Familial Aggregation of Childhood Health and the Socioeconomic Gradient of Disease:

A Longitudinal Population-Based Sibling Analysis

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

MASTER OF SCIENCE

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ABSTRACT

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This study explores the relationships that emerge between socioeconomic status (SES) and the prevalence of several health outcomes in children of different ages utilizing administrative data housed at The Manitoba Centre for Health Policy (MCHP). This research also determines the effect that family has on a child developing (or not developing) a specific health outcome. Finally, the relationship between prevalence and familial aggregation are examined.

The Johns Hopkins ACG(r) Case-Mix System grouped various physician and hospital diagnosis codes into 32 Aggregated Diagnostic Groups (ADGs). Eight of these ADGs were assessed at four age groups (0-3, 4-8, 9-13 & 14-18) for each member of the final study population. Each member was assigned to one of six SES groups, five income quintile groups and one social assistance group.

Familial aggregation was determined for eight selected ADGs using an intraclass correlation coefficient (ICC). Statistical contrasts were made for SA vs. Q1-Q5 and an overall linear trend (SA – lowest; Q5 – highest) to establish the SES differences for the prevalence and familial aggregation of a particular condition. Many of the conditions across SES had statistically significant ($p<0.05$) linear and SA vs. Q1-Q5 contrasts for

both ICCs and prevalence at all age groups. Of the eight ADGs that familial aggregation was calculated, chronic conditions related to the eye had the highest ICCs at all age groups. Injury ADGs had consistently lower ICCs for all age groups.

Factors that affected the results of ICC estimation for binary outcomes include the number of bootstrap selections, the width of the age group and the event rate for the outcome of interest. Suggested future research includes a validity review of ICC estimates for binary outcomes, exploring the variables that may reduce or eliminate the SES gradient for ICCs and exploring the aggregation for different study samples within Manitoba.

ACKNOWLEDGEMENTS

I would like to acknowledge the hard work and support of my advisor Dr. Leslie Roos. His direction and support throughout the duration of this thesis was helpful and much appreciated. I would also like to thank the contributions of my examining committee members, Dr. Robert Tate and Dr. Doug Jutte, and the support of the staff at the Manitoba Centre for Health Policy (MCHP) for their assistance and guidance whenever it was required. I would like to express my gratitude to all those involved with the Western Regional Training Centre for Health Services for providing me with funding throughout the first two years of my M.Sc. program. I would also like to acknowledge the late Dr. Evelyn Shapiro and other stakeholders at MCHP in selecting me for the Evelyn Shapiro Award for Health Services Research. Above all I would like to thank my family and fiancée for all of their love and support.

I acknowledge the Manitoba Centre for Health Policy for use of data contained in the Population Health Research Data Repository under project # (HIPC 2009/2010 - 46). The results and conclusions are those of me, and no official endorsement by the Manitoba Centre for Health Policy, Manitoba Health, or other data providers is intended or should be inferred.

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CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Research Setting

This research was conducted using data housed at the Manitoba Centre for Health Policy (MCHP) in Winnipeg, Manitoba, Canada. MCHP is a research centre within the Department of Community Health Sciences at the University of Manitoba. This centre conducts population-based research on health services, population and public health and the social determinants of health through the use of a comprehensive population-based data repository. All data housed at MCHP is stripped of personal identifiers and protected by several security safeguards including firewalls, passwords and file encryption. In accordance with MCHP policy, approvals for this study were obtained from the University of Manitoba Health Research Ethics Board and Health Information Privacy Committee.

1.2 Child Wellbeing and Socioeconomic Status

The relationships that exist between overall wellbeing and socioeconomic status (SES) have been well documented in several disciplines of child development literature, the consensus generally being that those living in areas of low SES suffer worse social, education and health outcomes. Studies which focus on the relationship between SES and overall health have highlighted that those living in disadvantaged areas not only experience worse physical health outcomes, but worse mental health outcomes as well (Marmot, Kogevinas, & Elston, 1987; Adler et al., 1994; Adler, Boyce, Chesney, Folkman, & Syme, 1993). More specifically, studies conducted at MCHP have shown

that children growing up in disadvantaged areas of Winnipeg experience higher rates of health care utilization along with worse educational outcomes compared to those living in more affluent neighbourhoods (Brownell et al., 2002; Fransoo, et al., 2008).

Children living in disadvantaged neighbourhoods suffer from far worse overall health outcomes than those in more economically developed areas. What remains unclear is exactly when these socioeconomic gradients emerge in life. Many lifespan researchers suggest that the association between SES and physical health may not be constant over different age groups (House, Kessler, & Herzog, 1990; Power, Manor, & Matthews, 1999; West, 1997). Chen, Martin, and Matthews (2006) utilized a nationally representative child health survey to investigate the age at which SES gradients appear for different health conditions. This research found that SES gradients for certain acute health conditions arose in adolescence. It also discovered that global health maintained a relatively consistent SES gradient throughout an individual's entire childhood.

1.3 Factors at Individual, Family and Neighbourhood Levels

Many studies that attempt to evaluate life course health outcomes across socioeconomic status have controlled for different individual, family, and neighbourhood covariates (Page & Solon, 2003; Wheaton & Clarke, 2003; Sanbonmatsu, Kling, Duncan, & Brooks-Gunn, 2006). Currie, Stabile, Manivong, & Roos (2010), utilized administrative data from MCHP to link together those who are specified as siblings. Analyses were carried out to assess whether the presence of a particular health condition in one sibling would lead to a poorer educational or socioeconomic outcome compared to

the sibling without the condition. Sibling matching has been used in several other studies as a method to both examine the genetic similarities of disease and control for potential unobserved family characteristics (Der, Batty, & Beary, 2006; Johnson, Mcgue, & Iacono, 2007; Lin, Su, Kuo, Hsiao, Soong, & Chen, 2007).

Previous research has used sibling and twin studies in an attempt to isolate the extent to which certain factors contribute to income disparities (Page & Solon, 2003; Bjorklund, Jantti, & Solon, 2007; Mazumder, 2008). Several methodologies have been discussed in these studies to obtain correlation estimates for different components that contribute to socioeconomic well-being including genetics, environment and location. Many research studies have also isolated the genetic and environmental effect on health conditions, behavioural characteristics and health living practices experienced between siblings and twins (Van Grootheest, Cath, Beekman & Boomsma, 2007; De Moor, Stubbe, Boomsma & De Geus, 2007).

The relationship between parental background and eventual child success has been well documented (Feldt, Kokko, Kinnunen, & Pulkkinen, 2005; Bjorklund et al., 2007). These studies identified that parental social well-being is related to eventual child success, with both genetic inheritance and environment contributing to this relationship. Conley, Pfeiffer, and Velez (2007) highlighted the importance of within- and between-family factors. This study found that siblings with fewer family resources are more similar on behavioural outcomes compared with siblings in more privileged families. This research suggests that siblings growing up in low-income neighbourhoods may experience stronger within family influences, causing them to follow more similar health trends compared with their counterparts in areas of high SES.

Several characteristics at the individual, family and neighbourhood levels may contribute to the health outcomes a child experiences at different ages. Determining the appropriate level at which certain variables should be considered is often difficult, as individual level characteristics may partially account for effects experienced at the family or neighbourhood level (Schoeni, House, Kaplan & Pollack, 2008, p.344). Inappropriately accounting for factors at each of the three levels may lead to imprecise estimates. Jackson & Mare (2007) suggest that residential mobility and neighbourhood change over time has little change on the estimates of neighbourhoods compared to cross-sectional estimates.

Belsky, Bell, Bradley, Stallard, & Stewart-Brown (2007), compared the relationship between parenting style and socioeconomic risk. This study identified that some of the detectable effects of SES in early child health may be attributable to poor parenting among those living in areas of low SES. These results suggest that interventions involving both families and children should be considered for reducing the existing inequalities in childhood health and SES. Understanding the specific health trends of children is critical for future policy discourse that addresses the issue of child development. Further exploration into the broader determinants of health may strengthen the ideology which suggests that advances in social policy are equally, if not more important than health care intervention in reducing the socioeconomic health gradient in Canada.

1.4 Social Assistance Requirement

Several research studies have focused on the association between families that receive social assistance and numerous early developmental outcomes. There is general agreement within the literature which suggests that those raised in families requiring social assistance have worse early childhood education outcomes, poorer future overall health including all-cause mortality and substance abuse, and future dependence on social assistance (Beaulieu, Duclos, Fortin & Rouleau, 2005; Fransoo, et al., 2008; Weitoft, Hjern, Batljan & Vinnerljung, 2008).

Identifying families who require social assistance can be a useful tool in a research setting because of the inherent differences that exist between families within underprivileged neighbourhoods. Schneiders et al. (2003) included an aggregate measurement of welfare receipt among other variables such as neighbourhood unemployment to estimate the level of neighbourhood socioeconomic disadvantage. Other studies have included financial assistance reception as a predictor variable in the analysis of different health and social outcomes (Entwisle & Astone, 1994; Nikiema, Spencer & Seguin, 2010).

Several studies support the hypothesis of an existing negative relationship between welfare receipt and child well-being (Duncan & Yeung, 1995; Orthner & Randolph, 1999). However, Klebanov, Brooks-Gunn & Duncan (1994) found that after controlling for other correlates of SES, the reception of financial support no longer had a significant bearing on the quality of children's home environment. Typically those who require social assistance will reside in neighbourhoods with low household income levels

(Vartanian, 1999). Appropriately defining those receiving social assistance who reside in neighbourhoods with high household income could potentially reduce the between family variability experienced within these neighbourhoods.

Individuals who receive social assistance tend to have worse overall health outcomes compared with the rest of the population (Vozoris & Tarasuk, 2004; Brooks-Gunn, Klebanov, Smith & Lee, 2001). Children who grow up in a family on long-term social assistance may have compromised long term development; however the within family relationships experienced by this population subset has yet to be explored in detail (Weitoft et al., 2008).

1.5 Within Group Aggregation

Determining the variability experienced within defined clusters is important for summarizing the aggregation of a population. A common tool to estimate within group variability is known as an intraclass correlation coefficient (ICC). More specifically, an ICC provides an estimate of homogeneity within defined clusters (MCHP, 2009). The magnitude of an ICC depends on the degree of clustering that occurs within particular study groups typically ranging from 0 (no aggregation) to 1 (complete aggregation).

ICC estimation is a common tool used in studies that estimate the genetic and environmental effects on particular outcomes related to health (Carmelli, Swan, DeCarli & Reed, 2002; Drake, Scofield & Roth, 2008; Zhai, Andrew, Kato, Blake & Spector, 2009). Sibling or twin ICCs are typically calculated in these types of studies to evaluate the within family or twin variability for certain genetic characteristics or health outcomes.

Neighbourhood ICCs have also been calculated in several studies in an attempt to address the aggregation that exists within a particular geographical area (Merlo, Chaix, Yang, Lynch & Rastam, 2005; Reading, Jones, Haynes, Daras & Emond, 2009).

Zhai et al. (2009) studied the ICCs between monozygotic and dizygotic twins with an outcome of change in bone loss at different sites of the body. Depending on the site, unadjusted ICC measurements ranged from 0.42 to 0.61 in monozygotic twins and 0.19 to 0.36 in dizygotic twins. Another study by Drake et al. (2008) stated a sibling ICC of 0.61 for an insomnia score outcome. Davey, Tucker, Fingerman and Savla (2009) found that cognitive recall in adult siblings had ICCs ranging from 0.24 to 0.43.

