University of Alberta

Determinants of Health-related Quality of Life among Grade Five Students in Canada and Application to School Based Promotion of Healthy Eating and Active Living

by

Xiu Yun Wu

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Public Health Sciences

Fall 2012
Edmonton, Alberta

Abstract

Childhood overweight and obesity have become a global public health problem that threatens children's future health. The impaired influence of childhood overweight and obesity on their health-related quality of life (HRQOL) has been documented using clinical and population-based samples among children. Very few studies have analyzed socio-demographic and neighbourhood determinants of HRQOL and underlying influencing factors of diet quality and physical activity (PA) for HRQOL among primary school children. While the beneficial effects of school-based programs on promoting healthy behaviors and some aspects of health among children have been documented, the impact of such interventions on their HRQOL has yet to be evaluated.

The purpose of the present study included: (1) to assess associations between socio-demographic and neighbourhood characteristics and the HRQOL among grade five students in Alberta; (2) to investigate how diet quality, PA and weight status correlate with their HRQOL; (3) to construct a scoring system for the EQ-5D-Y (youth) that can be used to derive health state index values for grade five students; and (4) to assess the influence of a school-based program promoting active living and healthy eating on HRQOL of the students. These objectives were addressed using population based data collected in 2008 and 2010 with the Raising Healthy Eating and Active Living Kids in Alberta surveys, and intervention data collected as part of the Alberta Project Promoting Active Living & Healthy Eating in Schools (APPLE Schools).

The results revealed that socio-demographic and neighbourhood characteristics

were determinants of HRQOL in grade five students, and students with better diet quality, higher physical activity levels, and normal weights reported better HRQOL than students who ate less healthy, were less active or were overweight or obese. The index value set for the EQ-5D-Y that was based on child self-rated Visual Analogue Scale (VAS) values resulted in parameter estimates that followed the expectation for different levels of EQ-5D-Y health states. Analysis of primary intervention of the APPLE Schools program did not show a statistically significant improvement in HRQOL of grade five students between 2008 and 2010. The results suggest a need to take into account of the important determinants for HRQOL among children in school based health interventions, and to further examine factors that could contribute to the observed variation in the HRQOL in this study. This will help inform public health policy to the benefits of both weight-related health and quality of life among children.

Acknowledgements

I would like to express my deepest thanks to my supervisors, Dr. Paul Veugelers, and Dr. Arto Ohinmaa for their guidance and support in my PhD studies. Their expertise, instructions, and inspiration greatly encouraged me to make efforts towards the success of the PhD study. Their comments and suggestions have been valuable for the accomplishment of the thesis. I would like to express my sincere thanks to my supervisor committee member, Dr. Jeffrey Johnson. His comments and suggestions on the analytical methods and result interpretation have been valuable contributions to the thesis. I would also like to thank the exam committee member, Dr. Ambikaipakan Senthilselvan, and Dr. Jennifer Taylor for their comments on the thesis.

I would also like to thank Dr. Stefan Kuhle and Connie Lu for data management, validation and quality control. Thanks also go to Andrea Cliff, and all staffs and students of the Population Health Intervention Research Unit, School of Public Health, University of Alberta for their assistance during the work on the thesis research. I thank all grade five students, their parents and schools for their participation in the REAL Kids Alberta evaluation, and the APPLLE Schools evaluation; and all the research assistants and regional health promotion coordinators for the execution of the data collection.

This research was funded by Alberta Health and Wellness and by a Canada Research Chair in Population Health and Alberta Innovates Health Solutions Scholarship to Dr. Paul Veugelers. I would like to thank Alberta Health and

Wellness and my supervisor Dr. Paul Veugelers for providing with funding for my PhD studies.

Contents

List of Tables

List of Figures

List of Appendices

Chapter 1- Introduction

1.1 Background

1.1.1 Neighbourhood Characteristics, Diet Quality, Physical Activity and Health-related Quality of Life in Children

Childhood obesity is an alarming epidemic that affects children's health worldwide (1). A recent survey indicated that approximately 26% of Canadian children and adolescents were overweight or obese, and 8.6% were obese (2). It has been widely acknowledged that overweight and obesity in children and adolescents contribute to a number of diseases, such as type 2 diabetes, cardiovascular disease, asthma, causing a great threat to their health and life expectancy (3-5). Besides the impaired physical health consequences, overweight and obesity also contribute to lower self-esteem, worse psychosocial health, poor school performance and impaired HRQOL among children and youth (6-8).

The importance of measurement of health-related quality of life (HRQOL) among children has been recognized in population health studies and evaluations of public health interventions (9-10). A review has documented associations of overweight and obesity with decreased HRQOL in children (11). However, the reviewed studies did not consider the underlying causes of excess body weight, diet quality and physical activity simultaneously. Very few studies have analyzed the impact of diet and physical activity (PA) on HRQOL in general population-based sample of school children (12). The few studies that have examined the association between diet, PA and HRQOL have shown that children participating in physical activity or eating healthy were more likely to report higher HRQOL than their peers who were less physically active or ate less healthy (12). Little research has yet examined whether the association between PA, diet quality and HRQOL in school children is independent of weight status and socio-demographic characteristics, and how PA and diet quality influence different aspects of psychological and physical functioning of the HRQOL. In addition, neighbourhood characteristics have been shown to have impact on individual health and health related behaviours in children (13). However, studies investigating the effects of neighbourhood variables on HRQOL among children are lacking.

1.1.2 Preference-based HRQOL Instruments and the EQ-5D

In general population, HRQOL can be measured by generic measures of health state profiles or preference-based index measures (14). Health profiles describe health status in different domains that reflect different aspects of physical, social and emotional functioning. Preference-based index measures provide a single index that summarizes the HRQOL for a particular health state (14). Measuring HRQOL using preference-based measures has the advantage that the index values generated can also be used in economic evaluations of various health intervention programs. In the last decade, economic evaluations have been increasingly used in assessing effectiveness of childhood intervention programs (15). In the evaluations, the quality-adjusted life-years (QALYs) gained is commonly used as an outcome measure to incorporate quantity and quality aspects of the health outcomes (16). QALYs are calculated as the product of the time (e.g. number of years) spent in each health state during the follow up and the value that is assigned to each health state (15).

To calculate the QALYs, a single index that represents HRQOL needs to be derived either by a direct valuation method such as the time trade-off (TTO), the standard gamble (SG), or the visual analogue scale (VAS) to value individuals' own health, or by an indirect valuation method (16). The indirect approach involves using a preference-based multi-attribute HRQOL questionnaire (e.g. EQ-5D or the Health Utility Index-HUI) to describe health states of the individuals. The HRQOL given by an individual is linked to a scoring algorithm to estimate a utility score (17). The scoring algorithm is based on preference values for hypothetical health states derived from a general public sample using TTO, SG or VAS.

One broadly used preference-based instrument that utilizes a summary index score for use in health economic evaluations in adult populations is the EQ-5D (18). Various country-specific value sets for the EQ-5D have been established using both TTO and VAS valuations (19-21). The child and youth version of the instrument, called EQ-5D-Y (youth), was developed by revising the EQ-5D wording to be easy to understand by children from age 8 years to 18 years (22) .

The EQ-5D-Y has been validated in several European countries (23). While the index value sets for the EQ-5D are available for adult populations, no value set for the EQ-5D-Y has been developed. There is a growing need to establish a specific preference value set for the new instrument.

1.1.3 Influence of School-based Childhood Obesity Prevention Programs on Health and HRQOL in Childhood

The rising rate of childhood obesity and its serious consequences on health call for effective health interventions aimed at improving children's health (24). A number of school-based programs to improve healthy behaviors and reduce obesity burden in children and youth have been conducted and their effectiveness has been evaluated (24, 25). Systematic reviews have revealed that most of the school-based childhood obesity prevention programs that involved physical activity and dietary interventions did not show significant improvement in BMI status, though some studies showed a small, positive impact on BMI (24).Research evidence has shown that the integration of school-based promotion of healthy eating and active living to a comprehensive school health (CSH) model is more effective in reducing childhood obesity than a single approach focusing on PA or diet promotion alone (26). Previous studies have also documented the beneficial effects of the CSH on eating habits, physical activity, bullying and on other health outcomes, such as mental health and well-being (26-28). However, no such studies have examined the impact of the interventions on childhood HRQOL.

Information regarding the influence of diet and PA promotion in schools on HRQOL in children can help identify population subgroups that could benefit from the intervention and optimize current intervention strategies to maximize the positive effect for children's health.

1.2 Measurement of Health-related Quality of Life in Children

The World Health Organization (WHO) defines 'health' as a state of complete physical, mental and social well-being, and not just merely the absence of disease or infirmity (29). Therefore, HRQOL is usually considered to be a multidimensional construct that includes physical, social and emotional functioning, as well as well-being (10).

Various HRQOL instruments have been developed and used in assessment of the HRQOL in children. These measures include disease-specific measures, which are designed to measure disease-related aspects of health, and generic measures, which are used to capture the health status across all diseases or conditions in a wide range of populations (9). Generic measures have advantages that they can be used in a variety of populations, allow for comparisons across conditions and interventions, and assess different aspects of health status (9).

Health-related quality of life is usually measured from the individual's perspective by self-report. Since children experience considerable changes in growth and cognitive development, measurement of HRQOL in children using generic

HRQOL instruments raises methodological considerations that are different from assessment of HRQOL in adult populations (14). One of the main challenges is that domains included in a HRQOL measure should be applicable for children, and the wording of the questions needs to be tailored to meet the comprehension ability of the target populations.

The EQ-5D-Y is a newly developed generic, HRQOL instrument for children and adolescents (22). It was developed by a multi-national expert group that modified the language of the domains in the EQ-5D, a preference-based HRQOL measure for adults (18). The EQ-5D consists of a five dimensional descriptive system and a Visual Analogue Scale which is anchored at 100 (best imaginable health) and 0 (worst imaginable health). The five dimensions are: mobility, self-care, usual activities, pain or discomfort, and anxiety or depression. Each dimension has three levels of problems (no problems, some problems, and extreme problems) (18). Its psychometric properties of the feasibility, reliability and validity have been tested in various populations, and showed comparable to several other main generic HRQOL measures, such as the Health Utilities Index (HUI), SF-36, and SF-6D (30-34). It is considered inappropriate to apply the EQ-5D directly to assessment of HRQOL in children and adolescents under age of 16 (14, 22).

The development of EQ-5D-Y included domain definition and age appropriate rewording that made it easier for children and adolescents to understand and complete. The EQ-5D-Y five-dimensional descriptive system includes three levels of questions indicating: 1) no problems; 2) some problems; or 3) a lot of problems with 1) walking; 2) looking after myself; 3) doing usual activities; 4) having pain or discomfort; and 5) feeling worried, sad or unhappy, respectively (22). The instrument also includes a VAS designed to capture self-rated values of health status in children. The EQ-5D-Y has been validated for several languages and countries (23). The main advantages of the questionnaire are that it is short and simple, and can be easily answered by children. It can potentially be used to estimate a single index score to be used subsequently in economic evaluation studies among children. However, there is no agreement what preference values should be used in the child populations (15, 23).

1.3 Valuing Health-related Quality of Life in Children

Individuals' preferences are important in facilitating health decision-making in evaluating the effectiveness of different health interventions (35). Preference-based instruments derive a numerical value that reflects the values that the population places on each health state. The value that represents the overall HRQOL pertaining to different health states is usually called health utility (36). Utilities are cardinal values that are assigned to each health state on a scale ranged between a value of 1.0 (being healthy) and 0.0 (being dead) (37). The utility values reflect the quality of the health states and allow morbidity and mortality changes to be combined into a single summary measure, QALY's gained (37). While various techniques have been used or proposed to derive utility values, standard direct and indirect approaches are commonly used to elicit the value for economic evaluation studies (17).

Most of previous childhood studies using utility values have used preferences that were obtained from adult studies (38). Relative to health state valuation for adult populations, valuing health states among children poses theoretical and methodological challenges as children are growing and their cognitive development is changing (15). The major methodological considerations in deriving utility or preference values for children include what type of health state values should be used, who (i.e. children or proxy) should complete valuation tasks, and how to elicit the preference values for health status of child populations (15, 39).

The generic preference-based measure of EQ-5D and the child version, EQ-5D-Y can be used to estimate a single index that represents health utility. The TTO and and VAS are the most commonly used approaches to elicit health state valuation for hypothetical EQ-5D health states in adults. Researchers argue that the TTO might be too difficult to complete by children (15). To overcome this limitation, some researchers suggest eliciting utilities from children and their family members, and combining the measures by appropriate mathematical function to generate utilities for children (39). However, these approaches are resource and time intensive, and raise methodological challenges in measurement of utilities and development of a valid mathematical function (39). Recent studies have also showed evidence of deriving health state values for the EQ-5D from the use of discrete-choice modeling technique (40). In addition to the preferences that are measured from hypothetical health states, the individuals own value for his/her health state needs also be considered. It is argued that individuals who lack experience of the health states may fail to make accurate assessment of the health when valuing hypothetical health states (41). Some studies provide simpler solutions to elicit the EQ-5D index based on the subject own VAS values (41, 42).

Despite the challenges encountered in eliciting health state preferences from children, arguments tend to favour eliciting them using values from children themselves whenever their cognitive and language skills are adequate to understand and complete the valuation task (39, 43). EQ-5D-Y provides choices of estimating values for health states from children. Since no child-specific set of values for EQ-5D-Y is available, earlier research for quality of life measurement in children using the EQ-5D have relied on the existing adult UK EQ-5D value sets (44, 45). Lack of an index value set for EQ-5D-Y limits its application in population health studies and in cost-effectiveness studies aiming to evaluate the effectiveness of different health interventions in younger populations (23).

1.4 Study Objectives

This study aims to assess relationships between HRQOL of grade five students and their socio-demographic and neighbourhood characteristics, diet quality and physical activity, and to analyze the influence of the Alberta Project Promoting Active Living & Healthy Eating in Schools (APPLE Schools) on their HRQOL.

The objectives of the thesis are following:

1. To describe the HRQOL of grade five students in Alberta, and to assess the correlations between their socio-demographic and neighbourhood characteristics and the HRQOL.

2. To investigate the associations of diet quality, PA and weight status with HRQOL among these students.

3. To construct a scoring system for the EQ-5D-Y that can be used to generate health state index values for children.

4. To assess the influence of a school based program promoting active living and healthy eating on HRQOL of the grade five students.

1.5 The Structure of This Paper Based Thesis

This first chapter provided a general introduction and description of study objectives. Chapter 2 addresses the first objective, examining the association between socio-demographic and neighborhood characteristics and HRQOL in grade five students. This chapter has meanwhile been published (46). In the second study (Chapter 3), we further assessed the association between diet quality, physical activity, weight status and HRQOL among the same population. These two studies demonstrate the importance of socio-demographic and neighborhood determinants, diet quality, physical activity, and weight status for the HRQOL in grade five students. I used the 2008 Raising Healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) survey for these first 2 studies. This chapter has meanwhile been published (47).

Chapter 4 presents an approach to establish a scoring system to derive values for the EQ-5D-Y health states. As no child-specific health state value set is available, the US EQ-5D scoring algorithm was used to estimate the EQ-5D-Y index in the first study. Chapter 4 provides a method to bridge the gap between the HRQOL and the health state index value among children measured by the EQ-5D-Y. I used the pooled data of 2008 and 2010 REAL Kids Alberta surveys for the third study.

Chapter 5 shows the evaluation results for the impact of school-based promotion of healthy eating and active living on HRQOL among the children. In this study, I used the data from the 2008 and 2010 REAL Kids Alberta surveys and from ten APPLE Schools that participated in the Alberta Project Promoting Active Living & Healthy Eating in Schools (APPLE Schools). The intervention effect was examined by the HRQOL and analyzing the underlying mechanisms for the changes in HRQOL during two-year period.

The final chapter summarizes the key findings, discusses strengths and limitations of the whole study and provides suggestions for future research and public health policy.

1.6 References

(1) Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360(9331) (Aug 10): 473-482.

(2) Statistics Canada. Canadian Health Measures Survey: Cycle 1 Data Tables, 2007 to 2009. 2010; 82-623-X. [http://www.statcan.gc.ca/pub/82-623-x/82-623-x2010002-eng.pdf]. (Accessed July 22, 2011).

(3) Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes (Lond).* 2011 Jul; 35(7): 891-898.

(4) Choudhary AK, Donnelly LF, Racadio JM, Strife JL. Diseases associated with childhood obesity. *AJR Am J Roentgenol* 2007 Apr; 188(4): 1118-1130.

(5) Ball GD, McCargar LJ. Childhood obesity in Canada: a review of prevalence estimates and risk factors for cardiovascular diseases and type 2 diabetes. *Can J Appl Physiol* 2003 Feb; 28(1): 117-140.

(6) Wang F, Veugelers PJ. Self-esteem and cognitive development in the era of the childhood obesity epidemic. *Obes Rev* 2008 Nov; 9(6): 615-623.

(7) Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD. Social, educational, and psychological correlates of weight status in adolescents. *Obes Res* 2001 Jan; 9(1): 32-42.

(8) Rampersaud GC, Pereira MA, Girard BL, Adams J, Metzl JD. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc* 2005 May; 105(5): 743-60; quiz 761-2.

(9) Solans M, Pane S, Estrada MD, Serra-Sutton V, Berra S, Herdman M, et al. Health-related quality of life measurement in children and adolescents: a

systematic review of generic and disease-specific instruments. *Value Health* 2008 Jul-Aug; 11(4): 742-764.

(10) Spieth LE, Harris CV. Assessment of health-related quality of life in children and adolescents: an integrative review. *J Pediatr Psychol* 1996 Apr; 21(2): 175-193.

(11) Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, et al. Health-related quality of life in obese children and adolescents. *Int J Obes (Lond)* 2009 Apr; 33(4): 387-400.

(12) Chen X, Sekine M, Hamanishi S, Yamagami T, Kagamimori S. Associations of lifestyle factors with quality of life (QOL) in Japanese children: a 3-year follow-up of the Toyama Birth Cohort Study. *Child Care Health Dev* 2005 Jul;31(4): 433-439.

(13) Veugelers P, Sithole F, Zhang S, Muhajarine N. Neighborhood characteristics in relation to diet, physical activity and overweight of Canadian children. *Int J Pediatr Obes* 2008; 3(3): 152-159.

(14) Connolly MA, Johnson JA. Measuring quality of life in paediatric patients. *Pharmacoeconomics* 1999 Dec; 16(6): 605-625.

(15) Prosser LA, Hammitt JK, Keren R. Measuring health preferences for use in cost-utility and cost-benefit analyses of interventions in children: theoretical and methodological considerations. *Pharmacoeconomics* 2007; 25(9): 713-726.

(16) Torrance GW. Measurement of health state utilities for economic appraisal. *J Health Econ* 1986 Mar; 5(1): 1-30.

(17) Tarride JE, Burke N, Bischof M, Hopkins RB, Goeree L, Campbell K, et al. A review of health utilities across conditions common in paediatric and adult

populations. *Health Qual Life Outcomes* 2010 Jan 27; 8: 12.

(18) Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. *Ann Med* 2001 Jul; 33(5): 337-343.

(19) Johnson JA, Coons SJ, Ergo A, Szava-Kovats G. Valuation of EuroQOL (EQ-5D) health states in an adult US sample. *Pharmacoeconomics* 1998 Apr; 13(4): 421-433.

(20) Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997 Nov; 35(11): 1095-1108.

(21) Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states: development and testing of the D1 valuation model. *Med Care* 2005 Mar; 43(3): 203-220.

(22) Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, Devlin N, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D. *Qual Life Res.* 2010 Aug; 19(6): 875-886.

(23) Ravens-Sieberer U, Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, et al. Feasibility, reliability, and validity of the EQ-5D-Y: results from a multinational study. *Qual Life Res.* 2010 Aug; 19(6): 887-897.

(24) Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev* 2009 Jan; 10(1): 110-141.

(25) Zenzen W, Kridli S. Integrative review of school-based childhood obesity prevention programs. *J Pediatr Health Care* 2009 Jul-Aug; 23(4): 242-258.

(26) Veugelers PJ, Fitzgerald AL. Effectiveness of school programs in preventing

childhood obesity: a multilevel comparison. *Am J Public Health* 2005 Mar; 95(3): 432-435.

(27) Stewart-Brown S. What is the evidence on school health promotion in improving health or preventing disease and, specifically, what is the effectiveness of the health promoting schools approach? Copenhagen: WHO Regional Office for Europe, 2006. Health Evidence Network report. 2006; [http://www.euro.who.int/document/e88185.pdf]. (Accessed March 11, 2011).

(28) Lister-Sharp D, Chapman S, Stewart-Brown S, Sowden A. Health promoting schools and health promotion in schools: two systematic reviews. *Health Technol Assess* 1999; 3(22): 1-207.

(29) World Health Organization. Constitution of the World Health Organization. Geneva: World Health Organization, 1948.

(30) Harrison MJ, Davies LM, Bansback NJ, Ingram M, Anis AH, Symmons DP. The validity and responsiveness of generic utility measures in rheumatoid arthritis: a review. *J Rheumatol* 2008 Apr; 35(4): 592-602.

(31) Badia X, Schiaffino A, Alonso J, Herdman M. Using the EuroQoI 5-D in the Catalan general population: feasibility and construct validity. *Qual Life Res.* 1998 May; 7(4): 311-322.

(32) Bharmal M, Thomas J,3rd. Comparing the EQ-5D and the SF-6D descriptive systems to assess their ceiling effects in the US general population. *Value Health* 2006 Jul-Aug; 9(4): 262-271.

(33) Johnson JA, Pickard AS. Comparison of the EQ-5D and SF-12 health surveys in a general population survey in Alberta, Canada. *Med Care* 2000 Jan; 38(1): 115-121.

(34) Macran S, Weatherly H, Kind P. Measuring population health: a comparison of three generic health status measures. *Med Care* 2003 Feb; 41(2): 218-231.

(35) Green C, Brazier J, Deverill M. Valuing health-related quality of life. A review of health state valuation techniques. *Pharmacoeconomics* 2000 Feb; 17(2): 151-165.

(36) Drummond ME, Sculpher MJ, Torrance GW, et al. Methods for the economic evaluation of health care programmes. 3rd ed. Oxford University Press, 2005.

(37) Torrance GW. Utility approach to measuring health-related quality of life. *J Chronic Dis* 1987; 40(6): 593-603.

(38) Ladapo JA, Neumann PJ, Keren R, Prosser LA. Valuing children's health: a comparison of cost-utility analyses for adult and paediatric health interventions in the US. *Pharmacoeconomics* 2007; 25(10): 817-828.

(39) Ungar WJ. Challenges in health state valuation in paediatric economic evaluation: are QALYs contraindicated? *Pharmacoeconomics* 2011 Aug; 29(8): 641-652.

(40) Stolk EA, Oppe M, Scalone L, Krabbe PF. Discrete choice modeling for the quantification of health states: the case of the EQ-5D. *Value Health* 2010 Dec; 13(8): 1005-1013.

(41) Kind P. Valuing EQ-5D health states - a VAStly simpler solution? 24th scientific Plenary Meeting of the EuroQol Group-Proceedings: 319-337. 2009.

(42) Kind P, Hennessy S, Macran S. The value of hypothetical and "real" EQ-5D health states and other things: a fairytale for the childrens' session at the EuroQoL Scientific Plenary. 21th scientific Plenary Meeting of the EuroQol Group-Proceedings: September, 2004.

(43) Petrou S. Methodological issues raised by preference-based approaches to measuring the health status of children. *Health Econ* 2003 Aug; 12(8): 697-702.

(44) Willems DC, Joore MA, Nieman FH, Severens JL, Wouters EF, Hendriks JJ. Using EQ-5D in children with asthma, rheumatic disorders, diabetes, and speech/language and/or hearing disorders. *Int J Technol Assess Health Care* 2009 Jul; 25(3): 391-399.

(45) Boyle SE, Jones GL, Walters SJ. Physical activity, quality of life, weight status and diet in adolescents. *Qual Life Res*. 2010 Sep; 19(7): 943-954.

