Examining determinants of health numeracy and processing of numeric health information by English-as-a-second language immigrants to Canada

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Introduction: Health numeracy is a necessary skill for accessing health services. Immigrants have lower levels of health numeracy compared to host populations which constrains their access to health information necessary to make quality health decisions. Factors contributing to immigrants' low health numeracy skills include language and mathematics self-efficacy. Language is associated with how people acquire and process numeric information. Some languages have more numeric concepts than others. Speakers of languages that lack one or more numeric concepts may be constrained in the comprehension of health information that contains such concepts. Moreover, they may lack the self-efficacy to engage in numeric tasks containing such concepts. Therefore, the overall objectives of this study were: 1) to investigate the effect of primary language and 2) mathematics self-efficacy on its speakers' comprehension of numeric health information presented in a different language; and also 3) to investigate how speakers of low and high numeric concept languages process numeric health information when the information is presented in a language which is not their primary or first language.

Method: The study involved sixty Kikuyu (a low numeric concept language) and sixty Mandarin (a high numeric concept language) speaking immigrants to

Canada. Demographic data was collected from the 120 participants using a general information questionnaire. Numeracy was assessed using a context-free numeracy tool (French Kit). Short test of functional literacy in adults (S-TOFHLA) and the newest vital signs (NVS) were used to assess health numeracy and literacy, and self-efficacy was measured with the Mathematics Self-Efficacy Scale (MSES) and the Subjective Numeracy Scale (SNS). Processing of numeric health information was assessed qualitatively using the think-aloud method. Descriptive statistics were generated for performance in numeracy, health numeracy and literacy, and in mathematics self-efficacy. Multiple regression analysis was conducted to determine the predictors of numeracy and health numeracy. Protocol analysis was conducted for the verbal information obtained from the think-aloud process.

Results: Mandarin-speakers had better scores in numeracy, health numeracy, and in mathematics self-efficacy while Kikuyu-speakers had better scores in health literacy. Regression models for numeracy and health literacy highlighted the importance of language, mathematics self-efficacy, education, age, gender, and duration of residency in Canada, and format of numeric health information. In processing numeric health information, Mandarin-speakers were mostly intuitive while Kikuyu-speakers were mostly analytical.

Conclusion: Primary language contributes to some of the differences in numeracy and health numeracy skill of immigrant speakers of English-as-a-second language. Mathematics self-efficacy may be an important factor in numeracy, and health numeracy for Kikuyu and Mandarin speaking immigrants for whom English is a second language. Speakers of a language with high numeric concepts may have more skills with numbers and consequently be able to process numeric health information intuitively compared to speakers of a language with low numeric concepts. These findings imply that factors that explain low numeracy may differ from those that explain low health numeracy in ESL immigrants. They also highlight the need for more research on the effect of primary language on immigrant's comprehension of numeric health information.

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"No one who achieves success does so without the help of others…"

(*Alfred North Whitehead*)

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Dedication

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Chapter 1 Introduction

Numeracy and health numeracy are necessary skills in navigating the health care environment. Numeracy is defined as the ability of an individual to understand and use mathematical information for everyday function in the workplace, at school, and in social contexts (Statistics Canada, 2005). According to the Skills for Life Survey 2011 (a survey on literacy numeracy and information and communication technology skills in England), individuals with poor numeracy (level 1) earn an average of 26% more than those with a level lower than 1 numeracy skills. They are also twice as likely to be unemployed and they are 2.5 times more likely to report having chronic illnesses or disabilities than individuals with higher numeracy level (above level 1). Numeracy skills appear to have a greater effect on individuals' labour market status than do literacy skills (Green & Riddell, 2002). Although numeracy is an important component of everyday life, even people with high numeracy skills may fail to apply or effectively transfer those skills to other contexts, such as a health context; this skill set is referred to as health numeracy.

Health numeracy is the extent to which people access, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical and probabilistic health information in order to make effective health decisions (Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005). Health numeracy allows individuals to apply numeracy skills in health contexts (Reyna, Nelson, Han, & Dieckmann, 2009). Individuals with low health numeracy skills have poor health outcomes compared to those with higher health numeracy skills (Zanchetta & Poureslami, 2006). They have less knowledge about health (Peters, Hibbard, Slovic, & Dieckmann, 2007; Peters, Slovic, Västfjäll, & Mertz, 2008), make less use of preventive health services (Huizinga, Beech, Cavanaugh, Elasy, & Rothman, 2008), and may have greater disease consequences due to failure to adhere to prescribed treatments and medication protocols (Apter et al., 2006).

The distributions of numeracy and health numeracy skill are not uniform in most populations. Low numeracy, health numeracy, and low health status are more common among immigrants than in the general population (Shomos, 2010; Zanchetta & Poureslami, 2006). In Canada, the increasing number of immigrants makes this phenomenon a public health concern. Currently, immigrants constitute about 20% of the Canadian total population and about 250, 000 immigrants arrive in Canada annually; it is estimated that by the year 2030, immigration will be the single most important factor in population growth in Canada (Statistics Canada, 2007).

Immigrants originate from different regions with different cultures and languages. According to the 2006 Canadian census, over half (58.3%) of the immigrants were from Asia, 16.1% from Europe, 10.8% from Central America, South America, and the Caribbean, 10.6% from Africa and the rest (4.2%) from the United States. Immigrants in Canada speak a variety of different languages, with more speakers of Chinese (18.6% either Cantonese or Mandarin), followed by Italian (6.6%), Punjabi (5.9%), Spanish (5.8%), German (5.4%), Tagalog (4.8%), and Arabic (4.7%) (Statistics Canada, 2009).

Many factors influence individual's numeracy and health numeracy skills. These include primary language, language of numeric information presentation, level of formal education, age, and mathematics self-efficacy. For immigrants, the duration of residence in the host country is also an important factor. Primary language is a crucial component in people's numeracy and health numeracy competencies because it shapes the number word system, and plays an important role in acquisition and expression of numbers and numeric concepts (Menninger, 1969; Spelke & Tsivkin, 2001). Speakers of a given primary language can efficiently apply only the numeric concepts available in their language. Educational attainment is related to the level of numeracy and health numeracy (Green & Riddell, 2002; Kirk et al., 2012), with low levels of education being associated with low numeracy skills. Age affects an individual's numeracy as well; older individuals may have lower numeracy arising from reduced physical and cognitive functioning (McGinnis, 2009;

Willms & Murray, 2007). Mathematics self-efficacy reflects confidence in individuals' perceived ability to successfully work or make sense of numbers and is also thought to contribute to numeracy performance (Hackett & Betz, 1989).

The research described in this thesis attempts to address the issues of numeracy and health numeracy among immigrant to Canada who are speakers of English-as-a-second language (ESL). The overall objectives are to investigate: 1) whether primary language (with respect to density of numeric concepts) affects its speakers' comprehension of numeric health information presented in a different language, 2) the role of self-efficacy in mathematics in the comprehension of numeric health information among immigrants with ESL, and 3) how speakers of languages with low and high numeric concepts process numeric health information when the information is presented in a language which is not their primary or first language.

The thesis is structured as follows. Chapter 1 (this chapter) is an overview of thesis research. Chapter 2 provides the background of important areas covered by the study, including information on numeracy and health numeracy, numeracy and health numeracy skills in Canada in general, and among immigrant populations, and factors affecting numeracy and health numeracy. Also covered is the effect of primary language on the processing of numeric health information, a brief discussion of the dual process theory of human information processing, and the effect of language on thought processes (Whorfian hypothesis). This chapter also covers mathematics self-efficacy and mathematics anxiety, two important concepts which affect individual's numeracy skills as well as a brief consideration of assessments of numeracy, health numeracy, and problem-solving of numeric tasks. The research objectives, questions, hypotheses and study components are described in Chapter 3. This is followed by a description of the methods used to collect and analyze data (Chapter 4). Chapter 5 presents the findings from the three study components. The thesis document concludes with a general discussion of the research findings, the limitations, and implications for public health practice and research (Chapter 6).

Chapter 2

Background and Literature Review on Numeracy and Health numeracy

The research presented in this thesis describes the effect of primary language and mathematics self-efficacy on numeracy and health numeracy among immigrants for whom English is not their primary language. The discussion in this chapter provides an overview and background about the constructs of numeracy, including its relationships with literacy, mathematics, and health numeracy. In addition, the chapter provides background information on numeracy and health numeracy in Canada and among immigrants for whom English is a second language (ESL), and factors affecting their numeracy and health numeracy. This chapter presents background information on assessments of numeracy, health numeracy, mathematics self-efficacy, and processing of numeric information. The presentation of background material in this chapter is meant to give the reader an overview in order to situate the thesis research. It is not meant to provide an exhaustive review of literature.

2.1 Literacy, Numeracy and Mathematics

The term literacy is generally used to refer to both the ability to read and understand written information (document literacy) and the ability to make sense of numbers (numeracy). Therefore, numeracy is treated as a component of literacy (Montori & Rothman, 2005; Nelson & Reyna, 2007). Some researchers however differentiate the two constructs but acknowledge that literacy levels influence numeracy (Charette & Meng, 1998). Nevertheless, numeracy is increasingly gaining recognition as a distinct concept from literacy (Golbeck, Paschal, Jones, & Hsiao, 2011). Numeracy is also referred to as 'quantitative literacy' (Schwartz, Woloshin, Black, & Welch, 1997), 'statistical literacy' (Gal, 2000) and 'mathematical literacy' (Breen, Cleary, & O'Shea, 2009).

Numeracy is related to mathematics though considerable debate exists about the distinction between the two concepts. Some investigators suggest that numeracy and mathematics are distinct concepts with mathematics dealing with abstracts and relationships between objects, and numeracy being perceived as contextual as well as addressing real life situations (Steen, 2001). Others suggest that numeracy is the ability to make sense of numbers, to understand how numerical concepts affect people's lives, and to use that information to make informed decisions (Adelswärd & Sachs, 1996).

A more extensive conceptualization of numeracy is that it entails the ability to use quantities, to measure, and to calculate. Numeracy implies the sum of knowledge, beliefs, inclinations and the life-skills that are used to address real life issues that have mathematical components (Gal, 1995). In this sense, numeracy has a functional role in the application of numeric or mathematical concepts and processes to life situations (Steen, 2001). In the definition given in the Adult Literacy and Lifeskills survey (ALL), an international comparative study conducted between 2003 and 2008 to provide information about adult literacy skills of the participating countries including Canada, numeracy encompasses "the knowledge and skills required for effectively managing and responding to the mathematical demands of diverse situations" (Gal, van Groenestijn, Manly, Schmitt, & Tout, 2002, p. 4). Numeracy is framed as behaviour that is "observed when people manage a situation or solve a problem in a real context; it involves responding to information about mathematical ideas that may be represented in a variety of ways; it requires the activation of a range of enabling knowledge, factors, and processes" (Gal et al., 2002, p. 7). This definition recognizes that the ability to understand numeric information depends on the individual's background, experience and context.

Gal (2000) suggests that adults do not solve mathematical problems like students do in academic contexts. Rather, adults apply mathematical skills (numeracy) to manage specific real life situations. Numeracy situations can be delineated into two broad categories: numeracy situations by external context or activity, and numeracy situations by cognitive activity. Numeracy situations by external context or activity include those where adults manage different situations involving numbers, quantities, measurements, mathematical ideas, formulas, patterns, displays, probabilities, uncertainties, and events. Numeracy situations by cognitive activity include those that adults encounter every day and have real implications for individuals. These situations occur in the "numeracy task space" consisting of: 1) generative situations (whereby individuals engage in computational and quantitative tasks), 2) interpretive situations (whereby individuals show an understanding of verbal or text information based on quantitative data and for which they are able to create an opinion) and, 3) decision situations (whereby individuals seek multiple pieces of information before making a decision).

2.2 Health Numeracy: Applying Numeracy to Health

Numeracy or facility with numbers is important because health information often includes approximations, percentages, probabilities, proportions and risk assessment (Apter et al., 2006). The skills set necessary for individuals to adequately apply numbers in health settings is termed health numeracy (Nelson, Reyna, Fagerlin, Lipkus, & Peters, 2008; Schapira, Walker, & Sedivy, 2009). Health numeracy has been defined as "the degree to which individuals have the capacity to access, process, interpret, communicate and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions" (Golbeck et al., 2005).

Health numeracy is often subsumed under health literacy, a term most authors use to represent the two constructs [see for example (Baker, Williams, Parker, Gazmararian, & Nurss, 1999; Gazmararian et al., 1999)]. The Canadian Council on Learning uses the collective term to describe health literacy and encompasses prose literacy, document literacy and numeracy skills) (Canadian Council on Learning, 2008). Although health literacy and health numeracy are related, health numeracy requires specific skills (Golbeck et al., 2011). Health numeracy proficiency can be decomposed into different abilities: basic, computational, analytical, and statistical. Individuals with basic health numeracy can make sense of simple information involving numbers, those with computational health numeracy skills can perform simple arithmetic operations such as counting, addition and subtraction, and those with analytical health numeracy skills are not only competent in basic and computational domains but can also estimate and understand percentages and frequencies(Golbeck et al., 2005).

Another way of describing health numeracy skills was developed by Schapira and colleagues (2008). Here, health numeracy is considered in three broad domains: (1) primary health numeracy skills which reflect one's ability to use basic arithmetic and to understand graphs, numbers, and dates, 2) applied health numeracy skills which reflect one's ability to use numbers in daily health care tasks, and 3) interpretive health numeracy skill which reflects one's analytical understanding so as to apply quantitative skills to analyze a wide range of tasks in the health care setting.

2.3 Numeracy and Health Numeracy in Immigrant Populations

2.3.1 Numeracy and Immigrant Populations

Numeracy is an important component of human capital, playing an essential role in labour market status, and positively affecting an individuals' earning capacity (Charette & Meng, 1998; Dougherty, 2003; Green & Riddell, 2002). An important survey that highlights the levels of literacy and numeracy across nations (including Canada) is the 2003 International Adult Literacy and Skills Survey (IALSS) (Statistics

Canada, 2005). The IALSS measures adults' proficiencies in literacy, numeracy and problem solving. Performance scores in all domains (prose literacy, document literacy, numeracy, and problem solving) fall into five levels. In the numeracy domain, those at Level 1 can understand basic numerical ideas and handle tasks involving simple and explicit mathematical content. At Level 2, individuals are able to handle simple tasks involving explicit mathematical content when there are few distracters. At Level 3 individuals can understand mathematical information represented in varying formats, and demonstrate higher facility with numbers. They can identify and interpret numeric information presented in proportions, data and statistics embedded in relatively simple texts where there may be some distracters. At Level 4 individuals access and make sense of a broad range of abstract mathematical information represented in diverse formats and identify numeric information embedded in complex contexts and with many distracters. This level requires individuals to solve problems using multiple processes, to reason, interpret, understand and work with proportions and formulae. Finally, Level 5 is the highest level in the IALSS and at this level, individuals have skills needed to work with complex representations, abstract mathematical concepts and statistical ideas in any context. They can draw inferences and justify processes used to get solutions to problems.

According to 2003 IALSS, 55% of Canadians aged 16 years and older scored at or below Level 3 in the numeracy scale (Statistics Canada, 2005). A report on the Adult Literacy and Lifeskills (2003 and 2008) surveys, provided a breakdown showing that 46% of recent immigrants, (less than 5 years), and 64% of established immigrants (more than 5 years) scored at or below Level 2 in numeracy compared to non-immigrants (46%). In contrast, 54% of native born Canadians (i.e., non-immigrants) relative to immigrants (41%) and established immigrants (43%) scored at Level 3 and above in the numeracy measure (OECD & Statistics Canada, 2011). Individuals scoring at or below Level 3 are uncomfortable with measurements, estimations and mathematical logic, and in making decisions on the appropriate operations needed to solve a particular problem (Rothman, Housam, Weiss, Davis, Gregory, Gebretsadik, Shintani, & Elasy, 2006). One factor that is thought to contribute to immigrants having low numeracy skills is because they may be fluent in a language other than English or French; indeed, numeracy assessments are usually given on one of the official languages in Canada. In addition, many immigrants received their formal education in different systems, and again, in languages other than in English or French. However, even people with high general numeracy skills in one domain may fail to apply or effectively transfer those skills to specific contexts (Fischbein, 1989). The next section is a brief consideration of numeracy in the health domain.

2.3.2 Health Numeracy and Immigrant Populations

Almost two-thirds (60%) of adult Canadians have low health literacy and health numeracy skills, implying that they have difficulties accessing and using health information to make informed decisions for their health (Canadian Council on Learning, 2008). The growing immigrant population likely contributes to the low level of health literacy in Canada. Immigrants' score in the 2003 International Adult Literacy Skills Survey (IALSS) was below Level 3 in health literacy and health numeracy, which was lower than the national average (Canadian Council on Learning, 2008). Individuals with low health literacy are more likely to self-report poor health status than those with high literacy (Simich, 2009). Low health numeracy skill is also associated with less use of health information, poor management of time and schedules for appointments, poor understanding of risk, poor adherence to prescribed medicine, and inadequate control of diseases (Estrada, Martin-Hryniewicz, Peek, Collins, & Byrd, 2004; Nelson et al., 2008; Schwartz et al., 1997; Tokuda, Doba, Butler, & Paasche-Orlow, 2009).

A study in the U.S. found that immigrant women with low health literacy and numeracy skills were more likely to suffer from depression than those with high health literacy numeracy skills (Bennett, Culhane, McCollum, Mathew, & Elo, 2007). Another study, also based in the U.S. found an association between high diabetes risk and low literacy and numeracy skills among Korean immigrants (Choi, Rush, & Henry, 2013).

Among other factors, low numeracy and health numeracy skills have contributed to immigrants' low health status across most dimensions compared to non-immigrants in Canada (Rootman, 2008). Immigrants in Canada are more likely than non-immigrants to develop type 2 diabetes; prevalence rates are between 1.35 to 12% across immigrants groups, with Asians and Africans being at a higher risk of developing the disease (Adhikari & Sanou, 2012; Creatore et al., 2010).

Numerous factors may affect immigrants' numeracy and health numeracy skills. Some of these factors are considered in the following section.

2.4 Factors Affecting Numeracy, Health Numeracy and Processing of Numeric Information

2.4.1 Effect of Primary Language on Numeracy

Language is interconnected with people's lives and plays an important role in the acquisition and expression of numbers and number concepts (Menninger, 1969). The language in which people acquire numbers and numeric concepts influences the efficiency of retrieval. Therefore primary language may be among the most important factors that influence numeracy and health numeracy of immigrant speakers of English-as-a-second language.

According to Kolers (1968), when multilingual individuals perform tasks involving numbers, they use their primary or native languages, or the language in which they acquired the mathematical skill. To illustrate, bilingual Russian and English speakers learned sets of items in their two languages and were tested in both languages for knowledge of the items. Participants were more efficient in retrieving information about exact numbers (whole numbers, fractions, percentages, and so on) in the language in which they first learned the exact number content (Spelke & Tsivkin, 2001). Efficiency in retrieving information about exact numbers implies that numbers and their meanings are closely linked to first language and that the meaning of numbers is confined to linguistic formulation specific to the language in which the mathematical skill was acquired. Numbers and number concepts learned in one language cannot be applied directly to other languages; they may have to be modified or newly learned in a second language before they are applied (Kolers, 1968; Shanon, 1984). Therefore, the language in which an individual first learns numeric concepts is important in the representation and retrieval of those concepts, irrespective of the individual's proficiency in other languages.

Representation of numerical information, however, varies across languages. Differences in number word systems are thought to contribute to variations in the representation and also in the mathematical performance among different groups internationally (Miura, Okamoto, Kim, & Chang, 1994). Some languages have a regular number-word system, whereas others have an irregular one. Dowker and colleagues (2008) suggest some characteristics that differentiate regular from irregular number word systems. These include: 1) the inclusion of number words in a language, and if there is an upper limit to what can be counted (for example, in some languages counting is limited to 2 and quantities above 2 are designated as "other"); 2) the base of the counting system (usually base 10, but other bases such as base 12, for example, a dozen, are used; French also uses a variety of bases for decades after sixty. For example, seventy is a base 10, while eighty and ninety are base 20. 3) The inclusion of a written number system in a language; 4) the regularity of the written number system with regard to clear and consistent representation of the base used, for example, base 10. The Roman system has an irregular system due to its inconsistency in assigning different letters to different counts (for example, "I" for units, "X" for tens, "C" for hundreds, and so on); and 5) the logical correspondence between the spoken and the written number systems. In English for example, the fraction "¼" does not correspond to the written word "a quarter". Hence the English speaker has to learn to map the number into the word.

An example of regular and irregular number systems is the Welsh and English languages. Welsh is more regular than English. In Welsh, knowledge of numbers 1 to 10 is enough for the speaker to construct other number words such as teens. To illustrate, number 11 (eleven) is rendered "one ten one", clearly linking the one and the teen. In contrast, there is no clear link between the one and the teen in English, and all teens and decades are presented as one word (e.g., ten, eleven, twelve, thirteen; and twenty, thirty, forty) (Dowker et al., 2008). Even the rendering of fractions can be regular or irregular. For example, in the Chinese number system, the fraction ⅓ (one-third) is rendered "one part of three", which makes it easier to show the relationship between the numerator and the denominator. Similarly, in the Korean language, ⅓ is rendered "of three parts, one". In contrast, the English system is less clear; ⅓ is rendered "one-third"; ½ and ¼ are inconsistently rendered "half" and a "quarter", terms that do not show a clear link between the numerator and the denominator (Ng & Rao, 2010). Whereas it is easier to follow the logic in the construction of the number words in a regular system, the same cannot be said of the irregular system.

Regular and irregular number systems may affect an individual's performance on numeric tasks. Dowker and colleagues (2008) involved twenty-six bilingual Welsh-English speaking and monolingual English speaking children in a study using three standardized tests: the Basic Number Skills test to measure written calculation; the Wechsler Intelligence Scale for Children (WISC) Arithmetic subtest to measure arithmetical reasoning using word problems, and the WISC Block Design subtest to measure both nonverbal reasoning and number comparison. The bilingual Welsh-speaking children were better than the monolingual English speakers in reading and comparing 2-digit numbers. Adjusting for educational differences between the groups, the variability in performance was attributed, in part, to the differences between the language structures.

There have also been studies suggesting that the regularity of languages contributes to the superior performance of children from East Asia in mathematical tasks (Campbell & Epp, 2004; Miller & Stigler, 1987). In one such study, Miura and colleagues (1994) compared mathematics performance of children from China, Japan, Korea, France, Sweden and the United States. The study involved 139 first graders (mean age 6.7 years of age) who were tested individually in their primary languages. All children were asked to use base 10 blocks to construct numbers. Chinese, Korean and Japanese children showed an understanding of place value as indicated by their use of tens and ones to represent numbers. French, Swedish and U.S. children used collections of units implying that they were representing numbers as groupings of counted objects. In addition, Asian-language speakers made two more constructions for each number. The authors suggested that this showed greater ability to manipulate numbers by Asian language speakers compared with non-Asian language speakers. Miura et al (1994) postulated that Asian language speakers were more skilled and efficient in the use of numbers than the non-Asian language speakers.

Ng and Rao (2010) reviewed 108 publications that compared mathematical achievement of students in Asian and Western countries. The review focused on linguistic and cultural factors that influenced performance in mathematics across nations. Among their findings were that number words in Mandarin gave an advantage to children in learning and performing mathematical tasks. The number words in Mandarin "are clear, transparent, straightforward, and conceptually well designed as well as being a logical representation of base-ten system" (Ng & Rao, 2010, p. 182). Another feature that the researchers reported was that numeric concepts contained in a language contribute to the performance of mathematical tasks. This is considered in the following section.

2.4.2 Primary Language and Quantity of Numeric Concepts

Numeracy can be influenced by many factors including numbers, counting, numerosity, experience, expertise, cognitive processing, language, and subjective dimensions. Particularly for speakers of English-as-a-second language, numeracy can also be influenced by quantity of numeric concepts in the primary language. These include constructs such as whole numbers, fractions, square roots, negative numbers, exact integers, proportions and ratios (Feigenson, Dehaene, & Spelke, 2004).

Languages differ on the quantity of numeric concepts embedded in their structure. A language could be designated as either low or high in numeric concepts depending on the quantity of numeric concepts contained in it. A language with one numeric concept (e.g., whole numbers, fractions, ratios, percentages) can be considered a "low numeric concept" language, whereas a language with two or more numeric concepts can be considered a "high numeric concepts" language. This is based on the fact that languages differ in the number words available in them (for instance, e.g., the Pirahã has an upper limit of 2 of the numbers available in the number word system (Gordon, 2004). Languages also differ in the quantity of numeric concepts embedded in their structure [Mandarin has whole numbers and rational numbers embedded in its structure (Miura, Okamoto, Vlahovic-Stetic, Kim, & Han, 1999)]. Languages such as Pirahã would be categorized as a low numeric concept languages, compared to other languages such as Mandarin, that have embedded in their structure whole numbers, fraction and percentages. Similarly, Kikuyu language (a language spoken by the Agikuyu people of Kenya) can be considered as being of "low numeric concept" for having only 1 numeric concept (whole numbers) but lacking concepts and words for fraction, proportions, and percentages(Leakey, 1977). It is important to highlight how numeric concepts are acquired.

There has been considerable debate about how people acquire number concepts. Some researchers suggest that infants are born with innate basic or primary quantitative abilities, such as counting (Geary, 2000; Butterworth, 2005). Others argue that infants are not born with such abilities; they acquire the concepts as they develop language skills (Condry & Spelke, 2008; Bloom, & Wynn, 1997). Still others suggest that a language involving exact numbers is a creation of specific cultures (W, Everett, Fedorenko, & Gibson, 2008). In other words, different cultural groups develop number systems and numeric concepts to address specific needs in their contexts.

In spite of the debate, it is generally agreed that most numeric skills are acquired in a deliberate manner, through culture and formal/informal education (Geary, 2000; Kelly, Miller, Fang, & Feng, 1999). Pre-school children may acquire numeric concepts outside the school environment, but they formally acquire such concepts through the educational system. Therefore, aside from language, the design and the implementation of the mathematics curricula are also important factors to consider when comparing mathematical performances internationally. The following is a brief comparison of mathematics curriculum focusing on two groups – Chinese individuals receiving their education in China, and East African individuals receiving their education in Kenyan. These two groups are highlighted because they represent speakers of high versus low numeric concept languages.

2.4.3 Language of Instruction in China and Kenya

In mainland China, the official language of instruction is Mandarin. In the first term of the first grade, every child goes through four to six weeks of learning proper pronunciation in Mandarin; this is considered the prerequisite for formal education (Barnes, 1978). Mandarin has been shown to convey mathematical concepts more clearly, aiding students to better understand concepts than would be the case if English was the language of instruction (Wang & Lin, 2005). The mathematics curriculum is designed to develop student's problem solving skills (Cai & Nie, 2007). According to the "Nine-year compulsory education in whole-day primary school mathematics curricula" (http://ywb.cqu.edu.cn/CDYW/views/show-one-item.do?id=35) the main mathematical concepts are introduced in Mandarin at the elementary level, a period of six years. For example, basic counting, addition, subtraction, multiplication, measurements, time and elementary geometry, are taught in the first year. These concepts are further developed in subsequent years. Fractions and statistics are introduced in the third year, and decimals and algebra are introduced in the fourth year, prime numbers in the fifth year and percentages, ratios, proportions and various ways of presenting data (various types of charts and tables) are introduced in the sixth year. One of the guiding principles is the practical application of mathematics in people's lives. "Learning materials of mathematics should be practical, significant and challenging, and mathematics teaching methods should be pragmatic, innovative and self-exploring" (Xie, 2009, p. 125).

Primary school education in Kenya is for eight years. The language of instruction in the first three years (grade 1 to 3) is the primary language (or vernacular) in rural schools; English and Kiswahili languages are used in urban schools due to the diversity of languages represented. English is the only language of instruction from grades 4 onwards (Bunyi, 1997; Cleghorn, Merrit, & Abagi, 1989). According to the Primary Education Syllabus (Ministry of Education, 2002), mathematics concepts introduced in grade 1 and 2 include whole numbers (counting, reading and place value), addition, subtraction, multiplication, division, measurements and geometry. In grade 3, more content is added to the concepts introduced earlier, while additional concepts are introduced. These include fractions, measurement (length, mass, capacity, money, time) and geometry. Grade 4 builds on concepts introduced earlier, with some additions in measurement (area and volume). Algebra, tables and graphs are also introduced at this level. Content for grade 5 consists of all the concepts introduced earlier, with only one single addition: scale drawing, where the students learn proportions in linear measurements. Percentages are introduced in grade 6, as are time and speed, and more geometrical concepts. Ratios and proportions are introduced in grade 7. Grade 8 covers all the mathematical concepts introduced in the earlier grades. Students are also prepared for the national examination. Those who pass the national examination proceed to secondary education.

An important difference in delivering mathematics curricula in China and Kenya is language. In China the curriculum is delivered consistently in the primary language throughout the education system. This consistency is absent in Kenya where the language of instruction changes in grade 4. Moreover, unlike the case of Mandarin, all the mathematical concepts, except whole numbers, are foreign to Kenyan languages such as Kikuyu. This implies that these mathematical concepts cannot be introduced during the early years of education, unless they are first translated and delivered in vernacular, potentially introducing confusion in the learning process (Cleghorn et al., 1989). Most Kenyans, including those living in urban areas, speak English as a second or third language (parenthetically, the author of this thesis has English as his third language). Thus, Kenyan and Chinese children may be exposed to the same concepts in elementary education, but the Chinese children may learn them more efficiently and more consistently than Kenyan children.

2.4.4 Effect of Mathematics Self-efficacy on Performance in Numeric Tasks

Self-efficacy is the belief and conviction of an individual's perceived ability to perform a task and produce the expected outcome; self-efficacy influences or regulates behavioural outcomes (Bandura, 1977). Beliefs reflect individuals' views of themselves and their surroundings and what they think about their abilities, issues, and objects (Macleod, 1992). Beliefs and the related concept, attitudes, affect an individual's performance positively or negatively in all tasks (Eagly & Chaiken, 2007). It has been argued that self-efficacy influences, and is itself influenced by, outcomes (Kirsch, 1982; Williams, 2010). This suggests that success in a specific task results in greater self-efficacy in the future performance of the task.

Self-efficacy in mathematics refers to an individual's perceived ability to work with or to make sense of numbers. This plays an important role in the willingness to attempt to solve problems involving numbers (Pajares & Miller, 1994). Among ways that mathematics self-efficacy help improve performance is by reducing mathematics anxiety, a condition that affects some people when presented with mathematical problems to solve (Ashcraft & Moore, 2009; Hackett & Betz, 1989; Hopko, Mahadevan, Bare, & Hunt, 2003; Pajares & Miller, 1994). Initially mathematics anxiety was seen as one-dimensional (Suinn, Edie, Nicoletti, & Spinelli, 1972) but subsequent studies revealed that it is multidimensional. Rounds and Hendel (1980) identified two factors that constituted mathematics anxiety and labeled them "mathematics test anxiety" and "numerical anxiety". A subsequent study suggested mathematics test anxiety and numerical anxiety were separate constructs (Kazelskis et al., 2000).

Mathematics test anxiety is fear of math tests and math courses, while numerical anxiety is fear stemming from everyday situations involving the use of numbers (Kagan, 1987). Numerical anxiety seems to be related to individual's disposition or attitude towards numbers, and may be the most important factor in mathematics anxiety (Kazelskis, 1998). Mathematics and numerical anxiety may occur if the individual lacks confidence (or self-efficacy) to perform mathematical tasks; if the problems are new, if the problems are perceived to be complex, or if the time to solve the problems is limited (Hoffman, 2010). Self-efficacy reduces mathematics and numeric anxiety and improves numeric problem-solving.

In the next section, the influence of language on numeric information processing is considered. A brief review of the Whorfian hypothesis (linguistic determinism) is also presented.

2.4.5 Effect of Language on Information Processing

The role of language in cognitive processes has received extensive attention (Brysbaert, Fias, & Noël, 1998; Hunt & Agnoli, 1991; Kay & Kempton, 1984; Macchi & Bagassi, 2012; Macchi & Bagassi, 2012). Macchi and Bagassi (2012) have suggested that language and thought "share a unitary cognitive activity" (p. 54). It has also been suggested that retrieval of basic numbers in mathematics problem-solving episodes depends on auditory and verbal representations of the first or primary language (Dehaene, 1992). The idea that language and cognition are inter-related has been termed the "Whorfian hypothesis". Although this thesis research does not address the Whorfian hypothesis with respect to the processing of numeric information, the role of language in acquisition, representation and retrieval of information needs to be briefly considered.

The debate on the influence of language on thought is based on variants of the Whorfian hypothesis on linguistic relativity or linguistic determinism. One form of the hypothesis suggests that language controls both thought and perception and a variant of the hypothesis asserts that language only influences, but does not determine, thought (Hunt & Agnoli, 1991; Kay & Kempton, 1984). According to the latter perspective "the presence of a language structure facilitates or hinders formation of certain concepts" (Zhang & Schmitt, 1998, p. 376). Zhang and Schmitt enrolled Chinese and English speaking participants in studies that showed that linguistic structures in the respective languages (the lexicon and the syntax) affected participants' perception and memory of objects. Hunt and Agnoli (1991) argue that although perception may not be affected by language, memory is. Memory is derived from the direct record of the sensory information at the time an event is perceived, and an indirect record of how individuals linguistically describe the event to themselves; memory is affected because it is coded by language, and memory is important in information processing as shown in the following section.

Human's cognitive processing is based on information available in the short-term memory, also known as working memory, and in the long term memory. Researchers suggest that to process information, people use one of the two systems, either an intuitive approach or an analytical one. These systems have been unified under the dual process theory (Evans, 2003; Sloman, 1996; Stanovich & West, 2002). More recently some models have emerged that incorporated the relationship between language and thought into the dual process models (Evans & Frankish, 2009; Macchi & Bagassi, 2012). Broad characteristics of the intuitive and the analytic systems are described below.

The intuitive system is associative, holistic, automatic, and relatively quick with low cognitive demands. It is acquired through life-long personal experiences and it is highly contextualized, whereby the reasoning processes are linked to the problem content (Evans, 2003; Klaczynski, 2001; Stanovich & West, 2002). Intuition helps individuals speed up the processing of mathematical concepts (Giardino, 2010). Intuition stems from experience and exposure to mathematical concepts and processes, which contributes to the development of mathematical sense by generating knowledge. This knowledge is stored in the long term memory in the form of a schema. A schema has been defined as "a program which enables the individual to 1) record, process, control and mentally integrate information, and 2) react meaningfully and efficiently to the environmental stimuli" (Fischbein, 1999, p. 39). Schemas are working models and knowledge systems comprising of past information, behaviours and experiences (Anderson, 1984).

According to Hunt and Agnoli (1991), numerical schemas represent highly restricted schemas in that some numerical concepts and processes are not universal. The authors cite as an example the ease with which English speakers express the idea that if there are 49 men and 37 pairs of shoes, some men will have no shoes. Some languages like Pirahã discussed earlier have limited numbers and their speakers would have difficulties because 49 and 37 are not part of their number schemas (Gordon, 2004).

Intuitive processing of numbers involves tapping into an already existing program that contains all acquired numbers and number concepts. Since mathematical intuition depends on background, knowledge and expertise, individuals relying on intuition processing would be fast in task performance and comprehension of numeric information (Dehaene, 2009; Giardino, 2010).

