Understanding the Role of the Ottawa Ankle Rules in Physicians' Radiography Decisions: A Social Judgment Analysis Approach

Ania Syrowatka

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Department of Epidemiology and Community Medicine

Faculty of Medicine

University of Ottawa

ABSTRACT

Clinical decision rules improve health care fidelity, benefit patients, physicians and healthcare systems, without reducing patient safety or satisfaction, while promoting cost-effective practice standards. It is critical to appropriately and consistently apply clinical decision rules to realize these benefits. The objective of this thesis was to understand how physicians use the Ottawa Ankle Rules to guide radiography decision-making. The study employed a clinical judgment survey targeting members of the Canadian Association of Emergency Physicians. Statistical analyses were informed by the Brunswik Lens Model and Social Judgment Analysis. Physicians' overall agreement with the ankle rule was high, but can be improved. Physicians placed greatest value on rule-based cues, while considering non-rule-based cues as moderately important. There is room to improve physician agreement with the ankle rule and use of rule-based cues through knowledge translation interventions. Further development of this Lens Modeling technique could lend itself to a valuable cognitive behavioral intervention.

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PREFACE

Dr. Brehaut developed a series of written hypothetical patient vignettes to elicit clinical decisions from a sample of emergency department physicians; the survey was already completed prior to beginning this thesis. The thesis involved statistical analysis of survey data using Social Judgment Analysis to assess whether rule-based and/or non-rule-based cues informed physician radiography decision-making. The study targeted three hypotheses designed to understand the role of the Ottawa Ankle Rules in these hypothetical decisions.

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INTRODUCTION

The strengths and weaknesses of evidence-based medicine

Evidence-based medicine is a cornerstone of modern medicine. David Sackett, a pioneer in this area, has defined evidence-based medicine as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients".[1] Evidence-based medicine involves asking the right clinical questions and appraising relevant evidence to apply the acquired knowledge to patient care.[2] In the practice of evidence-based medicine, the term 'evidence' refers to clinically relevant scientific literature, which includes research ranging from the basic medical sciences to qualitative studies to patient-centered clinical trials.[1;3] Current best evidence plays an integral role in the practice of medicine; without integration of new evidence, the medical practice can quickly become out-of-date, and fail to provide optimal patient care.[4]

Scientific evidence on its own is not sufficiently comprehensive to be the sole source of information guiding medical practice, and some experts consider evidence-informed medicine to be a more appropriate concept.[5] Evidence is not meant as the basis for all clinical decisions as the evidence-based medicine name might suggest, but serves to inform and supplement (rather than to substitute for) clinical expertise.[6] Clinical expertise is experience in medical decision-making and diagnosis that a physician acquires over time through clinical practice.[1] Clinical expertise is a necessary component of evidence-based medicine; evidence must be assessed to determine whether it is applicable and appropriate for specific patient cases. A valuable part of

expertise is acknowledging the limitations of evidence-based medicine; there are shortages of adequate scientific literature in many areas, and in such cases physicians must rely on clinical expertise to interpret and apply limited or inconsistent knowledge, or make decisions where no evidence exists.[7] Thus, appropriate practice of evidence-based medicine involves integration of the best available evidence with physicians' clinical expertise.[6]

The benefits of evidence-based medicine span all levels of healthcare.[2] Individual physicians rely on evidence-based medicine to update personal medical knowledge and as a result improve their confidence in medical decision-making and ensure that their patients get the best possible care. Healthcare systems benefit from evidence-based medicine because it helps to provide consistent, standardized care for all patients, while guiding better use of medical resources. Patients receive improved quality of care and evidence-based medicine helps to facilitate patient-physician communications about screening and treatment decisions.

Although evidence-based medicine has clear advantages, maintaining a current evidence base for all aspects of care is difficult, regardless of medical discipline. This thesis focused on emergency medicine, as its characteristics make it especially susceptible to overwhelming scientific literature; emergency medicine is a first-contact, comprehensive practice, which requires physicians to know about many aspects of care.[8] Over the past 20 years, there have been significant increases in the volume and diversity of scientific literature aimed to inform emergency medicine practice.[6] Sklar et al (2010) report that less than two decades ago, the number of National Institutes of

Health-funded emergency medicine investigators was minimal,[9] but the funding allocated to emergency medicine research had more than tripled by 2007. Increased interest in emergency medicine research activities by physicians and healthcare organizations indicates that this rise is likely to continue into the future.

Even physicians who are able to make time for assessing relevant scientific literature face another barrier; they may lack the training and skills necessary to evaluate the quality of evidence being presented. Generally, physicians do not have appropriate training in evidence-based medicine to find, assess, interpret and apply scientific evidence to practice.[6] The practice of evidence-based medicine requires a large time commitment from the physician to learn and to effectively apply knowledge in clinical practice.[2] As a result, it is becoming increasingly difficult, and may be impossible, for physicians to keep abreast of current best evidence without external help.

Many tools have been introduced in order to work around physician time constraints and critical appraisal barriers associated with evidence-based medicine. Evidence-based services have been created to make accessing current best evidence feasible and easy in clinical settings.[6] For example, physicians can now rely on electronic databases (e.g. through PubMed[10]), systematic reviews (e.g. The Cochrane Collaboration[11]), or journals that conduct quality reviews and summarize high-quality evidence (e.g. Evidence-Based Medicine by the British Medical Journal[12]), thereby providing multiple levels at which a physician can access the same evidence to use in clinical practice. In addition, physicians have access to many tools (examples listed at

the KT Clearinghouse[13]), such as websites summarizing evidence (e.g. BestBETs[14] and Centre for Evidence Based Medicine[15]) clinical guidelines (e.g. National Guideline Clearinghouse[16]), applications for handheld devices,[17] and continuing medical education courses[18] to support integration of evidence-based medicine into practice. Physicians should be encouraged to learn about and make better use of such resources to stay up-to-date with scientific evidence.

Health care fidelity: Are patients receiving optimal care?

The fidelity of health care is a concept that describes how well evidence-based medicine is integrated into medical practice. This includes, but is not limited to, proper delivery of necessary care, timely delivery of necessary care, and exclusion of unnecessary care.[19] Scientific literature has established a large and consistent gap between current best evidence and delivery of care.[20] Research has shown that a large number of patients, approximately 45%, are not receiving appropriate care as recommended by current best evidence.[21] For example, it is recommended that all adults over the age of 65 receive the annual influenza vaccine,[22] as people aged 65+ are at higher risk of serious complications (including death) resulting from an influenza infection.[23] However, over 30% of this susceptible population did not receive the potentially life-saving vaccine in 2009.[22]

Receiving appropriate care involves timely delivery of care. Lowering health care wait times for diagnostic testing and medical treatments in Canada has been a priority for years.[24] Despite efforts to reduce patient wait times in target areas such as cancer,[24] many wait times are still much higher than desired.[25] A recent study found that

approximately 28% of a Canadian sample of pediatric patients did not receive necessary cancer surgery within the maximum acceptable waiting time for their specific conditions.[25]

Fidelity of health care also encompasses the exclusion of unnecessary care.[19] Research has shown that approximately 20-25% of patients receive unnecessary care, including potentially harmful care.[26] For example, a set of guidelines exist to help physicians determine which patients with blunt ankle or foot trauma should be sent for x-rays; they are called the Ottawa Ankle Rules.[27] These guidelines aim to standardize efficient use of radiography for ankle injuries by excluding patients who are at low risk of fracture and thereby reducing unnecessary x-rays. Prior to the development and implementation of these rules, it was estimated that only 15% of ankle radiographies performed were positive for fracture.[28] These guidelines have the potential to significantly reduce radiography use.[29] However, it is clear that this evidence is not being applied to its full potential, as studies have shown that the rules are not being applied as intended in clinical practice.[30]

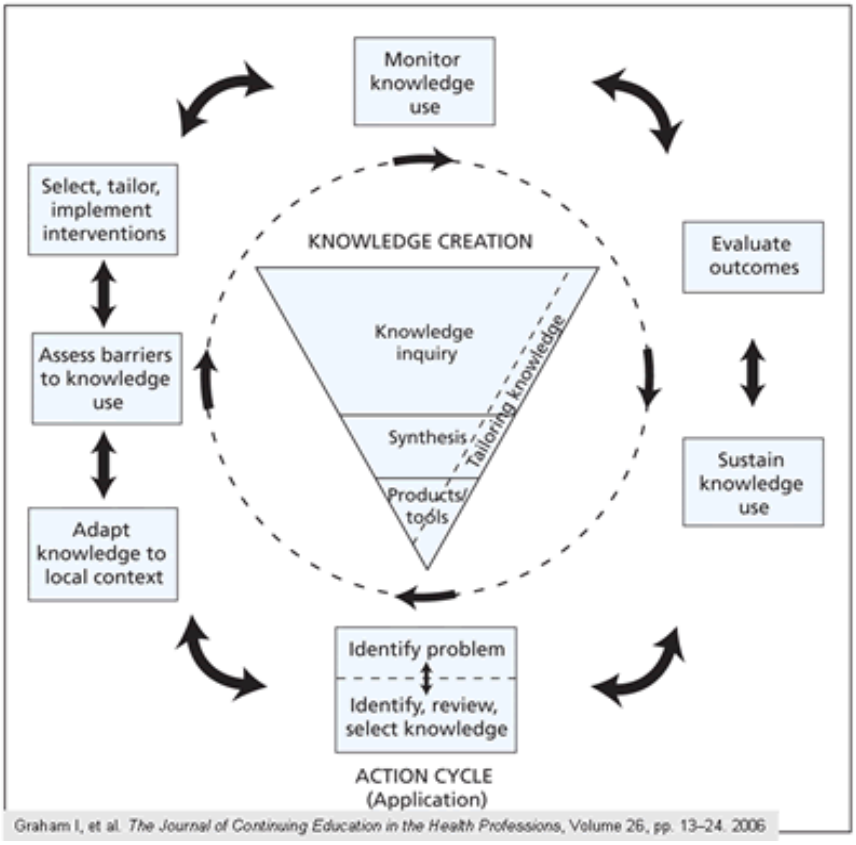
It is valuable to maximize the uptake of evidence-based medicine into medical practice to provide patients with the best possible care. Providing services that are not up-to-date or not evidence-based introduces unnecessary risks to patient health and safety. Successful implementation of evidence-based medicine research is critical to improve health care fidelity; if fidelity is low, there is greater potential for improvement that can be achieved through a process known as knowledge translation.

The role of knowledge translation for improving health care fidelity

Knowledge translation aims to improve the fidelity of health care through "the exchange, synthesis, and ethically-sound application of knowledge - within a complex set of interactions among researchers and users - to accelerate the capture of the benefits of research for Canadians through improved health, more effective services and products, and a strengthened health care system".[31] In a clinical context, knowledge translation involves identifying clinical areas where health care fidelity is low, and subsequently determining viable methods to facilitate adoption of new or updated medical knowledge into clinical practice. Knowledge translation is an important active dissemination strategy, as research has shown that passive diffusion of evidence (such as scientific presentations and publications) was not very effective in promoting behavioural changes in physician clinical care.[32] Active dissemination and implementation activities that target barriers and maximize facilitators have proven to be much more effective at driving clinical behaviour change.[33]

Graham's Knowledge-to-Action framework is one influential model of how actionable knowledge is generated and how such knowledge can be effectively implemented into clinical practice. The framework was developed by Graham et al (2006) guided by the work of Haynes (2001)[34] and a review of more than sixty relevant planned-action theories and frameworks.[4] Planned-action theories provide conceptual frameworks that aim to describe how behaviour change occurs, while taking into consideration potential barriers and facilitators to such behaviours.[35]

Figure 1. Graham's Knowledge-to-Action framework[4]



The Knowledge-to-Action framework has two components: a process of knowledge creation, and a process of knowledge implementation (Figure 1).[4] In the knowledge creation phase, evidence-based research can be thought of as 'distilled', where information from many individual scientific studies (at the top of the triangle) is distilled through a variety of methods (e.g. systematic reviews) to produce concise, actionable messages for healthcare professionals. Essentially, the creation phase progresses from inquiry (i.e. "asking the right questions"), through to knowledge synthesis (i.e. "pulling together research and information from other sources"), and finally to products (i.e. "delivering the right information in the right format").

The action cycle describes how to take an actionable product and successfully implement it into medical practice to improve health care fidelity. The action loop illustrates seven different phases that need to be considered (based on planned-action theories) to implement the actionable message or knowledge product into general practice and achieve deliberate change. **Identifying, reviewing, and selecting knowledge** involves identifying that there is an issue that deserves attention, appraising the literature for validity and usefulness, and selecting relevant evidence-based literature. **Adapting knowledge to a local context** requires knowledge adaptation (e.g. guidelines) for the relevant users and settings based on value and appropriateness of the knowledge to the specific context. **Assessment of barriers to knowledge use** includes identifying potential barriers to knowledge uptake (to target by intervention), as well as, facilitators (to exploit through intervention) that can maximize uptake of the information. **Selecting, tailoring, and implementing the actual interventions** involves selecting and tailoring interventions to specific knowledge users based on the known barriers and facilitators of knowledge uptake. **Monitoring knowledge use** means first defining knowledge use and subsequently gauging this use to determine whether the intervention has been successful in improving physician knowledge, or whether more or new interventions are necessary. **Evaluating the outcomes** builds on the previous step, and determines the impact of knowledge use by evaluating whether or not the use of knowledge actually has an impact on patient, physician and healthcare system outcomes. **Sustaining knowledge use** means assessing barriers to continued use of knowledge, which may differ from barriers to initiating knowledge uptake. This step involves repeating the action cycle to assess sustainability of knowledge use.

Clinical decision rules: Example of an actionable knowledge translation product

Clinical decision rules are an example of a knowledge translation product at the bottom of the Knowledge-to-Action triangle; i.e. an actionable message intended to be useful to healthcare professionals to improve clinical practice. Clinical decision rules are decision-making tools (commonly applied in the emergency department) that are derived from original research and quantify contributions of variables (called cues) from patient history, physical examination, or simple tests to help healthcare professionals make specific diagnostic or therapeutic decisions.[36-38]

Clinical decision rules are a good example of a knowledge translation intervention that can benefit from the components outlined in the Knowledge-to-Action cycle. Active methods for the dissemination and implementation of these types of knowledge products are essential to improve health care fidelity.

Clinical decision rules can improve all three aspects of health care fidelity, by improving not only proper and timely delivery of necessary care, but also exclusion of unnecessary care.[19] Clinical decision rules are a way of implementing evidence-based medicine and as a result encompass similar (but more specific) benefits compared to evidence-based medicine at the physician, patient, and healthcare system levels. Clinical decision rules strengthen clinical practice for physicians by reducing clinical uncertainty, facilitating translation of evidence-based medicine into practice, and improving patient flow.[39] For patients, clinical decision rules can improve quality and consistency of care and decrease exposure to unnecessary, even potentially harmful clinical procedures.[36] For healthcare systems, clinical decision rules can reduce costs by

limiting unnecessary use of resources.[40] These principles improve health care fidelity, benefit patients, physicians and healthcare systems, without reducing patient safety or satisfaction, while promoting cost-effective practice standards.[41]

Despite these end-point benefits, the knowledge creation phase of the Knowledge to-Action framework for clinical decision rules is costly and requires a large time commitment. Stiell & Wells (1999)[36] suggest six major stages for the development and testing of a new clinical decision rule. First, one should determine need, which involves identifying the problem and making a case for potential benefit from clinical decision rule creation. Second, a rule must be derived; this step involves employing rigorous methodological standards to create the decision rule. For example, the rule should be derived using appropriate definitions of predictors/ outcomes, sufficient sample sizes, and multivariate statistical approaches (e.g. logistic regression or recursive partitioning). Third, the rule should be prospectively validated and refined; this step involves testing the clinical decision rule using a new patient population for several factors, such as reproducibility, sensitivity, and acceptance by physicians. Fourth, the rule needs to be implemented, which involves determining whether or not clinical decision rule use has the ability to change physician behavior. Implementing entails providing physicians with the necessary knowledge to change behaviors and gauging whether or not it influences clinical practice. Fifth, a cost-effectiveness analysis should be conducted to demonstrate potential healthcare spending reductions as a result of implementing the clinical decision rule into general practice. Sixth, dissemination and implementation strategies must be developed; this step involves creating easily accessible and useable forms of the knowledge (e.g. Continuing Medical Education

seminars, pocket cards, posters, etc) in order to best reach the target audience (in this case, physicians).