The strength of sibling ICCs clearly vary in the literature depending on the age of the study subjects and the nature of the particular outcome(s). Typically ICCs are slightly higher in monozygotic twins than dizygotic twins (Carmelli et al., 2002; Zhai et al., 2009). A study by Segal (2000) determined a sibling ICC on intellectual ability for same-age unrelated siblings that were reared together from infancy, otherwise known as virtual twins. This study found an IQ test score ICC of 0.26 for virtual twins compared to ICCs of 0.86, 0.60 and 0.50 for monozygotic twins, dizygotic twins and full siblings respectively. These results suggest that both genetics and environment likely play some role in the strength of observed familial aggregation. In my literature review, limited research was found that cited sibling ICCs for specific health outcomes.

Mazumder (2005) discussed studies that highlighted economic success within fathers and sons. Within family variation was estimated in these studies using a term

called intergenerational elasticity, a term similar to an ICC that is defined between 0 and 1. A measurement of 0.4 in the context of income earnings between fathers and sons was stated as a "relatively high degree of similarity between fathers and sons" (Bowles et al., 2005, p. 80). Another study by Ellison et al. (1999) that explored the familial aggregation in cholesterol levels has stated that within family correlations of 0.29 and 0.31imply strong familial aggregation. The determination of whether or not an ICC is strong, moderate or weak depends on the context of the study population and nature of the observed outcome. In many studies the ICC strength is discussed in a manner that highlights certain outcomes or subpopulations that appear to have the strongest within-group similarities as opposed to stating its subjective strength (Segal, 2000; Davey et al., 2009; Zhai et al., 2009).

1.6 Purpose of Research

Many research studies have looked at different relationships between SES and child well-being. The health trend across SES has become apparent, with children living in areas of low SES experiencing worse overall outcomes. The previously discovered gradients revealing that those living in areas of low SES experience poor health outcomes will be further explored for a variety of specific health outcomes. The family aggregation that exists for various health conditions will also be determined, not only the prevalence of a particular health condition, but also the strength of within family similarities. The research undertaken by this Master's thesis will identify the disparities that exist within child health at different ages and across SES in an urban setting at the population level. Longitudinal population-based datasets will allow for certain aspects of healthcare

utilization to be monitored throughout an individual's entire childhood. The second part of this project will further look at the within family relationships of health at different SES groups.

1.7 Research Questions

1. What are the relationships that emerge between socioeconomic status and the prevalence of different health conditions at different ages?
2. What is the extent of family aggregation for these health conditions at different ages?
3. Do these measures of family aggregation differ across SES groups and are these gradients related to prevalence?

1.8 Significance of Research

This thesis will contribute to the child development literature by exploring health at different stages of childhood. Little research has highlighted specific health events throughout an individual's entire childhood. Administrative health data from birth to adulthood will give a clearer insight about conditions that may be more strongly linked to the environment in which a child grows up. This research will also examine whether children growing up in regions with limited resources have a harder time diverging from the overall disease trends of their siblings. Stratifying the analysis by age will help identify the stages of childhood that show to be crucial for future well-being. Finally,

examining familial aggregation may help distinguish the factors that cause those growing up in the same households to experience common health outcomes.

CHAPTER TWO: METHODOLOGY

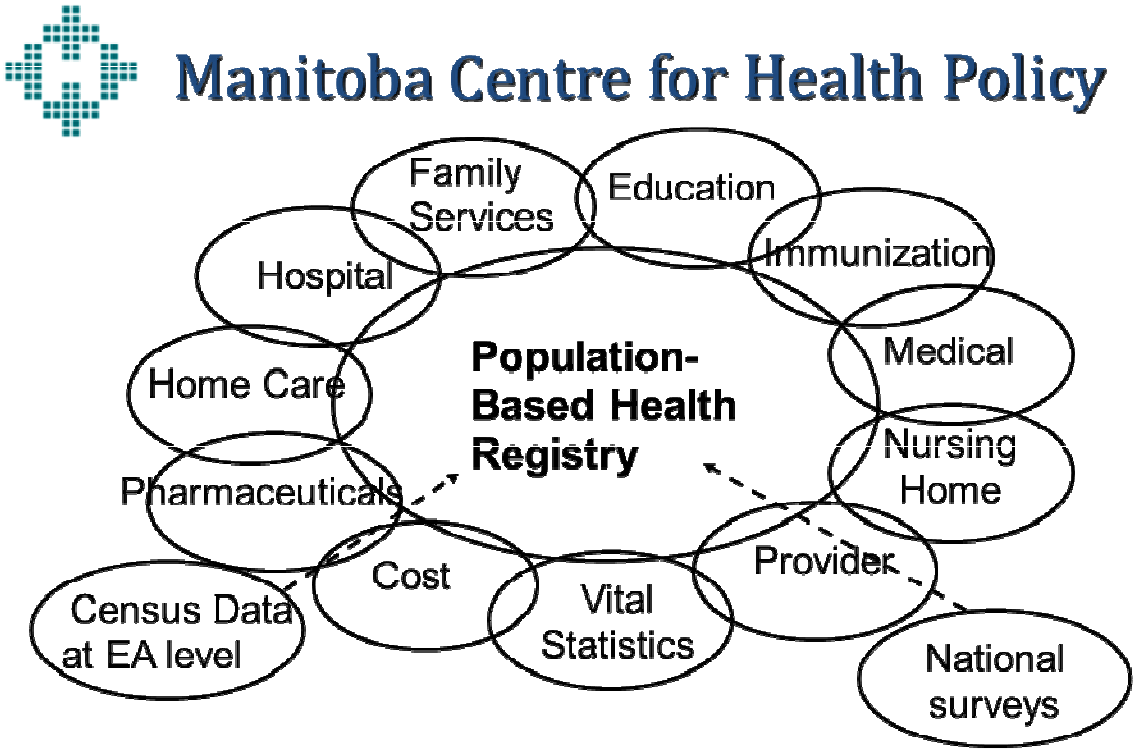
2.1 Data Sources

This research will make use of the Population Health Research Data Repository (*Figure 1*) housed at MCHP. Individual-level data containing scrambled Personal Health Identification Numbers (PHINs) allows for linkage between different datasets over several years. More in-depth descriptions of information contained within the repository are provided in other research studies (Roos, Soodeen, Bond, & Burchill, 2003; Roos, Menec, & Currie, 2004). At MCHP, vital statistics are incorporated into the registry annually by Manitoba Health (Roos & Nicol, 1999; Roos & Roos, 2001) giving us reasonably high confidence concerning the accuracy of the data sources. This study will link data between various datasets including the Manitoba Health Registry, Vital Statistics, Physician Claims, and Hospital Abstracts. For use of the data, submissions have been made to The University of Manitoba Bannatyne Research Ethics Board and Health Information Privacy Committee at Manitoba Health. Research protocols at MCHP state that study results may only be presented on an aggregate scale.

This research has made use of available longitudinal data by following children from birth until early adulthood. Population-based administrative datasets housed at MCHP were utilized to investigate the characteristics of child health care utilization in Winnipeg at different ages. Winnipeg contains approximately 60% of Manitoba's total population. The population of Manitoba is reasonably representative of Canada as a whole, being generally ranked in the middle of Canadian provinces when comparing

certain indicators of health status and health care expenditures (Shanahan & Gousseau, 1997; Oreopoulos, Stabile, Walld, & Roos, 2008; CIHI, 2008). The final study population was determined from the Manitoba Health Registry and Vital Statistics files. The exclusion/inclusion criterion for this research has been selected to reduce various potential biases that exist when working with administrative data.

FIGURE 1. Illustration of Population Health Research Data Repository at The Manitoba Centre for Health Policy (MCHP, 2008)



All relevant health information was obtained from physician claims and hospital abstract databases. A single International Classification of Disease (ICD) code is given on each administrative physician claim record. Hospital records may contain multiple diagnostic codes for each admission. All available hospital diagnoses were considered in the health assessments of siblings. These data sources were used to measure the specific health conditions experienced by each individual throughout childhood, along with

providing different aspects of overall health. The date in which an individual visited a physician's office is recorded on all physician claims. These dates were utilized to determine the time of occurrence for each particular health outcome. Hospital admission and discharge dates are available on all hospital abstracts. The admission date was used in determination of the time of occurrence.

The Manitoba Health registry has attached to every birth a family number (called the Registration Number or REGNO) which allowed linkage between the infant to the 'family head', usually the father. When an individual turns eighteen years old, they receive their own REGNO. A personal identification number of the mother is also provided on each child's birth record. This information allowed for the accurate identification of full siblings and half siblings. A more detailed description regarding the sibling linkage process can be found in the concept dictionary developed at MCHP (2008).

Statistics Canada census data provides neighbourhood income information at the aggregate level, a measure known to have a high correlation with individual family income, primarily in large urban centers (Mustard, Derksen, Berthelot & Wolfson, 1999; Statistics Canada, 2006). This available information was used for determination of the socioeconomic background of each sibling group.

Data from the Department of Education in Manitoba housed at MCHP was used to provide researchers with various indicators of school success. These data files contain information about standardized test scores, high school completion and enrollment. These

data were primarily be utilized to distinguish the educational differences between SES groups.

Social Assistance files provided a measure of social assistance receipt in childhood and labour force assimilation for the cohort. The available social assistance variables included whether the mother of an individual's received social assistance between the oldest child's age of 8 and 17, whether the individual received social assistance before the age of 17, and whether the child began receiving social assistance within 15 months following their 18th birthday. Information from this database will be used to define families who require social assistance.

2.2 Study Population

The study population for this research included all individuals born in Winnipeg between January 1, 1979 & December 31, 1982 or January 1, 1984 & December 31, 1989 who have at least one specifiable half or full sibling born within the same intervals, also in Winnipeg. All births occurring between January 1, 1983 and December 31, 1983 have been excluded from the analysis because of incomplete information on this birth cohort. All siblings born within the specified time periods have been considered a sibling group. An individual was excluded from a sibling group if they were not born within the specified time periods but had two or more siblings that were. These study years have been selected to ensure that hospital abstracts and physician claims data are available for each study subject's entire childhood until their 18th birthday.

The study subject and their identified sibling(s) must also have maintained residency in Winnipeg until their 18th birthday. This excludes children who move away from Winnipeg and those who do not survive to adulthood. The exclusion of a specific child from the analysis does not necessarily imply the exclusion of that same child's entire sibling group, providing at least two members of that family satisfy all criteria. Considering a large portion of the analysis revolves around socioeconomic status, those who cannot appropriately be assigned to an income group were also excluded from the analysis. Previous work conducted at MCHP utilizing similar sibling datasets has shown that the Manitoba sibling cohort and complete Manitoba birth cohorts over this time period are reasonably similar (Oreopoulos et al., 2008).

In Manitoba, The Public Trustee Office handles the affairs of those who are unable to do so themselves (Manitoba Health, 2010). According to the Statistics Canada Postal Code Conversion Files (PCCF) housed at MCHP, the postal codes of these individuals are assigned to either the Brandon or Winnipeg public trustee offices, depending on their area of residence in Manitoba. Generally in small area analysis studies conducted at MCHP, all individuals with these postal codes have been eliminated from the study population (Public Trustee Office and MCHP Data, 2001). Essentially the inclusion of these individuals with those assigned postal codes would likely overestimate the poor health outcomes experienced by these particular neighbourhoods.

According to data from the year 2000, approximately 1400 (age <18 years) in the Manitoba Health registry appear to have Winnipeg Child and Family Services (CFS) offices as their mailing address (MCHP Concept: CFS, 2009). These children may be assigned a CFS address for many reasons including issues of neglect or severe

disabilities. Generally when these regions are relatively small in population, individuals assigned the postal codes of these CFS offices were excluded from the analysis. These individuals were also excluded from the final study population to eliminate the possibility of an overestimation of the population and poverty experience by individuals living in this area.