(46) Wu XY, Ohinmaa A, Veugelers PJ. Sociodemographic and neighbourhood determinants of health-related quality of life among grade-five students in Canada. *Qual Life Res*. 2010 Sep; 19(7): 969-976.

(47) Wu X, Ohinmaa A, Veugelers PJ. Diet Quality, Physical Activity, Body Weight and Health-Related Quality of Life Among Grade Five Students in Canada. *Public Health Nutr.* 2011 Oct 4: 1-7. [Epub ahead of print]

Chapter 2 – Socio-demographic and Neighbourhood Determinants of Health-related Quality of Life among Grade-five Students in Canada [1]

2.1 Introduction

Measuring health-related quality of life (HRQOL) is becoming increasingly important in guiding policy decisions for resource allocation to health interventions in various populations. Knowledge of the distribution of the HRQOL by different socio-demographic and other background variables is important when society is directing interventions to different child subgroups aimed to improve their HRQOL and equity in health. Studies on HRQOL in adult populations using various instruments have demonstrated that the distribution of HRQOL varies among different sociodemographic groups and with different domains of physical, social and emotional functioning (1-5). Decreased HRQOL is usually associated with lower levels of education or income in persons compared to those of higher level of educational attainment or income. People in older age groups have worse HRQOL than younger adults, and some gender differences in HRQOL have also been found with female generally reporting more problems than male (4-5).

Most of the HRQOL studies from children and adolescents have analyzed various disease conditions (6-9). Although some studies have recently analyzed

[1] A version of this chapter has been published. Wu X, Ohinmaa A, Veugelers PJ. *Quality of Life Research*. 2010; 19 (7): 969-976.

sociodemographic and socio-economic differences in HRQOL in general populations of children and adolescents (10-13), we could find only two articles that have assessed the HRQOL of elementary school children using comprehensive population samples (14-15). Furthermore, background variables like neighbourhood characteristics have been shown to have impact on individual health and health related behaviours in children and adults (16-18). However, studies investigating the effects of neighbourhood variables on HRQOL among children are lacking. Such research can help policy makers to decide whether the risk prevention and health promotion to improve children's health and social well-being needs to be targeted to specific disadvantaged communities and neighbourhoods.

During the last two decades, various generic HRQOL measures have been developed to be used in many patient groups along with population health research. One widely used generic measure is the EQ-5D, a self-report, preference-based instrument (19-21) which standard adult version has been validated in numerous clinical conditions as well as in general populations (22-24). Its psychometric properties in terms of feasibility, reliability and validity are comparable to several other main generic HRQOL measures, such as the Health Utilities Index (HUI), SF-36, and SF-6D (25-28). Several country specific preference value sets have been estimated to produce a single EQ-5D index score that is used in economic evaluation studies and in population health studies to compare health status in different subgroups (29-30).

In the present study we aim to describe the HRQOL of grade five students and to assess how this correlates with their socio-demographic and neighbourhood characteristics.

2.2 Study Design and Methods

2.2.1 The Survey and Participants

In 2008, we conducted a large population-based survey on health and HRQOL among grade five students aged primarily from 10 to 11 years and their parents in the Canadian province of Alberta. The survey employed a one-stage stratified random sampling design. The sampling frame includes all elementary schools in the province of Alberta with the exception of private schools (4.7% of all Alberta children attend such schools), francophone schools (0.6%), on-reserve federal schools (2.0%), charter schools (1.7%), and colony schools (0.8%). Schools were stratified into three geographies: 1) urban: Calgary and Edmonton (about 1 million people each); 2) towns: other municipalities with more than 40,000 residents; and 3) rural: municipalities with less than 40,000 residents. Schools were randomly selected within each of these strata to achieve a balanced number of schools and students in each stratum. Of the 184 invited schools, 148 (80.4%) participated in the study. These schools were attended by 5,594 grade five students who received an envelope with a parent consent form and survey to take home. Of the 3,758 (67.2%) students that returned completed consent form to school, 3,645 (97.0%) had received parental consent to participate. Of these students, 3,407 were present when evaluation assistants visited the school to conduct the survey, 6 students declined to participate, and 20 absent students completed and mailed their surveys, resulting in 3,421 participating students (61.2% of total grade five student population in those schools).

2.2.2 Measurement and Assessments

2.2.2.1 Socio-demographic and Neighbourhood Characteristics

Of all 3,421 participating students, 3,340 parents completed a survey on educational attainment, household income, place of residency (urban, town, rural), and eight questions on their neighbourhoods: ‘ 1) I like where I live; 2) It is safe for children to play outside during the day; 3) In my neighbourhood there are good parks, playgrounds and/or places to play; 4) In my neighbourhood there are sidewalks on most of the streets; 5) Traffic makes my neighbourhood an unsafe place for my child; 6) Crime makes my neighbourhood an unsafe place for my child; 7) My grade five child has good access to sports and recreation programs; and 8) I have good access to stores to purchase fresh fruits and vegetables’. Response options for these items included ‘strongly disagree’, ‘disagree’, ‘agree’ and ‘strongly agree’. By means of principal component analysis we reduced these eight items to three components: 1) Neighborhood satisfaction and services; 2) Neighborhood safety; and 3) Neighborhood playgrounds and parks (see table 2-1) which we described in detail elsewhere (31).

2.2.2.2 Health-related Quality of Life

The EuroQol group developed a five questions (dimensions) tool (EQ-5D) to quantify HRQOL. The dimensions are mobility, self-care, usual activities, pain or discomfort, and anxiety or depression. The instrument also includes a Visual Analogue Scale (VAS) which is anchored at 100 (best imaginable health) and 0 (worst imaginable health). Most recently, the EuroQol group adopted a version that is suitable for children and youth between the ages of 8 to 18 years, called the EQ-5D-Y. The five questions are whether children have problems with 1) walking; 2) looking after myself; 3) doing usual activities; 4) having pain or discomfort; and 5) feeling worried, sad or unhappy, to which they could respond with 1) no problems; 2) some problems; and 3) a lot of problems. At the moment, there is no own single index formula developed for the EQ-5D-Y. To calculate single index (EQ-5D-Y index) to measure overall HRQOL we used the US EQ-5D index values. This scoring algorithm is based on time trade-off valuations of EQ-5D health states by a sample from the U.S general population, and the possible score of the index ranges between -0.109 (lowest) to 1.00 (highest) (32). The EQ-5D-Y has been validated for several languages and countries (33-34). The EQ-5D-Y instrument was included in the student survey that is available through the project website (REALKidsAlberta.ca). Of all 3,421 students, 15 (0.4 %) failed to complete one or more of the questions in the EQ-5D-Y descriptive system and 42 (1.2 %) did not complete the VAS. These missing outcomes were not considered in the analyses.

2.2.3 Statistical Analysis

We estimated the prevalence of problems in each of the EQ-5D-Y dimensions as well as the mean EQ-5D-Y index and mean VAS by gender, residential area, parents' education and household income. As very few students reported 'a lot of problems', we combined this with 'some problems' to create a dichotomous outcome. We applied Chi-square to test for differences in prevalence of reported problems. We applied multi-level linear regression to assess the associations of socio-demographic and neighborhood factors with the EQ-5D-Y index and the VAS. Multi-level regression methods accommodate clustering of student observations within that of their schools. These regression analyses were further adjusted for the confounding influence of gender, household income, parental education, place of residence and neighborhood factors. Likelihood-ratio tests were used to examine the variance between the full regression model with the observed indicators and the null model for the EQ-5D-Y index and the VAS, respectively. Missing values for family income and parental education were considered as separate covariate categories in the analysis but are not presented. All analyses were weighted to accommodate the design effect such that all estimates pertain to the population of grade five students in Alberta. Data were analysed using STATA 10.0 (Stata Corp, College Station, TX, USA). The study program was approved by Health Research Ethics Board of the University of Alberta.

2.3 Results

Table 2-1 depicts the prevalence of problems included in the EQ-5D-Y. The problems with 'walking' (n=288, 8.1%), 'looking after myself' (n=215, 6.5%) and 'usual activities' (n=431, 11.8%) were relatively low, while the problems with 'pain or discomfort' (n=1,600, 46.0%), and 'worried, sad or unhappy' (n= 1,292, 37.7%) were relatively high. Of these students, 37.8% (n=1,250) did not respond any problems in the five dimensions, whereas 29.2% (n=1,013), 21.8% (n=759), 7.9% (n=270), 2.7% (n=95), and 0.6% (n=19), reported problems for 1, 2, 3, 4, and all of the five problem areas respectively. Girls relative to boys reported more often being worried, sad or unhappy (table 2-1). Children of families with household incomes exceeding $100,000 reported statistically significantly less problems with respect to 'usual activities' relative to their peers from families with less income.

Grade five students have a mean EQ-5D-Y index score of 0.860 and a mean EQ-5D-Y VAS of 80.5. The EQ-5D-Y index was statistically significantly higher for students in urban settings, in higher educated and better earning families, and those residing in neighbourhood characterized as providing good satisfaction and facilities, and having sidewalks and parks (table 2-1). Relative to the EQ-5D-Y index score, the EQ-5D-Y VAS varied less across these socio-demographic and neighbourhood characteristics.

Table 2-2 shows the independent importance of socio-demographic and neighbourhood characteristics for the EQ-5D-Y index and EQ-5D-Y VAS. Likelihood ratio tests indicated that the full model with all independent variables observed in this study significantly improved the prediction of the EQ-5D-Y VAS ($\chi2=557.34$, $p<0.0001$) and the EQ-5D-Y index ($\chi2=784.65$, $p<0.0001$) as compared with the corresponding empty model, respectively. Children of families reporting higher educational attainment reported higher HRQOL both in terms of a higher EQ-5D-Y index and a higher EQ-5D-Y VAS. Also, children residing in neighbourhood characterized as providing good satisfaction and facilities reported higher HRQOL. In addition in the EQ-5D-Y index urban children had significantly higher HRQOL than children in towns and rural areas, and children from families whose income was between $50,000 and $75,000 had lower HRQOL than children from families with lower than $50,000 income (table 2-2).

2.4 Discussion

This study shows that sociodemographic and neighbourhood characteristics are important determinants of HRQOL in grade five students in Alberta, Canada. Students residing in towns and rural areas experience lower quality of life, as do those with parents with less educational attainment. Parents' perception of the quality of their neighbourhood in terms of satisfaction to live there and access to services like recreational programs and stores with fresh fruit and vegetables, appeared as the strongest determinant of HRQOL reported by their children.

In comparison to similar studies in other countries using the EQ-5D-Y in children and adolescents, Albertan children reported a slightly lower HRQOL in the VAS (mean 80.5) relative to children in Germany (mean 83.7) and Spain (mean 83.8). However, children and youth, age 13 and older, in South Africa had reported a lower mean VAS value (77.3) (33). The EQ-5D-Y is a relatively new instrument and EQ-5D-Y index scores of older populations have still to be published. We observed that the prevalence of problems that relate to 'pain and discomfort' and 'feeling worried, sad or unhappy' was substantially higher than for 'walking', 'looking after myself', and 'usual activities', which is consistent with the other EQ-5D-Y studies among children and youth in other countries (34).

Our observation that children from families with less educational attainment experience less HRQOL is also consistent with the finding from a European study (13). However, where various studies have shown income gradient such that wealth and quality of life coincide (11, 13, 15), we did not observe that for children in Alberta. Instead, we observed that children in a middle family income category tended to report less HRQOL, suggesting that financial barriers were not an important determinant for the HRQOL for the lowest income group. The economy of the province of Alberta had been fluorescing in the years preceding the survey in winter 2008 that could have impacted these results. In the analysis, low satisfaction to neighbourhood and its services had the strongest negative impact on the HRQOL scores. Since lower income groups are more likely to live in lower quality neighbourhoods, some part of the income effect may be connected to neighbourhood quality indicators and affordable housing among families with children.

Reasons for using the HRQOL instrument in our study are its brevity and simplicity, making it easy to answer by children, and its advantage that it can be utilized to produce a single index score for use subsequently in economic evaluation studies. EQ-5D-Y has been developed from a generic well known adult (18 years and older) HRQOL instrument and it is important to know how children population's HRQOL differs from adult population. Many health risk factors like obesity, poor diet and physical inactivity, some chronic conditions like asthma and type I diabetes are increasingly starting during childhood. Using an EQ-5D adapted to children population will help us to understand how the HRQOL will change once the children get older to adulthood with or without these risk factors and diseases.

The feasibility, reliability, and validity of the EQ-5D-Y have been demonstrated using multinational samples of youth (34). The present study confirms the feasibility of this instrument in the Canadian context as only very few grade five students were not able to answer the questions. Also the study results mainly follow the expectations for the background variables that are coming from other childhood and adult population studies. The main difference in our study to most of the other studies in the field is that the prevalence of problems in the pain or discomfort and worried, sad or unhappy dimensions was higher than expected. In a general population sample of adults from Alberta, Johnson and Pickard (26) also showed relatively high prevalence of pain or discomfort (43.6%) and anxiety or depression (28.6%) using EQ-5D. In a small sub-group (n=31) of young adults (18-24 years) the prevalence was 31.3% and 38.7%, respectively. Also the VAS score (mean 82.6) and the EQ-5D index (0.859) among young adults was relatively close to our results (26). Relative to similar studies in other countries, the prevalence of pain or discomfort (46.0%) in our study is higher than that for children in Germany (37.5%) and Italy (39.0%), but the prevalence of being worried, sad or unhappy (37.7%) is slightly lower than that in Germany (39.9%) and Italy (39.0%). It appears that children could rate higher problems with the two dimensions than adults (1, 24, 26-27). However, more research is needed to identify the possible origin of these high numbers.

An interesting outcome of the study was that the EQ-5D-Y index, while showing higher HRQOL level,was connected to somewhat different background variables than the EQ-5D-Y VAS that is based on children’s self-rating of their health state. The rural residency was connected to statistically significant lower EQ-5D-Y index and a higher EQ-5D-Y VAS (not significant) relative to urban children. It is possible that urban children had higher expectation in their overall HRQOL than the rural peers. Also it is possible that the filling of the descriptive system, which is summarized in the index, and valuing overall health is culturally affected in a different way by the residential areas.

The ceiling effect found in our study has also been demonstrated in other adult and youth population health studies (1, 24-25, 34), with 37.8% of the respondents reporting ‘no problem’ on all the five dimensions (the state 11111). Some researchers have suggested including other dimensions such as social well being or dimensions that are specific in school children to the EQ-5D-Y (24, 34). However, this would involve in in-depth examination of content and construct validity of the instrument, which is beyond the objective of the current study.

Our calculations of the EQ-5D-Y index scores were based on the US EQ-5D index tariff for adult general population as there is no children specific EQ-5D tariff available (32). There are both theoretical and practical issues slowing the development of tariff algorithm to children. Some of those are linked to valuation methods like the time-trade off and the standard gamble that might be too difficult to do for young children. The concept of death that is essential for the single index is difficult to incorporate even to adult valuations and it is even more difficult to be included in valuations done by children. Also the question, which should do the valuation of the HRQOL states children themselves or adults like parents, family members or adults without children, needs to be resolved (35). Before child specific tariffs have been generated, the adult tariffs are likely the best ‘proxy’ alternative when summary scores are calculated (8-9). In our study, the similarity in identifying sub-group differences in HRQOL between the EQ-5D-Y index and the VAS by socio-demographic and neighbourhood characteristics except for residential area appears to support some discriminant power of the US EQ-5D index tariff in school children in grade five in Canada.

The strength of this study is that it is based on a relatively large representative cohort of grade five students in Alberta. Specifically, this study is the first to reveal the independent importance of neighbourhood characteristics for HRQOL in children. Earlier studies mostly focused on the impact of neighbourhood characteristics on physical or mental health in children and adults (16-18). The influence of neighbourhood characteristics on self-rated health-related quality of life has received little research attention (36-38). This observation concurs with an increasing body of literature that has related neighbourhood characteristics such as good access to recreational facilities and stores for fresh produce with physical activity levels, diet quality and overweight rates in both children and adults (16, 39-41). Additionally, we applied multilevel regression analyses to allow variation in average HRQOL between children within a school and across schools to facilitate the interpretation of the results.

There are some limitations that should be addressed. Since participation in the survey was voluntary, selection bias may have existed due to potential different characteristics between the participants and the non-participants. As this study is based on a healthy sample of grade five students in Alberta, we do not systematically collect data on the diagnosed disease conditions, which limits us to examine the effect of various disease conditions on child HRQOL.

2.5 Conclusions

We demonstrated in this study that HRQOL of grade five students in Alberta varies considerably by residential area, parental educational attainment, household income and neighbourhood satisfaction/service. Our findings suggest that public health initiatives to improve equality and quality of life should take into account the influence of different socio-demographic and neighbourhood characteristics such that priority is given to towns, rural areas and neighbourhoods with poor access to services. We recommend that further research to examine the origin of high prevalence of health problems in the two EQ-5D-Y dimensions, pain or discomfort and worried, sad or unhappy. Future research is also recommended to extend similar investigation from the target population of this study to different age groups of youth in Canada and to assess how their HRQOL changes over time to address potential causal relations between HRQOL and the measured variables.

Table 2-1 Prevalence of problems on the EQ-5D-Y dimensions, mean EQ-5D-Y index and VAS scores by sociodemographic and neighbourhood variables

Variable	Percentage	Percentage of students reporting having problems with:					EQ-5D-Y index	EQ-5D-Y VAS
		Walking	Looking after myself	Usual activities	Pain or Discomfort	Worried, sad or unhappy	Mean (95% CI)	Mean (95% CI)
All grade five students	100.0	8.1	6.5	11.8	46.0	37.7	0.860 (0.855, 0.865)	80.5 (80.0, 81.1)
Gender						**P<0.001**		
Girls	51.4	8.0	5.8	13.0	45.8	44.2	0.855 (0.848, 0.862)	79.9 (79.1, 80.8)
Boys	48.6	8.3	7.3	10.7	46.3	30.9	0.866 (0.858, 0.873)	80.9 (80.0, 81.8)
Residential area				**P = 0.013**	**P = 0.014**			
Urban	47.3	7.1	7.2	10.1	43.6	37.2	0.871 (0.862, 0.880)	80.0 (78.9, 81.1)
Town	16.2	8.1	6.4	14.4	46.1	37.7	0.857 (0.847, 0.866)	80.3 (79.2, 81.4)
Rural	36.5	9.4	5.7	12.9	49.2	38.3	0.848 (0.840, 0.855)	81.0 (80.2, 81.8)
Parents' education								
Secondary or less	26.5	9.5	6.0	13.5	49.2	41.1	0.847 (0.837, 0.858)	79.1(77.8, 80.4)
College	40.0	8.2	6.1	11.6	46.6	37.7	0.857 (0.848, 0.865)	80.3 (79.3, 81.3)
University or above	33.5	6.7	7.2	10.9	42.7	34.9	0.873 (0.864, 0.883)	82.3 (81.2, 83.3)
Household income				**P<0.001**				
≤$50,000	23.4	8.0	5.2	13.2	45.0	39.4	0.857 (0.843, 0.871)	78.8 (77.0, 80.5)
$50,001 - $75,000	17.5	10.8	9.4	18.4	52.9	39.5	0.836 (0.818, 0.854)	78.4 (76.2, 80.5)
$75,001 - $100,000	22.2	6.9	7.5	11.3	48.6	36.7	0.862 (0.850, 0.874)	80.8 (79.2, 82.3)
>$100,000	36.9	6.6	5.3	9.8	43.8	35.4	0.868 (0.858, 0.878)	82.0 (80.9, 83.1)
Neighbourhood satisfaction/service				**P = 0.006**	**P = 0.007**	**P<0.001**		
Lowest one-third	--	9.7	7.3	14.0	49.2	42.4	0.845 (0.834, 0.855)	78.2 (76.9, 79.4)
Middle one-third	--	7.2	6.5	11.7	46.0	38.0	0.860 (0.850, 0.869)	81.2 (80.1, 82.3)
Highest one-third	--	7.0	5.8	9.0	41.5	32.2	0.878 (0.869, 0.887)	81.9 (80.8, 82.9)

Neighbourhood safety								
Lowest one-third	--	9.2	6.9	11.8	46.9	39.3	0.859 (0.850, 0.868)	80.0 (78.8, 81.2)
Middle one-third	--	7.6	6.5	12.0	42.6	35.1	0.867 (0.857, 0.876)	79.9 (78.8, 81.1)
Highest one-third	--	7.1	6.1	10.9	47.8	38.6	0.855 (0.845, 0.865)	81.4 (80.3, 82.5)
Neighbourhood sidewalks/parks		**P = 0.013**						
Lowest one-third	--	9.5	6.0	13.1	47.6	39.9	0.848 (0.838, 0.859)	79.6 (78.4, 80.8)
Middle one-third	--	8.8	5.7	12.2	46.0	37.0	0.863 (0.853, 0.872)	80.4 (79.3, 81.6)
Highest one-third	--	5.9	7.8	9.8	43.7	36.4	0.869 (0.859, 0.878)	81.0 (79.9, 82.2)

Table 2-2 Regression coefficients and confidence intervals of socio-demographic and neighbourhood characteristics for the EQ-5D-Y index and the EQ-5D-Y VAS

Variable	EQ-5D-Y Index		EQ-5D-Y VAS	
	Coefficient (95% CI)	**P value**	**Coefficient (95% CI)**	**P value**
Constant	0.840 (0.818, 0.863)	**< 0.001**	75.92 (72.85, 78.99)	**< 0.001**
Gender				
Boys relative to girls	0.010 (-0.001, 0.021)	0.077	0.56 (-0.91, 2.04)	0.453
Residential area				
Urban reference				
Town	-0.013 (-0.026, -0.001)	**0.041**	0.04 (-2.27, 2.34)	0.976
Rural	-0.018 (-0.031, -0.004)	**0.009**	1.72 (-0.38, 3.82)	0.108
Parents' education				
Reference: Secondary or below				
Community/Technical college	0.009 (-0.006, 0.024)	0.261	0.67 (-1.16, 2.50)	0.473
University or above	0.017 (0.002, 0.033)	**0.028**	2.12 (0.29, 3.96)	**0.023**
Household income				
Reference: < $50,000				
$50,001 - $75,000	-0.024 (-0.047, -0.001)	**0.043**	-0.77 (-3.81, 2.27)	0.619
$75,001 - $100,000	0.001 (-0.017, 0.019)	0.895	0.95 (-1.44, 3.35)	0.434
>$100,000	0.001 (-0.016, 0.019)	0.875	1.77 (-0.32, 3.86)	0.097
Neighbourhood satisfaction/service				
Reference: lowest one-third				
Middle one-third	0.015 (0.003, 0.027)	**0.013**	2.29 (0.63, 3.96)	**0.007**
Highest one-third	0.037 (0.021, 0.052)	**< 0.001**	2.69 (1.16, 4.22)	**0.001**
Neighbourhood safety				
Reference: lowest one-third				
Middle one-third	0.002 (-0.011, 0.016)	0.727	-1.11 (-3.01, 0.78)	0.249
Highest one-third	-0.012 (-0.028, 0.003)	0.126	-0.25 (-2.10, 1.61)	0.794
Neighbourhood sidewalks/parks				
Reference: lowest one-third				
Middle one-third	0.008 (-0.009, 0.025)	0.347	1.33 (-0.41, 3.07)	0.135
Highest one-third	0.000 (-0.016, 0.017)	0.960	0.53 (-1.11, 2.16)	0.527

2.6 References

(1) König HH, Bernert S, Angermeyer MC, Matschinger H, Martinez M, Vilagut G, Haro JM, de Girolamo G, de Graaf R, Kovess V, Alonso J; ESEMeD/MHEDEA 2000 Investigators. Comparison of population health status in six european countries: results of a representative survey using the EQ-5D questionnaire. *Med Care* 2009 Feb; 47(2): 255-261.