Given that each of the steps outlined above requires time and resources to complete, it is only practical to develop clinical decision rules in cases where the investment will yield substantial healthcare benefits, whether in terms of cost efficiency or improved practice, or, ideally, both. For this reason, methodological standards suggest that clinical decision rules are valuable in cases where there is an established inefficiency or variation in physician practice, and potential for improvement exists.[36]

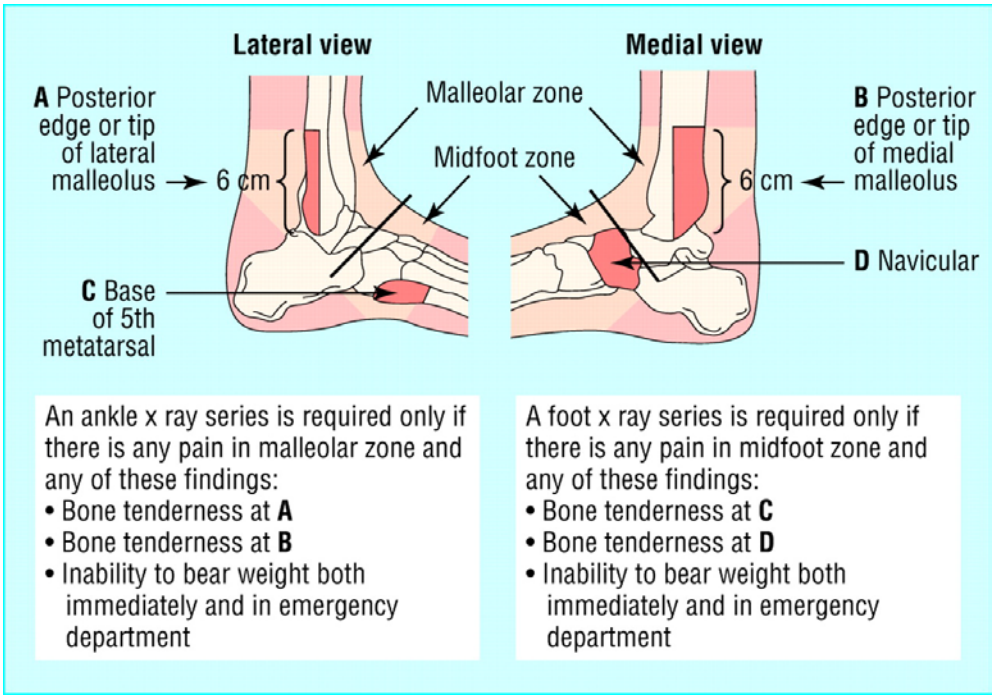
Case study: Ottawa Ankle Rules

Blunt ankle trauma is one of the most common injuries seen in the emergency department[27] and accounts for 3-12% of all emergency patient visits.[42] Prior to the development and implementation of clinical decision rules to guide radiography, approximately 95% of patients who presented at the emergency department with an acute ankle injury were referred for at least one radiographic series.[28] Literature has shown that less than 15% of these patient cases had clinically significant fractures (defined as any bone fragment > 3mm in breadth, because such injuries require plaster immobilization to heal[43]), which indicates that more than 85% of ankle radiographies were negative and a large proportion of these resulted in wasted healthcare resources.[27;44]

The Ottawa Ankle Rules were designed to reduce radiography in patient management of blunt ankle trauma without affecting the quality of care.[45] Designed to

the methodological standards discussed previously, use of the Ottawa Ankle Rules have been shown to significantly decrease ankle radiography, patient wait times, and healthcare costs, with no reductions in self-reported patient satisfaction and no more repeat visits or missed fractures than in previous practice.[27-29;43;45] The Ottawa Ankle Rules are widely accepted clinical decision rules.[46] Approximately 90% of National samples of Canadian emergency physicians self-reported frequently using the Ottawa Ankle Rules in everyday practice.[30;46]

Figure 2. Ottawa Ankle Rules[47]



The Ottawa Ankle Rules are comprised of two similar sub-rules for detecting fractures in the ankle (ankle rule) and foot (foot rule), which correspond to standard ankle (malleolar zone) and foot (midfoot zone) radiographic series, respectively.[27] The ankle part of the rule is outlined on the left hand side of Figure 2; this sub-rule is to be employed if the patient presents with ankle pain. The patient should be sent for an ankle

radiographic series if there is any pain in the malleolar zone AND any of the following three findings: (1) bone tenderness at the posterior edge or tip of the lateral malleolus, (2) bone tenderness at the posterior edge or tip of the medial malleolus, and/or (3) inability to bear weight both immediately and in the emergency department. Inability to bear weight is defined as the inability to take four steps without assistance (i.e. two steps on each foot).[27] This thesis focused on the ankle rule of the Ottawa Ankle Rules. The foot part of the rule is quite similar and is outlined on the right hand side of Figure 2. The Ottawa Ankle Rules should not be applied if patient assessment is unreliable, for example, if the patient: (1) is under the age of 18, (2) is intoxicated or uncooperative, (3) has other distracting painful injuries, (4) has diminished sensation in the legs, or (5) has gross swelling which prevents palpation of malleolar bone tenderness.[27]

In order to achieve the demonstrated sensitivity and specificity of these rules, they need to be applied as intended by the developers.[45] Evidence suggests that there is a lot of variability in how the Ottawa Ankle Rules are applied.[30] One element possibly contributing to variability is physicians' tendencies to apply the rules inappropriately, which includes combining rule cues inappropriately, or considering the rules along with other external factors.[30] In order to evaluate physician variability in cue use, this thesis employed a hypothetical decision task where physician decisions were made based on different combinations of cues.

For the purposes of this study, three different cue types that physicians may consider when making ankle radiography decisions were identified based on cues examined for the development of the Ottawa Ankle Rules.[29] Rule-based cues have been

shown to be correlated with the presence of a fracture and aggregated to create the ankle rule (i.e. bear weight, bone tenderness) through evidence-based research.[27-29;43;45] Non-rule-based cues can be separated into two different categories; related cues and unrelated cues. Related cues are those shown to be correlated with the presence of fracture, but were not included in the ankle rule because they do not contribute any additional information above and beyond rule-based cues.[29] An example of a related cue is age, which was found to be significantly related to presence of fracture, but did not add predictive value over and above the rule-based cues.[29;30] Unrelated cues are not correlated with the presence of fracture, however, have been mistakenly perceived to provide diagnostic value by some physicians. An example of an unrelated cue is previous fracture within 12 months, which was not found to be associated with fracture in univariate analyses.[29;30]

A survey-based study conducted by Brehaut et al (2005)[30] found that approximately 90% of physicians reported using the Ottawa Ankle Rules either always or most of the time in appropriate circumstances. When asked to identify how they apply components of the rules, most (84%) reported basing their decisions primarily on Ottawa Ankle Rules (i.e. rule-based cues), or primarily on rule-based cues while considering a few other key factors. Such self-reports gave the impression that physicians were appropriately applying the Ottawa Ankle Rules in practice.

Subsequent questions, however, revealed a different story. The study found that non-rule-based cues were considered by physicians when making radiography decisions; for example, age (a related cue) and previous fracture within 12 months (an

unrelated cue) were considered by 55% and 41% of physicians, respectively. Furthermore, only 33% of the physicians were able to correctly identify all rule-based cues and exclude all non-rule based cues from a list. It appears that the majority of physicians who self-reported basing their decisions primarily on Ottawa Ankle Rules may not have even had the knowledge to apply the rules as intended.

In essence, this study demonstrated a potential disconnect between physician self-reports, and their actual practice. While most physicians reported using the rules, the study showed that 'using' the rules might mean a range of different things, including not consulting the rules, or using them inaccurately or unreliably[30] This study suggested that the rules may not be applied as intended in real medical practice, despite the fact that most physicians believe that they are using the rules appropriately.[30]

Motivation for further research

The objective of this thesis was to understand the role of different cues (i.e. rule-based, related and unrelated) in ankle radiography decision-making, and the variability with which these cues contribute to radiography decision-making. In order to understand this variability, we looked at how individual physicians use specific components of the ankle sub-rule to make radiography decisions using Social Judgment Analysis. This physician-specific type of analysis provided a better understanding of how individual physicians make decisions, as opposed to how they report making decisions, and helped to describe how the ankle rule fits into individual and group level decision-making processes.

A secondary objective of this thesis was to determine whether specific factors (such as self-reported consistency in using the rule, and different levels of expertise) contributed to variability in rule use between physicians. The thesis sought to understand the relationship between physicians' self-reported use of the rule and actual clinical application. Given that clinical expertise (acquired over time through clinical practice) is an integral part of evidence-based medicine,[1] the thesis investigated whether years of clinical experience played a significant role in physician ankle radiography decision-making. Our findings could be used to inform future interventions to promote appropriate use of the ankle rule.

Social Judgment Analysis approach to evaluate medical decision-making

Social Judgment Analysis is a theoretical approach to conceptualizing judgments, which originates from the work of Austrian psychologist Egon Brunswik.[48] Brunswik opposed the popular trends and methodologies of experimental psychological research during the time of his career, which were focused on looking at how one independent variable affects one dependent variable, while keeping everything else constant. Brunswik's chief concern was the lack of generalizability of research to other contexts. Brunswik proposed a contrary viewpoint, which he named Probabilistic Functionalism.[48] His approach was designed to show that variables are ambiguous, can stand in for each other, and that judges use cues in different ways to extract similar information from complex environments. Brunswik argued that if you keep everything else constant, you are not studying how judgments are made in real life.

Brunswik rationalized his views using an analogy of visual perception.[48] He recognized that objects in the environment can be interpreted by relying on visual cues; however, these cues were often ambiguous. For example, an object that presents a small image on the retina can be small in size, or large in size and far away. Objects must therefore be interpreted using other pieces of information, or 'cues', to distinguish between the above two cases. Each of these cues may provide incomplete information, so it is important to consider all relevant cues at once (rather than one at a time) to get a better understanding of the true environment.

Kenneth Hammond and colleagues[49] expanded the work on Social Judgment Analysis into the realm of healthcare, specifically into medical decision-making. Hammond argued that clinical judgments were dependent on the physician perceiving and interpreting multiple ambiguous cues (e.g. patient history, symptoms, test scores, etc) to make diagnostic or treatment decisions. For example, Hammond provided the analogy of how patient behaviors, expressions and test scores all provide ambiguous cues to the patient's medical diagnosis.[49]

Brunswik's Lens Model provides a better understanding of medical decision-making by encompassing three core concepts: representative design, idiographic-statistical methodology, and vicarious functioning.[50]

a) Representative design

Representative design aims to encompass the true environment for the judgment being studied; this involves identifying all relevant cues. This framework was

developed to allow for cue values to be varied, creating many different combinations of cues for a judge to interpret. In effect, the combination of cues is sampled from a population, similar to how subjects would be sampled from a population. The extent to which the study design reflects real-world decisions is an important component of Lens Model studies (i.e. ideally, the proportion of certain cases in the task should mimic the proportion of cases in the real world).

b) Idiographic-statistical methodology

Idiographical-statistical methodology strives to represent one judge in the context of many diverse environments, as compared to standard scientific practice where many individuals are studied in one specific environment. The latter is called the nomothetic approach. The idiographic-statistical methodology of the Lens Model focuses on interpersonal differences in judgments as a measure of interest, as compared to the nomothetic approach, which treats judgment differences between individuals as random errors. The practical implication of this framework is that each subject is analyzed separately, rather than only determining an average of the group.

c) Vicarious functioning

Vicarious functioning describes the characteristic of redundancy within a typical judgment environment. Each cue has a certain correlation to the environment, which contributes to the predictability of the environment. This environmental predictability is not calculated simply as a sum of the individual correlations of all cues; in reality, overlaps occur between individual cues, meaning that different cues can provide much

of the same information. Therefore, different judges may use different cues to elicit the same information, and make the same judgment, based on the environment. In addition, in cases where a perfectly predictive cue is not available, a judge can rely on a different cue, which has less predictive value but offers similar environmental information to guide judgment.[48] Vicarious functioning is very useful in uncertain environments, as it implies that the judge can arrive at the same correct decision in various ways.

Figure 3. Brunswik's Lens Model[48]

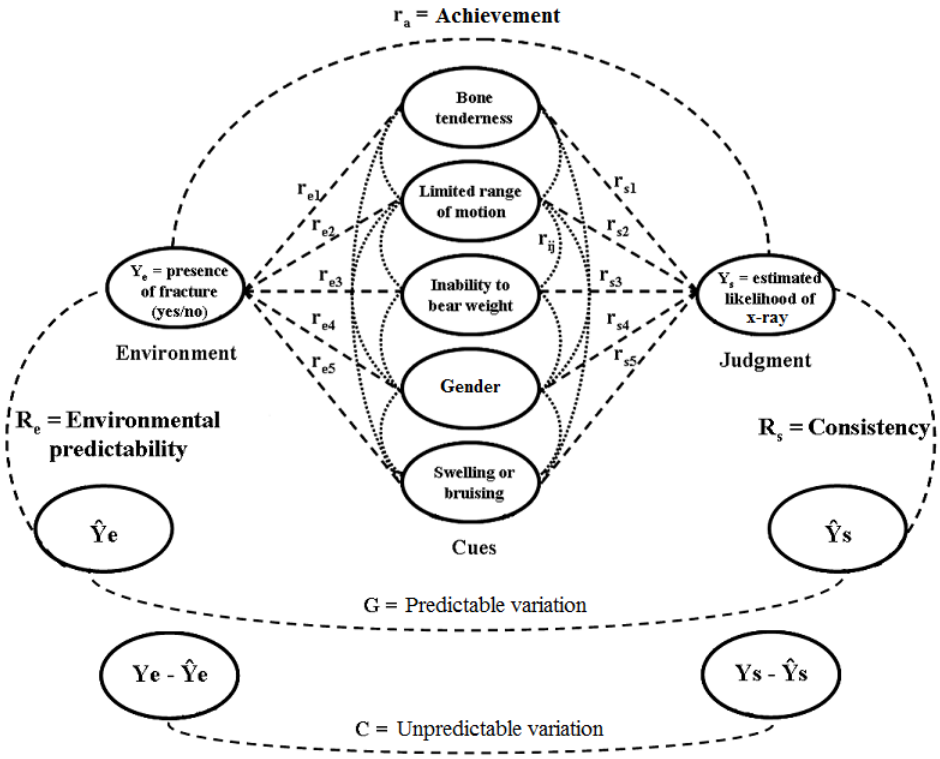


Figure 3 outlines the Social Judgment Analysis model, referred to as the Lens Model, because the judgment is made through a lens of fallible indicators, which divides the framework into two parts by a central column of cues.[48] The idiographical-statistical methodology is inherent in the framework, as the model is meant to be applied to determine individual judgment policies. This framework models judgments

as a series of bivariate relationships between the environment and cues, as well as, the cues and judgments. In terms of the ankle rule, the central column represents the available clinical cues that a physician may consider when making the decision of whether or not a patient requires ankle radiography. All cues included in the model were identified from the Ottawa Ankle Rules derivation study as potentially having an effect on physician behavior.[29;30] These cues are correlated with both the environment (i.e. presence of fracture, denoted by Y_e; value of yes or no) and the physicians' judgments (i.e. estimated likelihood of fracture, denoted by Y_s; value between 1 and 100%), and create the 'lens' that gives the model its name. The cues provide the basis for the representative design of this framework, because they can be varied to create multiple combinations of cues to assess how the judge responds in diverse environments. For example in the ankle rule, the age cue can be varied to determine the impact of patient age on physician judgments to x-ray.

The environment (i.e. the true state of the world, or the actual presence or absence of fracture) is depicted on the left-hand side of the model. The environment encompasses the environmental weights (i.e. $r_{e1} \rightarrow r_{e5}$; values between 0 and 1) and the objective value representing the true state of being (i.e. whether there is truly a fracture or not, denoted by Y_e; value of yes or no). The environmental predictability (R_e; value between 0 and 1) is the strength of association between the environment and all available cues. This association is a summary of all correlations between the environment and each individual cue. The environmental predictability is rarely perfectly correlated with the environment, as there may be cues that cannot be measured and/or errors that cannot be avoided that will ensure that the predictability is not perfect.

In the case of the ankle rule, the environmental predictability is based on the overall correlations between presence of fracture and available cues. For example, the two ankle rule rule-based cues (i.e. bone tenderness and inability to bear weight) are highly correlated with the presence of a fracture; however, do not perfectly predict the presence of a fracture.

The correlations between the environment and the eight cues (i.e. $r_{e1} \rightarrow r_{e5}$; values between 0 and 1) account for part of the vicarious functioning that occurs in the model. In the framework, overlaps can occur between individual cues, meaning that different cues can provide much of the same predictability information. For example, age is a related cue that has been shown to be correlated with the presence of a fracture, but was not included in the ankle rule because it does not contribute any additional information above and beyond the rule-based cues.[29]

The cognitive process is represented by the right-hand side of the model and outlines the relationship between the eight available cues and the physician judgment (i.e. estimated likelihood of radiography). The judgment estimate (Y_s; value between 0 and 100%) is the physician's assessment of whether or not the patient requires ankle radiography based on the eight available cues. The consistency (R_s; value between 0 and 1) is the strength of association between the judgment and all available cues. This association is a summary of all correlations between the judgment and each individual cue.

The correlations between the cues and the physician judgments (i.e. $r_{s1} \rightarrow r_{s5}$; values between 0 and 1) account for part of the vicarious functioning that occurs in the

model. Essentially, the physicians make decisions and statistical methods are used to calculate the weight of each cue in the decision-making process to form a 'judgment policy'. A judgment policy is a model of the physician's behavior when interpreting the environment to make a judgment. Individual differences always exist in the attribution of weights for each cue. In terms of the ankle rule, the physicians' simultaneously consider available cues, and make radiography decisions based on cues that they perceive as valid predictors of significant ankle fracture. The physician judgment policies outline which cues are valuable to each specific physician for ankle radiography decision-making, and which cues are perceived as inadequate to inform decision-making. The judgment policies are useful to compare cue utilization between judges, and predict physician judgments based on the policies.