Physician and hospital claims data were obtained throughout an individual`s childhood to determine whether or not they have any occurrence of an ICD diagnosis code of mental retardation (ICD 9: 317-319 & ICD 10: F70 - F79). Children with a diagnosis of mental retardation occurring at any point throughout childhood have also been excluded from the final study population. This exclusion criterion has been selected to improve the generalizability of the study results by excluding those who grow up under particularly different circumstances compared to those with a somewhat standard childhood. This will also likely result in a more accurate evaluation of within family variability with regards to various health outcomes.

2.3 Study Design

This study involves comparing different health conditions across several demographic characteristics of children, with a major emphasis on age and socioeconomic status. All individuals included in the defined population had certain aspects of their health status identified using administrative claims data. Hospital abstract and physician claims databases were used to produce individual and aggregate health information at four different childhood stages. Four age ranges were selected to highlight the differences experienced at different time points throughout the development of a

child. The ages birth to 3, 4 to 8, 9 to 13, and 14 to 18 were used to examine the differences in familial health aggregation as children get older. If a child experiences a particular health event at only one point throughout childhood, they have been defined as having that condition for a single age range. For example, if an individual suffers from a major injury between their 4th and 9th birthday, with no other defined major injury diagnoses between birth and adulthood, the child will only be assigned a major injury diagnosis for the 4 to 8 age range. A similar assessment of child health was performed by Currie et al. (2010).

At each age range, various health conditions were considered for all study participants utilizing version 8 of The Johns Hopkins ACG(r) Case-Mix System (The Johns Hopkins University, 2003). This software categorizes ICD9 and ICD10 diagnostic codes from physician claim and hospital discharge abstract databases into 34 mutually exclusive groups called Aggregated Diagnostic Groups (ADGs).Two ADGs (15 & 19) have since been discontinued from the software. A summary of the remaining 32 ADGs from Starfield, Weiner, Mumford and Steinwachs (1991) can be found in *table 1*. The grouping of ICD codes is based on five criterions: 1) Duration of the Condition (acute, recurrent, or chronic), 2) severity of the conditions (e.g. minor and stable versus major and unstable), 3) diagnostic certainty, 4) etiology of the condition, 5) specialty care involved. The number of ADGs an individual is assigned will provide an overall estimation of morbidity and disease burden. Each of the ADGs was assessed for each individual included in the study population at each age range, thus each individual will be defined as having a minimum of 0 and a maximum of 32 ADGs at each of the four age ranges.

TABLE 1. List of ambulatory diagnosis groups (ADG) health outcomes considered for final analysis along with common ICD diagnosis codes contained within specific ADG.

ADG	Common Diagnosis (ICD-9-CM Code)
1. Time Limited: Minor	Dermatitis (692.9)
2. Time Limited: Minor – Primary Infections	Acute upper respiratory infection (465.9)
3. Time Limited: Major	Synovitis (727.09)
4. Time Limited: Major – Primary Infections	Pneumonia (486)
5. Allergies	Allergic rhinitis (477.9)
6. Asthma	Asthma (493.90)
7. Likely to Recur: Discrete	Vaginitis (616.10)
8. Likely to Recur: Discrete – Infections	Otitis media (382.9)
9. Likely to Recur: Progressive	Diabetic ketoacidosis (250.10)
10. Chronic Medical: Stable	Hypertension (401.9)
11. Chronic Medical Unstable	Coronary Atherosclerosis (414.0)
12. Chronic Specialty: Stable – Orthopedic	Chondromalacia patellae (717.7)
13. Chronic Specialty: Stable – Ear, Nose, Throat	Hearing Loss (389.9)
14. Chronic Specialty: Stable – Eye	Refraction disorder (367.9)
16. Chronic Specialty: Unstable - Orthopedic	Juvenile osteochondrosis (732.4)
17. Chronic Specialty: Unstable – Ear, Nose, Throat	Chronic sinusitis (473.9)
18. Chronic Specialty: Unstable – Eye	Glaucoma (365.9)
20. Dermatologic	Acne (706.1)
21. Injuries/Adverse Effects: Minor	Ankle Sprain (845.00)
22. Injuries/Adverse Effects: Major	Tear of meniscus (836.0)
23. Psychosocial: Chronic	Depression (300.4)
24. Psychosocial: Other	Adjustment reaction (309.9)
25. Psychophysiologic	Migraine (346.9)
26. Signs/Symptoms: Minor	Headache (784.0)
27. Signs/Symptoms: Uncertain	Palpitation (785.1)
28. Signs/Symptoms: Major	Chest pain (786.50)
29. Discretionary	Sebaceous cyst (706.2)
30. See and Reassure	Skin scar/Fibrosis (709.2)
31. Prevention/Administrative	Routine medical exam (V70.0)
32. Malignancy	Malignant skin neoplasm (173.9)
33. Pregnancy	Pregnant state (V22.2)
34. Dental	Chronic gingivitis (523.1)

The Johns Hopkins ACG(r) Case-Mix Software (version 8) has been validated as an appropriate source for predicting overall health care expenditures and premature mortality in a Manitoba setting (Reid, MacWilliam, Verhulst, Roos, & Atkinson, 2001; Reid, Roos, MacWilliam, Frohlich, & Black, 2002). A study by Wilchesky, Tamblyn, & Huang (2004) explored the validity of diagnostic codes within medical claims data by investigating the sensitivity and specificity between medical charts and ADGs. Research in other countries has also extensively validated this software (Starfield et al.,1991; Weiner, Starfield, Powe, Stuart, Baker & Steinwachs, 1996; Orueta, Urraca, Berraondo, Darpon, & Aurrekoetxea, 2006).

Following the collection of health records for all study participants, Winnipeg income groups were used to look at the SES gradient for particular conditions. Aggregated Statistics Canada income data was available at the postal code level for all census years. Census data was linked to the postal code of residence for the oldest child at age 17 within a sibling group. This linkage provided each family with a neighbourhood income, a value known to have a high correlation with family income (Mustard et al., 1999; Statistics Canada, 2006). All members of a family were assigned the same amount of neighbourhood income for the 18 years of the study.

Families were then assigned into one of five income quintiles (Q1 – Q5), with approximately 20% of the entire Winnipeg population assigned to each group. This income group assignment is based on previous work on neighbourhood income allocation conducted at MCHP (Manitoba Centre for Health Policy, 2007). A sixth income group was also created to study the relationship between family social assistance requirement on childhood wellbeing. Families were re-assigned to the social assistance income group

(SA) if a recognized parent received social assistance payments between the 8th and 17th birthday of the oldest child in a sibling grouping. These time periods were selected because of data availability for social assistance receipt records.

Comparisons on prevalence and familial aggregation were possible for all 32 ADGs but for the purposes of this thesis eight individual ADG conditions were selected for illustration. For the selected ADGs, the four age groups were looked at separately to observe differences between SES and both the prevalence of an ADG condition and its overall familial clustering.

2.4 Analysis Techniques

All statistical analyses were performed using SAS version 9.2, developed in Cary, North Carolina. The available datasets were organized to understand various characteristics of child health in different age groups and measures of SES. For all individuals defined in the study population, 32 binary variables were created at each of four age ranges (0 to 3, 4 to 8, 9 to 13, and 14 to 18) to indicate whether each of the 8 selected Aggregated Diagnostic Groups (ADGs) were present. These 32 binary variables were used as the primary outcomes for the analysis on within family relationships.

Prevalence estimates were obtained for each ADG at different age ranges and across SES. The prevalence differences across SES were determined by calculating both a linear contrast and a contrast comparing the lowest SES group (SA) to the rest of the population (Q1-Q5). All prevalence contrasts were calculated using the SAS procedure GLIMMIX, a relatively new procedure that allows for statistical modelling of binary response variables with random effects (SAS, 2010). Various analytic methods have been

previously utilized to assess within-group factors, however for this study ICCs will provide a measure of family aggregation. To calculate sibling similarities, ICCs were calculated for individual ADG outcomes. The calculated ICCs provided estimates of homogeneity within sibling groups at different ages and levels of SES. Two level random intercept logistic regression models will be utilized to account for variation experienced at the individual and family levels. Stratification by the six previously mentioned income groups will determine the differences at the neighbourhood level.

All ICCs were calculated using the SAS procedure GLIMMIX. Two level models were utilized to account for variation at the individual and family levels with regards to having a particular ADG condition, with the family level considered as a random effect. The calculation of ICCs for binary outcomes were calculated using methods previously described in Snijders & Bosker (1999), who suggest that the logistic distribution for the level-one residual implies a variance of $\pi^2/3$ (p. 224). This implies that the second level ICC (ρ_t) for this type of model, with an intercept variance of τ_0^2 is:

FORMULA 1. Intraclass correlation coefficient for Binary Outcome

$$\rho_t = \tau_0^2 / \left(\pi^2/3 + \tau_0^2 \right)$$

ICCs were calculated first at each of the four age ranges for selected ADGs. After comparisons at each age range for the entire study population, similar analyses were performed across the six income groups (SA & Q1-Q5). This study design provided a

unique perspective which allowed for an exploration of the health conditions that may be more strongly linked to family environment and SES.

The distribution that an ICC follows for a particular ADG was unknown within our study population. To identify this distribution at different levels of age and SES for selected ADGs, a bootstrap sample selection methodology was utilized. For each age, SES and ADG combination, 500 bootstrap samples from the available study population were selected to obtain 500 unique ICC estimates. Obtaining multiple estimates allowed for the distribution of ICCs to be obtained for various ADG outcomes and for comparisons to be made across SES. A breakdown of how the bootstrapped ICC estimates were obtained can be found in *Figure 2*.