In contrast, analytical processing is rule-bound, relatively slow, and controlled and it uses considerable cognitive resources and requires substantial mental effort (Chandler & Sweller, 1991; Evans, 2003; Sloman, 1996; Stanovich & West, 2002). Analytical processing is decontextualized, in that the underlying reasoning processes are uncoupled from the problem content (Stanovich & West, 1997). Ability to use analytical processing is acquired through cultural and formal training (Evans, 2003; Sloman, 1996; Stanovich & West, 2002). Compared to intuitive processing, individuals who engage in analytical processing of numeric tasks would have slow performances and lack expertise in the domain (Giardino, 2010). Indeed, analytical processing is activated when an individual lacks the ability to solve a problem on the basis of prior knowledge from a similar situation (Anderson & Aydin, 2005; Giardino, 2010). Analytical processing also occurs when individuals are faced with difficulties in the reasoning process, for instance, due to the level of difficulty in the task as well as when the purpose of information processing is deductive, such as when drawing conclusions from a wide range of information sources. In such situations, more time and mental effort is required (Alter, Oppenheimer, Epley, & Eyre, 2007; Klaczynski, 2001).

Others argue the opposite: novices process information intuitively while experts process information analytically (Pretz, 2008). However, experts solve mathematical problems intuitively and novices solve mathematical problems analytically. Fischbein (1987) posited that through intuition, experts “generally grasp the universality of a principle, of a relation, of a law, of an invariant, through a particular reality" (p. 50).

As described earlier in this chapter, primary languages shape the number word system and play an important role in the acquisition of numeric concepts and numeric skills. However, numeracy or facility with numbers is also affected by personal factors, especially an individual’s confidence, or lack of it, to successfully engage in tasks involving numbers. Whereas individuals with greater confidence or mathematics self-efficacy are likely to perform well in numeric tasks, those with low mathematics self-efficacy may have anxiety towards mathematics which can affect their performance, as discussed below.

2.4.6 Factors Affecting Health Numeracy

The factors discussed above can certainly affect health literacy and health numeracy. Indeed, research has shown a strong association between education and health literacy (DeWalt, Berkman, Sheridan, Lohr, & Pignone; 2004; Cho, Lee, Arozullah & Crittenden, 2008). In their study on determinants of health literacy, Sun et al, (2013) found that one level increase in education attainment was associated 2.35 points increase in health literacy score. Another factor that affects health numeracy and health literacy is literacy. Although literacy is related to education, it is also distinct from it, and levels of education attainment are not necessarily related with levels of literacy (Health Canada, 1999). According to Kickbush (2001) health literacy is a discrete form of literacy that can be acquired through education and through other ways, including personal interest and motivation. Literacy, independent of education, has been shown to affect health literacy. In a study on the relationship between literacy, education and hypertension knowledge and control, Pandit et al. (2009) found that literacy independently predicted blood pressure control and, moreover, mediated education and hypertension knowledge. Health literacy is also affected by prior knowledge. In the study cited above, Sun et al. (2013) reported an association between prior knowledge of health issues and health literacy, especially for younger individuals. Therefore, factors that affect numeracy may differ from those that affect health numeracy.

In the following section, a brief overview of how numeracy, health numeracy, math self-efficacy, and numeric information processing is given. This section is not meant to be exhaustive but rather, to highlight some of key instruments and approaches that have been used in the literature.

2.5 Assessment of Numeracy, Health Numeracy, Mathematics Self-Efficacy and Processing of Numeric Information

2.5.1 Assessing Numeracy

Assessing adult numeracy is challenging for a number of reasons. Swain and colleagues (2008) lists some of these challenges. Firstly, numeracy, literacy, and language are intertwined. Although numeracy problems can be presented in texts, pictures, diagrams, orally, or in written form as numbers and symbols, an individual with difficulties in any of these areas may not perform well in an assessment. Secondly, adults' numeracy practices are as diverse as adult individuals, and their occupations and skills are embedded in specific contexts (Coben et al., 2003). This diversity in numeracy practices is illustrated by considering what an individual in construction may use compared with those involved in retail trade. Thirdly, an individual's achievements in numeracy at a given time and place may not translate into the same level of performance at a different time and place. For instance, adult immigrants may have specific numeracy and mathematical skills gained in their countries of origin. However, due to differences between immigrants' country with regard to the educational systems and language of instruction, these skills might not be adequate for effective functioning in their new (host) environment (Shomos, 2010). The fourth challenge is personal factors such as attitudes, beliefs and anxiety which affect performance and which may be difficult to measure.

The Adult Literacy and Lifeskills (ALL) survey (described in an earlier section) provides five facets of numerate behaviour to consider when assessing numeracy in adults. These are: 1) context (managing or solving a problem in a real situation), 2) responses (identifying or locating information, acting upon, interpreting and communicating), 3) mathematical information (quantity and number, dimension and shape, pattern, function and relationships, data and chance and change), 4) representation of mathematical information , and 5) other enabling factors (problem solving skills, literacy skills, beliefs and attitudes and numeracy related practices and experiences (Gal et al., 2002). These facets of numerate behaviour mirror situations individuals encounter in their daily living.

Most instruments that assess adult numeracy are generally designed for teaching and learning environments. For instance, standardized assessment tools such as the comprehensive adult student assessment system (CASAS) and the tests of adult basic education (TABE) provide a simple summary score of adults' literacy and numeracy attainment after completing certain levels of training in the United States (Cumming & Gal, 2000).

One of the most used instruments, the French Kit (*The Manual for Kit of Factor Referenced-Cognitive Tests,* 1976) (Ekstrom, French, Harman, & Dermen, 1976), has a more general use compared to CASAS and TABE. The French Kit comprises 72 factor referenced cognitive tests developed for use in research to measure a wide range of cognitive processes including verbal ability, reasoning, spatial ability and memory. Among the French Kits subtests is the number facility (or number facility forms 1 - 4) which assesses facility and speed in the performance of basic arithmetic operations. The number facility factor is composed of four tasks: *the addition test*, the *division test*, the *subtraction and multiplication test*, and the *addition and subtraction correction test*. The addition, the division, the subtraction and multiplication tests assess speed and accuracy of operations, and the score is assessed as the number of correct items for each item. The subtraction and multiplication test involves alternating 10 items of subtracting 2-digit numbers from 2-digit numbers and 10 items of multiplying 2-digit numbers by single digit numbers. The final test is the addition and subtraction correction test, which is a recognition task.

All or a select number of French Kit number facility tasks have been used extensively in research. Bermingham et al. (2013) used the number facility factor to measure the role of numeric ability and the use of cognitive strategies in predicting everyday number recall among one hundred participants aged between 18 and 69 years. There was no significant relationship between numeric ability and overall recall and forgetting activity. However, according to these researchers, numeric ability moderated the relationship between strategy use and recall and higher numeric ability contributed to the strategy and recall of numeric information. In another study using the addition subtest, Campbell and Xue (2001) enrolled Canadian Chinese (CC), non-Asian Canadians (NAC) and Chinese university students educated in China (AC) to examine retrieval and procedural strategies for simple arithmetic. The two Chinese groups relied on retrieval strategy (intuitive processing) while the NAC group relied on procedural strategy (analytical processing) for addition and multiplication tasks. Overall, the two Chinese groups (CC and AC) outperformed the NAC group in the arithmetic tasks.

2.5.2 Assessing Health Numeracy

Assessment of health numeracy is as challenging as the assessment of numeracy. In most studies, health numeracy is treated as a component of health literacy (for example, see Gazmararian et al., 1999; Kim, 2009; Wolf, Gazmararian, & Baker, 2005). However, health numeracy is a distinct skill that should have independent measurements (see Golbeck et al., 2011; Rothman, Montori, Cherrington, & Pignone, 2008). A range of measurements referred to as assessment tests (Straus, Sherman, & Spreen, 2006) are used among other things, to collect patients' information in many areas of cognitive abilities such as reading and mathematics. Examples include the Woodcock-Johnson Tests of Achievement III (WJ III ACH) (Woodcock, McGrew, & Mather, 2001a) (Woodcock et al., 2001a), the Wide Range Achievement Test –Revised (WRAT-3) (Wilkinson, 1993), and the Kaufman Functional Academic Stills Test (K-FAST) (Kaufman & Kaufman, 1994). These are briefly considered below.

The Woodcock-Johnson Tests of Achievement III (WJ III ACH) assesses academic achievements of children and adults (from 2 years to over 90 years old). It contains 22 subtests which can be administered individually or in clusters depending on need. The test covers reading, mathematics, written language, oral language and general knowledge. The examiner can derive scores at different levels that is, at the cluster, or at the subtest level. The WJ III was designed to 1) diagnose learning ability, 2) determine discrepancies (intra-achievement and ability-achievement), 3) plan educational programs and assess achievement over time" (Straus et al., 2006, p. 392). Each subset takes 5 to 10 minutes to administer. The math area (tests 5, 6, 10 and 18) covers calculation (simple additions to complex equations), math fluency (basic single digit addition, subtraction and multiplication), applied problems (analyzing and practical math problems), and quantitative concepts (identifying mathematical terms and formulas, and identifying numbers and patterns). The test has high reliability (r=.98) with all areas of the test having reliability levels above .80. There is no information on the use of the test among minority groups or people from across cultures (Straus et al., 2006).

The Wide Range Achievement Test –Revised (WRAT-3) was developed to assess academic achievements of children and adults (from 5 years to 74 years and 11 months old). It is also widely used to screen individuals' learning ability in basic reading, spelling and arithmetic (Klimczak, Bradford, Burright, & Donovick, 2000; Straus et al., 2006). Each subtest takes 15 to 30 minutes to administer. The mathematics subtest assesses counting, basic arithmetic and written computation and takes 15 minutes. There is no composite score for the tests. WRAT- 3 has an academic orientation (Klimczak et al., 2000) and, as such, may not be as applicable to non-school populations. Moreover some authors suggest that the test overestimates achievements, especially in mathematics, and there is no information on its appropriateness for use among people from different cultures (Snart, Dennis, & Brailsford, 1983; Straus et al., 2006). WRAT-3 has also been criticized for being too brief to adequately cover the reading and arithmetic domains (Flanagan et al., 1997).

The Kaufman Functional Academic Skills Test (K-FAST) (Kaufman & Kaufman, 1994) is a neuropsychological test that assesses individual's reading and mathematical skills necessary for daily living. For example, the arithmetic component measures individual's ability to handle situations that involve mathematical operations such as balancing of chequebooks and shopping. K-FAST can be used as a test of academic achievement, and also to diagnose disabilities in reading and mathematics (Klimczak et al., 2000). The test consists of the reading and the arithmetic subsets and can be administered to individuals aged 15 to 85 years, and it takes about 15 to 25 minutes to administer. Klimczak and colleagues found K-FAST and WRAT-3 to be highly correlated and Flanagan et al. (1997) suggested that K-FAST is a measure of academic skills.

Other instruments exist, but they either measure specific abilities, or they are designed for use in specific disease- or practice-related areas. For example, the Rapid Estimate of Adult Literacy in Medicine (REALM) was developed to measure health literacy only (Davis et al., 1993). It is a word recognition test that is used to assess an individual's ability, to read and pronounce, but not necessarily to understand, words. Disease- or practice-specific tests include the Diabetes Numeracy Test (DNT) (Huizinga et al., 2008), the Test of Health Literacy in Dentistry (TOFHLiD) (Gong et al., 2007), the Oral Health Literacy Instrument (OHLI) (Sabbahi, Lawrence, Limeback, & Rootman, 2009), the anticoagulation scale (Estrada et al., 2004), and the Asthma Numeracy Questionnaire (ANQ) (Apter et al., 2006). Another test, the Medical Data Interpretation Test (MDIT) (Schwartz et al, 2005), assesses an individual's understanding of medical statistical data. These tests may not be appropriate for general use in the population and have not been validated with speakers whose native language is not English (although REALM is available in a Spanish language version).

There are however, some instruments designed for more general usage in the health domain. One such instrument is the Test of Functional Health Literacy in Adults (TOFHLA) (Parker, Baker, Williams, & Nurss, 1995) which measures individuals' ability to perform tasks requiring reading and numeracy skills in health-related contexts. The test consists of a reading comprehension component (50 items) and a numerical component (17 items). All items are drawn from information used in hospitals, such as prescriptions and patient education materials, and are contextualized for a U.S. audience (Mancuso, 2009).The comprehension component of TOFHLA utilizes a modified cloze procedure where individuals read and fill-in words that have been deleted from a passage (Hafner, 1966). The numeric component is presented orally with the interviewer reading the question and the participant supplying the answer. It assesses an individual's ability to understand simple information on blood sugar, following prescriptions, keeping doctor's appointments, and understanding simple instructions on financial help. Both the prose and the numeracy scores are weighted. A score of 0 to 59 indicates inadequate health literacy; a score of 60 to 74 indicates marginal health literacy, and score of 75 to 100 indicates adequate health literacy. Although the test has high reliability (.98), it takes 22 minutes to administer and it is timed. The length and the timing could be potentially frustrating to individuals and the TOFHLA has more prose than numeric items (50 versus 17). It has been criticized as being biased towards health literacy rather than a balanced measure of health literacy and health numeracy (Mancuso, 2009).

The S-TOFHLA is a short version of TOFHLA (Baker et al., 1999). It includes 36 prose and 4 numeracy items that take 7 minutes and 5 minutes respectively to administer. Similar to full TOFHLA instrument, the prose component of the shortened version utilizes the cloze procedure with contents drawn from medical instruction used to prepare for a medical procedure, information of Medicaid insurance and patient rights. The four questions of the numeracy component assess understanding of instructions on a prescription bottle, ability to determine correct blood sugar and identifying time of appointment on a card. The scores are weighted for the prose component (72) and for the numeracy component (28) with a composite score of 100. A score of 0-53 indicates inadequate, 54 - 66 indicates marginal, and 67-100 indicates adequate health literacy and numeracy. The prose component has a reliability of .97 and the numeracy component .68. As with TOFHLA, the numeracy score is subsumed under the composite S-TOFHLA score.

Another measure of health numeracy is the Newest Vital Signs or the NVS (Weiss et al., 2005). The NVS has been used to screen patients' ability to read a nutrition label and apply the prose and numeric information to answer six questions that tap literacy and numeracy skills (Mancuso, 2009). The instrument takes three minutes to administer, and scores range from 0-6 points. A score of below 4 indicates inadequate literacy and numeracy. The NVS has adequate reliability (Cronbach'sα: = 0.76) and correlates marginally with TOFHLA (r=0.59, p< 0.001). NVS takes less time to administer. However, the NVS has been criticized for having high sensitivity and low specificity, implying it might misclassify individuals with high health literacy and numeracy skills and overrate those with low skills (Mancuso, 2009).

Nevertheless, NVS has been used in many studies, including one that assessed levels of health literacy and numeracy among caregivers in type 1 diabetes control (Hassan & Heptulla, 2010). Literacy and numerical skills of caregivers were found to be important in glycemic control of their children with type 1 diabetes. Another study using the NVS among adults in Turkey found that 72% of the participants had inadequate health literacy and numeracy (Ozdemir, Alper, Uncu, & Bilgel, 2010).

Another measure of health numeracy is the 8-item test developed by Lipkus and colleagues (2001) and tailored for use in health settings. It assesses people's abilities in probabilities, proportion and percentages. This test has adequate reliability (Cronbach's α: = 0.75) and it has been used to measure health numeracy (Donelle et al, 2008). In addition, there is the 3-item general context numeracy instrument that is used to measure general ability in numbers (Schwartz et al., 1997). It includes three questions that measure individual's ability in probability, percentages and proportions and it has been used together with other instruments to assess health numeracy (Donelle, Hoffman-Goetz, Gatobu, & Arocha, 2009; Sheridan, Pignone, & Lewis, 2003).

2.5.3 Assessing Mathematics Self-Efficacy

Affective factors, such as belief and attitudes, reflect individuals' view of themselves and their surroundings and what they think about their abilities, issues, and objects (Macleod, 1992). The association between affective factors and performance in mathematics has been extensively studied (Gierl & Bisanz, 1995; Ma & Kishor, 1997; Ruffell, Mason, & Allen, 1998), and measures have been developed to examine this relationship. There are a number of instruments to measure mathematics self-efficacy. The three most widely used are highlighted below.

The most extensively used instrument is the Fennema-Sherman mathematics attitudes scales (FSMAS). The FSMAS are described as a 9 domain specific Likert-types scales designed to measure student's attitude in learning mathematics (Fennema & Sherman, 1976). The nine specific scales are 1) the attitude toward success in mathematics scale (AS) which measures students' perceived consequences as a result of success in mathematics; 2) the mathematics as a male domain scale (MD) which measures the degree to which students perceive mathematics as a male, neutral or a female domain; 3) the mother (M) and the father (M) scales that assesses students' perception of their parents' (mother/father) interest in mathematics, and their confidence in the students' ability in mathematics; 5) the teacher scale (T) which assesses the perceived teachers attitude towards students' mathematics ability; 6) the confidence in learning mathematics scale (C) which assesses students' confidence in their ability to learn and perform mathematics tasks; 7) the mathematics anxiety scale (A) designed to assess feelings of anxiety, unease and discomfort while doing mathematics; 8) the affectance motivation scale in mathematics (E) which measures affectance ranging from lack of involvement to enjoyment and actively seeking challenges in mathematics; and 9) the mathematics usefulness scale (U) which assesses students' perception of the usefulness of mathematics in their lives. The reliability for all scales ranged from .86 to .93 (Mulhern & Rae, 1998). The complete instrument was designed for school and college level students with 4 of the scales (confidence, usefulness, success and anxiety) more appropriate for college level populations (Wikoff & Buchalter, 1986). The usefulness of the FSMAS outside of a classroom setting is not clear.

The Mathematics Self-efficacy Scale (MSES) was developed to examine beliefs regarding ability to perform various math-related tasks and behaviours (Betz & Hackett, 1993). The instrument is based on three areas relating to mathematics self-efficacy expectations: 1) everyday mathematics tasks (for example balancing a chequebook), 2) a test of mathematics mastery and knowledge (for college courses); and 3) math problems. The MSES consists of 52 items on which individuals rate their confidence on a 10 point Likert-scale, ranging from no confidence at all (0) to complete confidence (9). The internal reliability of the whole instrument is excellent (.96). The internal consistency of math tasks self-efficacy subscale is also excellent (.90), for the college courses (.93), and for math problems (92) (Betz & Hackett, 1993). The MSES has previously been used to show the association between teachers' mathematics self-efficacy mathematics teaching efficacy, and teachers' mathematical performance (Bates & Lathan, 2011).

The subjective numeracy scale (SNS) measures an individual's subjective feelings about numbers (Fagerlin et al., 2007). The SNS comprises the ability subscale (questions 1-4) and the preference subscale (questions 5-7). It has good internal reliability (α = 0.85) and adequate validity (r = 0.68) and it takes about 5 minutes to administer. As an example of the SNS, Paulson and Colleagues (2010) investigated neural activity patterns associated with numerical sensitivity in adults. They found an association between brain and behaviour measures of number discrimination. The SNS has been also been used to assess people's perception of a graphical ladder and how the perception was related to their subjective numeracy (Hess, Visschers, Siegrist, & Keller, 2011). The SNS is thought to be less intimidating for adults than other tests because it contains no numbers.

In the next section, ways of assessing problem-solving skills are described. As with measurement of numeracy and health numeracy, assessment of problem-solving is also challenging.

2.5.4 Assessing Problem-solving Approaches

Information processing and problem solving approaches can be assessed by analyzing written and verbal protocols obtained as individuals solve a problem through the think-aloud process. The think-aloud method is based on the information-processing model (Newell & Simon, 1972) whereby information in the short-term memory (STM) is verbalized while solving the problem (Trickett & Trafton, 2009; van Someren, Barnard, & Sandberg, 1994). Concurrent verbalization reflects what is happening as the individual solves the problem (Ericsson & Simon, 1980). In the problem solving process, verbalizing during a problem solving episode has little or no negative effect on the performance (Ericsson, 2003). Single person protocols, as opposed to protocols from groups, provide the best insight on cognitive processes during a problem solving situation (Schoenfeld, 1985).

Protocols generated through concurrent verbalization differ from those generated retrospectively. In retrospective generation, individuals first solve the problem and later explain how they did it. Unlike concurrent protocols, retrospective protocols draw information from the long-term memory. According to Nisbett and Wilson (1977), retrospective protocols may contain errors because individuals are constrained in the information they can draw from the long-term memory. A related problem is where an individual describes or explains the process and by so doing, the individual thinks and refers back to what he or she did rather than actually doing it. The individual may also explain what he or she thinks is desirable and not what is actually happening during the problem–solving episode (Ericsson, 2003). However, retrospective protocols are useful in memory research or when studying experts, with the objective of understanding the knowledge used when they perform tasks in their domain of expertise (Arocha, Wang, & Patel, 2005; Austin & Delaney, 1998).

The use of the think-aloud method and verbal data has been extensive particularly in clinical contexts (Elstein, Shulman, & Sprafka, 1978; Elstein, Shulman, & Sprafka, 1990; Fonteyn & Fisher, 1995; Lundgrén-Laine & Salanterä, 2010). Others have used the method to examine problem solving skills of engineers on the Internet (Hoppmann, 2007), and to study problem solving approaches among physics students (Thorsland & Novak, 1974).

2.5.4.1 Problem-solving Frameworks

Several frameworks have been developed to analyze mathematics verbal protocols. For example, Garofalo and Lester's framework (1985) categorizes the metacognitive actions which take place during problem solving as 1) orientation (or the strategic behaviour individuals use to make sense of a problem); 2) organization (how individuals plan and select what actions to take to solve the problem); 3) execution (implementation and monitoring of the strategies and actions) and; verification (final evaluation of both the orientation and organization phase); and 4) the execution phase. Artz and Armour-Thomas's cognitive-metacognitive framework consists of eight problem-solving episodes: read, understand, analyze, explore, plan, implement, verify, watch and listen (Artz & Armour-Thomas, 1992).The authors categorize an episode as either cognitive, metacognitive or both due to the overwrapping of these actions during problem-solving. Yimer and Ellerton's framework (2010) incorporates most of the areas in the earlier frameworks. This five-phase framework includes engagement (the initial exposure attempts to understand the problem); transformation-formulation (exploring and planning to engage the problem); implementation (acting on the plans); evaluation (assessing appropriateness of the plans, actions and solutions); and internalization (looking back on the whole process; the affect part of the problem solving).

The frameworks discussed above are based to a large extent on the work of Schoenfeld (1985) which describes the cognitive and the metacognitive behaviours people engage in as they solve mathematical problems. The framework comprises 4 categories which include 1) *resources*, that is the mathematical knowledge that an individual brings into the problem-solving context; 2) *heuristics,* that is that the strategies and techniques that the individual uses to solve the problem; 3) *control,* that is decisions on what resources and strategies to use; and 4) *belief systems* or *disposition,* that is the individual's views and feelings about mathematical tasks in general, the problem at hand and the context. The cognitive and metacognitive behaviours or episodes are 1) reading, 2) exploration, 3) planning, 4) implementation, 5) planning-implementation and 6) verification. Schoenfeld's framework has been extensively used in mathematical problem-solving research and training (for example, Hannah, Stewart, & Thomas, 2013; Kennedy, 2009).

To summarize the key points of this brief literature overview, health numeracy skill enables individuals to access and utilize health information presented in numbers in order to participate meaningfully in their health care. Immigrants not only have low health numeracy, they have low health status compared to non-immigrants in Canada and this may reflect low health numeracy (directly or indirectly). Many factors including the structure of primary language, numeracy skills and mathematics self-efficacy can affect health numeracy among immigrants.

There are several assessment tools of numeracy, health numeracy and self-efficacy. Some of the numeracy tools are oriented for school performance and others are used to measure learning outcomes for adult learners. However, others such as the French Kit can be used in different contexts to measure basic numeracy and processing of numeric information.

Health numeracy is difficult to measure as there is no instrument that has been designed to capture this construct independent of literacy. Among those which have been used is the TOFHLA which is long and has a heavy administration burden. A shorter version, the S-TOFHLA, has been developed and both instruments have more literacy than numeracy items. Nevertheless, they have been validated and extensively used in health literacy and health numeracy research. The Newest Vital Signs (NVS) measures both health literacy and numeracy although the numeracy component is embedded in text, and requires prose skills to perform it. NVS is also used widely in health literacy and health numeracy research, even in samples of speakers of English-as-a-second language (ESL). Also reviewed were measures of self-efficacy in mathematics. The Fennema-Sherman mathematics attitudes scale (FSMAS) has many subscales that are mostly relevant for assessment in academic settings. The everyday mathematics task component of the mathematics self-efficacy scale (MSES) taps the appropriate skills needed by adults to engage in their daily lives, and the subjective numeracy scale (SNS) is non-threatening since it does not involve any numbers, therefore it can be used among low numerate groups. The context-free arithmetic tasks and subjective measures (such as the MSES and the SNS) are useful in assessing numeracy and health numeracy among adults. Qualitative measures, such as the think-aloud, can be used to gain insight into the actual processing of numeric information, especially among people for whom English is not their primary language.

Chapter 3

Research Objectives, Questions, Hypotheses and Components

3.1 Research Objectives

This research has three main objectives: To understand (1) whether the primary language of immigrants speakers of English-as-a-second language (ESL) in Canada affects their comprehension of numeric health information presented in English; (2) the role mathematics self-efficacy plays in numeracy and health numeracy performance among immigrants with ESL; and (3) how speakers of low-numeric concept vs. high numeric concept languages process numeric health information, when the information is presented in a language other than their primary or first language. The underlying research question is as follows: *Does comprehension of numeric health information presented in English differ between ESL speakers of low numeric concept languages versus high numeric concept languages?*

3.2 Assumptions Underlying this Research

The structure of the primary language (number of numeric concepts, number-word systems) may affect performance in numeracy and health numeracy tasks. However, other factors such as mathematics self-efficacy, education, language of mathematics instruction and age may also affect numeracy and health numeracy skills. Individuals can intuitively or analytically solve problems involving numbers depending on their primary language and their mathematics self-efficacy. Therefore, this thesis research is based on three assumptions:

First, primary language is important in acquiring and processing of numeric information (Dehaene, Spelke, Pinel, Stanescu, & Tsivkin, 1999) and speakers of one language may be limited in the processing and comprehension of numeric information presented in another language, particularly if the numeric concepts in the second language are absent in the primary language. Second, speakers of a high numeric concept language have high mathematics self-efficacy, as expected of individuals with expertise and prior experience in the use of numeric concepts available in their primary language (Miura, 1994). Mathematics self-efficacy affects not only performance in context-free mathematics tasks, but it is also transferred to health contexts that involve numbers. Third, depending on the primary language (with greater or fewer numeric concepts), and prior experience and expertise in the use of the numeric concepts (which may also increase the level of self-efficacy), individuals will process numeric information either more intuitively or analytically (Fischbein, 1999).

3.3 Research Rationale

In Canada, most numeric health information is presented in one of the two official languages, English or French. However, the Canadian population is diverse in terms of the languages spoken. This linguistic diversity may be an obstacle to the successful access of health services due to the inability to communicate health concerns in English or French, and to understand health information presented in either of the two languages (Asanin, & Wilson, 2008; Kirmayer et al., 2007). The difference in the population size of the various immigrant groups may also pose a problem in the provision of health information. Some groups, such as the Chinese, constitute a sizable proportion of the Canadian population, whereas other groups, such as those from Kenya and East Africa only constitute a very small portion of the Canadian immigrant population. It is reasonable to assume that the health information needs of bigger groups are more likely met while those of smaller groups may not be met. To illustrate this, Mandarin or Cantonese speaking immigrants, because of their large number can access health information in their primary languages in Canada while others with fewer numbers, such as the Kikuyu-speakers from East Africa, cannot access similar health information. Moreover, it is easier to mobilize resources and to design health education and health intervention initiatives for a community with a large population than it is for a community with a small population. Such interventions have greater impact due to the numbers involved. The smaller groups (in terms of population demographic within Canada) need to be fluent in either English or French to enjoy similar information access privileges as their Mandarin and Cantonese counterparts.

To date, there is no published research on the effect of primary language number systems (including number word structures and quantity of numeric concepts) on the comprehension of numeric health information among immigrant populations for whom English is a second language. Also, research is lacking on the effect of mathematics self-efficacy on health numeracy among immigrants, and on how speakers of languages that differ in the quantities of numeric concepts embedded in their language structures process numeric health information. These gaps in research are important to address because Canada continues to attract large numbers of immigrants, from diverse language and educational backgrounds, who appear to have low numeracy skills. Information on the effect of primary language and mathematics self-efficacy on numeracy and health numeracy skills, and the general approach of processing numeric health information by immigrants with ESL could help public health educators and policy makers to meet the health information needs of immigrants in Canada. The following is a description of the specific questions, hypotheses tested, and the rationale underlying each of them.

3.4 Research Questions and Hypotheses

Question 1: Do ESL speakers of a low numeric concept language compared with high numeric concept language differ in their comprehension of numeric health information presented in English?

Hypothesis 1: Comprehension of numeric health information presented in English is greater for speakers of a high numeric concept language than for speakers of a low numeric concept language.

This hypothesis is based on studies showing that people use their primary language to process numeric information (Dornic, 1979; Kolers, 1968; Miura et al., 1994; Shanon, 1984). To illustrate, a functional magnetic resonance imaging (fMRI) was used to study the processing of numeric information among Chinese learners of English. Participants were imaged as they performed calculations, parity judgments, and linguistic tasks in their language 1 (Mandarin) and language 2 (English). Results showed that calculation tasks in the second language (English) were done through the first language (Mandarin) (Wang, Lin, Kuhl, & Hirsch, 2007). The results suggested a strong interaction between language and performance in mathematics (Campbell & Epp, 2004).

Question 2: Do ESL speakers from a primary language with low numeric concept differ in reported math self-efficacy from those with a high numeric concept language when performing numerical and health numeric tasks provided in English?

Hypothesis 2: English-as-a-second-language speakers of a high numeric concept language are more confident in their ability to perform numeric and health numeric tasks than are ESL speakers of a low numeric concept language.

The rationale for this hypothesis comes from the observation that mathematics self-efficacy influences and is itself influenced by outcomes of behaviour, and that high self-efficacy reduces the level of math anxiety caused by unfamiliarity and discomfort with numbers (Ashcraft & Moore, 2009; Hopko et al., 2003). Personal experience in a given discipline improves performance and forms the basis of self-efficacy (Rosenstock, Strecher, & Becker, 1988). For example, Hoffman (2010) investigated the association between mathematics anxiety and self-efficacy in mathematics problem solving efficiency of teachers-in-training and found that self-efficacy predicted both efficiency and accuracy in solving mathematical problems among the teachers.

Question 3: Do ESL speakers of a low numeric concept language compared with speakers of a high numeric concept language use different strategies (intuitive/analytical) to process numeric health information presented in English?

Hypothesis 3: Speakers of a low numeric concept language use analytical strategies while speakers of a high numeric concept language use intuitive strategies to process numeric health information presented in English.

This hypothesis is based on findings showing that in mathematical settings, intuition gives people immediate understanding of the problem (Fischbein, 1987). People with experience and expertise in mathematics solve mathematical problems relatively faster than others who do not have such experiences and expertise (Giardino, 2010). Further, people with practical experiences solve problems and make decisions intuitively because they already have the needed resources in their long term memories (Peters et al., 2008).

3.5 Study Components

Figure 1 below presents the study components and the measurements used in the thesis research. The components include the overall question (comprehension of health numeric information by immigrants with English-as-a-second language) and the main determinants, and primary language and participants' perception of their confidence in mathematics. The last component is the approach (intuitive or analytical) that immigrants with ESL use to process numeric information.

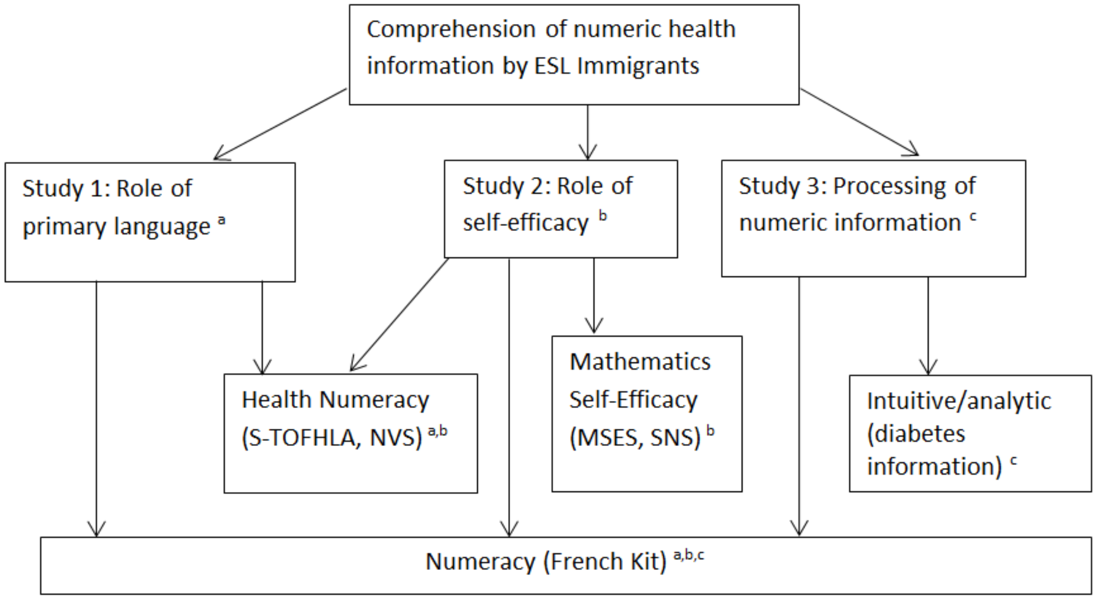


Figure 1: Representation of the research studies and the assessment tests used in each study.

The arrows show the study components and the related measures used for each component. The letters in superscript indicate the measure used in each component:

a. Study 1 assessed health numeracy (using S-TOFHLA and NVS) and numeracy (using the French kit tasks for numeracy);

b. Study 2 assessed the role of mathematics self-efficacy (using the MSES, the SNS, and French tasks for numeracy); and

c. Study 3 assessed processing of numeric information using the French kit numeracy task and a diabetes information task developed for this research.

Chapter 4

Methods

4.1 Pilot Study

This study involved two groups of immigrant speakers of English-as-a-second language (ESL) from Kenya (Kikuyu-speakers) and China (Mandarin-speakers). The two groups were selected because their primary languages differed in terms of the number-word structures and the quantity of numeric concepts embedded in the language structures. The two groups also differed in another important aspect which reflects the challenge of meeting health information needs of immigrants in Canada. The Chinese (Mandarin-speakers) are the largest immigrant population in Canada and consequently can more easily attract resources to have health information available in their language. The Kenyan immigrants constitute a small proportion of immigrants in Canada and are thus unlikely to have information available in Kikuyu; hence they rely on English to access health information in Canada.

This was in many ways an exploratory study and a pilot study was considered necessary before undertaking a larger investigation. There were several reasons for thinking a preliminary or pilot would be a useful step. First, no known (published) study has study has compared comprehension of numeric health information between two English-as-a-second language (ESL) immigrants in Canada with regard to numeric concepts contained in their primary language. Second, although studies have been conducted on the effect of mathematics self-efficacy in mathematics performance, there is no literature on the effect of mathematics self-efficacy on health numeracy. Third, Chinese constitute a sizable proportion of the Canadian population while Kenyans are very few in comparison. While it was assumed that it would be easier to recruit Chinese participants, the same could not be said of recruitment of Kenyan (Kikuyu-speaking) participants. It was felt that since information exists on the challenge of recruiting Spanish ESL participants for studies (Thomson & Hoffman-Goetz, 2011) such information for other immigrant groups including Kenyans would be helpful in future research. Fourth, although the instruments identified to measure numeracy and health numeracy have been widely used in various populations, the instrument used in the think-aloud process was developed specifically for this study and needed to be pretested with a smaller sample. The following question based on some of these issues guided the planning of pilot study. 1) How easy/difficult would it be to recruit participants from the two ethnic (Chinese and Kenyan) groups, and what would be the best strategy? 2) How appropriate were the instruments for use among the two immigrant groups? 3) How relevant/culturally sensitive were the instruments? 4) How much time was adequate for the administration of all the instruments? And, 5) what did the participants think about the instruments, the questions, and the process?