However, varying judgment policies do not necessarily yield different judgments. Vicarious functioning also occurs as a result of cue intercorrelations (r_{ij}; values between 0 and 1). Given that most cues are intercorrelated to some degree, judges are able to use two or more different cues to elicit the same information from the environment, and as a result arrive at the same decision. In the context of the ankle rules, many cues are associated with the presence of significant fracture, but are not a part of the rule because they are intercorrelated with the rule-based cues, and as a result do not contribute any additional information to improve decision-making.[29] This redundancy of information allows physicians to arrive at the same judgment of whether or not to order radiography via different judgment policies. However, to improve health care fidelity and provide consistent, standardized care for all patients, it is important for physicians to behave as though they are using rule-based cues.

Survey vignettes: A common method for conducting Social Judgment Analysis

Social Judgment Analysis can be conducted using vignette-based survey methodology. The use of written clinical vignettes as a valid method for assessing clinical decisions has been validated through the work of Peabody et al (2000).[51] Clinical vignettes were evaluated against standardized patients (which are the gold standard for measuring quality of clinical practice) and shown to be effective measures of physician competence and quality of administered care. In addition, clinical vignettes are relatively inexpensive, easily administered, and can effectively control for case-mix variations in any type of medical practice.[51]

However, there are drawbacks to administration of hypothetical patient vignettes. First, the task requires the physician to complete a highly repetitive time-consuming task, which may cause physician fatigue or loss of interest, and as a result yield unreliable data, in addition to low response rates. In an effort to minimize such problems, Bachmann et al (2008) suggest a maximum burden of 20 vignettes with no more than 6-8 variables per physician.[52] Also, given the fabricated nature of this task, the usefulness of collected data considerably depends on the extent to which vignettes mimic real-world cases; thus, it is critical to ensure that hypothetical patient vignettes are representative of the true environment (i.e. vignettes include all relevant cues, and combinations of cues are clinically sensible). Also, it has been argued that clinical vignettes measure competence rather than true clinical performance.[53] Peabody et al (2004) support the notion that true clinical behavior can be measured when clinical vignettes are (1) open-ended, (2) completed within appropriate time limit, (3) based on

scientific evidence, (4) encompass the complexity of clinical practice, (5) provide real-time information (if necessary), and (6) measure necessary, as well as unnecessary patient care.[54]

Summary

Clinical decision rules are a valuable way to improve health care fidelity.[41] The ankle rule is a widely accepted decision rule,[46] with the potential to significantly reduce unnecessary radiographies in patient management of blunt ankle trauma.[28] However, evidence suggests that there is variability in how this rule is applied in practice, and that self-report may not be a reliable measure of use.[30] In order to understand this variability, it was necessary to decompose the decision-making process to the level of individual cues to address whether physicians were primarily relying on rule-based cues, or other types of cues (i.e. related and unrelated). Social Judgment Analysis provided the ability to look at physician decisions with this level of detail, and provided a theoretical framework to understand how these judgments were made by individual physicians.[48] Understanding the role of different types of cues (i.e. rule-based, related, and unrelated) can inform knowledge translation interventions to improve adherence to the ankle rule. The thesis also aimed to determine whether specific factors (such as self-reported consistency in using the rule, and different levels of expertise) contributed to variability in rule use between physicians. If either of these factors plays a significant role in variability, then interventions could be developed to target specific physician populations to improve adherence to the rule.

RESEARCH QUESTIONS

1) What is the rate of physician agreement with the ankle rule?

The Ottawa Ankle Rules are widely accepted clinical decision rules, with approximately 90% of National samples of Canadian emergency physicians self-reporting frequent use of the rules in everyday practice.[30;46] Based on previous research, we would expect agreement to be high with the ankle rule. If physicians are using the rule to the extent that self-reported data suggest,[30;46] then we should find close to perfect agreement with the rule. We would expect agreement to be higher in cases where radiography is indicated by the rule, and relatively lower in cases where radiography is not recommended. Understanding what types of cases lead to lower physician agreement can guide future knowledge translation interventions to improve agreement with the rule.

2) A) Do cues based on the ankle rule have a greater impact on physician judgment than non-rule-based cues?

B) With regard to non-rule-based cues, do related cues have a greater impact on physician judgment than unrelated cues?

If physicians are using the Ottawa Ankle Rules as self-reported data suggest,[30;46] then we should find that physicians place greatest value on rule-based cues. Although self-reported use of the ankle rule is high, some data suggests that the rule, and thus the rule-based cues, may be used in a variety of different ways.[30] The Social Judgment Analysis approach allowed us to also assess whether other types of cues (i.e. related and

unrelated) were involved in the decision-making process, and if so, how often. If non-rule-based (especially unrelated) cues are found to be significant predictors of radiography in decision-making, then it may suggest that real error is entering into the decision process. Understanding the role of related and unrelated cues in decision-making can inform interventions to improve adherence to the rule.

3) Do judgment policies differ among identifiable subgroups of physicians (i.e. self-reported consistency in using the rule, and different levels of expertise)?

If physicians are using the ankle rule as they self-reported for our study, then we should find that physicians reporting primarily making decisions on the basis of the ankle should place greater value on rule-based cues, as compared to those who considered other factors in the decision-making process. We would expect rule-based cues to be weighted more heavily by physicians who have less clinical experience or expertise. Expertise is an integral part of evidence based medicine,[1] and greater years of clinical experience may instill more confidence in personal decision-making, with less focus on strictly following clinical guidelines or decision rules. Understanding the value of self-reported rule use and role of expertise in decision-making could guide future knowledge translation interventions to improve adherence to the rule.

METHODS: Work previously completed; Survey design and administration

Study participants

Two-hundred and eighty-one study participants were randomly selected from registered members of the Canadian Association of Emergency Physicians (CAEP; approximately 1,370 members). The random selection of physicians was achieved using the RAND function in Microsoft Excel. Non-Medical Doctors, retired physicians, and physicians not currently practicing in Canada were excluded prior to randomization.

Study administration

The survey was piloted by the investigators and two additional physicians, who completed the survey and provided feedback regarding format, clarity, and clinical realism (i.e. representativeness) of the vignettes. The study protocol and mail-outs were based on Dillman's Tailored Design Method.[55] The pre-notification letter described the study, assured confidentiality, and requested that physicians complete the forthcoming survey. All communications were signed by the investigators (Dr. Jamie C Brehaut and Dr. Ian G Stiell) and personally addressed to each physician. No incentives were provided for completing the survey. One week after the pre-notification letter, the survey, and a postage-paid addressed reply envelope were mailed to all physicians in the sample. One week later, a reminder card was sent to all non-responders, followed two weeks later by a second complete survey package. A reminder postcard was sent one week after the second package. A third survey package and reminder postcard followed at corresponding time intervals.

Survey design

The survey consisted of seven pages, including a cover page with instructions, a series of twenty written clinical judgment vignettes over five pages, and a final page inquiring about physician demographic, professional and practice information. The survey took approximately 30-40 minutes to complete. A copy of the survey is attached as Appendix A.

Demographic and professional information collected from study participants included gender (male or female), year of birth (open-ended response), year of graduation from medical school (open-ended response), emergency medicine employment status (full-time, part-time, or resident), number of years practicing emergency medicine (open-ended response), number of hours devoted to direct patient care in emergency medicine each week (open-ended response) and emergency medicine credentials (CCFP(EM), CCFP, FRCPC, Dip ABEM, or other, please specify (as open-ended response)).

The following Ottawa Ankle Rules practice information was collected from study participants; physicians' became aware of Ottawa Ankle Rules from (Medical School, course, participation in a research study, colleague recommendation, journal article, not familiar with the rule, or other, please specify (as open-ended response)), frequency of Ottawa Ankle Rules use (always, most of the time, sometimes, or never), number of years using Ottawa Ankle Rules in practice (open-ended response), role of Ottawa Ankle Rules in decision-making (primarily on basis of rule, rule plus other key factors, rule is one of many factors, do not consider the rule, or other, please specify (as

open-ended response)), confident that Ottawa Ankle Rules use will not miss fractures (yes or no), last referral to printed version of the Ottawa Ankle Rules (days, weeks, months, or years) and presence of Ottawa Ankle Rules posters in the clinical setting (yes or no).

Prior to completing the vignette portion of the survey, the participants were informed that each vignette represents a hypothetical patient presenting at the emergency department with blunt ankle trauma. The instructions requested that participants treat all vignettes as suffering from a five-step fall off of a ladder. In addition, participants were informed that all vignettes showed no midfoot pain or tenderness indicative of a midfoot fracture, and that there were no other injuries to consider.

Eight cues were varied between clinical vignettes. All cues included in the vignettes were identified from the Ottawa Ankle Rules derivation study as potentially having an effect on physician behavior.[29] The resulting task consisted of twenty vignettes focused on eight dichotomous clinical factors. These cues are outlined in Table 1.

Table 1. Factors systematically varied in survey vignettes.

Cue Type	Labels
Rule-based	
Bone tenderness	Some vs. None
Inability to bear weight	Yes vs. No
Related	
Swelling/bruising	Marked vs. Little
Limited motion	Moderate vs. None
Age (years)	65 vs. 45
Unrelated	
Gender	Man vs. Woman
Cracking sound	Yes vs. No
Previous fracture	Yes vs. No

The physicians were asked to examine the information presented in each vignette. A sample vignette is presented below:

> The patient is a **65-year-old man**. He heard a **cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, **no bone tenderness anywhere on the medial malleolus**, and **no bone tenderness anywhere on the lateral malleolus**. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation in range of motion** of the ankle.

Subsequently, the physicians were asked to make one clinical decision and two clinical judgments regarding the fictional patient vignette using the check boxes and ranking scales presented below:

Would you order an ankle x-ray series for this patient?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |-------|-------|-------|-------|-------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |-------|-------|-------|-------|-------|

Reliability check

The reliability check was conducted by visually scanning each of the completed surveys. The overall completion pattern was marked as 'OK' or 'possible problem'. Surveys were marked as having a possible problem if all questions were answered as 'yes', many were answered as 'no', large blocks of questions were left blank, or there was little variability in the likelihood ratings. Surveys that provided a low rating or relevant comment for the question addressing representativeness of the survey task were examined more carefully to ensure that the low rating or comment did not reflect a disinterest in completing the survey. Five surveys were flagged as having a possible problem due to a combination of the factors listed above. After further review, it was decided not to remove any of the surveys from analysis.

Interpreting decisions via Brunswik's Lens Model

The amalgamation of the environment and cognitive process sides creates the two-sided Lens Model (refer to Figure 3 on page 18). The model shows that the physician does not have direct access to the true state of whether or not a fracture is present. The physician must infer the likelihood of fracture based on the eight available cues to decide whether or not the patient requires ankle radiography. The accuracy of the judge's estimate to the true state of whether or not the patient has an ankle fracture is called achievement (r_a; value between 0 and 1). It is very rare that any subset of cue weights would be perfectly correlated with the presence of a fracture; this means that even by making optimal use of each cue, generally, the judge cannot perfectly predict the criterion or realize perfect judgment achievement.[48] Thus, the physician's interpretation is based on imperfect correlations between the true state and each cue, guided by the physician's judgment policy.

This thesis was not able to measure achievement, as the data relied solely on hypothetical patient vignettes to elicit physician judgment policies. In order to create a full lens model to measure achievement in our survey task, we could have used past Ottawa Ankle Rules validation study datasets to determine the real-world correlations between the cues studied in our vignettes, and the presence of fracture as determined by radiographies; however, we did not have access to such data. Therefore, data collected for the question: "What is the likelihood this patient would have a fracture?" was not used for analysis. Physician agreement with the Ottawa Ankle Rules was measured by

the question “Would you order an ankle x-ray series for this patient?” and used as a proxy for achievement.

Response rates and mail-out process

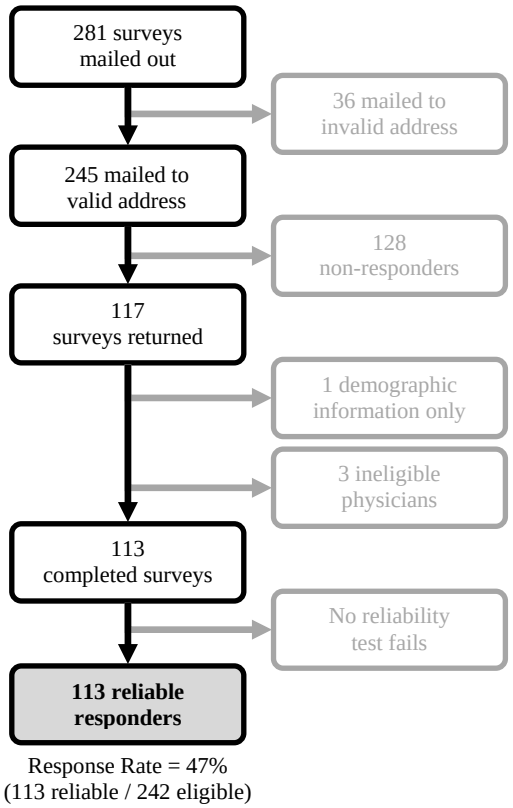
There are two important response rates for this type of Social Judgment Analysis. The power of the idiographic-statistical methodology increases with the number of completed vignettes, not with the number of responders; thus, each survey can have a low response rate as a result of partially completed vignettes. The reliability check ensured that no large blocks of questions were left blank in each survey.

The second (or standard) type of response rate encompasses the number of responders, which affects the power of between group comparisons (e.g. self-reported consistency in using the rule, and different levels of expertise). Although this does not affect the power of the idiographic-statistical approach, a greater number of participants provides a more comprehensive look at different types of judgment policies and frequency of such policies in the physician population.

Figure 4 describes the mail-out process and standard response rate. A random sample of 694 physicians was obtained from the Canadian Association of Emergency Physicians (approximately 1, 370 members) to contact for invitation to complete Ottawa Ankle Rule surveys. Another survey was administered (prior to the survey described in this thesis) and was sent to a random sample of 400 physicians from the original sample of 694 physicians. The results were published by Brehaut et al (2005).[30] Before administration of the survey described here, the Canadian Association of Emergency

Physicians amended its survey policy to limit re-sampling of physicians contacted through the first mail-out survey. Of the 294 remaining physicians, 13 were eliminated from participation on the basis of missing address information, not currently practicing in Canada, or affiliation with the Ottawa Hospital Civic Campus Emergency Department.

Figure 4. Mail-out survey response rate.



The remaining 281 Canadian emergency department physicians were contacted to participate in this study. Thirty-six surveys were returned to sender due to wrong or invalid addresses. These physicians could not be considered as contacted and more current addresses were not available, as a result these physicians were removed from the denominator for purposes of computing the standard response rate. Two-hundred-forty-

five surveys were received at the intended addresses. Of these mail-outs, 128 physicians did not return the survey and one physician provided only demographic information, for a total of 129 non-responders. Three pediatricians returned blank surveys with comments that they were not eligible to participate in this study; the Ottawa Ankle Rules have not been validated in pediatric populations and therefore these physicians do not use the rule in clinical practice. These physicians were excluded from our study, and were removed from the denominator for purposes of computing the standard response rate. The remaining 113 responders completed the survey and passed the reliability check. One survey was completed by a medical student, who was not a part of the target population; however, the survey was included in study analyses. This mail-out yielded a moderate standard response rate of 47% (113 reliable completions / 242 eligible responders).

METHODS: Work completed for thesis; Statistical analysis

All analyses were performed using SAS Statistical Software version 9.1. All graphs were prepared using Microsoft Excel. Outcomes focused on the first two questions of each vignette only, as presented in Appendix A; (1) *Order ankle x-ray?* (Yes/No), and (2) *What is the likelihood that you would order an ankle x-ray in this case?* (0-100%). All statistical tests were performed at a 0.05 alpha significance level. Tukey pairwise comparisons were used for analyses requiring multiple comparisons of means to correct for inflation of alpha error.

Exploratory and non-responder analyses

Descriptive statistics were carried out for demographic and practice information. Continuous variables were reported by mean, standard deviation (SD), range and missing values (absolute and percentage). The year of birth and year of graduation data were re-coded into age and time since graduation variables (in years).

Categorical variables were reported as percentage frequencies, and percentage missing values. Geographic location was dichotomized into Ontario and other provinces, given that the Ottawa Ankle Rules was developed in the province of Ontario, which may result in increased interest in the rule and influence survey standard response rates. Emergency medicine employment status was dichotomized into full-time and part-time (part-time included residents and one medical student), since employment status is expected to affect level of expertise, where physicians who spend

more time in the emergency department would be expected to see more cases, and as a result have a higher level of expertise.