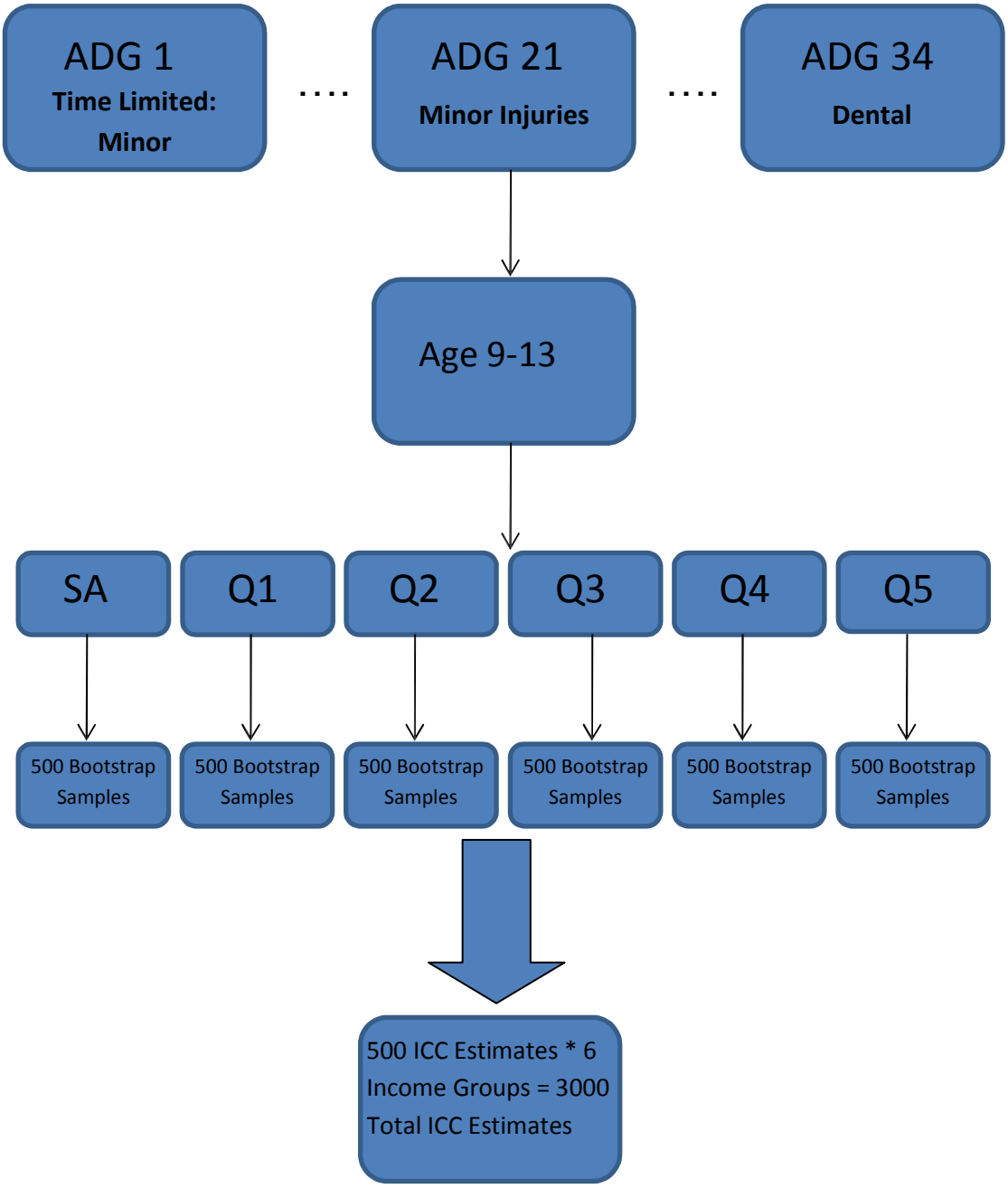
Multi-level modelling using the SAS procedure GLIMMIX allowed for the exploration of binary outcomes at the family level across SES groups. An estimate of the intercept variance at the family level was obtained for each combination of age, SES and ADG for all 500 bootstrapped samples. ICCs were calculated using these family level intercept variances resulting in a total of 3,000 estimates for each age and ADG. A point estimate and 95% confidence interval were obtained for each age, ADG and income group from the 2.5^{th}, 50^{th} (median) and 97.5^{th} percentile from a given ICC distribution.

Summaries of the ICC distributions were obtained for each ADG to verify the usual assumptions required for general linear models (GLM). SES contrasts were performed on ICC estimates using the SAS procedure GLM. An overall linear contrast across the six income groups along with a comparison of the lowest income group (SA) to the other five groups (Q1-Q5) was calculated for the ADGs that satisfied the required

assumptions. A summary of several population characteristics were obtained to reveal the inherent differences that existed between the SES groups. The characteristics of all members of the study population were assessed at both the individual and family levels. Family variables were deemed consistent across each member of a sibling grouping to account for the potential variation experienced between families. The available family variables included family size of the eligible members in the study population, the number of births to the biological mother according to the Manitoba Health Registry, the mother's marital status at birth of her first child, mother's age at first birth, whether or not the family received social assistance between the 8th and 17th birthday of the oldest sibling and the duration of social assistance receipt.

Individual level variables were determined for each member in the study population to highlight the potential individual-level variation experienced across SES. Oreopoulos et al. (2008) discussed the effect of health at birth on future outcomes. Results from this study suggest that variables such as birth weight and Apgar scores may explain a portion of future child health, thus these variables were made available at the individual level for the analysis. Other variables included at the individual level were the child's birth order according to the Manitoba Health Registry, education variables such as enrolment figures, high school graduation rates, grade 12 test scores and whether or not the child received social assistance within 16 months following their 18th birthday.

FIGURE 2. Bootstrap Sample Selection Methodology



2.5 Determination of Significant Familial Aggregation

Calculating familial aggregation for binary outcomes using an ICC is inherently different than assuming the ICC follows a normal distribution. Even with no familial aggregation, all members of a family could still have (or all not have) a particular ADG. The null hypothesis of no familial aggregation was simulated for different outcome prevalences for the same family structure as the final study sample for this research. Dummy outcome variables were simulated randomly for each member of the study population independent of family. Randomly simulating the observed prevalence independent of families imply a common shared intercept for the entire population, or no second level variation, hence representing, no familial aggregation.

In total, 500 simulations were made for different outcome probabilities at each level of SES defined for the study population. For each simulation, an ICC was calculated. The 95% and 99% confidence intervals were calculated by taking the 2.5^{th} and 97.5^{th} percentile and 0.5^{th} and 99.5^{th} percentile of the ICC distributions respectively. A calculated ICC for a particular ADG and SES group will be considered significant if the point estimate is greater than the upper 97.5^{th} percentile or 99.5^{th} percentile limit of the simulated confidence intervals.

Table 2 provides the required ICC at the 95% and 99% confidence level required for an outcome prevalence to be considered statistically significant familial aggregation. Outcome prevalence was selected up to 0.5 because confidence levels for a certain probability will be identical for 1.00 minus the probability. Since ADG prevalence

estimates will not have the exact values that have been determined for this table, statistical significance will be determined by linear extrapolation where required.

TABLE 2: Null hypothesis ICCs of no familial aggregation for the population familial structure in the study dataset

Probability	**Confidence Level**	**SA**	Q1	Q2	Q3	Q4	Q5
0.01	95%	0.273	0.301	0.289	0.254	0.227	0.213
	99%	0.313	0.331	0.337	0.280	0.258	0.255
0.05	95%	0.107	0.135	0.107	0.059	0.045	0.043
	99%	0.146	0.159	0.136	0.114	0.098	0.093
0.10	95%	0.066	0.086	0.070	0.059	0.045	0.043
	99%	0.078	0.104	0.084	0.081	0.061	0.053
0.20	95%	0.040	0.052	0.042	0.036	0.031	0.026
	99%	0.056	0.068	0.057	0.041	0.042	0.038
0.30	95%	0.034	0.047	0.033	0.028	0.026	0.022
	99%	0.047	0.063	0.043	0.036	0.033	0.026
0.40	95%	0.029	0.039	0.030	0.026	0.022	0.021
	99%	0.046	0.053	0.042	0.030	0.033	0.032
0.50	95%	0.028	0.035	0.029	0.024	0.020	0.019
	99%	0.037	0.055	0.038	0.032	0.028	0.032

2.6 Selection of ADGs for Final Analysis

Age and SES specific prevalence estimates of all ADG conditions were determined for the entire study population. Eight ADGs were selected to illustrate the complex analysis of familial aggregation. Although this analysis approach could be applied to all 32 ADGs, eight were selected for illustration in this thesis. Clinically relevant child health conditions with low, moderate and high prevalence estimates

experiencing downward, upward and flat trends across SES groups were selected to further highlight the effect that prevalence has on ICC estimation. A review of literature related to childhood health was conducted to select the conditions that were of greater relevance for the purposes of this research.

Asthma is the leading cause of school absence and pediatric hospitalizations and one of the most common chronic conditions of childhood (U.S. Environmental Protection Agency, 2006). A study on the determinants of childhood asthma in Canada (Martel et al., 2009) found that an increased risk of childhood asthma was associated with paternal asthma and asthma in siblings. Asthma, along with conditions sharing similar characteristics such as allergies and infections, were found to share a complex relationship with different environmental exposures and genetic background (Von Mutius, 2007).

Injury is a major public health concern and is a leading cause of mortality, morbidity and permanent disability in Canadian children (Gilbride, Wild, Wilson, Svenson & Spady, 2006). Generally the external causes of injury change substantially by developmental stage (Flavin, Dostaler, Simpson, Brison & Pickett, 2006). Socioeconomic status is known to contribute to childhood injury prevalence with those living in low income neighbourhoods experiencing higher prevalence of injury (Birken, Parkin & Macarthur., 2006; Owens, Zodet, Berdahl, Dougherty, McCormick & Simpson, 2008).

Mental health conditions in children have become increasingly recognized in recent years with as approximately one in five children and adolescents having signs or symptoms of mental or behavioural disorders (U.S. DHHS, 1999). Attention deficit

hyperactivity disorder (ADHD), the most common chronic mental health problem in children, was found to have prevalence rates estimates almost twice as high in low income families (Cuffe, Moore & McKeown, 2003). The presence of a mental health condition in childhood often lead to adult mental health problems that have been linked as a direct cause of high health care costs and poor labour force outcomes (Ettner, Frank & Kessler, 1997; Currie & Madrian, 1999).

Conditions that are primarily treated under a private insurance plan are also of interest in exploration of family aggregation. According to CIHI (2005), high-income earners are four times more likely than low-income earners to have some kind of coverage related to eye care. This suggests that families living in low income neighbourhoods may have a lower observed prevalence of conditions related to eye care than those residing in high neighbourhoods because of access issues surrounding those without adequate insurance. There is a strong possibility of high family aggregation for conditions that are typically funded under a non-public insurance plan because access issues are likely continuous for all members of a family.

The final list comprised of minor and major primary infections (ADG 2 & 4), asthma (ADG 6) chronic specialty conditions related to the eye (ADG 14) minor and major adverse effects / injuries (ADG 21 & 22), along with chronic and other psychosocial conditions (ADG 23 & 24). These ADGs were selected to represent a broad range of child health conditions and explore family aggregation for inherently different outcomes. Asthma, major and minor injuries will have prevalence and familial aggregation calculated from ages 0-18 in addition to each of the four age ranges. This

decision was made to explore the effect that widening age periods had on prevalence and familial aggregation estimates for both acute and chronic health conditions.

2.7 Ethical Considerations

All administrative data are locked within a secure area at MCHP. Strict security measures are in place to protect the data and restrict access. Individuals with access to the data have signed oaths developed by the University's lawyer to protect the confidentiality of the data. The process of scrambling PHINs for all of the datasets is undertaken at Manitoba Health. No names, addresses, or telephone numbers are contained in the databases. This rigorous process ensures that no individual identification is possible. All findings will only be presented in summary form, ensuring that all study cohorts contain a minimum of six individuals, the lowest number allowable by MCHP and Manitoba Health. Responsibilities outlined under the Personal Health Information Act and the Privacy Legislation will be followed. Requests for all data use were submitted to the Health Information Privacy Committee (HIPC) at Manitoba Health and the Bannatyne Research Ethics Board (REB) at the University of Manitoba.