The objectives of pilot study were to: 1) assess the process of recruiting participants; 2) test all the instruments with regard to relevance and cultural sensitivity and get feedback from participants; and 3) assess the administration of the data collection exercise in terms of respondent time burden.

4.1.1 Sample Recruitment and Setting

The pilot study involved a sample of 10 participants drawn from Kikuyu-speaking (Kenya) and Mandarin-speaking (China) immigrants, residing in the Kitchener-Waterloo Region of southern Ontario, Canada. The study strategy involved the following steps: 1) Recruiting a sample of 10 (5 participants from each group) men and women who: a) were 40 years and older, (b) were bilingual (that is able to speak and write in their primary language and in English), c) had lived in Canada for not more than 15 years, and d) were willing to attend one individual interview session and one focus group discussion session at the University of

Waterloo. Prescreening was done all potential participants to ensure they were not on treatment for any chronic disease.

The rationale for involving participants who were 40 years and older was the need to involve participants who had lived in their mother countries for most of their lives and therefore were assumed to be proficient in their primary language. Since learning and attaining proficiency in a second language is related to the age at immigration (Stevens, 1999), participants in this study would have limited English language skills. In addition, this study involved participants who had lived less than 15 years in Canada. Although the cut-off for recent and established immigrants is 5 years, length of stay does not seem to improve levels of numeracy among immigrants. In fact, recent immigrants (less than 5 years residency in Canada) seem to have better numeracy than established immigrants (more than 5 years residency) (Statistics Canada, 2005). Based on this, and for practical reasons of recruiting enough participants, the cut-off for this study was set at less than 15 years.

Participants for the pilot study were recruited separately from those involved in the main study. Recruitment was done through contacts in community centres in Waterloo Region and through personal phone calls to potential participants. Those who were identified were requested to suggest other participants who were later approached and requested to participate in the pilot study. All potential participants received an information letter with details of the study. All the sessions took place at the University of Waterloo during the day. All aspects of the pilot study were approved by the University of Waterloo Ethics Committee for Research involving humans.

4.1.2 Measures and Procedures

The instruments identified for the study were the Newest Vital Signs (NVS), the Short Test of Functional Health Literacy in Adults (S-TOFHLA), the Mathematics Self-Efficacy Scale (MSES), the Subjective Numeracy Scale (SNS) and the French-Kit. In addition, the two instruments developed for the study were a general information questionnaire and the think-aloud exercise. The general information questionnaire was adapted and modified from published research on English-as-a-second language-speaking Canadian populations (Todd & Hoffman-Goetz, 2010). The think-aloud task was developed by the student researcher and the supervisors base on diabetes diet information.

The pilot study was conducted in two sessions. The first session involved interviews with individual participants, while the second session was a group discussion involving all the 5 participants per language group, on separate days for the Kikuyu- and the Mandarin-speakers. Both sessions were held at the University of Waterloo.

4.1.2.1 Individual Interviews

Individual interviews were conducted in a quiet room at the University of Waterloo for approximately 1 hour and 30 minutes. For comfort and to be culturally safe for participants, a Mandarin-speaking facilitator was always present when Mandarin-speaking participants were being interviewed. First, participants filled the general information questionnaire, followed by the Subjective Numeracy Scale. Next was the S-TOFHLA numeracy and prose exercises. The MSES was administered subsequently followed by the NVS and the French-Kit (addition and addition and subtraction correction). The Think-aloud exercise was administered last. Following are details of the administration process.

Participants started by filling the general information questionnaire. This instrument had items that covered various issues of interest, such as everyday language usage, the language spoken as a child, the language used in elementary education math instruction, and the language used when talking with healthcare providers. This questionnaire was followed with the SNS where participants were instructed to self-assess their math ability and preference on a scale from 1 (not good at all) to 6 (extremely good). All questions except question 7 (which was reverse-coded 6-1) were scored on a Likert-Scale from 1-6. The SNS score was the average rating across the 8 questions. The scores for each item were tallied and the final score indicated the individual's reported anxiety level, with 6 being the highest level. SNS ability subscale score was the average rating on questions 1-4 and the SNS preference subscale score was the average rating on questions 5-8.

Participants were next introduced to the S-TOFHLA. Although they were not informed, participants were expected to take 5 minutes on the numeracy component and 7 minutes on the comprehension component. For the numeracy component, the interviewer gave participants cue card in the following sequence: 1) information on a prescription bottle, 2) prompt card with information on blood sugar level, 3) appointment card, and 4) information on prescription bottle. Participants read the information and orally answered the questions that were read to them. Each correct answer was awarded 7 points, with a maximum of 48 points.

Participants were then given the comprehension component of the S-TOFHLA which was self-administered. The interviewer secretly timed the process, noted the point at which the 7 minutes were used and carefully stopped the participant with words like "You can stop now. I think I now have all the information I need form that exercise. Thank you very much". The S-TOFHLA comprehension score was calculated by awarding each correct answer 2 points, up to a total of 72 points for the 32 items. Together, the numeracy and the comprehension scores constituted the individual's S-TOFHLA score. This score reflected whether the individual had 1) inadequate functional health literacy (0-53), 2) marginal functional health literacy (54-66), and 3) adequate functional health literacy (67-100).

After the S-TOFHLA, the MSES was introduced. The MSES involved answering 18 questions on a Likert scale from 0 (no confidence at all) to 9 (complete confidence). This instrument was self-administered and participants used pencil and paper to mark their level on the scale. The MSES score was obtained by summing the response numbers given to each of the 18 items in the scale and dividing that sum by 18, to derive an average score.

The next exercise was the NVS. Participant were given and asked to read a laminated copy of the nutrition label of an ice cream can. After reading, they were asked the six NVS questions based on the label. Participants referred to the nutrition label when answering the questions. The questions were asked orally and the responses were recorded on a score sheet. This process took about 3 minutes. The maximum NVS score is 6 points, with each correct answer getting one point.

The exercise to test participants' response time and facility with simple math process involved two arithmetic tasks from the French-Kit (addition, and addition and subtraction-correction test). To avoid anxiety, participants were not informed that the exercise was timed although each exercise was supposed to take 2 minutes. In the addition exercise, participants wrote solutions to a set of arithmetic problems. Each correct answer was awarded 1 mark. In the second exercise, participants were asked to mark "C" (correct) or "I" (incorrect) beside each answer of the math problem. The score for this exercise was the number of items marked correctly minus the number marked incorrectly.

The final exercise was the think-aloud. Participants were given information on diabetes diet involving whole numbers and fractions. The problems were developed from diabetes information from the Canadian Diabetes Association website, and involved five items that included simple addition, division and/or multiplication. The task was to calculate the daily diet intake of a mother who had diabetes. Participants were asked for permission to be audio-recorded as they did the exercise, because they were supposed to "think aloud" as they solved the problems. If a participant was silent, the researcher politely reminded him of her to "think aloud". Study participants were advised to focus on solving the problem and to only express their thoughts verbally. The recording from the think-aloud exercise were transcribed and analyzed and the results were used to develop the think-aloud task for the main study.

4.1.2.2 Group Discussion

The group sessions were held on separate days for the Kikuyu- and Mandarin-speakers. The sessions were held in a comfortable and well-lit room at the University of Waterloo. Participants were welcomed into the room and asked to pick a name tag. They were asked to write down one name that they wished to use in the session. They were also asked to pick a drink, i.e., water or juice and an apple and then take their seats.

The moderator thanked them for attending this session and reminded them that they would be discussing the activities that they had done individually in the previous session. They were asked to freely express their feelings and were assured that the discussions were confidential. They were also informed that the objective of the discussion was to improve the interview exercise for others who would be taking part in the main study, and that feedback was very important. To ensure correct record of the proceedings, the moderator asked for their permission to audio-record the discussion. The participants agreed and each of them signed the consent form.

The discussions began immediately after that. The group discussion guide is presented in Appendix D.

4.1.3 Results and Conclusion

Overall, participants did not have concerns about the general information questionnaire once they understood why the questions were being asked. As a result of the pilot study, two items were added to find out what language participants used when they interacted with fellow community members and with their family members. The student researcher felt that would provide information on what language participants used in various settings and provide information about their level of integration into the Canadian society.

4.1.3.1 The Newest Vital Signs

The main issues about the NVS hinged on the relevance and familiarity with nutrition labels among Mandarin-speakers. They pointed out that they were not familiar with the various terms used on nutrition labels. They also noted that they paid little attention to nutrition labels because they purchased wholesome foodstuffs from Chinese stores. With regard to the administration of the instrument, participants had a problem following the interviewer as he read the NVS question. Participants preferred being given the questions to read for themselves, alongside the interviewer. The following is the excerpt on the proceedings of the group discussion with the Mandarin-speaking group.

Moderator: What did you think about this exercise?

Voice 5: I remember you gave me that on… (NVS)...we specialize in Chinese... I am not specializing in this...confusing

Voice 2: In Chinese we cook natural...vegetables...less people eat that canned food...we do not read that label... we rarely buy those things.

Moderator: Thank you... that was our next item. I am glad you have introduced it... what do you think we can improve in this? Something you think we can do to make it better for other people?

Voice 5: I think the questions are enough

Voice 4: (Speaking in Chinese ...)

Moderator: Please say that in English so we can all understand what you are saying...

Voice 3: Some people can read...others cannot read...

Voice 2: It's ok for me...but we don't focus on that when we buy things...

Moderator: What about some of the Chinese who are training people in nutrition...don't they tell people about this?

Voice 2: Every time I buy veggies, we always buy fresh...the Chinese food...we use veggies and meat... different from our lifestyle

Voice 3: I have started reading that because my husband has cholesterol...my doctor suggested he joins a class to study...first time he came and taught me about that label...sometime my son comes from school and tells me about this label?

Moderator: So, what did you find very hard... was this making sense to you?

Voice: Yes

Moderator: What was very hard about this exercise?

Voice 2: The exercise is not hard...but the exercise is not familiar to us...

Voice 4: I have a question...when you read I cannot understand...

Moderator: Thank you...I have been told that I speak very first...

Voice 4: The question is very long...Question 5...

Voice: would it be helpful if you had the questions printed for you?

Voices: yes...

Moderator: Thank you...thank you very much...

Is there something else you would like to say?

Voice: 5 Chinese culture is very different...we need to pay more attention to this information...we need to learn to...

Voice 1: We do things by instinct...we rarely use specific measurements...

The Kikuyu-speaking group's concerns about the NVS included unfamiliarity with nutrition labels, and lack of interest. Two relevant comments are presented below.

Voice 1: I think what they show...they indicate the exact presentation...and unless you know how to decipher it, it is of no use to you at all...so if you go through this instead of panicking...if you do not know then you do not know...the questions are good...people realize, I see this every day but I have no idea what it is...unless you are in the medical field.

Voice 2 : The way I look at it, I have only seen somebody start paying attention to this table because of something...somebody goes for medical check-up, and then the doctor starts complaining about cholesterol and calories, then they single out daily calories...

4.1.3.2 S-TOFHLA Numeracy Component

Most participants did not have any concerns with the S-TOFHLA numeracy components. However, during the individual interviews, three participants (one Mandarin- and two Kikuyu-speakers) had difficulties removing themselves from the context and thought the question on blood sugar referred to their personal health status.

One Kikuyu-speaker had this to say:

> *Voice 4: I think the purpose for this is to show how easy it is for people to get confused...you might assume...for me I had to read again to get it...especially when you are rushed...is it my blood sugar…?*

4.1.3.3 S-TOFHLA Literacy Component

On the S-TOFHLA literacy component, one Mandarin-speaking participant felt that the exercise had many unfamiliar words and wanted to know if the words could be replaced. Another Mandarin-speaking participant felt that the instructions were not clear. Consequently, in the larger study words like Medicaid and TANF were replaced with OHIP and "extra health insurance" to reflect the Canadian context.

4.1.3.4 Subjective Numeracy Scale (SNS) and Mathematics Self-Efficacy Scale (MSES)

There were no difficulties or concerns raised by the pilot study participants with the SNS. Most participants were also comfortable with the MSES, although two Mandarin-speakers had difficulties understanding some phrases such as "mark-down". This was later replaced with "discount". Another Mandarin-speaker did not see the relevance of the instruments in the health context. However, it was explained that the instrument was used to help individuals to assess their own confidence in the use of numbers. One Kikuyu-speaker commented on the range of the scale:

> *Voice 4: The graduations are very many...each category had many options...for example: little confidence has three choices…*

However, the range could not be changed without compromising the character of the instrument and was used in the main study as originally developed by the originators of the scale.

4.1.3.5 French Kit

With regard with to the French-Kit addition, and addition and subtraction-correction exercises, participants thought the two exercises needed to be shortened. One Kikuyu- and one Mandarin-speaker wanted the addition and subtraction-correction exercise to be modified. Another one wanted the addition problems to be separated from the subtraction problems in the recognition test. One Mandarin- and one Kikuyu-speaker felt there were too many for them to solve and the number of items needed to be reduced. However, these changes were not possible because this would again compromise the character of the instruments. To minimize math anxiety due to timing, instructions on timing in the two instruments were deleted.

4.1.3.6 Think-aloud Exercise

The think-aloud task generated some useful feedback especially from the Mandarin-speakers. The task concerned diabetes and involved adding the grams for individual food items, and calculating the total daily dietary intake. One participant had a problem with the word “diabetes”. Others suggested that diabetes be described as the “disease that makes a person’s blood have more sugar than it should” to make it is easier to understand. The following is the Mandarin-speakers discussion on the think-aloud task. Kikuyu-speakers did not have any concerns with the task.

Moderator: Let us go to question number 2. What do you think about that question?

Voice 6: This is a good question…but what is diabetes?

Moderator: Diabetes is just a disease…what should we call it?

Voice 4: Instead of using the word "diabetes" describe it as a "disease in which the person needs to control the sugar in the blood".

Voice 5: (Speaking in Chinese). That is what it means…sugar in the blood.

Moderator: Is the word sugar common? Do people understand what sugar is?

Voices: Yes…it is understood

Moderator: Is that all?

Voices: yes

In summary, the feedback from the pilot study was useful in improving the quality of the instruments and the interviewing process during the main study which is described in the remaining part of this thesis.

4.2 Main Study: Study 1 and 2

4.2.1 Study Sample

Studies 1 and 2 involved 120 participants, comprising 60 Kikuyu-speaking and 60 Mandarin-speaking immigrants to Canada. The two groups have characteristics relevant to this study, namely, they speak English as a second language, and they differ in number word system and structure, and in the numeric concepts embedded in their primary languages. Mandarin has its own numeric (number and number word) system and also includes the concepts of whole numbers and fractions. In contrast, Kikuyu has whole number concepts but lacks a written number and number word system, and fractions. These distinctions make the two language groups ideal for investigating how primary language influences comprehension of numeric health information.

The decision on the sample size was based on comparisons of samples used in the few available studies on numeracy among Chinese and non-Chinese people in Canada. Campbell and Xue (2001) had a total of 72 participants enrolled in a study that explored the sources of cross-cultural differences in arithmetic performance among young adults. These researchers compared arithmetic performance between 24 Canadian university students of Chinese origin (CC), 24 of non-Asian origin (NAC) and 24 Chinese university students who were educated in Asia (AC). The

Asian Chinese subjects (AC) outperformed non-Asian subjects (NAC) (Mean = 177, SD 45.6; and 112, SD=35.1 respectively, $p < 0.01$). The means and the standard deviations were used to calculate the effect size for this study. Cohen's d ($d = \bar{x}_1 - \bar{x}_2/S$ pooled) was 1.597 implying there was a difference of 1.597 standard deviations between the mean score of Chinese-Canadians and non-Asian Canadians. In another study, Lefevre and Liu (1997) involved a total of 40 Canadian and Chinese participants to investigate the role of experience in numerical skills. The mean correct scores for one of the tasks, the French Kit were 120.6 for the Chinese (n=20), and 91.5 for the non-Chinese samples (n=20), t (36) =4.29. SE=6.8 ($p < 0.05$). Lefevre and Liu's findings implied a difference of 1.353 standard deviations in the performance of the two groups, with the Chinese students performing better than the non-Chinese students.

Todd and Hoffman-Goetz (2010) investigated whether comprehension of colon cancer prevention information predicted health literacy among older Chinese immigrants in Canada who were speakers of English-as-second-language (ESL). The study involved 106 Cantonese-speaking participants. The mean score for S-TOFHLA was 18.1 (out of 36) with a standard deviation of 10.6. Findings were that presentation of cancer information using an individual's first language improved health literacy. Based on these studies, assuming a medium effect size

(Cohen's f^2=.15) and an α level of 0.05 and a power of 0.80 (Green, 1991) resulted in a sample of 120 participants for the main study.

4.2.1.1 Recruitment and Ethics Approval

As noted in the pilot study description, participants were recruited from southern Ontario urban centres, drawing members or visitors of churches, temples, and recreational centres. Posters (Appendix B) were placed on bulletin boards in places of worship and at community centres. The poster for the Chinese participants was translated into Mandarin. There was no need for a Kikuyu translation because the Kikuyu were assumed to be fluent in English as a result of coming from a country where English is one of the official languages.

The most effective means of recruiting participants from both groups was personal contacts through a respected member of the respective community. For example, an individual who was knowledgeable about the social activities of the Chinese community in Kitchener-Waterloo region helped in contacting and in recruiting community leaders for the study. These initial contacts were requested to and they agreed to help recruit others from the community, and through this snowball strategy more potential participants were identified (Berg, 2009). All Mandarin-speaking participants were recruited from Kitchener-Waterloo region of southern Ontario, Canada. However, there were few Kikuyu-speakers in Kitchener-Waterloo region. Therefore most of them were recruited in the Greater Toronto Area (GTA), and a few were from Hamilton and Niagara region. The same method of identifying key people in the community to help recruit others (as was done with Mandarin-speakers) was used. All potential participants were sent the information letter (Appendix A).

Participants were included if they were 1) immigrants to Canada with fewer than 15 years residency; 2) bilingual (speak Kikuyu or Mandarin, and English); 3) able to read, speak and write in English, and in their primary language; and 4) 40 years or older. Participants were asked if they were being treated or had been treated for any chronic diseases (e.g., diabetes, cancer, heart disease). Only participants who were not on any treatment currently or who had not been treated in the past were included in the study. Each participant signed the consent form (Appendix C) before the interview session began. Each participant received a small honorarium of $30 in appreciation his or her time. The University of Waterloo Research Ethics Board gave full ethics approval for the study.

4.2.2 Data Collection

Sociodemographic data were collected using a general information questionnaire which was adapted from published research on English-as-a-second language-speaking populations in southern Ontario. This questionnaire has been used previously by the student researcher's supervisors (Todd & Hoffman-Goetz, 2010). The questionnaire included items on participants' age, gender, education achievement, income, employment, and years of residency in Canada. The questionnaire was modified to include items on language used for elementary mathematics instruction, language spoken in different situations, and the preferred language when speaking with health care provider. It also included items on participants' perceived abilities in numeric formats such as whole numbers, fractions and percentages. Two versions of the questionnaire were developed to make the questions relevant to Kikuyu-speaking and the Mandarin-speaking groups. The two versions are included in Appendix E. The questionnaire was pretested in the pilot study as noted earlier.

For study 1 that examined the role of primary language in the comprehension of numeric health information among Kikuyu-speaking and Mandarin-speaking immigrants, the following instruments were used to collect data: 1) the Kit of Factor-

Referenced Cognitive Tests (French Kit); 2) the Short-test of Functional Health Literacy in Adults (S-TOFHLA); 3) the Newest Vital Sign (NVS).

Study 2 was an examination of the effect of mathematics self-efficacy on numeracy (using the French Kit addition, and addition and subtraction-correction tasks) and health numeracy (using the S-TOFHLA numeracy component and the NVS). Mathematics self-efficacy was assessed using two instruments: the Mathematics Self-Efficacy Scale (MSES) and the Subjective Numeracy Scale (SNS).

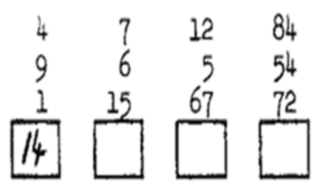
Study 3 examined the processing of numeric heath among the ESL participants. Data was collected using the French Kit (addition subtraction-correction task) and the diabetes diet information task which was developed specifically for the think-aloud exercise.

For all studies, data collection took place in the privacy of a quiet, easy-to-access room. For Mandarin speakers most for the interviews took place at the university. For Kikuyu speakers, interviews took place in private rooms provided at community centres, and in private offices provided free of charge by some of the participants. All interviews took approximately 1 hour and 30 minutes.

The order of testing of the French Kit, S-TOFHLA, NVS, MSES and the SNS were randomly assigned to reduce potential order effect bias. Background information on the instruments was presented in Chapter 2. The sociodemographic questionnaire was always given first and the think-aloud task was always given last. The following section provides a detailed description of the instruments used in the 3 study components.

4.2.2.1 Measuring Numeracy

Two French Kit tasks, (the addition task, and the addition and subtraction correction tasks) (Ekstrom et al., 1976) were used in study 1 and 2 to assess context-free numeracy skills. The addition test comprises 60 sets of 1- or 2 -digit addition problems. Participants were required to provide answers to the vertically arranged problems as shown in the example below.



The objective was to test participants' speed and accuracy in simple addition tasks. Following the developer's guidelines, the test was timed at 2 minutes, and the score was the number of correct items that were added correctly.

Similar to the addition test alone, the addition and subtraction correction test involved 60 problems. However, unlike the addition test, the problems in the addition and subtraction-correction test are already solved, and answers provided beside the problem. Participants were only required to indicate whether the answer provided for each problem was correct or incorrect by marking the "C" (correct) the "I" (incorrect). An example is shown below.

11 + 23 = 34	C	I
35 – 10 = 20	C	I

Following the developers' instructions, the test was timed at 2 minutes, and the score for this test was the number of the correct answers, minus the incorrect answers. For both tests participants were not informed in advance about the timing to avoid creating anxiety which is known to happen with timed mathematics tasks (Ashcraft & Moore, 2009). The interviewer discreetly monitored the time and after the 2 minutes elapsed informed the participant that what he/she had done was adequate, and that he/she needed to stop. The French Kit tests (addition and addition and subtraction-correction) are shown in Appendix J.

4.2.2.2 Measuring Health Numeracy

For study 1, two instruments were used to measure healthy numeracy: The Short Test of Functional Health Literacy for Adults (S-TOFHLA) (Baker et al., 1999), and the Newest Vital Signs (NVS). The total S-TOFHLA comprises 36-items literacy/prose component (with a weighted score of 72). Participants were provided the two passages that constitute the S-TOFHLA literacy component. Passage A contains instructions on preparation for a gastrointestinal X-ray procedure and Passage B deals with patients' rights and responsibilities. Participants were instructed to carefully read the passage and to use any of the 4 words to fill the blank spaces in order to complete and make the sentence make sense. Although the task was timed at 7 minutes, to avoid stress, participants were not informed of the timing. The interviewer keenly watched the progress and marked the point at which the 7 minutes elapsed. Any work after that point did not count for this task.

The S-TOFHLA numeracy component comprises 4 items which, according to the developers were selected based on perceived importance and frequency in health care settings. The S-TOFHLA numeracy measure includes information on a prescription bottle, information on blood sugar, and information on a doctor's appointment card. Participants were asked to read this information and use it to verbally answer questions that the interviewer asked. An example of information on a prescription bottle is: *Take one tablet by mouth every hour as needed.* The interviewer then asked the question: *If you take your first tablet at 7:00 a.m., when should you take the next one?* The expected answer was: *1:00 p.m.* The task was timed at 4 minutes. Each of the questions has a weighted score of 7 for a total S-TOFHLA numeracy score of 28. Sample S-TOFHLA prose/literacy questions, and all the numeracy questions are presented in Appendix I.

The Newest Vital Signs (NVS) (Weiss et al., 2005) was the second instrument used to measure health numeracy/literacy. The NVS involves comprehension of information on an ice cream nutrition label. However, the numeric and prose/literacy components of NVS overlap and require participants to answer numeracy questions within a prose context. Following the instructions on the administration of the NVS, participants were given a copy of the nutrition label, and also a copy of the questions in line with their wishes during the pilot study. This helped them to refer to both documents as the 6 questions were being verbally asked. Having a copy of the questions helped them to better understand the questions because of language and accent differences between the interviewer and the participants. The task took about 3 minutes to administer. A score of below 4 in the NVS indicates inadequate health numeracy/literacy. The NVS instrument items are presented in Appendix H.

4.2.2.3 Measuring Math Self-efficacy

Participants' mathematics self-efficacy was assessed in study 2 using the Mathematics Self Efficacy Scale (MSES) and the Subjective Numeracy Scales. In the MSES (Betz & Hackett, 1993) participants were asked to assess their math self-efficacy using a 10 point scale (0 = no confidence; 9 = complete confidence). An example of an MSES test item is *"How much confidence do you have that you could successfully: Add two large numbers in your head?"* The test took about 10 minutes to administer. The MSES score was obtained by summing up the response numbers for each item and dividing the sum by the number of items. For example, if the participant's response was "6" (much confidence) to all the 18 items, the total sum of 108 was divided by 18 to yield an average score of "6".

The 8-item Subjective Numeracy Scale (SNS) assesses individuals' perception of their mathematical abilities and preference for numerical information (Fagerlin et al., 2007). The test uses a Likert scale from 1- 6. The SNS test includes questions such as *"How good are you at figuring out how much a shirt will cost if it is 25% off?"* and *"When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?* SNS took about 5 minutes to administer. Following the developers recommendation, all questions except question 7 were scored on a Likert-Scale from 1- 6. Question 7 was reverse coded (6 - 1). The composite SNS score was the average rating across the 8 questions, with question 7 reverse coded. SNS ability subscale score was the average rating on questions 1- 4 and the SNS preference subscale score was the average rating for questions 5- 8 (question 7 reverse coded)

Both the MSES and the SNS were administered and responded to by participants in print form rather than orally. The MSES and the SNS are presented in Appendices F and G, respectively.

4.2.3 Data Analysis

Data in study 1 and study 2 were analyzed using SPSS (Version 20.0). Sociodemographic characteristics of participants (for example, gender, age, education, language of mathematics instruction, language spoken as a child, language spoken in different situations) were summarized. For study 1, the means of the numeracy measure (French Kit) and of the S-TOFHLA and NVS by language groups were examined for differences using the Mann-Whitney *U* test. The Mann-Whitney *U* (a nonparametric test) was used because the data did not meet the assumption of normality, and homogeneity of variance, and because of the small size of the study sample (Field, 2005).

Multiple regression analyses were conducted to test if language predicted numeracy, health numeracy and health literacy, after adjusting for sociodemographic factors (gender, age, and education, duration of residency in Canada, employment, and income). Using forward and stepwise methods all variables that had a *p* value of 0.05 were identified and forced into the final regression models. Gender was retained in all models.

In study 2 the means of the self-efficacy measures (MSES and SNS), numeracy measures (French Kit) and health numeracy (numeracy component of S-TOFHLA) of the two groups were examined for differences using the Mann-Whitney *U* test. Spearman correlation was used to test relationships between MSES and SNS. Multiple regression analyses were conducted to determine if math self-efficacy contributed to numeracy and health numeracy skill after adjusting for the socio-demographic factors (age, gender, language, length of residency in Canada, education and format of numeric health information).

4.3 Study 3: Assessing Processing of Numeric Health Information

4.3.1 Participants

Study 3 was qualitative in methodology using the think-aloud method to collect verbal data from a subsample of 20 Kikuyu-speaking and 20 Mandarin-speaking participants. The subsample was drawn from the larger sample of 120 participants who participated in studies 1 and 2. Although this sample is small, it was considered adequate to generate data for a think-aloud process. Virzi (1992) demonstrated that on the average, nine participants are required to gather enough information on usability problems. The author suggested that 80% of usability problems are identified by four-to-five participants, and participants beyond five are less likely to provide more information. Hoppman (2009) involved ten experts to explore the information needs of small and medium-sized enterprises in Germany. The study involved examining properties of websites, information searching process, and changes of moods during the Internet search. This researcher reported that the ten experts were sufficient to detect problems they had when searching for information on the websites used. In another study, twenty-four participants were recruited to explore the validity of verbal protocols (Russo & Johnson, 1989).

Decision on the number of participants followed Hoppmann's (2009) suggestion of 10 to 30 participants for studies that have a quantitative component.

The 40 participants (men and women in equal numbers) were selected because they had performed either at the top ten or at the bottom ten in the French-Kit addition and addition subtraction-correction task. Study 3 was an exploration of intuitive and analytical problem solving approaches, and the addition and subtraction-correction is ideal because it is a recognition/associative task that taps information in the long-term memory. The participant either knows or does not know the answers in this task.

Others have used performance in French Kit tasks to select a subsample from a bigger sample of participants. For example, from a sample of 143 undergraduate students, Núñez-Peña et al, (2011) selected nineteen high numeracy individuals who had scored above the third quartile, and eighteen low numeracy individuals who had scored below the first quartile in the French Kit addition task. The smaller sample was then involved in a study on problem size effect.

4.3.2 Data Collection

Study 3 was an assessment of participants' dominant approach (intuitive or analytical) when processing numeric health information. Data was collected using the think-aloud method. The exercise involved calculating the number of grams a diabetic mother ate within one day. The exercise involved 5 items tapping different skills. Item 1 and 3 tapped simple addition or multiplication skill, item 2, 4 and 5 tapped conversion of fractions (using either multiplication or division) and addition skills. Participants were required to calculate the total number of grams for each food item; they were also required to provide the final figure showing the total number of grams the mother ate in a day. Participants were informed and shown how to think-aloud, or speak out their thoughts as they solved the problem. They were also specifically instructed not to describe or to explain what they were doing (Austin & Delaney, 1998; Russo, Johnson, & Stephens, 1989). The focus was on the process of arriving at the final number of grams. The instructions were simple and clear, and written for reading level 6 (SMOG readability formula: http://www.harrymclaughlin.com/SMOG.htm). The diabetes management task used for problem solving is presented in Appendix K.

4.3.3 Data Analysis

Quantitative data (numeracy scores from the French Kit) were analyzed and frequency distributions summarized for performance on the French Kit and on the processing of numeric information. Since study 3 involved a small sample, and the data was not normally distributed, the nonparametric Mann-Whitney's *U* test was used to examine the differences in the means for the French Kit, and for differences in response time on the diabetes task.

Qualitative data comprised protocols of participants' verbal data recorded as they solved the diabetes diet problem. Protocols were analyzed using NVivo 10 (QSR International Pty, 2012), a qualitative data analysis software. Protocols are a "record of the subject's ongoing behavior, and an utterance at time *t* is taken to indicate knowledge or operation at time *t*" (Kuipers & Kassirer, 1984, p. 367). Protocols reveal the specific aspects of what participants are concentrating on as they solve a problem (Lundgrén-Laine & Salanterä, 2010). An individual with expertise in transcribing verbal data transcribed the verbal scripts. The transcribed protocols and the written scripts were matched and data were segmented as complete thoughts (Trickett & Trafton, 2009) which were then coded based on Schoenfeld's episodes or behaviours (read, explore, plan, implement, plan-implement and verify) (Schoenfeld, 1985). Inter-rater reliability was assessed by having two individuals independently code 20 protocols and reach a substantial level of agreement (Cohen's kappa = .81). The time spent solving the diabetes problem was used to determine intuitive or analytical processing; the shorter the time the more intuitive and the longer the time the more analytic the processing was deemed to be.

Chapter 5

Results

5.1 Sociodemographic Characteristics of Participants

There were more women than men (*n* = 73, 61%). The age of most participants was between 40 and 66 years. To break this down, *n* = 88 (73%) were between 40 and 50 years old; *n* = 19 (15.8%) were between 51-55 years old; *n* = 5(4.2%) were between 56-60 years; *n* = 5 (4.2%) were between 61-65 years, and the rest (*n* = 3, 2.5%) were over 66 years. More Mandarin-speakers had a university or postgraduate education (*n*=43, 71.6%) compared to Kikuyu-speakers (*n* = 23, 38.3%). Most Kikuyu-speakers (*n* = 42, 70%) received mathematics instruction (post grade 3) in English whereas only 14 received primary mathematics education in Kikuyu. In contrast, all Mandarin-speakers received their mathematics instruction in Mandarin. More Kikuyu-speakers were recent immigrants to Canada (about 28% having emigrated < 5 years ago) compared with Mandarin-speakers (15% having emigrated < 5 years ago). Table 1 shows the general demographic characteristics of participants.

Table 1: General demographic characteristics of participants

		Kikuyu-speakers %(*n*)	Mandarin-speakers %(*n*)
Gender	Men	35.0(21)	43.0(26)
	Women	65.0(39)	57.0(34)
Age	<50 years	76.7(46)	70.0(42)
	≥50 years	23.3(14)	30.0(18)
Education	High School or less	18.6(11)	1.7(1)
	>High School and <University (e.g., technical training)	42.4(25)	25.4(15)
	University degree	18.6(11)	42.4 (25)
	Graduate degree	20.3(12)	30.5(18)
Employment	Not employed	25.0(15)	25.0(15)
	Employed	75.0(45)	75.0(45)
Income (Canadian $)	< $14,999	28.3(17)	30.0(18)
	$15,000 - 34,999	15.0(9)	21.7(13)
	$35,000 - 54,000	18.4(11)	18.3(11)
	$55,000 - 75,000	21.7(13)	10.0(6)
	>$75,000	11.7(7)	16.7(10)
Residence in Canada	<5 years	28.3(17)	15.0(9)

n/a = not applicable; percentages may not total 100% due to missing responses

5.2 Language used by English-as-a-second Language Participants

5.2.1 Language of Mathematics Instruction

Table 2 presents the language used in the education system of the participants' country of origin, and duration since participants studied mathematics in their primary language and in English. More Mandarin- (93%) than Kikuyu- (23%) speakers learned mathematics in their primary language. For the majority of participants (Mandarin 93% and Kikuyu 92%), it was more than 10 years since they studied mathematics in their primary language.

Table 2: Language used in mathematics

		Kikuyu-speakers %(n)	**Mandarin-speakers %(n)**
Language of math instruction	Kikuyu	23.3(14)	n/a
	Mandarin	n/a	98.3(59)
	English	70.0(42)	0.0
	Others	5.0(3)	1.7(1)
Last studied math in primary language	<10 years ago	7.8(4)	6.9(4)
	≥ 10 years ago	92.2(47)	93.1(54)

5.2.2 Language used at Home

All participants had lived a large part of their lives in their home countries. It was expected that extended living in their home countries would make them highly proficient in their primary language, and in the use of numeric concepts embedded in the languages. As shown in Table 3 most of the participants (about 87% and 92% for Mandarin and Kikuyu, respectively) spoke their primary language when they were children. Only about 13% of the Kikuyu-speakers spoke both English and Kikuyu as children. Even fewer of the Chinese participants, (5%) spoke both Mandarin and English when they were children. The dominant language that the parents of Kikuyu participants spoke to them as children was Kikuyu (100% for mothers and about 98% for fathers.) The same applied to Mandarin speaker (95% for both mothers and fathers). It was expected that use of primary language would be extended to Canada. Results showed that 85% of the Kenyan, and 98% of Chinese participants spoke their primary language (Kikuyu or Mandarin) at their homes in Canada. Only about 12% of the Kikuyu participants spoke English at home; about 2% of the Chinese participants spoke languages other than Mandarin, such as Mongolian.

