but also children and the elderly who are normally not included in the analysis of other literature. Several indices of socioeconomic inequality of obesity and overweight are used. Firstly, a traditional Concentration index is applied to the full sample. Secondly, a Concentration index which counts only those who are obese and overweight is used. Thirdly, an Achievement Index that incorporates the mean level of ill health is used. Fourthly, the Erreygers Corrected Index is analyzed. We find large gender and ethnic differences in socioeconomic inequality with different degrees of obesity and overweight among children, adults and senior populations. Distinct patterns of inequality are identified in general. For example, non-ethnic groups have higher inequality among adults. Ethnic groups have higher inequality among seniors. Females with lower income are more likely to become obese or overweight. As for children, ethnic girls tend to suffer from higher degree of socioeconomic inequality.

Keywords: Socioeconomic Inequality, Obesity, Concentration Index, Achievement Index, Erreygers Corrected Index.

1. Introduction

Improved nutrition and technology undoubtedly benefit world citizens a great deal. However, the problem of obesity has become a global concern as a consequence. According to the Public Health Agency of Canada, approximately one in four Canadian adults are obese. A figure from Streib (2007) shows that the United States has the highest ratio of overweight population (74.1%), and that Canada ranks number 5 (at 61.1%) in 2007. In other words, well over half of the population are overweight in both the United States and Canada. Between 1981 and 2007, obesity rates in Canada roughly doubled among both males and females in most age group (PHAC and CIHI, 2011). This increase in the obesity rate contributes to the Canadian public health care burden as obesity is associated with various health risks and costs. As reported by PHAC and CIHI, the economic cost of obesity increased from \$3.9 billion in 2000 to \$4.6 billion in 2008, which is a 19% increase within just 8 years. Thus, Canadian society is in need of effective control towards obesity as a serious health epidemic.

The starting point for effectively managing obesity through health policy is getting to know how income-related (socioeconomic) inequality is distributed within the obesity groups. Many researchers have looked at the existence of socioeconomic health inequality among different socioeconomic groups. Specifically speaking, empirical economists and social scientists have developed empirical methods which allow quantifying the degree of inequality in the distribution of health and health care

utilization so as to compare the degree of inequality over time and space (Costa-Front and Hernandez-Quevedo, 2012).

Various measures of health inequality have been developed to assist study of the socioeconomic equity or inequality of health. Odds ratios (OR) and beta coefficients are frequently used in the biomedical field to indicate the direction and the magnitude of the relationship between Social Equity Status (SES) and obesity (Sobal and Stunkard, 1989; Wang 2001). However, these methods suffer from several limitations though they are straightforward (Zhang and Wang, 2004). In contrast popular indices such as the Gini index and concentration index give not only the direction of the inequality but also give quantitative measurement of inequalities within the distribution of socioeconomic status. Based on Concentration indices (CI) and Gini indices, a large number of papers have carried out research on income-related inequality related to obesity and overweight. For example, Zhang and Wang (2004) put forward the analysis towards socioeconomic inequalities among obesity in US using CI. They find that various degree of inequality exist among gender, ethnic and age groups for obesity among the US population.

Similar analysis on socioeconomic inequality in Canada has been presented by Hajizadeh et al.(2013). By comparing CIs of decomposed groups for obesity from different regions in Canada, they believe there is a decreasing trend of income-related inequality for obesity and that health policies should target females with less income and wealthier males who are more likely to be obese. This paper is related to their work but different in several aspects. Firstly, this paper conducts socioeconomic

inequality analysis not only on adult but also on children and senior populations which are not included in their work. Secondly, the Achievement index and Erreygers corrected concentration index are also applied in addition to the standard use of the concentration index which is the only measure found in their paper. Lastly, this paper decomposes the population into different ethnic, gender and age groups rather than geographical groups as done in Hajizadeh et al.(2013).

The merits of the concentration index in the study of socioeconomic inequality have been debated in the literature. Wagstaff et al. (1991) confirm that the concentration index is a good measure of health inequality since it reflects the socioeconomic dimension to inequalities in health and is sensitive to changes in the distribution of the population across socioeconomic groups. However, Wagstaff (2002) believes that the concentration index is not perfect because it ignores the mean level of health status among comparable groups in the population. Thus, Wagstaff (2002) introduced the health Achievement index to correct this problem.

Another problem associated with the concentration index was identified by Clarke et al. (2002) who defines a “mirror problem” as “the inconsistency of rankings produced by health attainment of health shortfalls”. Following this, Erreygers (2009) proposes a corrected concentration index to overcome this “mirror problem”.

This paper will follow similar logic to the decomposition of health inequality in obesity as developed in Zhang and Wang (2004), but will further complete their study by incorporating more decomposed groups and by using improved alternatives to the concentration index such as the Wagstaff Achievement index and Erreygers corrected

concentration index.

The purpose of this paper is to compare the degree of income-related health inequality among the decomposed groups using different inequality indices. Implication generated from this paper will contribute to the health economics literature and potentially facilitate health policymakers to implement more efficient health initiatives targeting specific groups which suffer greater health inequality.

The remaining part of the paper will be constructed as follows: Section 2 presents the measurement methodology. Section 3 presents empirical results. Section 4 discusses the results. Section 5 concludes.

2. Methodology

We use three indices that have been identified in the literature, namely the concentration index, the achievement index and the Erreygers corrected concentration index. Regarding the concentration index, Wagstaff et al. (1991) give a relatively complete critical review and provide a comparison of six indices of health inequality. They conclude that the concentration index, which indicates both the direction and magnitude of socioeconomic inequality, is the best measure as it satisfies the primary requirements they identified. The graphical representation of the concentration index is popular since readers can interpret the graph intuitively. Figure 2.1 is an example of

the concentration index curve where the horizontal axis is the cumulative share of population ranked by socioeconomic status and the vertical axis is the cumulative share of population ranked by health status. In this paper, the socioeconomic status will be income and the health status will be obesity.