CHAPTER THREE: RESULTS

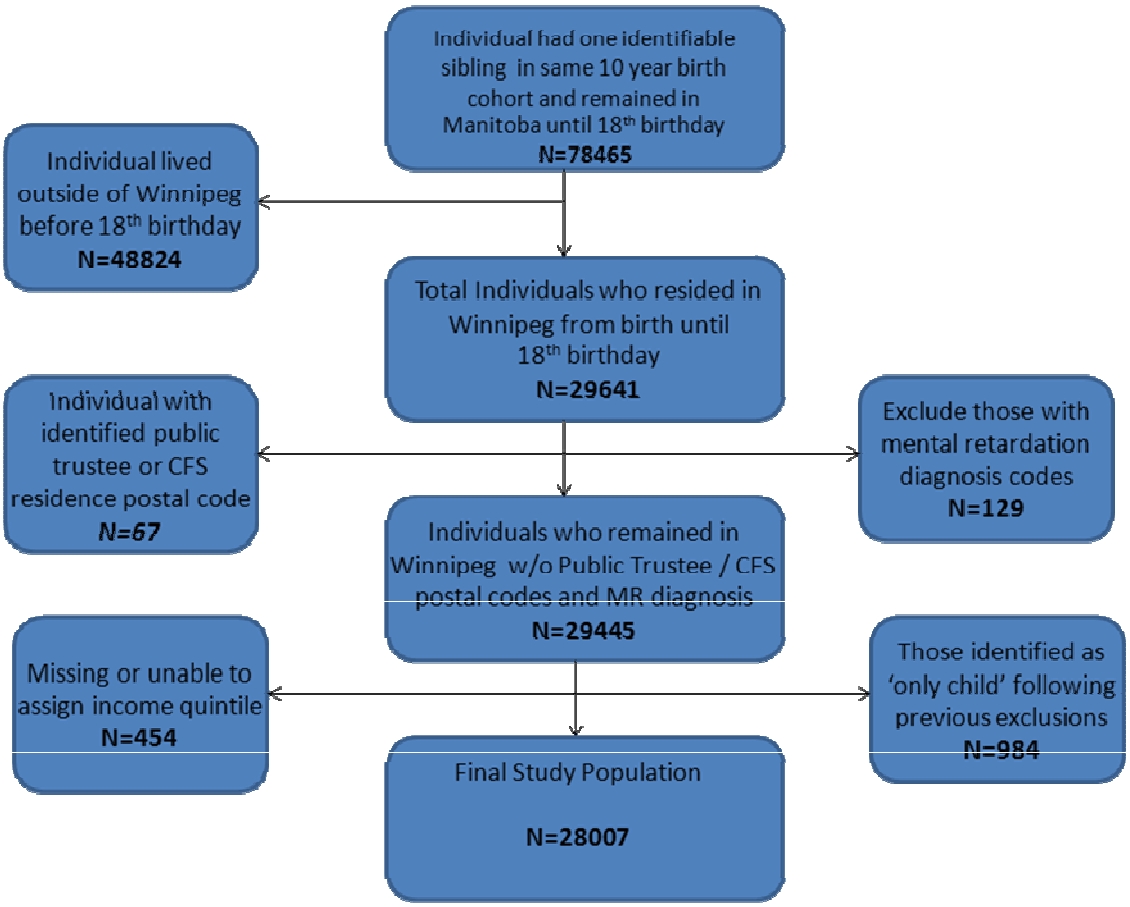
3.1 Population Characteristics

The original study population contained 78,465 individuals born between 1979 and 1989 (excluding 1983) and who were initially identified as having one sibling and remained in the province until their 18th birthday. To qualify for the final study population, individuals and their sibling(s) must not have resided outside of Winnipeg from birth to age 18 (N=48,824), not had a postal code of residence at any point their entire childhood that was designated to an identified Child and Family Services (CFS) or Public Trustee office (N=67), not have a diagnosis of mental retardation in his/her physician or hospital claims from birth to age 18 (N=129), be appropriately assigned to an income group (N=454), and still have an identifiable sibling meeting these same criteria (N=984). The resulting sample contained 28,007 individuals and 12,771 sibling groups. *Figure 3* provides a description of the exclusion criteria for the study sample.

A much larger representation of the study sample was contained within Q5, the highest income quintile (N=8336, 29.8%), than the SA group (N=3057, 10.9%) or Q1, the lowest income quintile (N=1940, 6.9%). This large difference in representation may be attributable to higher rates of mobility within Manitoba or Canada for those living in disadvantaged neighbourhoods, eventually leading to larger exclusion in the initial study sample development as a result of their moving out of Winnipeg or leaving the province altogether. Another explanation is that the majority of those requiring social assistance generally reside in lower income neighbourhoods. In effect, the SA designation is pulling

individuals out of the lower income quintiles and reducing them in size relative to the highest (Q5) income quintile.

FIGURE 3. Description of final study population containing all exclusions criteria



An in-depth description of the study population was conducted to assess the differences that existed at different ages and SES groups. Several variables were collected within the datasets including those measured at both the family level and individual level. *Table 2* provides a description of the individual level characteristics of the study population, while *table 3* describes the family level characteristics that are identical for each member of a sibling group.

TABLE 3. Individual level characteristics of final study sample

*Variable	SA	Q1	Q2	Q3	Q4	Q5	Total
Gender							
Male	1537	965	1722	2340	3466	4252	14282
Female	1520	975	1692	2212	3242	4084	13725
Residences in Winnipeg (Birth to age 18)							
1	153	583	1051	1583	2132	2082	7584
2	333	500	957	1414	2529	3680	9413
3	347	362	660	762	1130	1627	4888
4	351	218	340	367	503	558	2337
5 or more	1873	277	406	426	414	389	3785
Teenage Pregnancy							
Yes	475	122	179	184	213	170	1343
No	1045	853	1513	2028	3029	3914	12382
Grade 12 LA Index							
75 – 100%	155	364	686	1126	1791	3168	7290
50 – 75%	544	774	1459	1999	3250	3698	11724
0 – 50%	163	153	263	370	506	428	1883
born late	309	112	173	180	198	202	1174
absent / drop	93	65	97	139	123	150	667
S4 - no test	375	169	271	300	357	342	1814
S3 or lower	733	174	284	251	310	205	1957
Not enrolled	81	17	19	18	31	17	183
Withdrawn	604	112	162	169	142	126	1315
APGAR Score – 5 Minute							
7 or less	105	58	110	143	171	259	846
8	311	180	363	459	667	747	2727
9	2207	1387	2367	3169	4792	6000	19922
10	366	299	528	729	1013	1225	4160
Birth Weight							
1500 Grams or less	24	7	16	11	29	42	129
1500-2500 Grams	188	108	186	236	311	320	1349
2500-3500 Grams	1578	1091	1788	2214	3333	3957	13961
3500 Grams and over	1208	718	1384	2041	2971	3919	12241
Social Assistance Requirement After Age 18							
Yes	813	85	117	89	95	76	1275
No	2244	1855	3297	4463	6613	8260	26732
Total	3057	1940	3414	4552	6708	8336	28007

*Variable descriptions that do not add up to final study sample are attributable to missing values

Health characteristics at birth were collected to look at early child wellbeing. Approximately 5.3% of the study population had a birth weight of 2500 grams or less, compared to 7.1% in the SA group, and 4.4% in Q5. The 5-minute Apgar score did not appear to have noticeable differences across income groups, with a large proportion of individuals having a score of nine or ten.

Standardized S4 LA test scores were also available for all individuals in the study population following their expected completion of grade 12. Those without a recorded test score were provided with one of the following reasons: i) Born Late ii) Absent or dropped course iii) In S4, no test iv) Enrolled in S3 or lower v) Not enrolled vi) Withdrawn. A much larger proportion of individuals in the SA group were already withdrawn (19.8%) or enrolled in S3 or lower (24.0%) compared to the rest of the population (2.9% and 4.9% respectively).

High residential mobility within Winnipeg was also noticeably different across SES groups. Approximately 61.3% of individuals assigned to the SA group resided in five or more different Winnipeg residences between birth and age 18, compared with 14.3% for Q1, 9.4% for Q3, and 4.7% for Q5. A similar gradient was observed for very high residential mobility as well, with 21.5% in the SA group residing in nine or more different Winnipeg residences, compared to 0.5% for the rest of the study population.

Teenage pregnancy rates were also much higher in low SES groups. In total, 31.3% of females in the SA group were pregnant before their 18th birthday compared with 12.5% in Q1, 8.3% in Q3 and 4.2% in Q5. These rates are comparable to pregnancy

figures found in the prevalence tables (ADG 33) for ages 14-18, but are slightly higher with the inclusion of all pregnancies before age 18.

Requirement of social assistance in early adulthood was another variable used to explore the differences between SES groups within the study population. Individuals whose families required social assistance during their childhood were much more likely to require social assistance payments in early adulthood (26.6%) compared to the rest of the study population (1.9%). The 16-month follow up period after an individual's 18th birthday was selected because of data availability for the entire birth cohort.

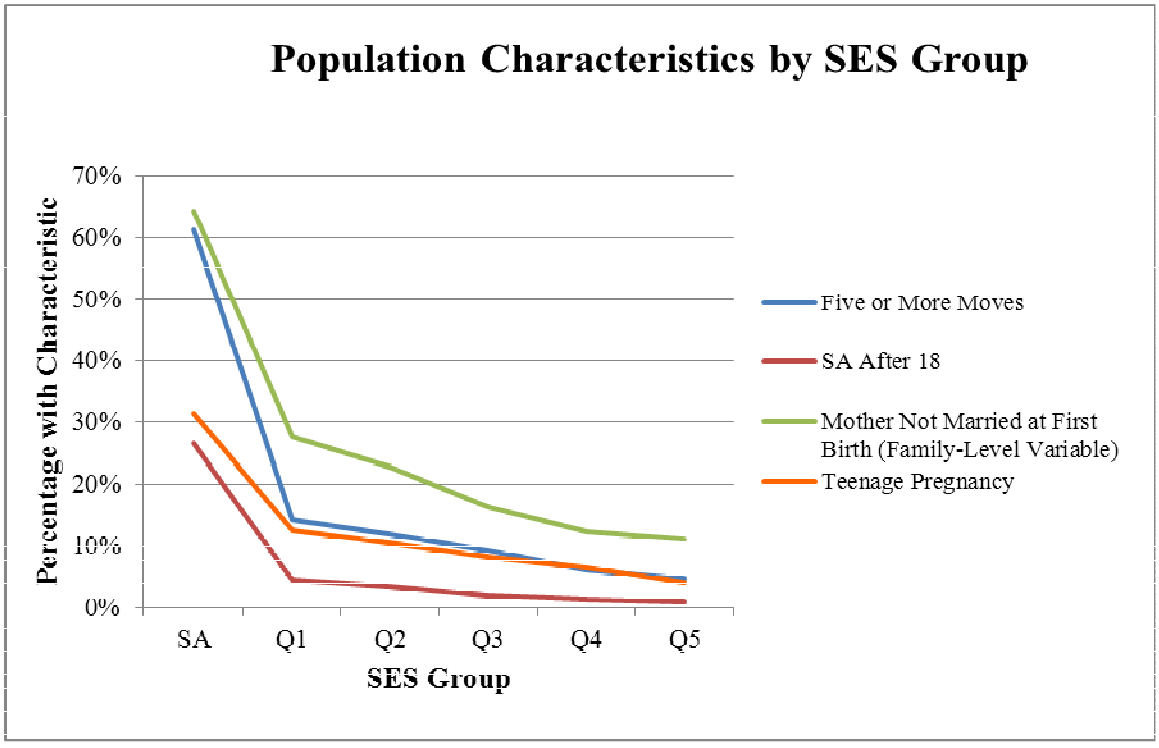
TABLE 4. Family level characteristics of final study population

*Variable	SA	Q1	Q2	Q3	Q4	Q5	Total
Sibling Group Size							
Two Children	1076	695	1292	1742	2578	3192	10575
Three Children	243	152	221	304	455	588	1963
Four or more children	41	22	36	36	42	56	233
Mother's Marital Status at First Birth							
Not Married	847	228	339	332	371	419	2536
Married	468	598	1151	1692	2634	3331	9874
Mother's Age at First Birth							
Under 20	661	142	234	194	215	163	1609
20-24	479	319	578	764	1044	998	4182
25-29	167	261	525	831	1324	1899	5007
30-34	42	119	177	254	428	702	1722
Over 35	11	27	35	39	64	74	250
Total	1360	869	1549	2082	3075	3836	12771

*Variable descriptions that do not add up to final study sample are attributable to missing values

The final study population consisted of mostly two child families (82.8%) and three child families (15.4%). Family size in this research project did not appear to be strongly related to SES groups, with 79.1% of two child families in the SA group and 83.2% of two child families in Q5. Mother's marital status and age at the birth of her first child had a strong relationship with SES. A large percentage of families in the SA group had mothers who were not married at the birth of their first child (64.4%) compared to other SES groups Q1 (27.6%), Q3 (16.4%) and Q5 (11.2%). Several variables that were contrasted across SES for the final study population appeared to have a strong gradient, particularly in the SA group. As seen in *figure 4*, the percentage of the population with certain social indicators is visibly higher in the lowest SES group, with a slight decrease occuring between Q1 and Q5.