(2) Pappa E, Kontodimopoulos N, Papadopoulos AA, Niakas D. Assessing the socio-economic and demographic impact on health-related quality of life: evidence from Greece. *Int J Public Health* 2009; 54(4): 241-249.

(3) Robert SA, Cherepanov D, Palta M, Dunham NC, Feeny D, Fryback DG. Socioeconomic status and age variations in health-related quality of life: results from the national health measurement study. *J Gerontol B Psychol Sci Soc Sci*. 2009; 64(3): 378-389.

(4) Burström K, Johannesson M, Diderichsen F. Swedish population health-related quality of life results using the EQ-5D. *Qual Life Res.* 2001; 10(7): 621-635.

(5) Kind P, Dolan P, Gudex C, et al. Variations in population health status: results from a United Kingdom national questionnaire survey. *BMJ.* 1998; 316(7133): 736-741.

(6) Varni JW, Seid M, Smith Knight T, Burwinkle T, Brown J, Szer IS. The PedsQL in pediatric rheumatology: reliability, validity, and responsiveness of the Pediatric Quality of Life Inventory Generic Core Scales and Rheumatology Module. *Arthritis Rheum.* 2002; 46(3): 714-725.

(7) Williams J, Wake M, Hesketh K, Maher E, Waters E. Health-related quality of

life of overweight and obese children. *JAMA.* 2005; 293(1): 70-76.

(8) Willems DC, Joore MA, Nieman FH, Severens JL, Wouters EF, Hendriks JJ. Using EQ-5D in children with asthma, rheumatic disorders, diabetes, and speech/language and/or hearing disorders. *Int J Technol Assess Health Care* 2009; 25(3): 391-399.

(9) Stolk EA, Busschbach JJ, Vogels T. Performance of the EuroQol in children with imperforate anus. *Qual Life Res.*2000; 9(1): 29-38.

(10) Michel G, Bisegger C, Fuhr DC, Abel T; The KIDSCREEN group. Age and gender differences in health-related quality of life of children and adolescents in Europe: a multilevel analysis. *Qual Life Res.* 2009; 18(9): 1147-1157.

(11) Ravens-Sieberer U, Erhart M, Wille N, Bullinger M; BELLA study group. Health-related quality of life in children and adolescents in Germany: results of the BELLA study. *Eur Child Adolesc Psychiatry* 2008; 17 Suppl 1: 148-156.

(12) Bisegger C, Cloetta B, von Rueden U, Abel T, Ravens-Sieberer U; European Kidscreen Group. Health-related quality of life: gender differences in childhood and adolescence. *Soz Praventivmed.* 2005; 50(5): 281-291.

(13) von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. *J Epidemiol Community Health.* 2006; 60 (2): 130-135.

(14) Laaksonen C, Aromaa M, Heinonen OJ, Koivusilta L, Koski P, Suominen S, Vahlberg T, Salanterä S. Health related quality of life in 10-year-old schoolchildren. *Qual Life Res.* 2008; 17(8): 1049-1054.

(15) Felder-Puig R, Baumgartner M, Topf R, Gadner H, Formann AK. Health-related quality of life in Austrian elementary school children. *Med Care* 2008; 46(4): 432-439.

(16) Veugelers P, Sithole F, Zhang S, Muhajarine N. Neighborhood characteristics in relation to diet, physical activity and overweight of Canadian children. *Int J Pediatr Obes.* 2008; 3(3): 152-159.

(17) Mujahid MS, Diez Roux AV, Morenoff JD, Raghunathan TE, Cooper RS, Ni H, Shea S. Neighborhood characteristics and hypertension. *Epidemiology* 2008; 19(4): 590-598.

(18) Truong KD, Ma S. A systematic review of relations between neighborhoods and mental health. *J Ment Health Policy Econ.* 2006; 9(3): 137-154.

(19) EuroQol Group. EuroQol EQ-5D: A new facility for the measurement of health-related quality of life. *Health Policy* 1990; 19: 199-208.

(20) Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. *Ann Med.* 2001; 33(5): 337-343.

(21) Brooks R, EuroQol Group. EuroQol: The current state of play. *Health Policy.* 1996; 37(1): 53-72.

(22) Harrison MJ, Davies LM, Bansback NJ, Ingram M, Anis AH, Symmons DP. The validity and responsiveness of generic utility measures in rheumatoid arthritis: a review. *J Rheumatol.* 2008; 35(4): 592-602.

(23) Haywood KL, Garratt AM, Lall R, Smith JF, Lamb SE. EuroQol EQ-5D and condition-specific measures of health outcome in women with urinary incontinence: reliability, validity and responsiveness. *Qual Life Res.* 2008;

17(3): 475-483.

(24) Badia X, Schiaffino A, Alonso J, et al. Using the EuroQol 5D in the Catalan general population: feasibility and construct validity. *Qual Life Res.*1998; 7(4): 311–322.

(25) Bharmal M, Thomas J III. Comparing the EQ-5D and the SF-6D descriptive systems to assess their ceiling effects in the US general population. *Value Health* 2006 Jul-Aug; 9(4): 262-271.

(26) Johnson JA, Pickard AS. Comparison of the EQ-5D and SF-12 health surveys in a general population survey in Alberta, Canada. *Med Care* 2000; 38(1): 115-121.

(27) Johnson JA, Coons SJ. Comparison of the EQ-5D and SF-12 in an adult US sample. *Qual Life Res.* 1998; 7(2): 155-166.

(28) Macran S, Weatherly H, Kind P. Measuring population health: a comparison of three generic health status measures. *Med Care* 2003; 41(2): 218-231.

(29) Johnson JA, Luo N, Shaw JW, Kind P, Coons SJ. Valuations of EQ-5D health states: are the United States and United Kingdom different? *Med Care* 2005; 43(3): 221-228.

(30) Lubetkin EI, Jia H. Health-Related Quality of Life, Quality-Adjusted Life Years, and Quality-Adjusted Life Expectancy in New York City from 1995 to 2006. *J Urban Health* 2009; 86(4): 551-561.

(31) Simen-Kapeu A, Kuhle S, Veugelers PJ. Geographic differences in childhood overweight, physical activity, nutrition and neighborhood facilities: implications for prevention. *Can J Public Health* 2010; 101(2): 128-132.

(32) Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states: development and testing of the D1 valuation model. *Med Care 2005; 43*(3): 203-220.

(33) Wille N, Badia X, Bonsel G, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D. *Qual Life Res.* 2010; 19(6): 875-886.

(34) Ulrike Ravens-Sieberer, Nora Wille, Dipl.-Psych. MPH, et al. Feasibility, reliability and validity of the EQ-5D-Y – results from a multinational study. *Qual Life Res.* 2010; 19(6): 887-897.

(35) Prosser L, Hammit J, Keren R. Measuring health preferences for use in cost-utility and cost-benefit analyses of interventions in children. *Pharmacoeconomics.* 2007; 25(9): 713-726.

(36) Yen, I.H., Yelin, E.H., Katz, P., Eisner, M.D., Blanc, P.D. Perceived neighborhood problems and quality of life, physical functioning, and depressive symptoms among adults with asthma. *Am J Public Health* 2006; 96(5): 873-879.

(37) Yen IH, Yelin E, Katz P, Eisner MD, Blanc PD. Impact of perceived neighborhood problems on change in asthma-related health outcomes between baseline and follow-up. *Health Place* 2008; 14(3): 468-477.

(38) Poortinga W, Dunstan FD, Fone DL. Perceptions of the neighbourhood environment and self rated health: a multilevel analysis of the Caerphilly Health and Social Needs Study. *BMC Public Health* 2007; 7: 285.

(39) Boehmer TK, Hoehner CM, Deshpande AD, Brennan Ramirez LK, Brownson RC. (2007). Perceived and observed neighborhood indicators of obesity

among urban adults. *Int J Obes.* 2007; 31(6): 968-977.

(40) Timperio A, Salmon J, Telford A, Crawford D. Perceptions of local neighborhood environments and their relationship to childhood overweight and obesity. *Int J Obes*. 2005; 29(2): 170-175.

(41) Timperio A, Crawford D, Telford A, Salmon J. Perceptions about the local neighborhood and walking and cycling among children. *Prev Med.* 2004; 38(1): 39-47.

Chapter 3 – Diet Quality, Physical Activity, Body Weight and Health-Related Quality of Life Among Grade Five Students in Canada[2]

3.1 Introduction

Excess body weight has become a public health burden in both developing and developed countries (1). In Canada, 25.7% of children and adolescents were overweight or obese, and 8.6% were obese (2). Excess body weight has been widely acknowledged to contribute to various chronic diseases, resulting in diminished life expectancy (3-5). Overweight or obesity in children and adolescents has also negative consequences for self-esteem, psychosocial health and cognitive development (6-8).

Unhealthy diet, characterized by increased intake of fat and sugar and inadequate intake of fruits, vegetables, and whole grains (9), as well as insufficient physical activity (PA) have been identified as two fundamental factors leading to overweight and obesity (10-11). Most childhood obesity strategies therefore include the combination of promotion of healthy eating and active living (12-13). Such approaches have also been shown to benefit self-esteem and academic performance (6, 9, 13-14).

---

2 A version of this chapter has been accepted for publication. Wu X, Ohinmaa A, Veugelers PJ. *Public Health Nutrition.* 2011; Oct 4: 1-7. [Epub ahead of print]

The importance of excess body weight for impaired health-related quality of life (HRQOL) in children and adolescents has been documented in both clinical and population-based studies (15-22). However, only few studies have looked at the importance of the factors underlying excess body weight, being diet quality and PA, for HRQOL. And the few that were conducted were mostly among children and adolescents with chronic diseases or specific health conditions (19, 23-24). Very few studies on diet quality, PA, and weight status in relation to HRQOL in children used representative population-based samples (25-26). Though such studies are important to identifying the undesired dietary and activity patterns and to designing effective intervention strategies, no such studies have been conducted in Canada.

The purpose of the present study is therefore to establish the associations of diet quality, physical activity, and weight status with HRQOL among children in Canada.

3.2 Study Design and Methods

3.2.1 The Survey and Participants

The Raising Healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) survey was developed to evaluate Alberta Health and Wellness initiatives that promote healthy body weights among children and youth. The survey was conducted in 2008 among grade five students who are primarily 10 to 11 years old. The survey employed a one-stage stratified random sampling design. The sampling frame includes all elementary schools in the province with the exception of private schools (4.7% of all Alberta children), francophone schools (0.6%), on-reserve federal schools (2.0%), charter schools (1.7%), and colony schools (0.8%) (27), leaving primarily Public and Catholic schools in the sampling frame. Schools were stratified into three geographies: 1) urban: Calgary and Edmonton; 2) cities: other municipalities with more than 40,000 residents; and 3) rural: municipalities with less than 40,000 residents. Schools were randomly selected within each of these three strata to achieve a balanced number of schools and students in each stratum.

Of the 184 invited schools, 148 (80.4%) participated in the study. All grade five students (N=5,594) attending these schools received an envelope with a consent form and a survey to take home for their parent/guardian(s) to complete. A total of 3,645 students returned the forms and had received parental consent to participating in the study. In total, 3,421 students (61.2% of all students) completed the survey when trained assistants visited their schools to administer the surveys and to measure heights and weights. The surveys included questions on nutrition, physical activity, and HRQOL measured by the youth version of the EQ-5D (EQ-5D-Y) (28). The questionnaires, both for students and parents, are posted on www.REALKidsAlberta.ca.

3.2.2 Measurement and Assessments

3.2.2.1 Diet Quality Assessment

The Harvard Food Frequency Questionnaire for Youth and Adolescents (YAQ) is a validated food frequency instrument that is suitable for grade five students (29-30). The YAQ provides detailed information on the frequency and kinds of foods that children and youth consume (29). On the basis of students' responses to the YAQ and Canadian Nutrient Files (31), we calculated intakes of nutrient and energy for each participant. We subsequently calculated the Diet Quality Index (DQI-I), which is a diet quality composite measure that encompasses variety, adequacy, moderation, and overall balance of diet (32). We divided the DQI scores into tertiles for the purpose of our analysis.

3.2.2.2 Physical Activity Assessment

Students and their parent/guardian(s) responded to questions on: 1) travel to and from school; 2) time spent to get to and from school; 3) frequency of child's activities outside of school hours; 4) activities at morning and lunch recess in the past seven days; and 5) frequency of involvement in sports and physical activities in the past seven days. These questions, containing 29 items, were largely adopted from the Physical Activity Questionnaire for Children (PAQ-C) which has been demonstrated to be valid and have high reliability (33-34). We derived a composite score ranging from 0 to 5 based on the score given to the 29 items.

3.2.2.3 Weight Assessment

Standing height was measured to the nearest 0.1 cm without shoes and body weight to the nearest 0.1 kg on calibrated digital scales. Body mass index (BMI) was calculated by dividing weight (in kilograms) by height (in meters) squared. Body weight was categorized as normal weight, overweight and obese using the

BMI cut-off points for children and youth by the International Obesity Task Force (35). These cut-offs are based on adult definitions of overweight (25 kg/m^2 or more) and obesity (30 kg/m^2 or more), adjusted to specific age and gender groups for children.

3.2.2.4 Measurement of Health-related Quality of Life

HRQOL was assessed by the EQ-5D-Y (youth) where the language of the EQ-5D instrument for adults is modified so that children can better understand it. The HRQOL instrument consists of a five-dimensional descriptive system asking whether children have 1) no problems; 2) some problems; or 3) a lot of problems with 1) walking; 2) looking after myself; 3) doing usual activities; 4) having pain or discomfort; and 5) feeling worried, sad or unhappy, respectively (28). The instrument also includes a Visual Analogue Scale (VAS) which is anchored at 100 (best imaginable health) and 0 (worst imaginable health) to capture self-rated values of health status in children. The EQ-5D-Y has been validated for several languages and countries (36). The main advantages of the instrument are that it is short and simple, and can be completed within 10 minutes by children, and it can be used to estimate a single index score to be analyzed subsequently in economic evaluation studies (28).

3.2.3 Analytical methods

We applied chi-square tests to examine differences in the prevalence of reported health problems for each of the five EQ-5D-Y dimensions by the observed predictors. As very few students reported ‘a lot of problems’, we combined this with ‘some problems’ to create a dichotomous outcome (no problems vs. with any problems). We described generic HRQOL by different groups of diet quality, physical activity and weight status as measured by the EQ-5D-Y VAS score. We applied multilevel multivariable linear regression to assess the association of diet quality, physical activity, body weight with the generic HRQOL. We applied multilevel multivariable logistic regression to examine the effect of diet quality, physical activity and body weight for the EQ-5D-Y dimensions. These regression models accommodate hierarchical data structure in that student observations are nested within their schools. The regression analyses were adjusted for the confounding influence of gender, place of residence, household income and parental education.

The EQ-5D-Y descriptive system was fully completed by 3,406 students (99.6 %) and 3,379 students (98.8 %) answered the VAS. These missing outcomes were not considered in the analyses. Of all participating students, 3,340 parents completed a survey on educational attainment, household income, place of residency (urban, town, rural), and their children’s physical activity. Missing values for education and income were considered as separate categories in the analysis but the estimates are not presented. All analyses were weighted to accommodate the design effect such that all estimates pertain to the population of grade five students in Alberta. Data were analyzed using STATA 11.0 (Stata Corp, College Station, TX, USA). The study program was approved by Health Research Ethics Board of the University of Alberta.

3.3 Results

Students who were physically inactive reported significantly more HRQOL problems relative to their peers who were physically active on four of the five dimensions: ‘looking after myself’, ‘doing usual activities’, ‘having pain or discomfort’, and ‘feeling worried, sad or unhappy’. Compared with the normal weight group, obese students had significantly more HRQOL problems on the ‘looking after myself’, and ‘feeling worried, sad or unhappy’. And across diet quality tertiles, statistically significant differences were reported with respect to ‘having pain or discomfort’ (table 3-1). Mean HRQOL scores for students with highest one-third of diet quality, physically active lifestyle, and with healthy weight were 82.2, 84.2, and 81.5, respectively (table 3-1).

Table 3-2 shows multivariate adjusted associations of HRQOL with diet quality, physical activity, and body weight status. The VAS value was statistically significant higher for students who were physically active, normal weight and in the highest DQI tertile relative to students who were not physically active, overweight or obese and in the lowest DQI tertile.

Table 3-3 presents the adjusted odds ratio of reporting problems on the EQ-5D-Y dimensions. Diet quality, body weight status and physical activity significantly affect one, two and four of the five dimensions, respectively, after accounting for the effect of socio-demographic variables. The results are very much similar to those unadjusted results in table 3-1.

3.4 Discussion

This study reveals that diet quality, physical activity, and body weight are associated with HRQOL in grade five students. These associations were independent gender and socio-demographic factors. The study further reveals an association of diet quality with the VAS score whereby children with better diet quality reported better HRQOL. Students who were physically inactive, overweight or obese had reportedly a lower HRQOL.

The relationship between physical activity and HRQOL has been well described in adults relative to younger populations. An association of higher HRQOL scores with higher physical activity levels has been consistently documented in healthy adults (38). Our observations that physically active children have significantly higher HRQOL scores than those in the inactive group support the previous findings in both adult (38) and in the few children and adolescents studies (25-26, 39-40). A systematic review of HRQOL among children and adolescents reported that excess body weight had a moderate to strong negative influence on HRQOL, whereas the role of psychosocial, emotional and school functioning on HRQOL had been inconsistent (41). Our observation in a large population based sample of grade five students confirms this relationship of excess body weight with lower quality of life. We also showed that children from parents who received less education had lower quality of life. Identifying determinants for different aspects of the HRQOL is essential to developing public health intervention strategies and targets. This study revealed that physical activity has a significant impact on each of the five EQ-5D-Y dimensions except ‘walking’. This is consistent with the few previous studies that have demonstrated that physically active children exhibit better physical and psychological quality of life (26), better self-esteem (42), and better psychosocial quality of life (19, 42). We observed that overweight and obese children were reportedly more worried, sad or unhappy which seems consistent with HRQOL studies reporting that obesity is associated with impaired psychosocial functioning (17-18, 21-22), lower physical functioning (41) lower emotional functioning (16, 22), and lower self-esteem (17, 22).

Relative to studies in other countries using the EQ-5D-Y, children in Alberta reported higher prevalence of health problems in the dimension of pain or discomfort (46.0%). The high percentage of any health problems in pain or discomfort (43.6%) was also presented in a general population sample of adults in Alberta using the EQ-5D (43). A possible explanation for this finding in our study may be that response to the EQ-5D-Y descriptive system could be culturally different across different countries or in geographic areas within a country. Further analysis using the EQ-5D-Y in other provinces in Canada and in other countries may help to ascertain the origin of this finding.

In addition, it is also important to examine the magnitude of the difference is to estimate minimally important differences (MIDs) in HRQOL scores between comparison groups (44). MIDs for the EQ-5D index and the EQ-5D VAS have been previously estimated for some disease conditions (45-46). We have not identified any study demonstrating a MID value for the EQ-5D-Y VAS or index. Estimation of MIDs in HRQOL scores requires a variety of approaches, both distribution-based and anchor-based (47), and a rigorous examination of various factors that may affect the degree of minimal differences (48). Future research is warranted to investigate the magnitude and direction of differences/changes in HRQOL to establish MID cut-points for the EQ-5D-Y for the general population of child and youth.

In the present study, we did not estimate an index score for EQ-5D-Y as we were interested in quality of life that was measured and described by children themselves. Since no EQ-5D-Y tariff is available for use in younger population, several previous studies in quality of life assessment in children and youth using the EQ-5D or EQ-5D-Y have reported on utility indexes generated from the existing US or UK EQ-5D tariffs (37, 49). There is a debate about the applicability of the existing social tariffs for adults to children (36). Current research interest in the field is to establish a child-specific value set for the EQ-5D-Y for use in population health research and economic evaluation studies (36).

This is the first study to reveal the associations of diet quality, physical activity, and body weight with HRQOL among preteen children. Specifically, this study contributes to the evidence of positive associations between diet quality, physical activity and HRQOL in school children, independently of weight status and socio-demographic characteristics. These findings suggest that school-based programs promoting healthy eating and active living may not only help to prevent children from becoming overweight, but may also benefit their HRQOL regardless of weight status. The differences in HRQOL outcomes by diet quality specifically suggest the importance of nutrition programs focusing on improving diet quality among children in the development of school health promotion. One Canadian study has shown that nutrition programs that are based on comprehensive school health exhibit a greater positive effect on students' diets, physical activity and overweight reduction than a single nutrition program (13). More research is needed to examine whether such comprehensive school health approaches that integrate nutrition education, nutrition policy, healthy food services, environmental support and various physical activity strategies into a whole school model will result in an improvement of HRQOL among children. This may justify broader investments in school programs to the benefits of health and quality of life among children (13, 50).

Major strengths of this study include the use of a large population-based sample of students, the use of objective measurement of height and weight, the adjustment for socio-demographic factors in the analysis, the use of a validated generic multidimensional HRQOL measure for children, and the application of multilevel regression to account for hierarchical data structure and with weighted analysis to accommodate the survey design effect.

Limitations of this study should also be clarified. The observed associations of diet quality, physical activity, and body weight with HRQOL could not be inferred as causality based on the cross-sectional survey design. Since participation in the survey is voluntary, selection bias may have occurred due to possible differences in characteristics between the participants and the non-participants. Our study was conducted in a sample of grade five students, which limits the generalizability of the results to other age groups of children. Physical activity and diet assessments in the current study were based on measurement of self-report, and may have been affected by measurement error. The use of objective measures of physical activity (e.g. pedometers) would allow for more accurate evaluation of physical activity of students, although this may pose challenges in financial and resource support in large scale population-based studies (51).

3.5 Conclusions

This study demonstrated the importance of diet quality, physical activity and body weight status for health-related quality of life which will help justify broader implementation of school health programs that promote healthy eating and active living, as these programs will help reduce the burden of childhood obesity and improve quality of life.

Table 3-1 Prevalence of problems in the EQ-5D-Y dimensions, and mean VAS by diet quality, physical activity and weight status

Variable	Percentage (n=3421)	Percentage of students reporting having problems with:					VAS scores
		Walking	Looking after myself	Doing usual activities	Having pain or discomfort	Feeling worried, sad or unhappy	Mean (95% CI)
All grade five students	100.0	8.1	6.5	11.9	46.1	37.7	80.4 (79.8, 81.1)
DQI		P = 0.894	P = 0.698	P = 0.274	P = 0.049	P = 0.388	
Lowest one-third	--	8.4	7.0	13.1	49.2	39.4	78.5 (77.4, 79.5)
Middle one-third	--	8.2	6.4	11.7	43.6	36.4	80.5 (79.4, 81.6)
Highest one-third	--	7.8	6.0	10.8	45.6	37.3	82.2 (81.1, 83.2)
Physical activity		P = 0.112	**P = 0.005**	**P<0.001**	**P = 0.003**	**P<0.001**	
Not active	73.9	8.6	7.3	13.4	47.7	39.9	79.1 (78.3, 79.8)
Active	26.1	6.8	4.4	7.6	41.5	31.4	84.2 (83.1, 85.2)
Weight category		P = 0.146	**P = 0.009**	P = 0.170	P = 0.440	**P = 0.035**	
Obese	7.0	10.8	11.7	15.8	49.8	46.0	75.4 (73.1, 77.8)
Overweight (excluding obese)	21.7	9.2	6.3	12.2	47.1	38.3	78.5 (77.1, 79.9)
Normal weight	71.3	7.6	6.1	11.4	45.5	36.7	81.5 (80.8, 82.2)

Note: The EQ-5D-Y-VAS score, ranged 0-100 where 100 is best imaginable health.
Chi-square tests were used to obtain the p values where weighted percentages of students with problems in different dimensions are presented.
CI-confidence interval; DQI-diet quality index.