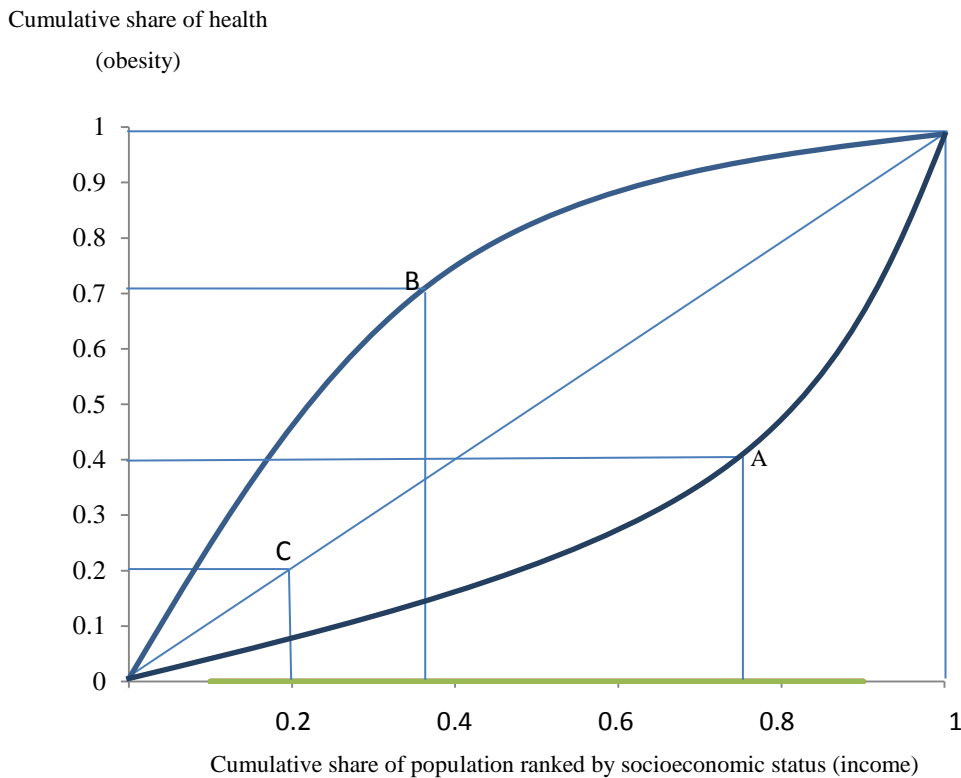


Figure 2.1 Health Concentration Curve. The 45° line in the middle separates the lower “progressive concentration curve” and the upper “regressive concentration curve”.

The curve which lies below the diagonal is the “progressive concentration curve” and the one above the diagonal is the “regressive concentration curve”. The points lying on different curves are translated into different meanings. For example, at point A, the bottom 75% of the population ranked by income account for 40% of the obese population. It means that income is not equally distributed across the obese population. More specifically, the rich contribute more to the obesity than the poor. Point B, on

the other hand, lies on the regressive line and represents an opposite situation where the poor contributes more to the obesity than the rich (i.e. approximately 35% of the population ranked by income constitutes 70% of the obese population). In contrast, points on the 45° line show a perfect situation where obesity is equality distributed across all income levels. For example, point C indicates that 20% of the cumulative population ranked by income account for exactly 20% of the obese population. Since points on the diagonal represent perfect equality, the distance between the concentration curve and the 45° line is defined as the degree of inequality among the obesity. Therefore, the concentration index is defined as twice the area between the concentration curve and the 45° line. As introduced in the literature, the mathematical form for the concentration index is written as:

$$\text{Concentration Index(CI)} = 1 - 2 \int_0^1 L(p) dp \quad (1)$$

$L(p)$ represents the concentration curve where p is the cumulative proportion of the population. This formulation of equation (1) determines that the concentration index take values within $[-1, 1]$. The concentration curve is similar to the Lorenz curve in nature but different in some aspects. The Lorenz curve was applied initially by Le Grand (1987, 1989) in the health literature and plots the cumulative population share ranked by health on the horizontal axis and cumulative health status on the vertical axis. Therefore, the horizontal axis for the Lorenz curve and the concentration curve is different, since the latter ranks cumulative population based

on socioeconomic status instead of pure health on the horizontal axis. The Gini index generated from the Lorenz curve is defined as twice the area between the 45 degree line and the Lorenz curve. Thus, the Gini index is the measure for pure health inequality rather than socioeconomic health inequality. Since socioeconomic health inequality analysis is the focus in this paper, the concentration index will be reported instead of Gini index

Many scholars have argued that CI is not perfect as a health equity measurement because of two reasons: a) the ignorance of the mean level of health status and b) the “mirror problem” (Clarke et al., 2002). The “mirror problem” is the inconsistent ranking of health attainment and morbidity which can be potentially caused by the concentration index. Therefore, in order to make the study more complete, two relatively new indices (the achievement index and the Erreygers corrected concentration index) will be reported together with CI.

The use of the achievement index (AI) was introduced by Wagstaff (2002) and can be seen as “the average level of health and the inequality in health between the poor and the better-off”. The general form starts from (see Wagstaff, 2002):

$$AI(v) = \frac{1}{n} \sum_{i=1}^n y_i v (1 - R_i)^{(v-1)} \quad (2)$$

where i is an index for individuals running from 1 to n (the number of individuals in a sample or population). The standard version of this form is defined as the following:

$$AI = \frac{2}{n} \sum_{i=1}^n h_i (1 - R_i) \quad (3)$$

where n is the number of observation, h_i is individual's health status and R_i is the individual's relative rank in the income distribution. In the standard form, the inequality aversion parameter ν is set to equal to 2 which means more weight is attached to equity concerns (Costa-Font and Hernandez-Quevedo, 2012¹).

Wagstaff points out that equation 3 measures the overall “achievement” within the population of interest. In other words, “achievement” can be treated as the “weighted average of the health levels of the members of the community, where higher weights are attached to poorer people than to better-off people”. After normalizing weights to one, the equation 3 can be simply transformed into (see Wagstaff, 2002):

$$AI = \mu (1 - CI) \quad (4)$$

It is easy to see that this equation combines the average level of health (μ) and the distribution of health (CI). Therefore, this index is developed to potentially correct the first problem of the concentration index, which is the ignorance of the average level of health status. AI is a measure of ill health and, in this paper, is defined as being overweight and obesity. This index is the combined effect of the average level of health and health inequality. For example, two groups may share the

¹ See more discussions on inequality aversion parameter in Costa-Font and Hernandez-Quevedo (2012)

same degree of obesity inequality but have different mean values which are reflected in different AI values. Clearly, the achievement index captures not only the distribution of health but also the average health level which can affect the level of inequality as well.