FIGURE 4. Characteristics of Final Study Population



3.2 ADG 2 - Time Limited: Minor – Primary Infections

Minor primary infections (ADG 2) had high overall prevalence estimates in ages 0-3 (95.0%) and 4-8 (92.7%). There were no statistically significant prevalence trends occurring across SES for ages 0-3. A statistically significant overall linear trend ($p<0.05$) was present in ages 4-8, but there was small absolute difference in prevalence between the highest and lowest income group (1.4%). Overall prevalence estimates still remained high in ages 9-13 (82.6%) and ages 14-18 (75.2%). These ages had significant linear and SA vs. Q1-Q5 contrasts ($p<0.001$) with higher prevalence estimates occurring in lower SES groups. The difference in prevalence across SES for older age groups largely occurred within the SA group. Prevalence estimates were much higher in the SA group (81.2%) compared to Q1 (73.4%), Q3 (74.9%) and Q5 (74.1%).

Familial aggregation was present for each age and SES group ($p<0.01$). Overall family aggregation for minor primary infections was higher in younger age groups (0-3 & 4-8) than older age groups (9-13 & 14-18). ICC linear trends were statistically significant for all age groups across income groups ($p<0.001$). SA vs. Q1-Q5 contrasts were significant for age groups 0-3, 9-13 & 14-18 ($p<0.001$). The absolute difference in median ICCs across income groups was relatively small for all age groups. ICC estimates were highest in income group Q1 for ages 0-3 (0.467) & 14-18 (0.354) and highest in the SA group for ages 4-8 (0.445) & 9-13 (0.414). The 95% confidence intervals that were calculated from bootstrapped ICCs often contained a value of 1.00 for the upper limit for ages 0-3 & 4-8. ICC Confidence intervals for the oldest age group were narrower in Q5

TABLE 5. Prevalence and ICC Figures: ADG 2 – Time Limited: Minor – Primary Infections

Unadjusted ADG 2- Minor Primary Infections	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	95.6%	95.6%	94.6%	94.6%	95.2%	94.8%	95.0%		
	ICC	0.436	0.467	0.421	0.420	0.433	0.419	0.427	****	****
	95% CI	(0.405-1.00)	(0.421-0.51)	(0.392-1.00)	(0.394-1.00)	(0.412-1.00)	(0.400-1.00)	(0.418-0.437)		
4-8	Prevalence	93.7%	93.0%	93.0%	92.4%	92.8%	92.3%	92.3%	*	
	ICC	0.445	0.442	0.405	0.406	0.407	0.431	0.418	****	
	95% CI	(0.416-1.00)	(0.404-0.482)	(0.373-1.00)	(0.383-1.00)	(0.388-1.00)	(0.414-1.00)	(0.409-0.428)		
9-13	Prevalence	86.9%	82.2%	81.4%	82.0%	83.2%	81.4%	82.6%	****	****
	ICC	0.414	0.406	0.379	0.376	0.377	0.383	0.384	****	****
	95% CI	(0.388-1.00)	(0.376-0.436)	(0.351-0.409)	(0.357-0.396)	(0.359-0.397)	(0.368-0.398)	(0.376-0.394)		
14-18	Prevalence	81.2%	73.4%	75.3%	74.9%	74.7%	74.1%	75.2%	****	****
	ICC	0.345	0.354	0.339	0.345	0.322	0.349	0.341	****	****
	95% CI	(0.316-0.371)	(0.319-0.386)	(0.310-0.367)	(0.320-0.368)	(0.304-0.341)	(0.334-0.366)	(0.333-0.350)		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.005$; ****$p < 0.001$

(0.334-0.366) than SA (0.316-0.371) despite having similar point estimates (0.349 and 0.345 respectively).

High prevalence in ages 0-3 & 4-8 likely contributed to some of the bootstrap ICC estimates having a value of 1.00. High family aggregation will occur when all siblings within a family have similar health outcomes, which is likely the case in conditions that have a very high or low prevalence within a population. This effect becomes apparent with confidence intervals in older age groups not containing 1.00 because of a decrease in overall prevalence.

Typically prevalence and ICC contrasts resulted in similar conclusions. Linear and SA vs. Q1-Q5 contrasts for ages 9-13 & 14-18 had similar decreasing trends for both ICC and prevalence estimates. The similar trends between prevalence and ICCs for these age groups suggest that both the risk of developing minor primary infections is higher in lower SES groups, and that siblings in these groups are experiencing greater familial aggregation. The SA vs. Q1-Q5 contrast for ages 4-8 were not significant for both ICC and prevalence, but the overall linear trends were.

Both contrasts for ages 0-3 were significant for the ICCs, but non-significant for the prevalence values. This result indicates a change in family aggregation across SES groups without a change in prevalence at younger ages. The absolute changes in prevalence across income groups were small with a difference of 1.0% between the highest (SA) and lowest (Q3) prevalence estimates for ages 0-3. This small absolute change in prevalence was associated with a percentages change in ICC of 10.3% between the highest (Q1) and lowest (Q5) ICC estimate.

3.3 ADG 4 - Time Limited: Major – Primary Infections

Major primary infections (ADG 4) had much lower overall prevalence estimates as compared to minor primary infections (ADG 2). Overall prevalence decreased with age ranging from 17.8% in ages 0-3 to 7.7% in ages 14-18. There were statistically significant linear and SA vs. Q1-Q5 contrasts for all age groups ($p<0.005$). These significant trends reflected an overall decrease in prevalence in higher income groups, particularly compared to the SA group. Age range 0-3 experienced the largest difference in prevalence across SES groups with estimates of 22.7% in the highest prevalence group (SA) and 16.0% in the lowest (Q5). The largest relative difference occurred in ages 14-18 with a relative decrease in prevalence of 37% between the SES groups with the highest (SA) and lowest (Q4) prevalence estimates.

Familial aggregation was present for each age and SES group ($p<0.01$). Familial aggregation for major primary infections did not appear to vary as much across age as minor primary infections. All ICC linear and SA vs. Q1-Q5 contrasts were significant at all age ranges ($p<0.001$). There was only a slight absolute decreasing trend across SES groups for ages 0-3 with an estimate of 0.332 in the SA group compared to an estimate of 0.320 in Q5. All other ages had increasing family aggregation across SES groups. The lowest ICC estimates occurred in the SA group for ages 4-8 (0.309) 9-13 (0.338) and 14-18 (0.328). The highest ICCs occurred in Q1 for ages 4-8, Q3 for ages 9-13 and Q1 for ages 14-18 with estimates of 0.363, 0.375 and 0.369 respectively. The upper 95% confidence limits in older ages were 1.00 in higher SES groups. This suggests that certain bootstrap samples contained only families that all had or did not have the condition.

TABLE 6. Prevalence and ICC Figures: ADG 4 – Time Limited: Major – Primary Infections

Unadjusted ADG 4- Major Primary Infections	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	22.7%	18.5%	17.8%	17.8%	17.5%	16.0%	17.8%	****	****
	ICC	0.332	0.326	0.316	0.322	0.332	0.320	0.325	****	****
	95% CI	(0.306-0.360)	(0.287-0.362)	(0.291-0.345)	(0.3-0.345)	(0.315-0.352)	(0.303-0.333)	(0.316-0.333)		
4-8	Prevalence	15.9%	12.8%	13.8%	12.7%	12.9%	13.1%	13.4%	***	****
	ICC	0.309	0.363	0.355	0.346	0.360	0.351	0.348	****	****
	95% CI	(0.283-0.334)	(0.329-0.405)	(0.331-0.382)	(0.323-1.00)	(0.342-1.00)	(0.335-1.00)	(0.339-0.355)		
9-13	Prevalence	11.5%	9.8%	9.0%	7.7%	8.1%	7.7%	8.5%	****	****
	ICC	0.338	0.340	0.346	0.375	0.373	0.359	0.358	****	****
	95% CI	(0.310-0.876)	(0.307-0.373)	(0.314-1.00)	(0.353-1.00)	(0.349-1.00)	(0.343-1.00)	(0.350-0.366)		
14-18	Prevalence	10.9%	7.6%	7.3%	7.8%	6.9%	7.3%	7.7%	****	****
	ICC	0.328	0.369	0.366	0.345	0.350	0.346	0.346	****	****
	95% CI	(0.298-0.928)	(0.334-0.407)	(0.341-1.00)	(0.318-1.00)	(0.333-1.00)	(0.329-1.00)	(0.339-0.354)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

Similar effects on ICC estimation that were seen in high prevalence groups of ADG 2 were also seen in low prevalence groups for ADG 4. High income groups with low prevalence estimates, particularly in older age groups, had upper confidence limits of 1.00. This result supports the idea that bootstrap samples taken from conditions with high similarity within a population (low or high prevalence) may have some estimates of "perfect" family aggregation.

Overall linear and SA vs. Q1-Q5 contrasts were statistically significant for all age groups. There was a decreasing trend in familial aggregation and prevalence with increasing SES for ages 0-3. Prevalence decreased from 22.7% in SA to 16.0% in Q5 compared to an ICC decrease of 0.332 to 0.320 between SA and Q5 respectively. Ages 4-8, 9-13 and 14-18 all had decreasing prevalence in higher levels of SES, but familial aggregation got stronger in higher income groups. The pattern of ICC movement across SES was not completely similar to that of the changes in prevalence. Ages 9-13 had a relatively smooth decrease in prevalence across age with a decrease from 11.5% in SA, 9.8% in Q1, 8.1% in Q4, and 7.7% in Q5. The pattern of ICCs did not exhibit this similar smooth trend across SES groups with increasing ICCs of 0.338 in SA, 0.340 in Q1, and 0.373 in Q4, followed by a decrease to 0.359 in Q5.

Stronger familial aggregation in older age groups was typically associated with an overall decrease in prevalence. Overall prevalence in ages 0-3 was 17.8% with a measured ICC of 0.325. Total familial aggregation got slightly larger in ages 4-8 (0.348) and 9-13 (0.358) before decreasing in ages 14-18 (0.346). Concurrently, prevalence decreased across all ages with an overall estimate of 7.7% in ages 14-18.

3.4 ADG 6 - Asthma

Asthma (ADG 6) had relatively flat prevalence estimates across SES groups for ages 9-13 and 14-18. A significant linear prevalence trend was observed for ages 0-3 ($p<0.001$) with prevalence estimates decreasing in higher SES groups. The asthma prevalence ranged from 11.8% and 12.4% in SA & Q1 respectively to 9.4% in Q5. There was also a significant SA vs. Q1-Q5 contrast for ages 4-8 ($p<0.01$) with a lower prevalence occurring in the SA group compared to the five income quintiles. Older ages experienced little change in prevalence across SES with maximum differences of 2.8% and 2.2% for ages 9-13 and 14-18 respectively. Overall asthma prevalence was lowest in ages 0-3 (10.6%) then increased in ages 4-8 (18.0%) and 9-13 (19.7%) before slightly decreasing in ages 14-18 (15.5%).

Familial aggregation was present for each age and SES group ($p<0.01$). Family aggregation was strongest in younger ages ranging from 0.353 in ages 14-18 to 0.395 in ages 4-8. Linear and SA vs. Q1-Q5 contrasts were statistically significant for all age groups ($p<0.05$). The observed differences in magnitude of ICCs were relatively small for asthma in spite of the low p-values. An example of this effect is seen in ages 14-18 with a maximum difference of 0.014 between the highest ICC in Q1 (0.362) and lowest ICC in Q5 (0.348). Ages 0-3 had a decreasing ICC trend across the five income quintiles ranging from 0.409 in Q1 to 0.385 in Q5, but had its lowest estimate occur in the SA group (0.384). Ages 4-8 had a similar trend with an ICC of 0.393 in the SA group, followed by a general decrease in ICCs from Q1 (0.413) to Q5 (0.384).