Non-responder bias was assessed by comparing gender and geographic location variables for responders versus non-responders using Chi-square tests of independence. Early versus late responders were also compared based on gender, geographic location, self-reported role of the Ottawa Ankle Rules in decision-making, last referral to printed version of the rule, employment status, and time since graduation from medical school using Chi-square tests of independence. Late responders are the best proxy for non-responders, since without the follow-up reminder cards administered as part of the Dillman's Tailored Design Method,[55] late responders may have become non-responders.[56;57]

The overall fit of the Brunswik Lens Model was described using individual associations between the cues and the judgment (i.e. $r_{s1} \rightarrow r_{s8}$; Figure 3, page 18), and the overall consistency (R_s; Figure 3, page 18) of the model, which is the strength of association between the judgment and all available cues. In this case, since the cues in the vignettes are not correlated, the strength of association is simply calculated as the sum of the individual correlations of all cues; in reality, the association would be smaller than the sum of its parts, since overlaps occur between individual cues, which are providing the same information.[58] The fit was measured to determine how much of the overall variation in decision-making was attributable to the eight cues. Means and ranges were reported.

Important physician policy types were described, using real judgment policies selected from our study as examples. The number of physicians employing each of the three policy types was reported.

Analysis: Research Question 1. *What is the rate of physician agreement with the ankle rule?*

The ankle rule guides physician radiography decision-making based on the distribution of rule-based cues in each vignette; if either the bone tenderness or inability to bear weight cues (or both) are positive, then the ankle rule indicates that radiography is necessary; otherwise, radiography is not indicated. Physician responses to the vignettes were evaluated to examine what percentage of physician decisions were consistent with the ankle rule.

Several variables were re-categorized for analysis. 'Role of the Ottawa Ankle Rules in decision' was collapsed into two levels. 'Primarily on basis of rule' remained as one level, and the other categories (rule plus other key factors, rule is one of many factors, do not consider the rule, or other, please specify) were collapsed to create the second level named 'consider other factors'. This categorization was chosen to create adequate sample sizes within each category. This dichotomous variable was named 'role in decision'.

'Last referral to printed version of the Ottawa Ankle Rules' was collapsed into three levels. 'Days' and 'weeks' was combined to create one level, 'months' remained unchanged to form the second level, and 'years' remained unchanged to form the third

level. This categorization was chosen to create adequate sample sizes within each category. This variable was named ‘last referral’.

The continuous ‘time since graduation’ was categorized into three levels. Physicians who graduated from medical school less than 10 years ago (<10) formed the first level. Physicians who graduated between 10 to 20 years ago (10-20, inclusive) formed the second group, and physicians who completed medical school over 20 years ago (20+) constituted the third level. This categorization was chosen to create adequate sample sizes within each category. This categorical variable was named ‘time of graduation’.

Physician decisions were assessed by computing the N, mean percentage agreement, SD and range based on physician responses to the clinical decision of whether or not to order radiography (yes or no) in each vignette. Percentage agreements with the Ottawa Ankle Rules were computed by comparing physician responses with Ottawa Ankle Rules recommendations. Missing values were counted as a disagreement.

Mean percentage agreements across physicians overall and based on vignette type (i.e. ankle rule indicates radiography versus does not indicate radiography) were compared to perfect agreement with ankle rule recommendations. Differences among three groups based on cue distribution within vignettes (i.e. both rule-based cues positive, only bone tenderness positive, or only ability to bear weight positive) were assessed by repeated measures ANOVA, with Tukey pairwise comparisons if the overall ANOVA was significant. Mean percentage agreements were transformed using the arcsine-root transformation ($\sin^{-1}\left(\sqrt{p}\right)$) prior to ANOVA in an effort to stabilize

the variance of proportions.[59] If the variance had not been stabilized, it could have lead to unreliable p-values if the proportions were considerably varied.

Key variables were selected for additional post hoc analyses based on literature that a large proportion of physicians do not remember all components of the Ottawa Ankle Rules; in particular, recall errors were higher in physicians who did not use the rule consistently, practiced emergency medicine on a part-time basis, and were more experienced.[30] In addition, previous research has shown that the majority of physicians cannot remember all components of the Ottawa Ankle Rules, which may be attributable to the majority of physicians not having viewed the rule in months, or even years. To test whether this was true of our sample, we compared agreements between groups for each of the key variables.

Differences among two subgroups based on 'role in decision' (primarily on basis of rule or consider other factors) and 'employment status' (full-time or part-time) were assessed by t-test. Differences among three levels of 'last referral' (days/weeks, months, or years) and 'time of graduation' (<10, 10-20, or 20+) were assessed using a 1-way ANOVA, with Tukey pairwise comparisons if the overall ANOVA was significant. The variance was stabilized using the arcsine-root transformation prior to ANOVA.

Analysis: Research Question 2. *(A) Do cues based on the ankle rule have a greater impact on physician judgment than non-rule-based cues? (B) With regard to non-rule-based cues, do related cues have a greater impact on physician judgment than unrelated cues?*

The statistical approach used for Research Question 2 was informed by the Brunswik Lens Model and Social Judgment Analysis.

The initial dataset contained physician identification numbers and all survey responses (the clinical decisions and judgments for each vignette, as well as physician demographic, professional, practice information) at the level of individual physicians. The dataset was reduced to identification number and a clinical judgment (likelihood of ordering radiography; response options: 0 – 100%) for each vignette. The dataset was transposed to create a new dataset at the level of the vignette (i.e. twenty lines per physician), with each line corresponding to likelihood of ordering radiography in one of the twenty vignettes. New data was merged to the transposed dataset to include dichotomous values (0, 1) for all eight cues (as outlined in Methods Table 1, page 28) corresponding to the cue distribution in each of the twenty vignettes.

Consistent with the Social Judgment Analysis idiographic-statistical approach, a multiple linear regression was conducted for each physician, with the probability assessment (likelihood of ordering radiography; response options: 0 – 100%) as the response variable, and the dichotomous cue values (0, 1) as the independent variables. The Social Judgment Analysis approach seeks to understand the judgment policies of individual physicians, and thus the beta regression coefficients are derived from

individual physician responses on the twenty vignettes. Each person-specific regression yielded a set of beta coefficients for each of the eight cues. These beta weights were imported to a new dataset, with one line per physician. Each line of the working dataset contained the physician identification number, coefficients of determination (r^2) and beta regression coefficients for each of the eight cues.

The beta regression coefficients were standardized in order to make physician beta weights comparable between judges. The beta regression coefficients were transformed into relative weights using the formula: $rw_{\beta i} = [|\beta_i|/(\Sigma^k_{i=1} |\beta_i|)]*100$.[48] This method produces a new set of weights that effectively partitions 100% of the predictable variation, where each weight becomes a proportion of this total;[60] a bone tenderness cue that accounts for 50% of the total predictable variation means that it accounts for half of the predictability based on the available eight cues. The above formula is standard for Social Judgment Analysis, but can only be applied in cases where all cues are independent of each other; that is to say that none of the cues are intercorrelated. Alternative methods of standardization are available for vignettes employing intercorrelated cues. This type of standardization may be misinterpreted as the eight cues presented in the vignettes perfectly predict physician judgments; in fact, the cue weights need to be considered in the context of how much of the overall variability is predictable.

The mean relative weights across physicians were reported for each of the cues, and by combined groups of cues for rule-based (bone tenderness, ability to bear weight) and non-rule-based (related: marked swelling/bruising, age, limited range of motion,

unrelated: previous fracture, cracking sound, gender). The data was visually represented by histogram; this method of presentation highlights where physicians place greatest weight and emphasizes variation in cue use. Combined cue group analyses compared cumulative relative weights using associated 95% confidence intervals.

Bootstrapping methods were used to obtain robust non-parametric 95% confidence intervals. Bootstrapping relies on repeated random samples with replacement from the original data to estimate standard errors.[58] Standard binomial confidence intervals were not appropriate for relative weights, as the sampling distribution was unknown. Bootstrapping does not appear to be the standard in Social Judgment Analysis literature; however, it is a recommended approach.

Research question 2A compared the cumulative relative weights across physicians of the rule-based group to the non-rule-based groups (related and unrelated), whereas research question 2B comparing the cumulative relative weights across physicians of the related group to the unrelated group. Both analyses were conducted using the 95% bootstrapped confidence intervals.

Analysis: Research Question 3. *Do judgment policies differ among identifiable subgroups of physicians (i.e. self-reported consistency in using the rule, and different levels of expertise)?*

The statistical approach used for Research Question 3 was informed by the Brunswik Lens Model and Social Judgment Analysis.

Value of self-reported use of the rule in radiography decision-making

'Role in decision' was imported to the dataset as an additional covariate to allow for comparison of judgment policies based on this variable.

The mean relative weights were reported for each cue, and by combined groups of cues (rule-based, related, and unrelated) by level of the 'role in decision' variable with bootstrapped 95% confidence intervals. The data was visually represented by histogram. Combined cue group analyses compared cumulative relative weights by level of the 'role in decision' variable using bootstrapped 95% confidence intervals.

Role of physician expertise in radiography decision-making

'Time of graduation' was imported to the dataset as an additional covariate to allow for comparison of judgment policies based on this variable.

The mean relative weights were reported for each cue, and by combined groups of cues (rule-based, related, and unrelated) by level of the 'time of graduation' variable with bootstrapped 95% confidence intervals. The data was visually represented by histogram. Combined cue group analyses compared cumulative relative weights by level of the 'time of graduation' variable using bootstrapped 95% confidence intervals.

RESULTS

Exploratory and non-responder analyses

Table 2. Demographic and professional information for responders and non-responders.

	Responders (N=113)	Non-responders (N=129)	χ^2 (p-value)
Gender, N (%)			
Male	84 (74.3)	87 (67.4)	
Female	29 (25.7)	32 (24.8)	0.05 (0.83)
Missing	0 (0.0)	10 (7.8)	
Geographic location, N (%)			
Ontario	51 (45.1)	61 (47.3)	
Other provinces	62 (54.9)	68 (52.7)	0.11 (0.74)
Missing	0 (0.0)	0 (0.0)	
Age (years)			
Mean (SD)	39.2 (7.9)	---	
Median	39		
Range	26–63	---	
Missing, N (%)	27 (24.8%)	---	
Time since graduation (years)			
Mean (SD)	13.5 (7.5)	---	
Median	12.5		
Range	0–34	---	
Missing, N (%)	3 (2.7%)	---	
Credentials†*, N (%)			
CCFP (EM)	59 (52.2)	---	
CCFP	25 (22.1)	---	
Dip ABEM	16 (14.2)	---	
FRCPC	9 (8.0)	---	
Other	13 (11.5)	---	
Missing	6 (5.3)	---	
Employment status, N (%)			
Full-time	83 (73.5)	---	
Part-time (incl. residents and students)	28 (24.8)	---	
Missing	3 (2.7)	---	
Time devoted to direct patient care (hours/week)			
Mean (SD)	28.2 (10.2)	---	
Median	30		
Range	3–50	---	
Missing, N (%)	6 (5.3%)	---	
Time practicing emergency medicine (years)			
Mean (SD)	10.2 (7.1)	---	
Median	9		
Range	0–30	---	
Missing, N (%)	6 (5.3%)	---	

† Note: These percentages do not add up to 100%, because some responders indicated multiple credentials.

***** CCFP(EM) = Emergency Medicine Certification, Canadian College of Family Physicians; CCFP = Certification, Canadian College of Family Physicians; Dip ABEM = Diploma, American Board of Emergency Medicine; FRCPC = Fellowship, Royal College of Physicians of Canada.

Table 2 describes demographic and professional information of responders, and when available, of non-responders. The majority of responders were male (74%) and almost half practiced in Ontario (45%). The average age of the responders was 39.2 years (*SD* = 7.9) with an average time since graduation of 13.5 years (*SD* = 7.5). Approximately half (52%) of the responders were certified in Emergency Medicine from the Canadian College of Family Physicians (CCFP[EM]). Given that advanced standing or completion of the one-year basic certification from the Canadian College of Family Physicians (CCFP) accreditation is required to begin the more focused CCFP[EM] program, it appears that CCFP[EM] physicians under-reported completion of the CCFP accreditation at 22%. The number of physicians with a Fellowship, Royal College of Physicians of Canada (FRCPC) accreditation was quite low at 8.0%. The majority of responders were employed full-time (74%), devoted on average 28.2 hours per week (*SD* = 10.2) in the emergency department, and had been working in emergency medicine on average for 10.2 years (*SD* = 7.1).

Our non-response bias analysis was limited to gender and geographic location of the respondent. These characteristics did not significantly differ from non-responders, who were also mostly men (67%, $\chi^2(1, N = 242) = 0.05, p = 0.83$) and practicing in Ontario (47%, $\chi^2(1, N = 242) = 0.11, p = 0.74$). The chi-square analyses did not account for missing data. There was no evidence of any differences between groups with respect to gender and geographic location, but the non-responder analysis didn't preclude differences on other, potentially more meaningful, variables.

Table 3. Ottawa Ankle Rules practice information for responders.

	Responders (N=113)
Became aware of OAR in[†], N (%)	
Medical school	44 (38.9)
Colleague recommendation	38 (33.6)
CME course	22 (19.5)
Participating in research study	8 (7.1)
Journal articles	7 (6.2)
Other	12 (10.6)
Not familiar with the OAR	0 (0.0)
Missing	1 (0.9)
Time using OAR in practice (years)	
Mean (SD)	6.2 (2.7)
Median	5
Range	2–15
Missing, N (%)	8 (7.1%)
Frequency of OAR use, N (%)	
Always	45 (39.8)
Most of the time	52 (46.0)
Sometimes	14 (12.4)
Never	1 (0.9)
Missing	1 (0.9)
Role of the OAR in decision, N (%)	
Primarily on basis of rule	46 (40.7)
Rule plus other key factors	45 (39.8)
Rule is one of many factors	17 (15.0)
Do not consider rule	2 (1.8)
Other	1 (0.9)
Missing	2 (1.8)
Confident that OAR use will not miss fractures, N (%)	
Yes	80 (70.8)
No	22 (19.5)
Missing	11 (9.7)
Last referral to printed version of OAR, N (%)	
Days	7 (6.2)
Weeks	15 (13.3)
Months	46 (40.7)
Years	44 (39.0)
Missing	1 (0.9)
OAR poster in emergency department, N (%)	
Yes	69 (61.1)
No	38 (33.6)
Missing	6 (5.3)

OAR = Ottawa Ankle Rules

[†] Note: These percentages do not add up to 100%, because some responders indicated multiple ways of becoming familiar with the Ottawa Ankle Rules.

Table 3 describes Ottawa Ankle Rules practice information for responders. The most commonly reported methods for being exposed to the Ottawa Ankle Rules were in medical school (39%), from a colleague recommendation (34%), or through a Continuing Medical Education (CME) course (20%). No physician reported being unfamiliar with the Ottawa Ankle Rules. Responders had been using the Ottawa Ankle Rules in practice on average for 6.2 years (*SD* = 2.7). Most (86%) responders reported using the Ottawa Ankle Rules always or most of the time. Similarly, most (81%) reported basing decisions primarily on the Ottawa Ankle Rules, or primarily on the rule with few other key factors. The majority (71%) of physicians did not believe that they were more likely to miss a fracture if appropriately applying the Ottawa Ankle Rules. Most physicians had not referred to a printed version of the Ottawa Ankle Rules in months (41%) or years (39%), and many (34%) reported not having an Ottawa Ankle Rules poster for reference in their emergency departments.

Early versus late responder analysis

Given that scientific literature suggests that late responders are the best available proxy for non-responders,[56] our study compared various characteristics of early (< 31 days) and late responders (> 31 days) to determine whether there were any significant differences.

The early versus late responder analysis in Table 4 assessed gender and geographic location, as well as more meaningful variables such as role of Ottawa Ankle Rules in decision-making, last referral to printed version of the rules, emergency

medicine employment status, and time of graduation from medical school. There was no evidence of any significant differences between early and late responders.

Table 4. Demographic and practice characteristics of early and late responders.

	Early responders (%, N=58)	Late responders (%, N=55)	χ^2 (p-value)
Gender			
Male	77.6	70.9	0.66 (0.42)
Female	22.4	29.1	
Missing, N	0	0	
Geographic location			
Ontario	50.0	40.0	1.14 (0.29)
Other provinces	50.0	60.0	
Missing, N	0	0	
Role in decision			
Primarily on basis of rule	42.1	40.7	0.02 (0.89)
Consider other factors	57.9	59.3	
Missing, N	1	1	
Last referral			
Days/weeks	43.1	38.9	0.48 (0.79)
Months	17.2	22.2	
Years	39.7	38.9	
Missing, N	0	1	
Employment status			
Full-time	79.3	69.8	1.32 (0.25)
Part-time (incl. residents and students)	20.7	30.2	
Missing, N	0	2	
Time of graduation (years)			
< 10	47.4	32.1	3.08 (0.21)
10 - 20	24.6	26.4	
20 +	28.1	41.5	
Missing, N	1	2	

Fit of the Lens Model

The fit of the Lens Model is shown in Table 5. The fit was assessed using coefficients of determination (r^2) based on individual associations between the cues and the judgment, and the overall model, which is the association between the judgment and

all available cues. In essence, the overall r^2 measured how much of the overall variation in decision-making was attributable to physician judgment policies.