Similarly, another corrected version of the concentration index is developed by Erreygers (2009). It aims at solving the “mirror problem” of the CI. The fundamental issue underlying this problem is that the CI is estimated by relative health inequality rather than absolute health inequality. In order to incorporate the absolute health difference into the CI, Erreygers (2009) starts off by constructing the initial generalized health Concentration Index (see Erreygers , 2009) :

$$V(h) = \mu_h C(h) \quad (5)$$

$C(h)$ is the Concentration Index estimated for a particular health indicator (h) and μ_h is the mean level of health status of the population. The generalized health Concentration Index is the product of these two i.e. $V(h)$. Similarly, a generalized form of the Concentration Index concerning ill health can be represented by the following (see Erreygers , 2009):

$$V(s) = \mu_s C(s) \quad (6)$$

where:

$$C(s) = -\frac{\mu_h}{\mu_s} C(h) \quad (7)$$

where s (which is different from h) is an ill health variable defined as $(b_h - h_i)$ and b_h is the upper bound of the health status.

So, we can immediately see by substituting (7) into (6) that:

$$V(h) = -V(s) \quad (8)$$

Therefore, the new generalized concentration index is subject to s instead of h . Erreygers (2009) argues that this specification of concentration index (in equation 8) is an absolute measure of inequality, which means it can eliminate the “mirror problem” of the original concentration index. After introducing this generalized form of index, Erreygers (2009) uses an axiomatic approach² to derive a corrected version of generalized Concentration Index which can be represented by the following:

$$V(h) = \frac{2}{n^2} \sum_{i=1}^n z_i h_i \quad (9)$$

where:

$$z_i = \frac{n+1}{2} - \lambda_i \quad (10)$$

where λ_i is the socioeconomic rank of individual I , and z_i is an individual's relative rank compared to the median individual, taking on positive values when the individual has high socioeconomic rank and negative values when the individual has low socioeconomic rank.

In order to make the above Index meet all four properties for health equity

² See Erreygers, G., (2009), for detail derivation using Axiomatic Approach.

measurement³ and transform it into a generalized form, Erreygers (2009) derives the ultimate corrected form of generalized concentration index from the following equation:

$$E(h) = \frac{8}{n^2(b_h - a_h)} \sum_{i=1}^n z_i h_i \quad (11)$$

where a_h is the lower bound of the health status.

To further generalize it, a few steps of manipulation of equations (9), (10) and (11) can produce the final version of the corrected form of Concentration Index. It can be written as:

$$E(h) = \frac{4 \mu_h}{(b_h - a_h)} C(h) \quad (12)$$

As b_h and a_h are the higher and lower bounds of health status respectively within the population of interest, we can simply write it as:

$$E(h) = \frac{4 \mu_h}{(h_{max} - h_{min})} C(h) \quad (13)$$

However, all three indices presented cannot be readily used due to the third measurement problem - “the arbitrariness of the concentration index” (Erreygers, 2006;

³ The four properties Erreygers (2009) used to test his generalized concentration index, are 1) property of transfer; 2) level independence; 3) cardinal consistency and 4) mirror. He proved that his ultimate generalized index satisfied all these four requirements, which makes his index superior than the traditional CI.

Zheng, 2008). Two approaches so far have been proposed by previous literatures to address this problem. One is the ratio scaled transformation of data and the other one is to build a new equity measurement that is relatively less sensitive to ratio scaled variable. Makdissi and Yazbeck (2014) followed the first approach and found a relatively simple and intuitive way to transform the available information. They proved in a mathematical manner that when one switches the dimension to the categorical data and puts emphasis on the width instead of the depth of data, the problem of arbitrariness of Concentration Index can be eliminated ⁴ (see Makdissi and Yazbeck, 2014). More simple interpretation of their logic is to base the socioeconomic health inequality measurement on the “widths of the well-functioning attributes”. But we don’t face the problem of “arbitrariness” in this paper, since the analysis in this paper is based on ratio-scaled dataset instead of categorical data. So the concentration index, the Wagstaff achievement index and the Erreygers corrected concentration index can be safely used in this paper.

⁴ See detailed mathematical proof of the state in Makdissi, P. and M. Yazbeck (2014)

3. Empirical Results

3.1 Data and Study Variables

3.1.1 Data

The source of data in this paper comes from the Canadian Community Health Survey, 2012: Annual component (CCHS, 2012), which is a cross-sectional survey designed to collect the information concerning health status, health care utilization and health determinants targeting Canadian population. CCHS surveyed a sample of 61,707 individuals living in private dwellings aged 12 and over across 115 health regions except Indian Reserves and Crown Lands. Institutional residents, full-time members of the Canadian Forces, and residences from certain remote regions are also excluded. Samples are classified into “white” and “visible minority” ethnic groups under self-reported race and ethnicity.

In this paper, the entire sample will be divided into three target groups for detailed analysis. These three groups are “children” (aged less than 18 years old), “adult” (aged 18 to 65) and “senior” (age 65 and over). Analysis of the socioeconomic inequality of obesity will be conducted under each of the three groups.

3.1.2 Study variables

Obesity

Based on self-reported height and weight, the Body Mass Index (BMI)⁵ is calculated for each individual. As suggested by the World Health Organization, adults with the BMI value over 25 are considered overweight and BMI over 30 are considered obese. However, these two groups are not mutually exclusive, since people who are characterized as obese, are also overweight. Additionally, criteria for overweight and obese are slightly different for children (age 12-17). Children are classified as “obese” and “overweight” according to the Cole age and sex specific BMI cut-off points⁶.

Socioeconomic Status (SES)

In order to compute socioeconomic inequality indices, we need to rank individuals according to their socioeconomic status. There are many dimension of SES such as education and income. Since the dataset includes the information on the income percentile of the household, we will use income ranking as an indicator for socioeconomic status in this paper. Note that income is measured by household income from all sources for the last 12 months.