Table 3: Language used at home

		Kikuyu-speakers	Mandarin-speakers
Primary language spoken at home	Kikuyu	85.0(51	n/a
	Mandarin	n/a	98.3(59)
	English	11.7(7)	-
	Other	3.3(2)	1.7(1)
Language spoken as a child	Kikuyu	86.7(52)	n/a
	Kikuyu and English	13.3(8)	n/a
	Mandarin	n/a	91.7(55)
	Mandarin and English	n/a	5.0(3)
	Other	-	3.3(2)
Language mother spoke	Kikuyu	100.0(60)	n/a
	Mandarin	n/a	95.0(57)
	Other	-	5.0(3)
Language father spoke	Kikuyu	98.3(58)	n/a
	Mandarin	n/a	95.0(59)
	English	1.7(1)	-
	Other	-	5.0(3)

5.2.3 Language Used in Different Situations in Canada

Table 4 shows the language participants used in various situations in Canada such as at the grocery store when adding prices, at the gas station, when calculating tips at the restaurant, when counting things, and when remembering phone numbers. Also in the table is information on language spoken with friends and family. As shown, in Table 4, 20% of the Kikuyu- speaking compared to 50% of the

Mandarin-speaking participants used their primary language when adding the price of groceries at the store. A larger proportion of Kikuyu-speakers used mainly English (about 46%) or both English and Kikuyu (about 32%) when adding prices of groceries. In contrast, fewer Mandarin-speakers (about 23%) used mainly English, and another 25% used both English and Mandarin to add the price of groceries.

Overall, except when speaking with family members, Kikuyu participants spoke mainly English in all situations; Mandarin participants spoke mainly Mandarin. This could suggest that due to the small population of Kikuyu-speakers in Canada, Kikuyu-speakers may not have the opportunities for regular use of their primary language.

Table 4: Language used in different situations

		Kikuyu-speakers	Mandarin-speakers
Adding price of groceries	Mainly Kikuyu	20.0(12)	n/a
	Mainly English	46.7(28)	23.3(14)
	Kikuyu and English	31.7(19)	n/a
	Mainly Mandarin	n/a	50.0(30)
	Mandarin and English	n/a	25.0(15)
Calculating price of gas	Mainly Kikuyu	11.7(7)	n/a
	Mainly English	55.0(33)	28.3(17)
	Kikuyu and English	21.7(13)	n/a
	Mainly Mandarin	n/a	43.3(26)
	Mandarin and English	n/a	21.7(13)
Calculating tip at restaurant	Mainly Kikuyu	18.3(11)	n/a
	Mainly English	55.0(33)	30(18
	Kikuyu and English	25.0(15)	n/a
	Mainly Mandarin	n/a	40.0(24)
	Mandarin and English	n/a	28.3(17)
Counting things	Mainly Kikuyu	16.9(10)	n/a
	Mainly English	58.3(35)	13.6(8)
	Kikuyu and English	23.2(14)	n/a
	Mainly Mandarin	n/a	56.7(34)
	Mandarin and English	n/a	28.3(17)
Remembering phone numbers	Mainly Kikuyu	17.2(10)	n/a
	Mainly English	62.1(36)	13.3(8)
	Kikuyu and English	19.0(11)	n/a
	Mainly Mandarin	n/a	60.0(36)
	Mandarin and English	n/a	26.7(16
With friends	Mainly Kikuyu	66.7(40)	n/a
	Mainly English	15.0(9)	-
	Kikuyu and English	18.3(11)	n/a
	Mainly Mandarin	n/a	96.7(58)
	Mandarin and English	n/a	3.3(2)
With family	Mainly Kikuyu	51.7(31)	n/a
	Mainly English	20.0(12)	-
	Kikuyu and English	25.0(15)	n/a
	Mainly Mandarin	n/a	93.3(56)
	Mandarin and English	n/a	5.0(3)

5.2.4 Language used in Health Care Settings

Table 5 shows the language used and the preferred language when speaking with a doctor. About 87% and 70% of the Kikuyu- and Mandarin-speaking participants spoke English with their doctors. However, 20% of the Mandarin-speakers spoke Mandarin with their doctors; only about 7% spoke Kikuyu and another 7% spoke both English and Kikuyu with their doctors. Over 70% of Mandarin-speakers indicated that they would prefer to speak Mandarin with their doctors, with another 18% preferring both English and Mandarin. Among Kikuyu-speakers, 58% indicated that they preferred to speak English, and 30% indicated that they preferred both languages when speaking with the healthcare provider.

Table 5: Language use in health-care setting

		Kikuyu-Speakers	**Mandarin-speakers**
Language spoken with doctor in Canada	Kikuyu	6.7(4)	n/a
	Kikuyu and English	6.7(4)	n/a
	Mandarin	n/a	20.0(12)
	English	86.7(52)	70.0(42)
	Other	-	5.0(3)
Language preferred with doctor in Canada	Kikuyu	10.0(6)	n/a
	English	58.3(35)	10.0(6)
	Kikuyu and English	30.0(18)	n/a
	Mandarin	n/a	71.7(43)
	Mandarin and English	n/a	18.3(11)

5.3 Participants' Self-assessment of Their Facility with Numbers

Table 6 presents participants self-reported ability to use different numerical formats in English and in their primary languages. A significant proportion of Kikuyu (about 73%) and Mandarin (about 97%) speakers reported that they enjoyed learning mathematics in school. Over 86% of Kikuyu-speakers felt that they were good in using numbers in English compared to 70% Mandarin-speakers. However, Mandarin-speakers (about 97%) were more proficient in numbers in their primary language compared to Kikuyu-speakers (about 77%). Overall, a large proportion of Kikuyu-speakers reported themselves as being good in mathematic tasks presented in English. Such tasks include addition and subtraction tasks (about 92%), working with proportions (90%), percentages (78%) and fractions (80%). Their "good" responses were lower when some of the tasks were presented in their primary language, except for proportions where responses were high. For instance, they reported that in their primary language they were good in addition and subtraction (about 73%), percentages (about 55%), in fractions (about 54%), and in proportions (90%). Their reported ability in proportions, percentages and fractions was surprising because the Kikuyu language does not have these concepts in its lexicon (Leakey, 1977).

Overall a large proportion of Mandarin-speakers were good in numeric formats in both English and their primary language. In English they were good in addition and subtraction (70%), in proportions, (81%), in percentages (81%) and in fractions (85%). In their primary language they reported being good in addition and subtraction (about 98%), in proportions (81%), in percentages (about 97%) and in fractions (93%).

Table 6: Participants self-assessment of facility with numbers

		Kikuyu-speakers	Mandarin-speakers
Did you enjoy learning math?	Yes	73.3(44)	96.7(58)
	No	26.7(16)	3.3(2)
Ability in numbers in English	Good	86.4(51)	70.0(42)
	Poor	13.6(8)	30.0(18)
Ability in numbers in primary language	Good	76.5(39)	96.7(58)
	Poor	23.5(12)	3.3(2)
Ability to add, subtract in English	Good	91.7(55)	70.0(42)
	Poor	8.3(5)	30.0(18)
Ability to add, subtract in primary language	Good	72.9(43)	98.3(59)
	Poor	27.1(16)	1.7(1)
Ability in proportions in English	Good	90.0(54)	81.4(48)
	Poor	10.0(6)	18.6(11)
Ability in proportions in primary language	Good	90.0(54)	81.4(48)
	Poor	10.0(6)	18.6(11)
Ability in percentages in English	Good	78.3(47)	81.7(49)
	Poor	21.7(13)	18.3(11)
Ability in percentages in primary language	Good	54.9(28)	96.7(58)
	Poor	45.1(23)	3.3(2)

Ability in fractions in English	Good	80.0(48)	85.0(51)
	Poor	20.0(12)	15.0(9)
Ability in fractions in primary language	Good	53.8(28)	93.3(56)
	Poor	46.2(24)	6.7(4)
Preferred format for numeric health information	Numbers only	6.8(4)	11.9(7)
	Numbers and detailed explanation	93.2(55)	88.1(52)

5.4 Participants Self-assessment of the Facility with Numeric Health Information

The results (Table 7) also showed that most Kikuyu and Mandarin participants (about 77% and 80% respectively) sometimes had difficulties with numeric health information. More Kikuyu-speakers (58.3%) than Mandarin-speakers (38.3%) needed help to understand numeric health information.

Table 7: Self-assessment of facility with numeric health information

		Kikuyu-speakers	**Mandarin-speakers**
Problems understanding numeric health information	Always	3.3(2)	1.7(1)
	Sometimes	76.6(46)	80.0(48)
	Never	18.3(11)	18.3(11)
Action taken to understand numeric health information	Able to understand	39.0(23)	61.7(37)
	Ask for help to understand	58.3(35)	38.3(23)

5.5 Who Makes the Decision to See the Doctor?

When unwell (Table 8), more than ⅔ of participants (about 70% Kikuyu and 67% Mandarin) made the decision (on their own) to see a doctor. When the spouses/partners needed to seek medical help, more Mandarin (30%) than Kikuyu (9%) participants had the decision made for them and in other cases, the spouse/partner (on his/her own) made the decision (about 31% Kikuyu and 27% Mandarin) to see a doctor. In some other instances, both the participant and the spouse/partner made the decision. When a child took ill, both partners made the decision to seek medical help (53% Kikuyu and 48% Mandarin) although a number of participants made the decision without involving their spouses/partners (30% Kikuyu and 37% Mandarin).

Table 8: Decision to see a doctor

		Kikuyu-speakers	Mandarin-speakers
Decision to see doctor: Own	Respondent	69.5(41)	66.7(40)
	Spouse/partner	1.7(1)	10.0(6)
	Both(Respondent and partner	25.4(15	23.3(14)
	Another family member	3.4(2)	-
Decision to see doctor: Spouse	Respondent	8.5(5)	30.0(18)
	Spouse/partner	30.5(18)	26.7(16)
	Both(Respondent and partner	44.1(26)	36.7(22)
	Another family member	-	3.3(2)
Decision to see doctor: Child	Respondent	30.0(21)	36.7(22)
	Spouse/partner	1.7(1)	5.0(3)
	Both(Respondent and partner	53.3(32)	48.3(29)
	Another family member	-	3.3(2)

In summary, between the two groups, more Mandarin-speakers than Kikuyu-speakers who took part in this study made decisions for their partners when the partners needed to see a doctor. Similarly, when a child was unwell, more Chinese, than Kikuyu participants made the decision without involving their partners.

5.6 Numeracy Characteristics of Participants (Study 1 and 2)

In studies 1 and 2 participants' numeracy skills were determined using the addition, and the addition and subtraction correction tasks. Mandarin-speakers had higher mean scores in both tasks (16.23; 95% *CI* = 14.95, 17.51 and 33.85; 95% *CI* = 31.22, 36.48) than Kikuyu-speakers (11.70; 95% *CI* = 10.52, 12.88 and 19.37; 95% *CI* = 17.52, 21.00). The differences were statistically significant (*U* = 918.0, p<.001 and *U* = 456.0, p<.001, respectively). Gender differences were observed in the performance of the addition subtraction correction task, with men outperforming women (*M*=28.8; 95% CI =25.7, 31.9 and *M* = 25.2; 95% *CI* = 22.5, 28.0; *U* = 1381.5, p= .036)

Since most Kikuyu-speakers learned basic mathematics beyond third grade in the English language, a comparison was performed for basic numeracy tasks of those educated in Kikuyu only (*n* = 14) versus those educated in both Kikuyu and English (*n* = 42). There were no statistically significant differences between the two Kikuyu groups for the addition task (*M* = 11, 71; 95% *CI* = 8.70, 14.73 vs. *M*= 11.49; 95% *CI* = 10.12, 12.86; *U* = 277.5, p=.760) and the addition and subtraction-correction task (*M* = 19.14; 95% *CI* =15.09, 23.19 vs. *M* = 19.51; 95% *CI* = 17.17, 21.86; *U* = 282.00, p=.826). In addition, a comparison was made on their performance in the tests of health numeracy and health literacy. Again, there were no statistically significant differences on the S-TOFHLA health numeracy test (*M* = 24.00; 95% *CI* = 21.39, 26.61

vs. *M* = 23.40; 95% *CI* =21.57, 25.21 *U* = 286.0, p=.876), the S-TOFHLA composite (*M* = 83.86; 95% *CI* =72.12, 95.59 vs. *M* = 85.44; 95% *CI* = 80.91, 89.91; *U* = 272.0, p=.682) and the NVS (*M* = 3.57; 95% *CI* = 2.36, 4.79 vs. *M* = 3.17; 95% *CI* =2.58, 3.77; *U* = 245.00, p=.417). Therefore, for all subsequent analyses the two groups of Kikuyu-speakers were treated as a single group.

5.7 Study 1: The Role of Primary Language in Comprehension of Numeric Health Information among Kikuyu and Mandarin Speaking Immigrants in Canada

5.7.1 Health Literacy and Numeracy Characteristics of Participants

Overall, Kikuyu-speakers had a higher S-TOFHLA score (M = 84.57; 95% CI = 80.48, 88.65) than Mandarin-speakers (M = 73.55; 95% CI = 68.81, 78.29). The difference was statistically significant (U = 1141.5, p<.001). Twenty-six percent (n =31) of all participants had inadequate or marginal health numeracy/literacy skills with the majority (n = 23) being Mandarin-speakers. Inadequate or marginal health numeracy/literacy was indicated by a composite S-TOFHLA score of below 67. Fewer Mandarin-speakers (n = 37, 31%) had adequate health numeracy/literacy skills - a composite S-TOFHLA score of >67 - compared with Kikuyu-speakers (n = 52, 43%).

Following Golbeck and colleagues (2011), health numeracy was treated as conceptually different from health literacy by separately analyzing the S-TOFHLA prose and numeracy components. Mandarin-speakers had higher health numeracy scores (M = 25.55; 95% CI = 24.56, 26.54) than Kikuyu-speakers (M = 23.33, 95% CI = 21.93, 24.73; U = 1413.5, p=.023). In contrast, Kikuyu-speakers had significantly higher S-TOFHLA prose scores (M = 61.23, 95% CI = 57.62, 64.85) than the Mandarin-speakers (M = 48.0 95% CI = 43.62, 52.38; U = 890.0, p<.001).

No statistically significant differences were found on the NVS scores between Kikuyu-speakers (*M* = 3.32, 95% *CI* = 2.80, 3.84) and Mandarin-speakers (*M* = 3.17, 95% *CI* = 2.67, 3.68) (*U* = 1610.5, *p* =.581). Fifty one percent of Kikuyu-speakers showed adequate health literacy and numeracy on the NVS compared with 42% of Mandarin-speakers. Each question in NVS taps prose and mathematical skills to a varying extent (Ozdemir et al., 2010). Therefore the individual questions were examined to explore why Kikuyu- and Mandarin-speakers differed on the composite S-TOFHLA scores but not on the NVS scores. Table 9 presents the number and percentage of the Kikuyu and Mandarin-speakers and their responses for the six NVS questions. More Mandarin-speakers (64%, and 75%) than Kikuyu-speakers (52% and 52%) answered questions 2 and 4 correctly. These questions had an easily identifiable numeracy component.; In contrast, more Kikuyu-speakers (41%, 60%, 71% and 69%) than Mandarin-speakers (34%, 34%, 53% and 53%) answered correctly questions 1, 3, 5, and 6 that required greater facility in prose/language skills.

Table 9: Performance in individual NVS questions by emphasis on numeric or prose skill

NVS Question	Skill needed	Score	Kikuyu-speakers	Mandarin-speakers
Q 1. If you eat the entire container, how many calories will you eat?	Mostly prose/language	Wrong	34 (58.7%)	39 (66.1%)
		Right	24 (41.4%)	20 (33.9%)
Q 2. If you are allowed to eat 60 g of carbohydrates as a snack, how much ice cream could you have?	Mostly numbers	Wrong	23 (39.7%)	21 (35.6%)
		Right	35 (51.7%)	38 (64.4%)
Q 3. Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42 g of saturated fat each day, which includes 1 serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be consuming each day?	Mostly prose /language	Wrong	35 (60.3%)	39 (66.1%)
		Right	23 (39.7%)	20 (33.9%)
Q 4. If you usually eat 2500 calories in a day, what percentage of your daily value of calories will you be eating if you eat 1 serving?	Mostly numeracy	Wrong	28 (48.3%)	15 (25.4%)
		Right	30 (51.7%)	44 (74.6%)
Q 5. Pretend that you are allergic to the following substances: Penicillin, peanuts, latex gloves, and bee stings. Is it safe for you to eat this ice cream?	Prose/language	Wrong	17 (29.3%)	28 (47.5%)
		Right	41 (70.7%)	31 (52.5%)
Q 6. Why	Prose/language	Wrong	18 (47.5%)	28 (47.5%)
		Right	40 (69%)	31(52.5%)

5.7.2 Predictors of Health Numeracy

Multiple regression analyses were conducted to test if primary language and sociodemographic characteristics of the participants predicted numeracy, health numeracy, and health literacy performance. Prediction was made for the French Kit tasks, the composite S-TOFHLA, the prose and numeric components of S-TOFHLA, and the NVS. Only the composite score for NVS was used because of the overlap in the prose and numeracy domains for most questions and the difficulty in clearly separating distinct subcomponents. Stepwise selection was used to identify predictor variables and variables with p <.050 were retained in the final models. The reduced models are presented in Appendix L.

For study 1, the independent variables were language (Kikuyu, Mandarin), age, gender, education, and residency in Canada. For study 2, mathematics self-efficacy and subjective numeracy, and preferred format for numeric health information were included in the models.

Education attainment between the two groups differed: the Kikuyu group had 11 participants who had an education up to high school level, while the Mandarin group had only one participant in this category. To address this difference in educational attainment, two regression analyses were performed. One analysis excluded the 12 individuals who had an educational attainment of high school level or less while in the second analysis the 12 individuals were included.

5.7.2.1 ***Regression Analysis Excluding High School and Less Educational Attainment***

Table 10 presents multiple regression results excluding the high school level and less education level for the French Kit addition and addition and subtraction-correction tasks, S-TOFHLA composite, S-TOFHLA numeracy, S-TOFHLA prose, and NVS performance, with language (Kikuyu, Mandarin), gender (male, female), age (50 years and less, over 50 years), education (>high school and < university, which was the reference group; university level, and graduate level), and duration of residence in Canada (less than 5 years, 5 years and above) as predictors. The regression models are presented in Appendix M.

The final model for the French Kit addition task ($F_{6, 99} = 5.87$, $p<.001$) accounted for about 22% of the variation in performance, with language, and duration of residence in Canada explaining the variation, controlling for the effect of each of the variables in the model. Mandarin-speakers outperformed Kikuyu-speakers in this numeracy test. For the French Kit addition and subtraction-correction task, the final model ($F_{6, 99}$ = 15.73, p<.001) accounted for 46% of the variation in the scores. Adjusting for the effect of each of the variables in the model, language (being a Mandarin-speaker), education, and duration of residency in Canada explained the variation in performance.

For the S-TOFHLA composite literacy and numeracy measure, the final model ($F_{6, 99}$ = 11.61, p<.001) accounted for a significant proportion of the variance (about 38%) in S-TOFHLA composite scores. Adjusting for the effect of each variable in the model, language, age and education explained the variation in the score with Kikuyu-speakers outperforming Mandarin-speakers in this composite measure. For the S-TOFHLA numeracy task, the final model ($F_{6, 99}$ = 2.12, p = .057) accounted for only about 6% of the variability in the performance. Holding constant the effect of each variable in the model, only education (university) approached significance (p=.069) in explaining the variation in the score. For the S-TOFHLA prose component, the final model ($F_{6, 99}$ = 16.12, p<.001) accounted for about 46% of the variance. Controlling for each variable in the model, being a Kikuyu language speaker, being relatively younger (less than 50 years old) and being more educated explained the variation in the score. Gender (female) approached significance in predicting health literacy (p=.060). The final model for the NVS ($F_{6, 97}$ = 3.15, p = .007) accounted for only about 11% of the variance in scores, which was explained by language and education, after adjusting for the effect of each of the variables in the model.

Table 10: Multiple Regression table for French Kit, composite S-TOFHLA, S-TOFHLA numeracy and NVS performance, excluding high school and less educational attainment

	French Kit (addition)		**French Kit (addition and subtraction-correction)**		**S-TOFHLA (composite)**		**S-TOFHLA (numeracy)**		**S-TOFHLA (prose)**		**NVS**	
Variable	B(SE)	*p*	B(SE)	*P*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*
(Constant)	-.59(3.36)	.861	-.849(6.05)	.889	87.21(10.44)	<.001	16.13(3.38)	<.001	71.08(9.06)	<.001	3.50(1.40)	.014
Language	3.25(.92)	.001	11.54(1.66)	.000	-18.38(2.87)	<.001	1.28(.93)	.172	-19.65(2.49)	<.001	-1.01(.37)	.008
Gender	1.16(.99)	.243	.219(1.78)	.902	5.51(3.07)	.076	.45(.99)	.653	5.07(2.67)	.060	.07(0.41)	.870
Age	.26(1.02)	.796	-1.48(1.83)	.422	-7.61(3.16)	.018	1.16(1.02)	.261	-8.77(2.75)	.002	-.52(0.41)	.204
>High Sch and < University	-	-	-	-	-	-	-	-	-	-	-	-
University	.91(.56)	.107	3.52(1.00)	.001	7.26(1.73)	<.001	1.03(.56)	.069	6.23(1.50)	<.001	.62(.23)	.008
Graduate	.67(.41)	.103	1.29(.73)	.081	5.39(1.26)	<.001	.43(.41)	.295	4.96(1.10)	<.001	.37(.17)	.029
*Residency	3.67(1.20)	.003	4.95(2.15)	.024	7.03(3.72)	.061	1.76(1.20)	.146	5.27(3.23)	.105	.70(.49)	.155
Unadjusted R^2	.26		.49		.41		.11		.49		.16	
Adjusted R^2	.22		.46		.38		.06		.46		.11	

* Duration of residency in Canada
(Language: Kikuyu, Mandarin; Gender: Male, Female; Age: <50, ≥ 50; Education: Education: >High School<University (reference) for University and Graduate; Residency: < 5 years, <5 years)

5.7.2.2 Regression Analysis with Full Sample

Table 11 presents results of regression modeling using the full sample. Details are presented in Appendix M. Similar to the models discussed above, prediction was made for performance in French Kit addition and addition and subtraction-correction tasks, S-TOFHLA composite, S-TOFHLA numeracy, S-TOFHLA prose, and NVS. Language (Kikuyu, Mandarin), gender (male, female), age (50 years and less, over 50 years), education (high school and less, which was the reference, > high school and < university, university level, and graduate level), and duration of residency in Canada (less than 5 years, 5 years and over) were the predictors.

Regression analysis for French Kit addition produced a final model ($F_{7, 110}$ = 7.13, p<.001) which accounted for about 27% of the variation in performance. Language, education and duration of residence in Canada explained the variation in performance, adjusting for the effect of each of the variables in the model. For the French Kit addition and subtraction-correction task, the final model that emerged ($F_{7, 110}$ = 19.68, p<.001) accounted for 53% of the variation in the performance. Language, education, and duration of residency in Canada explained the variation in performance, adjusting for the effect of each of the variables in the model. In the two tasks undertaken, being a Mandarin-speaker, having more education and having lived longer in Canada were associated with better performance after controlling for the variables in the model.

For the S-TOFHLA composite (literacy and numeracy measures), the final model ($F_{7, 110}$ = 12.52, p<.001) accounted for a significant proportion of the variance (about 41%) in the S-TOFHLA score. Adjusting for the effect of each of the variables in the model, language, age and education explained the variation in the S-TOFHLA composite score with Kikuyu-speakers outperforming Mandarin-speakers. Duration of residency in Canada (p=.072) and gender (p=.059) approached significance. For the S-TOFHLA numeracy task, the final model ($F_{7, 110}$ = 1.86, p = .084) accounted for only about 5% of the variability in the performance. This variance was not explained by any variable in the model, suggesting that other factors not measured in this study were responsible for individuals' comprehension of S-TOFHLA numeracy task.

The final model was for the S-TOFHLA prose component ($F_{7, 110}$ = 16.91, p<.001) and accounted for about 49% of the variance in the scores. After adjusting for the effect of each of the variables in the model, being a Kikuyu- speaker, being a woman, being relatively young (less than 50 years old), and being more educated predicted performance in this measure. Having lived longer in Canada approached significance (p=.072). The final model for the NVS ($F_{7, 107}$ = 5.30, p <.001) accounted for only about 21% of the variance in the score, which was explained by language and education, after adjusting for the effect of each of the variables in the model.

Table 11: Multiple Regression table for French Kit, composite S-TOFHLA, S-TOFHLA numeracy and NVS performance among 60 Kikuyu and 60 Mandarin speaking ESL study participants

	French Kit (addition)		French Kit (addition and subtraction-correction)		S-TOFHLA (composite)		S-TOFHLA (numeracy)		S-TOFHLA (prose)		NVS	
Variable	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*
(Constant)	1.50(2.77)	.588	.50(4.83)	.918	82.76(8.45)	<.001	18.63(2.88)	<.001	64.13(7.40)	<.001	2.49(1.10)	.026
Language	3.14(.91)	.001	11.42(1.58)	<.001	-18.21(2.77)	<.001	1.47(.95)	.123	-19.68(2.43)	<.001	-.87(.36)	.016
Gender	1.10(.96)	.254	.05(1.67)	.975	5.57(2.93)	.059	.21(.99)	.832	5.36(2.56)	.039	-.01(.39)	.987
Age	.71(.95)	.455	-.85(1.66)	.611	-7.91(2.90)	.007	1.42(.99)	.155	-9.32(2.54)	<.001	-.56(.38)	.138
*≤High Sch	-	-	-	-	-	-	-	-	-	-	-	-
>High Sch <University	1.66(1.58)	.294	3.78(2.75)	.173	12.20(4.81)	.013	-.17(1.64)	.920	12.37(4.22)	.004	1.85(.63)	.004
University	3.62(.56)	.039	10.99(3.03)	.000	26.80(5.30)	<.001	1.98(1.81)	.277	24.82(4.64)	<.001	3.04(.68)	<.001
Graduate	3.72(1.76)	.037	7.66(3.07)	.014	28.44(5.38)	<.001	1.05(1.83)	.567	27.39(4.71)	<.001	2.89(.69)	<.001
**Residency	3.16(1.11)	.005	4.25(1.93)	.029	6.13(3.37)	.072	.76(1.15)	.511	5.37(2.96)	.072	.52(.44)	.245
Unadjusted R^2	.31		.56		.44		.11		.52		.26	
Adjusted R^2	.27		.53		.41		.05		.49		.21	

*High school and less education

**Duration of residency in Canada.

(Language: Kikuyu, Mandarin; Gender: Male, Female; Age: 40-50, >50 years; Education: ≤ High School (reference) for >High School <University, University and Graduate; Residency: < 5 years, > 5 years)

In summary, the two regression analyses (including or excluding participants with education of high school or less) produced slightly different results (Table 12). Overall, the percentage of explained variance was higher with the full sample of 120 participants, except for S-TOFHLA numeracy. The analysis identified language, education, and duration of residency in Canada, age and gender as factors that contribute to numeracy and health numeracy of Kikuyu-speaking and Mandarin-speaking immigrants in Canada.

Table 12: Explained variance of using partial and full sample

	Partial sample		**Full sample**	
	Adjusted R^2	Predictors	Adjusted R^2	Predictors
Measure				
Addition task	22	Language; residency	27	Language; education; residency
Addition and subtraction - correction task	46	Language; education; residency	53	Language; education; residency
S-TOFHLA composite	38	Language; age; education; residency (.061) gender (.076)	41	Language; age; education; gender (.059); residency (.072)
S-TOFHLA numeracy	6	Education (.069)	5	None
S-TOFHLA prose	46	Language; age; education; gender (.60)	49	Language; age; education; gender; residency (.072)
NVS	11	Language; education	21	Language; education

5.8 Study 2: Role of Mathematics Self-Efficacy in Numeracy and Health Numeracy among Kikuyu-speaking and Mandarin-speaking Immigrants

5.8.1 Math Self-Efficacy Characteristics of Participants

Not surprisingly, the two measures of self-efficacy [math self-efficacy scale (MSES) and subjective numeracy scale (SNS)] were correlated (*rs* =.74, $p < 0.001$). Kikuyu-speaking immigrants expressed lower confidence in mathematics compared to Mandarin-speaking immigrants. The differences in the means (Table 13) were statistically significant ($p < 0.05$). Men had higher self-efficacy than women (MSES mean = 6.50; 95 *CI* = 6.01, 6.98 and 4.87; 95 *CI* = 4.41, 5.34; *U* = 878.5, $p<.005$. SNS mean = 4.56; 95% *CI* = 4.30, 4.83 and 3.73; 95% *CI* = 3.46, 3.99; *U* = 941.5, $p<.001$).

Table 13: Math self-efficacy and subjective numeracy characteristics of participants

Full Sample			
	Means (95% *CI*)		Mann-Whitney U test
	Kikuyu-speakers	Mandarin-speakers	
MSES	4.97 (4.39, 5.54)	6.16 (5.72, 6.60)	1120.0, p <.001
SNS	3.58 (3.28, 3.89)	4.59 (4.39, 4.79)	845.5, p<.001

5.8.2 Math Self-efficacy and Other Predictors of Numeracy and Health Numeracy

To determine if math self-efficacy of participants predicted numeracy and health numeracy performance, multiple regression analyses were conducted. Since educational attainment differed between the Kikuyu-speakers and Mandarin-speakers, two regression analyses were performed. One analysis excluded the 12 participants who had high school and less education while in the second analysis these 12 individuals were included.

5.8.2.1 Regression Analyses Excluding High School and Less Educational Attainment

For the regression analyses excluding participants with less than high school education, language (Kikuyu, Mandarin), gender (male, female), age (≤ 50 years > 50 years), education (> high school and < university - the reference group; university and graduate level), and duration of residence in Canada (less than 5 years and 5 years and above) were included as predictors. For predicting health numeracy (S-TOFHLA numeracy component), preferred format of presentation of numeric information (numbers only versus numbers with detailed explanation) was also included in the final regression models. MSES and SNS were run separately because of the high collinearity between these measures. Appendix M presents the regression models with high school or less education attainment participants excluded.

As shown in Table 14, using MSES, prediction for basic numeracy skill on the addition task produced a final model ($F_{6, 98} = 8.05$, $p = <.001$) that accounted for about 30% of the variation in the numeracy score, with gender, language, residency in Canada, and self-efficacy explaining the variation in the addition score, adjusting for the effect of each of the variables in the model. For the addition and addition subtraction-correction task, the final model ($F_{6,98} = 18.07$, $p<.001$) accounted for about 50% of the variance in score, with language, residency in Canada, education and math self-efficacy explaining the variation in the score, adjusting for the effect of each of the variables in the model.

The final regression model with the SNS measure of mathematics self-efficacy explained about 28% ($F_{6, 98} = 7.67$, $p<.001$) of the variation in the addition task scores. Adjusting for the effect of each of the variables in the model, language, residence in Canada, and math self-efficacy were significant predictors of the variation in addition performance; gender approached significance (p=.059). For the addition-subtraction correction test, 53% ($F_{6, 98} = 20.41$ $p<.001$) of the variation in performance was explained by language, having a university education, and self-efficacy, adjusting for the effect of each of the variables in the model. The duration of residence approached significance (*p*=.063). When math self-efficacy was considered, gender contributed to basic numeracy (addition) but not to the more intuitive numeracy (addition subtraction-correction).

Table 14: Multiple regression results including MSES and SNS to Predict Numeracy

	With MSES				With SNS			
	Addition task		Addition Subtraction-correction task		Addition task		Addition Subtraction-correction task	
	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*
Constant	-4.87(3.31)	.161	-9.78(6.03)	.108	- 4.54(3.37)	.181	-12.76(5.89)	.033
Gender	2.07(.98)	.038	1.96(1.79)	.277	1.87(.98)	.059	2.19(1.71)	.204
Language	2.85(.90)	.002	10.65(1.64)	< .001	2.40(.96)	.014	9.10(1.68)	<.001
*Residency	3.47(1.15)	.003	4.38(2.09)	.038	3.35(1.16)	.005	3.82(2.03)	.063
>High school <University	-	-	-	-	-	-	-	-
University	.605(.54)	.262	3.18(.98)	.002	.39(.56)	.483	2.50(.97)	.012
Graduate	.446(.39)	.257	1.01(.712)	.160	.31(.41)	.444	.55(.71)	.442
MSES	.768(.25)	.003	1.26(.46)	.008				
SNS					1.38(.51)	.008	3.38(.89)	<.001
Unadjusted R^2	.33		.53		.32		.56	
Adjusted R^2	.30		.50		.28		.53	

*Duration of residency in Canada
(Gender: Male, Female; Language: Kikuyu, Mandarin; Residency: <5years, >5 years; Education: >High School <University (reference) for University and Graduate; MSES: score; SNS: score)

For the prediction of health numeracy skill (S-TOFHLA numeracy), gender, language, education, residency in Canada, self-efficacy, and preferred format for numeric health information were included in the models (Table 15). Analysis with MSES resulted in a final model ($F_{7, 97}$ = 2.54, p=.019) that accounted for about 9% of the variation. Adjusting for the effect of each of the variables in the model, only format (numbers versus numbers with explanation) was a marginally significant predictor of health numeracy (p=.050). Using SNS produced a final model ($F_{7, 97}$ = 3.00, p =.007) which accounted for 12% of the variance. Adjusting for the effect of each of the variables in the model, preferred format for numeric health information and math self-efficacy were the only significant predictors of health numeracy.

As shown on Table 15, regression modeling was also conducted for the NVS measure of health literacy/numeracy. The emerging model for health literacy/numeracy with MSES ($F_{7, 95}$ = 3.08, p = .006) accounted for about 13% of the variation in the literacy/numeracy skill of ESL immigrants. The variation was explained by language, education and self-efficacy (MSES), adjusting for the effect of each of the variables in the model. A separate model including the SNS ($F_{7, 96}$ = 4.68, p <. 001) accounted for about 20% of the variation. Adjusting for the effect of each of the variables in the model, being a Mandarin-speaker and having greater math self-efficacy predicted health literacy/numeracy skill. In fact, the inclusion of self-efficacy reduced the effect of education in this model. The multiple regression results are presented in Appendix M.