Both rule-based cues (i.e. inability to bear weight and bone tenderness) individually were moderately associated with the judgment, but together accounted for over half (0.284 + 0.270 = 0.554) of the overall variation. All other cues were given low value, with associations less than 0.05, and together only accounted for 0.179 of the overall variation.

The mean overall r^2 was 0.728 (SD=0.099; range=0.427-0.917), which indicated that, on average across all physicians, 73% of the overall variation in decision-making was attributable to physician judgment policies. The mean overall r^2 represented a high degree of fit for the Lens Model.

Table 5. Fit of the Lens Model. N=113.

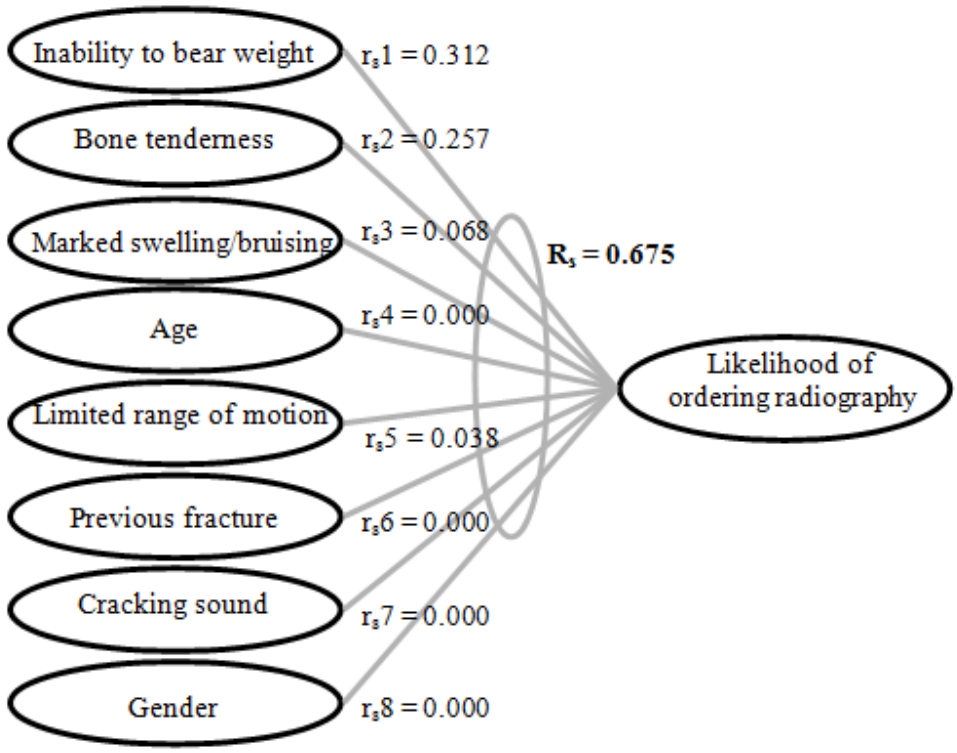
Cue	Mean r^2 (SD)	Range
Inability to bear weight	0.284 (0.129)	0.013 – 0.754
Bone tenderness	0.270 (0.134)	0.013 – 0.777
Marked swelling/bruising	0.043 (0.051)	0.000 – 0.339
Age	0.044 (0.055)	0.000 – 0.267
Limited range of motion	0.028 (0.032)	0.000 – 0.140
Previous fracture	0.032 (0.045)	0.000 – 0.249
Cracking sound	0.019 (0.031)	0.000 – 0.185
Gender	0.013 (0.016)	0.000 – 0.074
All cues	**Mean overall r^2 = 0.728 (0.099)**	**0.427 – 0.917**

Three types of judgment policies

Figure 5, on the next pages, illustrates three real judgment policies selected from our study. Responders in (a) and (b) had perfect agreement with the ankle rule, despite relying on different cues to guide decision-making, which supports the vicarious functioning concept of the Lens Model. The responder in (c) had a low agreement of 75% with the rule. The figure also presents the number of responders employing each of the three judgment policy types.

Figure 5. Three examples of real physician judgment policies.

(A) This responder demonstrated perfect agreement with the ankle rule, and used the rule as intended. The associated r_s values and overall consistency (R_s) are depicted below. The responder placed greatest weight on rule-based cues (inability to bear weight, bone tenderness), negligible weight on related cues (marked swelling/bruising, age, limited range of motion) and no weight on unrelated cues (previous fracture, cracking sound, gender). The implications of such a policy are a reduction in unnecessary radiographies for patients at low risk of fracture, and no missed opportunities to provide radiographies for patients with potential significant fractures. The majority (88 of 113; 78%) of our responders demonstrated a similar judgment policy, where the two greatest weights were placed on the two rule-based cues.



(B) This responder demonstrated perfect agreement with the ankle rule, but did not use the rule exactly as intended. The associated r_s values and overall consistency (R_s) are depicted below. The responder placed the majority of weight on the two rule-based cues (inability to bear weight, bone tenderness) as advised, but also placed significant weight on one related cue (age) that does not provide any additional value above and beyond the rule-based cues. The responder placed negligible weight on the remaining cues (marked swelling/bruising, limited range of motion, previous fracture, cracking sound, gender). This physician happened to agree with the rule in our study; however, the implications of this type of policy are an increased likelihood of ordering unnecessary radiographies in other circumstances. An appreciable number (19 of 113; 17%) of our responders showed a similar judgment policy, where one non-rule-based cue was considered to have equal or greater value than one of the rule-based cues.

(C) This responder demonstrated lower agreement (75%) with the ankle rule, and did not appear to be applying the rule at all. The associated r_s values and overall consistency (R_s) are depicted below. The responder placed negligible weight on the two rule-based cues (inability to bear weight, bone tenderness), and instead focused attention on two related cues (marked swelling/bruising, limited range of motion) and one unrelated cue (previous fracture) to guide decision-making. The implications of such a policy are an increased likelihood of missed opportunities to provide radiographies for patients with potential significant fractures, while ordering unnecessary radiographies for patients at low risk of significant fractures. A small number (6 of 113; 5%) of our responders demonstrated a similar judgment policy, where two non-rule-based cues were considered to have equal or greater value than both of the rule-based cues.

Representativeness of the survey task

In an effort to understand the representativeness of the survey task, each physician was asked to rate on a scale of 1-10 (with 1 indicating that the survey was completely irrelevant to the clinical decision, and 10 representing a perfect model of the clinical decision) how well the vignettes modeled real-world clinical decisions of whether or not to order radiography in cases of blunt ankle trauma.

The survey vignettes were found to be moderately representative of real-world clinical scenarios, with a mean representativeness score of 6.1 (*SD* = 2.14, range = 1-10). All cues included in the study were chosen based on research that such clinical indicators have or are perceived to have diagnostic value by physicians,[29;30] and pilot testing supported that the cues were clinically relevant.

A survey question asked the responders to explain their vignette representativeness ratings. Many responders agreed that the survey captured all necessary factors and was quite representative of real-world clinical decisions. Responder feedback also indicated reasons for lower ratings on representativeness of the survey task. Examples are provided in Table 6 on the next page.

Table 6. Responder representativeness ratings and comments about the survey task.

Representativeness rating	Comments
Positive feedback	
7	"[The vignettes included] similar factors to those I choose in deciding on radiography"
5	"[The vignettes] reflect the fact that most patients have some positive indicators and some negative indicators"
10	"The vignettes provided all the information necessary to make the decision based on the [ankle rule]"
8	"The factors I use to assess need for radiography were present [in the vignettes]"
7	"Good mix of potential cases"
9	"I'm using the [ankle rule] in my practice. So I think the vignettes reflect the clinical cues I'm using in my practice"
9	"[The vignettes] match the real world"
Negative feedback	
1	"Population is skewed, I see mostly young people and only rarely do they have previous fracture"
2	"Statements like *moderate swelling* and *some bone tenderness* can be interpreted in various ways"
3	"Unlikely that if patient cannot bear weight that there would be no tenderness"
7	"I'm surprised that there was no case where the patient could weight bear at the time of the injury, but not in the [emergency department], which is a common presentation"
5	"Vast majority of ankle injuries occur with walking running or jumping, not falls"
4	"[The vignettes] do not account for the other variables in the clinical setting e.g. patient distress"
7	"[The survey does not consider] x-rays ordered by triage [registered nurse] due to long [emergency room] waits"

Results: Research Question 1. *What is the rate of physician agreement with the ankle rule?*

Mean percentage agreement of physician responses with the ankle rule was calculated to determine physician adherence to the rule. Missing values were counted as disagreements to provide conservative estimates. Missing agreement values accounted for 0.8% (18 missing/113 responders*20 vignettes) of data entries.

Table 7. Mean agreements with the ankle rule overall and by vignette type.

Vignette types	N	Mean percentage agreement (SD)	Range
All vignettes (20 vignettes)	113	88.8 (11.5)	55.0-100.0
Rule indicates radiography (15 vignettes)	113	93.5 (13.0)	40.0-100.0
Rule indicates no radiography (5 vignettes)	113	74.7 (30.4)	0.0-100.0

Table 7 shows that the mean percentage agreement was quite high, but not perfect, at 89% (*SD* = 11.5%). When the ankle rule indicated radiography, agreement was 94% (*SD* = 13.0). When the ankle rule indicated no radiography, agreement was lower at 75% (*SD* = 30.4) of vignettes.

In Table 8, on the next page, we examined four important cue distributions varied in the vignettes, based on the presence (or absence) of rule-based cues, in order to further explore the variation in agreement with the ankle rule; only inability to bear weight rule-based cue positive, only bone tenderness rule-based cue positive, both rule-based cues positive, or no rule-based cues positive. Given that the vignettes were varied

in a fractional-factorial design (not full-factorial), it is possible that other cue differences between the subgroups influenced agreement.

Table 8. Mean agreements with the ankle rule by cue distribution.

Cue distribution	N	Mean percentage agreement (SD)	Range
Rule indicates radiography			
Only inability to bear weight (5 vignettes)	565	90.1 (22.5)[a]	0.0-100.0
Only bone tenderness (5 vignettes)	565	92.0 (17.6)[a]	0.0-100.0
Both (5 vignettes)	565	98.2 (7.3)[b]	60.0-100.0
Neither (i.e. Rule indicates no radiography)	565	74.7 (30.4)[c]	0.0-100.0

* Means associated with the same letter superscript are not significantly different, as determined by ANOVA with Tukey comparisons.

The overall ANOVA identified significant differences between at least two groups, $F(115, 2144) = 4.85$, $p<0.0001$. The Tukey pairwise comparisons showed significant differences in all cases, except where only one rule-based cue was present. Mean percentage agreement did not differ between vignettes where only the inability to bear weight (90%, *SD*=22.5%) or bone tenderness (92%, *SD*=17.6%) cues were positive. The mean percentage agreement for vignettes where both inability to bear weight and bone tenderness rule-based cues were positive was 98% (*SD*=7.3%), making it significantly higher than when only one rule-based cue suggested radiography. The mean percentage agreement for vignettes where no rule-based cues were positive was significantly lower as compared to vignettes where at least one cue indicated radiography.

In order to understand whether specific physician characteristics or experience influenced mean percentage agreement with the ankle rule, we conducted specific post hoc comparisons of four key variables supported by literature;[30] role in decision, last referral, employment status, and time of graduation, shown in Table 9.

Table 9. Mean agreements with the ankle rule for key univariate comparisons.

	N	Mean percentage agreement (SD)	Range	P-value
Role in decision				
Primarily on basis of rule	46	93.2 (10.0)	55.0-100.0	p=0.001*
Consider other factors	65	86.0 (11.5)	60.0-100.0	
Last referral				
Days/weeks	22	89.8 (10.1)	60.0-100.0	p=0.985†
Months	46	88.6 (12.2)	55.0-100.0	
Years	44	88.5 (11.7)	60.0-100.0	
Employment status				
Full-time	83	88.9 (11.7)	55.0-100.0	p=0.948*
Part-time (incl. residents and students)	28	88.8 (11.3)	60.0-100.0	
Time of graduation (years)				
< 10	38	87.6 (10.6)	55.0-100.0	p=0.359†
10 - 20	44	90.2 (11.2)	60.0-100.0	
20 +	28	88.9 (13.3)	60.0-100.0	

* T-test p-value comparing grouped means
† ANOVA p-value comparing grouped means

Table 9 confirms that agreement was higher in physicians who reported making ankle radiography decisions primarily on the basis of the rule as compared to those who reported considering other factors (93%, *SD* = 10.0%; 86%, *SD* = 11.5%; $t(109) = 3.40$, $p = 0.001$). Agreement did not differ depending on time since last referral to the rule for physicians reporting days/weeks, months, or years (90%, *SD* = 10.1%; 89%, *SD* = 12.2%; 89%, *SD* = 11.7%; $F(2, 109) = 0.01$, $p = 0.985$). Agreement did not differ based on full-time or part-time emergency medicine employment status (89%, *SD* = 11.7%;

89%, SD = 11.3%; $t(109) = 0.07$, $p = 0.948$). Agreement did not differ as a result of time of graduation from medical school for those who graduated <10, 10-20, or 20+ years ago (88%, $SD = 10.6\%$; 90%, $SD = 11.2\%$; 89%, $SD = 13.3\%$; $F(2, 107) = 1.03$, $p = 0.359$).

Interpretation

Overall, the findings show that the rate of agreement was quite high, but not perfect, at 89%; this indicates that physicians, on average, were not in line with the ankle rule in 11% of vignettes. In 94% of vignettes that indicated radiography, the emergency physicians would have ordered radiography; however, this means that 6% of hypothetical patients requiring radiography would not have received an x-ray, and could have potentially left the emergency department with an undiagnosed fracture. In 75% of vignettes that did not indicate radiography, the emergency physicians would not have ordered radiography; however, this means that 25% of hypothetical patients not requiring x-rays would have been exposed to unnecessary, and potentially harmful diagnostic testing.

It appears that physician radiography decisions were guided by rule-based cues, but perhaps not exactly as intended by the ankle rule. Physicians were more likely to order radiography when both rule-based cues were present, and ordered fewer radiographies when only one rule-based cue was positive in the vignettes. The ankle rule indicates radiography whether one or two of the rule-based cues are positive; this means that either cue on its own is sufficient. Based on the data, it appears that

physicians may have interpreted the presence of both cues as cumulative evidence, and as a result attributed a higher risk of fracture and ordered radiography more frequently.

Based on the post hoc analyses, imperfect agreement can be most attributed to physicians' self-reported role of the Ottawa Ankle Rules in radiography decision-making, which was the only comparison that had an associated p-value of < 0.05. The significant difference between the two self-report groups is valuable for establishing target groups for Ottawa Ankle Rules training.

Results: Research Question 2. *(A) Do cues based on the ankle rule have a greater impact on physician judgment than non-rule-based cues? (B) With regard to non-rule-based cues, do related cues have a greater impact on physician judgment than unrelated cues?*

Table 10. Mean relative weights for all cues with bootstrapped 95% confidence intervals. N=113. Mean relative weights were adjusted to add to 100.

Cue	Mean relative weights*	Bootstrapped 95% confidence intervals
Rule-based	**55.4**	**53.1 – 57.7**
Inability to bear weight	27.9	26.4 – 29.5
Bone tenderness	27.5	26.0 – 29.0
Non-rule-based	**44.6**	**42.3 – 46.9**
Related	**26.0**	**24.5 – 27.6**
Marked swelling / bruising	9.4	8.5 – 10.5
Age	8.9	7.8 – 10.0
Limited range of motion	7.7	6.8 – 8.6
Unrelated	**18.5**	**17.1 – 20.0**
Previous fracture	7.6	6.6 – 8.6
Cracking sound	5.7	5.0 – 6.5
Gender	5.2	4.6 – 5.8

Bold text indicates cumulative mean relative weights by combined cue type.
* Relative weight was calculated by $rw_{\beta i} = [|\beta_i|/(\Sigma^{k}_{i=1}|\beta_i|)]*100$.

Table 10 presents physicians' mean relative weights for all cues with bootstrapped 95% confidence intervals. Cumulative mean relative weights were calculated for each combined cue type. A visual representation of this data from Table 10 is presented in Figures 6 and 7 below.

Figure 6. Mean relative weights for all cues with bootstrapped 95% confidence intervals. N=113. Mean relative weights were adjusted to add to 100.