⁵ $BMI = \text{weight}(\text{kg})/\text{height}(\text{m}^2)$

⁶ As introduced by Statistics Canada, the Cole cut-off points are based on pooled international data (Brazil, Great Britain, Hong Kong, Netherlands, Singapore and United States) for BMI and linked to the internationally accepted adult BMI cut-off points of 25 (overweight) and 30 (obese).

Age, Gender, Ethnicity

Subjects in the dataset will be classified into three major groups, namely “Children” (age 12-17), “Adult” (age 18-64) and “Senior” (age \geq 65). We will analyze socioeconomic inequality of each group. Further decomposition of the population by sex and ethnic will be implemented within each group. Note that the survey only includes two ethnic groups which are “white” and “visible minority” groups and two gender groups which are “male” and “female” groups.

3.2 Results

3.2.1 Children Socioeconomic Inequality

1) Overall socioeconomic inequality of obese children and overweight children

Table 3.2.1.1 gives the CIs of the children population. As we can see from the table, the CI of child obesity is -0.080 and the CI of overweight child is -0.049. The negative values of CIs imply that both obesity and overweight are negatively related to SES. The values also mean that number of obese and overweight children is more concentrated on the lower income family.

Index	
CI Estimate	
Total Obese	-0.080
Total Overweight	-0.049
Difference	0.030

Table 3.2.1.1 Overall Socioeconomic Inequality of Obese and Overweight Children

2) *Children socioeconomic inequality by sex*

Gender decomposing of the children group can provide more detailed information on which portion of child contributes more to inequality. The results from Table 3.2.1.2 suggest that both obese girls and obese boys have negative socioeconomic inequality (-0.138 and -0.062). However, CIs remain negative with a slight decrease in inequality for girls and an unnoticeable increase for boys when overweight children are included (-0.026 and -0.063 respectively). The interpretation of the results is that girls have larger degree of inequality in obesity than boys have. And poorer households tend to have more obese girls than obese boys. It seems that children, both boys and girls, who are from richer families tend to have less problem of obese and overweight.

Group	Obesity	Overweight
	CI	CI
	Estimate	Estimate
Girls	-0.138	-0.026
Boys	-0.062	-0.063
White	-0.106	-0.101
Non-white	-0.063	0.078
Population	-0.080	-0.049

Table 3.2.1.2 *Children Socioeconomic Inequality by Gender and Ethnicity Respectively*

3) *Children socioeconomic inequality by ethnicity*

Since ethnicity only includes “white” and “visible minority” in the survey, we can divide the children group into two groups, namely “white children” and “children of visible minority”. The third and the fourth entries of Table 3.2.1.2 present the results of inequality among obese and overweight “white children” as well as “children of visible minority”. To be specific, the CI for obese “white children” is -0.106 and -0.063 for “children of visible minority”. It implies that there is more inequality among “white children” than among “children of visible minority”.

However, when overweight children are included in the analysis, SES becomes positively related to overweight (0.078) for “children of visible minority” and the relationship remains negative (-0.101) for “white children”. In other words, “white children” suffers more inequality than the other child group, and most overweight white children are from lower-income family and vice versa for non-white kids. The trend found in white children is in accordance with the finding in International Obesity Task Force (2002). It finds that children grow up in low-income households are more likely to become overweight. Obviously, this trend applies to white children in this paper. In contrast, the converse trend displayed by non-white children indicates that the finding in International Obesity Task Force (2002) is only partially right.

4) *Children socioeconomic inequality by both sex and ethnicity*

In this section, further decomposition of child group by gender and ethnicity is implemented. So child group is going to be divided into more specific groups, namely “white girls”, “non-white girls”, “white boys” and “non-white boys”.

sex	Obesity/Overweight	Ethnicity	CI
Girl	Obesity	White	-0.247
		Non-white	0.351
	Overweight	White	-0.185
		Non-white	0.323
Boy	Obesity	White	-0.042
		Non-white	-0.118
	Overweight	White	-0.054
		Non-white	-0.060

Table 3.2.1.3 Children Socioeconomic Inequality by Both Gender and Ethnicity

Table 3.2.1.3 shows CIs of four gender-ethnicity specified child groups. As for obesity, “non-white girls” exhibits positive relationship between SES and obese (0.351). It means that “non-white girls” from higher income family has a tendency to become obese. However, both “white boys” and “non-white boys” show a negative relationship between SES and obesity (-0.042 and -0.118). Therefore, obese boys, white or non-white, are mostly from poorer families. But “non-white boys” shows more inequalities than “white boys” does.

As for overweight children, “non-white girls” still has the highest degree of inequality but with positive CI (0.323). Thus, richer “non-white girls” has higher possibility to become obese, while richer “white girls” is on the opposite situation with negative CI (-0.185). Each group of boys in general has lower degree of inequality compared with girls. Both “White boys” and “non-white boys” have negative inequality (-0.054 and -0.060). Therefore, socioeconomic inequality favors rich boys, meaning there are more obese boys from less-income families.

3.2.2 Adult Socioeconomic Inequality

1) Overall socioeconomic inequality of obese adult and overweight adult

The results of CIs for obese and overweight adults are 0.014 and 0.037 respectively (Table 3.2.2.1). Obviously, these two positive values of CI tell us that more obese and overweight adults come from higher income families.

Regarding socioeconomic inequality, overweight adults have slightly larger inequality than the obese adults. In other words, there is more inequality among overweight adults than among obese adults. In order to understand the results more intuitively, we will impose further decomposition to adults.

Index	
CI Estimate	
Total Adult Obese	0.0142
Total Adult Overweight	0.0376
Difference	0.023

Table 3.2.2.1 Overall Socioeconomic Inequality of Obese and Overweight Adults

2) Adult socioeconomic inequality by sex

Now we decompose the adult group simply by gender. Thus, we only have female and male groups for estimating. Table 3.2.2.2 shows that CI is negative for obese women (-0.043) and is positive for obese men (0.065). So obesity is negatively related to SES for female and is positively related to SES for male. It is easy to find that there

is a big gender difference in inequality among obese adults, since women and men do not share the same direction of CI. Simply put, women with lower income are more likely to become obese, while men with more income are more likely to become obese.