Table 15: Predictors of health numeracy (S-TOFHLA numeracy and NVS)

	Health Numeracy (S-TOFHLA)				NVS			
	MSES		SNS		MSES		SNS	
	B (SE)	*p*	B (SE)	*p*	B (SE)	*p*	B (SE)	*p*
(Constant)	9.66(4.45)	.032	8.09(4.47)	.073	.56(1.89)	.768	-.67(1.84)	.716
Gender	.83(1.02)	.414	.99(.99)	.321	.50(.42)	.234	.63(.40)	.115
Language	1.54(.94)	.106	1.01(.98)	.308	-1.16(.37)	.003	-1.53(.38)	< .001
*Residency	1.60(1.20)	.183	1.38(1.18)	.246	.57(.48)	.239	.43(.46)	.351
>High school < University	-	-	-	-	-	-	-	-
University	.66(.56)	.237	.43(.57)	.455	.56(.22).	.013	.41(.22)	.066
Graduate	.25(.41)	.545	.08(.41)	.839	.34(.16)	.042	.23(.16)	.149
**Preferred format	3.01(1.51)	.050	3.15(1.49)	.037	.40(.62)	.517	.55(.59)	.369
MSES Score	.34(.26)	.205			.24(.11)	.026		
SNS			1.08(.51)	.038			.76(.20)	< .001
Unadjusted R^2	.16		.18		.19		.26	
Adjusted R^2	.09		.12		.13		.20	

*Duration of residency in Canada
**Preferred format of numeric health information (numbers only vs numbers with detailed explanation)
(Gender: Male, Female; Language: Kikuyu, Mandarin; Residency: <5years, >5 years; Education: >High School <University (reference) for University and Graduate; MSES: score; SNS: score)

5.8.2.2 Regression Analysis with Full Sample

Table 16 presents the multiple regression results of the full sample which included all participants including those with high school or less education. Separate analyses were conducted with the MSES and the SNS measures of self-efficacy.

For the addition task, the final model that included the MSES ($F_{7, 109} = 8.64$, $p < .001$) accounted for about 32% of the variation in the score. Adjusting for the effect of each of the variables in the model, being a Mandarin speaker, having lived longer in Canada and having a greater mathematics self-efficacy explained the variation in performance on the addition test. Gender approached significance (p=.055). The French Kit addition and subtraction-correction task produced a final model ($F_{7, 109} = 21.71$, $p<.001$) which accounted for about 56% of the variation in performance on the task. Adjusting for the effect of each of the variables in the model, being a speaker of Mandarin, having higher education and having greater mathematics self-efficacy explained the variation in addition and subtraction-correction scores. Duration of residency in Canada approached significance ($p = .054$) in this measure.

Inclusion of the SNS in the regression models produced only slightly different results from those of the MSES. This was not unexpected because of the correlation between the SNS and MSES. Modeling for the addition task produced a final model

($F_{7,108}$ = 8.12, p<.001) which accounted for about 30% of the variation in the score. Adjusting for the effect of each of the variables in the model, being a Mandarin-speaker, having lived longer in Canada and having a greater mathematics self-efficacy explained the variation in the scores. For the addition and subtraction-correction task, the final model ($F_{7, 108}$ = 23.162, p<.001) accounted for about 57% of the variation in the performance. Being a Mandarin-speaker, having higher education and having greater mathematics self-efficacy explained this variation in performance on addition and subtraction-correction test, adjusting for the effect of each of the variables in the model.

Table 16: Multiple regression results with the full sample

	With MSES				With SNS			
	Addition task		Addition Subtraction-correction task		Addition task		Addition Subtraction-correction task	
	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*	B(SE)	*p*
Constant	-.78(2.63)	.763	-5.96(4.60)	.198	-1.50(2.82)	.597	-9.78(4.75)	.042
Gender	1.89(.97)	.055	1.51(1.71)	.377	1.75(.96)	.071	1.83(1.63)	.264
Language	2.85(.90)	.002	10.76(1.57)	<.001	2.40(.95)	.013	9.31(1.60)	<.001
*Residency	2.83(1.11)	.010	3.70(1.90)	.054	2.73(1.11)	.014	3.11(1.85)	.097
**≤High Sch	-	-	-	-	-	-	-	-
>High school <University	.86(1.56)	.580	2.66(2.73)	.332	1.12(1.60)	.480	2.50(2.67)	.350
University	2.25(1.73)	.195	9.20(3.02)	.003	2.03(1.77)	.253	7.71(2.99)	.011
Graduate	2.31(1.76)	.193	5.77(3.11)	.064	2.10(1.80)	.246	4.22(3.04)	.168
MSES	.67(.25)	.008	1.07(.44)	.015				
SNS					1.34(.50)	.008	3.16(.84)	<.001
Unadjusted R^2	**.36**		**.58**		**.35**		**.60**	
Adjusted R^2	**.32**		**.56**		**.30**		**.57**	

*Duration of residency in Canada; **High School and less education
(Gender: Male, Female Language: Kikuyu, Mandarin; Residency: <5 years, >5 years; Education: ≤High School (reference) for >High School <University, University and Graduate; MSES: score; SNS: Score)

Multiple regression analysis was conducted for prediction of health numeracy (S-TOFHLA numeracy) with the MSES and the SNS separately (Table 17). Participants' preferred format of presentation of numeric health information (numbers only vs numbers with detailed explanation) was included in the model. Including the MSES, a final model emerged ($F_{8,106} = 2.62$, p=.012), which accounted for about 10% of the variation in the S-TOFHLA numeracy score. Adjusting for the effect of each of the variables in the model, only preference for numeric health information provided in numbers with detailed explanation (instead of numbers only) explained the variation in performance. When SNS was included, the final model ($F_{8, 105}$=3.20, p=.003) accounted for about 14% of the variation in the S-TOFHLA numeracy score. Adjusting for the effect of each of the variables in the model, preference for numeric health information in numbers and detailed explanation, and a greater mathematics self-efficacy, explained the variation in the S-TOFHLA numeracy score.

Table 17: Predictors of health numeracy (S-TOFHLA numeracy component)

	MSES		SNS	
	B (SE)	*p*	B (SE)	*p*
(Constant)	10.90 (4.05)	.008	8.41 (4.19)	.047
Gender	.62(1.02)	.548	.68(.99)	.493
Language	1.56(.97)	.105	1.07(1.01)	.289
*Residency	.57(1.15)	.623	.56(1.14)	.627
≤High School	-	-	-	-
>High school < University	.43(1.73)	.802	1.23(1.74)	.482
University	1.82(1.11)	.340	2.10(1.92)	.276
Graduate	1.10(1.93)	.571	1.37(1.95)	.483
**Preferred format	3.48(1.50)	.022	3.63(1.48)	.015
MSES Score	.36(.26)	.176		
SNS			1.08(.51)	.038
Unadjusted R^2	.17		.20	
Adjusted R^2	.10		.14	

*Duration of residency in Canada**Preferred format of numeric health information (numbers only vs numbers with detailed explanation); (Gender: Male, Female Language: Kikuyu, Mandarin; Residency: <5 years, >5 years; Education: ≤High school (reference) for >High School <University, University and Graduate; MSES: score; SNS: Score)

The newest vital sign (NVS) includes numeracy and literacy (prose) components. Multiple regression analysis was conducted for prediction of health numeracy using this measure, with both MSES and SNS included as separate models (Table 18). With the MSES, the model which emerged ($F_{8,103} = 5.61$, $p<.001$) accounted for about 25% of the variation in the NVS score, which was explained by language (being a speaker of Kikuyu), being more educated, and having a greater mathematics self-efficacy, adjusting for the effect of each of the variables in the model. With the inclusion of SNS, the final model ($F_{8,102} = 7.07$, $p < .001$ explained for more variation (about 31%) compared with the variation accounted for with the inclusion of the MSES (25%). However, the same variables (being a Kikuyu-speaker, being more educated, and having greater mathematics self-efficacy) explained the variation in the NVS score after adjusting for the effect of each of the variables in the model.

Table 18: Predictors of health literacy/numeracy (NVS)

	MSES		SNS	
	B (SE)	*p*	B (SE)	*p*
(Constant)	-.55(1.576)	.730	-2.17(1.6)	.178
Gender	.38(.395)	.336	.50(.38)	.188
Language	-1.15(.362)	.002	-1.51(.37)	<.001
*Residency	.52(.437)	.236	.43(.42)	.309
≤High School	-	-	-	-
>High school < University	2.12(.66)	.002	2.29(.66)	.001
University	3.24(.78)	<.001	3.08(.71)	<.001
Graduate	3.08(.73)	<.001	2.93(.72)	<.001
**Preferred format	.32(.59)	.576	.50(.55)	.365
MSES Score	.23(.10)	.025		
SNS			.74(.19)	<.001
Unadjusted R^2	.30		.36	
Adjusted R^2	.25		.31	

*Duration of residency in Canada
**Preferred format of numeric health information (numbers only and numbers with detailed explanation)
(Gender: Male, Female Language: Kikuyu, Mandarin; Residency: <5 years, >5 years; Education: ≤High School (reference) for >High School <University, University and Graduate; MSES: score; SNS: Score)

In summary, results from the multiple regression analysis with the full sample show a higher level of explained variance compared to the analysis in which participants with high school or less education were excluded. Overall, the results of

Study 2 show that the contribution of mathematics self-efficacy to numeracy (addition, and addition and subtraction-correction) is stronger than it is for health numeracy (S-TOFHLA) with the contribution for S-TOFHLA numeracy through SNS (.038) and not through MSES (.176). Details of the multiple regression analysis are presented in Appendix M.

5.9 Study 3: Processing of Numeric Information

In the smaller sample used for study 3, Mandarin-speakers outperformed Kikuyu-speakers in the numeracy (French Kit) task (M= 34.10; 95% CI =28.0, 40.2 and 20.15; 95% CI = 15.3, 24.7). The difference was statistically significant (U = 94.5, p=.002). The problem-solving time and the codes (episodes or behaviours) from the verbal protocols and participants' notes (pencil and paper) were analyzed qualitatively to determine whether participants solved the problem intuitively or analytically. The following is a description of the findings from the analysis, with Mandarin-speakers designated as *M* and Kikuyu-speakers designated as *K*.

5.9.1 Phases of Problem Solving

Participants engaged in various cognitive and metacognitive behaviours (episodes) as they solved the diabetes diet problem. These included *reading*, *exploring*, *planning*, *implementing*, *planning-implementing,* and *verification*. Local assessment, or monitoring, occurred during and between the episodes. Some participants did a global evaluation of the whole process after the last episode. On average, the participants' verbalizations revealed that more Kikuyu-speakers engaged in all five episodes while Mandarin-speakers tended to engage in three episodes for the whole task. The results of the behaviours that participants engaged in are described below, followed by examples of selected protocols.

5.9.1.1 Reading

In the *reading* phase all participants initially read the question either aloud or silently to understand the problem (Garofalo & Lester, 1985; Yimer & Ellerton, 2010). The reading phase is important in gauging one's comfort with the problem and in deciding the next step. Not unexpectedly, some participants read the question more than once. In addition, some participants read the question and immediately related the quantities of the food items in the question with the weights in grams, and even provided an immediate solution. For example, in the first task, participant M060 (with a bachelor degree) had a high score in the French Kit recognition task (46 correct/ 60 total), read the question and immediately linked it to provided information on quantities:

"You eat 2 slices of bread…one of them is 50 grams".

Similarly, participant K019 (with a bachelor degree) who had a high numeracy score (that is 32 correct /60 total in the French Kit addition and subtraction-correction tasks) among the Kikuyu-speakers said the following:

"…grams…that means she ate 100 grams of bread"

Others read the question and engaged in metacognitive behaviour, which indicated an assessment of their comfort or familiarity with the problem and their intentions. For example, after the initial reading, participant M044 (with some university education) who had a low numeracy score (21 correct/ 60 total) in the French Kit recognition test), said the following:

"Okay…mmm…wait. I need to do this…mmmm…and the total here…now…"

and participant K002 (bachelor degree), who had a low French Kit score (10 correct /60 total) among the Kikuyu-speakers said the following:

"Okay…let's find out how much she ate…Okay. So 1 slice of bread, okay…so 2 slices of bread…"

5.9.1.2 Exploration

Due to the nature of the tasks, reading and exploration often merged seamlessly. Exploration takes place when an individual tried to access as much information as possible about the problem and the strategies needed to solve it and to guide the next phase of problem solving (Garofalo & Lester, 1985). In exploration the individual becomes aware of her knowledge of the problem and the cognitive skills necessary to solve it. By self-monitoring, problem-solvers keep problem exploration focused. Overall, Kikuyu-speakers engaged in more verbalized exploration episodes than did Mandarin-speakers.

As an illustration, on the cooked rice sub-task, participant K011 (with a graduate level education) who had one of the highest scores on the French Kit among the Kikuyu-speakers (29 correct/60 total), engaged in some level of exploration:

"Then she ate ⅓ cup of rice…and one cup of rice weighs 180 grams…so this would be divided by 3, or multiplied by a ⅓…"

The above excerpt suggests that K011 felt at ease with the problem subtask, showing knowledge of the strategies to solve it. In a similar way, participant K028 (also with graduate level education) engaged in exploration when expressing the following:

> *"For muffin, she ate 1 and ¼…which means she ate 120 times ...what?...times 1 and ¼...that's a bit complicated… so it's …what?…it's 120 grams and ¼…I don't know how much ¼ comes to..."*

In this excerpt, participant K028 engaged in some local assessment *("that's a bit complicated"*) and even a conclusion about his or her ability to do the task *("I don't know how much ¼ comes to…"*). This self-evaluation takes place at the metacognitive level and might indicate the knowledge of her cognitive ability to accomplish the task. This participant had a low score (14 correct /60 total) in the French Kit recognition task, despite having a graduate level education.

5.9.1.3 Planning

Planning was the least obvious of the episodes, with the fewest verbalizations. Planning involves clear evidence of intentions, sub-goals and goals. As Schoenfeld and Herman (1982) have shown, planning even if not always explicitly verbalized does not imply its absence. The individuals' responses to a task depend on their expertise in the domain, the heuristics (the strategies, techniques, and short-cuts) that they use to solve the problem, and the control strategies used (decisions on what resources and strategies to use and their perception of the problem) (A. Schoenfeld, 1985). These factors are engaged in implicit and explicit planning. Depending on the individual's expertise and the nature of the problem, planning might occur simultaneously with other episodes such as reading and implementation. For example, in subtasks 1 and 3 participant M057 (with a bachelor degree) had this to say:

> *"She ate 2 slices of bread…100 grams"*
>
> and
>
> *"…and you have ½ cup of cereal …contain 330 grams".*

This was done without reference to the problem statement: "1½ cup cereal…with 1 cup cereal having 220 grams." This suggests that simultaneous planning and implementation might be based on an intuitive grasp or recognition of the problem and its solution. In his case, the intuitive grasp of the problem and its solution could be expected given the participant's high score (53 correct/60 total) on the French Kit recognition task.

5.9.1.4 Implementation (Planning-Implementation)

The implementation and the planning-implementation phases were combined. This phase corresponds to the execution phase in Garofalo and Lester's model (1985) and entails the execution of the plan and concurrent assessment of the process. Typically, implementation follows a plan, but it needs careful monitoring in order to reach the desired goal. As was expected, implementation was the most coded episode in all the protocols, because no problem-solving process would take place without some level of implementation. This phase involved explicit (or implicit) decisions on the operations to perform, the individual's ability to perform the task, and the next course of action. Several operations were needed for problem solving: For task 1 and 3, multiplication and addition operations were required; for tasks 2 and 4 and 5, ability to convert fractions into whole numbers using multiplication or division was required. In this task, explicit and implicit implementations were observed. As an illustration, consider for example participant K004's verbalization:

"Then she needs 1 and ½ cup cereal…that is on cereal is 22…, so it will be …220 grams and half 22… will be 110...he (sic) have (sic) eaten ….330 grams"

Here one can only infer that a conversion was done either by multiplication or division (to get 110 which is ½ of 220 grams) and addition (of 110 to 220 to get the total of 330 grams). This participant had a college level education. However, many participants implicitly implemented their plans and provided the result without verbalizing the intermediate processes between reading the problem statement and the solution. For example, participant M024 (who had some university level of education) only stated the following:

"1 (and ½) cooked rice is 330 grams".

This participant had a high score (45 correct/60 total) in the French Kit recognition task, and had the shortest time (32 seconds) to complete the diabetes task.

5.9.1.5 Verification

Verification is closely linked to the solution of the problem, and involves reflecting on the process and the solution to ascertain if it meets the requirement of the task and this is largely a metacognitive process. Participants who had the correct solution to the individual tasks were able to select and use the appropriate operation and to monitor the process to solve the problem. Table 19 shows the accuracy of performance by problem sub-tasks.

As Table 19 shows, the subtasks and the final performances on the problem were virtually the same regardless of group. It was hypothesized that possessing superior numeric skill (as is evident in the French Kit test) may not increase performance on a health numeracy problem that is embedded in the English language, such as the diabetes problem used in this study. It may be possible that understanding the verbal context of the problem is required for successful performance. In the following section, the results were analyzed in terms of the dual-process model of information processing in relation to problem-solving performance in the diabetes task.

Table 19: Final performance on the diabetes task by problem subtasks showing accuracy of solution to each sub-task.

	Kikuyu		Mandarin	
Subtask	Correct	Incorrect	Correct	Incorrect
1	20	0	20	0
2	15	5	13	7
3	18	2	18	2
4	15	5	17	3
5	14	6	19	1
Task total	12	8	10	10

5.9.2 Intuitive and Analytical Processing of Numeric Information

The time needed to solve the diabetes task was examined. On the average, Mandarin-speakers took less time to complete the task (M=1.7 minutes; SD=1.11) than did Kikuyu-speakers (M= 2.6 minutes; SD =1.08). This difference was statistically significant (Mann-Whitney U = 109.50, p = .007).

This performance on the problem-solving task was compared with the French Kit score (addition, subtraction correction task) to assess whether time was a common factor in the two tasks. There was a statistically significant negative correlation between the time it took to complete the diabetes task and the French Kit recognition task score (rs = -.641, p < 0.001): those who took longer to complete the diabetes task had a lower score in the French-Kit task. Using time as a factor, with a cut-off of 2 minutes, Kikuyu and Mandarin-speakers differed on whether they solved problem intuitively or analytically.

Figure 2 below presents the time-bound problem solution by Mandarin and Kikuyu-speakers. Over half of the Mandarin-speaking participants solved the problem in less than 3 minutes whereas only five Kikuyu-speakers did. Using the 2-minute cut-off time, more Mandarin-speakers (*n*=13) demonstrated intuitive processing compared to Kikuyu-speakers (*n*=5). More Kikuyu-speakers (*n*= 12) provided the correct problem solution than Mandarin-speakers (*n*= 10). Participants with shorter solution times were more successful in generating the correct solution than participants who took longer to solve the problem.

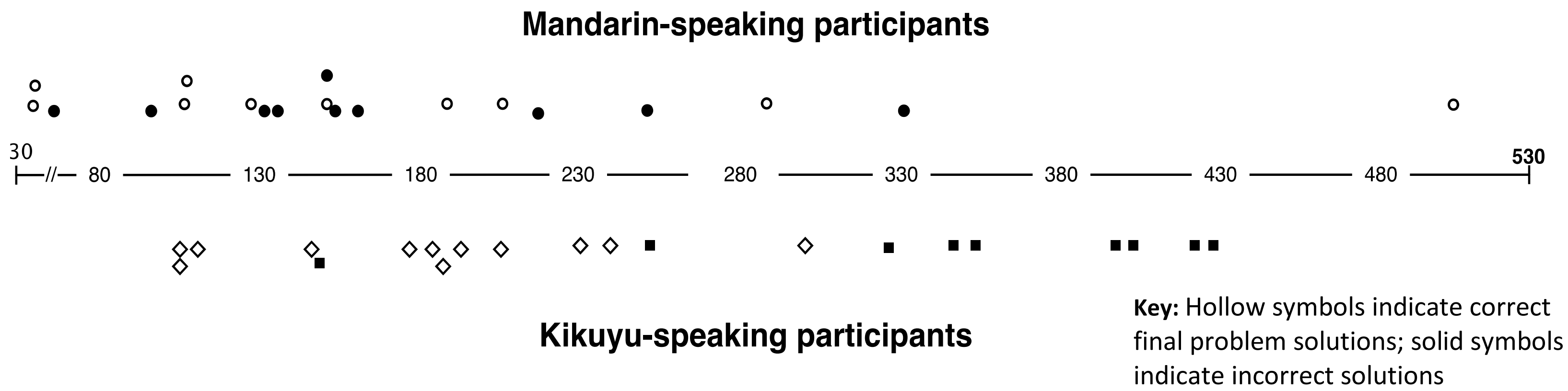


Figure 2: Speed of problem-solving processing by Mandarin and Kikuyu-speakers. Time is represented in seconds.

Consistent with results on the study of domain expertise (Chi, Glaser, & Rees, 1982), the time taken in solving a problem is associated with the level of experience of the problem-solver with similar problems. This suggests that the length of a verbal protocol has something to do with the ability to do the task successfully. As an illustration of an intuitive problem-solving process, the excerpt (Table 20) shows the problem-solving protocol of participant M024. For each subtask only two episodes are made explicit; reading and verification (result), indicating implicit processing which was consistent with the time participant M024 took to solve the problem. The protocol includes only 7 statements or propositions, while the complete process took less than one minute. However, despite the short time to solve the problem, M024 appears to do some assessment of the calculations, hence the following statement:

"*So, oh, I just want to know, I …yeah…780*".

Table 20: Verbal protocol of the diabetes problem by participant M024 showing an intuitive problem solving processing approach

M/024	Episodes/behaviours	Total problem-solving time
1. Is 100 grams	Reading, Verification	52 seconds
2. And one English muffin 150 grams.	Reading, Verification	
3. And one rice cake 140 grams,	Reading, Verification	
4. 1 cup cereal 330 grams,	Reading, Verification	
5. and one cup cooked rice 60 grams	Reading, Verification	
6. total is 780 grams….	Planning-Implementation	
7. So, oh, I just want to know, I …yeah…780	Verification/assessment	

In contrast to the previous problem-solving process by participant M024, the following example from participant K003 (Table 21) shows more episodes of various types, which included local assessments and monitoring of the process. In this example, by assessing work already done, participant K003 realizes that the solution for subtask 2 was wrong and attempts to correct it, as shown in lines 12 and 13:

12. "and then she eats … 2 rice cake is 140, which is here…

13. So this one is not correct…140."

K003 (with college level education) generated one of the longest protocols (Table 21), with a recorded time of 4.11 minutes. Regardless of verifications and assessments, the participant failed to successfully solve the problem. A similar performance was observed in other participants. Some successfully solved all the subtasks, but failed to provide the correct final solution. Other participants failed in some of the subtasks as well as getting the final solution wrong; yet others failed the subtasks, but were able to generate the correct final problem solution.

Table 21: Verbal protocol of the diabetes problem by participant K003, showing mostly analytical problem solving processing

K/003	Episodes/behaviour	Total problem solving time
1. Is 100 grams	(Reading),Verification	4.11 minutes
2. When I continue, 1 English muffin 120 gram.	Reading	
3. Times 2, is 240 grams	Planning-implementation	
4. Okay…1, 1 rice cake, which is …. …to 1 gram with 70 grams.	Reading, Exploration	
5. And 2 is 140 grams.	Exploration, Verification	
6. 1 cup cereal, each is 220 grams.	Reading	
7. Times 2 is 440 grams.	Exploration, Verification	
8. This one I think is …., that is times two… ¼ and the, each is 120.	Reading, (Assessment), Exploration	
9. So ¼ is 45 gram.	Planning-Implementation, Verification	

10. Muffin is 2. And 1 muffin is 120. English muffin.	Assessment (see 2)
11. So if she get two slices of bread here, the first one, then she took 1 and ¼ English muffin, then she eats 2 rice cake, rice cakes,	Assessment (see 1)
12. and then she eats … 2 rice cake is 140, which is here.	Assessment, verification (see 4)
13. So this one is not correct…140.	Verification (see 4)
14. So 1 cup cereal is ¼, and the, and the cereal is 220,	Reading
15. so the quarter is 75….	Verification
16. What about cooked rice…cooked rice was a third.	Exploration
17. One third of 180 is 45.	Planning-Implementation, Verification
18. Total is 100 plus 140 gram, is 240. 240 plus 90 …. Zero ……?…. two, no sorry 15, 330 plus 75. It is 5, zero, carry one, 405 …. 405…grams.	Planning-Implementation, Verification

The level of education did not have a clear effect on the outcome of the task. Some participants with less educational attainment performed better than the ones with more educational attainment. To illustrate, participant M024 (with some university level education) not only had one of the highest scores in the French kit task (45 correct/60 total), but this participant also solved the problem in the shortest time (32 seconds) and provided the correct answer for the task. Participant M117 had a bachelor level education, had the second highest score in the French Kit (53 correct/60 total), solved the problem in 52 seconds, and provided an incorrect answer for the diabetes task. Another participant, K028, had a graduate level education, a low score in the French kit task (14 correct/ 60 total), took over 3 minutes to solve the diabetes task, and failed to provide a correct answer for the task. Participants with low levels of education (K008 and K010) also had low French Kit scores, took over 4 minutes to solve the problem, and failed to get the correct answer for the task. K004 and K006 had a college level education, and a low French Kit scores (6 and 5 respectively) but only K006 got the correct answer for the task. Figure 3 below shows participants educational levels and their performance in the French Kit.

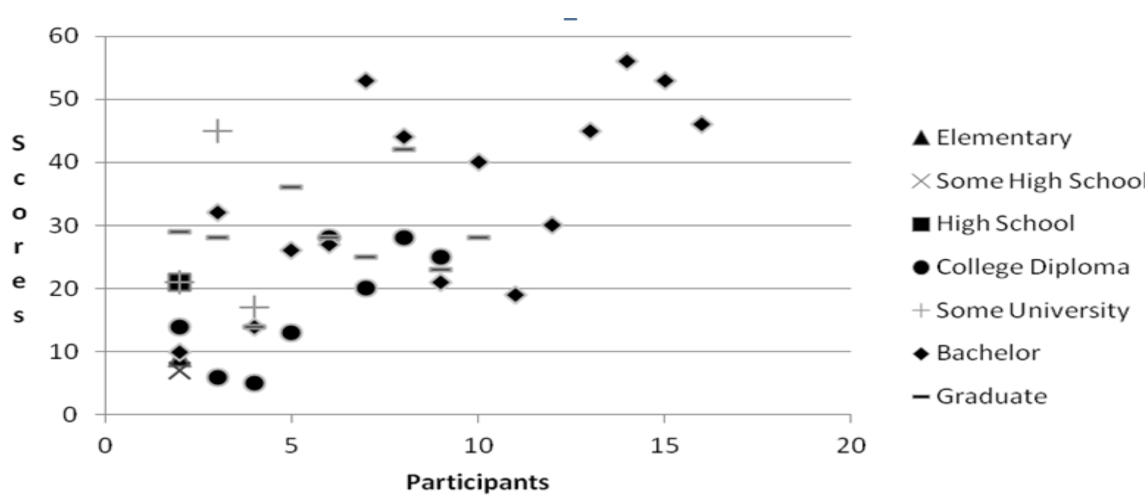


Figure 3: Education level and performance in French Kit task

In summary, the results of study 3 suggests that Mandarin-speakers used a more intuitive or associative approach, while Kikuyu-speakers used a more analytical problem-solving approach. Mandarin-speakers took less time to solve the task compared with the Kikuyu-speakers, supporting the findings from the verbal analysis of intuitive approaches by the Mandarin-speakers compared with analytical approaches by the Kikuyu-speakers.

Chapter 6

General Discussion and Implications for Practice and Research

It was hypothesized that 1) comprehension of numeric health information presented in English would be greater for speakers of a high numeric concept language than for speakers of a low numeric concept language; 2) speakers of a high numeric concept language would be more confident in their ability to perform numeric and health numeric tasks than would ESL speakers of a low numeric concept language; and 3) speakers of a high numeric concept language would use intuitive strategies while speakers of a low numeric concept language would use analytical strategies to process numeric health information tasks. To test these hypotheses, Mandarin-speaking immigrants (representing high numeric concept languages) and Kikuyu-speaking immigrants (representing low numeric concept languages) were recruited to take part in this study.

The novel and key findings of this thesis research were as follows:

1. Speakers of Kikuyu and speakers of Mandarin differed in their performance of numeracy and health numeracy tasks presented in English. As was hypothesized, Mandarin-speakers outperformed Kikuyu-speakers in numeracy tasks (addition, and addition subtraction-correction), and in health numeracy tasks (numeracy

component of S-TOFHLA). However, although Mandarin-speakers outperformed Kikuyu-speakers in numeracy tasks, Kikuyu-speakers outperformed Mandarin-speakers in prose (health literacy) tasks.

2. With regard to self-efficacy or confidence in mathematics, Mandarin-speakers had greater mathematics self-efficacy compared to Kikuyu-speakers.

3. Regarding the processing of numeric information, Mandarin-speakers solved numeric tasks mostly intuitively, while Kikuyu-speakers solved the problems mostly analytically. In the following sections the key findings are discussed with regard to the individual research studies and the hypotheses.

6.1 The Role of Primary Language in Comprehension of Numeric Health Information

It was hypothesized that speakers of a high numeric concept language compared to speakers of a low numeric concept language would have better comprehension of numeric health information presented in English. The finding that speakers of Mandarin (a high numeric concept language) outperformed speakers of Kikuyu (a low numeric concept language) in numeracy and health numeracy supports this hypothesis, albeit with some caveats as explained in the following section.

Numeracy was measured using the context-free addition and subtraction tasks from the Kit of Factor Referenced (French-Kit). Mandarin-speakers had higher scores in the addition, and the addition subtraction-correction tasks. Similarly, Mandarin-speakers outperformed Kikuyu-speakers in health numeracy (S-TOFHLA numeracy component). These findings are consistent with other studies that show superior mathematical skills among speakers of the Chinese-based languages compared to other groups (Geary, Bow-Thomas, Fan, & Siegler, 1993; Miller, Kelly, & Zhou, 2005). Among the factors that may contribute to this superior performance are the structures of number words and the quantity of the numeric concepts embedded in the Chinese languages. The education system or system of instruction in the home country may also play an important role in the mathematical ability of participants.

Compared to other languages, Mandarin has a more regular structure and a simpler system of naming numbers, which may influence performance in mathematical tasks (Miura, Okamoto, Kim, Steere, & Fayol, 1993). The term 'regular' in spoken and written number system implies a consistent representation of a base system, that is, the counting system used in a given language (Dowker et al., 2008), with many languages using base 10. Mandarin, like other Chinese languages, is considered regular because the spoken and the written number systems correspond. In Mandarin, teens are made of two-digit (11= ten one; 16 = ten six and so on) and decades as multiples of ten (33 = three ten; 40 = four ten, and so on) (Brysbaert et al., 1998). In contrast, English has an irregular number system where the spoken and written systems do on not correspond. In English, teens are presented as one word (e.g., ten, eleven, twelve, thirteen,) and decades are presented with a different one word representations (e.g., twenty, thirty, and forty). The regular system makes it easy for Mandarin-speaking children to efficiently learn and apply mathematical operations later in life (Miura et al., 1993).

A simpler system of naming numbers implies that number words in Chinese are short and easily pronounced compared to numbers words in other languages, such as English. In an experiment on short-term memory for digits between Chinese and English speakers, Stigler and colleagues (1986) found that Chinese speakers had better digit memory than English speakers, which was attributed to the short Chinese numbers words. It appears that the regularity of short number words in the Mandarin language places a lighter load on the working memory (Baddeley, 1992), and this could potentially improve performance in numeric tasks.

Similar to Mandarin, the Kikuyu language, has a regular structure including the use of base 10 (Leakey, 1977). However, it has only one embedded numeric concept (whole numbers). Other numeric concepts which appear in Kikuyu, such as rational numbers or words for exact quantities are borrowed or acquired from other languages including English (Zavlasky, 1973; Cleghorn, 1989; Bunyi, 1997). These differences could potentially affect acquisition, memory and utilization of such concepts, affecting the performance of numeric tasks (Dornic, 1979). This is further supported by the findings of study 3 of this thesis research, where participants were required to solve a problem using numeric diabetes diet information. The problem included 3 items with fractions. More Mandarin-speakers answered correctly two of the items, while Kikuyu-speakers answered correctly only one item. However, in the two items that involved whole numbers, the two groups tied in the number of correct answers they gave a finding that is consistent with the lack of number concept of fractions in Kikuyu. However, more research will be needed involving speakers of other low numeric concept languages to further examine how they handle information that has numeric concepts absent in their primary language.

Another factor, not measured in this study, which could potentially contribute to the findings is the effect of different methods of mathematics instruction on Kikuyu-speakers and Mandarin-speakers' numeric performance.

Leung (2001) differentiated between Western and East Asian systems of learning and argued that features and values unique to East Asian mathematics education contribute to the superior performance of East Asian language speakers compared to other groups. One feature of mathematics instruction in China is the emphasis of content over procedure process. Although both process and content are important in mathematics instruction, Chinese learners have the advantage in that they acquire mathematical content, as opposed to Western learners who mainly concentrate on the procedures of doing mathematics.

Another feature of instruction in China is learning by rote memory (as opposed to meaning learning), which entails memorizing and repeated practice of the learned materials (Leung, 2001). From a study on the role of repetition in memorizing and understanding information among students with Western (German) and Asian (Chinese) backgrounds, Dahlin and Watkins (2000) observed that repetitive learning among the Chinese helped create lasting images in the mind and helped the learners to discover new meanings of the learned material. Miura and colleagues (1994) found that Japanese children's superior performance in mathematics could be attributed, at least in part, to differences in the time devoted to learning mathematics and differences in teaching approaches. In their review of the effect of Chinese number words, culture and mathematics learning, Ng and Rao

(2010) suggested that apart from number word system and the structure of the language, contextual factors such as parental support, and the degree of appreciation of mathematics in Asian culture also contribute to superior performance in mathematics among Chinese students. Given that Kikuyu-speakers learn mathematics in a Western-oriented system, it is possible that their learning emphasized process rather than content and meaningful learning rather than learning by rote (memorizing and repetitive practice).

Besides the number-word structure of the primary language, the quantity of numeric concepts embedded in the language structure, other factors such as education, duration of residency in Canada, age, and gender contributed to numeracy and health numeracy skills of the Kikuyu- and Mandarin-speakers involved in this study. These factors are discussed in the following section.

6.2 The Effect of Education on Numeracy and Health Numeracy

The level of formal education predicted basic numeracy (addition, and addition subtraction-correction tasks). Education also predicted health numeracy (S-TOFHLA composite, prose and NVS) adjusting for other variables. However, level of education did not predict performance on the numeracy component of S-TOFHLA. These findings are discussed in the following sections.

The findings that higher levels of education were associated with better performance in some of the numeracy and health literacy/numeracy tasks are consistent with what has been reported elsewhere (OECD & Statistics Canada., 2011) showing an association between education and numeracy, and health numeracy levels. International studies such as International Adult Literacy Survey and Adult Literacy and Lifeskills survey have consistently demonstrated a strong association between numeracy skill and education levels. For instance, in Canada, individuals with high levels of education (university degree) constituted the highest proportion (73%) of those who performed at Level 3 or above in the 2003 IALS. In contrast, a smaller proportion (18%) of individuals with educational levels below high school scored at Level 3 and above (Statistics Canada, 2005). Similarly, educational attainment has a strong association with health literacy and numeracy. A study using the Health Activities Literacy Scale (HALS) reported an average score of 220 (out of 500) for adults with an educational attainment of high school and less, compared to 306 of those with high school and above (Rudd, 2007). Another study that assessed health literacy and numeracy among older adults with diabetes found that individuals with low educational levels had lower scores in health literacy/numeracy measures (S-TOFHLA and NVS) compared to those with higher educational levels (Kirk et al., 2012).

Education also predicted numeracy at the more intuitive level (addition and subtraction-correction task) in the participants in this research. It was hypothesized that the addition subtraction-correction task requires a higher level of mathematics expertise and experience to recognize the correct and the incorrect answer to each problem. Recognition is an intuitive process borne of expertise and prior experience with similar mathematical concepts and processes (Fischbein, 1999), which may be associated partly to education attainment.