Table 3-2 Associations of diet quality, physical activity, and body weight status with the VAS

Variable	Regression coefficient (95% CI)	P value
Constant	75.97 (73.43, 78.52)	<0.001
DQI (reference: lowest one-third)		
Middle one-third	1.47 (-0.22, 3.15)	0.088
Highest one-third	2.76 (1.26, 4.26)	**<0.001**
Physical activity (reference: not active)		
Active	4.49 (2.98, 6.00)	**<0.001**
Weight status (reference: normal weight)		
Overweight (excluding obese)	-2.48 (-4.00, -0.96)	**0.001**
Obese	-5.39 (-7.64, -3.13)	**<0.001**
Gender (boys relative to girls)	0.47 (-0.96, 1.90)	0.517
Residential area (reference: urban)		
Town	0.22 (-1.95, 2.40)	0.840
Rural	1.45 (-0.28, 3.19)	0.100
Parents' education (reference: secondary or below)		
Postsecondary or college	1.18 (-0.41, 2.76)	0.147
University or above	2.42 (0.76, 4.09)	**0.004**
Household income (reference: ≤$50,000)		
$50,001 - $75,000	-0.84 (-3.45, 1.76)	0.524
$75,001 - $100,000	0.80 (-1.33, 2.92)	0.462
>$100,000	1.41 (-0.46, 3.28)	0.139

Note: The EQ-5D-Y-VAS score ranged 0-100 where 100 is best imaginable health.
CI-confidence interval; DQI-diet quality index.
The regression analysis was mutually adjusted for variables in the table.
All estimates were weighted to represent population estimates.

Table 3-3 Odds ratios of reporting problems in the EQ-5D-Y dimensions by diet quality, physical activity, weight status and socio-demographic factors

Variable	Walking		Looking after myself		Doing usual activities		Having pain or discomfort		Feeling worried, sad or unhappy	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
DQI (reference: lowest one-third)										
Middle one-third	1.01 (0.70, 1.46)	0.941	0.94 (0.67, 1.31)	0.710	0.92 (0.70, 1.21)	0.538	0.81 (0.68, 0.98)	**0.026**	0.88 (0.73, 1.07)	0.193
Highest one-third	0.98 (0.68, 1.41)	0.918	0.89 (0.63, 1.25)	0.495	0.84 (0.63, 1.12)	0.234	0.90 (0.75, 1.08)	0.254	0.92 (0.77, 1.11)	0.393
Physical activity (reference: active)										
Not active	1.29 (0.92, 1.81)	0.140	1.71 (1.21, 2.43)	**0.002**	1.82 (1.37, 2.42)	**<0.001**	1.29 (1.06, 1.58)	**0.012**	1.31 (1.11, 1.54)	**0.001**
Weight category (reference: normal weight)										
Overweight	1.20 (0.90, 1.59)	0.210	1.04 (0.70, 1.53)	0.860	1.02 (0.79, 1.31)	0.901	1.04 (0.84, 1.28)	0.735	1.04 (0.87, 1.26)	0.654
Obesity	1.38 (0.91, 2.07)	0.128	2.05 (1.20, 3.50)	**0.009**	1.34 (0.94, 1.91)	0.104	1.11 (0.82, 1.50)	0.499	1.47 (1.10, 1.98)	**0.010**
Gender (Boys relative to girls)	1.07 (0.81, 1.41)	0.633	1.36 (1.02, 1.82)	**0.038**	0.85 (0.66, 1.10)	0.219	1.05 (0.91, 1.22)	0.493	0.57 (0.48, 0.67)	**<0.001**
Residential area (reference: urban)										
Town	1.18 (0.87, 1.61)	0.297	0.92 (0.59, 1.43)	0.702	1.61 (1.22, 2.13)	**0.001**	1.11 (0.93, 1.33)	0.256	1.00 (0.80, 1.24)	0.968
Rural	1.33 (0.99, 1.77)	0.055	0.78 (0.54, 1.13)	0.197	1.37 (1.03, 1.82)	**0.031**	1.22 (1.04, 1.43)	**0.013**	1.05 (0.86, 1.28)	0.661
Parents' education (reference: secondary or below)										
Postsecondary or college	0.88 (0.65, 1.18)	0.396	0.97 (0.68, 1.39)	0.860	0.84 (0.64, 1.12)	0.234	0.89 (0.75, 1.06)	0.179	0.86 (0.70, 1.04)	0.124
University or above	0.76 (0.52, 1.11)	0.150	1.19 (0.77, 1.81)	0.434	0.90 (0.66, 1.23)	0.509	0.79 (0.65, 0.97)	**0.025**	0.80 (0.66, 0.97)	**0.026**
Household income (reference: ≤$50,000)										
$50,001 - $75,000	1.43 (0.91, 2.23)	0.120	1.88 (1.10, 3.20)	**0.021**	1.41 (0.95, 2.10)	0.090	1.39 (1.06, 1.83)	**0.017**	0.99 (0.73, 1.34)	0.962
$75,001 - $100,000	0.89 (0.57, 1.40)	0.618	1.55 (0.89, 2.70)	0.120	0.81 (0.53, 1.23)	0.321	1.18 (0.92, 1.50)	0.189	0.91 (0.69, 1.22)	0.539
>$100,000	0.89 (0.57, 1.37)	0.588	1.08 (0.63, 1.85)	0.769	0.73 (0.51, 1.03)	0.073	1.03 (0.84, 1.27)	0.781	0.90 (0.69, 1.16)	0.409

Note: OR-odds ratio; CI-confidence interval; DQI-diet quality index.
All analyses were mutually adjusted for variables in the table. All estimates were weighted to represent population estimates.

3.6 References

(1) Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360(9331): 473-482.

(2) Statistics Canada. Canadian Health Measures Survey: Cycle 1 Data Tables, 2007 to 2009. 2010; 82-623-X. [http://www.statcan.gc.ca/pub/82-623-x/82-623-x2010002-eng.pdf]. (Accessed July 18, 2011).

(3) Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes (Lond)* 2011 Jul; 35(7): 891-898.

(4) Choudhary AK, Donnelly LF, Racadio JM, Strife JL. Diseases associated with childhood obesity. *AJR Am J Roentgenol*. 2007; 188(4):1118-1130.

(5) Ball GD, McCargar LJ. Childhood obesity in Canada: a review of prevalence estimates and risk factors for cardiovascular diseases and type 2 diabetes. *Can J Appl Physio*.2003; 28(1): 117-140.

(6) Wang F, Veugelers PJ. Self-esteem and cognitive development in the era of the childhood obesity epidemic. *Obesity Rev.* 2008; 9 (6): 615-623.

(7) Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD. Social, educational, and psychological correlates of weight status in adolescents. *Obes Res.* 2001; 9(1): 32-42.

(8) Li Y, Dai Q, Jackson JC, Zhang J. Overweight is associated with decreased cognitive functioning among school-age children and adolescents. *Obesity* 2008; 16(8): 1809-1815.

(9) Florence MD, Asbridge M, Veugelers PJ. Diet quality and academic performance. *J Sch Health* 2008; 78(4): 209-15; quiz 239-241.

(10) Swinburn BA, Caterson I, Seidell JC, James WP. Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutr.* 2004 Feb; 7(1A): 123-146.

(11) Janssen I, Katzmarzyk PT, Boyce WF, Vereecken C, Mulvihill C, Roberts C, Currie C, Pickett W; Health Behaviour in School-Aged Children Obesity Working Group. Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obes Rev.* 2005; 6(2): 123-132.

(12) Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev.* 2009; 10(1): 110-141.

(13) Veugelers, PJ, Fitzgerald AL. Effectiveness of school programs in preventing childhood obesity: a multilevel comparison. *Am J Public Health* 2005; 95(3): 432-435.

(14) Rampersaud GC, Pereira MA, Girard BL, Adams J, Metzl JD. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc.* 2005; 105(5): 743-760; quiz 761-762.

(15) Ravens-Sieberer U, Gosch A, Abel T, Auquier P, Bellach BM, Bruil J, Dür W, Power M, Rajmil L; European KIDSCREEN Group. Quality of life in children and adolescents: a European public health perspective. *Soz Praventivmed.* 2001; 46(5): 294-302.

(16) Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA.* 2003; 289(14): 1813-1819.

(17) Friedlander SL, Larkin EK, Rosen CL, Palermo TM, Redline S. Decreased quality of life associated with obesity in school-aged children. *Archives of Pediatrics & Adolescent Medicine* 2003; 157(12): 1206-1211.

(18) Williams J, Wake M, Hesketh K, Maher E, Waters E. Health-related quality of life of overweight and obese children. *JAMA*. 2005; 293(1): 70-76.

(19) Shoup JA, Gattshall M, Dandamudi P, Estabrooks P. Physical activity, quality of life, and weight status in overweight children. *Qual Life Res.* 2008; 17(3): 407-412.

(20) Pinhas-Hamiel O, Singer S, Pilpel N, Fradkin A, Modan D, Reichman B. Health-related quality of life among children and adolescents, associations with obesity. *Int. Journal of Obesity.* 2006; 30(2): 267-272.

(21) Varni JW, Limbers CA, Burwinkle TM. Impaired health-related quality of life in children and adolescents with chronic conditions: a comparative analysis of 10 disease clusters and 33 disease categories/severities utilizing the PedsQL 4.0 Generic Core Scales. *Health Qual Life Outcomes* 2007; Jul 16; 5: 43.

(22) Swallen KC, Reither EN, Haas SA, Meier AM. Overweight, obesity, and health-related quality of life among adolescents, the National Longitudinal Study of Adolescent Health. *Pediatrics* 2005; 115(2): 340-347.

(23) Yackobovitch-Gavan M, Nagelberg N, Phillip M, Ashkenazi-Hoffnung L, Hershkovitz E, Shalitin S. The influence of diet and/or exercise and parental compliance on health-related quality of life in obese children. *Nutr Res.* 2009; 29(6): 397-404.

(24) Hamiwka LA, Cantell M, Crawford S, Clark CG. Physical activity and health related quality of life in children following kidney transplantation. *Pediatr Transplant* 2009; 13(7): 861-867.

(25) Chen X, Sekine M, Hamanishi S, Yamagami T, Kagamimori S. Associations of lifestyle factors with quality of life (QOL) in Japanese children, a 3-year follow-up of the Toyama Birth Cohort Study. *Child Care Health Dev.* 2005; 31(4): 433-439.

(26) Chen X, Sekine M, Hamanishi S, Wang H, Gaina A, Yamagami T, Kagamimori S. Lifestyles and health-related quality of life in Japanese school children: a cross-sectional study. *Prev Med.* 2005 Jun; 40 (6): 668-678.

(27) Alberta Education. Student Population by Grade, School and Authority, Alberta 2006/2007 School Year. [http://education.alberta.ca/apps/eireports/pdf_files/eis1004_2007/eis1004_2007.pdf]. (Last accessed July 16, 2011)

(28) Wille N, Badia X, Bonsel G., Burstrom K, Cavrini G., Devlin N, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D.Qual *Life Res.* 2010; 9(6): 875-886.

(29) Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J Am Diet Assoc.* 1995; 93(3): 336-340.

(30) Rockett HR, Breitenbach M, Frazier AL, Witschi J, Wolf AM, Field AE, Colditz GA. Validation of a youth/adolescent food frequency questionnaire. *Prev Med.* 1997; 26(6): 808-816.

(31) Health Canada: Canadian Nutrient File (CNF). 2007. [http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/index-eng.php]. (Last accessed July 16, 2011).

(32) Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. *J Nutr.* 2003; 133(11): 3476-3484.

(33) Crocker PR, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Med Sci Sports Exerc.* 1997; 29(10): 1344-1349.

(34) Kowalski KC, Crocker PR, Faulkner RA. Validation of the physical activity questionnaire for older children. *Pediatric Exercise Science* 1997; 9: 174–186.

(35) Cole, T.J., Bellizzi, M.C., Flegal, K.M., Dietz, W.H. Establishing a standard definition for child overweight and obesity worldwide, international survey. *BMJ.* 2000; 320(7244): 1240-1243.

(36) Ravens-Sieberer U, Wille N, Badia X, Bonsel G, Burström K, Cavrini G, Devlin N, Egmar AC, Gusi N, Herdman M, Jelsma J, Kind P, Olivares PR, Scalone L, Greiner W. Feasibility, reliability and validity of the EQ-5D-Y: results from a multinational study. *Qual Life Res.* 2010; 19(6): 887-897.

(37) Wu XY, Ohinmaa A, Veugelers PJ. Sociodemographic and neighbourhood determinants of health-related quality of life among grade-five students in Canada. *Qual Life Res.* 2010; 19(7): 969-976.

(38) Bize R, Johnson JA, Plotnikoff RC. Physical activity level and health-related

quality of life in the general adult population: a systematic review. *Prev Med.* 2007; 45(6): 401-415.

(39) Sánchez-López M, Salcedo-Aguilar F, Solera-Martínez M, Moya-Martínez P, Notario-Pacheco B, Martínez-Vizcaíno V. Physical activity and quality of life in schoolchildren aged 11-13 years of Cuenca, Spain. *Scand J Med Sci Sports* 2009; 19(6): 879-884.

(40) Boyle SE, Jones GL, Walters SJ. Physical activity, quality of life, weight status and diet in adolescents. *Qual Life Res.* 2010; 19(7): 943-954.

(41) Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, Hills AP, Howe PR, Coates AM. Health-related quality of life in obese children and adolescents. *Int J Obes (Lond).* 2009; 33(4): 387-400.

(42) Strauss RS, Rodzilsky D, Burack G., Colin M. Psychosocial correlates of physical activity in healthy children. *Arch Pediatr Adolesc Med.* 2001; 155(8): 897-902.

(43) Johnson JA, Pickard AS. Comparison of the EQ-5D and SF-12 health surveys in a general population survey in Alberta, Canada. *Med Care* 2000; 38(1): 115–121.

(44) Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials* 1989; 10(4): 407-415.

(45) Pickard AS, Neary MP, Cella D. Estimation of minimally important differences in EQ-5D utility and VAS scores in cancer. *Health Qual Life Outcomes* 2007; 5: 70.

(46) Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res.* 2005; 14(6): 1523-1532.

(47) Lydick E, Epstein RS. Interpretation of quality of life changes. *Qual Life Res.* 1993 Jun; 2(3): 221-226.

(48) Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care* 2003; 41(5): 582-592.

(49) Willems DC, Joore MA, Nieman FH, Severens JL, Wouters EF, Hendriks JJ. Using EQ-5D in children with asthma, rheumatic disorders, diabetes, and speech/language and/or hearing disorders. *Int J Technol Assess Health Care* 2009; 25(3): 391-399.

(50) Deschesnes M, Martin C, Hill AJ. Comprehensive approaches to school health promotion: how to achieve broader implementation? *Health Promot Int.* 2003; 8(4): 387-396.

(51) Simen-Kapeu A, Veugelers PJ. Should public health interventions aimed at reducing childhood overweight and obesity be gender-focused? *BMC Public Health* 2010; 10: 340.

Chapter 4 – Assessment of Children's own Health Status Using Visual Analogue Scale and Descriptive System of the EQ-5D-Y: Linkage Between Two Systems

4.1 Introduction

Economic evaluations have been increasingly used in assessing and comparing the cost and effectiveness of various childhood intervention programs in both clinical and public health settings. One form of such evaluation approaches is cost-utility analysis in which the quality-adjusted life-years (QALYs) gained is commonly used as the outcome measure to accommodate quantity and quality of life (1). In the QALY approach, health-related quality of life (HRQOL) is typically measured with a single index health utility or preference instrument that combines the descriptive system and the utility values attached for each health state in the instrument.

QALY indexes can be derived either by a direct valuation method that uses techniques such as the time trade-off (TTO), the standard gamble (SG), or the visual analogue scale (VAS) to value patients or subjects own health states (2), or by an indirect valuation method (1). The indirect valuation approach uses the same techniques to value hypothetical health states that are usually described by a standardized multi-attribute HRQOL instrument. Population preferences for the different health states of the instrument are then estimated using a scoring algorithm linked to the multi-attribute HRQOL questionnaire (3-4). One broadly used preference-based instrument that utilizes a summary index score for use in health economic evaluations is the EQ-5D (5). Various country-specific value sets for the EQ-5D have been established using both TTO and VAS valuations (3, 6-14). To the best of my knowledge, no value set for the EQ-5D is available for Canadian population.

Recently, the EuroQol group developed a new instrument that is suitable for children between 8 and 18 years by revising the standard version of EQ-5D (15). The instrument, named the EQ-5D-Y (youth), has been validated in several European countries, and South Africa (16-17). Relative to valuation of the adult EQ-5D, there is disagreement about what type of HRQOL values should be used among children. To date, no existing value set for the EQ-5D-Y has been developed. There is an increasing need to establish a specific preference value set for the new EQ-5D-Y instrument considering that its wording differs from the EQ-5D instrument (15).

The aim of this study is to derive a value set for the EQ-5D-Y based on children's own assessment of their health status with a VAS and with a descriptive system. A secondary aim is to assess the psychometric properties of the VAS-based EQ-5D-Y index.

4.2 Study Methods

4.2.1 The Survey

The Raising Healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) surveys were conducted to evaluate a provincial initiative aimed to promote healthy body weights among children and youth. The survey utilized a single-stage stratified random sampling design among grade five students, aged primarily 10 to 11 years, and their parents. The design and results of the survey were reported elsewhere (18-19), and can be found at REALKidsAlberta website (www.REALKidsAlberta.ca). Students completed the EQ-5D-Y at school, where a study assistant explained the survey instruments to the children prior to their completion of the survey. Parents responded to questions on educational attainment, household income, and place of residency (urban, town, rural). In this study, we report on data collected in 2008 and 2010.

Parent consent and student consent for participation were obtained before conducting the survey. The study was approved by Health Research Ethics Board of the University of Alberta.

4.2.2 The Instrument

The standard EQ-5D-Y consists of a descriptive system that includes five dimensions: 1) walking; 2) looking after myself; 3) doing usual activities; 4) having pain or discomfort; and 5) feeling worried, sad or unhappy. Each dimension has three levels, representing severity: no problems; some problems; and a lot of problems. Similar to the adult version of EQ-5D, the five dimensional EQ-5D-Y descriptive system classifies 243 (3^5) health states. The instrument also includes a Visual Analogue Scale (VAS) which is anchored at 100 (best imaginable health) and 0 (worst imaginable health) to represent the overall health status rated by the subject (15).

4.2.3 Statistical Analysis

4.2.3.1 Sample Splitting

We randomly split the full sample into two equally-sized subsamples by generating random number of 0 and 1. One half sample was used as modeling sample. Here we applied regression analyses to estimate parameters that predict VAS values and to produce a VAS index. The other half was used as validation sample. Here we applied the estimated parameters from the modeling sample to compute goodness-of-fit statistics.

4.2.3.2 Modeling of the EQ-5D-Y VAS Index

To obtain the health state value, multilevel regression was used to linearly impute VAS scores for all possible states described in the EQ-5D-Y. Multilevel regression methods accommodated the clustered data, in that individual observations were nested within their schools. The self-assessed VAS (dependent variable) values were regressed on the five dimensions (independent variables) of the EQ-5D-Y descriptive system. As each dimension consists of three levels, two dichotomous dummy variables were generated within each dimension to represent either the movement from response level 1 (no problem) to response level 2 (some problems) or to response level 3 (a lot of problems). The regression model used to estimate the VAS score is defined as follows:

$$VASscore=\beta_0+\beta_1 WK2+\beta_2 WK3+\beta_3 LS2+\beta_4 LS3+\beta_5 UA2+\beta_6 UA3+\beta_7 PD2+\beta_8 PD3+\beta_9 WS2+\beta_{10} WS3$$

In the equation, WK2, LS2, UA2, PD2 and WS2 were the 5 dummy variables representing the health state shifts away from response level 1 to response level 2 in each of the five dimensions (Walking-WK; Looking after myself-LS; Doing usual activities-UA; Having pain/discomfort-PD; Feeling worried, sad or unhappy- WS). For example, WK2 takes the value 1 whenever the student reported having some problems in walking, and the value 0 otherwise. Similarly, WK3, LS3, UA3, PD3 and WS3 indicated health state shifts away from level 1 to level 3 in each dimension. The coefficient β_0 represents the overall mean VAS score for the best health status (state 11111) when the value of all other variables in the model equals zero, and the coefficients β_1-β_{10} represent the decrement in the mean VAS score relative to β_0 within each dimension.

In the model, we require that response level 3 states would show equal or lower VAS scores than that for level 2, that is, the model should be logically consistent. Wherever the coefficient for level 3 in a dimension did not show statistically significant difference ($p>0.05$), an alternative model (named estimation model) was constructed, where levels 2 and 3 responses in that particular dimension were combined into a single response level. The VAS values for the EQ-5D-Y health states that were not observed in the sample were then computed using the estimated equation. Interaction terms between dimensions were not considered as the number of students with multiple problems in the EQ-5D-Y was low.

The estimated VAS scores took a scale between 0-100. To produce a VAS-based index value, the predicted VAS score was transformed to 0-1 scale by the following formula: Index X= (ESX–ES33333)/(ES11111–ES33333), where Index X indicates the adjusted VAS-based index value for state X, ESX represents the estimated VAS score given to state X, ES11111 and ES33333 represents the estimated VAS score given to state 11111 and state 33333, respectively. As such, an index value of 1 represents ‘perfect health’ and 0 represents ‘worst health’.

4.2.3.3 Validation of the Model

The estimated VAS score was compared with the observed VAS value for the health states before rescaling the VAS values to obtain the index. Paired t-test was used to examine differences between estimated and observed VAS scores. Previous studies for the EQ-5D utilities suggested that a score of 0.07 was considered a minimally important difference (MID) between groups (20).

The scoring algorithm that was based on the parameter estimates from the modeling sample was then applied to the validation sample to estimate VAS values based on students’ responses. Goodness of fit statistics were subsequently computed respectively for the validation sample and modeling sample. Goodness of fit statistics included: (1) The Pearson's correlation coefficient between the observed and estimated VAS values for all states in the modeling sample and validation sample; The Pearson's correlation coefficient between the observed and estimated VAS values for the most frequent observed states (95% of the respondents) in the modeling sample and validation sample. (2) Mean absolute error (MAE) of predicting VAS for all the observed health states and for the most frequent observed states (95% of the respondents) among modeling sample and validation sample. The smaller the MAE, the better fit of the model.

Multilevel linear regression was applied to estimate the association between the index and socio-demographic variables including students’ gender, residential area, parental educational attainment and household income. The VAS-based index was also compared with the US-based EQ-5D index (6) by performing similar regression of the US index on the same socio-demographic variables as in the VAS-based index model, and by testing the correlation between the two sets of indices. The US EQ-5D scoring algorithm is based on TTO valuations of EQ-5D health states from a sample of the adult US general population (6).

Missing values for family income and parental education were considered as separate covariate categories in the regression analysis but the estimates were not presented. We weighted all analyses to accommodate the design effect. Data analysis was performed using STATA 11.0 (Stata Corp, College Station, TX, USA).

4.3 Results

4.3.1 Sample Characteristics

3,421 students (61.2% of all students) in 2008, and 3,398 (60.7% of all students) in 2010 responded to the survey, resulting in 6,819 respondents in total. Of all students, 41 (0.6 %) did not respond to one or more of the questions in the EQ-5D-Y descriptive system and 66 (1.0%) failed to complete the VAS, these students were excluded from the analysis. As a result, 3,370 in the modeling sample and 3,361 students in the validation sample were available for the analysis in this study.

The distribution of the socio-demographic characteristics and HRQOL of the respondents is reported in table 4-1**.** Of all participating students, 51.0% were girls. Metropolitan, city and rural-town children accounted for 46.7%, 15.0%, and 38.3% respectively.

In the EQ-5D-Y descriptive system, most problems were observed in the dimension of 'having pain or discomfort' where 42.4% and 3.4% of the students reported some and a lot of problems, respectively, followed by the dimension 'feeling worried, sad or unhappy', where 32.7% and 3.4% rated some and a lot of problems, respectively. The prevalence of reported problems in 'walking', 'looking after myself', 'doing usually activities' were relatively low (table 4-1).