Regarding the overweight inequality, a significant difference emerges within both groups. Women now have positive inequality (0.007) after including the overweight population. Men on the other hand still keep a positive relationship between SES and obesity but with a small decrease in inequality from 0.065 to 0.046. It means that both men and women with higher income are more likely to become overweight.

Group	Obesity	Overweight
	CI Estimate	CI Estimate
Female	-0.043	0.007
Male	0.065	0.046
White	-0.000	0.031
Non-white	-0.040	0.011
Population	0.014	0.037

Table 3.2.2.2 Adults Socioeconomic Inequality by Gender and Ethnicity Respectively

3) Adult socioeconomic inequality by ethnicity

In this section, the adult group is divided into “white adults” and “non-white adults”. According to Table 3.2.2.2, socioeconomic inequalities among obesity are -0.000(white) and -0.040(non-white), which are all negative. However, CI values for

overweight white adults and non-white adults are positive (0.031) and 0.011 accordingly). For inequality among obesity, both white and non-white adults with more income are less likely to become obese than adults with less income. But there is more inequality among non-white adults who are obese. It is interesting to find that, both groups of obesity have negative signs of CI while the population has a positive CI. The reason for this is that inequality is composed of inter-group inequality and inter-sector inequality. Therefore, decomposition of group inequality is a process of isolating inter-group inequality from inter-sector inequality.

As for inequality among overweight adults, both rich white and non-white subjects are more likely to become overweight than poor subjects. And there is a slightly higher degree of inequality within non-white adults than within white adults.

4) Adult socioeconomic inequality by both sex and ethnicity

Results for decomposed groups are presented in Table 3.2.2.3, which includes “female white”, “female non-white”, “male white” and “male non-white”. Among obese female, “non-white female” (-0.045) has higher degree of inequality than “white female” (-0.109). As for obese male, “non-white male” (0.062) has slightly higher degree of inequality than “white male” (0.032). These values serve as evidences indicating that both white women and non-white women with higher income are less likely to become obese. The values also suggest that white men and non-white men have significantly different situation as compared to women, because both groups of male with higher income are more likely to become obese.

sex	Obesity/Overweight	Ethnicity	CI
Women	Obesity	White	-0.045
		Non-white	-0.109
	Overweight	White	-0.004
		Non-white	-0.001
Men	Obesity	White	0.032
		Non-white	0.062
	Overweight	White	0.040
		Non-white	0.016

Table 3.2.2.3 Adults Socioeconomic Inequality by Both Gender and Ethnicity

If overweight subjects are included into estimation, directions of CIs for all four groups have not changed. To be conclude, both “white female” and “non-white female” have negative association between SES and overweight (-0.004 and -0.001 respectively), while “white male” and “non-white male” have positive relationship between SES and overweight (0.040 and 0.016 respectively). The CIs for overweight adults can be interpreted as that richer white women and non-white women are less likely to become overweight than poorer white women and non-white women, though white women have higher inequality than non-white women. Positive CIs for male suggests that the problem of overweight are more concentrated on richer “white male” and “non-white male”, though “white male” group has approximately 0.03 higher degree of inequality than “non-white male”.

5) *Results of the Achievement Index and the Erreygers Corrected Index*

When CIs are estimated based on h_1 ($h_1 = \max\{BMI - 30, 0\}$) and h_2 ($h_2 = \max\{BMI - 25, 0\}$), we only concern the distance between the threshold of ill health (obese and overweight) and the actual ill health level of each individual. Then the values of new CIs, h_1 and h_2 are imposed into the Achievement Index and the Erreygers Corrected Index.

Table 3.2.2.4 gives the values of Wagstaff achievement index and the Erreygers corrected index for obese adults. Firstly, the first four groups will be concerned, which are decomposed by gender and ethnicity respectively. As we can see from the table, the new Concentration Index which considers h_1 and h_2 , shows that women have higher degree of inequality of obesity (-0.083) than any of other three groups. Rankings of inequality given by the Achievement Index and the Erreygers corrected index are the same as that given by the new Concentration Index. In the first four groups, however, magnitudes of inequality among obesity suggested by the Erreygers corrected index are smaller than that given by the new Concentration Index. For example, “female” has the highest inequality of -0.083 as suggested by the Concentration Index. The Erreygers corrected index also indicates that “female” has the highest inequality, but the number of index is smaller than that given by the Concentration Index (-0.014).

Moving on to the second four groups of obesity, “white female” has the highest degree of socioeconomic inequality as indicated by all the three indices. To be specific, “white female” is the group with the severest and negative inequality out of

four groups as pointed out by three indices. Therefore, the most obvious inequality exists in “white female”, where poor “white female” are more likely to become obese.

Indices Comparison of Adult Obesity				
Group	Mean h_1	CI	A	E
Female	1.066	-0.083	1.155	-0.014
Male	0.914	0.051	0.867	0.007
White	1.045	-0.058	1.106	-0.009
Non-white	0.777	-0.030	0.801	-0.003
Group				
White Female	1.113	-0.115	1.241	-0.0203
Non-white Female	0.873	-0.096	0.957	-0.013
White Male	0.967	0.012	0.954	0.001
Non-white Male	0.665	0.092	0.604	0.009

Table 3.2.2.4 Results of new Concentration Index, Achievement Index and the Erreygers Corrected Index of obese Adults. * A represents the Achievement Index and E is the Erreygers Concentration Index; $h_1 = \max\{BMI-30, 0\}$

Regarding overweight adults, Table 3.2.2.5 presents completely divergent results for the first four groups and the second four groups. Among the first four groups, two out of three indices show that “male” has the highest degree in inequality of overweight. This result simply indicates that “male” has severer inequality when the overweight population is included in the analysis. One thing worth noticing within the first four groups is that the signs of all three indices remain unchanged when overweight individuals are taken into consideration, though the highest ranking of inequality shifts from women to men. Degree of inequality reduced in women, but

increased in men. Additionally, all-time positive signs of the CI and the Erreygers corrected index of “male” implies that their income is always positively associated with ill health level.