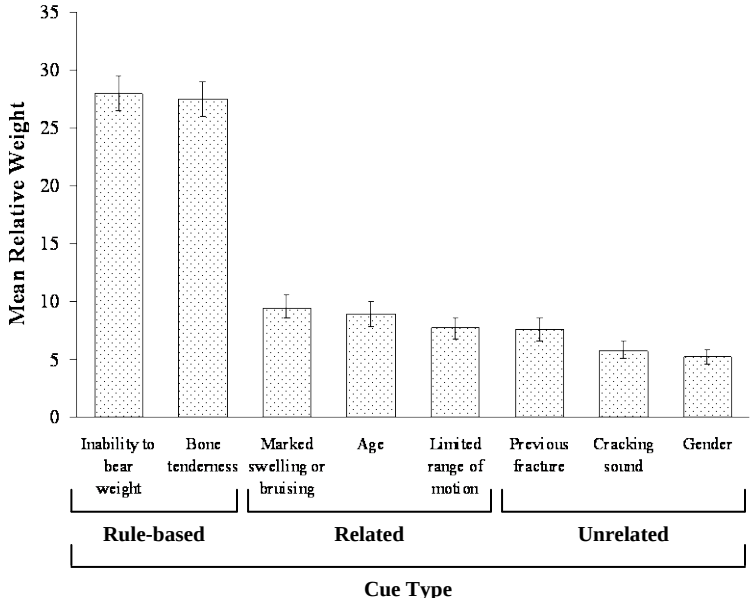


Figure 7. Cumulative relative weights for combined groups with bootstrapped 95% confidence intervals; (A) rule-based compared to non-rule-based cues, and (B) rule-based compared to related and unrelated cues. N=113. Mean relative weights were adjusted to add to 100 within each graph.

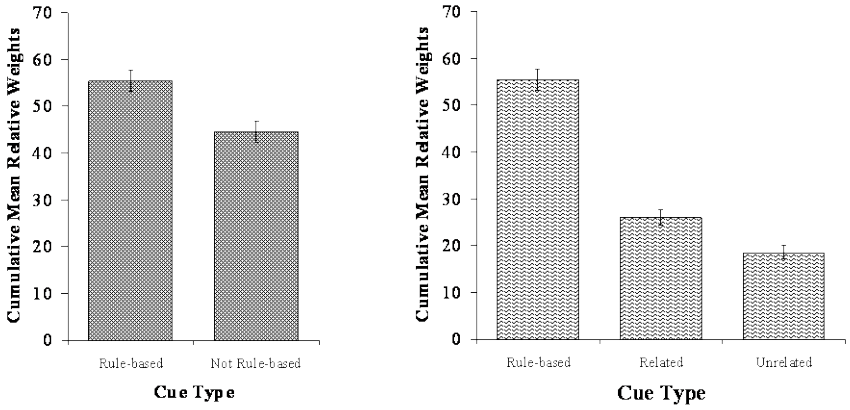


Table 10 and figures 6 and 7 show that rule-based cues are weighted more heavily than any other type of cue. Of the total predictable variance, 55.4% (*CI*=53.1-57.7) was attributable to rule-based cues. Each of the non-rule-based cues were modestly valued with mean relative weights < 10.0, and accounted for the remaining 44.6% (*CI*=42.3-46.9) of predictable variance. Predictable variance was higher for rule-based cues compared to non-rule-based cues, as determined by independent confidence intervals. Related and unrelated cues contributed 26.0% (*CI*=24.5-27.6) and 18.5% (*CI*=17.1-20.0), respectively, to the overall predictable variance. Predictable variance was higher for related cues compared to unrelated cues, as determined by independent confidence intervals.

Interpretation

Physicians placed greatest importance on rule-based cues, while still considering other cues as moderately important in decision-making; physicians placed greater value on related cues compared to unrelated cues. It appears that physicians are informing radiography decisions based on the rule, but a large proportion of the predictable variance is still being attributed to cues that are not a part of the ankle rule.

Results: Research Question 3. *Do judgment policies differ among identifiable subgroups of physicians (i.e. self-reported consistency in using the rule, and different levels of expertise)?*

Value of self-reported use of the rule in radiography decision-making

Table 11, below, presents physicians' mean relative weights for all cues with bootstrapped 95% confidence intervals based on the role of the Ottawa Ankle Rules in decision-making. A visual representation of this data is presented in Figure 8.

Table 11. Mean relative weights with bootstrapped 95% confidence intervals based on role of the Ottawa Ankle Rules in radiography decision-making. Mean relative weights were adjusted to add to 100.

Cues	Mean relative weights* with bootstrapped 95% confidence intervals	
	Primarily on basis of rule, *N*=46	**Consider other factors,** *N*=65
Inability to bear weight	30.0 (27.7 – 32.2)	26.5 (24.4 – 28.6)
Bone tenderness	30.4 (28.0 – 32.8)	25.3 (23.6 – 27.0)
Swelling / bruising	7.6 (6.4 – 9.0)	10.7 (9.4 – 12.1)
Age	7.8 (6.4 – 9.3)	9.6 (8.0 – 11.3)
Limited range of motion	7.7 (6.6 – 8.9)	7.7 (6.4 – 9.0)
Previous fracture	6.1 (5.0 – 7.2)	8.7 (7.2 – 10.2)
Cracking sound	5.4 (4.7 – 6.2)	6.1 (5.0 – 7.3)
Gender	5.0 (4.3 – 5.8)	5.5 (4.5 – 6.4)

* Relative weight was calculated by $rw_{\beta i} = [|\beta_i|/(\Sigma^{k}_{i=1}|\beta_i|)]*100$.

Figure 8. Mean relative weights for all cues with bootstrapped 95% confidence intervals based on role of the Ottawa Ankle Rules in radiography decision-making. Mean relative weights were adjusted to add to 100.

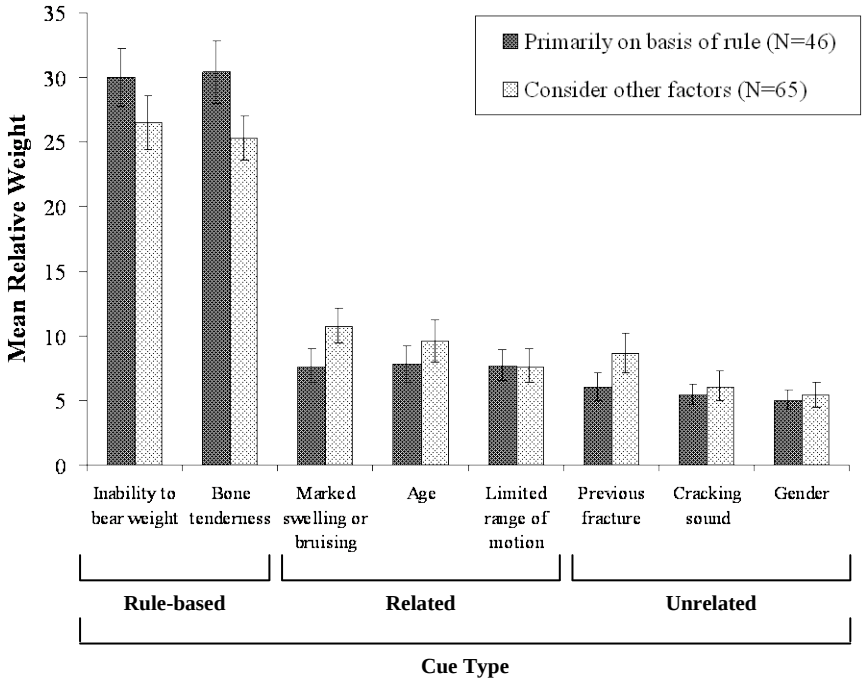


Table 12, below, and its visual representation (Figure 9) summarize the above table and figure to concisely address the research question.

Table 12. Summary of mean relative weights by cue type with bootstrapped 95% confidence intervals based on role of the Ottawa Ankle Rules in radiography decision-making. Mean relative weights were adjusted to add to 100.

Cue type	Mean relative weights* with bootstrapped 95% confidence intervals	
	Primarily on basis of rule, *N*=46	**Consider other factors,** *N*=65
Rule-based	60.3 (57.7 – 62.8)	51.8 (48.6 – 54.9)
Non-rule-based		
Related	23.1 (21.2 – 25.0)	28.0 (26.0 – 30.1)
Unrelated	16.5 (14.8 – 18.2)	20.2 (18.1 – 22.3)

* Relative weight was calculated by $rw_{\beta i} = [|\beta_i|/(\Sigma^{k}_{i=1}|\beta_i|)]*100$.

Figure 9. Summary of mean relative weights by cue type with bootstrapped 95% confidence intervals based on role of the Ottawa Ankle Rules in radiography decision-making. Mean relative weights were adjusted to add to 100.

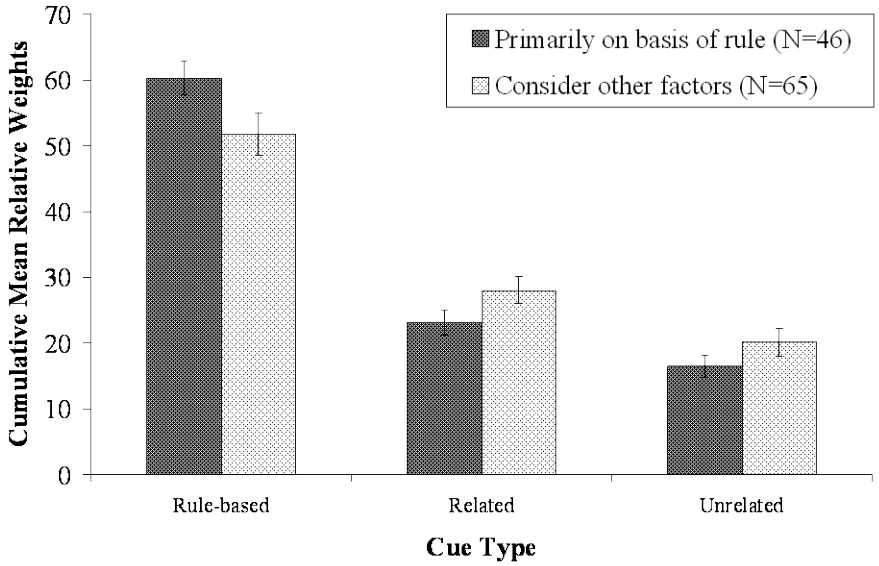


Figure 9 shows that rule-based cues were weighted more heavily by physicians who reported making decisions primarily on the basis of the Ottawa Ankle Rules compared to those who reported considering other factors (60.3, *CI*=57.7-62.8; 51.8, *CI*=48.6-54.9; determined by independent confidence intervals). Conversely, related cues were more valued by physicians who reported considering other factors compared to those who primarily based decisions on the rules (28.0, *CI*=26.0-30.1; 23.1, *CI*=21.2-25.0; determined by independent confidence intervals). There was no evidence of a significant difference between the two groups for unrelated cue use (20.2, *CI*=18.1-22.3 vs. 16.5, *CI*=14.8-18.2; determined by overlapping confidence intervals).

Interpretation

Overall, there was a clear judgment policy difference between physicians who self-reported primarily making decisions on the basis of the Ottawa Ankle Rules and those who considered other factors in the decision-making process. Physicians who self-reported primarily using the Ottawa Ankle Rules were, in fact, making better use of rule-based cues and placing less value on related cues, as compared to physicians who self-reported considering other factors. The significant difference between the two self-report groups is valuable for establishing target groups for Ottawa Ankle Rules training.

Role of physician expertise in radiography decision-making

Table 13, on the next page, presents physicians' mean relative weights for all cues with associated 95% confidence intervals and ranges based on time of graduation from medical school in years. A visual representation of this data is presented in Figure 10.

Table 13. Mean relative weights for all cues with bootstrapped 95% confidence intervals based on time of graduation from medical school in years. Mean relative weights were adjusted to add to 100.

Cues	Mean relative weights* with bootstrapped 95% confidence intervals		
	< 10 years, *N*=38	**10 – 20 years,** *N*=44	**20+ years,** *N*=28
Inability to bear weight	26.2 (23.4 – 29.1)	29.2 (27.2 – 31.3)	29.7 (26.7 – 32.5)
Bone tenderness	26.6 (23.7 – 29.6)	28.7 (26.3 – 31.1)	27.9 (25.9 – 29.9)
Swelling / bruising	8.5 (7.0 – 10.1)	9.6 (8.0 – 11.2)	9.4 (7.9 – 11.0)
Age	10.8 (9.1 – 12.5)	8.6 (6.9 – 10.4)	6.6 (4.4 – 9.1)
Limited range of motion	7.2 (5.9 – 8.7)	7.2 (5.7 – 8.7)	8.8 (7.3 – 10.5)
Previous fracture	8.9 (7.1 – 10.7)	6.9 (5.4 – 8.5)	6.2 (4.5 – 8.0)
Cracking sound	6.2 (5.1 – 7.4)	4.9 (3.8 – 6.1)	6.3 (4.9 – 8.0)
Gender	5.5 (4.6 – 6.4)	4.9 (3.8 – 6.0)	5.0 (3.8 – 6.2)

* Relative weight was calculated by $rw_{\beta i} = [|\beta_i|/(\Sigma^{k}_{i=1}|\beta_i|)]*100$.

Figure 10. Mean relative weights for all cues with bootstrapped 95% confidence intervals based on time of graduation from medical school in years. Mean relative weights were adjusted to add to 100.

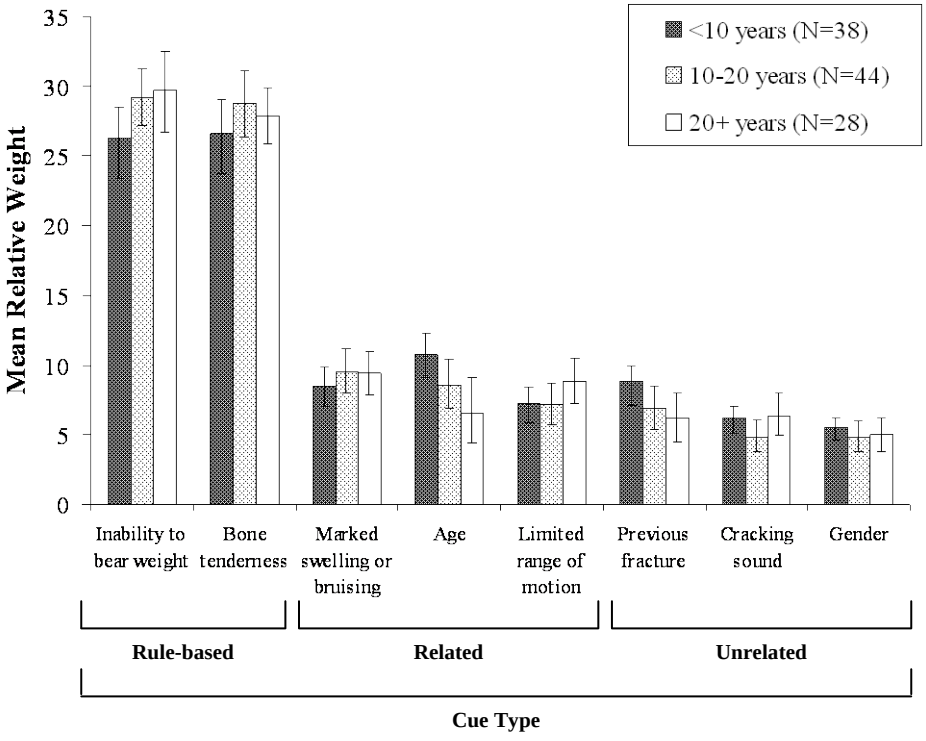


Table 14 and its visual representation (Figure 11) summarize the previous table and figure to concisely address the research question.

Table 14. Summary of mean relative weights by cue type with bootstrapped 95% confidence intervals based on time of graduation from medical school in years. Mean relative weights were adjusted to add to 100.

Cue type	Mean relative weights* with bootstrapped 95% confidence intervals		
	<10 years, *N*=38	**10 – 20 years,** *N*=44	**20+ years,** *N*=28
Rule-based	52.8 (49.3 – 56.3)	58.0 (54.4 – 61.3)	57.6 (53.3 – 61.4)
Non-rule-based			
Related	26.6 (24.3 – 28.9)	25.4 (22.9 – 28.0)	24.9 (22.3 – 27.7)
Unrelated	20.6 (18.2 – 23.1)	16.7 (14.5 – 18.9)	17.5 (15.0 – 20.1)

* Relative weight was calculated by $rw_{\beta i} = [|\beta_i|/(\Sigma^{k}_{i=1}|\beta_i|)]*100$.

Figure 11. Summary of mean relative weights by cue type with bootstrapped 95% confidence intervals based on time of graduation from medical school in years. Mean relative weights were adjusted to add to 100.