Education did not predict health numeracy measured using the S-TOFHLA numeracy component. This finding was not unexpected. Although some researchers have used the S-TOFHLA numeric component to assess health numeracy *per se* (Kirk et al, 2011; Shaw, Armin, Torres, Orzech, & Vivian, 2012) there are a number of issues with its use for health numeracy: first, it was not designed as a stand-alone measure of health numeracy; second, it has not been validated as a measure of health numeracy independent of health literacy. Moreover, the numeracy component of S-TOFHLA has been reported to have only moderate reliability (.68) (Baker et al., 1999). This implies that it may be inconsistent for variables such as education vary due to factors including individuals' education system background and language. Moreover, some ESL speakers fail to respond correctly to the S-TOFHLA numeracy questions because they cannot remove themselves from the context of the test, and think that the instrument assesses their own health experiences (Shaw et al., 2012). This was also observed in the pilot phase of the current study: some participants had difficulties with the blood sugar question and argued that they could not answer it because it did not reflect their blood sugar status on that day. It is conceivable that some ESL speakers in the main may also have had difficulties with the S-TOFHLA because of personal context issues. If this is so, further research may be needed to examine ESL speakers' perception of this instrument.

Furthermore, it may be that education is a necessary but not a sufficient factor for distinguishing performance in the S-TOFHLA numeracy test. Familiarity with the health context in which numeric information is presented contributes to health numeracy performance regardless of education. Individuals who are familiar with the health context may use this familiarity to overcome poor numeric skills. Prior knowledge of health issues has been associated with greater health literacy/health numeracy levels (Sunn et al., 2013).

6.3 The Effect of Duration of Residency in Canada

The duration of residency in Canada was an important factor in basic numeracy (addition, and addition and subtraction-correction); a longer duration of residency was associated with greater numeracy skills in the sample of Mandarin- and Kikuyu-speaking immigrants. However, duration of residency was not a factor in health numeracy/health literacy skills (S-TOFHLA numeracy component and the NVS). It also did not predict performance in health literacy/numeracy (S-TOFHLA composite and S-TOFHLA prose components).

Duration of residency in the host country is a complex variable indicating not only how long a person has lived in the new country but also to some extent, the degree of acculturation (Bharmal, Hays, & McCarthy, 2013). The duration of residence may affect the degree of integration and thereby, influence numeracy skills of immigrants. Language plays an important part in integrating into a new community. Driessen and Merry (2011) found that regular use of the Dutch language was associated with the development of numeracy skills among immigrants in the Netherlands. In Canada, immigrants are forced by circumstances to learn and use one of the two official languages (English or French). For instance, in 2001, 99% of the African (which includes Kikuyu-speakers) and 77% of Chinese communities in Canada reported that they used at least one of the official languages at work (Statistics Canada, 2007; Statistics Canada, 2007). The work atmosphere could expose immigrants to numeric tasks which could contribute to the development of both English language and numeracy skills.

Other factors that may contribute to the development of numeracy skills among ESL immigrants include interactions with more people who are numerate (Ciampa et al., 2013) and increased opportunities to utilise numeracy skills, such as filing tax returns, paying bills and adding receipts (Charette & Meng, 1998). Programs existing to help immigrants integrate into the community could also provide opportunities to improve numeracy skills (McHugh & Challinor, 2011).

However, the findings that duration of residence in Canada did not contribute to health literacy/health numeracy (S-TOFHLA and NVS) were surprising. It is not clear why this was the case in this study. As discussed earlier, other factors (not captured in this research) may be responsible for low performance in S-TOFHLA health numeracy among immigrants who speak English-as-a-second language. A possible reason for duration of residence not contributing to health literacy/health numeracy could be that this sample reflected the general level of health literacy among Canadians. It is reported that an estimated 55% of adults in Canada lack adequate health literacy skill (Rootman, 2008). According to Canadian

Council on Learning (2008) immigrants have even lower health literacy levels, performing at below Level 3 in the 2003 IALS.

Performance could also have been affected by the nature of the instruments used. For example, according to Fransen and colleagues (2011), low literate and ESL individuals have problems with NVS because they do not understand the food labels and therefore are not able to perform the required calculations. Another reason for lack of association between duration of residence and health literacy may be fluency in English language. Proficiency in a second language is strongly related to the age at immigration (Stevens, 1999). Participants in this study were 40 years and older, and had lived in their countries for most of their lives (they had lived in Canada for less than 15 years). Although they now live in an English/French-speaking country, the majority still speak Kikuyu (85%) and Mandarin (98%) at home. This means that they are still attached to their primary language, which may limit their integration and use of the host languages. Nevertheless, the precise reasons as to why the ESL immigrants in the current study did not have an increase in health literacy/health numeracy as a function of length of residency in Canada are not clear from the data.

6.4 Effect of Age on Numeracy and Health Numeracy of ESL Immigrants

Age contributed to health literacy/numeracy skill (S-TOFHLA composite (*p*=.007) and prose component (*p*=.001), but not to the numeracy and health numeracy skills (NVS) of the ESL participants in this study. Younger participants (50 years and less) had better health literacy/numeracy skills than those who were over 50 years old (S-TOFHLA composite mean = 82.2 and 70.4 respectively). The respective mean score for S-TOFHLA prose was 58.1 and 45.0.

This finding is consistent with other studies showing a decline in health literacy with increased age (Sheridan et al., 2003). About 88% of Canadians over 65 years old had below Level 1 proficiency in health literacy (Statistics Canada, 2005).

In a study on age and health literacy among older adults (Baker, Gazmararian, Sudano, & Patterson, 2000) health literacy declined with age, with a 1.3 points decline in S-TOFHLA score for one year increase in age, after adjusting for gender, race, ethnicity and education. Another reason for poor performance in the S-TOFHLA could be due to the Cloze test format of the instrument which makes demands on the verbal fluency of older adults (Ownby & Waldrop-Valverde, 2013). Robinson et al., (2011) reported that due to the timed nature of S-TOFHLA, it may wrongly categorize adults (53 years and older) as having low or marginal health literacy/numeracy skills.

Another study comparing measures of health literacy and numeracy using the rapid estimate of literacy in medicine (REALM) and NVS found that participants who were 60 years and older were more likely to have inadequate health literacy and numeracy skills compared to participants whose age was less than 60 years (Shigaki, Kruse, Mehr, & Ge, 2013). Age can be associated with a slowing of working memory and reduced speed of processing of information (Caplan, Dede, Waters, Michaud, & Tripodis, 2011).

There are several reasons for age-literacy association. Apart from age-related reduction of cognitive functioning, older adults may have fewer opportunities to engage in regular numeracy and prose skill building than younger adults (Willms & Murray, 2007). Another factor that affects literacy and numeracy among older people is dropping out of the labour force and as a consequence having fewer opportunities to use, practice and develop their skills further (Shomos, 2010).

Age was not a significant predictor of numeracy (addition, and addition subtraction-correction) and health numeracy (S-TOFHLA numeracy and the NVS). This is in contrast to other reports associating older age with low numeracy skills (LaVallie, Wolf, Jacobsen, Sprague, & Buchwald, 2012). One possible reason for the lack of prediction by age could be the unequal distribution in the age variable; more participants (n = 88) being less than 50 years old compared to fewer who were over

50 years old (*n* =32). This may have affected the power to detect a significant difference. Another reason for lack of the age effect could be that the instruments measured processes that are not affected by age. A study on the counting speed which involved a sample of young and older adults (ages 20 to 86 years) provided some evidence that not all arithmetic operations (such as basic arithmetic) are affected by the aging process because age does not affect all mental processes equally (Sliwinski, 1997). In another study (Allen, Ashcraft, & Weber, 1992), age was associated with slower judgment but not with problem size [that is whether the problems to be solved involved small (2 x 3) or large numbers (9 x 8)]; this suggested to the authors that age does not affect important mental process like memory retrieval and decision making. Skill and expertise, especially in basic mathematics, may moderate aging-related effects in processing information.

6.5 Effect of Gender on Numeracy and Health Numeracy of ESL Immigrants

Women outperformed men on the S-TOFHLA composite and S-TOFHLA prose component. This finding is consistent with other reports in literature showing that women perform better than men on the S-TOFHLA among heart failure patients (Robinson et al., 2011). In another study involving Hispanic and non-

Hispanic participants (Aguirre, Ebrahim, & Shea, 2005), women outperformed men in both the English and the Spanish versions of S-TOFHLA. Moreover, women may be more familiar with health information than men. Studies show that in general, women are more proactive than men in seeking health information from a variety of sources including the Internet (Kassulke, Stenner-Day, Coory, & Ring, 2010; Cohen & Stussman, 2009).

The contribution of higher basic literacy skill in women (in Canada) may also be a contributing factor to better health literacy performance. According to the Programme for International Student Assessment (PISA) 2009 report (OECD, 2010), girls continue to outperform boys in literacy, with the gap widening by 39 points between 2000 and 2009. This superior performance is not new. Hedges and Nowell (1995) conducted a review on gender differences in literacy and mathematics between 1962 and 1992. The review involved analyzing six large data sets from surveys involving a nationally (U.S.) representative sample of 73, 425 examinees who were 15 years-old high school students. The investigators found that girl's performance in literacy remained stable over time, whereas boys' performance varied with time; girls were also found to have better comprehension, perceptual speeds, and in associative memory. Also, girls have been found to have fewer reading difficulties than boys (Hawke, Olson, Willcut, Wadsworth, & DeFries, 2009).

Gender (women) approached significance (p = .055) in its prediction of numeracy (basic addition) when mathematics self-efficacy (MSES) was included. This is notable because, although some studies show men performing better than women in mathematics (Benbow & Stanley, 1980; Geary, 1996) these differences reflect environmental and cultural factors of gender inequality that cast mathematics as a male domain rather than a reflection of women's innate abilities (Guiso, Monte, Sapienza, & Zingales, 2008; Hyde & Mertz, 2009). Evidence is now available on the narrowing of gender gap between boys and girls in mathematics performance (Hyde & Mertz, 2009).

6.6 Preferred Format of Numeric Health Information

Participants preferred health information in a combination of number and detailed explanation (text), as opposed to health information in numbers only. This preferred format of numeric health information was the only variable that predicted health numeracy (S-TOFHLA numeracy component). Again this finding was not unexpected. Over ¾ of the Kikuyu-speakers (about 77%) and Mandarin-speakers (about 80%) answered "sometimes" to the question: *"How often do you have problems learning about your medical condition because you have problems understanding the* *numbers in the information?"* Similarly, almost two-thirds of the Kikuyu-speakers and about one third of the Mandarin-speakers reported requiring help to understand numeric health information.

Format of information presentation encompasses not only text and numbers, but also various types of graphics (Ruiz et al., 2013; Donelle, Hoffman-Goetz, Gatobu, & Arocha, 2009). There seems to be no single best format for presenting numeric health information to the general population, much less ESL immigrants. Some researchers have recommended combining verbal explanations with numbers, or presenting health information qualitatively to people with low health numeracy (Gordon-Lubitz, 2003; Paling, 2003). Brewers and colleagues (2009) found that information formats that combined verbal with numeric information received the highest rating among breast cancer survivors. Others have reported contradicting information between what people say they prefer and what their comprehension of numeric information is when presented in different formats. In a study on the effect of the format of probabilistic information on breast cancer, women said that they preferred the information in numeric formats; however, comprehension was higher when the information was presented in verbal or text format, irrespective of participants' preference and educational background (Vahabi, 2010).

The use of graphics to convey numeric health information is also not universally accepted. Ancker and colleagues (2006) conducted a systematic review of published research on the use of graphics in health risk communication and concluded that graphics were not more intuitive than text; comprehension of information in graphic formats was dependent on factors such as training and expertise. Other factors such as basic numeracy skill, age, education, language, disposition, and culture influenced format preference (Lipkus, 2007; Timmermans, Ockhuysen-Vermey, & Henneman, 2008; Wright, Whitwell, Takeichi, Hankins, & Marteau, 2009a). Personal preference and ability (for example, graphical literacy and numeracy) have been found to affect people's comprehension and memory of statistical information. Additionally, individuals with high graphical literacy skills, rate information in graphics highly, and those with high numeracy skills rate numeric formats highly (Gaissmaier et al., 2012; Lipkus, 2007; Wright, Whitwell, Takeichi, Hankins, & Marteau, 2009). These findings suggest that further research will be necessary to understand not only people's health information needs, but also how best how to present complex health the information to them.

6.7 Numeric Information Embedded in Prose

Comprehension of numeric information embedded in text requires prose, literacy and numeracy skills. It was observed that when the numeric information was embedded in prose, Kikuyu-speakers had better performance than did Mandarin-speakers. For example, fewer Mandarin-speakers (31%) than Kikuyu-speakers (43%) had adequate health literacy skills as measured using S-TOFHLA. Kikuyu-speakers' had higher S-TOFHLA prose score (*M* = 61.23 compared to 48.0 among Mandarin-speakers). This was also reflected in the NVS performance in which more Kikuyu-speakers (51%) than Mandarin-speakers (42%) had adequate literacy and numeracy skills.

Items in the NVS tap prose and numeracy skills. An analysis of the individual NVS questions found that more Mandarin-speakers answered correctly those questions which had an easily identifiable numeracy component (Questions 2 and 4), whereas more Kikuyu-speakers answered correctly questions that required greater prose/language skill (Questions 1, 3, 5, and 6). This suggests better English skills among the Kikuyu-speakers, which was not unexpected considering Kikuyu-speakers were more comfortable in English due in part to their use of English (post Grade 3) in Kenya (Bunyi, 1997). In fact, when asked what language they used in different situations, more Kikuyu than Mandarin-speakers cited "mainly English" when adding groceries (46.7% vs 23.3%), calculating the price of gas (55% vs 28.3%), calculating tips at the restaurant (55% vs 30%), counting things (58.% vs 14%) and remembering phone numbers (62.% vs 13). In all these situations Mandarin-speakers used either mainly Mandarin or Mandarin and English.

There are may be other reasons why Kikuyu-speakers were relatively more fluent in English than Mandarin-speakers. Immigrants from Kenya including Kikuyu-speakers account for only 0.07% of the Canadian population [in fact about 4300 Kenyans migrated to Canada in 2006 (Statistics Canada, 2009)]. Given their small numbers, Kenyan and Kikuyu speaking immigrants to Canada are less likely to settle in specific linguistic enclaves. In an article on ethnic settlements in Toronto, Canada, black people were cited as least likely to settle in ethnic enclaves. In 2001, less than 1% of the black people lived in ethnic enclaves in Toronto (Qadeer & Kumar, 2006). In contrast, Chinese immigrants constitute a sizeable demographic proportion of the Canadian population (approximately 1.2 million in a population of 31.6 million using the 2006 census). Much of the health information available to the Canadian public is available in Mandarin. Chinese immigrants also tend to settle in ethnic and linguistic enclaves (Hou & Picot, 2003). In a 2001 survey, almost half (just over 46%) of the Toronto residence of Chinese origin lived in ethnic enclaves (Qadeer & Kumar, 2006). Moreover, when asked what language they used with family and friends, 93% and 97% of Mandarin-speakers answered that they spoke Mandarin. In contrast, a lower percentage of Kikuyu-speaking participants used their language when interacting with family (52%) and friends (67%).

Extensive use of primary languages and settlements in ethnic enclave may limit integration into the broader English-speaking community (Haan, 2006) and restrict the development of immigrants' English language skills. Another factor may be the exposure to and availability of health literature in English, Mandarin and Kikuyu. Although health information brochures and pamphlets in Canada are available in several languages, it is unlikely that any health information would be available in the Kikuyu language. Thus, it would not be unreasonable to assume that the Kikuyu-speakers in this study access health information largely in English rather than in Kikuyu and that Mandarin-speakers access health information largely in Mandarin. However, participants' use of printed health information in Kikuyu, Mandarin, or English was not measured, and it is not known if the level of integration and more exposure to English contributed to differences in prose/ literacy skills.

A large proportion Kikuyu and Mandarin-speakers (87% and 70% respectively) communicated with their doctors in English and about 7% Kikuyu and 20% Mandarin-speakers communicated with the doctor in their primary languages.

More Kikuyu (58%) than Mandarin (10%) speakers reported that they would prefer English when speaking to the doctor.

Findings of the National Physicians Survey, 2010 (www.nationalphysiciansurvey.ca) indicate that majority of physicians in Canada communicate with their patients in either English (90%) or French (33%). However, 14% of the physicians communicated with their patients in "other" languages, which included Chinese (Cantonese and Mandarin), Hindi, Italian, German, Arabic. No African language was used to communicate with patients suggesting very low numbers of physicians spoke African languages including the Kikuyu language. This may reflect the situation that not all English-as-a-second language immigrants prefer a doctor from their corresponding ethnic group; it could also mean that some immigrants are aware of the challenge they face locating a doctor who speaks their primary language, and they have adjusted to the available healthcare services in English language.

6.8 Ability to Use Numeric Concepts

Although Kikuyu language does not have the concepts of fractions, and proportions in its structure or in its lexicon (Leakey, 1977), this was not reflected in Kikuyu-speakers' responses to questions about their ability to understand numeric information presented in proportions and fraction in their primary language (Kikuyu). For example, 90% of the Kikuyu-speakers answered "good" to their ability to understand proportions in their primary language; 54% and 53% responded with a "good" in their ability to understand information in percentages and fractions, respectively. Although an equally high proportion of Mandarin-speakers answered the same way, the difference is that Mandarin has some of these concepts in its structure and in its lexicon unlike Kikuyu language.

The Kikuyu-speakers' responses could also mean they did not understand the question. However, this is unlikely because two questions were included for each format. To avoid confusion, for each format, one question assessed ability in English and the second question assessed ability in primary language. For example, the two questions for ability in fractions were:

"How would you describe your ability to understand health information that is given in fractions in English? (e.g., ¾ of population is healthy)." And

"How would you describe your ability to understand health information that is given in fractions in Kikuyu/Mandarin? (e.g., ¾ of population is healthy)".

Another reason for answering "good" could reflect individual's tendency to present themselves at their best, a phenomenon known as social desirability (Neely & Cronley, 2004). It could be that Kikuyu-speakers needed to protect their dignity by not wanting to be perceived as innumerate. However, this is only a speculation because social desirability was not tested in this study.

6.9 The Role Math Self-efficacy on Numeric and Health Numeracy Kikuyu and Mandarin Speaking Immigrants to Canada

In Study 2 the hypothesis was that math self-efficacy would affect performance on health numeracy tasks, with higher self-efficacy leading to higher performance. To this end, the focus was on the effect of mathematics self-efficacy on numeracy and health numeracy of speakers of high numeric concept (Mandarin) versus speakers of a low numeric concept language (Kikuyu). Findings were that Kikuyu-speakers had lower mathematical self-efficacy scores and lower numeracy scores (addition, and addition subtraction-correction) than Mandarin-speakers. In addition, Kikuyu-speakers had lower health numeracy scores (S-TOFHLA numeracy component) than Mandarin-speakers. In regression analyses, self-efficacy in mathematics (MSES and SNS) contributed to numeracy (addition and addition subtraction-correction) and to health numeracy (S-TOFHLA numeracy). It also contributed to health literacy/numeracy measure (NVS).

These findings support the hypothesis that speakers of a high numeric concept language (Mandarin) are more confident in their ability to perform well in numeric and health numeric tasks compared to speakers of a low numeric concept language (Kikuyu). Self-efficacy reflects individuals' attitudes and beliefs about their ability to engage in and succeed in a given task. Self-efficacy regulates behaviour which varies depending on individuals and tasks to be accomplished (Bandura, 1977). Mathematics self-efficacy is the perception of one's ability to perform and succeed in situations that involve mathematical or numerical tasks (Hackett & Betz, 1989; Pajares & Miller, 1994). Studies show that mathematics self-efficacy is negatively associated with mathematics anxiety, which refers to intense negative feelings about mathematics and numbers; low mathematics self-efficacy is associated with high mathematics anxiety and low performance in mathematics (Ashcraft & Moore, 2009).

The effect of mathematics anxiety can be severe. According to recent findings, extreme mathematics anxiety is associated with activation of pain networks in the central nervous system among math anxious individuals (Lyons & Beilock, 2012). Therefore it is possible that Mandarin-speakers' greater self-efficacy attenuated the feelings of anxiety when performing the numeric tasks. Some Kikuyu-speakers expressed their low self-efficacy in mathematics during the interviews for study 3. There were comments such as *"I am not good in this…"* and *"I can't do this…"* In addition, fewer Kikuyu-speakers (73%) than Mandarin-speakers (96%) answered that they enjoyed learning mathematics, a finding which suggests their disposition towards the subject.

Perceptions of self-efficacy in any domain are affected by factors such as prior experience and support from significant others such as parents, teachers and, peers (Bandalos, Yates, & Thorndike-Christ, 1995). Performance is determined by mastery of content and ability to apply it to solve problems. Studies show that in the Chinese education system, mathematics training tends to focus on rote learning and problem solving strategies (Leung, 2001). This educational feature could potentially give Mandarin children not only mastery of content, but also equip them with skills for problem-solving which they carry on to adulthood (Kelly et al., 1999). A meta-analysis to determine within-personal relationships between self-efficacy and performance found a strong effect of past performance on self-efficacy across tasks (Sitzmann & Yeo, 2013,). People with prior successes at a given task are aware of their ability, which is reflected in their self-efficacy ratings, and in success in subsequent similar tasks (Paunonen & Hong, 2010). Regular life-long practice with familiar numeric concepts would ideally equip Mandarin-speakers with confidence in their ability to perform mathematical tasks. A study on arithmetic performance between adults educated in China and adults educated in Canada (Lefevre & Liu, 1997) lends some support to that argument. In essence, the effect of early learning and continued use of mathematical concepts on mathematical skills later in life was significant. What Lefevre and Liu found was that adults who were educated as children in China performed better in multiplication tasks than adults who were educated as children in Canada.

Self-efficacy in numbers predicted health literacy/health numeracy as measured with the NVS. NVS requires both numeracy and literacy (English language) skills (Patel et al., 2011). In addition, appreciation of food labels depends on interest in, and knowledge of nutrition facts (Grunert, Wills, & Fernandez-Celemin, 2010). Interest in, prior knowledge of, and experience with a subject or topic fosters self-efficacy in any domain. It is possible that some participants were interested in nutrition facts and had previously used them due to medical conditions. One Mandarin-speaker had this to say during in the pilot phase of this study.

> *Voice 3: I have started reading that because my husband has cholesterol...my doctor suggested he joins a class to study...first time he came and taught me about that label...sometime my son comes from school and tells me about this label...*

However the strong prediction by mathematics self-efficacy for context-free numeric tasks was not replicated in context-specific health numeracy domain (S-TOFHLA numeracy component). This finding supports self-efficacy as being context and domain-specific (Bandura, 1997; Zimmerman, 2000). Context-free numeracy and health numeracy differ. In context-free numeracy, individuals are required to apply mathematical skills to the task. Other factors, such as anxiety may play a role in an individual's ability to apply mathematical skills to a task. Nevertheless, they may not have any personal attachment to the numbers when they are presented context-free. Health numeracy, however, requires some level of analysis and interpretation (Schapira et al., 2008) and for tasks such as the S-TOFHLA, numbers may arouse certain feelings about individuals' personal experiences. This personal connection and prior experience could potentially affect their confidence in performing the task.

6.10 Cognitive Processing of Numeric Health Information by Kikuyu and Mandarin-speakers

For Study 3, it was hypothesized that ESL immigrants (Chinese and Kikuyu) would use an intuitive or analytical approach to solve simple arithmetic problems involving food items within a health (diabetes) context. This component was also used to give insight into the participants' numeracy skills. The think-aloud method was used to collect verbal data that were later analyzed. The key findings were that Mandarin-speakers (a high numeric concept language) solved the problem mostly intuitively, while Kikuyu-speakers (a low numeric concept language) solved the problem mostly analytically. This supported the hypothesis that speakers of a high numeric concept language use the intuitive approach while speakers of low numeric concept language use the analytical approach to solve problem involving numbers.

Overall, Mandarin-speakers took less time to solve the diet problem and showed better performance on the French Kit recognition task, a measure of speed of context-free mathematical performance. In contrast, Kikuyu-speakers took relatively more time to complete the problem-solving task. They also had poorer performance than Mandarin-speakers on the French Kit context-free mathematical assessment. However, their performance on the diabetes problem-solving task was at par with that of Mandarin-speakers. A number of factors might explain this difference in the problem-solving speed between Mandarin-speakers and Kikuyu-speakers.

Intuitive and analytic reasoning can be conceptualized as a continuum with the two approaches at the opposite extremes; individuals' reasoning occurs anywhere between these two extremes (Keren & Schul, 2009). Highly intuitive people have an advantage over highly analytic people when solving arithmetic problems (Thorsland & Novak, 1974), which can be attributed to familiarity with mathematical problems of similar kind. Personal experience through exposure and practice with similar concepts and processes generates knowledge that is stored in long-term memory as a schema (Fischbein, 1999). Schemas serve as a reservoir that the individual can draw from to speed up processing of mathematical information (Giardino, 2010). From experience with similar problems, such schemas get reinforced in the long-term memory to later become easily accessible for problem solving. Studies of experts and novice problem solvers show that experience in a given knowledge domain leads to better and faster problem solving (Schoenfeld & Herrmann, 1982).

As described earlier, a close association exists between language and arithmetic memory. Given that Kikuyu language lacks many number concepts, Kikuyu-speakers may tend to rely on the language of instruction to process numeric information, which may explain why, despite their poorer performance on the French Kit recognition task (an indication of unfamiliarity with number manipulation when compared to Mandarin-speakers), they performed well on the diabetes problem. This was the case even for the 3 Kikuyu-speakers (K006, K019 and K032) who received their education instruction in Kikuyu.

In this study, higher scores in the French Kit task were from participants who had university (bachelor level) education. Indeed, some graduate level participants had low scores in the French Kit, and also failed to get the correct answer for the diabetes task. This supports studies showing that although an attained level of education improves numeracy skills in most areas including health contexts (Kirk et al., 2012; Rothman, Housam, Weiss, Davis, Gregory, Gebretsadik, Shintani, & Elasy, 2006b), individuals with high levels of education might have difficulties performing numeric tasks (Lipkus et al., 2001). Although education plays an important role in acquisition of numeracy, the language of instruction and the language in which the problem is presented could be important factors in the actual performance of tasks involving numbers. Mandarin-speakers may have used the intuitive approach because the problem task was clearly arithmetic and their performance did not depend on their (more limited) English skills, thus relying more on their primary language-dependent arithmetic memory.

An interesting finding was the performance in the addition and the addition subtraction-correction tasks. When Kikuyu and Mandarin-speakers performed the addition task, the highest score was almost the same for the two groups (22 correct/60 total for Kikuyu-speakers and 28 correct/60 total for Mandarin-speakers). However, in the addition and subtraction-correction task that utilized associative processing (Sloman, 1996), Mandarin-speakers produced the individual with the highest score (58 correct/60 total) compared to the Kikuyu group's highest score (36 correct/60 total). It may be that the two groups were slow in the addition task for different reasons. For the Kikuyu-speakers, it could have been the manifestation of Kikuyu-speakers' low numeracy skills. Since most of them had learned mathematics in English, language difficulties could have contributed a little to their slow speed when solving the task. For the Mandarin-speakers, it could have been that they performed the task in their primary language and had to translate the answer in the required language or format. As pointed put earlier, bilinguals often perform mental calculations in their native languages and translate the answer into the required language of the problem, which slows down the processing speed (Marsh & Maki, 1976). However, the addition and subtraction-correction task requires an intuitive or an associative approach to recognize the correct answer. Mandarin-speakers, tapping into their number schema (in their language) were faster in performing this task. Kikuyu-speakers may have been slower in this task because they lacked such number schemas in their language. This difference in performance needs further exploration. Nevertheless, it is important to note that individuals may differ in their comprehension of numeric information for different reasons.

However, possessing superior numeric skill does not mean better performance in health numeracy problems in the English text, used in this study. It is possible that factors such as domain relevant knowledge and understanding the verbal context of the problem are necessary to successfully solve such problems. Another factor could be the individual's level of fluency in the English language. One can argue that Kikuyu-speakers had better English skills based on the fact that English was the language of formal instruction after Grade 3. However, they might have lacked adequate memory of numeric concepts and would use their English language skills to surmount their low numeracy skills and generate the correct solution to the diabetes problem. This might also explain the finding that they had longer protocols compared to Mandarin-speakers.

In terms of the problem-solving process, the participants made use of various problem-solving strategies, with intuitive problem-solvers focusing on the first and last phases of the process, while analytical problem-solvers used a larger variety of strategies including some monitoring processes. However, regardless of group affiliation whether Kikuyu or Mandarin, there was limited assessment and monitoring at different points in the problem-solving process, which can affect the final problem solution. Assessment, or reflection, is an important factor in problem solving, (Schoenfeld, 1985; Yimer & Ellerton, 2010) and it is often seen in skillful problem solvers (Mayer, 1998). By reflecting on the immediate task, and the problem as a whole, individuals can identify where they used the wrong strategy, or where they simply wrote the wrong thing. Better use of monitoring and reflection could have helped the study participants improve their problem solving performance.

6.11 Limitations of the Study

This study was not without a number of limitations. These are described below.

One: A convenience sample composed of volunteers, rather than a probability sample based on Canadian census data was used in this study. Random sampling was not possible because no reliable sampling frame exists for Kenyan (Kikuyu-speaking) immigrants to southern Ontario. Consequently, a convenience sample using networking and snowball sampling was the best approach to reach the two groups. Using a convenience sample affects the external validity and therefore the findings may not be representative or generalizable to the general population from which the sample was drawn.

Two: Most Kikuyu-speakers received their elementary level mathematics education in English, whereas most Chinese participants were instructed in Mandarin throughout their education in mainland China. This limited the level of comparison based on numeric concepts learned using primary languages. Ideally, involvement of Kikuyu-speakers who were only educated in Kikuyu beyond grade three would have addressed this limitation. Nevertheless, there were no differences in performance on numeracy and health numeracy measures between Kikuyu-speakers who received primary math education only in Kikuyu compared with those whose primary math education was in English and Kikuyu. Although the curricula of Kenya and China were reviewed, differences may exist between the curriculum and its actual delivery; some systems emphasize the process while others emphasize mastery of content. Participants in the study were not asked about the style of instruction used in their elementary level math instruction.

Three: More Mandarin-speakers (about 70%) had an attained university level of education or above, compared to Kikuyu-speakers (about 40%). In the regression analysis, education was controlled for when other variables, such as language and residency in Canada were considered. Moreover, although education predicted performance in most of the numeracy and health numeracy/health numeracy measures, it did not predict health numeracy measured using S-TOFHLA. Attained education remains an imperfect marker for health literacy (Chew, Bradley, & Boyko, 2004), and for economic and social well-being (OECD Better Life Index http://www.oecdbetterlifeindex.org/topics/education/). Furthermore, most English-as-a-second language immigrants have poor numeracy skills regardless of their educational attainment (Smyth & Lane, 2009). Immigrants' numeracy skills depend on many other factors such as background, language and culture (Shomos, 2010) which may not be captured by an attained level of education. In addition, numeric development is specific in terms of concepts and tasks, and transference from one context and task to another may be difficult or may not occur at all (Wynn, 1992).

Four: None of the tests used were designed to assess health numeracy independent of health literacy. A more recent test, the Numeracy Understanding in Medicine Instrument (Schapira et al., 2012), may have produced different results. The Instrument was developed to specifically measure health numeracy independent of health literacy. It has high reliability (α = .86), and correlates well with the Wide Range Achievement Test–Arithmetic (0.73, p<.001) which measures basic numeracy, the Lipkus Expanded Numeracy Scale (0.69, p<.001), which measures individuals' abilities in simple mathematics and risk magnitudes, and the

Medical Data Interpretation Test (0.75, $p<.001$), which assesses individuals' understanding of medical statistical data. The NUMi effectively discriminated among individuals with inadequate health numeracy (Schapira et al., 2012), and would most probably have done the same in this study. However, this test was not available at the outset of the study.

A part from NUMi, other instruments have been developed to capture health numeracy (for example, Schwartz, Woloshin, & Welch, 2005) but they tend to assess more advanced statistical skills (Rothman et al., 2008) and are less appropriate to measure health numeracy skills immigrants who may not have some or all of the statistical concepts in their primary languages. The tools used in this thesis research are widely accepted measures of numeracy as well as health literacy and numeracy. They include the S-TOFHLA, and NVS, and the French Kit which have been used in English-as-a-second language populations (Campbell & Epp, 2004; Donelle, Arocha, & Hoffman-Goetz, 2008; Lefevre & Liu, 1997).

Five: Similar to other forms of behavioural data, verbal protocols do not provide complete information about the cognitive processes taking place as an individual engages in problem solving (Payne, Braunstein, & Carroll, 1978). To address this concern, the French Kit recognition task was used as a context-free measure to verify the results of the protocols. Therefore, findings in the study are based on performance on a numeric task and verbal data, whereby one was used to support the other.

Six: Although published literature shows that low health numeracy is associated with poor health outcomes of immigrants, health outcomes and health status were not measured in this study. Future research incorporating clinical measures will be needed to determine how primary language, math self-efficacy, and numeracy affect the actual health status of non-native speakers of English.

Seven: Missing from this study was a formal measure of acculturation which is known to affect literacy and health literacy. Nevertheless participants were asked what language they used in multiple situations and what language they preferred to use with their doctors. These questions, albeit imperfect, provide an indirect indication of acculturation into the English speaking Canadian society because language use is a key variable in the acculturation process (Coronado, Thompson, McLerran, Schwartz, & Koepsell, 2005). Future research with this English-as-a-second language (ESL) sample could incorporate measures of acculturation, numeracy and healthy numeracy.

Eight: Social desirability was not measured and, therefore, it is unclear from the data whether participants' responses were influenced by their need to avoid the stigma associated with having low numeracy skills. This was particularly applicable for questions on participants' ability to understand numeric information in different number formats. However, use of self-administered questionnaires was meant to attenuate social desirability. It has been shown that with self-administration the interviewers' presence is minimized which increases privacy for the respondents. This in turn minimizes the respondents' feelings of embarrassment and subjectivity. Therefore, respondents are more likely to be more honest in their responses to sensitive questions (Krumpal, 2013). Another area where social desirability could have been an issue was when screening participants to find out if they were on treatment for any chronic diseases. Since this is a very personal issue, there was no way of verifying their responses.

Nine: Format of preference for numeric health information was captured by a single prose item on the questionnaire rather than providing illustrations (e.g., a pie graph) or by multiple questions to establish face validity. However, the focus of this thesis research was not on the best format for delivering numeric health information. Future research can incorporate numbers, text and various types of graphics to assess this ESL population's preferred format.

Lastly, this was an exploratory study, and there was little published research to draw upon for hypothesis testing on the role of language in numeric problem-solving (Pugalee, 2001) in health contexts, and among people for whom English is a second language. Kikuyu and Mandarin-speakers are only two of a diverse population of immigrants in Canada. Immigrants come from many cultures, languages and educational system backgrounds, which may singularly or collectively affect their health numeracy skills. The current trend of interaction between people from different cultures and languages will necessitate considerably more research in different areas and using different methods would help meet their health information needs.

6.12 Implications for Public Health Practice and Research

This study was designed to assess the effects of immigrants' primary language on their numeracy and health numeracy skills, with regard to the number of numeric concepts embedded in the primary language. To develop effective health education and promote interventions for immigrant groups, it will be necessary to consider not only their demonstrated numeracy and health numeracy skills, but also to examine the underlying factors that determine these skills. The rationale to do this comes from a number of arguments.