Indices Comparison of Adult Overweight				
Group	Mean h_2	CI	A	E
Female	2.749	-0.037	2.853	-0.013
Male	2.989	0.062	2.802	0.024
White	2.964	-0.002	2.973	-0.001
Non-white	2.398	-0.000	2.398	-0.000
Group				
White Female	2.837	-0.05	3.000	-0.021
Non-white Female	2.408	-0.054	2.540	-0.017
White Male	3.109	0.035	3.000	0.014
Non-white Male	2.386	0.065	2.229	0.020

Table 3.2.2.5 Results of the new Concentration Index, the Achievement Index and the Erreygers corrected Index of overweight Adults. * A represents the Achievement Index and E is the Erreygers Concentration Index; $h_2 = \max \{BMI-25, 0\}$;

When looking at the second four groups in Table 3.2.2.5, we can hardly find a consistent ranking of three indices. In other words, they all point out different “winner” for the inequality. The new Concentration index indicates that “non-white male” has the highest inequality with positive association with socioeconomic status (0.065). The achievement index shows that “white male” instead of “non-white male” has the highest degree of inequality (3.000), while the Erreygers index gives the highest rank to “white female” with a negative coefficient (-0.021).

3.2.3 Elderly Socioeconomic Inequality

1) Overall socioeconomic inequality of obese elderly and overweight elderly

As Table 3.2.3.1 shows, the socioeconomic inequality of obesity among the elderly is -0.036 and inequality of overweight is 0.013. The negative association between SES and obese suggests that the richer elderly have less likely to become obese than the poor. As for overweight, however, seniors with less income are less likely to become overweight than seniors with more income. Clearly, having included the overweight elderly, we find that there are more overweight rich seniors than overweight poor seniors and there are more obese poor seniors than obese rich seniors. Consistent with an American finding by Rhoades (2005), our findings also suggest that “individuals with the highest income were the most likely to be overweight” among the American elderly population. It seems that there are some similarities between the American senior population and the Canadian ones. In order to have a clearer understanding of the inequality distribution across the senior group, we will further decompose the elderly group in the following sections.

	Index
	CI Estimate
Total Elderly Obese	-0.036
Total Elderly Overweight	0.013
Difference	0.050

Table 3.2.3.1 Overall Socioeconomic Inequality of Obese and Overweight Elderly

2) *Elderly socioeconomic inequality by gender*

Table 3.2.3.2 informs us that there is a big gender difference in inequality with respect to signs of CIs. The female elderly has consistent negative inequality of obese and overweight (-0.065 and -0.004), while male has consistent positive inequality of obese and overweight (0.003 and 0.024).

Group	Obesity	Overweight
	CI Estimate	CI Estimate
Female	-0.065	-0.004
Male	0.003	0.024
White	-0.049	0.002
Non-white	-0.011	0.033
Population	-0.036	0.013

Table 3.2.3.2 Elderly Socioeconomic Inequality by Gender and Ethnicity Respectively

We can interpret the results as women who are poor have higher probability to be obese or overweight, and men who are rich are more likely to become obese or overweight. The other characteristic of inequality within two gender groups is that obese female has relatively more inequality than male, and the overweight male instead of female has relatively more inequality.

3) *Elderly socioeconomic inequality by ethnicity*

When we decompose elderly groups into white and non-white subgroups, the direction of inequality among obese becomes negative with more inequality in “white

senior” (-0.049) than in “non-white senior” (-0.011). It can be concluded that both “white senior” and “non-white senior” with higher income are less likely to become obese than those with less income (see Table 3.2.3.2).

Regarding overweight elderly, positive value of CIs for both “white” (0.002) and “non-white”(0.033) tell us that “white senior” with more income are more likely to become overweight than “white senior” with less income; Same interpretation applies to “non-white senior ” as well (Table 3.2.3.2).

4) Elderly socioeconomic inequality by both sex and ethnicity

Table 3.2.3.3 shows us that three groups of obese elderly exhibit negative socioeconomic inequality except “non-white male” which has a positive relationship between SES and obese (0.056). And “white female” appears to be the group with the largest inequality (-0.078). So, among richer elderly, only “non-white men” is more likely to become obese, while rich “non-white men”, “white women” and “non-white women” are less likely to be obese than those who are poor.

Regarding overweight elderly, “white female” seems to be the only group with negative inequality (CI= -0.018), while all other three groups have positive relationship between SES and overweight but with different degree of inequality. Additionally, the biggest socioeconomic inequality exists in “non-white female” with the largest positive CI (0.062). Thus, rich “non-white female” is the biggest contributor to the overweight problem.

Sex	Obesity/Overweight	Ethnicity	CI
Women	Obesity	White	-0.078
		Non-white	-0.045
	Overweight	White	-0.018
		Non-white	0.062
Men	Obesity	White	-0.011
		Non-white	0.056
	Overweight	White	0.012
		Non-white	0.000

Table 3.2.3.3 Elderly Socioeconomic Inequality by Both Gender and Ethnicity

5) Results of the Achievement Index and the Erreygers Corrected Index

Next step is to incorporate new health status variable h into the CI and two other indices – the Achievement Index and the Erreygers Corrected Index. h is equal to $\max\{BMI - 25, 0\}$. Values of the Achievement Index and the Erreygers Corrected Index giving slightly different ranking of inequality are listed in the following Table.

Table 3.2.3.4 presents the results for inequality in obesity among senior citizens. Interestingly, all three indices in this table generate consistent rankings for eight groups. For the first four groups, all three indices indicate that “non-white” has the highest degree of negative inequality (CI=-0.104, A=0.904, E=-0.016). Among the second four groups, “non-white female” is featured by the highest degree of socioeconomic inequality of obesity. Additionally, inequality of obesity is negatively related to the income level for “non-white female” because of the negative CI and

Erreygers index (CI=-0.192, E=-0.036).