4.3.2 Modeling Results

Table 4-2 presents results of the basic regression model and the adjusted estimation model. As expected, all the coefficients were negative. Children who reported having problems on any dimension had consistently lower VAS scores relative to children reported no problems. The coefficients at level 3 in 'walking' and 'looking after myself' were not statistically significant ($p>0.05$) in the basic model. The equation for VAS scoring based on the estimation model in Table 4-2 is defined as:

$$\text{VASscore}=86.05 - 3.74\text{WK2} - 3.74\text{WK3} - 5.75\text{LS2} - 5.75\text{LS3} - 6.30\text{UA2} - 15.55\text{UA3} - 3.27\text{PD2} - 9.54\text{PD3} - 4.35\text{WS2} - 9.83\text{WS3}$$

An example of calculation of the predicted VAS and the VAS index was as follows:

Estimated VAS for health state 12333=86.05-5.75-15.55-9.54-9.83 =45.38

The VAS index for state 12333 =(45.38-41.63)/(86.05-41.63)= 0.084

4.3.3 Validation Results

Mean observed VAS score was 81.3 (SD: 17.1), and mean estimated VAS score was 81.2 (SD: 5.7) for the modeling sample. Overall, there was no significant difference between the observed and the predicted VAS values (t=0.79, p=0.433 for the full sample). The mean health status of the children using the rescaled VAS-based index was 0.889 (SD: 0.130), 0.891 (0.128) and 0.888 (0.131) for full sample, modeling sample and validation sample, respectively (table 4-1).

In total, 137 (56%) different health states out of the 243 possible health states defined by the EQ-5D-Y were reported. Table 4-3 and figure 4-1 to 4-2 compared the mean observed and the mean predicted VAS for 27 most frequent health states in the modeling sample and validation sample respectively. Respondents for these most frequent health states accounted for 95.3% of the total respondents in each sample. Four of these most frequent health states showed an absolute difference of equal to or greater than 7.0 points between the observed and predicted VAS. The four states (11132, 11131, 21112, 22122) were mostly in the lower range of worse states among the 27 health states with relatively small number of observations (less than 17 in each state).

Table 4-4 presents fit indices for the modeling sample and the validation sample. The correlation between the observed and predicted VAS for all observed health states was 0.35 (P<0.001) for the modeling group and 0.38 (P<0.001) for the validation group. The correlation between the observed and predicted VAS for 27 most frequent health states in each sample was 0.73 (P<0.0001, the modeling sample) and 0.86 (P<0.001, validation sample). Mean absolute error of VAS prediction for the most frequent 27 health states was 2.88 in the modeling sample and 2.44 in the validation sample.

The Pearson's correlation coefficient between the index that is based on children's VAS values of their own health status and the index that is based on the US EQ-5D TTO value set was 0.90 (P<0.0001). However, the VAS index showed slightly higher health status values than the TTO-based index for those extreme health states (figure 4-3).

The association between the different indexes and socio-demographic variables is given in table 4-5. The VAS-based index and the TTO-based index were similar in discriminating socio-demographic subgroup differences by gender, residency and parental education in terms of the direction of coefficient and statistical significance test. The two index value sets varied slightly in distinguishing differences across categories of family income, where children from families with highest income level showed significantly higher HRQOL in VAS index than children from families with lowest income (p=0.009) compared to non-significant difference between the two groups measured by TTO-based index.

4.4 Discussion

This is the first study attempting to elicit a value set for the EQ-5D-Y using a large population-based sample of Canadian children. The result shows that the estimated VAS values for dimensions were logically consistent and produced decreasing index values for increasingly severe health states. The estimated VAS values were lower for worse health states as described in the EQ-5D-Y descriptive system. The observed VAS values were very close to the estimated VAS value using the EQ-5D-Y descriptive system. The VAS index shows similarities in discriminating socio-demographic difference in HRQOL to the adult US TTO-based index.

There is disagreement about what type of health state values could be used and how to establish a preference value set for the EQ-5D-Y health states (16, 21). Valuing health states in children raises some methodological issues relative to valuing health states for adults (21-22). While the TTO and SG are the two standard approaches to directly eliciting health state values from adults for different health states, it is argued that the TTO and the SG approach may be too difficult to complete by children (21, 23). As such, some researchers suggest that VAS may be more feasible, and practical in use to measure values for health states though there are limitations that are related to the theoretical foundation and rating scale (24-26).

Earlier studies of quality of life assessment in children using the EQ-5D or EQ-

5D-Y mostly relied on the existing US or UK EQ-5D value sets for adults since no child-specific EQ-5D value set is available (27-29). The alternative approach of obtaining health state index values for children that applies an existing scoring algorithm established from general adult populations to children themselves also poses a question about whether the existing adult social tariffs reflect the health state values experienced by children (16, 21). Previous studies have shown that different sources of subjects used in the measurement of utility or preferences among children may lead to different values for the health states to be derived (30). It is argued that proxy (e.g. parents) estimation of utility values for children may fail to make accurate assessment of the health state value for children (21-22, 30).

In the present study, derivation of the index value for EQ-5D-Y was based on children's self-rated values on the VAS that was linked with the five dimensional classification system. The estimated VAS value for the health state of each of the respondents mirrored direct experience from children for their health, and thus may be less likely to suffer from bias assessment compared to proxy-report. Moreover, use of EQ-5D-Y with the own VAS value provides a simple, time and cost saving technique of directly valuing health states in children. There is so far no standard recommendation on what is the best approach to generate child-specific value set for the EQ-5D-Y. The scoring algorithm constructed in this study may offer a practical choice to estimate the EQ-5D-Y index scores for use in young children.

High correlation between the VAS-based index and the US TTO-based index indicates that two value sets show a similar linear trend across different health states. However, the VAS-based index is slightly higher than the TTO-based index for some extreme states. This is consistent with some other studies from general populations demonstrating that TTO approach yields much lower index values for the extreme states than VAS approach (31). The transformation formula in the present study used the state 33333 as the zero point while the TTO valuation produces a negative value for the state 33333 since the state is valued worse than death and death is set to get the value of zero (3, 6). Neither adult nor child version of the EQ-5D instrument includes death in the self-health VAS rating, so it is not possible to use that state in the anchoring of the own VAS-based scales. Valuing dead is difficult even for adult populations and it is more difficult to be valued in young children (21). For the purpose to use the VAS-based index for the EQ-5D-Y in cost-utility analysis among children in the future, alternative approaches to obtaining the value for the state 'dead' need to be developed from other valuation methods that may include the state death valued by adults (24).

Comparison of the effect of socio-demographic variables on the two sets of indices, the US TTO and children' VAS based index, shows both value sets are very similar in identifying sub-group differences in HRQOL in the sample by gender, residency and parental educational levels. A difference exists in that VAS based index can also discriminate differences in HRQOL by household income categories in terms of statistically significance. It is also important to consider if these differences of the HRQOL among the socio-demographic groups represent the minimal clinically important difference (MIDs) (32-33). MIDs for the EQ-5D index and the EQ-5D VAS have been documented for some disease conditions in adults (20, 34). The EQ-5D-Y is a newly developed HRQOL instrument, and the MIDs have yet to be studied and established. According to Cohen, effect size for HRQOL changes is defined as small (0.2), moderate (0.5), and large (0.8) in magnitude for differences (35). The effect size is calculated as the mean difference in score between two subgroups divided by the standard deviation of the mean score among total sample. This study showed that the expected VAS-based index of 0.2SD and of 0.5SD (designated as MID) were approximately 0.03 (0.13×0.2) points and 0.07 (0.13×0.5) points (35-36). This is close to 0.07 points, a MID score for EQ-5D observed by previous studies (20, 34). Based on the criterion of 0.5SD, the socio-demographic differences in HRQOL scores did not achieve the MID score (0.07) identified either by the VAS-based index or the TTO-based index in this study. Future research is needed to investigate the magnitude and direction of differences/changes in HRQOL to recommend a MID for the EQ-5D-Y by using combined approaches of distribution-based and anchor-based (37).

The major strength of this study is that the model is based on the use of a large population-based sample representing grade five students in the province of Alberta, Canada. Additionally, a multilevel model was used to account for the individual and school differences in the index estimation, and thus enabled relatively more robust parameter estimates.

Limitations of this study should also be acknowledged. The study elicited a value set for EQ-5D-Y using a sample of Canadian children aged 10 to 11 years. It remains uncertain to what extent the present value set represents the values of children in other age groups. Another limitation is that due to a small number of observations available for severe health states, the model for the value set was mainly based on the upper range of relatively better health states rated by the respondents, and thus may limit the predictability of the scoring system for health states in the lower range classified by the EQ-5D-Y. Future research that incorporates hypothetical severe health states as a VAS valuation task among children would add information on the performance of the scoring system for extreme health states.

Finally, since the value set is based on children' own VAS values, the scoring system does not represent preferences or utilities and thus has somewhat limited use in cost-utility analysis. However, until preference-based approaches for valuation of EQ-5D-Y (e.g., TTO or SG) are developed this may provide useful proxy value set for other researchers and policy makers.

4.5 Conclusions

In conclusion, this study estimates an index value set for the EQ-5D-Y that is based on self-rated VAS values from a large cohort of grade five students in Canada. The model results in expected parameter estimates in terms of the sign and the value of coefficients for different EQ-5D-Y levels of health states considered as worse than perfect health. The findings suggest that young populations can logically assess their own health status on VAS scale. This has important implications for HRQOL assessment and economic analysis of public health interventions among young populations. Evidence of valid health state values for the EQ-5D-Y elicited from children and youth themselves will help address the current debate of whose values (children and youth vs. adult proxy assessment) can be used in health state assessment and economic evaluation studies in young people and justify whether the values rated by children and adolescents are useful (16). I recommend to expand studies on the feasibility, validity and reliability of different hypothetical health states (indirect) valuation techniques among different age groups of children. However, since the use of the state “death” as an anchor among children is difficult, alternative ways to rescale the index may need to be developed.

Table 4-1 Socio-demographic characteristics of the students and the HRQOL measured by the EQ-5D-Y dimensions, VAS-based index and the US EQ-5D index

Variable	**Full sample** (n=6,819)	**Modeling Sample** (n=3,370)	**Validation Sample** (n=3,361)
Gender %			
Girls	51.0	52.2	49.8
Boys	49.0	47.8	50.2
Residential area %			
Metropolitan	46.7	45.4	48.0
City	15.0	15.6	14.5
Rural -Town	38.3	39.0	37.6
Parents' education %			
Secondary or less	26.0	25.4	26.5
College	39.5	40.0	39.1
University or above	34.5	34.6	34.4
Household income %			
≤$50,000	24.0	23.2	24.7
$50,001 - $75,000	17.6	17.6	17.6
$75,001 - $100,000	21.3	22.5	20.1
>$100,000	37.2	36.7	37.6
Walking %			
No problems	90.9	90.9	90.8
Some problems	8.5	8.4	8.6
A lot of problems	0.6	0.6	0.6
Looking after myself %			
No problems	94.2	94.3	94.2
Some problems	5.3	5.3	5.4
A lot of problems	0.4	0.4	0.4
Doing usual activities %			
No problems	88.5	88.6	88.4
Some problems	10.9	10.7	11.0
A lot of problems	0.6	0.6	0.6
Having pain/discomfort %			
No problems	54.3	54.7	53.8
Some problems	42.4	41.9	42.8
A lot of problems	3.4	3.3	3.4
Feeling worried, sad or unhappy %			
No problems	63.9	64.4	63.5
Some problems	32.7	32.6	32.8
A lot of problems	3.4	3.1	3.7
Mean observed VAS	80.9 (17.3)	81.3 (17.1)	80.5 (17.6)
Mean predicted VAS	81.1 (5.8)	81.2 (5.7)	81.1 (5.8)
VAS-based index	0.889 (0.130)	0.891 (0.128)	0.888 (0.131)
US EQ-5D index	0.858 (0.151)	0.860 (0.151)	0.856 (0.153)

The EQ-5D-Y VAS score ranged from 0 to 100, where 100 is best imaginable health.
VAS-based index ranged between 0 and 1, where 0 represents value for the worst health (state 33333), and 1 for the perfect health (state 11111).

Table 4-2 Regression results for estimated parameters from basic model and estimation model

Variable	Basic Model			Estimation Model		
	Coefficient	**(95% CI)**	**P value**	**Coefficient**	**(95% CI)**	**P value**
Constant	86.06	(85.17, 86.95)	0.000	86.05	85.15, 86.94	0.000
Walking (reference: no problems)						
Some problems	-3.57	(-6.01, -1.13)	0.004	-3.74	(-6.09, -1.40)	0.002
A lot of problems	-5.87	(-15.77, 4.04)	0.246	-3.74*	(-6.09, -1.40)*	
Looking after myself (reference: no problems)						
Some problems	-5.25	(-8.61, -1.89)	0.002	-5.75	(-9.03, -2.48)	0.001
A lot of problems	-11.96	(-27.93, 4.01)	0.142	-5.75*	(-9.03, -2.48)*	
Doing usual activities (reference: no problems)						
Some problems	-6.26	(-8.40, -4.13)	0.000	-6.30	(-8.48, -4.13)	0.000
A lot of problems	-15.10	(-25.49, -4.71)	0.004	-15.55	(-25.25, -5.85)	0.002
Having pain/discomfort (reference: no problems)						
Some problems	-3.32	(-4.82, -1.81)	0.000	-3.27	(-4.77, -1.77)	0.000
A lot of problems	-9.31	(-14.54, -4.09)	0.000	-9.54	(-14.71, -4.37)	0.000
Feeling worried, sad or unhappy (reference: no problems)						
Some problems	-4.38	(-5.87, -2.89)	0.000	-4.35	(-5.82, -2.88)	0.000
A lot of problems	-9.80	(-15.50, -4.09)	0.001	-9.83	(-15.51, -4.15)	0.001

* The regression coefficients and 95% CI for ‘A lot of problems’ were assumed to be same as for ‘some problems’.

Table 4-3 Absolute difference between mean observed and estimated VAS score for 27 EQ-5D-Y health states in each sample

Modeling sample					Validation sample				
Health State	N	Observed VAS	Estimated VAS	Absolute Difference │(2)-(3)│	Health State	N	Observed VAS	Estimated VAS	Absolute Difference │(6)-(7)│
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
11111	1286	86.7	86.1	0.6	11111	1258	85.7	86.0	0.4
11121	526	82.9	82.8	0.1	11121	558	81.4	82.8	1.4
11122	457	78.6	78.4	0.2	11122	432	78.7	78.4	0.2
11112	311	80.9	81.7	0.8	11112	301	80.2	81.7	1.5
21121	58	78.6	79.0	0.4	11222	80	72.1	72.1	0.0
11221	58	76.4	76.5	0.1	11211	69	78.5	79.7	1.2
11222	55	75.4	72.1	3.2	21122	61	72.8	74.7	1.9
11211	54	77.9	79.7	1.8	21121	60	81.0	79.0	2.0
21122	50	73.7	74.7	1.0	11221	49	78.1	76.5	1.6
12122	38	69.0	72.7	3.7	11123	40	72.6	73.0	0.4
11123	34	73.1	73.0	0.2	11212	30	78.3	75.4	2.9
11212	33	75.8	75.4	0.4	21222	27	72.2	68.4	3.8
21222	28	72.6	68.4	4.2	12122	27	71.5	72.7	1.2
21221	28	69.1	72.7	3.6	12111	25	78.6	80.3	1.6
11132	26	76.4	72.2	4.3	21111	23	82.7	82.3	0.4
12121	22	75.5	77.0	1.5	12121	21	80.1	77.0	3.0
21111	21	82.7	82.3	0.4	11131	21	81.3	76.5	4.7
11113	19	70.2	76.2	6.0	11113	19	71.0	76.2	5.3
12112	17	73.0	75.9	2.9	21221	17	78.4	72.7	5.7
12111	15	76.0	80.3	4.3	11132	16	64.8	72.2	**7.4**
12221	13	66.7	70.7	4.0	12222	14	70.5	66.4	4.1
11131	13	69.6	76.5	**6.9**	12112	13	74.1	75.9	1.8
12222	11	64.5	66.4	1.9	11133	9	70.2	66.7	3.5
11133	10	68.9	66.7	2.3	21112	9	76.4	78.0	1.5
21112	10	67.7	78.0	**10.3**	22222	8	63.8	62.6	1.2
11223	9	69.5	66.7	2.8	11223	8	64.1	66.6	2.5
22122	9	78.8	68.9	**9.9**	22122	8	73.2	68.9	4.2

Table 4-4 Fit indices for modeling sample and validation sample

Index	Value	P value
Modeling sample		
R- overall	0.35	<0.001
R-between for the most frequent 27 health states	0.73	<0.0001
MAE-overall	12.4	--
MAE for the 27 health states	2.88	--
Validation sample		
R-between for all the observed states	0.38	<0.001
R-between for the most frequent 27 health states	0.86	<0.0001
MAE-overall	12.7	--
MAE for the 27 health states	2.44	--

Note: R-overall: Correlation coefficient between the observed and predicted VAS for the total sample.
R-between -Correlation coefficient between the observed and predicted VAS by health state.
MAE-overall: Mean absolute error of VAS prediction for the total sample.
Modeling sample-split group one; validation sample-split group two.

Table 4-5 Regression results on the association between the index and the socio-demographic variables

	VAS-based index			US EQ-5D index		
Variable	**Coefficient**	**(95% CI)**	**P value**	**Coefficient**	**(95% CI)**	**P value**
Constant	0.876	(0.864, 0.887)	0.000	0.843	(0.828, 0.859)	0.000
Gender (Ref. Female)	0.013	(0.006, 0.020)	**0.001**	0.010	(0.001, 0.018)	**0.023**
Residential area (Ref. Metropolitan)						
Rural -Town	-0.013	(-0.022, -0.004)	**0.004**	-0.017	(-0.028, -0.007)	**0.001**
City	-0.007	(-0.016, 0.002)	0.115	-0.010	(-0.020, 0.001)	0.065
Household income (Ref. ≤ $50,000)						
$50,001 - $75,000	-0.012	(-0.026, 0.002)	0.082	-0.012	(-0.029, 0.005)	0.164
$75,001 - $100,000	0.007	(-0.005, 0.019)	0.256	0.010	(-0.004, 0.024)	0.163
> $100,000	0.013	(0.003, 0.023)	**0.009**	0.011	(-0.002, 0.024)	0.106
Parents' education (Ref. Secondary or below)						
College	0.008	(-0.001, 0.016)	0.067	0.011	(0.000, 0.021)	0.054
University	0.015	(0.005, 0.024)	**0.003**	0.022	(0.010, 0.034)	**0.000**

Ref.: reference group

Figure 4-1 Mean observed and estimated VAS scores for the 27 most frequent health states among modeling sample

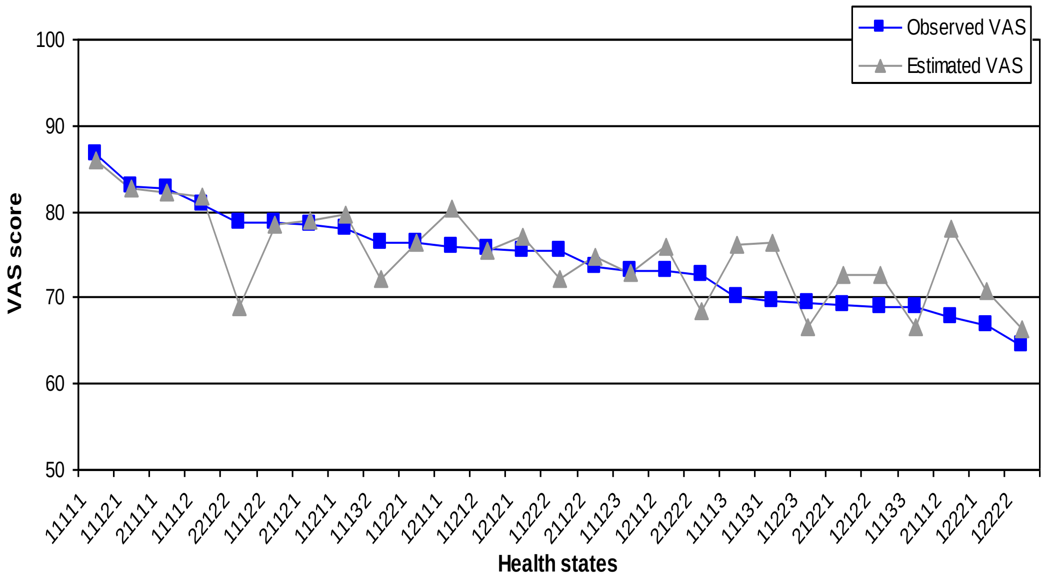


Figure 4-2 Mean observed and estimated VAS scores for the 27 most frequent health states among validation sample

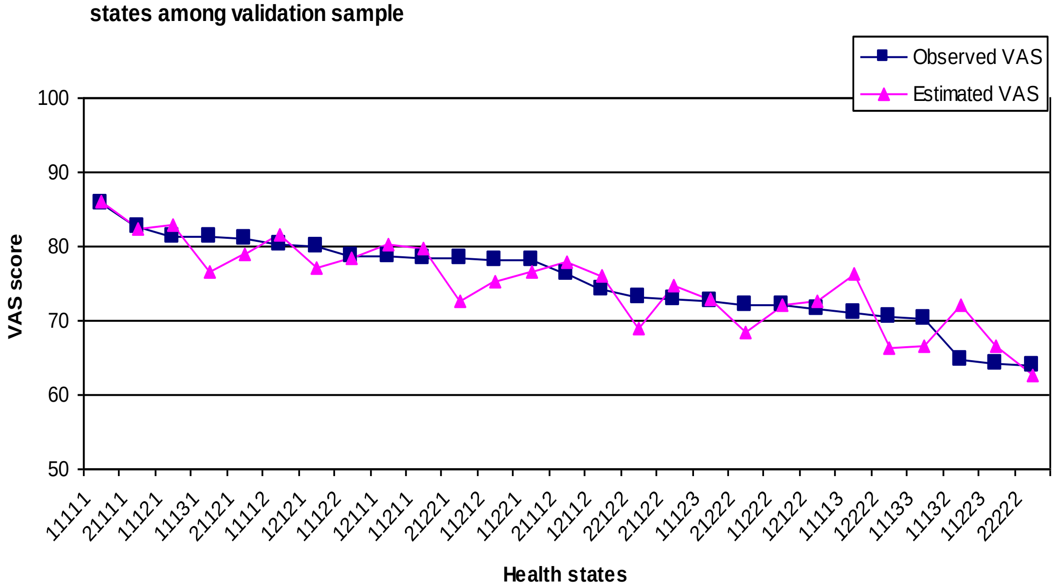
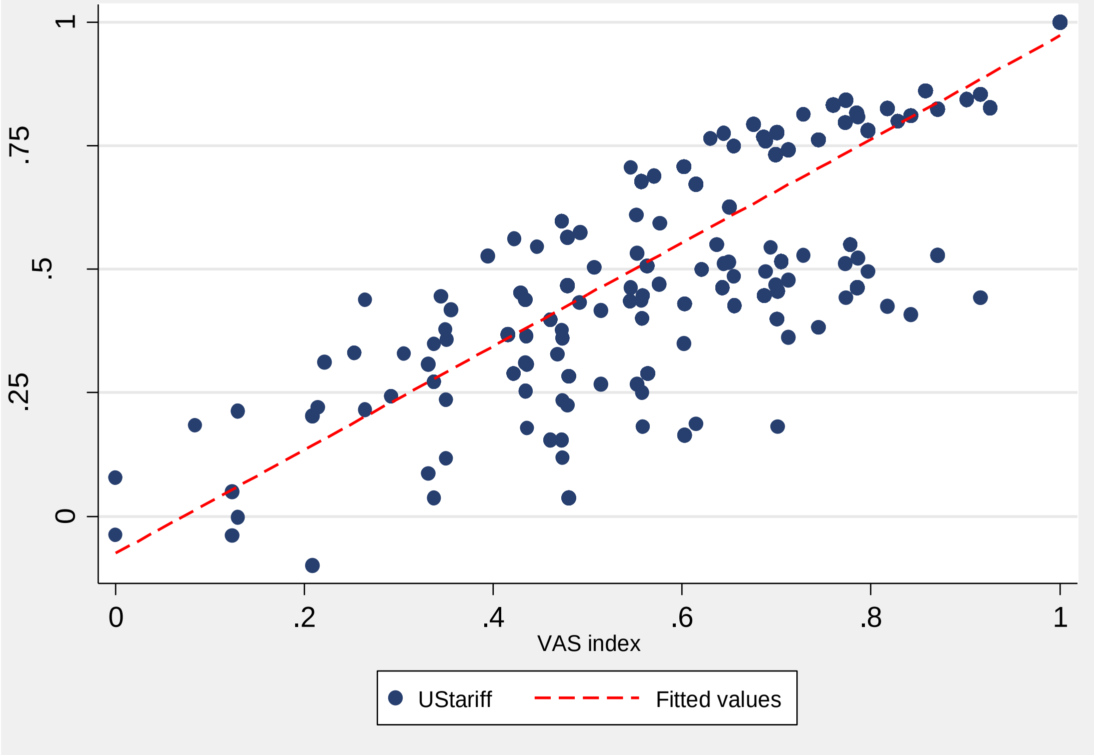


Figure 4-3 : Comparison of the EQ-5D-Y VAS-based index and the US EQ-5D index



4.6 References

(1) Torrance GW. Preferences for health outcomes and cost-utility analysis. Am J *Manag Care* 1997; 3 Suppl: S8-20.