TABLE 7. Prevalence and ICC Figures: ADG 6 – Asthma

Unadjusted ADG 6- Asthma	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	11.8%	12.4%	11.4%	9.3%	11.5%	9.4%	10.6%	****	
	ICC	0.384	0.409	0.398	0.396	0.391	0.385	0.392	****	*
		(0.358-1.00)	(0.376-0.446)	(0.370-1.00)	(0.186-1.00)	(0.370-1.00)	(0.011-1.00)	(0.384-0.400)		
4-8	Prevalence	16.0%	19.1%	18.9%	17.1%	19.0%	17.6%	18.0%		**
	ICC	0.393	0.413	0.393	0.400	0.396	0.384	0.395	****	****
		(0.368-0.418)	(0.377-0.441)	(0.368-0.419)	(0.377-0.420)	(0.378-0.414)	(0.367-0.401)	(0.386-0.403)		
9-13	Prevalence	19.2%	19.0%	20.4%	18.1%	20.9%	19.6%	19.7%		
	ICC	0.371	0.360	0.365	0.362	0.374	0.355	0.364	****	****
		(0.344-0.396)	(0.325-0.394)	(0.338-0.390)	(0.340-0.383)	(0.356-0.392)	(0.337-0.370)	(0.357-0.373)		
14-18	Prevalence	16.7%	16.1%	14.5%	15.0%	16.0%	15.4%	15.5%		
	ICC	0.354	0.362	0.362	0.354	0.358	0.348	0.353	***	**
		(0.327-0.378)	(0.329-0.399)	(0.334-0.393)	(0.332-0.379)	(0.339-0.377)	(0.331-0.363)	(0.345-0.362)		
0-18	Prevalence	37.2%	37.4%	36.4%	34.0%	37.8%	35.7%	36.3%		
	ICC	0.370	0.396	0.369	0.369	0.375	0.351	0.368	****	****
		(0.342-0.399)	(0.363-0.427)	(0.345-0.397)	(0.349 – 0.393)	(0.358–0.395)	(0.336-0.368)	(0.359-0.377)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

A statistically significant overall linear trend ($p<0.001$) was observed for both prevalence and ICCs across SES for ages 0-3. Prevalence estimates generally decreased in higher SES groups, however familial aggregation was lowest in SA, highest in Q1, then gradually decreased from Q2 to Q5. For ages 0-3, the SA vs. Q1-Q5 contrast was significant for ICCs ($p<0.05$) but not significant for prevalence. For ages 4-8, a significantly lower prevalence in SA compared with Q1-Q5 ($p<0.01$) was associated with a significantly lower ICC in SA as compared with Q1-Q5 ($p<0.001$). These contrasts show that lower familial aggregation and lower prevalence are present in the SA group compared with Q1-Q5, with Q5 being the only SES group having a lower ICC estimate than SA for ages 4-8.

Ages 9-13 had a significantly decreasing linear trend in familial aggregation across SES groups with ICCs of 0.371 in SA and 0.355 in Q5. There was also a statistically significant SA vs. Q1-Q5 contrast for this age group as well. These ICC trends were associated with no significant differences occurring in prevalence across SES groups. Similar results were seen in ages 14-18 with significant linear and SA vs. Q1-Q5 contrasts ($p<0.01$) but no significant difference in prevalence.

Total prevalence was lowest in ages 0-3, increased in ages 4-8 and 9-13, before decreasing in ages 14-18. Concurrently, ICCs slightly increased between ages 0-3 (0.392) and 4-8 (0.395) before decreasing in ages 9-13 and again in ages 14-18. Widening the age range to 0-18 increased prevalence to 36.3% in the total population, but familial aggregation remained relatively similar to all other age ranges (0.368). SES contrasts were statistically significant for ICCs ($p<0.001$), but not for prevalence.

3.5 ADG 14 – Chronic Specialty: Stable - Eye

Prevalence estimates for chronic specialty stable conditions related to the eye (ADG 14) had much lower overall prevalence estimates in ages 0-3 (16.7%) compared to ages 4-8 (60.4%), ages 9-13 (66.5%) and ages 14-18 (64.3%). Large increases in prevalence were seen across SES groups with statistically significant ($p<0.001$) linear and SA vs. Q1-Q5 prevalence trends for all age groups. Ages 0-3 had an increase in prevalence across SES from 12.0% in the SA group to 20.2% in Q5. Similar prevalence increases were seen for older age groups as well. Ages 4-8 had an increase in prevalence from 49.8% in the SA group to 66.1% in Q5; ages 9-13 had an increase in prevalence from 55.8% in the SA group to 71.3% in Q5; and ages 14-18 had an increase in prevalence from 47.8% in the SA group to 69.5% in Q5.

Familial aggregation was present for each age and SES group ($p<0.01$). Familial aggregation for ADG 14 was strong for all age groups with overall estimates ranging from 0.413 in ages 14-18 to 0.457 in ages 4-8. There was a slight increasing linear trend in familial aggregation for ages 0-3 ($p<0.05$) with ICC estimates ranging from 0.421 in SA to 0.440 in Q5. Statistically significant linear and SA vs. Q1-Q5 contrasts were seen in ages 4-8 ($p<0.001$) with lower family aggregation occurring in the SA group (0.425) compared to Q1 (0.455), Q3 (0.456) and Q5 (0.460). Ages 9-13 had a less obvious, but still statistically significant linear ICC trend across SES with the lowest familial aggregation occurring in the SA group (0.400) compared to Q1 (0.450), Q3 (0.433) and Q5 (0.449).

TABLE 8. Prevalence and ICC Figures: ADG 14 – Chronic Specialty: Stable – Eye

Unadjusted ADG 14- Chronic Specialty- Eye	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	12.0%	12.1%	15.3%	16.3%	16.7%	20.2%	16.7%	****	****
	ICC	0.421	0.422	0.427	0.428	0.432	0.440	0.433	*	
		(0.391-1.00)	(0.388-0.453)	(0.404-0.482)	(0.408-0.454)	(0.415-0.455)	(0.425-0.454)	(0.426-0.441)		
4-8	Prevalence	49.8%	49.2%	56.0%	62.3%	62.1%	66.1%	60.4%	****	****
	ICC	0.425	0.455	0.467	0.456	0.450	0.460	0.457	****	****
		(0.400-0.451)	(0.425-0.484)	(0.445-0.487)	(0.437-0.476)	(0.433-0.467)	(0.445-0.476)	(0.449-0.464)		
9-13	Prevalence	55.8%	58.9%	64.1%	67.4%	68.0%	71.3%	66.5%	****	****
	ICC	0.400	0.450	0.443	0.433	0.443	0.449	0.441	****	****
		(0.372-0.424)	(0.419-0.483)	(0.419-0.469)	(0.412-0.452)	(0.426-0.458)	(0.436-0.464)	(0.433-0.450)		
14-18	Prevalence	47.8%	59.9%	61.7%	65.4%	67.4%	69.5%	64.3%	****	****
	ICC	0.389	0.402	0.425	0.401	0.413	0.411	0.413	****	****
		(0.362-0.415)	(0.367-0.435)	(0.401-0.448)	(0.380-0.422)	(0.396-0.429)	(0.395-0.426)	(0.405-0.421)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

An increasing linear prevalence trend in higher SES groups was associated with a slightly increasing linear ICC trend for ages 0-3. The differences between SA and Q1-Q5 were quite clear for prevalence (<0.001) but not statistically significant for familial aggregation. Age range 4-8 had statistically significant linear and SA vs. Q1-Q5 contrasts for both prevalence and ICCs. Ages 4-8 had an increase in prevalence from 49.8% to 66.1% and an increase in ICC from 0.425 to 0.460 from SA to Q5 respectively.

Ages 9-13 had low familial aggregation occur in the SA group (0.400) followed by a large increase in Q1 (0.450), a decrease in Q3 (0.433) and another increase in Q5 (0.449). Prevalence trends had a more consistent pattern for ages 9-13 with higher rates occurring at each increase in SES. Statistically significant linear and SA vs. Q1-Q5contrasts showed that despite the slight differences in pattern, ICCs and prevalence estimates were larger in high SES groups. Prevalence and ICCs both increased across SES groups in ages 14-18 as well.

Generally, familial aggregation and prevalence increased at higher levels of SES. This result indicated that greater within family similarities were associated with increased prevalence for higher SES groups. Younger age groups had increased movement in prevalence across SES groups, but a relatively stable trend in familial aggregation. A clear relationship between prevalence and ICCs was not observed across the four age groups.

3.6 ADG 21 – Injuries / Adverse Effects: Minor

Minor injury (ADG 21) prevalence estimates were relatively high for all age groups ranging from 35.0% in ages 0-3 to 51.2% in ages 9-13. A linear ICC prevalence trend was statistically significant in ages 0-3 & 4-8 ($p<0.001$) but not in older age groups. Even though the overall linear trend was significant for younger age groups, there was little difference in prevalence across Q1 to Q5. Individuals in the SA group had noticeably higher rates of injury for all age groups. For ages 0-3, prevalence ranged from 45.4% in the SA group to 32.8% in Q5. The differences in prevalence between the SA group and income quintiles appeared to get smaller in the oldest age group. A maximum prevalence difference in ages 14-18 occurred between SA (49.6%) and Q1 (43.5%). All SA vs. Q1-Q5 contrasts were statistically significant ($p<0.001$). The prevalence of minor injuries from birth to age 18 ranged from 81.3% in Q1 to 89.8% in Q5. Linear and SA vs. Q1-Q5 prevalence trends were statistically significant ($p<0.001$) for ages 0-18.

Familial aggregation was present for each age and SES group ($p<0.01$). Overall ICC estimates ranged from 0.287 in ages 0-3 to 0.312 in ages 9-13. Significant linear ICC trends were observed for ages 4-8 & ages 14-18. Ages 4-8 had an ICC of 0.277 in the SA group, followed by estimates of 0.305 in Q1, 0.279 in Q3 and 0.295 in Q5. All SA vs. Q1-Q5 ICC contrasts were significant ($p<0.001$) with lower familial aggregation occurring in the SA group. The differences in ICCs were relatively small despite statistically significant linear and SA vs. Q1-Q5 contrasts. The maximum difference across SES groups occurred at ages 4-8 with a difference of 0.028 between the highest

TABLE 9. Prevalence and ICC Figures: ADG 21 – Injuries/Adverse Effects: Minor

Unadjusted ADG 21- Minor Injuries	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	45.4%	34.1%	35.7%	34.3%	33.5%	32.8%	35.0%	****	****
	ICC	0.279	0.290	0.288	0.273	0.290	0.282	0.287		****
		(0.248-0.310)	(0.253-0.327)	(0.261-0.314)	(0.248-0.298)	(0.269-0.309)	(0.263-0.300)	(0.277-0.297)		
4-8	Prevalence	50.8%	38.8%	39.1%	39.4%	37.3%	38.5%	39.8%	****	****
	ICC	0.277	0.305	0.283	0.279	0.295	0.295	0.292	****	****
		(0.246-0.309)	(0.264-0.339)	(0.255-0.313)	(0.245-0.302)	(0.264-0.315)	(0.241-0.313)	(0.281-0.302)		
9-13	Prevalence	58.0%	45.7%	47.9%	49.9%	50.0%	52.8%	51.2%		****
	ICC	0.303	0.317	0.313	0.323	0.309	0.307	0.312		****
		(0.274-0.330)	(0.278-0.355)	(0.286-0.340)	(0.296-0.348)	(0.286-0.329)	(0.287-0.326)	(0.303-0.321)		
14-18	Prevalence	49.6%	43.5%	44.4%	45.5%	46.1%	49.2%	46.9%		****
	ICC	0.288	0.312	0.287	0.296	0.304	0.304	0.299	****	****
		(0.260-0.321)	(0.275-0.351)	(0.257-0.317)	(0.267-0.318)	(0.281-0.325)	(0.284-0.320)	(0.289-0.309)		
0-18	Prevalence	89.8%	81.3%	82.8%	83.4%	82.9%	84.9%	84.2%	****	****
	ICC	0.369	0.387	0.348	0.366	0.344	0.353	0.356	****	****
		(0.283 – 0.747)	(0.354-0.423)	(0.321-0.373)	(0.343-0.386)	(0.325-0.364)	(0338-0.370)	(0.348-0.365)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

(Q1) and lowest (SA) ICC estimate. Overall familial aggregation increased when all four age groups were combined (0.356). Familial aggregation was highest in Q1 (0.387) and lowest in Q4 (0.344) for ages 0-18. Linear and SA vs. Q1-Q5 ICC contrasts were statistically significant ($p<0.001$) for ages 0-18. Overall aggregation increased noticeably in the 0-18 age range. This suggests that certain sibling groups had similar injury characteristics throughout the entire duration of their childhood, but these injuries may have occurred at different ages, making it seem like aggregation was lower.