First, immigrants constitute about 20% of the Canadian total population and by 2030 immigration will be the single most important factor in population growth in Canada (Statistics Canada, 2007). Addressing underlying causes of low numeracy and health numeracy among this significant population demographic may be necessary to enhance engagement and active participation in civic society in Canada.

Second, given the documented link between low numeracy and poor health outcomes for immigrants addressing underlying causes of low numeracy and health numeracy could lead to cost-saving interventions, strategies and policies for provincial and national health care systems.

Third, low numeracy among immigrants may translate directly into lower economic performance for individuals and for the country as a whole. Numeracy (and by extension health numeracy) are necessary skills for workers in a highly competitive, knowledge-driven economy. Understanding and addressing the component elements of numeracy and health numeracy skills may potentially play a role in enhancing the competitiveness of the Canadian labour force.

Fourth, primary language is an important factor in the acquisition, representation and expression of thought (Frankish, 2010). Findings in this research support others that show an association between the structure of a language including the embedded numerical concepts and the language speakers' ability to use such concepts (Miura, 2003). This has implications on health promotion and education, particularly in Canada whose immigrant population is diverse in culture and language. Health education and promotion interventions involving information in number formats need to be designed with speakers of different languages in mind.

Fifth, much has been reported about the effect of format on presentation of numeric health information (for example, Tait, Voepel-Lewis, Zikmund-Fisher, & Fagerlin, 2010; Vahabi, 2010), although there is no agreement on the best format for different populations and different settings. The results of this thesis research showed that over 90% of the Kikuyu and Mandarin-speakers preferred health information in a combination of numbers and detailed explanation (text) rather than in numbers alone. Although other formats or representations were not tested, preference for numeric health information was one of the two predictors of health numeracy performance (S-TOFHLA numeracy). Indeed, although the two groups (Mandarin-speakers and Kikuyu-speakers) originated from different parts of the world, they had a common preferred format. This finding suggests that in a health context, numbers alone may not be the most effective representation of conveying risk information. People need contextualization about numbers when they are situated together with health issues. This appears to be the case regardless of what their primary language is or where they come from.

Duration of residence in Canada did not improve the health numeracy level of the English-as-a-second language immigrants in this study. Duration of residency is associated with the degree of acculturation (Bharmal et al., 2013), but it may not translate into improvement in health numeracy levels among immigrants. It is important to note that health numeracy is a distinct skill that is influenced by factors other than years spent in the host country. The findings in this thesis indicate that it may be an erroneous assumption that the longer the residency in Canada the higher the health numeracy (or health literacy) is among immigrants who are speakers of English-as-a-second language. Thus, public health practitioners will need to give greater attention to assessing actual health numeracy performance, even among long-time immigrant residents of Canada.

The above arguments have implications for health communication strategies. First, when developing health communication strategies for ESL speakers, it might help to consider their age and the age at migration. The older immigrants are when they arrive in their new country, the more dependent they are in the use of their primary language .This may affect their ability to interact meaningfully with health information provided in English in Canada. Second, knowledge of immigrants' primary language with regard to embedded numeric concepts may help to educators and policy-makers design and disseminate numeric health information tailored to specific groups of immigrants.

This research has potential implications for research. Factors related to the primary language and its effect on health numeracy need to be examined, measured, and integrated into health education and promotion interventions. The current research is only exploratory and used a convenient sample. Further comprehensive and systematic investigation is needed involving diverse random samples of different language groups to improve external validity of the findings. Such an investigation could yield important generalizable information to help address the low health numeracy skills of immigrants, in order to improve their health outcomes. However, conceptual issues need to be addressed.

First, the construct of health numeracy needs further development (Donelle, Hoffman-Goetz, & Arocha, 2007). In this study, none of the tests used were designed to assess health numeracy independent of health literacy. Although health numeracy is gaining recognition as distinct from health literacy (Golbeck, Paschal, Jones, & Hsiao, 2011) more work is needed to allow for its further development in terms of concepts and processes. Such development would include definitions of health numeracy and clarifications of concepts associated with health numeracy.

Second, duration of residency is also important to the acculturation process. However, older immigrants may differ from younger immigrants in their rate of acculturation (Yamada, Valle, Barrio, & Jeste, 2006). There is need for longitudinal studies involving younger and older ESL immigrants to provide information regarding the association between acculturation and health numeracy. Preferably, such studies should have both a quantitative and qualitative components to help describe the status of the ESL immigrant's acculturation process (in the health domain) and to explore personal reasons that facilitates or hinders effective acculturation process. Longitudinal studies would also control for cohort effect of, for instance, older and younger immigrants health numeracy skill at the time of arrival, and changes that may occur over time.

More research is necessary on ESL immigrants perceptions of the instruments used to measure health numeracy. It would be necessary to examine how factors such as primary language background, culture, gender and duration of residency affect ESL immigrants' perception of the instruments. This information would be used to tailor the instruments to fit the needs of ESL immigrants.

Appendices

Appendix A: Information letters

For Kikuyu-speakers

Date: Dear

Re: Taking part in a study on factors that affect health numeracy among new Canadians who speak English as a second language

I would like to invite you to take part in a study that I am carrying out. The study is part of my PhD degree in the School of Public Health and Health Systems at the University of Waterloo. The study will look at the factors that affect how new Canadians who do not speak English as their first language feel about health information that is offered in numbers. It will involve people who speak either Kikuyu or Kiembu as their first language. I am working with Dr. Laurie Hoffman-Goetz and Dr. Jose Arocha. I would like to give you more details about this project. I would also like to let you know what you would be asked to do if you decide to take part.

Most health information in Ontario is in English although many people have a first language or a mother tongue other than English. This means that new Canadians may find it hard to use the information to make a choice on their health care. The purpose of this study is to look at whether a person who learned and spoke another language as a child is able to understand health information that is given in numbers and in English.

You can decide not to take part in this study. If you choose to take part, you will be asked to attend one session that will take place at an agreed time. The session will include filling out 5 questionnaires. You will be asked about yourself, what language you use at different times and your comfort with numbers. You will also take part in 2 tasks where you will work with numbers. With your consent the sessions will be audio recorded. Also, with your consent, anonymous quotes may be used in the thesis and other publications that may result from this research. The entire session should take about 1 hour.

There is no risk to those who take part in this study. You may decline to answer any of the questions if you so wish. Further, you may decide to withdraw from this study at any time. Simply tell the researcher that you would like to stop. All information you provide will be fully confidential and will be pooled with information from all others who will take part. Anything that will be deemed private data will be removed. The data will be kept for 10 years in a locked space in the Consumer Health Informatics Research Partners (CHIRP) office, at the University of Waterloo. Only the two supervisors and I will have access to the data.

By taking part in this study you will help us find out how Canadians who speak Kikuyu process health information that is in numbers. This will help public health educators design ways to better present health information. This may help those who speak English as a second language to make good health care choices.

To thank you for your time, you will receive $30.00 at the end of the 1 hour session. You may decide to withdraw from this study at any time. Should you decide to withdraw, you will receive $15.00 to thank you. Please let me know if you wish to withdraw. You have to pay tax for the amount received. It is your duty to report this amount for the purpose of income tax.

If you have any questions about this study please contact me at (519) 888 4567 Extension 33333 or by email at sgatobu@uwaterloo.ca. You can also contact my supervisors Dr. Laurie Hoffman-Goetz at (519) 888 4567 Ext 33098 or by email at lhgoetz@uwaterloo.ca, or Dr. Jose Arocha at (519) 888-4567 ext. 32729 or by email at jfarocha@uwaterloo.ca.

Please be assured that this study has been reviewed and has received ethics consent through the Office of Research Ethics at the University of Waterloo. If you have any comments or concerns as a result of taking part in this study, please contact Dr. Susan Sykes of the Office of Research Ethics at (519) 888-4567 ext. 36005 or by email at ssykes@uwaterloo.ca.

We look forward to speaking to you further about this project. Thank you in advance for your support.

Sincerely yours,

Sospeter Gatobu
Ph.D., Candidate
School of Public Health and Health Systems
University of Waterloo
(519) 888-4567 ext. 33333
Email: sgatobu@uwaterloo.ca

For Mandarin-speakers

Dear

Re: Taking part in a study on factors that affect health numeracy among new Canadians who speak English as a second language

I would like to invite you to take part in a study that I am carrying out. The study is part of my PhD degree in the School of Public Health and Health Systems at the University of Waterloo. The study will look at the factors that affect how new Canadians who do not speak English as their first language feel about health information that is offered in numbers. It will involve people who speak Mandarin as their first language. I am working with Dr. Laurie Hoffman-Goetz and Dr. Jose Arocha. I would like to give you more details about this project. I would also like to let you know what you would be asked to do if you decide to take part.

Most health information in Ontario is in English although many people have a first language or a mother tongue other than English. This means that new Canadians may find it hard to use the information to make a choice on their health care. The purpose of this study is to look at whether a person who learned and spoke another language as a child is able to understand health information that is given in numbers and in English.

You can decide not to take part in this study. If you choose to take part, you will be asked to attend one session that will take place at an agreed time. The session will include filling out 5 questionnaires. You will be asked about yourself, what language you use at different times and your comfort with numbers. You will also take part in 2 tasks where you will work with numbers. With your consent the sessions will be audio recorded. Also, with your consent, anonymous quotes may be used in the thesis and other publications that may result from this research. The entire session should take about 1 hour.

There is no risk to those who take part in this study. You may decline to answer any of the questions if you so wish. Further, you may decide to withdraw from this study at any time. Simply tell the researcher that you would like to stop. All information you provide will be fully confidential and will be pooled with information from all others who will take part. Anything that will be deemed private data will be removed. The data will be kept for 10 years in a locked space in the Consumer Health Informatics Research Partners (CHIRP) office, at the University of Waterloo. Only the two supervisors and I will have access to the data.

By taking part in this study you will help us find out how Canadians who speak Mandarin process health information that is in numbers. This will help public health educators design ways to better present health information. This may help those who speak English as a second language to make good health care choices.

To thank you for your time, you will receive $30.00 at the end of the 1 hour session. You may decide to withdraw from this study at any time. Should you decide to withdraw, you will receive $15.00 to thank you. Please let me know if you wish to withdraw. You have to pay tax for the amount received. It is your duty to report this amount for the purpose of income tax.

If you have any questions about this study please contact me at (519) 888 4567 Extension 33333 or by email at sgatobu@uwaterloo.ca. You can also contact my supervisors Dr. Laurie Hoffman-Goetz at (519) 888 4567 Ext 33098 or by email at lhgoetz@uwaterloo.ca, or Dr. Jose Arocha at (519) 888-4567 ext. 32729 or by email at jfarocha@uwaterloo.ca.

Please be assured that this study has been reviewed and has received ethics consent through the Office of Research Ethics at the University of Waterloo. If you have any comments or concerns as a result of taking part in this study, please contact Dr. Susan Sykes of the Office of Research Ethics at (519) 888-4567 ext. 36005 or by email at ssykes@uwaterloo.ca.

We look forward to speaking to you further about this project. Thank you in advance for your support.

Sincerely yours,

Sospeter Gatobu
Ph.D., Candidate
School of Public Health and Health Systems
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Email: sgatobu@uwaterloo.ca

Appendix B: Recruitment Posters for the Study on Factors affecting health numeracy among English-as-a-Second Language immigrants to Canada

Poster for Mandarin-speakers

欢迎讲普通话的志愿者来参与我们的研究项目
影响英语非母语移民健康的主要因素》

我们正在寻找讲普通话的志愿者,如果:

- 你年龄超过40岁.
- 你的第一语言是普通话(国语)
- 你在加拿大生活十五年或者低于十五年
- 你可以读, 讲和写简单的英语

我们欢迎你参加我们的研究,并且非常感谢你对我们的支持.

在调研中你将简要回答5个与健康常识有关的数字问题和完成两个部分的简单测试.

本项研究采用英语进行,整个过程大约需要一小时左右.

你所参与的这项研究将为政府对于公共健康教育的决策提供参考, 有助于寻找发布公共健康信息的最好途径并且回馈于英语非母语移民社会.

为感谢你对移民公共健康的贡献和你所付出的时间,在面谈结束时,你将收到$30.00报酬.

如果你想知道关于本次研究的更多信息,或者你想支持和参与这项研究,
请联系:

Sospeter Gatobu
Health Study and Gerontology
University of Waterloo
(519)888-4567 ext.33333 or
E-mail: sgatobu@uwaterloo.ca

本项研究不涉及任何个人隐私,并已经由滑铁卢大学伦理研究办公室审核通过

Poster for Kikuyu-speakers

Please volunteer to take part in the study on:

Factors affecting health numeracy among English-as-a-Second Language Immigrants to Canada

You can participate if:

- **You are 40 years of age and older**
- **Your primary or first language is Kikuyu**
- **You have lived for less than 15 years in Canada**
- **You can read, speak and write in English**

You will be asked to complete 5 short questionnaires on your understanding of health information that contains numbers. You will also take part in two short tasks where you will work with numbers.

The study session will take approximately 1 hour and will be conducted in English.

<u>By taking part in this study you will help public health educators design ways to better present health information to people who speak Kikuyu language.</u>

In appreciation for your time, you will receive $30.00 at the end of the session.

For more information about this study, or to volunteer for this study,
please contact:

Sospeter Gatobu
School of Public Health and Health Systems
University of Waterloo
(519) 888-4567 ext. 33333 or
Email: sgatobu@uwaterloo.ca

This study has been reviewed by, and received ethics clearance through the Office of Research Ethics, University of Waterloo

Appendix C: Consent Form

When you sign this consent form you do not waive your legal rights. You also do not release the researcher(s) or concerned institution (s) from their legal and expert duty.

I have read the letter about a study being carried out by Sospeter Gatobu of the Department of Health Studies and Gerontology at the University of Waterloo. I have been informed that the study is on the factors that affect how new Canadians who speak English as their second language feel about health information that is given in the form of numbers. I am aware that he is working with Dr. Laurie Hoffman-Goetz and Dr. Jose Arocha. I have had the chance to ask any questions about this study. I received good answers to my questions. I also got any other detail that I wanted on the study.

I am aware that I can allow the session to be audio recorded. This will ensure the correct record of my answers. I am also aware that thesis and/or papers will be written from this research. The thesis and/or papers may include quotes from the interview. But, I have been assured that such quotes will be anonymous. I know that I may withdraw my consent at any time without penalty. I only need to inform the researcher about my wish to withdraw.

I know that this project has been reviewed by Office of Research Ethics at the University of Waterloo. I am also aware that the Ethics Office has allowed the study to be done. I know that if I have any comments or concerns as a result of taking part in this study, I may contact Dr. Laurie Hoffman-Goetz at (519) 888 4567 Ext 33098 or by email at lhgoetz@uwaterloo.ca. I may also contact Dr. Jose Arocha at (519) 888-4567 ext. 32729 or by email at jfarocha@healthy.uwaterloo.ca. I can also contact Dr. Susan Stykes, Office of Research Ethics, University of Waterloo, at 519-888-4567 ext. 36005 or by email at ssykes@uwaterloo.ca.

I agree, of my own free will, to take part in this study.
☐YES ☐NO

I agree to the session being audio recorded.
☐YES ☐NO

I agree to the use of anonymous quotations in the thesis and/or publications that may come out of this research.

☐YES ☐NO

Participant Name: ______________________ (Please print)
Signature: ______________________
Witness Name: ______________________ (Please print)
Signature: ______________________ Dater ______________

Appendix D: Pilot study (Focus Group Discussion Guide)

Ice-breaker: Participants picked a drink, i.e., water or juice and then take their seats. Each participant was asked to introduce himself/herself to the person seated on his/her right side. That person then introduced the participant to the group.

Moderator: Thank you for attending this session. We will be discussing the activities that we did in our last session (during the individual interviews). Please feel free to express your feelings. Once again, all the discussions are confidential and nothing you say can be identified with you. We just want to improve the interview exercise for others who will come after you and your feedback is very important to us. To ensure that I have the correct record of this session, I am going to record this discussion. This is only for my use and afterwards I will delete all the information from the tape.

Let us begin

1. What are your thoughts on the general information questionnaire?
    a. What did you like about it?
    b. What changes would you recommend?
2. What are your thoughts on these tasks
    a. The S-TOFHLA
    b. Newest Vital Signs
    c. Subjective Numeracy Scale
    d. Mathematics Self-efficacy Scale
3. What did you like about these tasks?
    a. The S-TOFHLA

b. Newest Vital Signs
c. Subjective Numeracy Scale
d. Mathematics Self-efficacy Scale

4. What did you not like about these tasks?
    a. The S-TOFHLA
    b. Newest Vital Signs
    c. Subjective Numeracy Scale
    d. Mathematics Self-efficacy Scale
5. What can you say about the:
    a. Addition and Subtraction correction exercise?
    b. Subtraction and Multiplication exercise?
    c. What did you like about these tasks
        i. Addition and Subtraction correction exercise?
        ii. Subtraction and Multiplication exercise?
    d. What did you not like about these tasks
        i. Addition and Subtraction correction exercise?
        ii. Subtraction and Multiplication exercise?
6. What are your thoughts on the think-aloud exercise?
    a. What did you like about it?
    b. What changes would you recommend?
7. Do you have anything else that you would like to say about the session or about any specific exercise you completed?

Thank you very much for your time

Appendix E: General Demographic Questionnaire

Mandarin-speakers

Please circle the answer that applies to you. You may choose to skip any question if you do not wish to answer it.

1) I am:
   a) Male
   b) Female
2) My age is:
   a) 40 – 45 years
   b) 46 – 50 years
   c) 51 – 55 years
   d) 56 – 60 years
   e) 61 – 65 years
   f) Over 66 year
3) I was born in:
   a) China
   b) Canada
   c) Other (please specify) ________________________________
4) I have lived in Canada for:
   a) Less than one year
   b) 1 – 2 years
   c) 3 – 4 years
   d) 5 years and longer
5) My employment in the last year was:
   a) Full-time
   b) Part-time
   c) Self-employed
   d) Retired
   e) Not employed
6) In the last year my estimated income from all sources was:
   a) Less than $14,999
   b) $15,000 to $34,999
   c) $35,000 to $54,999
   d) $55,000 to $74,999
   e) $75,000 to $99,999
   f) More than $100,000

7) My highest level of education is:
   a) Elementary school/Primary school
   b) Some high school
   c) High school diploma
   d) College/Trade diploma
   e) Some university
   f) Bachelor's degree
   g) Graduate degree
   h) Other: Please specify:______________________________

8) In what country did you do your elementary (or primary) school education?
   ____

9) What was the language of instruction for mathematics in your elementary (primary) school education? ____

10) Did you enjoy studying mathematics in elementary (primary) school?
    (Please tick) YES NO

11) How long has it been since you last studied mathematics in English? (please circle one)
    a) Less than one year ago
    b) 1 – 2 years ago
    c) 3 – 4 years ago
    d) 5 – 6 years ago
    e) 7 –10 years ago
    f) Over 10 years ago

12) How long has it been since you last studied mathematics in Mandarin? (please circle one)
    a) Less than one year ago
    b) 1 – 2 years ago
    c) 3 – 4 years ago
    d) 5 – 6 years ago
    e) 7 –10 years ago
    f) Over 10 years ago

13) What is the primary language that you speak at your home?
    a) Mandarin
    b) English
    c) Other____
    d) If more than one language is spoken at home, please indicate which languages:____

14) What language did you speak as a child?
   a) Mandarin
   b) English
   c) Mandarin and English
   d) Other (Please specify) ______________________
15) What language did your mother speak to you as a child?
   a) Mandarin
   b) English
   c) Mandarin and English
   d) Other (Please specify) ______________________
16) What language did your father speak to you as a child?
   a) Mandarin
   b) English
   c) Mandarin and English
   d) Other (Please specify) ______________________
17) What language do you use when talking to your doctor?
   a) Mandarin
   b) English
   c) Both Mandarin and English
   d) Other (Please specify) ______________________
18) What language do you prefer to use when talking to your doctor?
   a) Mandarin
   b) English
   c) Both Mandarin and English
   d) Other (Please specify) ______________________

19) The main language I use in the following situations is: (Please check (√) one). If your answer is "**Other**" please write it down.

Situation	**Mainly Mandarin**	**Mainly English**	**Mandarin and English equally**	**Other (Please write it down)**
When I add the price of groceries				
When I calculate the price of gas at the gas station				
When I calculate the amount of tip to give at the restaurant				

When I count the number of something (people, tables, medicine, etc.)				
When I want to remember a phone number				
When I am with friends from the Chinese community				
When I am with family members				

In the remaining part of the questionnaire, the term "health information that contains numbers" includes information that is given as whole numbers (for example, 10 pills), fractions (for example, ¼ bottle), percentages (for example, 30%) and proportions (for example, 3 out of 10).

20) How would you describe your ability to read health information that contains numbers when the information is given in English?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know
21) How would you describe your ability to read health information that contains numbers when the information is given in Mandarin?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know
22) How would you describe your ability to solve addition and subtraction tasks in English?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know

23) How would you describe your ability to solve addition and subtraction tasks in Mandarin?
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
24) How you would describe your ability to understand health information that is given in form of proportions in English? (Example: 1 out of 4 teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
25) How would you describe your ability to understand health information that is given in form of proportions in Mandarin? (Example: 1 out of 4 teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
26) How would you describe your ability to understand health information that is given in percentages in English? (Example: 25% of teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

27) How would you describe your ability to understand health information that is given in percentages in Mandarin? (Example: 25% of teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
28) How would you describe your ability to understand health information that is given in fractions in English? (e.g., ¾ of population is healthy).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
29) How would you describe your ability to understand health information that is given in fractions in Mandarin? (e.g., ¾ of population is healthy).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know
30) How often do you have problems learning about your medical condition because you have problems understanding the numbers in the information?
   a) Always
   b) Often
   c) Sometimes
   d) Occasionally
   e) Never
   f) I do not know
31) What do you do when the doctor gives you health information that has numbers?
   a) I ignore it
   b) I ask him/her to explain it to me
   c) I am able to read and understand the information
   d) I go away and ask a friend to explain it to me
   e) I go away and ask a family member to explain it to me
   f) Other (Please describe) ______________________________________

32) In your home, when you are sick who makes the decision about seeing the doctor?

   a) I make the decision
   b) My spouse/partner makes the decision
   c) My spouse/partner and I discuss and agree on the decision to make
   d) Another family member makes the decision
   e) Other (please explain)____
   f) It depends on (Please explain) _________________________________

33) In your home, when your spouse is sick, who makes the decision about seeing the doctor?

   a) I make the decisions
   b) My spouse/partner makes the decisions
   c) My spouse/partner and I discuss and agree on the decision to make
   d) Another family member makes the decision
   e) Other (please explain)____
   f) It depends on (Please explain) __________________________________

34) When your child (less than 18 years old) is sick, who makes the decision about seeing the doctor?

   a) I make the decision
   b) My spouse/partner makes the decision
   c) My spouse/partner and I discuss and agree on the decision to make
   d) Another family member makes the decision
   e) Other (please explain)____
   f) It depends on (Please explain) __________________________________

35) In what language would you prefer printed health information that has numbers to be given to you?

   a) Mandarin
   b) English
   c) Mandarin and English
   d) Other (Please specify)____

36) How would you prefer to receive health or medical information that has numbers?

   a) In numbers only
   b) In numbers and detailed explanation
   c) In detailed explanation and no numbers
   d) Other (Please explain) _______________________________________

Kikuyu-speakers

Please circle the answer that applies to you. You may choose to skip any question if you do not wish to answer it.

1) I am:
   a) Male
   b) Female
2) My age is:
   a) 40 – 45 years
   b) 46 – 50 years
   c) 51 – 55 years
   d) 56 – 60 years
   e) 61 – 65 years
   f) Over 66 years
3) I was born in:
   a) Kenya
   b) Canada
   c) Other (please specify) ________________________________
4) I have lived in Canada for:
   a) Less than one year
   b) 1 – 2 years
   c) 3 – 4 years
   d) 5 years and longer
5) My employment in the last year was:
   a) Full-time
   b) Part-time
   c) Self-employed
   d) Retired
   e) Not employed
6) In the last year my estimated income from all sources was:
   a) Less than $14,999
   b) $15,000 to $34,999
   c) $35,000 to $54,999
   d) $55,000 to $74,999
   e) $75,000 to $99,999
   f) More than $100,000

7) My highest level of education is:
   a) Elementary school/Primary school
   b) Some high school
   c) High school diploma
   d) College/Trade diploma
   e) Some university
   f) Bachelor's degree
   g) Graduate degree
   h) Other: Please specify:____________________________
8) In what country did you do your elementary (or primary) school education?
   ____

9) What was the language of instruction for mathematics in your elementary (primary) school education? ____
10) Did you enjoy studying mathematics in elementary (primary) school?
    (Please tick) YES NO
11) How long has it been since you last studied mathematics in English? (please circle one)
    a) Less than one year ago
    b) 1 – 2 years ago
    c) 3 – 4 years ago
    d) 5 – 6 years ago
    e) 7 –10 years ago
    f) Over 10 years ago
12) How long has it been since you last studied mathematics in Kikuyu? (please circle one)
    a) Less than one year ago
    b) 1 – 2 years ago
    c) 3 – 4 years ago
    d) 5 – 6 years ago
    e) 7 –10 years ago
    f) Over 10 years ago
13) What is the primary language that you speak at your home?
    a) Kikuyu
    b) English
    c) Other____
    d) If more than one language is spoken at home, please indicate which languages:______________________________________

14) What language did you speak as a child?
   a) Kikuyu
   b) English
   c) Kikuyu and English
   d) Other (Please specify) ______________________________
15) What language did your mother speak to you as a child?
   a) Kikuyu
   b) English
   c) Kikuyu and English
   d) Other (Please specify) ____________________________
16) What language did your father speak to you as a child?
   a) Kikuyu
   b) English
   c) Kikuyu and English
   d) Other (Please specify) ____________________________
17) What language do you use when talking to your doctor?
   a) Kikuyu
   b) English
   c) Both Kikuyu and English
   d) Other (Please specify) ____________________________
18) What language do you prefer to use when talking to your doctor?
   a) Kikuyu
   b) English
   c) Both Kikuyu and English
   d) Other (Please specify) _____________________________
19) The main language I use in the following situations is: (Please check (√) one). If your answer is "**<u>Other</u>**" please write it down.

Situation	**Mainly Kikuyu**	**Mainly English**	**Kikuyu and English equally**	**Other** (Please write it down)
When I add the price of groceries				
When I calculate the price of gas at the gas station				
When I calculate the amount of tip to give at the restaurant				
When I count the number of something (people, tables, medicine, etc.)				

When I want to remember a phone number				
When I am with friends from the Kikuyu community				
When I am with family members				

In the remaining part of the questionnaire, the term "<u>health information that contains numbers</u>" includes information that is given as whole numbers (for example, 10 pills), fractions (for example, ¼ bottle), percentages (for example, 30%) and proportions (for example, 3 out of 10).

20) How would you describe your ability to read health information that contains numbers when the information is given in English?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know
21) How would you describe your ability to read health information that contains numbers when the information is given in Kikuyu?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know
22) How would you describe your ability to solve addition and subtraction tasks in English?
    a) Excellent
    b) Very good
    c) Good
    d) Fair
    e) Poor
    f) I do not know

23) How would you describe your ability to solve addition and subtraction tasks in Kikuyu?
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

24) How you would describe your ability to understand health information that is given in form of proportions in English? (Example: 1 out of 4 teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

25) How would you describe your ability to understand health information that is given in form of proportions in Kikuyu? (Example: 1 out of 4 teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

26) How would you describe your ability to understand health information that is given in percentages in English? (Example: 25% of teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

27) How would you describe your ability to understand health information that is given in percentages in Kikuyu? (Example: 25% of teenage girls in Canada are overweight).
   a) Excellent
   b) Very good
   c) Good
   d) Fair
   e) Poor
   f) I do not know

28) How would you describe your ability to understand health information that is given in fractions in English? (e.g., ¾ of population is healthy).

a) Excellent
b) Very good
c) Good
d) Fair
e) Poor
f) I do not know

29) How would you describe your ability to understand health information that is given in fractions in Kikuyu? (e.g., ¾ of population is healthy).

a) Excellent
b) Very good
c) Good
d) Fair
e) Poor
f) I do not know

30) How often do you have problems learning about your medical condition because you have problems understanding the numbers in the information?

a) Always
b) Often
c) Sometimes
d) Occasionally
e) Never
f) I do not know

31) What do you do when the doctor gives you health information that has numbers?

a) I ignore it
b) I ask him/her to explain it to me
c) I am able to read and understand the information
d) I go away and ask a friend to explain it to me
e) I go away and ask a family member to explain it to me
f) Other (Please describe) ____________________________________

32) In your home, when you are sick who makes the decision about seeing the doctor?

a) I make the decision
b) My spouse/partner makes the decision
c) My spouse/partner and I discuss and agree on the decision to make
d) Another family member makes the decision
e) Other (please explain)______________________________________
f) It depends on (Please explain) ________________________________

33) In your home, when your spouse is sick, who makes the decision about seeing the doctor?
   a) I make the decisions
   b) My spouse/partner makes the decisions
   c) My spouse/partner and I discuss and agree on the decision to make
   d) Another family member makes the decision
   e) Other (please explain)____
   f) It depends on (Please explain) _________________________________

34) When your child (less than 18 years old) is sick, who makes the decision about seeing the doctor?
   a) I make the decision
   b) My spouse/partner makes the decision
   c) My spouse/partner and I discuss and agree on the decision to make
   d) Another family member makes the decision
   e) Other (please explain)____
   f) It depends on (Please explain) _________________________________

35) In what language would you prefer printed health information that has numbers to be given to you?
   a) Kikuyu
   b) English
   c) Kikuyu and English
   d) Other (Please specify)____________________________________

36) How would you prefer to receive health or medical information that has numbers?
   a) In numbers only
   b) In numbers and detailed explanation
   c) In detailed explanation and no numbers
   d) Other (Please explain) ______________________________________

Thank you very much

Appendix F: Subjective Numeracy Scale (SNS)

(Fagerlin, A., Zikmund-Fisher, B.J., Ubel, P.A., Jankovic, A., Derry, H.A., & Smith, D.M. Measuring numeracy without a math test: Development of the Subjective Numeracy Scale (SNS). *Medical Decision Making*, 2007: 27: 672-680).

For each of the following questions, please check the box that best reflects **how good you are at doing the following things**:

1. How good are you at working with fractions?

1	2	3	4	5	6

Not at all good **Extremely good**

2. How good are you at working with percentages?

1	2	3	4	5	6

Not at all good **Extremely good**

3. How good are you at calculating a 15% tip?

1	2	3	4	5	6

Not at all good **Extremely good**

4. How good are you at figuring out how much a shirt will cost if it is 25% off?

1	2	3	4	5	6

Not at all good E**xtremely good**

For each of the following questions, please check the box that best reflects your answer:

5. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?

1	2	3	4	5	6

Not at all helpful **Extremely helpful**

6. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?

1	2	3	4	5	6

Always Prefer Words **Always Prefer Numbers**

7. When you hear a weather forecast, do you prefer predictions using percentages (e.g., "there will be a 20% chance of rain today") or predictions using only words (e.g., "there is a small chance of rain today")?

1	2	3	4	5	6

Always Prefer Percentages **Always Prefer Words**

8. How often do you find numerical information to be useful?

1	2	3	4	5	6

Never **Very Often**

Appendix G: Mathematics Self-Efficacy Scale (MSES)

There are two parts to this instrument: Part I and Part II.
Please read all instructions and respond carefully and completely.

Score: ______________

Please provide the following information:

Name or I.D.____

Date ____________________ Age ____________________ Gender (*Please Circle*): **F M**

Part I: Everyday Math Tasks

Please indicate how much confidence you have that you could successfully accomplish each of these tasks by circling the number according to the following 10-point confidence scale.

Confidence Scale:

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

Example: How much confidence do you have that you could successfully:

91. Multiply two large numbers in your head. **0 1 2 3 4 5 6 7 8 9**

If your response on the 10-point continuum was #5, "Some Confidence", you would circle the number 5 next to question #91 like so:.

91. Multiply two large numbers in your head. **0 1 2 3 4 (5) 6 7 8 9**

Now turn to the next page and begin Part I. Be sure to answer every item.

Name or I.D.____

Part I

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

1. Add two large numbers (e.g., 5379 + 62543) in your head....................................	0	1	2	3	4	5	6	7	8	9
2. Determine the amount of sales tax on a clothing purchase.	0	1	2	3	4	5	6	7	8	9
3. Figure out how much material to buy in order to make curtains.........................	0	1	2	3	4	5	6	7	8	9
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.	0	1	2	3	4	5	6	7	8	9
5. Multiply and divide using a calculator.	0	1	2	3	4	5	6	7	8	9
6. Compute your car's gas mileage.....................	0	1	2	3	4	5	6	7	8	9
7. Calculate recipe quantities for a dinner for 3 when the original recipe is for 12 people.	0	1	2	3	4	5	6	7	8	9
8. Balance your checkbook without a mistake.	0	1	2	3	4	5	6	7	8	9
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.	0	1	2	3	4	5	6	7	8	9

Go on to next page.

Name or I.D.____

Part I (Cont.)

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

10. Figure out how long it will take to travel from Toronto to Ottawa driving at 100 km per hour.	0	1	2	3	4	5	6	7	8	9
11. Set up a monthly budget for yourself taking into account how much money you earn, bills to pay, personal expenses, etc.	0	1	2	3	4	5	6	7	8	9
12. Compute your income taxes for the year.	0	1	2	3	4	5	6	7	8	9
13. Understand a graph accompanying an article on business profits.	0	1	2	3	4	5	6	7	8	9
14. Figure out how much you would save if there is a 15% mark-down on an item you wish to buy.	0	1	2	3	4	5	6	7	8	9
15. Estimate your grocery bill in your head as you pick up items.	0	1	2	3	4	5	6	7	8	9
16. Figure out which of 2 summer jobs is the better offer: one with a higher salary but no benefits; the other with a lower salary but with room, board, and travel expenses included.	0	1	2	3	4	5	6	7	8	9
17. Figure out the tip on your part of a dinner bill total split 8 ways.	0	1	2	3	4	5	6	7	8	9
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.	0	1	2	3	4	5	6	7	8	9

Go on to Part II.

Appendix H: Newest Vital Signs (NVS)

(Weiss, B.D., Mays, M.Z., Martz, W., Castro, K.M, DeWalt, D.A., Pignone, M.P., et al., (2005). Quick assessment of literacy in primary care: The Newest Vital Sign. *Annals of Family Medicine*, 3(6), 514-522).

1. If you eat the entire container, how many calories will you eat?

   (Answer: 1000 is the only answer.)

2. If you are allowed to eat 60g of carbohydrates as a snack, how much ice cream could you have?

   (Answer: Any of the following: 1 cup (or any amount up to 1 cup); half of the container.)

   Note: If the participant answers "2 servings" ask, "How much ice cream would that be if you were to measure that into a bowl?")

3. Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42g of saturated fat each day, which includes 1 serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be consuming each day?

   (Answer: 33 is the only correct answer.)

4. If you usually eat 2500 calories in a day, what percentage of your daily value of calories will you be eating if you eat 1 serving?

   (Answer: 10% is the only correct answer.)

5. Pretend that you are allergic to the following substances: Penicillin, peanuts, latex gloves, and bee stings.

   Is it safe for you to eat this ice cream? (Answer: No.)

6. (Ask only if patient responds "no" to question 5): Why not?

   (Answer: Because it has peanut oil.)

Total Correct: _____

Appendix I: S-TOFHLA

(Baker, D. W., Williams, M. V., Parker, R. M., Gazmararian, J. A. & Nurss, J. (1999). Development of a brief test to measure functional health literacy. *Patient Education and Counselling*, 38(1), 33-42).