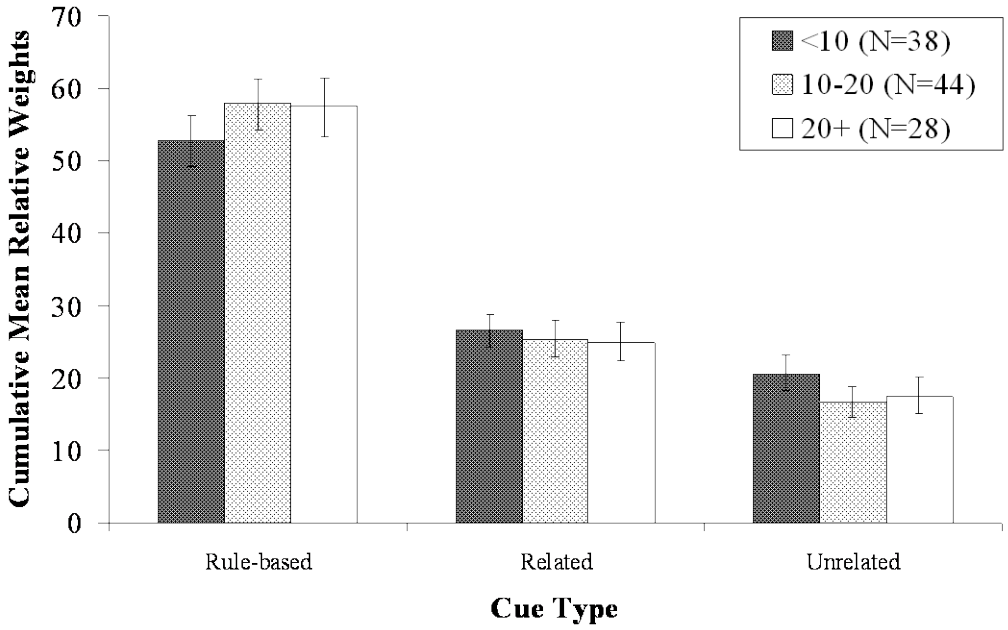


Figure 11 shows that there was no evidence of any significant differences between time of graduation groups and any of the three cue types. Rule-based cues were equally valued by physicians who graduated <10, 10-20, and 20+ years ago (58.2, *CI*=49.3-56.3; 58.0, *CI*=54.4-61.3; 57.6, *CI*=53.3-61.4; determined by overlapping confidence intervals). This was also the case for related cues based on graduation groups of <10, 10-20, and 20+ years (26.6, *CI*=24.3-28.9); 25.4, *CI*=22.9-28.0; 24.9, *CI*=22.3-27.7; determined by overlapping confidence intervals). Unrelated cues were, again, not significantly different in physicians who graduated <10, 10-20, and 20+ years ago (20.6, *CI*=18.2-23.1; 16.7, *CI*=14.5-18.9; 17.5, *CI*=15.0-20.1; determined by overlapping confidence intervals).

Interpretation

Overall, there was no indication of any significant differences in physician judgment policies based on time of graduation from medical school. All three groups appeared to equally inform decisions using rule-based, related, and unrelated cues. Our results indicate that physician time of graduation should not be used to identify target groups for Ottawa Ankle Rules training.

DISCUSSION

The global objective of this thesis was to better understand how Canadian emergency department physicians use the ankle rule to inform ankle radiography decision-making. Despite previous survey work showing that physicians report using the rule, tests of memory indicated that many physicians seem unable to recall important cues comprising the rule.[30] The Social Judgment Analysis approach allowed us to examine exactly which cues seemed to be guiding radiography decisions, both for each individual respondent, and on a group level. Before discussing the more complex Lens Model analyses, much can be learned from examining simple agreement with the rule.

Basic agreement with the ankle rule

Simple agreement with the rule allowed us to gauge health care fidelity of the ankle rule by evaluating delivery of necessary care and exclusion of unnecessary care.[19] It is critical to ensure that emergency physicians are appropriately applying the ankle rule to avoid missing potential fractures, while minimizing resources wasted on unnecessary radiographies. Consequences may arise in cases where the rule is not applied as intended for various reasons, not limited to misremembering, misinterpreting, or unreliably applying the rule.[30] Large quantities of relatively inexpensive, but unnecessary radiographies can add up to countless wasted healthcare dollars.[28] On the other hand, missed fractures may cause decreased patient satisfaction, increased patient risk or discomfort due to potential medical complications, and as a result, rises in

medical treatment and medico-legal costs.[45] The ankle rule only maintains almost perfect sensitivity when applied as intended by its developers.

Given that agreement in cases not requiring radiography was 75%, an additional 25% of hypothetical patients not requiring radiography would have received radiography, and been exposed to unnecessary and potentially harmful diagnostic testing. By ordering unnecessary radiographies, these physicians are undermining the key goals of the ankle rule implementation. The rule was created and implemented to reduce the number of unnecessary radiographies, while limiting associated medical costs, without sacrificing patient safety or satisfaction.[29] Limiting resources wasted on unnecessary radiographies has great implications for long-term sustainability of the healthcare system and ordering unnecessary radiographies results in lost opportunity costs that would have been better spent on beneficial diagnostic testing and/or medical treatments.

Despite an overall tendency to order too many radiographies, there were still cases where physicians may have missed important fractures by not ordering radiographies when indicated by the ankle rules. Given that agreement in cases where radiography was necessary was 94%, 6% of hypothetical patients requiring radiography would not have received it, and potentially left the emergency department with an undiagnosed fracture.

Literature has shown that approximately 11.5-14.5% of patient cases have clinically significant fractures,[44] and if the ankle rule is applied appropriately, then approximately 40% of blunt ankle trauma patients should be sent for a radiographic

series.[29] These numbers indicate that physicians in this study could have missed 0.3% of significant fractures [40%*0.06*0.13] by not ordering radiographies when indicated; in more relatable terms, 3 out of 1000 patients entering the emergency department with blunt ankle trauma could have left the emergency department with an undiagnosed fracture. Missed opportunities such as this undermine the value of the ankle rule and highlight the risks of implementing clinical decision rules.

The physicians' overall rate of agreement with the ankle rule was quite high, but not perfect. Although achieving perfect agreement with the ankle rule is not a feasible goal,[19] it appears that there is ample opportunity to improve physician adherence to the rule. The overall agreement was 89% (*SD*=11.5%), which indicates that physicians did not agree with the rule in 11% of cases. Agreement was significantly higher when the ankle rule indicated radiography at 94%, as compared to cases where the rule did not indicate radiography at 75%, which can be attributed to a physician general tendency to over-order radiographies. Literature suggests that not only is physician over-ordering a persistent problem, but it is also increasing over time. A study conducted by Dowdall et al (2011) found that physicians' radiography rates have been increasing by approximately 3% per year from 2001 to 2007 (after adjustment for total proportion of significant fractures). [44]

Summary

Simple agreement can be used as a yard stick to measure health care fidelity of the ankle rule and can highlight situations where physicians order unnecessary radiographies, or do not order radiographies when they are indicated by the ankle rule.

Simple agreement, however, cannot explain the reasons for agreement or disagreement with the rule underlying radiography decisions.

Fit of the Lens Model

Social Judgment Analysis was chosen because it provided a way to deconstruct physician decisions into component parts, or cues. This provided a better understanding of how physicians made decisions, as opposed to how they reported making decisions, and described how the ankle rule fits into individual decision-making processes. Social Judgment Analysis is a novel way of addressing fidelity issues in health care, by evaluating use of individual cues (i.e. rule-based and non-rule-based) in the decision-making process.

The fit of the Lens Model was assessed to determine the value of using Social Judgment Analysis for this thesis. The overall consistency (R_s) of the model was high, accounting for 73% of the total variance of the model. In other words, 73% of the variance was attributable to the eight cues chosen for the judgment task. Despite limited numbers and types of cues, the close fit of the Lens Model confirmed that the appropriate cues were chosen for inclusion in the vignettes, and that the resulting Lens Model can support robust analyses for this thesis.

Social Judgment Analysis

Social Judgment Analysis required the transformation of each crude cue weight to produce a new set of relative weights that partitioned 100% of the predictable

variation, where each weight became a proportion of this total.[60] It is evident that rule-based cues were weighted far more heavily than any non-rule-based cues.

Physicians placed greatest importance on the two rule-based cues (with a mean relative weights of around 28 for both bone tenderness and inability to bear weight), which accounted for approximately 55% of predictable variance. More specifically, eighty-eight physician judgment policies (78%; Figure 5, page 48) valued the two rule-based cues as most important in decision-making. Each of the six non-rule-based cues were modestly valued with mean relative weights < 10.0, and accounted for the remaining 45% of predictable variance. Overall, physicians were informing radiography decisions based on the rule, but a large proportion of the predictable variation could still be attributed to cues that were not a part of the ankle rule. Specifically, twenty-five physician judgment policies (22%; 19+6 of 113 in Figure 5, pages 49-50) valued at least one non-rule-based cue as equally or more important in decision-making than one of the rule-based cues. Our finding were consistent with Brehaut et al (2005), which found that non-rule-based cues were considered by physicians when making radiography decisions.[30]

Despite placing considerable value on non-rule-based cues, it is important that physicians were more likely to guide radiography decision-making based on related cues (with a mean relative weight of 26.0), as compared to unrelated cues (with a mean relative weight of 18.5). If the Ottawa Ankle Rules was applied as intended in this vignette exercise then both related and unrelated cues would not contribute to predictable variation based on the study design.

However in real-world practice, related cues are correlated with the rule-based cues, as both types of cues are associated with the risk of fracture.[29] As a result, it is possible that physicians' policies reflect the fact that they pay attention to other related cues because they are correlated with the presence of fracture outside of our vignettes. In this way, physicians can have high agreement and arrive at the same radiography decision using different cues. In Social Judgment Analysis literature, this phenomenon is known as vicarious functioning, which is the redundant characteristic of the environment. Each cue has a certain correlation to the environment, which contributes to the environmental predictability. The environmental predictability is not calculated simply as a sum of the individual correlations of all cues; in reality, overlaps occur between individual cues, which are providing the same information.

Relying on related cues may be a valid and useful way to supplement assessments of blunt ankle trauma in cases where assessment of rule-based cues is inconclusive; given that bone tenderness and inability to bear weight can be somewhat subjective measurements, it may be appropriate to consider related cues to inform radiography decision-making in special cases. However, when appropriate, the rule should be applied as intended, to minimize wasted resources while maintaining almost perfect sensitivity for identifying ankle fractures.

Physicians' misconceptions about unrelated cues guided radiography decision-making. Our results showed that unrelated cues accounted for 18.5% of predictable variance. If the Ottawa Ankle Rules was applied as intended, then unrelated cues would not contribute to predictable variance. Unrelated cues are neither correlated with rule-

based cues nor risk of fracture.[29] It can be dangerous for physicians to guide radiography decision-making based on unrelated cues, whilst overlooking rule-based cues.

Despite the fact that over the whole sample rule-based cues appeared to drive decision-making, there was a substantial minority for whom decisions appeared to be guided by non-rule-based factors (22%; 19+6 of 113 in Figure 5, pages 49-50). For example, one responder did not value rule-based cues, which only accounted for 18% of their predictable variance, but highly valued non-rule-based cues, with related cues contributing 46% and unrelated cues contributing 36% of the predictable variance. As a result, the responder missed five opportunities to provide hypothetical patients with radiography when the ankle rule indicated doing so, and the hypothetical patients may have left the emergency department with an undiagnosed fracture. It is critical for physicians to be aware of which cues are, in fact, associated with the risk of fracture; this is why the ankle rule was created to inform ankle radiography decision-making. It is important to ensure that emergency physicians are appropriately using the ankle rule to avoid missing fractures.

Factors influencing physician agreement

The ankle rule indicates whether or not to order ankle radiography based on two rule-based cues; a patient should be sent for an ankle radiographic series if there is any bone tenderness, and/or inability to bear weight. The ankle rule indicates radiography whether one or two of the rule-based cues are positive; in effect, either cue on its own is sufficient to suspect a fracture. If the rule is applied as intended by the developers,

radiography rates should not be dependent on whether one or two rule-based cues are positive.

However, physician agreement was, in fact, influenced by the number of positive rule-based cues presented in the vignettes; agreement was higher in vignettes where both of the rule-based cues were positive at 98%, as compared to when only one of the rule-based cues was positive (90% for inability to bear weight, and 92% for bone tenderness). Based on the differences in agreement, it appears that physicians may have interpreted the presence of both cues as cumulative evidence, attributed a higher risk of fracture, and as a result ordered radiography more frequently. This notion of cumulative evidence may be consistent with an implicit rule that more positive cues indicates a greater need for radiography and may extend to non-rule-based cues, which would explain the general tendency to over-order radiographies.

Value of self-reported use of the rule in radiography decision-making

Of four univariate comparisons, only one physician practice characteristic was found to influence agreement; agreements were higher in physicians who reported that the Ottawa Ankle Rules had a more central role in decision-making (93%), as compared to physicians who considered other factors in their decision-making process (86%).

Physician judgment policies also differed based on whether physicians self-reported making decisions primarily on the basis of the rule or considering other factors. Physicians who reported that the Ottawa Ankle Rules had a more central role in their decision-making were, in fact, more likely to use rule-based cues and place less value

on non-rule-based cues, as compared to those who considered other factors in decision-making.

Physicians who self-reported primarily basing decisions on the rule still considered non-rule-based cues as moderately important in decision-making; for this sub-set of physicians, each rule-based cue only contributed a mean relative weight of 30. Physician self-reports appeared to over-emphasize use of the Ottawa Ankle Rules; mean relative weights of 30 (or 60 total) may be considered consistent with primarily applying the rule-based cues, but not necessarily with primarily applying the rule, as these weights do not demonstrate appropriate use of the rule as intended, since much weight is still attributable to non-rule-based cues. These findings are consistent with past studies, which presented a disconnect between the behaviors physicians self-reported, and what actually occurred in clinical practice.[61] Such discrepancies are generally anticipated based on social desirability effects (i.e. providing responses that will be viewed favorably) and/or errors in recall (e.g. forgetting an event, or misremembering it as occurring more recently or more frequently than it actually did).[61]

Brehaut et al (2005) found that only 31% of emergency department physicians were able to remember all components of the Ottawa Ankle Rules.[30] Given that our sample is from the same Canadian Association of Emergency Physicians population, and the survey question asked was the same, it is likely that the same proportion of physicians in the current sample would be able to remember all components of the rule. This suggests that not even all responders in our study who reported a central role of the Ottawa Ankle Rules in decision-making would be able to accurately describe the ankle

rule. This lack of knowledge may explain the disconnect between physician self-reported and actual behaviors. Although physician self-reports should not be used to gauge true adherence to the rule, it appears that self-reports can be useful in gauging relative adherence between physicians. It appears that when physicians self-report using the rule, they may actually be reporting use or value of rule-based cues in decision-making.

Role of physician expertise in radiography decision-making

Physician judgment policies did not differ based on when they attended and graduated from medical school. We hypothesized that physicians with more expertise (acquired over time through clinical practice) may have increased confidence in personal decision-making, and as result focus less on strictly following clinical decision rules. There was no indication of any significant differences in cue use. Our findings did not support literature that showed that older, more experienced physicians are less likely to uptake guidelines, such as clinical decision rules.[62] Successful implementation of the ankle rule through various strategies may explain why this study did not find any differences. The rule is straightforward and easy to use, and it was developed and validated using strict methodological standards. Such factors may be responsible for the high uptake of the rule, and can be used to inform future interventions.

Generalizability of research findings

The Dillman Tailored Design Method was employed for mail-outs of the postal surveys[55] in an effort to increase standard response rates and subsequently reduce the

impact of potential non-responder bias. Non-responder bias occurs when the responders are inherently different from non-responders based on one or more variables (such as gender or socioeconomic status), which may influence the way in which they answer survey questions. Our survey standard response rate was 46%, which fell short of the Dillman projected response rate of 80% or greater,[55] and possibly introduced non-responder bias into the data.

Our findings were consistent with literature, which found no significant differences with regard to demographic variables between first round responders and late responders in physician populations.[56] Research has shown that non-responder bias may not be as important of a factor with physician surveys, as physicians are a very small, unique subset of the general population, who have similar knowledge, training, attitudes, beliefs, and as a result, similar behaviors.[56] Though variations are present, these differences do not impact survey response rates or non-responder biases to the same degree as seen with the general population. Effectively, interpretation of physician surveys with low response rates may be more generalizable compared to the general population,[56] which is positive, considering that physician survey response rates (mean 54%) tend to be significantly lower than general public survey response rates (mean 68%).[56]

To extrapolate these findings, it is plausible that non-response bias would be even smaller amongst our sample in the current study, as all physicians were trained in emergency medicine. Emergency medicine is a further subset of the medical profession, and thus these individuals would have more in common with their emergency medicine

colleagues. To test this, we compared physician demographic, professional, and Ottawa Ankle Rules practice information from our study to a previous study conducted by Brehaut et al (2005), which sampled from the same population of members of the Canadian Association of Emergency Physicians.[30] Both surveys used independent samples, as the Canadian Association of Emergency Physicians limited re-sampling of the physicians contacted through the first mail-out survey. There was no evidence of any significant differences between the two survey populations based on demographic, professional, or practice characteristics. Taking this information into consideration, our survey standard response rate of 46%, which accounts for approximately 8% of overall Canadian Association of Emergency Physicians membership at the time of administration, may be generalizable to all members.

In the event that our survey sample was not representative of the Canadian Association of Emergency Physicians members, then we would be more likely to miss physicians who are not interested in the Ottawa Ankle Rules, or those who actively disagree with the rule. If this were the case, then our mean percentage agreement results may have been inflated and our cue weights may have been skewed in favor of rule-based cues.