Indices Comparison of Elderly Obesity				
Group	Mean h_1	CI	A	E
Female	0.788	-0.087	0.857	-0.013
Male	0.670	0.018	0.658	0.002
White	0.736	-0.056	0.778	-0.008
Non-white	0.818	-0.104	0.904	-0.016
Group				
White Female	0.779	-0.085	0.845	-0.012
Non-white Female	0.976	-0.192	1.164	-0.036
White Male	0.673	0.003	0.671	0.000
Non-white Male	0.632	0.053	0.598	0.006

Table 3.2.3.4 Results of the new CI, the Achievement Index and the Erreygers Concentration Index for obese Elderly. * A represents the Achievement Index and E is the Erreygers Concentration Index; $h_1 = \max \{BMI-30, 0\}$

Indices Comparison of Elderly Overweight				
Group	Mean h_2	CI	A	E
Female	2.585	-0.042	2.695	-0.016
Male	2.671	0.020	2.616	0.008
White	2.630	-0.024	2.694	-0.009
Non-white	2.598	-0.023	2.658	-0.009
Group				
White Female	2.592	-0.049	2.720	-0.019
Non-white Female	2.750	-0.068	2.939	-0.029
White Male	2.686	0.003	2.676	0.001
Non-white Male	2.417	0.048	2.299	0.018

Table 3.2.3.5 Results of the new CI, the Achievement Index and the Erreygers Concentration Index for overweight Elderly. * A represents the Achievement Index and E is the Erreygers Concentration Index; $h_2 = \max \{BMI-25, 0\}$

When we include overweight senior population, we find that rankings of inequality among seniors will change. As Table 3.2.3.5 presents, all three indices show that “female” suffers from the severest inequality in overweight with a negative association between SES and overweight among the first four groups (CI=-0.042, A=2.695, E=-0.016). And the overweight problem is mostly contributed by poor female seniors. With respect to signs of inequality, “male” is the only group with a positive inequality of overweight within the first four groups. Among the second four groups, all three indices show that the group with the highest degree of inequality of overweight is “non-white female”. In addition, “non-white female” has negative inequality, meaning non-white senior females with less income are more likely to become overweight.

4. Discussion

This paper has estimated socioeconomic inequality across a number of different demographic groups. The inequality analysis is based on three types of population, namely the Children, the Adults and the Elderly. In addition to the Concentration Index, the Achievement Index and the Erreygers Corrected Index are also used for inequality analysis in order to compare different rankings of socioeconomic inequality. After a series of analysis, no single pattern can be found to represent the SES inequality for all groups. In other words, across all demographic groups, only a large dispersion of inequality is found, because different group has different magnitude and

direction of socioeconomic inequality among obesity and overweight. Although unanimous and representative pattern of inequality cannot be found across all groups, several interesting patterns regarding the relationship between SES and Obesity are discovered.

Starting with Children, three prominent patterns of socioeconomic inequality are captured by CIs. Firstly, there is hardly any gender difference in inequality of white children, but that is not true for minority children. White children no matter boys or girls always display a negative association between SES and obesity. This negative association is not changed even if we target the overweight population instead of the obese population. However, different from white children, there a big gender difference in inequality among ethnic children regarding the consistency of the signs of inequality. To be specific, minority girls have a prevalent positive correlation between SES and obesity, while minority boys have an all-time negative correlation between SES and obesity. Secondly, a strong evidence of ethnic difference in inequality is found in teenage girls, but not in teenage boys. The third pattern relates to the magnitude of inequality. It can be immediately identified from the table that, larger inequalities are found in minority children especially in ethnic teenage girls, which are approximately two times larger than in other children groups.

All three patterns of Children indicate that maybe ethnic teenage boys and girls do not share the same attitude towards obesity nowadays in Canada. Some other existing studies have also showed that there are some differences between boys and girls from the same ethnic origin with respect to the childhood obesity and overweight.

Since most teenagers are not socially independent, family impact is important for their social behavior. For example, Higgins and Dale (2010) find that another possible predictor of childhood obese or overweight is whether having obese or overweight parents. Therefore, it might be reasonable to consider the probability that family attitude towards obesity varies from ethnic boys to ethnic girls. Additionally, to support the results found in children, we also find a number of literatures suggesting the similar idea that ethnic children are more fragile to obesity in Canada. According to Irigoyen et al. (2008), “the children at greatest risk for overweight at an early age are low-income and minority children.”

As for Adults, different but stronger patterns of socioeconomic inequality are found. Three conspicuous patterns show entirely different characteristics of adults’ social value and even social behaviors with respect to obesity. First pattern found in the Canadian adults is similar to the pattern found in the US data by Zhang and Wang (2001). We find that the direction of socioeconomic inequality appears to be different in different gender groups. Based on the estimation of CI, SES is found consistently associated with obesity and overweight in a negative way within both white female and ethnic female. In contrast, men including white men and non-white men are characterized by showing unified positive relationship between SES and obesity/overweight. This absence of ethnic difference in adults is in strong contrast with the prevalent ethnic difference found in children. In addition, either in female group or in male group, the sign of inequality is found to be different in different ethnic groups.

The second pattern discovered among Canadian adults is slightly different from the pattern found in US adults by Zhang and Wang (2001). In US, the CI of obese men is negative while the CI becomes positive for overweight men (Zhang and Wang, 2001). However, Canadian adults show a consistent direction of socioeconomic inequality among obesity and overweight. The signs of inequality for obese adults including different gender and ethnic groups remain the same when the target of observation expands to overweight adults. Specifically, the negative direction of inequality among obesity for all ethnic groups remains negative when overweight women are included. Additionally the positive direction of inequality stays unchanged when subjects changed from obese men to overweight men. This is a strong pattern to support the idea that women with higher socioeconomic status held a negative attitude towards obesity and overweight in Canada.

A third pattern unveiled among adults supports some patterns discovered by other studies in the literature. But it may as well hold against some findings by others. For example, the pattern found is obviously not in accordance with the research showed by McDonald and Kennedy (2005). They conclude that minority groups exert great influence on the obese and overweight society, and may as well “drive a weight gain with additional years in Canada”. However, the third pattern we have found demonstrates that larger magnitudes of inequalities are not found in ethnic groups in Canada, such as -0.004 for white women and 0.040 for white men. Moreover, when using the new Concentration index meaning only taking those who suffer from obesity into consideration, white female has the highest inequality. This result for the

obesity groups is supported by both Achievement index and the Erreygers index. As for obese adults, the Achievement index indicates that mean level of ill health attribute⁷ is higher among white women than other decomposed groups and the Erreygers index implies that the distance between two extreme ill attributes⁸ is smaller for white women. According to these two indices, non-ethnic adult groups are not necessarily more fragile to ill health (obesity), or non-ethnic adults are more easily to become obese. All three indices suggest that non-ethnic groups can also be contributors to weight gain with additional years in Canada. Therefore, it might be safe to conclude that not only ethnic but also other standards should be adopted so that we can draw some clues on which portion of population has higher possibility to accelerate weight gain in future in Canada.