PASSAGE A: X-Ray PREPARATION

You doctor has sent you to have a ___________________X-ray.

a. Stomach
b. Diabetes
c. Stitches
d. germs

You must have an __________________ stomach when you come for ____________

a. asthma
b. empty
c. incest
d. anemia

a. is
a. am
b. if.
c. it.

PASSAGE B: RIGHTS AND RESPONSIBILITIES

I agree to give correct information to _______________if I can receive OHIP coverage.

a. hair
b. salt
c. see
d. ache

I __________________ to provide the county information to ____________ any

a. agree
b. probe
c. send
d. gain

a. hide.
b. risk.
c. discharge.
d. prove.

S-TOFHLA Numeracy items

1. (Participant will read a prescription bottle)

   Take one tablet by mouth every 6 hours as needed.

   Oral Question: If you take your first tablet at 7:00 a.m., when should you take the next one?

   Answer: 1:00 p.m.

2. (Participant will read from prompt card)

   Normal blood sugar is 60-150. Your blood sugar is 160.

   Oral Question: If this was your score, would your blood sugar be normal today?

   Answer: No

3. (Participant will read an appointment slip)

CLINIC APPOINTMENT				
CLINIC: Diabetic			LOCATION: 3rd floor	
DAY: Thurs.	DATE: April 2nd		HOUR: 10:20	a.m. / p.m.
Issued by:				
YOU MUST BRING YOUR PLASTIC CARD WITH YOU				

   Oral Question: When is your next appointment?

   Answer: April 2nd or Thursday, April 2nd

4. (Participant will read a prescription bottle)

   Take medicine on an empty stomach one hour before or two to three hours after a meal unless otherwise directed by your doctor.

Oral Question: If you eat lunch at 12:00 noon, and you want to take this medicine before lunch, what time should you take it?

Answer: 11:00 or before 11:00

Appendix J: French Kit

Ekstrom, R.B. French, J.W., Harman, H.H., & Dermen, D. (1976). Manual for Kit of Factor-Referenced Cognitive Tests. Educational Testing Service. Princeton, New Jersey).

ADDITION TEST — N-1

This is a test to see how quickly and accurately you can add. It is not expected that you will finish all the problems in the time allowed.

You are to write your answers in the boxes below the problems. Several practice problems are given below with the first one correctly worked. Practice for speed on the others. This practice may help your score.

<u>Practice Problems:</u>

4	7	12	84	7	34	17	45	31	80
9	6	5	54	38	81	50	41	52	78
1	15	67	72	80	51	74	89	19	15
14									

8	2	12	43	67	23	83	63	19	48
3	51	42	71	95	74	14	99	57	17
7	8	53	11	52	8	19	5	83	39

19	69	6	30	50	75	39	52	17	81
8	40	67	98	42	17	90	45	55	83
27	44	38	59	13	19	82	91	58	42

4	75	36	18	40	5	16	49	44	99
98	34	20	63	3	26	18	27	7	88
31	22	54	92	59	89	39	36	80	77

25	11	76	85	33	42	13	31	62	54
47	23	41	47	59	23	87	8	38	34
17	48	53	85	16	18	58	53	49	78

14	74	65	38	58	63	47	84	62	22
41	86	58	25	86	29	74	34	15	83
38	93	34	77	55	22	31	19	26	19

6	91	17	33	73	66	78	19	63	47
37	13	38	51	78	89	34	56	23	2
98	87	67	65	45	32	65	45	43	39

ADDITION AND SUBTRACTION CORRECTION — N-4

This will try out your ability and speed at adding and subtracting 2-digit numbers. You may use this sheet for scratch paper, but you will probably move along faster if you solve the problems in your head, because they are not very hard. There will be more items than you will be able to finish.

For each item, two numbers are given to be added or subtracted according to the sign between them (+ or -). In all cases an answer is suggested. If the suggested answer is correct, make an X on the letter "C" for correct. If the suggested answer is not correct, make an X on the letter "I" for incorrect.

Sample problems:

1. 11 + 23 = 34	C	I
2. 20 - 17 = 3	C	I
3. 35 - 10 = 20	C	I

You would mark C (correct) for problems 1 and 2, because 11 added to 23 is 34, and 20 minus 17 is 3. For problem 3 you would mark the I (incorrect), because 35 minus 10 is 25, not 20.

Check whether these additions or subtractions are Correct (C) or Incorrect (I).

1.	10 + 10 = 20	C	I	31.	17 + 22 = 39	C	I
2.	10 + 27 = 27	C	I	32.	23 - 15 = 8	C	I
3.	12 + 13 = 25	C	I	33.	23 + 15 = 28	C	I
4.	17 - 15 = 2	C	I	34.	22 + 29 = 41	C	I
5.	15 + 15 = 25	C	I	35.	17 + 18 = 35	C	I
6.	30 - 10 = 10	C	I	36.	19 - 12 = 7	C	I
7.	25 - 15 = 10	C	I	37.	26 + 18 = 42	C	I
8.	21 - 10 = 21	C	I	38.	31 - 27 = 6	C	I
9.	14 + 17 = 31	C	I	39.	25 + 17 = 42	C	I
10.	21 + 21 = 42	C	I	40.	31 - 13 = 44	C	I
11.	32 - 11 = 21	C	I	41.	36 - 15 = 21	C	I
12.	16 + 11 = 25	C	I	42.	23 + 19 = 44	C	I
13.	19 + 11 = 30	C	I	43.	29 + 17 = 47	C	I
14.	19 - 13 = 7	C	I	44.	28 - 17 = 11	C	I
15.	23 - 21 = 4	C	I	45.	22 + 12 = 32	C	I
16.	17 + 12 = 27	C	I	46.	28 + 16 = 44	C	I
17.	20 + 18 = 38	C	I	47.	19 - 13 = 32	C	I
18.	26 + 11 = 37	C	I	48.	18 + 13 = 31	C	I
19.	24 - 17 = 41	C	I	49.	22 + 22 = 42	C	I
20.	31 - 11 = 20	C	I	50.	19 - 14 = 5	C	I
21.	49 - 27 = 29	C	I	51.	29 - 25 = 4	C	I
22.	28 - 19 = 47	C	I	52.	21 - 13 = 6	C	I
23.	18 + 25 = 43	C	I	53.	27 + 13 = 40	C	I
24.	16 + 19 = 35	C	I	54.	28 + 19 = 47	C	I
25.	22 - 15 = 8	C	I	55.	31 - 19 = 50	C	I
26.	18 + 31 = 39	C	I	56.	23 - 11 = 34	C	I
27.	12 + 29 = 41	C	I	57.	12 + 23 = 33	C	I
28.	27 - 15 = 22	C	I	58.	22 - 17 = 5	C	I
29.	39 - 15 = 14	C	I	59.	34 - 15 = 9	C	I
30.	33 - 17 = 16	C	I	60.	35 - 22 = 13	C	I

Appendix K: Think-aloud exercise

Description of the problem given to the participants in the study of cognitive processes in health numeracy

Please <u>speak out</u> (speak aloud) as you do this exercise.
Your mother has the disease that makes her blood have more sugar than it should. This disease is also called diabetes. Your mother does not speak English. She needs your help to add and record her daily intake of foods in her food chart. In one day she ate 2 slices of bread, 1¼ English muffin, 2 rice cakes, 1½ cups cereal, and ⅓ cup cooked rice.

Use the chart below to find out how much food she ate.

Food item		Weight in grams
1 slice of bread	=	50 grams
1 English muffin	=	120 grams
1 rice cake	=	70 grams
1 cup cereal	=	220 grams
1 cup cooked rice	=	180 grams

Please speak out loud as you work out how many grams of <u>each food,</u> and the <u>total grams</u> your mother ate. As you speak, write everything in the space below

Appendix L: Representative Statistics: Reduced Regression Models

French Kit (Addition)

	Model 1		Model 2	
Variable	*B(SEB)*	*β*	*B(SEB)*	*β*
Constant	7.51(1.42)		5.28(1.49)	
Language	4.30(.90)	.41****	3.825(.86)	.37****
Residency			3.76(1.05)	.30****
R^2	.17		.25	
Adjusted R^2	.16		.24	

***** <.001*

French Kit (Addition and subtraction-Correction)

	Model 1		Model 2		Model 3		Model 4	
Variable	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*
Constant	5.10(2.62)		5.29(2.47)		1.91(2.64)		1.87(2.59)	
Language	14.37(1.65)	.63****	12.38(1.60)	.57****	12.38(1.60)	.55****	11.59(1.57)	.51****
University			6.73(1.74)	.27****	5.79(1.71)	.24***	7.78(1.89)	.32****
Residency					5.66(1.88)	.21***	4.99(1.87)	.18**
Graduate							4.40(1.90)	.17**
R^2	.40		.47		.51		.53	
Adjusted R^2	.40		.46		.50		.51	

**** *p < .001; *** p < .005; **p <. 010*

S-TOFHLA Composite

	Model 1		Model 2		Model 3		Model 4		Model 5	
Variable	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*
Constant	76.06(1.72)		93.92(4.74)		105.78(5.95)		101.59(5.95)		97.91(6.06)	
Income: Over $ 75,000	17.65(4.48)	.35****	18.83(4.21)	.37****	18.25(4.06)	.36****	20.29(4.00)	.40****	22.66(4.07)	.45****
Language			-11.99(2.99)	-.33****	-11.31(2.89)	-.31****	-10.04(2.84)	-.28***	-9.88(2.78)	-.27***
Age					-10.00(3.22)	-.25***	-9.90(3.12)	-.25***	-9.04(3.09)	-.23***
Income: $55,000 -$ 74,999							11.13(3.86)	.23**	13.52(3.94)	.28***
Dummy income: $35,000 -$ 54,999									8.37(3.71)	.18*
R^2	.12		.23		.29		.34		.37	
Adjusted R^2	.11		.22		.27		.32		.34	

**** *p < .001; *** p < .005; **p <. 010; *<.050*

S-TOFHLA Numeracy

	Model 1		Model 2		Model 3	
Variable	*B(SEB)*	*β*	*B(SEB)*	*β*	*B(SEB)*	*β*
(Constant)	23.71(.47)		20.44(1.35)		19.47(1.39)	
Income: Over $ 75,000	3.87(1.23)	3.12***	3.66(1.20)	.269***	4.14(1.20)	.305***
Language			2.20(.85)	.228*	2.50(.85)	.259***
Income: $55,000 -$ 74,999					2.66(1.16)	.205*
R^2	.08		.13		.17	
Adjusted R^2	.07		.12		.15	

**** *p < .001; *** p < .005; **p <. 010; *p <.050*

S-TOFHLA Prose/Literacy

	Model 8		Model 9	
Variable	*B(SEB)*	*β*	*B(SEB)*	*β*
Constant	74.40(5.4)		61.02(7.25)	
Language	-18.99(2.44)	-.56****	-19.12(2.37)	-.56****
Income: Over $ 75,000	8.82(3.35)	.19*	11.12(3.36)	.23***
Age	-9.64(2.54)	-.25****	-8.99(2.48)	-.24****
Graduate	25.77(4.52)	.67****	29.00(4.54)	.75****
University	25.41(4.53)	.70****	26.50(4.42)	.72****
>High school < University	15.04(4.19)	.42****	15.21(4.07)	.43****
Gender			6.96(2.55)	.200**
R^2	.53		.55	
Adjusted R^2	.50		.53	

**** *p < .001; *** p < .005; **p <. 010; *p <.050*

NVS

	Model 1	
Variable	*B(SEB)*	*β*
Constant	2.30(.41)	
Residency	1010(.45)	.23*
R^2	.05	
Adjusted R^2	.04	

*p <.050

Appendix M: Representative Statistics: Multiple Regression (Full Models)

Prediction for Numeracy and Health Numeracy (Excluding High School and Less Education Attainment)

Regression Modelling for Numeracy (Addition Task)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.512[a]	.262	.218	4.496

31 Predictors: (Constant), Residency in Canada, Graduate, Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	711.405	6	118.567	5.866	.000[b]
1	Residual	2000.945	99	20.212		
	Total	2712.349	105			

a. Dependent Variable: French Kit_ Addition Score

b. Predictors: (Constant), Residency in Canada, Graduate, Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	-.592	3.361		-.176	.861
	Language	3.245	.924	.319	3.512	.001
	Gender	1.161	.988	.113	1.174	.243
1	Age	.264	1.019	.023	.259	.796
	University	.906	.557	.170	1.625	.107
	Graduate	.667	.406	.178	1.644	.103
	Residency in Canada	3.685	1.197	.273	3.079	.003

a. Dependent Variable: French Kit_ Addition Score

Regression Modelling for Numeracy (Addition and Subtraction-Correction Task)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.699[a]	.488	.457	8.091

a. Predictors: (Constant), Residence in Canada, Graduate, Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6179.341	6	1029.890	15.731	.000[b]
	Residual	6481.574	99	65.470		
	Total	12660.915	105			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), Residence in Canada, Graduate, Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.849	6.050		-.140	.889
	Language	11.537	1.663	.525	6.938	.000
	Gender	.219	1.779	.010	.123	.902
	Age	-1.479	1.833	-.060	-.807	.422
	University	3.522	1.003	.305	3.511	.001
	Graduate	1.289	.731	.159	1.765	.081
	Residency in Canada	4.951	2.154	.170	2.299	.024

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression Modelling for Health Numeracy/Literacy (S-TOFHLA composite)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.643[a]	.413	.377	13.963

a. Predictors: (Constant), Residency in Canada, Graduate, Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13580.374	6	2263.396	11.610	.000[b]
	Residual	19300.721	99	194.957		
	Total	32881.094	105			

a. Dependent Variable: S-TOFHLA Composite
b. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	87.207	10.439		8.354	.000
	Language	-18.378	2.869	-.519	-6.405	.000
	Gender	5.514	3.070	.154	1.796	.076
	Age	-7.612	3.163	-.191	-2.406	.018
	University	7.256	1.731	.390	4.192	.000
	Graduate	5.392	1.261	.414	4.277	.000
	Residency in Canada	7.033	3.716	.150	1.892	.061

a. Dependent Variable: S-TOFHLA Composite

Regression Modeling for Health Numeracy (S-TOFHLA Numeracy)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338[a]	.114	.060	4.5154

a) Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	259.572	6	43.262	2.122	.057[b]
	Residual	2018.466	99	20.389		
	Total	2278.038	105			

a. Dependent Variable: S-TOFHLA Numeric

b. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.131	3.376		4.778	.000
	Language	1.276	.928	.137	1.375	.172
	Gender	.448	.993	.047	.451	.653
	Age	1.157	1.023	.110	1.131	.261
	University	1.030	.560	.210	1.840	.069
	Graduate	.429	.408	.125	1.052	.295
	Residence in Canada	1.760	1.202	.143	1.464	.146

a. Dependent Variable: S-TOFHLA Numeric

Regression Modelling for Health Literacy (S-TOFHLA Prose)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.703[a]	.494	.464	12.123

a. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14215.494	6	2369.249	16.121	.000[b]
	Residual	14550.128	99	146.971		
	Total	28765.623	105			

a. Dependent Variable: S-TOFHLA Prose
b. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	71.077	9.064		7.842	.000
	Language	-19.654	2.491	-.594	-7.889	.000
	Gender	5.066	2.666	.151	1.901	.060
	Age	-8.769	2.747	-.235	-3.193	.002
	University	6.226	1.503	.358	4.142	.000
	Graduate	4.963	1.095	.407	4.534	.000
	Residency in Canada	5.273	3.227	.120	1.634	.105

a. Dependent Variable: S-TOFHLA Prose

Regression Modeling Health Numeracy/Literacy (NVS)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.404[a]	.163	.111	1.7800

a. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	59.888	6	9.981	3.150	.007[b]
	Residual	307.333	97	3.168		
	Total	367.221	103			

a. Dependent Variable: NVS Score

b. Predictors: (Constant), Residency in Canada, Graduate , Age, Language, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.498	1.396		2.506	.014
	Language	-1.006	.371	-.266	-2.710	.008
	Gender	.067	.408	.017	.164	.870
	Age	-.520	.407	-.123	-1.278	.204
	University	.616	.226	.312	2.731	.008
	Graduate	.368	.166	.266	2.215	.029
	Residency in Canada	.697	.486	.137	1.433	.155

a. Dependent Variable: NVS Score

Regression Modeling (Using the Full Sample)

Regression Modeling for Numeracy (Addition)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.559[a]	.312	.268	4.515

a. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1017.426	7	145.347	7.130	.000[b]
	Residual	2242.439	110	20.386		
	Total	3259.864	117			

a. Dependent Variable: French Kit_ Addition Score
b. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.503	2.768		.543	.588
	Language	3.136	.908	.298	3.455	.001
	Gender	1.098	.959	.101	1.146	.254
	Age	.711	.950	.060	.749	.455
	>High school < University	1.662	1.577	.150	1.054	.294
	University	3.618	1.736	.317	2.084	.039
	Graduate	3.716	1.761	.308	2.109	.037
	Residency	3.161	1.106	.249	2.859	.005

a. Dependent Variable: French Kit_ Addition Score

Regression modeling for Numeracy (Addition and Subtraction-Correction Task)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.746[a]	.556	.528	7.876

a. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8542.532	7	1220.362	19.675	.000[b]
	Residual	6822.892	110	62.026		
	Total	15365.424	117			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.496	4.829		.103	.918
	Language	11.416	1.583	.500	7.211	.000
	Gender	.052	1.672	.002	.031	.975
	Age	-.845	1.656	-.033	-.510	.611
	>High school < University	3.771	2.750	.156	1.371	.173
	University	10.988	3.029	.443	3.628	.000
	Graduate	7.663	3.073	.292	2.494	.014
	Residency	4.254	1.929	.155	2.206	.029

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression Modeling for Health Numeracy/Literacy (S-TOFHLA Composite)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666[a]	.443	.408	13.777

a. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	16631.580	7	2375.940	12.517	.000[b]
1	Residual	20879.276	110	189.812		
	Total	37510.856	117			

a. Dependent Variable: S-TOFHLA Composite score
b. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	82.758	8.448		9.796	.000
	Language	-18.209	2.769	-.511	-6.575	.000
	Gender	5.574	2.926	.152	1.905	.059
	Age	-7.908	2.897	-.197	-2.729	.007
1	>High school < University	12.203	4.811	.324	2.537	.013
	University	26.799	5.298	.692	5.058	.000
	Graduate	28.437	5.375	.694	5.291	.000
	Residency	6.133	3.374	.143	1.818	.072

a. Dependent Variable: S-TOFHLA Composite score

Regression Modeling for Health Numeracy (S-TOFHLA Numeracy)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.325[a]	.106	.049	4.7007

a. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	287.233	7	41.033	1.857	.084[b]
	Residual	2430.606	110	22.096		
	Total	2717.839	117			

a. Dependent Variable: S-TOFHLA Numeracy
b. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.629	2.882		6.463	.000
	Language	1.470	.945	.153	1.555	.123
	Gender	.212	.998	.021	.212	.832
	Age	1.416	.989	.131	1.432	.155
	>High school < University	-.165	1.641	-.016	-.101	.920
	University	1.975	1.808	.189	1.093	.277
	Graduate	1.052	1.834	.095	.574	.567
	Residency	.758	1.151	.066	.659	.511

a. Dependent Variable: : S-TOFHLA Numeracy

Regression Modeling for Health Literacy (S-TOFHLA Prose)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.720[a]	.518	.488	12.073

a. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	17252.927	7	2464.704	16.911	.000[b]
1	Residual	16032.124	110	145.747		
	Total	33285.051	117			

a. Dependent Variable: S-TOFHLA Prose weighted
b. Predictors: (Constant), Residency, Age , >High school < University, Language, Gender, Graduate, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	64.129	7.402		8.663	.000
	Language	-19.679	2.427	-.586	-8.109	.000
	Gender	5.362	2.564	.155	2.092	.039
	Age	-9.324	2.539	-.247	-3.672	.000
1	>High school < University	12.368	4.215	.349	2.934	.004
	University	24.824	4.643	.681	5.347	.000
	Graduate	27.385	4.710	.710	5.814	.000
	Residency	5.374	2.957	.133	1.818	.072

a. Dependent Variable: S-TOFHLA Prose weighted

Regression Modeling for Health Numeracy/Literacy (NVS)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.507[a]	.257	.209	1.7459

a. Predictors: (Constant), Residency, Age , Graduate, Language, >High school < University, Gender, University

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	112.996	7	16.142	5.295	.000[b]
	Residual	326.169	107	3.048		
	Total	439.165	114			

a. Dependent Variable: NVS Score
b. Predictors: (Constant), Residency, Age , Graduate, Language, >High school < University, Gender, University

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.485	1.101		2.256	.026
	Language	-.869	.356	-.222	-2.441	.016
	Gender	-.007	.386	-.002	-.017	.987
	Age	-.560	.375	-.127	-1.494	.138
	>High school < University	1.849	.630	.445	2.937	.004
	University	3.043	.682	.722	4.465	.000
	Graduate	2.894	.693	.650	4.178	.000
	Residency	.515	.440	.107	1.170	.245

a. Dependent Variable: NVS Score

Regression Modeling for Numeracy and Health Numeracy including Mathematics Self-Efficacy Measures (Excluding High School and Less Education Attainment)

Regression Modelling for Numeracy (Addition) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.575[a]	.330	.289	4.295

a. Predictors: (Constant), MSES Score, University, Residency in Canada, Language, Gender, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	891.494	6	148.582	8.053	.000[b]
	Residual	1808.221	98	18.451		
	Total	2699.714	104			

a. Dependent Variable: French Kit_ Addition Score
b. Predictors: (Constant), MSES Score, University, Residency in Canada, Language, Gender, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.677	3.309		-1.413	.161
	Gender	2.066	.982	.200	2.104	.038
	Language	2.847	.900	.280	3.162	.002
	Residency in Canada	3.469	1.146	.258	3.028	.003
	Bachelor	.605	.536	.113	1.129	.262
	Graduate	.446	.391	.119	1.140	.257
	MSES Score	.768	.254	.284	3.020	.003

a. Dependent Variable: French Kit_ Addition Score

Regression Modeling for Numeracy (Addition and Subtraction-correction) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725[a]	.525	.496	7.821

a. Predictors: (Constant), MSES Score, University, Residency in Canada, Language, Gender, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6629.807	6	1104.968	18.065	.000[b]
	Residual	5994.421	98	61.168		
	Total	12624.229	104			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), MSES Score, University, Residency in Canada, Language, Gender, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.782	6.026		-1.623	.108
	Gender	1.955	1.788	.088	1.094	.277
	Language	10.651	1.639	.484	6.497	.000
	Residency in Canada	4.381	2.086	.151	2.100	.038
	University	3.176	.975	.275	3.256	.002
	Graduate	1.009	.712	.125	1.417	.160
	MSES Score	1.261	.463	.216	2.723	.008

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression Modeling for Numeracy (Addition) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565[a]	.319	.278	4.330

a. Predictors: (Constant), SNS Score, Residency in Canada, University, Gender, Language, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	862.360	6	143.727	7.666	.000[b]
	Residual	1837.354	98	18.749		
	Total	2699.714	104			

a. Dependent Variable: French Kit_ Addition Score
b. Predictors: (Constant), SNS Score, Residence in Canada, University, Gender, Language, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.542	3.372		-1.347	.181
	Gender	1.867	.978	.181	1.910	.059
	Language	2.401	.962	.236	2.496	.014
	Residency in Canada	3.351	1.161	.249	2.885	.005
	University	.392	.556	.073	.705	.483
	Graduate	.311	.405	.083	.768	.444
	SNS Score	1.381	.507	.291	2.725	.008

a. Dependent Variable: French Kit_ Addition Score

Regression Modeling for Numeracy (Addition and Subtraction-correction) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.745[a]	.555	.528	7.567

a. Predictors: (Constant), SNS Score, Residency in Canada, University, Gender, Language, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7012.473	6	1168.746	20.410	.000[b]
	Residual	5611.755	98	57.263		
	Total	12624.229	104			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), SNS Score, Residency in Canada, University, Gender, Language, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-12.760	5.894		-2.165	.033
	Gender	2.185	1.709	.098	1.278	.204
	Language	9.103	1.681	.414	5.415	.000
	Residency in Canada	3.820	2.030	.131	1.882	.063
	University	2.500	.972	.216	2.571	.012
	Graduate	.547	.709	.068	.772	.442
	SNS Score	3.384	.885	.329	3.822	.000

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression modelling for Health Numeracy (S-TOFHLA Numeracy) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.393[a]	.155	.094	4.4427

a. Predictors: (Constant), MSES Score, Format , University, Residency in Canada, Language, Gender, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	350.640	7	50.091	2.538	.019[b]
	Residual	1914.560	97	19.738		
	Total	2265.200	104			

a. Dependent Variable: S-TOFHLA Numeric
b. Predictors: (Constant), MSES Score, Format , University, Residency in Canada, Language, Gender, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.663	4.447		2.173	.032
	Gender	.834	1.016	.088	.821	.414
	Language	1.535	.942	.165	1.630	.106
	Residency in Canada	1.595	1.189	.129	1.341	.183
	University	.663	.557	.135	1.189	.237
	Graduate	.246	.405	.072	.607	.545
	Format	3.005	1.511	.190	1.988	.050
	MSES Score	.336	.263	.136	1.276	.205

a. Dependent Variable: S-TOFHLA Numeric

Regression modelling for Health Numeracy (S-TOFHLA Numeracy) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.422[a]	.178	.119	4.3811

a. Predictors: (Constant), SNS Score, Format , University, Residency in Canada, Gender, Language, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	403.340	7	57.620	3.002	.007[b]
	Residual	1861.860	97	19.194		
	Total	2265.200	104			

a. Dependent Variable: S-TOFHLA NUMERIC SCORE
b. Predictors: (Constant), SNS Score, Format , University, Residency in Canada, Gender, Language, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.090	4.470		1.810	.073
	Gender	.988	.991	.105	.997	.321
	Language	1.006	.981	.108	1.026	.308
	Residence in Canada	1.377	1.180	.112	1.167	.246
	Bachelor	.425	.566	.087	.750	.455
	Graduate	.084	.410	.024	.204	.839
	Format	3.147	1.489	.199	2.114	.037
	SNS Score	1.078	.513	.248	2.102	.038

a. Dependent Variable: S-TOFHLA Numeric

Regression modelling for Health Numeracy/Literacy (NVS) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.430[a]	.185	.125	1.7461

a. Predictors: (Constant), MSES Score, Format , University, Residency in Canada, Language, Gender, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	65.823	7	9.403	3.084	.006[b]
	Residual	289.633	95	3.049		
	Total	355.456	102			

a. Dependent Variable: NVS Score
b. Predictors: (Constant), MSES Score, Format , University, Residency in Canada, Language, Gender, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.556	1.881		.295	.768
	Gender	.500	.418	.132	1.197	.234
	Language	-1.155	.373	-.310	-3.100	.003
	Residence in Canada	.568	.479	.114	1.186	.239
	University	.563	.222	.289	2.540	.013
	Graduate	.338	.163	.248	2.065	.042
	Format	.404	.620	.061	.651	.517
	MSES Score	.236	.105	.239	2.258	.026

a. Dependent Variable: NVS Score

Regression modelling for Health Numeracy/Literacy (NVS) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.506[a]	.256	.202	1.6680

a. Predictors: (Constant), SNS Score, Format , University, Residency in Canada, Gender, Language, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	91.158	7	13.023	4.681	.000[b]
	Residual	264.299	95	2.782		
	Total	355.456	102			

a. Dependent Variable: NVS Score
b. Predictors: (Constant), SNS Score, Format , University, Residency in Canada, Gender, Language, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.671	1.837		-.365	.716
	Gender	.629	.395	.166	1.591	.115
	Language	-1.528	.376	-.410	-4.062	.000
	Residency in Canada	.431	.460	.086	.938	.351
	University	.405	.218	.208	1.859	.066
	Graduate	.232	.160	.170	1.453	.149
	Format	.535	.592	.081	.904	.369
	SNS Score	.755	.197	.434	3.833	.000

a. Dependent Variable: NVS Score

Regression Modeling for Numeracy and Health Numeracy including Mathematics Self-Efficacy Measures (Using the Full Sample)

Modeling for Numeracy (Addition) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.597[a]	.357	.316	4.380

a. Predictors: (Constant), MSES Score, University, Residency, Language, Gender, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1160.367	7	165.767	8.643	.000[b]
	Residual	2090.624	109	19.180		
	Total	3250.991	116			

a. Dependent Variable: French Kit_ Addition Score
b. Predictors: (Constant), MSES Score, University, Residency, Language, Gender, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.795	2.628		-.303	.763
	Gender	1.886	.974	.174	1.937	.055
	Language	2.853	.899	.271	3.173	.002
	Residency	2.832	1.086	.223	2.607	.010
	>High school < University	.863	1.557	.077	.555	.580
	University	2.248	1.725	.197	1.303	.195
	Graduate	2.306	1.759	.191	1.311	.193
	MSES Score	.671	.249	.255	2.697	.008

a. Dependent Variable: French Kit_ Addition Score

Regression Modeling for Numeracy (Addition and Subtraction-correction) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.763[a]	.582	.555	7.668

a. Predictors: (Constant), MSES Score, University, Residency, Language, Gender, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8935.188	7	1276.455	21.707	.000[b]
	Residual	6409.581	109	58.803		
	Total	15344.769	116			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), MSES Score, University, Residency, Language, Gender, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.958	4.601		-1.295	.198
	Gender	1.513	1.705	.064	.887	.377
	Language	10.755	1.574	.470	6.832	.000
	Residency	3.702	1.902	.134	1.947	.054
	>High school < University	2.656	2.726	.109	.974	.332
	University	9.202	3.021	.371	3.046	.003
	Graduate	5.767	3.079	.220	1.873	.064
	MSES Score	1.073	.435	.188	2.464	.015

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression Modeling for Numeracy (Addition) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.587[a]	.345	.302	4.396

a. Predictors: (Constant), SNS Score, University, Residency, Gender, Language, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1099.165	7	157.024	8.124	.000[b]
	Residual	2087.413	108	19.328		
	Total	3186.578	115			

a. Dependent Variable: French Kit_ Addition Score
b. Predictors: (Constant), SNS Score, University, Residency, Gender, Language, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.493	2.816		-.530	.597
	Gender	1.754	.963	.163	1.821	.071
	Language	2.403	.950	.229	2.531	.013
	Residency	2.732	1.097	.214	2.489	.014
	>High school < University	1.120	1.580	.101	.709	.480
	University	2.033	1.769	.179	1.149	.253
	Graduate	2.101	1.801	.176	1.167	.246
	SNS Score	1.336	.497	.282	2.686	.008

a. Dependent Variable: French Kit_ Addition Score

Regression Modeling for Numeracy (Addition and Subtraction-Correction) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.775[a]	.600	.574	7.421

a. Predictors: (Constant), SNS Score, University, Residency, Gender, Language, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8928.395	7	1275.485	23.162	.000[b]
	Residual	5947.355	108	55.068		
	Total	14875.750	115			

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score
b. Predictors: (Constant), SNS Score, University, Residency, Gender, Language, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.775	4.754		-2.056	.042
	Gender	1.826	1.625	.079	1.123	.264
	Language	9.313	1.603	.411	5.810	.000
	Residency	3.105	1.852	.113	1.676	.097
	>High school < University	2.504	2.666	.104	.939	.350
	University	7.706	2.986	.315	2.581	.011
	Graduate	4.223	3.041	.163	1.389	.168
	SNS Score	3.163	.840	.309	3.767	.000

a. Dependent Variable: French Kit_ Addition and Subtraction correction Score

Regression Modeling for Health Numeracy (S-TOFHLA Numeracy) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.407[a]	.165	.102	4.5941

a. Predictors: (Constant), MSES Score, Preferred format, University, Residency, Language, Gender, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	442.870	8	55.359	2.623	.012[b]
	Residual	2237.217	106	21.106		
	Total	2680.087	114			

a. Dependent Variable: S-TOFHLA NUMERIC SCORE
b. Predictors: (Constant), MSES Score, Preferred format, University, Residency, Language, Gender, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.903	4.049		2.693	.008
	Gender	.615	1.022	.062	.602	.548
	Language	1.589	.973	.165	1.633	.105
	Residency	.568	1.151	.048	.493	.623
	>High school < University	.434	1.728	.043	.252	.802
	University	1.820	1.898	.175	.959	.340
	Graduate	1.095	1.927	.100	.569	.571
	Preferred format	3.478	1.496	.212	2.324	.022
	MSES Score	.360	.264	.147	1.364	.176

a. Dependent Variable: S-TOFHLA NUMERIC SCORE

Regression Modeling for Health Numeracy (S-TOFHLA numeracy) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443[a]	.196	.135	4.5181

a. Predictors: (Constant), SNS Score, Preferred format, University, Residency, Gender, Language, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	523.204	8	65.400	3.204	.003[b]
	Residual	2143.428	105	20.414		
	Total	2666.632	113			

a. Dependent Variable: S-TOFHLA NUMERIC SCORE
b. Predictors: (Constant), SNS Score, Preferred format, University, Residency, Gender, Language, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.413	4.193		2.006	.047
	Gender	.682	.992	.069	.688	.493
	Language	1.073	1.007	.111	1.066	.289
	Residency	.557	1.144	.046	.487	.627
	>High school < University	1.225	1.738	.120	.705	.482
	University	2.104	1.920	.202	1.096	.276
	Graduate	1.369	1.945	.125	.704	.483
	Preferred format	3.627	1.467	.221	2.473	.015
	SNS Score	1.077	.514	.244	2.097	.038

a. Dependent Variable: S-TOFHLA NUMERIC SCORE

Regression Modeling for Health Numeracy/Literacy (NVS) including MSES

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.551[a]	.303	.249	1.7003

a. Predictors: (Constant), MSES Score, Preferred format, University, Residency, Language, Gender, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	129.641	8	16.205	5.605	.000[b]
	Residual	297.779	103	2.891		
	Total	427.420	111			

a. Dependent Variable: NVS Score
b. Predictors: (Constant), MSES Score, Preferred format, University, Residency, Language, Gender, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.546	1.576		-.346	.730
	Gender	.382	.395	.095	.966	.336
	Language	-1.148	.362	-.294	-3.167	.002
	Residency	.522	.437	.106	1.192	.236
	>High school < University	2.117	.664	.510	3.187	.002
	University	3.237	.718	.774	4.507	.000
	Graduate	3.083	.729	.699	4.232	.000
	Preferred format	.323	.576	.047	.561	.576
	MSES Score	.226	.099	.226	2.282	.025

a. Dependent Variable: NVS Score

Regression Modeling for Health Numeracy/Literacy (NVS) including SNS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.597[a]	.357	.306	1.6322

a. Predictors: (Constant), SNS Score, Preferred format, University, Residency, Gender, Language, >High school < University, Graduate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	150.684	8	18.836	7.070	.000[b]
	Residual	271.748	102	2.664		
	Total	422.432	110			

a. Dependent Variable: NVS Score
b. Predictors: (Constant), SNS Score, Preferred format, University, Residency, Gender, Language, >High school < University, Graduate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.173	1.602		-1.357	.178
	Gender	.497	.375	.124	1.325	.188
	Language	-1.514	.367	-.388	-4.128	.000
	Residency	.433	.424	.087	1.023	.309
	>High school < University	2.286	.657	.553	3.478	.001
	University	3.081	.712	.739	4.326	.000
	Graduate	2.929	.720	.667	4.067	.000
	Preferred format	.501	.551	.074	.909	.365
	SNS Score	.735	.188	.408	3.911	.000

a. Dependent Variable: NVS Score

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