Limitations

The interpretation of results is dependent on the extent to which the most relevant variables to the decision were presented in the vignettes. This is true of all studies, but particularly important in Lens Model studies, given the relative weight approach to analyzing the data. Social Judgment Analysis limits judgment policies to

include only a particular set of cues, and research has suggested a maximum burden of eight variables within each vignette.[52] If not all appropriate cues are presented, then the analyses will generate judgment cue weights that are not accurate compared to real-life practice. All cues included in this study were chosen based on clear empirical evidence from the Ottawa Ankle Rule derivation study that such clinical cues have or are perceived to have diagnostic value by emergency department physicians.[29;30] It appears that the cues were chosen appropriately, as the non-rule-based cues explained 45% of the predictable variance, which reinforced that the vignettes were capturing and evaluating use of relevant non-rule-based cues. In addition, pilot testing supported that the cues were clinically relevant, and responders rated the survey task as moderately representative of real-world clinical scenarios with an average score of 6.1 (*SD* = 2.14) on a scale of 1 to 10. Although responders suggested the inclusion of many external factors (such as patient distress, medico-legal considerations, Workplace Safety and Insurance Board claims, and degree of pain), the physicians did not suggest inclusion of any additional clinical or patient history cues.

A number of limitations of this work related to the implementation of a fractional-factorial survey design warrant consideration. The fractional-factorial design is not consistent with the principle of representativeness. The proportion of vignettes requiring radiography by Ottawa Ankle Rules standards in our survey was not representative of real-world practice, and as a result overall agreement is likely an overestimation of real-world agreement. Research has shown that if the Ottawa Ankle Rules is applied appropriately, then approximately 40% of blunt ankle trauma patients should be sent for a radiographic series.[29] However, in our Social Judgment Analysis

survey, 75% of vignettes required radiography according to Ottawa Ankle Rules standards. Adjusting for the difference in proportions, a crude estimate of the real-world agreement would be 83% ([94%*0.4]+[75%*0.6]). This adjustment for proportions assumes that the paper cases were highly representative of real-world scenarios, and can be used as markers of real-world practice. The use of written clinical vignettes, similar to the ones employed in this study, has been validated through the work of Peabody et al (2000).[51] Clinical vignettes have been shown to be effective measures of physician competence and quality of administered care.

This study aimed to create vignettes that were as representative as possible, but they are still simplifications of real-world decisions. Clinical practice is full of complicating factors, each one of which might increase physician uncertainty enough to prompt ordering radiography; the fact that physicians did not have perfect agreement in these simplified cases means that the problem may be much greater in the real-world practice.

This is not a limitation of Social Judgment Analysis itself, but of the fractional-factorial design. Social Judgment Analysis can rely on more representative real-world case mixes in vignettes; however, there are trade-offs to such an approach. For example, such a design would have required more vignettes for each physician to complete, resulting in a greater time commitment and potential decrease in both types of response rates. In addition, real-world case mixes would make it difficult, if not impossible, to measure variability of clinical cues that present rarely.[56]

The fractional-factorial design also lacked representativeness in that it did not allow for all possible combinations of cues to be presented in the survey. A complete factorial design of manipulated cues was not feasible due to exponential increases in the number of vignettes required, resulting in a higher time commitment and potential decrease in both types of response rates from physicians.[56] Also, in such a design, particular combinations of cues would not realistically occur in practice and inclusion of such vignettes would undermine the representativeness of the survey task. Another implication of our study design was that interactions between cues could not be measured. Cues that are intercorrelated in the real world were not correlated in this study, which undermined the representativeness of the survey judgment task. Cue intercorrelations were omitted to allow for straightforward statistical analyses, where all cues provided virtually independent contributions. For the purposes of the hypotheses tested here, we were more interested in the internal validity of our results than external validity, thus we implemented the fractional-factorial approach. Future work can examine whether these findings generalize to more real-world case mixes.

Social Judgment Analysis is limited because this Lens Modeling technique relies on multiple linear regression and assumes linearity, despite the possibility that judgment policies may incorporate non-linear relationships.[63] For example, research has shown that physicians have a threshold, where low and medium levels of cues did not influence decision-making, but high levels had an impact on decision-making.[64] Our study accommodated for the threshold effect by using standard decision-making cutoffs to set dichotomous values for each variable, ensuring that one value was below and one was above each threshold.

Given that our study employed the maximum suggested burden of twenty vignettes per physician survey,[52] we were unable to assess the clinical decision of "would you order an ankle x-ray series for this patient?" using Social Judgment Analysis methodology. Although this clinical decision is most relevant to real-world practice, the dichotomous nature of the question did not provide sufficient power for analyses.

Our study applied simple summary measures, rather than more comprehensive clustering methodologies, to account for correlation among repeated responses to the twenty vignettes from each physician. Given the small number of missing values (0.8% of data entries), it is unlikely that applying cluster analyses would have influenced the results in an important way.

Significance and future directions

Our results have shown that physician adherence to the ankle rule, even in relatively simple vignettes, is not perfect and can be improved. Knowledge translation interventions, informed by Graham's Knowledge-to-Action Framework,[4] can increase emergency physician agreement with the ankle rule and use of rule-based cues.

Our study identified one practice characteristic that can be used to identify target populations for ankle rule training. It would be most valuable to identify and target physicians who consider external non-rule-based cues, especially unrelated cues, in cases where direct application of the ankle rule is appropriate. No special instruments

are necessary to identify this subgroup; a simple self-report question can be used to detect who would benefit most from further training.

Our study identified a variety of physician performance characteristics that can be used to identify target populations at greater need of ankle rule training. These target groups can be identified through formal testing using a vignette task, such as the one employed in this study.

Physicians who demonstrate low agreement with the ankle rule, especially those who demonstrate low agreement in cases where the rule indicates radiography, are likely misremembering the rule. In such cases, targeting knowledge issues is valuable to ensure that the physicians are able to identify (and subsequently use) rule-based cues as primary information to guide decision-making. On the other hand, physicians who demonstrate low agreement with the rule when radiography is not indicated may have learned the rule, but oppose its application. For example, some physicians may believe that radiography should always be used to rule out fracture, and may not understand or fully appreciate the negative aspects of ordering unnecessary radiographies. Interventions should target such uninformed beliefs.

Physicians who show higher agreement when both rule-based cues are present, as compared to only one rule-based cue would benefit from additional training through a simple refresher of how the rule should be applied. The intervention should discourage the use of both cues as cumulative evidence, and emphasize that one positive rule-based cue is sufficient to warrant radiography in blunt ankle trauma cases.

Interventions that target physicians who attribute a high percentage of predictable variation (i.e. place significant weight) on cues that are not a part of the ankle rule should focus on knowledge issues. This group should be educated about the redundancy of relying on related cues and the lack of utility of using unrelated cues to guide radiography decision-making.

In addition, further development of the Lens Modeling technique could lend itself to a cognitive behavioral intervention. Physicians could complete a series of clinical vignettes, similar to the ones employed in this study, and receive feedback about what factors are driving their decisions after the completion of each vignette. The feedback would present a graphical display of personal cue weights compared to optimal cue weights, so that physicians could learn to adjust behaviors accordingly. Such efforts have been successful in the past.[65-67] Research has shown that cognitive feedback is more effective at influencing physician behavior than outcome (i.e. agreement) feedback.[50]

A study conducted by Poses et al (1992) assessed the value of a computerized cognitive feedback intervention to improve adherence to a clinical decision rule that predicts the probability of streptococcal pharyngitis.[66] The cognitive feedback part of the study employed a vignette fractional-factorial design similar to this thesis; however, after each set of twelve cases the physicians received feedback in the form of a bar graph comparing personal cue weights with optimal cue weights, so that they could modifying their decision-making process to more closely match the optimal cue weights.[65] The intervention was successful at improving physician judgments and the

improvement was maintained for at least one year post-intervention.[66] Given the similar outcomes (teaching a clinical decision rule), populations (physicians) and methods (fractional-factorial vignettes with 7 or 8 cues, each with two levels), suggests that this type of cognitive feedback intervention might be effective for improving physician adherence to the Ottawa Ankle Rules. However, the Poses (1992) study[66] did not target or evaluate behavior change, and as shown in the Knowledge-to-Action framework,[4] increased knowledge and changing judgments may be only one part of the puzzle in changing actual clinical behavior.

Clinical decision rules are meant to inform clinical decisions, and not to act as hard-and-fast rules. Knowledge translation interventions aimed to decrease the number of radiographies in cases where the rule does not indicate it should be approached with care. The interventions should serve to educate and inform physicians about the ankle rule, but also emphasize the role of clinical expertise in the decision-making process.

Clinical expertise is an integral part of evidence-based medicine,[1] and necessary for physicians to evaluate whether or not the Ottawa Ankle Rules can be applied in a given case. Clinical expertise is invaluable in assessing blunt ankle injuries in cases where exclusion criteria apply. Real-world cases are more complex than the vignettes presented in our study, and there are likely various situations where it is appropriate to order radiographies when the ankle rule does not indicate it. Further work, perhaps based on real-world chart reviews, could examine when over-ordering as compared to ankle rule standards is advisable. However, when appropriate, the rule should be

applied as intended, in an effort to minimize wasted resources while maintaining almost perfect sensitivity for identifying ankle fractures.

Our findings can be expanded to the future design and assessment of clinical decision rules in general. Our study supported literature[30] that although physicians self-report using a clinical decision rule, there is variability in what 'using' a rule really means. Misuse of a clinical decision rule undermines its value and missed diagnoses (or treatments) highlight the risks associated with implementing such rules. Future designs of clinical decision rules should strongly consider potential misuse and consequences, and how to effectively create and implement rules to ensure appropriate use. This thesis has shown that Social Judgment Analysis is a viable method to evaluate cues influencing physician decision-making. This methodology can be applied in the future to assess physicians' current use of other clinical decision rules, or to assess implementation of new rules.

Conclusion

Physicians' overall agreement with the ankle rule was high, but not perfect. Physicians placed greatest importance on rule-based cues, while considering non-rule-based cues as moderately important. It appears that physician radiography decisions were guided by rule-based cues, but perhaps not exactly as intended by the ankle rule. There is room to improve emergency physician agreement with the ankle rule and use of rule-based cues through knowledge translation interventions aimed to increase adherence to the rule. Given that real-world cases can be complex, interventions must emphasize the role of expertise in decision-making.

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APPENDIX A

OTTAWA HEALTH RESEARCH INSTITUTE
INSTITUT DE RECHERCHE EN SANTÉ D'OTTAWA

Following this page are 20 short vignettes, each describing a hypothetical patient presenting to your emergency department with ankle pain. Following each vignette are three questions pertaining to the decision about whether or not to order radiography for this patient.

Note that the **cues in bolded type** vary systematically across the 20 vignettes. By asking you about your decision to x-ray for each of the 20 vignettes, we will be able to determine which cues are most important in determining your decision; however, this will only be possible if you complete all 20 vignettes.

For each vignette, please determine whether to order radiography as you would in normal practice

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For all 20 vignettes, assume that the patient presents to the emergency department with ankle pain after falling five feet off a step ladder. Examination shows no midfoot pain or tenderness, and there are no other injuries.

Case #1: The patient is a **65-year-old man**. He heard **a cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation** in range of motion of the ankle.

Would you order an ankle x-ray series for this patient?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #2: The patient is a **65-year-old woman**. She heard **no cracking sound** at the time of the incident. She reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. She was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #3: This patient is a **45-year-old woman**. She heard **a cracking sound** at the time of the incident. She reports **no previous fractures**, and reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. She was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #4: This patient is a **45-year-old man**. He heard **a cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. He was **unable to bear weight** on the foot in the emergency department or at the time of the incident, but shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #5: The patient is a **65-year-old man**. He heard **no cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. He was **unable to bear weight** on the foot in the emergency department or at the time of the incident, and shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #6: The patient is a **65-year-old woman**. She heard **no cracking sound** at the time of the incident. She reports **no previous fractures**, and reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. She was **able to bear weight** on the foot in the emergency department and at the time of the incident, but shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #7: The patient is a **65-year-old woman**. She heard **a cracking sound** at the time of the incident. She reports **no previous fractures**, and reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. She was **unable to bear weight** on the foot in the emergency department or at the time of the incident, but shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #8: The patient is a **65-year-old woman**. She heard **a cracking sound** at the time of the incident. She reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. She was **unable to bear weight** on the foot in the emergency department or at the time of the incident, and shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #9: This patient is a **45-year-old woman**. She heard **a cracking sound** at the time of the incident. She reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. She was **able to bear weight** on the foot in the emergency department and at the time of the incident, but shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #10: The patient is a **65-year-old man**. He heard **a cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #11: This patient is a **45-year-old woman**. She heard **no cracking sound** at the time of the incident. She reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. She was **unable to bear weight** on the foot in the emergency department or at the time of the incident, but shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #12: The patient is a **65-year-old man**. He heard **a cracking sound** at the time of the incident. He reports **no previous fractures**, and reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. He was **unable to bear weight** on the foot in the emergency department or at the time of the incident, and shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #13: This patient is a **45-year-old woman**. She heard **no cracking sound** at the time of the incident. She reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. She was **unable to bear weight** on the foot in the emergency department or at the time of the incident, and shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #14: This patient is a **45-year-old man**. He heard **a cracking sound** at the time of the incident. He reports **no previous fractures**, and reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. He was **unable to bear weight** on the foot in the emergency department or at the time of the incident, and shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #15: This patient is a **45-year-old man**. He heard **no cracking sound** at the time of the incident. He reports a **previous fracture** in the same ankle about 12 months ago, but reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, but shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #16: This patient is a **45-year-old man**. He heard **no cracking sound** at the time of the incident. He reports **no previous fractures**, and reports no other fracture risk. Examination shows **marked swelling and bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. He was **unable to bear weight** on the foot in the emergency department or at the time of the incident, but shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #17: The patient is a **65-year-old man**. He heard **no cracking sound** at the time of the incident. He reports **no previous fractures**, and reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, but **some bone tenderness** on the posterior edge of the lateral malleolus. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, but shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #18: The patient is a **65-year-old woman**. She heard **no cracking sound** at the time of the incident. She reports **no previous fractures**, and reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. She was **unable to bear weight** on the foot in the emergency department or at the time of the incident, but shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #19: This patient is a **45-year-old woman**. She heard **a cracking sound** at the time of the incident. She reports **no previous fractures**, and reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. She was **able to bear weight** on the foot in the emergency department and at the time of the incident, but shows **moderate limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Case #20: This patient is a **45-year-old man**. He heard **no cracking sound** at the time of the incident. He reports **no previous fractures**, and reports no other fracture risk. Examination shows **little swelling or bruising laterally**, no bone tenderness anywhere on the medial malleolus, and **no bone tenderness** anywhere on the lateral malleolus. He was **able to bear weight** on the foot in the emergency department and at the time of the incident, and shows **no limitation** in range of motion of the ankle.

Order ankle x-ray?	❑ No ❑ Yes
What is the likelihood that you would order an ankle x-ray in this case?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|
What is the likelihood this patient would have a fracture?	0% 20 40 60 80 100% |------|------|------|------|------|------|------|------|------|------|

Please rate how well you feel these vignettes model the real-world clinical decision of whether to order radiography.

Completely irrelevant to the clinical decision 0 1 2 3 4 5 6 7 8 9 10 A perfect model of the clinical decision
|---|---|---|---|---|---|---|---|---|---|---|
Reasonably relevant

Please explain your rating.

How did you first become aware of the Ottawa Ankle Rules?

- ❑ Medical school
- ❑ Continuing Medical Education
- ❑ Participating in a research study
- ❑ Colleague recommendation
- ❑ Journal Articles
- ❑ Other _____
- ❑ I'm not familiar with the Ottawa Ankle Rules (Please proceed to final section)

How often do you apply the Ottawa Ankle Rules to patients who present with isolated ankle injuries?

❑ Always ❑ Most of the time ❑ Sometimes ❑ Never

Approximately how long have you used the Ottawa Ankle Rules in your practice? _____ years

How would you describe the role of the Ottawa Ankle Rules in your decision about whether to order an x-ray?

- ❑ When appropriate, I generally make my decision primarily on the basis of the rule
- ❑ I generally make my decision on the basis of the rule plus a small number of other key factors
- ❑ The rule is one of many factors I consider
- ❑ I generally do not consider the rule when I make my decision
- ❑ Other _____

If you governed your decision to x-ray SOLELY on the basis of the Ottawa Ankle Rules in cases of isolated ankle injury, would you be more likely to miss an important fracture than you are now?

❑ Yes *Why?*
❑ No *Why?*

How long has it been since you referred to a printed version of the Ottawa Ankle Rules?
#_____ *(circle)* Years / Months / Weeks / Days

Is there an Ottawa Ankle Rules poster in your Emergency Department? ❑ Yes ❑ No

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Are you: ❑ Male ❑ Female *Year of birth:* 19____

Year of graduation from medical school: 19_____

Emergency Medicine Employment Status: ❑ Full-time ❑ Part-Time ❑ Resident

How many years have you been practicing Emergency Medicine? _____

Emergency Medicine Credentials:

- ❑ CCFP (EM)
- ❑ CCFP
- ❑ FRCPC
- ❑ Dip ABEM
- ❑ Other, please specify _____

On average, how many hours per week do you devote to direct patient care in emergency medicine? ____