(2) Torrance GW. Measurement of health state utilities for economic appraisal. *J Health Econ.* 1986 Mar; 5(1): 1-30.

(3) Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; 35(11): 1095-1108.

(4) Konerding U, Moock J, Kohlmann T. The classification systems of the EQ-5D, the HUI II and the SF-6D: what do they have in common? *Qual Life Res.* 2009; 18(9): 1249-1261.

(5) Rabin, R., & de Charro, F. EQ-5D: A measure of health status from the EuroQol Group. *Annals of Medicine* 2001; 33: 337–343.

(6) Shaw, J. W., Johnson, J. A., & Coons, S. J. US valuation of the EQ-5D health states: Development and testing of the D1 valuation model. *Medical Care* 2005; 43(3): 203–220.

(7) Lamers LM, McDonnell J, Stalmeier PF, Krabbe PF, Busschbach JJ. The Dutch tariff: results and arguments for an effective design for national EQ-5D valuation studies. *Health Econ.* 2006; 15(10): 1121-1132.

(8) Greiner W, Weijnen T, Nieuwenhuizen M, Oppe S, Badia X, Busschbach J, et al. A single European currency for EQ-5D health states. Results from a six-country study. *Eur.J.Health.Econ.* 2003; 4(3): 222-231.

(9) Johnson JA, Ohinmaa A, Murti B, Sintonen H, Coons SJ. Comparison of Finnish and U.S.-based visual analog scale valuations of the EQ-5D measure. *Med Decis Making* 2000; 20(3): 281-289.

(10) Tsuchiya A, Ikeda S, Ikegami N, Nishimura S, Sakai I, Fukuda T, Hamashima C, Hisashige A, Tamura M. Estimating an EQ-5D population value set: the case of Japan. *Health Econ.* 2002 Jun; 11(4): 341-353.

(11) Björk S, Norinder A. The weighting exercise for the Swedish version of the EuroQol. *Health Econ.* 1999 Mar; 8(2): 117-126.

(12) Johnson JA, Coons SJ, Ergo A, Szava-Kovats G. Valuation of EuroQOL (EQ-5D) health states in an adult US sample. *Pharmacoeconomics*1998; 13(4): 421-433.

(13) Rue M, Badia X. The Spanish EuroQol tariff: results from the Catalan Health Interview Survey based on self-rated health. In: Badia X, Herdman M, Segura A, eds Discussion Papers from the EuroQol Plenary Meeting. Barcelona: Catalan Institute of Public Health, 1995; 77-98.

(14) Augustovski FA, Irazola VE, Velazquez AP, Gibbons L, Craig BM. Argentine valuation of the EQ-5D health states. *Value Health* 2009;12(4): 587-596.

(15) Wille N, Badia X, Bonsel G, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D. *Qual Life Res.* 2010; 19(6): 875-886.

(16) Ulrike Ravens-Sieberer, Nora Wille, Dipl.-Psych. MPH, et al. Feasibility, reliability and validity of the EQ-5D-Y – results from a multinational study. *Qual Life Res.* 2010; 19(6): 887-897.

(17) Burström K, Svartengren M, Egmar AC. Testing a Swedish child-friendly pilot version of the EQ-5D instrument--initial results. *Eur J Public Health* 2011 Apr; 21(2): 178-183.

(18) Simen-Kapeu A, Kuhle S, Veugelers PJ. Geographic differences in childhood overweight, physical activity, nutrition and neighbourhood facilities: implications for prevention. *Can J Public Health* 2010 Mar-Apr; 101(2): 128-132.

(19) Fung C, Kuhle S, Lu C, Purcell M, Schwartz M, Storey K, Veugelers PJ. From "best practice" to "next practice": the effectiveness of school-based health promotion in improving healthy eating and physical activity and preventing childhood obesity. *Int J Behav Nutr Phys Act.* 2012 Mar 13; 9(1): 27. [Epub ahead of print].

(20) Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res.* 2005 Aug; 14(6): 1523-1532.

(21) Prosser LA, Hammitt JK, Keren R. Measuring health preferences for use in cost-utility and cost-benefit analyses of interventions in children: theoretical and methodological considerations. *Pharmacoeconomics* 2007; 25(9): 713-726.

(22) Ungar WJ. Challenges in Health State Valuation in Paediatric Economic Evaluation: Are QALYs Contraindicated? *Pharmacoeconomics* 2011 Aug 1; 29(8): 641-652.

(23) Juniper EF, Guyatt GH, Feeny DH, Griffith LE, Ferrie PJ. Minimum skills required by children to complete health-related quality of life instruments for

asthma: comparison of measurement properties. *Eur Respir J.* 1997; 10(10): 2285-2294.

(24) Kind P. Valuing EQ-5D health states - a VAStly simpler solution? 24th scientific Plenary Meeting of the EuroQol Group-Proceedings: 319-337. 2009.

(25) Parkin D, Devlin N. Is there a case for using visual analogue scale valuations in cost-utility analysis? *Health Econ.* 2006 Jul; 15(7): 653-664.

(26) Kind P, Hennessy S, Macran S. The value of hypothetical and "real" EQ-5D health states and other things: a fairytale for the childrens' session at the EuroQoL Scientific Plenary. 21th scientific Plenary Meeting of the EuroQol Group-Proceedings: September, 2004.

(27) Willems DC, Joore MA, Nieman FH, Severens JL, Wouters EF, Hendriks JJ. Using EQ-5D in children with asthma, rheumatic disorders, diabetes, and speech/language and/or hearing disorders. *Int J Technol Assess Health Care* 2009; 25(3): 391-399.

(28) Stolk EA, Busschbach JJ, Vogels T. Performance of the EuroQol in children with imperforate anus. *Qual Life Res.* 2000; 9(1): 29-38.

(29) Wu XY, Ohinmaa A, Veugelers PJ. Sociodemographic and neighbourhood determinants of health-related quality of life among grade-five students in Canada. *Qual Life Res.* 2010; 19(7): 969-976.

(30) Petrou S. Methodological issues raised by preference-based approaches to measuring the health status of children. *Health Econ.* 2003 Aug; 12(8): 697-702.

(31) Badia X, Monserrat S, Roset M, Herdman M. Feasibility, validity and test-retest reliability of scaling methods for health states: the visual analogue scale and the time trade-off. *Qual Life Res.* 1999 Jun; 8(4): 303-310.

(32) Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials* 1989; 10(4): 407-415.

(33) Samsa G, Edelman D, Rothman ML, G et al. Determining clinically important differences in health status measures: a general approach with illustration to the Health Utilities Index Mark II. *Pharmacoeconomics* 1999 Feb; 15(2): 141-155.

(34) Pickard AS, Neary MP, Cella D. Estimation of minimally important differences in EQ-5D utility and VAS scores in cancer. *Health Qual Life Outcomes* 2007 Dec 21; 5: 70.

(35) Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, N. J.: Laurence Erlbaum; 1988.

(36) Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. Med Care 2003; 41(5): 582-592.

(37) Lydick E, Epstein RS (1993) Interpretation of quality of life changes. *Qual Life Res.* 1993 Jun; 2(3): 221-226.

Chapter 5 – The Influence of School Based Promotion of Healthy Eating and Active Living on Health-Related Quality of Life among Grade Five Students in Canada

5.1 Introduction

Childhood obesity is a global epidemic expected to affect children's future health (1). Overweight and obesity in children contribute to morbidity during childhood and adulthood and premature mortality in adulthood (2-4). Excessive weight is also linked to impaired psychosocial health and quality of life among children and youth (5-7). The rising rate of childhood obesity and the serious adverse effect on health emphasizes the importance of public health interventions to benefit children's health.

Schools are considered valuable settings to implement health promotion as children spent most of their waking hours in schools (8, 9). A number of school-based intervention studies promoting physical activity (PA) and healthy eating among children have been conducted and their effectiveness has been evaluated (10-12). One type of approach that has demonstrated effectiveness is Comprehensive School Health (CSH) (13). CSH is defined as an internationally recognized framework for supporting improvements in students' educational outcomes while addressing school health in a planned, integrated and holistic way (13). Studies on CSH have documented benefits for eating habits, physical activity, other behaviors and some health outcomes including overweight/obesity reduction, and improved mental health and well-being (10,12,14).

Health-related quality of life (HRQOL) has been increasingly used as a health outcome measure in both clinical practice and public health settings. The association between diet, PA and HRQOL has been documented mostly in children and adolescents with specific health conditions (15,16). Very few studies have analyzed the impact of diet and physical activity on HRQOL using population based sample of children (17). Our recent study using a cross-sectional survey of grade five students showed that children with higher diet quality and active lifestyle experienced higher HRQOL than children with lower diet quality and inactive lifestyle, and overweight and obese children reported worse HRQOL than that normal weight peers (18). While favorable effects of school-based programs of promoting healthy eating and active living on obesity prevention in children have been previously reported (12), no public health interventions has evaluated potential influence on HRQOL among school children. It is unknown whether promotion of healthy eating and active living for overweight prevention using a CSH model has a positive effect on the HRQOL among school age children. Evidence on benefits to HRQOL from such interventions will help add to existing justification to broadly investing in promotion of healthy eating and active living.

The aim of the present study is to assess the impact of a CSH program, specifically the Alberta Project Promoting active Living & healthy Eating in

Schools (APPLE Schools), on HRQOL of grade five students in Canada.

5.2 Study Design and Methods

5.2.1 Overview

The Raising Healthy Eating and Active Living Kids in Alberta (REAL Kids Alberta) surveys intend to evaluate the Alberta Health and Wellness initiative to promote healthy body weights among children. The survey employed a one-stage stratified random sampling design in the province. The surveys, conducted in 148 schools in the spring of 2008 and 2010, provide provincial estimates on diet, PA, body weights and HRQOL of grade five students. The initiative incorporated a series of programs: a provincial policy on food and nutrition (The Alberta Nutrition Guidelines for Children and Youth which includes healthy menu and food offerings) and physical activity; healthy weights social marketing strategies to support for healthy school environments; health promotion coordinators working across the province through Alberta Health Services, and healthy school community wellness fund for some schools to create healthy school communities. Information detail of the initiative can be found at website, www.REALKidsAlberta.ca.

The APPLE Schools program also uses the REAL Kids Alberta surveys for tracking changes in diet, PA, body weights and HRQOL over time. The APPLE Schools program was launched in April, 2008 after the baseline data were collected. The APPLE Schools surveys were conducted annually in spring and the last survey has been done in 2011. For the purpose of the present study, we examined the impact of the APPLE Schools program on HRQOL in grade five students by comparing the changes in HRQOL scores over the two-year period between the APPLE Schools (intervention group) and the REAL Kids Alberta provincial sample (as control group). The random sample of schools from the REAL Kids Alberta surveys had also been exposed to an intervention (the provincial program) as stated above. However, the APPLE Schools had received a much higher intervention dose by implementing CSH program in addition to the benefits of the provincial programs.

We assumed that after two years of interventions, students in the APPLE Schools would show positive changes in HRQOL, and the changes in HRQOL scores would be greater than children in REAL Kids Alberta group.

The REAL Kids survey, APPLE School program as well as the present analyses were approved by Health Research Ethics Board of the University of Alberta, and by participating school boards and schools.

5.2.2 The REAL Kids Alberta Surveys

The sampling frame of the REAL Kids Alberta surveys included all elementary schools in the province with the exception of private schools (4.7% of all Alberta children), francophone schools (0.6%), on-reserve federal schools (2.0%), charter schools (1.7%), and colony schools (0.8%). Schools were stratified into three levels of geographies: 1) urban (Calgary and Edmonton); 2) towns (other municipalities with more than 40,000 residents); and 3) rural (municipalities with less than 40,000 residents). Schools were randomly selected within each of these strata to achieve a balanced number of schools and students in each stratum. Participants were grade five students aged primarily 10 to 11 years and their parents. All grade five students in these schools received an envelope with a parent consent form and a survey to take home for their parent/guardian(s)'s responses. The questionnaires used for both students and parents are posted on www.REALKidsAlberta.ca.

In 2008, 148 (80.4%) out of 184 invited elementary schools participated in the survey. These schools had in total 5,594 grade five students who received an envelope with a parent consent form and a survey to take home for their parents' response. Of these students, 3,421 participated in the investigation (61.2% of students). At schools, the students completed the Harvard Youth & Adolescent Food Frequency Questionnaire (19), a survey on their physical activities, and HRQOL measured by the EQ-5D-Y(20). Study representatives visited the schools to measure the height and weight of the students. The parent survey included questions on educational attainment, household income, place of residency, and their neighborhoods. In 2010, 3,398 (60.7% of students) grade five students out of 151 randomly selected schools participated in the survey. Questionnaires used and the survey procedure were same as that in the 2008 survey.

5.2.3 The APPLE Schools Program

The program aimed to improve the eating habits, physical activity, and reduce obesity and overweight among schoolchildren to enhance their health (21-22). In the beginning, ten schools participated in the intervention that incorporated CSH approach (22). Pre-intervention data were collected in 2008 from 293 (85%) grade five students attending the ten schools. Evaluations focus on changes in the health, nutrition, and physical activity of grade five students over the intervention period. In 2010, 394 (84%) grade five students in these schools participated in the survey. In two years, the intervention has demonstrated positive influences: improved diet quality, increased physical activity levels, and a 14% reduction in obesity prevalence (23).

5.2.4 The Interventions among APPLE Schools

Interventions used in the APPLE Schools cover all components of the CSH. This is a multifactorial approach that encompasses four essential elements of CSH: 1) teaching and learning; 2) social and physical environments; 3) healthy school policy; and 4) partnerships and services (13). Detailed information on the school selection and the interventions are described elsewhere (22), and it can also be found in the APPLE Schools website, www.appleschools.ca.

The main content of the intervention includes: 1) health education for school teachers, students and their parents; 2) a provincial guideline on food, nutrition, and physical activity for children and youth is implemented in all schools; 3) school physical environment committed to healthy nutrition to provide healthy food choices, space and equipment to ensure all students have access to daily physical activity to live in active lifestyle; 4) social school environment aimed at establishing sustainable relationships among teachers, staffs and students, and with families and school communities; 5) schools worked together with communities, and other organizations to support healthy school environment and enhance school health (22).

Organizationally, each school had an 'APPLE Core Committee' that included parents, students, administrators, teachers, and community stakeholders, and they made recommendations that supported the development of a healthy active school. Furthermore, an important feature of the APPLE Schools project was that it implemented CSH approach through use of full-time school health facilitators to ensure that the unique needs and challenges to healthy eating and active living in each school can be addressed in an efficient manner (22).

5.2.5 Measurement and Assessments

5.2.5.1 Socio-demographic Characteristics

Socio-demographic characteristics included gender and residential area of the grade five students, their parental educational attainment and household income. In this study, place of residency was classified as two groups: 1) metropolitan, 2) other residency (city, town and rural area). Parental educational attainment was categorized as secondary or below secondary graduation; postsecondary or college graduation; and university or above university graduation. Household income was divided into four categories: less than $50,001 per year; $50,001 to

75,000; $75,001 to $100,000; and more than $100,000 per year.

5.2.5.2 Measurement of Health-related Quality of Life

HRQOL of the children was assessed by the EQ-5D-Y. The EQ-5D-Y instrument consists of a five-dimensional descriptive system including 1) walking; 2) looking after myself; 3) doing usual activities; 4) having pain or discomfort; and 5) feeling worried, sad or unhappy (20). Each dimension has three levels of problems: 1) no problems; 2) some problems; or 3) a lot of problems. The instrument also includes a Visual Analogue Scale (VAS) which is anchored at 100 (best imaginable health) and 0 (worst imaginable health) to capture self-rated values of health status in children. The EQ-5D-Y has been validated for several languages and countries, and it has been shown to be feasible, reliable and valid for HRQOL measurement in children and adolescents (24).

Since there is no single index formula specifically developed for the EQ-5D-Y, we recently constructed an EQ-5D-Y scoring system based on own VAS rating among an Alberta sample of grade five students (25). In the current study, I applied the VAS based single index as one of the outcome measure of the HRQOL of the children. The VAS based index value ranges between 1 (healthy) and 0 (all dimensions on lowest level of the health state). The US EQ-5D scoring system for adults was also used to estimate EQ-5D-Y index. The US EQ-5D scoring system is based on time trade-off valuations of EQ-5D health states from a U.S general population sample of adults. The possible score of the index ranges between-0.109, the lowest health state, and 1.00, the highest health state (26).

5.2.6 Statistical Analysis

The prevalence of HRQOL categorical outcomes, VAS and the index scores were described for the APPLE Schools and the Provincial average. The outcomes of interests include HRQOL, expressed by the EQ-5D-Y VAS, VAS based index and TTO-based index scores, and the prevalence of health problems in each of the EQ-5D-Y dimensions. Multilevel regression methods were used, with adjustment for potential confounding of the socio-demographic variables. The multilevel regression accommodated hierarchical data structure, in that student observations are nested within their schools.

Multilevel linear regression was used to quantify changes in HRQOL scores (VAS or index) from 2008 to 2010. Multilevel logistic regression was used to analyze the probability of reporting health problems in the EQ-5D-Y dimensions in 2010 relative to 2008. Since there were small number of students reporting ‘a lot of problems’ for each dimension, ‘some problems’ and ‘a lot of problems’ were combined to create a dichotomous outcome (i.e., any problems vs. no problems) for analysis. To compare the difference in HRQOL changes over time between the two school groups, I included an additional variable in the regression analysis that permits examination of the interaction between the group and survey time (group × time interaction) and adjusted for socio-demographic covariates of gender, residency, household income, and parental education.

Multilevel linear regression models are expressed as:

$$E(QOL) = \beta_{0j} + \beta_1 \text{group}_{ij} + \beta_2 \text{year}_{ij} + \beta_3 \text{group}_{ij} \times \text{year}_{ij} + \beta_4 \text{gender}_{ij} + \beta_5 \text{region}_{ij} + \sum_k \beta_{6k} \text{education}_{ijk} + \sum_k \beta_{7k} \text{income}_{ijk} + \varepsilon_{ij}$$

Multilevel logistic regression models are specified as:

$$\text{Logit}[P(\text{QOL}_D)] = \beta_{0j} + \beta_1 \text{group}_{ij} + \beta_2 \text{year}_{ij} + \beta_3 \text{group}_{ij} \times \text{year}_{ij} + \beta_4 \text{gender}_{ij} + \beta_5 \text{region}_{ij}$$
$$+ \sum_k \beta_{6k} \text{education}_{ijk} + \sum_k \beta_{7k} \text{income}_{ijk}$$

Where E(QOL)-predicted VAS, or VAS index, or TTO-based index score; i-ith student; j-jth school; k-kth dummy variable for the categorical variables; D-each of the five dimensions; group- APPLE Schools or REAL Kids Alberta group.

It was hypothesized that after two years of interventions, children in the APPLE Schools group would show statistically significant improvement in VAS or VAS-based index or TTO-based index, and the magnitude of the change scores would be greater than the changes in HRQOL among children in the REAL Kids Alberta group. The null hypothesis was that there was no significant change in the child HRQOL in the APPLE schools over the two-year period of interventions. P-values<0.05 were considered as statistically significance in distinguishing between group differences in HRQOL. To facilitate interpretation of the changes in HRQOL occurred over two years among students in the APPLE Schools, and the differences in the HRQOL between APPLE Schools and the Alberta average, a mean difference of 7.0 for VAS, and 0.07 points, for VAS-based index and US TTO-based index was used as minimally important differences (MIDs) in HRQOL scores between comparison groups (26-27).

Missing values for family income and parental education were entered as separate covariate categories in the analysis. All analyses pertaining to the randomly selected schools were weighted to accommodate the design effect such that all estimates represent the population of grade five students in Alberta. Data were analyzed using STATA 11.0 (Stata Corp, College Station, TX, USA).

5.3 Results

Characteristics of grade five students by socio-demographic factors, and HRQOL are presented in table 5-1. Relative to 2008, there were more students in 2010 reporting HRQOL problems in 'walking'. Students in Alberta reported a lower rate of problems in 'feeling worried, sad or unhappy' in 2010 compared to 2008. Mean VAS score for students in the Alberta sample increased and in the APPLE schools group decreased about one unit respectively from 2008 to 2010 (table 5-1).

Table 5-2 shows the adjusted odds ratio of reporting problems on each of the EQ-5D-Y dimensions. Students in RealKids Alberta group in 2010 were more likely to report HRQOL problems relative to 2008 in 'walking', after controlling for the effect of socio-demographic variables, and the interaction between survey time and the intervention group. There was no significant difference in the change over time in the probability of reporting problems in each of the EQ-5D-Y dimensions among children between the APPLE Schools and the provincial average ($P>0.05$). Comparing changes to students in the rest of Alberta, the odds of reporting problems in the domain of 'walking' was 43% higher for students in the APPLE Schools. However, the difference of the odds change between the school groups was not statistically significant ($P=0.103$).

Compared to metropolitan students, students in other city, and rural-town were more likely to experience HRQOL problems in ‘doing usual activities, having pain or discomfort’ adjusting for the intervention effect. Students with higher parental educational level (university or above) were less likely to have problems in ‘walking and having pain or discomfort’.

Table 5-3 presents the HRQOL measured by VAS and the changes over the two years. The interaction between school group and intervention time was not statistically significant (P=0.27), suggesting there is no evidence of a significant decrement in VAS over time for the APPLE Schools compared with other Alberta schools.

Table 5-4 shows VAS-based index, and US TTO-based index over the two years. Compared with the HRQOL in 2008, students in 2010 samples did not show statistically significant differences in VAS-based index, and US TTO-based index either in the APPLE Schools or the Alberta group. Similarly, no statistically significant difference in the change of the two index values over time was observed between APPLE Schools and the provincial average though the index value showed a decrease among the APPLE Schools.

Socio-demographic differences in VAS, VAS-based index and US TTO-based index remained after the adjustment for the intervention effect. Boys relative to girls, metropolitan residency relative to rural-town and other cities, children from families with more educational attainment and more income experienced better HRQOL.

Examination of the magnitude of the difference in HRQOL among groups and of the change score over time indicated that the observed differences in HRQOL scores between the groups were smaller than 7.0 for VAS or 0.07 points for the index. These differences did not reach MIDs in magnitude and should not be considered to have an important implication on changes of public health policy for health interventions.