Regarding socioeconomic inequality among the elderly, strong and clear patterns are not discovered. Relatively weak patterns compared to what found in adults are identified. To be concluded, the direction and magnitude of socioeconomic inequality vary from group to group among the elderly population. Both gender difference and ethnic difference exist in senior groups with no apparent characteristic of pattern. Absence of strong pattern of inequality may itself indicate that there is a great variety of inequality among the elderly population. However, three features of inequality within the senior population still weakly stand out.

Firstly, inconsistent signs of inequality are found in two groups, white men and non-white women. Initially both CIs are negative for two groups when the inequality

⁷ Mean level of ill health attribute in this case the average level of $h1$, where $h_1 = \max\{BMI-30, 0\}$;

⁸ The distance between two extreme ill attributes is just $(h_{max} - h_{min})$

of obesity was estimated. But negative CIs change to positive when we estimate the inequality of overweight instead of inequality of obese. In contrast, the signs of inequality for white women and non-white men remain unchanged even if we are estimating the overweight inequality rather than estimating the inequality of obesity. The long-lasting inverse inequality for white women shows that there is a stable and negative association between SES and ill health for white women.

The second feature of socioeconomic inequality among the elderly is that higher level of inequality is mostly detected in ethnic groups. This feature is inconsistent with a pattern found in adult groups. Minority groups of the elderly population are seemingly easier to become obese and overweight than white groups are.

Thirdly, the Achievement index and the Erreygers index show similar rankings of inequality among the elderly. Among obese seniors, as pointed out by the Achievement index, the Erreygers index and the new Concentration index, non-white female has the largest degree of SES inequality than other groups. As for overweight seniors, all three indices indicate that the highest inequality is still found in non-white female. So non-white women still characterized by the largest degree of socioeconomic inequality. By interpreting these rankings, we have known more about inequality of the elderly population. What can be concluded from the different rankings are 1) non-white female have higher average ill health (obese and overweight); 2) the distance between two extreme ill attributes is smaller for non-white women than other elderly groups.

Overall, observed patterns seem to vary from group to group. Gender difference

and ethnic difference are found in almost all groups. This dispersion of patterns is supported by many previous literatures studying gender and ethnic difference in morbidity, such as Read and Gorman (2013). They point out that “the magnitude of gender difference varies considerably by racial/ethnic group, health outcome, and comparison category”. However, the reasons causing these various patterns in inequality remain in dispute. A number of possible explanations are proposed by many scholars and scientist. For example, some believe that education and occupation are important factors causing variations in ethnic and gender inequality (Wardle et al., 2002; Winkleby, 1997), and others think that the way energy metabolism works is different among ethnic groups (Kumanyika, 1999). All dimensional differences in equality complicate the health policy making, since certain adjustments of policy are needed in order to match each demographic group, and the process of obesity management can be complicated.

On the bright side, two prevalent and unique patterns are found in both adults and seniors. The first one is the persistent negative association between SES and obese/overweight among women and persistent positive association between SES and obese/ overweight among men according to the traditional CI. The second one is that women tend to have higher inequality according to the new CI, the Achievement Index and the Erreygers Index. Therefore, we may be able to conclude that women’s attitude towards obesity is different from that of men. As for women, the richer they are, the more they care about being overweight. Men, on the other hand, especially rich ethnic men tend to care less about being obese and overweight. These two

patterns might facilitate health policy makers to formulate gender-specific health policies for the obese management purpose in Canada. For example, a health policy aiming at reducing the overall obesity might be more efficient if it could focus more on female groups and ethnic groups which contribute more to ill health. However, there is no perfect measurement or analysis without flaws. Further analyzing methods are certainly needed to find the closest values of true inequality, though all quantitative analysis done in this paper allow us gain some understandings on the composition of income-related inequality among the Canadian society.

Conclusion

In this paper, we have applied not only the Concentration Index but also the Achievement Index and the Erreygers Corrected Index to measure income-related inequality among the obese and overweight population. The Concentration Index provides the direction and magnitude of inequality by sacrificing the average ill health level in each group. In order to complete the analysis, the Achievement Index and the Erreygers Index are introduced. These two indices which consider the mean level and extreme values of ill health have given rankings different from those given by the Concentration Index. By comparing the results of each index, we have discovered some patterns and characteristic of socioeconomic inequality within the obese and

overweight population.

All demographic groups have more or less shown the existence of income-related inequality. However, the magnitude of inequality varies across all decomposed groups. Though inconclusive implications are drawn from traditional Cis in this paper, several distinct implications can still be gathered through comparing three indices. Firstly, based on three indices, we find that there are more inequalities in non-ethnic groups among adults. But minority groups tend to have higher inequality than other groups among the elderly population. Secondly, richer women have less possibility to become obese and overweight among adults and seniors. Since child obesity use different and obscure scale of BMI, the Achievement Index and the Erreygers Index are not included. However, it is interesting to find that, among children groups, minority girls is the only group whose SES is positively related to obesity and overweight, which means that ethnic girls coming from richer families concern less about obesity and overweight while other richer boys and girls care more about being obese and overweight. Moreover, ethnic boys and girls tend to have relatively higher inequality than non-ethnic children.

To sum up, there is a prevalent phenomenon of socioeconomic inequality among the obese and overweight Canadian population. Different demographic groups tend to show their own patterns of inequality, which surely complicates the work of health policy makers. Thus, the analysis in this paper might assist similar researches by providing dimensional comparisons of different index results. However, to manage the problem of obesity and clarify the complex composition of socioeconomic

inequality, more delicate analysis towards socioeconomic inequality should be carried out continuously.

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