5.4 Discussion

This study examined HRQOL changes over two years when a school-based program promoting healthy eating and active living was being implemented. The study observed that promoting healthy eating and active living did not show statistically significant improvements in HRQOL among grade five students when considering socio-demographic factors. Compared to pre-intervention, there was not a significant difference ($p>0.05$) after two years of the intervention in VAS, VAS index and the TTO-based index for both the APPLE Schools and provincial average. Also, no statistically significant difference was observed comparing changes in HRQOL among students in the APPLE Schools and students in the rest of the province. It appeared that the result was mostly driven by the ‘walking’ responses. Students in 2010 were more likely to report walking problems compared to their counterparts in 2008.

The socio-demographic differences in HRQOL in terms of residency, parental educational attainment and family income remain consistent with our earlier study based on 2008 data (28). Further, the results across categories of socio-demographic variables were very similar between the VAS-based index and the US TTO-based index. The observation that girls, children with less familial education exhibited lower HRQOL than boys, and children in families with higher educational level is consistent with some previous HRQOL studies in childhood (29, 30).

The intervention from APPLE Schools program has shown positive effects on diet and physical activity levels, and on reducing childhood obesity (23). The results for HRQOL from present study seem to be inconsistent with the findings that better diet and more PA are associated with better HRQOL. To my best knowledge, this study is the first to evaluate a school-based CSH program on HRQOL in a sample of grade five students. Little research has been conducted to examine the impact of school-based PA and/or diet interventions on HRQOL in children. A school-based PA intervention study from a cluster randomized trial of elementary schools in Switzerland also showed little effect on HRQOL in grade five students over one-year period of the intervention (31). There is a lack of comparative studies that evaluate the association between a school-based multi-component promotion of healthy eating and active living and HRQOL and the pattern of changes of HRQOL over time among school age children. For the results in the current study, several factors may help explain the insignificant improvement in HRQOL after two years from inception of the intervention.

One possible explanation may be due to different samples across/within school groups over the two years. We investigated independent samples of grade five students in two years among the same schools that was based on a repeated cross sectional survey design, as the objective of the intervention is to change the school environment. Unlike cohort studies, the individual changes in HRQOL over time were not captured in this study. HRQOL of students may be different in different years, across schools or classes, or among different families. Students and parents at APPLE Schools may choose to leave the schools during the intervention period due to new schools openings or change of residence location, leading to shorter period of exposure to the intervention. The positive HRQOL change over time in this study may be diluted by the effect from students who moved into or out of the APPLE schools during two-year period of the intervention (32). The disparities in characteristics of the students between the APPLE Schools and the Alberta sample may also contribute to the insignificant difference in HRQOL between the two groups. Although multilevel analysis accounted for the difference in the outcome by schools, characteristics of families of the students in the two samples were different. Participation rates were higher in APPLE Schools (85% in 2008 and 84% in 2010) than the rest of other schools in the province (61.2% in 2008 and 60.7% in 2010). The effect of the intervention on HRQOL among RealKids Alberta schools may be affected by non-response bias if some characteristics of the students were potentially different from APPLE Schools.

Students in APPLE Schools may change the ‘point of reference’ in rating their HRQOL after the intervention, resulting in underestimation of their HRQOL in 2010. For example, students in APPLE School may see school health facilitators as ‘health role models’ and herewith think themselves ‘walk better than before (reference in 2008) but not walk better than the school health facilitator (reference in 2010)’. Thus, children may score differently during the intervention period from pre-intervention.

The CSH interventions aim to improve children’s health status by modifying the whole school social and physical environment. Children in the APPLE Schools were engaged in more healthy living activities than other schools in the province. There may also be unintended consequences from the primary intervention that have led to the current observations. Obese children or children with other chronic conditions may experience limitations due to increased amount of physical activities, thus feel more marginalized than healthy children. As Frolich and Potvin described, population health intervention may increase disparities in health (33). However, since we did not collect information of diagnosed disease conditions, we were not able to analyze and confirm the possible unintended consequences. Future research is recommended to examine how various disease conditions could contribute to the variance in the HRQOL over time.

In addition, I did not include the analysis of the effect of interventions on HRQOL in students with different weight status as the number of obese students was small in the APPLE Schools. As the CSH model is implemented among more schools in Alberta, it is hoped to analyze how and to what extent the HRQOL varies with changes of weight status among students in the near future (21).

In the assessment of intervention effect on HRQOL and interpretation of the changes/differences in HRQOL among sub-groups of children and youth, it is also essential to consider minimally important differences (MIDs) in HRQOL between comparison groups to determine whether the magnitude of the difference/change also is clinically important /meaningful (34). The psychometric properties of the EQ-5D-Y have been previously examined among children and youth and demonstrated evidence of feasibility, reliability and convergent validity. However, no published study so far has specifically examined the responsiveness of the instrument in population health studies. Responsiveness is defined as the ability of a HRQOL measure to detect clinically important changes over time (35). It is not clear whether the EQ-5D-Y is sensitive to identify a MID when QOL changes occur. As no prior study has evaluated pre-post changes in child HRQOL from primary prevention program using the EQ-5D-Y, we used a MIDs score (0.07) provided by earlier studies for the EQ-5D index from adult patients cohorts (27, 36). Other prior studies suggest using a score of 0.03 as an estimation of MID for the EQ-5D, which is approximately equivalent to the MID for SF-6D (37-38). Estimation of MIDs in HRQOL scores for EQ-5D-Y is beyond the scope of this study as it requires a specific design and different analytical methods, both distribution-based and anchor-based approaches may be needed (39). Future research is warranted to investigate threshold scores for MID for the EQ-5D-Y that can be used in child and youth populations.

The EQ-5D-Y, corresponding to the adult version of EQ-5D-3L, provides three levels of severity in five dimensions. The ceiling effect of the EQ-5D and EQ-5D-Y is a common problem (40). The limited number of response levels of the EQ-5D-Y may reduce the sensitivity to discriminate HRQOL changes over time. To reduce the ceiling effect and improve the sensitivity of the EQ-5D, a 5-level version of the EQ-5D (EQ-5D-5L) has been developed and undergone psychometric tests in adult patients (41-42). Previous studies have shown that EQ-5D-5L has less ceiling effect and are more sensitive to detect differences between groups (42). However, it is not clear whether it is also feasible to increase severity levels from 3 to 5 among children and youth version of the measure. At the moment, there is no child/youth version of EQ-5D-5L available.

The major strengths of the present study include the availability of the identical survey data for the two groups that allows for comparisons of the outcome between the two years in each group as well as comparisons between the two groups in the same year; the use of a previous-validated HRQOL measure; the analysis to adjust for potential confounders; and the application of multilevel regressions with weighted analysis to account for hierarchical data structure and survey design effects.

Efforts should also be made to clarify the limitations of this study. Since participation in the survey was voluntary, selection bias may have affected the findings. Since we investigated only grade five students and their parents in this study, caution needs to be taken to genralize the findings to other age groups of children in the province. All analyses in the present study were based on secondary data. I had no control over the study design and the data collection.

5.5 Conclusions

This study attempts to address the influence of a school-based program promoting active living & healthy eating on HRQOL in grade five students in Canada. The results from the initial two-year period of primary intervention did not provide evidence from significant improvement in HRQOL whereas diet and PA improved over the same period. Future research is needed to explore what factors underlie the observed pattern of the HRQOL change in the present study. The result also suggests a need to examine the magnitude and direction of the HRQOL changes/differences among subgroups by weight status and various diseases in childhood. Further examination of the ability of EQ-5D-Y in detecting minimally important differences and responsiveness to changes is also recommended.

Table 5-1 Socio-demographic characteristics and HRQOL among grade five students over the two years by the intervention groups

Variable	APPLE Schools		REAL Kids Alberta Schools	
	2008 (n=293)	2010 (n=394)	2008 (n=3,421)	2010 (n=3,398)
Gender %				
Girls	50.9	56.4	51.5	50.5
Boys	49.1	43.6	48.5	49.5
Residential area %				
Metropolitan	64.5	63.4	46.8	46.6
City and Rural -Town	35.5	36.6	53.2	53.4
Parents' education %				
Secondary or less	30.8	23.3	26.8	25.2
Postsecondary or college	40.3	42.5	39.8	39.3
University or above	28.9	34.2	33.4	35.6
Household income %				
≤$50,000	35.0	30.0	23.9	24.0
$50,001 - $75,000	23.5	20.2	17.6	17.6
$75,001 - $100,000	14.8	22.1	22.2	20.4
>$100,000	26.8	27.7	36.3	38.0
Walking %				
No problems	93.5	88.7	91.9	89.8
Some problems	5.8	10.5	7.6	9.4
A lot of problems	0.7	0.8	0.4	0.8
Looking after myself %				
No problems	92.1	93.9	93.5	94.9
Some problems	6.9	4.3	6.2	4.5
A lot of problems	1.0	1.8	0.3	0.6
Doing usual Activities %				
No problems	86.3	86.3	88.1	89.0
Some problems	12.3	12.7	11.5	10.3
A lot of problems	1.4	1.0	0.4	0.8
Having pain or discomfort %				
No problems	53.2	52.2	54.1	54.4
Some problems	44.0	43.3	43.0	41.8
A lot of problems	2.7	4.6	2.9	3.8
Feeling worried, sad or unhappy %				
No problems	64.0	62.6	62.4	65.4
Some problems	32.2	32.1	34.6	30.8
A lot of problems	3.8	5.3	3.0	3.8
VAS score (95%CI)	78.1 (76.0, 80.2)	77.2 (75.2, 79.2)	80.4 (79.7, 81.0)	81.4 (80.8, 82.1)
VAS-based index (95%CI)	0.884 (0.867, 0.900)	0.876 (0.862, 0.891)	0.889 (0.884, 0.893)	0.890 (0.886, 0.895)
TTO-based index (95%CI)	0.854 (0.836, 0.872)	0.842 (0.825, 0.860)	0.860 (0.855, 0.866)	0.856 (0.850, 0.862)

Table 5-2 Odds ratio of reporting problems for each dimension of the EQ-5D-Ycomparing 2010 to 2008 by the intervention groups

Variable	**Walking**		**Looking after myself**		**Doing usual activities**		**Having pain or discomfort**		**Feeling worried, sad or unhappy**	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
Year 2010 (Reference: 2008)	1.30 (1.08, 1.56)	0.005	0.77 (0.61, 0.98)	0.034	0.92 (0.78, 1.09)	0.356	1.00 (0.89, 1.11)	0.943	0.88 (0.77, 1.00)	0.055
APPLE Schools (Reference: REALKids Alberta schools)	0.78 (0.61, 1.00)	0.052	1.17 (0.75, 1.82)	0.485	1.19 (0.85, 1.68)	0.315	1.06 (0.81, 1.38)	0.680	0.89 (0.68, 1.18)	0.425
Year 2010 × APPLE Schools	1.43 (0.93, 2.19)	0.103	1.00 (0.55, 1.83)	0.995	1.10 (0.72, 1.69)	0.653	1.06 (0.69, 1.62)	0.800	1.19 (0.85, 1.67)	0.322
Gender (Boys relative to girls)	0.99 (0.83, 1.19)	0.931	1.24 (1.00, 1.53)	0.052	0.91 (0.77, 1.08)	0.269	0.98 (0.88, 1.08)	0.659	0.59 (0.53, 0.66)	0.000
Residential area (Reference: metropolitan)										
City-Rural -Town	1.07 (0.87, 1.32)	0.508	0.97 (0.73, 1.28)	0.817	1.35 (1.13, 1.62)	0.001	1.19 (1.06, 1.33)	0.003	0.99 (0.87, 1.12)	0.814
Parents' education (Reference: secondary or below)										
Postsecondary or college	0.93 (0.76, 1.15)	0.522	0.94 (0.73, 1.21)	0.621	0.86 (0.69, 1.08)	0.188	0.90 (0.79, 1.01)	0.081	0.93 (0.80, 1.08)	0.334
University or above	0.74 (0.57, 0.96)	0.022	1.18 (0.84, 1.64)	0.341	0.83 (0.66, 1.05)	0.128	0.81 (0.70, 0.93)	0.003	0.87 (0.74, 1.02)	0.082
Household income (Reference: ≤$50,000)										
$50,001 - $75,000	1.18 (0.86, 1.62)	0.315	1.39 (0.88, 2.21)	0.156	1.35 (1.05, 1.75)	0.020	1.20 (0.98, 1.48)	0.077	0.97 (0.79, 1.20)	0.782
$75,001 - $100,000	1.01 (0.75, 1.35)	0.969	1.11 (0.76, 1.63)	0.574	0.87 (0.64, 1.18)	0.382	1.02 (0.83, 1.25)	0.874	0.87 (0.71, 1.06)	0.163
>$100,000	0.90 (0.69, 1.18)	0.457	0.81 (0.59, 1.12)	0.202	0.72 (0.58, 0.89)	0.003	0.96 (0.81, 1.13)	0.632	0.88 (0.75, 1.04)	0.122

Table 5-3 Regression coefficients and confidence intervals for the VAS scores comparing changes between 2008 and 2010 among the intervention schools

Variable	**Coefficient**	**(95% CI)**	**P value**
Constant	78.51	(76.81, 80.21)	0.000
Year 2010 (Reference: 2008)	1.02	(-0.16, 2.20)	0.089
APPLE Schools (Reference: REAL Kids Alberta schools)	-2.62	(-5.11, -0.14)	0.039
Year 2010 × APPLE Schools (score change of APPLE Schools relative to REAL Kids Alberta schools)	-1.99	(-5.53, 1.54)	0.269
Gender (Boys relative to girls)	0.75	(-0.17, 1.66)	0.108
Residential area (Reference: metropolitan)			
City -Rural -Town	0.25	(-1.10, 1.61)	0.715
Parents' education (Reference: secondary or below)			
Postsecondary or college	0.42	(-0.68, 1.53)	0.455
University or above	1.24	(0.17, 2.30)	0.023
Household income (Reference: ≤$50,000)			
$50,001 - $75,000	-1.28	(-3.40, 0.83)	0.234
$75,001 - $100,000	0.87	(-0.99, 2.72)	0.362
>$100,000	2.50	(0.97, 4.02)	0.001

Table 5-4 Regression coefficients and confidence intervals for the VAS-based index and US TTO-based index comparing changes between 2008 and 2010 among the intervention schools

Variable	VAS-based index			US TTO-based index		
	Coefficient	**(95% CI)**	**P value**	**Coefficient**	**(95% CI)**	**P value**
Constant	0.875	(0.863, 0.886)	0.000	0.845	(0.831, 0.860)	0.000
Year 2010 (Reference: 2008)	0.002	(-0.005, 0.009)	0.662	-0.005	(-0.013, 0.003)	0.209
APPLE Schools **(**Reference: REAL Kids Alberta schools)	-0.004	(-0.016, 0.008)	0.519	-0.005	(-0.016, 0.006)	0.329
Year 2010 × APPLE Schools (score change of APPLE Schools relative to REAL Kids Alberta schools)	-0.009	(-0.025, 0.006)	0.231	-0.008	(-0.027, 0.011)	0.421
Gender (Boys relative to girls)	0.013	(0.006, 0.020)	0.000	0.010	(0.001, 0.018)	0.022
Residential area **(**Reference: metropolitan)						
City - Rural -Town	-0.011	(-0.019, -0.003)	0.005	-0.015	(-0.025, -0.006)	0.002
Parents' education (Reference: secondary or below)						
Postsecondary or college	0.008	(0.000, 0.016)	0.066	0.010	(0.000, 0.021)	0.050
University or above	0.015	(0.005, 0.024)	0.002	0.023	(0.011, 0.034)	0.000
Household income (Reference: ≤$50,000)						
$50,001 - $75,000	-0.011	(-0.025, 0.002)	0.096	-0.011	(-0.028, 0.006)	0.190
$75,001 - $100,000	0.007	(-0.005, 0.019)	0.229	0.010	(-0.004, 0.024)	0.154
>$100,000	0.013	(0.004, 0.023)	0.006	0.012	(-0.001, 0.024)	0.079

5.6 References

(1) Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360(9331)(Aug 10): 473-482.

(2) Reilly JJ, Kelly J. Long-term impact of overweight and obesity in ch ildhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *Int J Obes (Lond).* 2011 Jul; 35(7): 891-898.

(3) Choudhary AK, Donnelly LF, Racadio JM, Strife JL. Diseases associated with childhood obesity. *AJR Am J Roentgenol* 2007 Apr; 188(4): 1118-1130.

(4) Ball GD, McCargar LJ. Childhood obesity in Canada: a review of prevalence estimates and risk factors for cardiovascular diseases and type 2 diabetes. *Can J Appl Physiol* 2003 Feb; 28(1): 117-140.

(5) Wang F, Veugelers PJ. Self-esteem and cognitive development in the era of the childhood obesity epidemic. *Obes Rev* 2008 Nov; 9(6): 615-623.

(6) Li Y, Dai Q, Jackson JC, Zhang J. Overweight is associated with decreased cognitive functioning among school-age children and adolescents. *Obesity (Silver Spring)* 2008 Aug; 16(8): 1809-1815.

(7) Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, et al. Health-related quality of life in obese children and adolescents. *Int J Obes (Lond)* 2009 Apr; 33(4): 387-400.

(8) Foster GD, Sherman S, Borradaile KE, Grundy KM, Vander Veur SS, Nachmani J, et al. A policy-based school intervention to prevent overweight and obesity. *Pediatrics* 2008 Apr; 121(4): e794-802.

(9) Kolbe LJ, Collins J, Cortese P. Building the capacity of schools to improve the health of the nation. A call for assistance from psychologists. *Am Psychol* 1997 Mar; 52(3): 256-265.

(10) Stewart-Brown S. What is the evidence on school health promotion in improving health or preventing disease and, specifically, what is the effectiveness of the health promoting schools approach? Copenhagen: WHO Regional Office for Europe, 2006. Health Evidence Network report. 2006; [http://www.euro.who.int/document/e88185.pdf]. (Accessed March 11, 2011).

(11) Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev* 2009 Jan; 10(1): 110-141.

(12) Veugelers PJ, Fitzgerald AL. Effectiveness of school programs in preventing childhood obesity: a multilevel comparison. *Am J Public Health* 2005 Mar; 95(3): 432-435.

(13) Joint Consortium for School Health. What is Comprehensive School Health? [http://www.jcsh-cces.ca/index.php?option=com_content&view=article&id=40&Itemid=62]. (Accessed February 11, 2011).

(14) Lister-Sharp D, Chapman S, Stewart-Brown S, Sowden A. Health promoting schools and health promotion in schools: two systematic reviews. *Health Technol Assess* 1999; 3(22): 1-207.

(15) Yackobovitch-Gavan M, Nagelberg N, Phillip M, Ashkenazi-Hoffnung L, Hershkovitz E, Shalitin S. The influence of diet and/or exercise and parental compliance on health-related quality of life in obese children. *Nutr Res* 2009 Jun; 29(6): 397-404.

(16) Shoup JA, Gattshall M, Dandamudi P, Estabrooks P. Physical activity, quality of life, and weight status in overweight children. *Qual Life Res.* 2008 Apr; 17(3): 407-412.

(17) Chen X, Sekine M, Hamanishi S, Yamagami T, Kagamimori S. Associations of lifestyle factors with quality of life (QOL) in Japanese children: a 3-year follow-up of the Toyama Birth Cohort Study. *Child Care Health Dev* 2005 Jul; 31(4): 433-439.

(18) Wu XY, Ohinmaa A, Veugelers PJ. Diet Quality, Physical Activity, Body Weight and Health-Related Quality of Life Among Grade Five Students in Canada. *Public Health Nutr.* 2011 Oct 4: 1-7. [Epub ahead of print]

(19) Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J Am Diet Assoc* 1995 Mar; 95(3): 336-340.

(20) Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, Devlin N, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D. *Qual Life Res.* 2010 Aug; 19(6): 875-886.

(21) APPLLE Schools. [http://www.appleschools.ca/docs/APPLE_backgrounderNov11.pdf] (Accessed Aug.31, 2012).

(22) Schwartz M, Karunamuni ND, Veugelers PJ. Tailoring and implementing comprehensive school health: The Alberta Project Promoting active Living and healthy Eating in Schools. *Physical & Health Education Academic Journal* 2010; Vol 2(No1).

(23) Fung C, Kuhle S, Lu C, Purcell M, Schwartz M, Storey K, Veugelers PJ. From "best practice" to "next practice": the effectiveness of school-based health promotion in improving healthy eating and physical activity and preventing

childhood obesity. *Int J Behav Nutr Phys Act.* 2012 Mar 13; 9(1): 27. [Epub ahead of print].

(24) Ravens-Sieberer U, Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, et al. Feasibility, reliability, and validity of the EQ-5D-Y: results from a multinational study. *Qual Life Res.* 2010 Aug; 19(6): 887-897.

(25) Wu XY, Ohinmaa A, Veugelers PJ. Assessment of children's own health status using visual analogue scale and descriptive system of the EQ-5D-Y: Linkage between two systems [submitted].

(26) Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states: development and testing of the D1 valuation model. *Med Care* 2005 Mar; 43(3): 203-220.

(27) Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res.* 2005 Aug; 14(6): 1523-1532.

(28) Wu XY, Ohinmaa A, Veugelers PJ. Sociodemographic and neighbourhood determinants of health-related quality of life among grade-five students in Canada. *Qual Life Res.* 2010 Sep; 19(7): 969-976.

(29) Michel G, Bisegger C, Fuhr DC, Abel T, KIDSCREEN group. Age and gender differences in health-related quality of life of children and adolescents in Europe: a multilevel analysis. *Qual Life Res.* 2009 Nov; 18(9): 1147-1157.

(30) von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. *J Epidemiol Community Health* 2006 Feb; 60(2): 130-135.

(31) Hartmann T, Zahner L, Puhse U, Puder JJ, Kriemler S. Effects of a school-based physical activity program on physical and psychosocial quality of life in elementary school children: a cluster-randomized trial. *Pediatr Exerc Sci* 2010 Nov; 22(4): 511-522.

(32) Diehr P, Martin DC, Koepsell T, Cheadle A, Psaty BM, Wagner EH. Optimal survey design for community intervention evaluations: cohort or cross-sectional? *J Clin Epidemiol* 1995 Dec; 48(12): 1461-1472.

(33) Frohlich KL, Potvin L. The inequality paradox: the population approach and vulnerable populations. *Am J Public Health* 2008; 98: 216–221.

(34) Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials* 1989; 10(4): 407-415.

(35) Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, Bouter LM,de Vet HC. Quality criteria were proposed for measurement properties of health status questionnaires. *J Clin Epidemiol.* 2007 Jan; 60(1): 34-42.

(36) Pickard AS, Neary MP, Cella D.Estimation of minimally important differences in EQ-5D utility and VAS scores in cancer. *Health Qual Life Outcomes*. 2007 Dec 21; 5: 70.

(37) Kontodimopoulos N, Pappa E, Papadopoulos AA, Tountas Y, Niakas D. Comparing SF-6D and EQ-5D utilities across groups differing in health status. *Qual Life Res.* 2009 Feb; 18(1): 87-97.

(38) Walters SJ, Brazier JE. What is the relationship between the minimally important difference and health state utility values? The case of the SF-6D. *Health Qual Life Outcomes.* 2003 Apr 11; 1: 4.

(39) Lydick E, Epstein RS. Interpretation of quality of life changes. *Qual Life Res.* 1993 Jun; 2(3): 221-226.

(40) Bharmal M, Thomas J,3rd. Comparing the EQ-5D and the SF-6D descriptive systems to assess their ceiling effects in the US general population. *Value Health* 2006 Jul-Aug; 9(4): 262-271.

(41) Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, Bonsel G, Badia X. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L*).* *Qual Life Res*. 2011 Dec; 20(10): 1727-36.

(42) Pickard AS, De Leon MC, Kohlmann T, Cella D, Rosenbloom S. Psychometric comparison of the standard EQ-5D to a 5 level version in cancer patients. *Med Care*. 2007 Mar; 45(3): 259-63.

Chapter 6 – Discussion

<u>6.1 Key Findings</u>

This thesis research revealed new insights on determinants of health-related quality of life among grade five students in Alberta, Canada, and how a school-based program promoting healthy eating and active living in schools influences the HRQOL of the students. The key findings of this study are summarized as follows.

The first study (Chapter 2) revealed the importance of socio-demographic and neighbourhood characteristics in determining HRQOL of the grade five students. Students in schools in towns and rural areas, and students with parents having a lower educational attainment, had lower HRQOL than students residing in urban and with higher parental educational attainment. Parents' perception of their neighbourhoods characterized as satisfaction with living in them and access to services was shown to be a strongest determinant of HRQOL of the children among the three kinds of neighbourhood characteristics.

The second study (Chapter 3) showed that diet quality, physical activity, and body weight were associated with the HRQOL in grade five students, and the associations were independent of socio-demographic factors. Children who had better diet quality, were physically active and were normal weight, reported a higher HRQOL relative to their peers with lower diet quality, inactive lifestyle and overweight (or obese) status.

The third study (Chapter 4) sought to estimate a value set to generate index values for EQ-5D-Y health states. The result showed that the VAS-based index exhibited expected values, with lower values for health states that were logically worse. Children who reported having problems on any dimension had consistently lower VAS scores than children with no problems. There was no statistically significant difference between the observed and the predicted VAS values in this sample ($P>0.05$). The goodness of fit test statistics (Table 4-4) with regard to correlations and mean absolute errors of prediction between the observed and estimated VAS indicated that the estimation model fits the observed data well. VAS-based index was highly correlated with the US TTO-based index ($r=0.90$), though the VAS-based index was slightly higher than the TTO-based index for some extreme health states.

The fourth study (Chapter 5) was designed to investigate the influence of a CSH intervention, the APPLE Schools program focusing on promotion of healthy eating and active living, on the HRQOL of the grade five students. Compared with the pre-intervention (2008) measurement, students in 2010 did not show statistically significantly different HRQOL in terms of VAS, VAS-based index, and US TTO-based index scores both in the APPLE Schools or other Alberta schools. There was not a statistically significant difference in the childhood

HRQOL changes between APPLE Schools and other schools in Alberta (P>0.05).

6.2 Validity and Reliability of the Data

6.2.1 HRQOL Measurement

The feasibility, reliability, and validity of the EQ-5D-Y have been demonstrated using multinational samples of children and youth, including Germany, Italy, South Africa, Spain, and Sweden (2). The instrument showed high feasibility for HRQOL measurement in children. Test–retest reliability was examined and demonstrated. Validity of the instrument was tested by comparing the performance of the instrument with several other measures (2). The present study confirms the feasibility of this instrument in a population-based sample of Canadian children as very few grade five students did not answer all the questions. Also, our research added evidence to the validity of the questionnaire in Canadian context in that VAS score showed a convergence with the US EQ-5D index in identifying sub-group differences in HRQOL by sociodemographic and neighbourhood characteristics (1). One common problem of the EQ-5D and the EQ-5D-Y is the ceiling effect as it has only three levels for each question to indicate the severity of the problem. The ceiling effect of the EQ-5D has been demonstrated in adult population health studies (3). Our first study showed 37.8% of the respondents reporting ‘no problem’ on all the five dimensions. In comparison with some other studies for the EQ-5D among adults, the ceiling effect in this EQ-5D-Y study was less pronounced (1, 3).

6.2.2 Overweight and Obesity Assessment

This study used objective measurement of height and weight, and calculated BMI for each student. Body weight was then classified as normal weight, overweight or obese using the BMI cut-off criterion for children and youth developed by the International Obesity Taskforce (4). These cut-offs are based on adult definitions of overweight (25 kg/m2 or more) and obesity (30 kg/m2 or more), adjusted to specific age and gender for children. The International Obesity Taskforce cut-offs are now widely used in children and adolescents.

6.2.3 Diet Quality Assessment

Based on the student responses to the Harvard Youth & Adolescent Food Frequency Questionnaire (YAQ) (5) and Canadian food table (6), we calculated the Diet Quality Index (DQI), which scales from 0 to 100, with 100 indicating highest diet quality (7). The YAQ has been previously validated, and it is suitable for grade five students (8). The DQI is a composite measure that encompasses variety, adequacy, moderation, and overall balance of diet (7). The questionnaire can be used to evaluate public health programs promoting healthy eating habits in developed and developing countries (7).

6.2.4 Physical Activity Assessment

In the survey, the physical activity of the students was assessed using the Physical Activity Questionnaire for Children (PAQ-C) (9). The PAQ-C is a 7-day recall questionnaire developed to assess general physical activity levels for children in grade four and higher. It has been validated and showed convergent and discriminate validity with several other PA questionnaires (10). I used a composite score that summarized each aspect of the physical activity included in the questionnaire.

6.3 Strengths and Limitations of the Study

Several strengths of the present study should be highlighted. 1) The study is based on a large sample of students that represents well grade five students in Alberta. 2) Weight classification was based on objective measurement of height and weight, which makes it less subject to measurement error. 3) All the measures used in this study have previously undergone psychometric testing, and been demonstrated to be valid and reliable. 4) Application of multilevel regression to account for hierarchical data structure and of weighted analyses to accommodate the design effect is another important strength of the present study. 5) In the examination of the effect of school health intervention on HRQOL of the students, the availability of the identical survey data for the APPLE Schools and the Alberta sample allows for comparisons in the outcome between the two years in each group and cross-sectional comparisons between the two groups in the same year. 6) As far as I know, this study is the first study to include neighbourhood characteristics and diet quality in the analysis of HRQOL in school age children, and the first to assess the HRQOL changes associated with a CSH program.

It is also worth noting the limitations of this study. Since participation in the survey is voluntary, selection bias may have occurred and affected the results. With cross-sectional survey design, the associations observed in this study, including the relations between neighbourhood and HRQOL, between diet quality, PA, body weight and HRQOL could not be inferred as causality. Cautions also need to be taken to suggest a conclusive evidence of a causal relationship for HRQOL changes over the two years associated with the programs in this study due to the complex relationships between health promotion efforts and changes in health outcomes. A variety of evidences from quantitative and qualitative research would warrant a causal influence of the health and wellness initiatives on health and HRQOL values (11,12). The study analysed data based only on grade five students primarily aged between 10 and 11 years and their parents, which limits the ability to generalize the finding to other age groups of children in the province. In the survey, the information from diagnosed disease conditions was not collected, and thus it is not possible to account for the effect of potential difference in the distribution of diseases on the HRQOL in the subgroups of samples. In addition, all analyses in the present study were based on secondary data, for which the study design, data selection and collection were pre-determined.

6.4 Implications for Future Research and Public Health Policy

This study provides implications for public health policy and suggestions for future research to enhance HRQOL and health equity among children. The study findings suggest that public health initiatives that aim to improve HRQOL in childhood should consider the importance of socio-demographic and neighbourhood characteristics on outcomes, and give priorities for intervention strategies that are directed to children living in towns and rural areas, in families with lower education and lower income levels, and in neighbourhoods with poor access to services and lower parental satisfaction.

The disparities of HRQOL among socio-demographic variables of parental educational attainment and family income were consistently observed in the province over the two years, and these observations were mostly consistent with some other HRQOL studies among children and youth (13-14), indicating the necessity to account for these factors in the intervention. As poor diet quality, physical inactivity and overweight status have been shown to influence HRQOL in school children, promotion of healthy eating and active living to reduce the burden of childhood overweight and obesity should also be a continuous focus in the design and development of school health intervention programmes.

The study showed higher prevalence of HRQOL problems in the pain or discomfort dimension of EQ-5D-Y in Alberta children relative to similar studies in European countries (15). Further research is needed to examine the underlying factors for the high prevalence of problems in this dimension in Alberta. Extended research using EQ-5D-Y in other provinces in Canada and other countries may help ascertain the root factors for the higher number of HRQOL problems in the current study. Future research is also suggested to conduct similar investigations among other age groups of children and youth in Canada to confirm the above observations.

The study constructed an index value set for EQ-5D-Y that is based on self-rated VAS values from a sample of grade five students in Alberta (chapter 4). The goodness of fit statistics shows that the model fits the data well. The VAS-based index based on child self-rated health suggests that children assign a value on VAS scale for their own health logically. The health state values rated by young people themselves may be useful in describing their HRQOL. Future studies are required to further test the psychometric properties of this type of value set among different age groups of children and among children with diagnosed diseases. For the purpose, more research is needed to test the validity and reliability of this kind of value set by comparing the performance with the US adult EQ-5D TTO-based scoring systems. Also, future studies are recommended to integrate preference-based valuation approaches for EQ-5D-Y and compare performance properties between the value set that is based on self-rated VAS and the value sets that are based on different hypothetical health states valuation techniques.

Analysis for the HRQOL data from the sample did not show a statistically significant improvement in HRQOL over two-year period among students received primary prevention programs in Alberta (chapter 5). The present finding urges further school-based intervention studies to address the relations between HRQOL and the measured variables. Evaluations and analyses for CSH intervention programs in the future are recommended to include more students from more schools among a variety of residential areas to allow for subgroup comparisons in terms of socio-demographic characteristics, weight status and school characteristics. As CSH approach has been expanding to include additional 30 APPLE Schools throughout the province of Alberta, it would be expected that ongoing evaluations from the new APPLE Schools will address the benefits of the APPLE Schools intervention for health-related quality of life of school children. The findings from this study suggest that future studies go further to examine the whether the EQ-5D-Y is sensitive to identify clinically important differences/changes among subgroups of children. This will help judge the broader implementation of school health promotion, and ongoing investments in such programs to benefit childhood obesity prevention as well as health-related quality of life of children.

6.5 Conclusions

This study has demonstrated that residential area, parental educational attainment, household income and neighbourhood satisfaction/service are important factors that influence HRQOL of grade five students in Alberta. Diet quality, physical activity, and weight status are essential determinants of HRQOL. The index value set that was based on child self-rated VAS values produces parameter estimates that meet the expectation, where worsening health states correspond consistently to lower index values. School-based program promoting active living & healthy eating that was successful in improving diet and PA among students, did not show positive effect on HRQOL. Our findings suggest that future research extend studies from grade five students to different age groups of youth in Canada and to assess how their HRQOL changes and what factors could contribute to the changes when healthy eating and active living is successfully promoted. There is a need to examine the effect of school-based program promoting active living & healthy eating on HRQOL changes by weight status in childhood, and whether the CSH intervention has potential unintended influences on children's health. Future research also needs to examine sensitivity of the EQ-5D-Y to change in both clinical and population health samples. Evidence from such studies for HRQOL benefits will help inform public health policy for broader and ongoing investing in comprehensive school health programs that have the potential to improve students' HRQOL.

6.6 References

(1) Wu XY, Ohinmaa A, Veugelers PJ. Sociodemographic and neighbourhood determinants of health-related quality of life among grade-five students in Canada. *Qual Life Res.* 2010 Sep; 19(7): 969-976.

(2) Ravens-Sieberer U, Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, et al. Feasibility, reliability, and validity of the EQ-5D-Y: results from a multinational study. *Qual Life Res.* 2010 Aug; 19(6): 887-897.

(3) Bharmal M, Thomas J,3rd. Comparing the EQ-5D and the SF-6D descriptive systems to assess their ceiling effects in the US general population. *Value Health* 2006 Jul-Aug; 9(4): 262-271.

(4) Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000 May 6; 320(7244): 1240-1243.

(5) Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J Am Diet Assoc* 1995 Mar; 95(3): 336-340.

(6) Health Canada: Canadian Nutrient File (CNF). 2007. [http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/index-eng.php]. (Accessed Feb.11, 2012).

(7) Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. *J Nutr* 2003 Nov; 133(11): 3476-3484.

(8) Rockett HR, Breitenbach M, Frazier AL, Witschi J, Wolf AM, Field AE, et al.Validation of a youth/adolescent food frequency questionnaire. *Prev Med* 1997 Nov-Dec; 26(6): 808-816.

(9) Crocker PR, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Med Sci Sports Exerc* 1997 Oct; 29(10): 1344-1349.

(10) Kowalski KC, Crocker PR, Faulkner RA. Validation of the physical activity questionnaire for older children. *Pediatric Exercise Science* 1997; 9: 174-86.

(11) Dooris M. Healthy settings: challenges to generating evidence of effectiveness. *Health Promot Int* 2006 Mar; 21(1): 55-65.

(12) Deschesnes M, Martin C, Hill AJ. Comprehensive approaches to school health promotion: how to achieve broader implementation? *Health Promot Int* 2003 Dec; 18(4): 387-396.

(13) Ravens-Sieberer U, Erhart M, Wille N, Bullinger M, BELLA study group. Health-related quality of life in children and adolescents in Germany: results of the BELLA study. *Eur Child Adolesc Psychiatry* 2008 Dec; 17 Suppl 1: 148-156.

(14) von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. *J Epidemiol Community Health* 2006 Feb; 60(2): 130-135.

(15) Wille N, Badia X, Bonsel G, Burstrom K, Cavrini G, Devlin N, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-5D. *Qual Life Res.* 2010 Aug; 19(6): 875-886.

Appendices

Appendix 1: Table 4-1 Definition of variables used in the regression analysis (main effect model)

β_0	Intercept: mean VAS score for state 11111 (perfect health) when the value of all variables in the model is zero
WK2	1 if 'walking' is level 2; 0 otherwise
WK3	1 if 'walking' is level 3; 0 otherwise
LS2	1 if 'looking after myself' is level 2; 0 otherwise
LS3	1 if 'looking after myself' is level 3; 0 otherwise
UA2	1 if 'doing usual activities' is level 2; 0 otherwise
UA3	1 if 'doing usual activities' is level 3; 0 otherwise
PD2	1 if 'having pain or discomfort' is level 2; 0 otherwise
PD3	1 if 'having pain or discomfort' is level 3; 0 otherwise
WS2	1 if 'feeling worried, sad or unhappy' is level 2; 0 otherwise
WS3	1 if 'feeling worried, sad or unhappy' is level 3; 0 otherwise

Appendix 2: Table 4-2 Comparison of the US EQ-5D index and the EQ-5D-Y VAS Index for all 243 Health States

State ID	Health State	US EQ-5D index	EQ-5D-Y VAS index	Predicted VAS score
1	11111	1.000	1.000	86.05
2	11112	0.844	0.902	81.70
3	11113	0.550	0.779	76.22
4	11121	0.827	0.926	82.78
5	11122	0.800	0.828	78.43
6	11123	0.517	0.705	72.95
7	11131	0.463	0.785	76.51
8	11132	0.446	0.687	72.16
9	11133	0.289	0.564	66.68
10	11211	0.860	0.858	79.74
11	11212	0.833	0.760	75.39
12	11213	0.550	0.637	69.91
13	11221	0.816	0.784	76.47
14	11222	0.768	0.686	72.12
15	11223	0.506	0.563	66.65
16	11231	0.463	0.643	70.20
17	11232	0.435	0.545	65.85
18	11233	0.289	0.422	60.38
19	11311	0.626	0.650	70.50
20	11312	0.609	0.552	66.15
21	11313	0.452	0.429	60.67
22	11321	0.592	0.576	67.23
23	11322	0.565	0.478	62.88
24	11323	0.418	0.355	57.40
25	11331	0.365	0.435	60.96
26	11332	0.348	0.337	56.61
27	11333	0.220	0.214	51.13
28	12111	0.825	0.870	80.29
29	12112	0.797	0.773	75.94
30	12113	0.514	0.649	70.47
31	12121	0.781	0.797	77.03
32	12122	0.732	0.699	72.68
33	12123	0.470	0.576	67.20
34	12131	0.427	0.656	70.76
35	12132	0.400	0.558	66.41
36	12133	0.253	0.434	60.93
37	12211	0.814	0.729	73.99

38	12212	0.765	0.631	69.64
39	12213	0.503	0.507	64.16
40	12221	0.748	0.655	70.72
41	12222	0.678	0.557	66.37
42	12223	0.438	0.434	60.89
43	12231	0.416	0.514	64.45
44	12232	0.368	0.416	60.10
45	12233	0.242	0.292	54.62
46	12311	0.590	0.520	64.75
47	12312	0.563	0.422	60.39
48	12313	0.416	0.299	54.92
49	12321	0.546	0.447	61.48
50	12322	0.497	0.349	57.13
51	12323	0.372	0.226	51.65
52	12331	0.329	0.306	55.21
53	12332	0.302	0.208	50.86
54	12333	0.184	0.084	45.38
55	13111	0.529	0.870	80.29
56	13112	0.512	0.773	75.94
57	13113	0.355	0.649	70.47
58	13121	0.496	0.797	77.03
59	13122	0.468	0.699	72.68
60	13123	0.321	0.576	67.20
61	13131	0.268	0.656	70.76
62	13132	0.251	0.558	66.41
63	13133	0.123	0.434	60.93
64	13211	0.529	0.729	73.99
65	13212	0.501	0.631	69.64
66	13213	0.354	0.507	64.16
67	13221	0.485	0.655	70.72
68	13222	0.436	0.557	66.37
69	13223	0.310	0.434	60.89
70	13231	0.268	0.514	64.45
71	13232	0.240	0.416	60.10
72	13233	0.123	0.292	54.62
73	13311	0.431	0.520	64.75
74	13312	0.414	0.422	60.39
75	13313	0.286	0.299	54.92
76	13321	0.397	0.447	61.48
77	13322	0.370	0.349	57.13

78	13323	0.253	0.226	51.65
79	13331	0.199	0.306	55.21
80	13332	0.182	0.208	50.86
81	13333	0.084	0.084	45.38
82	21111	0.854	0.916	82.30
83	21112	0.827	0.818	77.95
84	21113	0.543	0.694	72.47
85	21121	0.810	0.842	79.03
86	21122	0.761	0.744	74.68
87	21123	0.499	0.621	69.21
88	21131	0.456	0.701	72.76
89	21132	0.429	0.603	68.41
90	21133	0.282	0.480	62.94
91	21211	0.843	0.774	76.00
92	21212	0.794	0.676	71.65
93	21213	0.533	0.552	66.17
94	21221	0.778	0.700	72.73
95	21222	0.708	0.602	68.38
96	21223	0.467	0.479	62.90
97	21231	0.446	0.559	66.46
98	21232	0.397	0.461	62.11
99	21233	0.271	0.338	56.63
100	21311	0.619	0.566	66.75
101	21312	0.592	0.468	62.40
102	21313	0.445	0.344	56.93
103	21321	0.575	0.492	63.49
104	21322	0.527	0.394	59.13
105	21323	0.401	0.271	53.66
106	21331	0.358	0.351	57.21
107	21332	0.331	0.253	52.86
108	21333	0.214	0.130	47.39
109	22111	0.808	0.786	76.55
110	22112	0.759	0.688	72.20
111	22113	0.497	0.565	66.72
112	22121	0.742	0.713	73.28
113	22122	0.672	0.615	68.93
114	22123	0.432	0.491	63.45
115	22131	0.410	0.571	67.01
116	22132	0.361	0.473	62.66
117	22133	0.236	0.350	57.18

118	22211	0.775	0.644	70.24
119	22212	0.705	0.546	65.89
120	22213	0.465	0.423	60.42
121	22221	0.689	0.571	66.98
122	22222	0.597	0.473	62.63
123	22223	0.378	0.349	57.15
124	22231	0.378	0.429	60.71
125	22232	0.308	0.331	56.36
126	22233	0.204	0.208	50.88
127	22311	0.573	0.436	61.00
128	22312	0.524	0.338	56.65
129	22313	0.399	0.215	51.17
130	22321	0.508	0.362	57.73
131	22322	0.437	0.265	53.38
132	22323	0.333	0.141	47.91
133	22331	0.312	0.221	51.46
134	22332	0.263	0.123	47.11
135	22333	0.167	0.000	41.63
136	23111	0.522	0.786	76.55
137	23112	0.495	0.688	72.20
138	23113	0.348	0.565	66.72
139	23121	0.478	0.713	73.28
140	23122	0.430	0.615	68.93
141	23123	0.304	0.491	63.45
142	23131	0.261	0.571	67.01
143	23132	0.234	0.473	62.66
144	23133	0.117	0.350	57.18
145	23211	0.512	0.644	70.24
146	23212	0.463	0.546	65.89
147	23213	0.337	0.423	60.42
148	23221	0.446	0.571	66.98
149	23222	0.376	0.473	62.63
150	23223	0.272	0.349	57.15
151	23231	0.250	0.429	60.71
152	23232	0.202	0.331	56.36
153	23233	0.106	0.208	50.88
154	23311	0.424	0.436	61.00
155	23312	0.397	0.338	56.65
156	23313	0.279	0.215	51.17
157	23321	0.380	0.362	57.73

158	23322	0.331	0.265	53.38
159	23323	0.235	0.141	47.91
160	23331	0.193	0.221	51.46
161	23332	0.165	0.123	47.11
162	23333	0.077	0.000	41.63
163	31111	0.442	0.916	82.30
164	31112	0.426	0.818	77.95
165	31113	0.268	0.694	72.47
166	31121	0.409	0.842	79.03
167	31122	0.382	0.744	74.68
168	31123	0.235	0.621	69.21
169	31131	0.181	0.701	72.76
170	31132	0.165	0.603	68.41
171	31133	0.037	0.480	62.94
172	31211	0.442	0.774	76.00
173	31212	0.415	0.676	71.65
174	31213	0.268	0.552	66.17
175	31221	0.398	0.700	72.73
176	31222	0.350	0.602	68.38
177	31223	0.224	0.479	62.90
178	31231	0.181	0.559	66.46
179	31232	0.154	0.461	62.11
180	31233	0.036	0.338	56.63
181	31311	0.344	0.566	66.75
182	31312	0.327	0.468	62.40
183	31313	0.199	0.344	56.93
184	31321	0.311	0.492	63.49
185	31322	0.283	0.394	59.13
186	31323	0.166	0.271	53.66
187	31331	0.112	0.351	57.21
188	31332	0.096	0.253	52.86
189	31333	-0.003	0.130	47.39
190	32111	0.407	0.786	76.55
191	32112	0.379	0.688	72.20
192	32113	0.232	0.565	66.72
193	32121	0.363	0.713	73.28
194	32122	0.314	0.615	68.93
195	32123	0.188	0.491	63.45
196	32131	0.145	0.571	67.01
197	32132	0.118	0.473	62.66

198	32133	0.001	0.350	57.18
199	32211	0.396	0.644	70.24
200	32212	0.347	0.546	65.89
201	32213	0.222	0.423	60.42
202	32221	0.330	0.571	66.98
203	32222	0.260	0.473	62.63
204	32223	0.156	0.349	57.15
205	32231	0.135	0.429	60.71
206	32232	0.086	0.331	56.36
207	32233	-0.010	0.208	50.88
208	32311	0.308	0.436	61.00
209	32312	0.281	0.338	56.65
210	32313	0.164	0.215	51.17
211	32321	0.264	0.362	57.73
212	32322	0.216	0.265	53.38
213	32323	0.120	0.141	47.91
214	32331	0.077	0.221	51.46
215	32332	0.049	0.123	47.11
216	32333	-0.038	0.000	41.63
217	33111	0.247	0.786	76.55
218	33112	0.230	0.688	72.20
219	33113	0.102	0.565	66.72
220	33121	0.214	0.713	73.28
221	33122	0.186	0.615	68.93
222	33123	0.069	0.491	63.45
223	33131	0.016	0.571	67.01
224	33132	-0.001	0.473	62.66
225	33133	-0.100	0.350	57.18
226	33211	0.247	0.644	70.24
227	33212	0.220	0.546	65.89
228	33213	0.102	0.423	60.42
229	33221	0.203	0.571	66.98
230	33222	0.154	0.473	62.63
231	33223	0.058	0.349	57.15
232	33231	0.015	0.429	60.71
233	33232	-0.012	0.331	56.36
234	33233	-0.100	0.208	50.88
235	33311	0.178	0.436	61.00
236	33312	0.162	0.338	56.65
237	33313	0.063	0.215	51.17

238	33321	0.145	0.362	57.73
239	33322	0.118	0.265	53.38
240	33323	0.030	0.141	47.91
241	33331	-0.024	0.221	51.46
242	33332	-0.040	0.123	47.11
243	33333	-0.109	0.000	41.63