Minor injuries in ages 0-3 had statistically significant SA vs. Q1-Q5 contrasts for both prevalence and ICCs. These contrast differences worked in opposite directions for ICCs and prevalence, with higher overall injury rates and lower familial aggregation occurring in the SA group. Ages 4-8 had a similar result, with significantly lower familial aggregation and higher prevalence rates occurring in the SA group. A linear trend was also significant for both prevalence and ICCs for these ages. Ages 9-13 also had significant SA vs. Q1-Q5 trends with high prevalence and lower aggregation occurring in the SA group. The same was seen in ages 14-18, with a linear trend also emerging for ICCs but not prevalence.

These similar results for each age group suggests that injuries occur more often in individuals whose families require social assistance, but are less clustered within these families as compared to higher income groups. Total prevalence and ICC estimates appeared to follow a similar pattern as well. Overall prevalence and familial aggregation were lowest in ages 0-3, increased in ages 4-8, and peaked in ages 9-13 then slightly decreased in ages 14-18.

3.7 ADG 22 – Injuries / Adverse Effects: Major

Major injuries (ADG 22) had comparable overall prevalence estimates to minor injuries for younger ages, but lower rates for ages 9-13 and 14-18. The prevalence of major injury remained relatively stable across age groups ranging from 35.1% in ages 14-18 to 40.3% in ages 0-3. Linear and SA vs. Q1-Q5 contrasts were statistically significant ($p<0.001$) at all age groups. Ages 0-3 had a major injury prevalence of 52.1% in the SA group, compared to 39.0% in Q5. Ages 4-8 had highest prevalence estimates in the SA group (48.8%) and similar rates in Q1 (36.4%), Q3 (37.2%) and Q5 (36.5%). Ages 9-13 & 14-18 had similar prevalence patterns across SES groups. Though linear trends were significant at all age groups, little change in prevalence was seen across Q1 to Q5, with most of the differences occurring in the SA group. Major injuries had an overall prevalence of 79.3% over the entire duration of childhood. There were significant linear and SA vs. Q1-Q5 contrasts ($p<0.001$) for ages 0-18 as well, with a much higher prevalence in the SA group (87.5%) as compared to the lowest prevalence in Q4 (76.4%).

Familial aggregation was present for each age and SES group ($p<0.01$). Overall ICCs for major injuries were relatively similar to minor injuries for all age groups. Ages 0-3 had statistically significant linear and SA vs. Q1-Q5 contrasts ($p<0.001$) with the highest aggregation occurring in the SA group (0.323) and lowest in Q2 (0.272). Ages 4-8 had little difference in ICCs across SES groups, ranging from 0.274 in Q3 to 0.293 in Q1. Despite the small changes in magnitude of median ICCs, there were significant linear ($p<0.001$) and SA vs. Q1-Q5 contrasts ($p<0.05$) for this age group, with a slight decrease in familial aggregation at higher SES groups. Significant linear and SA vs. Q1-Q5

TABLE 10. Prevalence and ICC Figures: ADG 22 – Injuries/Adverse Effects: Major

Unadjusted ADG 22- Major Injuries	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	52.1%	39.0%	40.2%	38.8%	37.9%	39.0%	40.3%	****	****
	ICC	0.323	0.282	0.272	0.291	0.294	0.283	0.292	****	****
		(0.294-0.350)	(0.244-0.319)	(0.240-0.305)	(0.257-0.316)	(0.243-0.316)	(0.240-0.301)	(0.282-0.301)		
4-8	Prevalence	48.8%	36.4%	37.4%	37.2%	35.6%	36.5%	37.9%	****	****
	ICC	0.282	0.293	0.284	0.274	0.288	0.278	0.284	****	*
		(0.253-0.310)	(0.252-0.331)	(0.252-0.312)	(0.234-0.297)	(0.265-0.307)	(0.235-0.298)	(0.272-0.294)		
9-13	Prevalence	44.5%	33.6%	33.7%	34.3%	33.3%	35.9%	35.5%	****	****
	ICC	0.275	0.317	0.283	0.296	0.279	0.287	0.286	****	****
		(0.243-0.307)	(0.281-0.358)	(0.254-0.313)	(0.273-0.321)	(0.256-0.298)	(0.265-0.305)	(0.275-0.296)		
14-18	Prevalence	43.3%	31.5%	33.5%	33.6%	32.9%	36.1%	35.1%	****	****
	ICC	0.283	0.295	0.268	0.269	0.290	0.282	0.284	***	*
		(0.253-0.310)	(0.254-0.333)	(0.240-0.298)	(0.242-0.296)	(0.269-0.308)	(0.246-0.300)	(0.272-0.294)		
0-18	Prevalence	87.5%	77.9%	79.2%	78.0%	76.6%	79.4%	79.3%	****	****
	ICC	0.359	0.323	0.314	0.346	0.317	0.317	0.329	****	****
		(0.331-0.529)	(0.283-0.361)	(0.287-0.341)	(0.323-0.369)	(0.298-0.335)	(0.299-0.332)	(0.321-0.337)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

contrasts were also found in ages 9-13 ($p<0.001$), with the lowest familial aggregation occurring in the SA group. Ages 14-18 also had significant contrasts ($p<0.05$) but the direction of the gradient was difficult to determine with similar ICC estimates in SA, Q1, Q4 & Q5, and lower estimates in Q2 and Q3. Overall familial aggregation for ages 0-18 (0.329) was larger than overall ICC estimates for the four smaller age ranges.

Major injuries had strongly significant ($p<0.001$) linear and SA vs. Q1-Q5 trends for prevalence and ICCs in ages 0-3. The highest prevalence and ICC occurred in the SA group, suggesting that both familial aggregation and prevalence followed a decreasing trend in higher SES groups for younger ages. Ages 9-13 also had significant linear and SA vs. Q1-Q5 trends for prevalence and ICCs, however the direction of the ICCs changed, with the lowest ICC and highest prevalence estimate occurring in the SA group. Ages 14-18 had a significantly higher prevalence estimate in the SA group as compared with Q1-Q5. The SA vs. Q1-Q5 contrast was also significant ($p<0.05$) for ICCs, but the movement across SES groups was less obvious.

Familial aggregation and prevalence remained at relatively the same level across age groups. Both prevalence and ICCs were slightly higher in ages 0-3, and slightly decreased at the other three age ranges. Combining all age groups resulted in a much higher prevalence, and a slightly higher estimate of familial aggregation. Higher ICCs in ages 0-18 suggests that familial aggregation for childhood injuries appears weaker when shorter assessment periods are selected.

3.8 ADG 23 – Psychosocial: Chronic

Overall prevalence for chronic psychosocial conditions (ADG 23) were relatively low in ages 0-3 (0.9%), ages 4-8 (1.6%) and ages 9-13 (2.7%) before largely increasing in ages 14-18 (7.7%). Ages 0-3 had statistically significant linear and SA vs. Q1-Q5 prevalence contrasts ($p<0.005$) ranging from 1.8% in SA to 0.8% in Q5. Ages 4-8 had a significant SA vs. Q1-Q5 prevalence contrast ($p<0.001$) but a non-significant linear trend. Prevalence estimates for this age group were highest in the SA group (2.7%) and lowest in Q1 (1.0%). Prevalence estimates were also much higher in the SA group for ages 9-13 (4.9%) compared to Q1 (2.2%), Q3 (2.4%) and Q5 (2.6%). Linear and SA vs. Q1-Q5 prevalence contrasts for ages 14-18 were also statistically significant, with the prevalence in the SA group (14.9%) almost double that of any other income group.

Familial aggregation was present for each age and SES group ($p<0.01$). ICC point estimates for ages 0-3 were 0.646 for the SA group, and 1.0 for Q1to Q5. Ages 4-8 had similar results with a calculated ICC of 0.429 for the SA group, and ICCs ranging from 0.951 to 1.000 for Q1 to Q5. These results illustrates that many of the bootstrap samples taken from a particular income group resulted in “perfect” familial aggregation in ages 0-3 and age 4-8. High familial aggregation was also observed in ages 9-13, with ICCs ranging from 0.401in SA to 0.675 in Q5. There were statistically significant linear and SA vs. Q1-Q5 ICC contrasts ($p<0.001$) for ages 14-18. The lowest ICC for this age group occurred in the SA group (0.324) and the highest occurred in Q1 (0.407). With the exception of the SA group for ages 14-18, all upper limits of the 95% confidence intervals was calculated as 1.0 for each age range and SES group combination.

TABLE 11. Prevalence and ICC Figures: ADG 23 – Psychosocial: Chronic

Unadjusted ADG 23- Psychosocial: Chronic	Measure	Social Assistance (SA)Group	Q1	Q2	Q3	Q4	Q5	Total	Overall Linear Trend	Contrast SA vs. Q1-Q5
0-3	Prevalence	1.8%	0.6%	0.9%	0.9%	0.6%	0.8%	0.9%	***	****
	ICC	0.646	1.000	1.000	1.000	1.000	1.000	0.482	****	****
		(0.00-1.00)	(0.00-1.00)	(0.410-1.00)	(0.441-1.00)	(0.475-1.00)	(0.474-1.00)	(0.466-1.00)		
4-8	Prevalence	2.7%	1.0%	1.6%	1.7%	1.5%	1.5%	1.6%		****
	ICC	0.429	0.971	0.951	0.973	0.996	1.000	0.990	****	****
		(0.397-1.00)	(0.057-1.00)	(0.00-1.00)	(0.00-1.00)	(0.466-1.00)	(0.406-1.00)	(0.466-1.00)		
9-13	Prevalence	4.9%	2.2%	2.5%	2.4%	2.3%	2.6%	2.7%	****	****
	ICC	0.401	0.496	0.473	0.451	0.477	0.675	0.896	****	****
		(0.373-1.00)	(0.407-1.00)	(0.433-1.00)	(0.427-1.00)	(0.448-1.00)	(0.102-1.00)	(0.448-1.00)		
14-18	Prevalence	14.9%	7.9%	7.8%	6.7%	6.5%	6.6%	7.7%	****	****
	ICC	0.324	0.407	0.386	0.376	0.394	0.384	0.376	****	****
		(0.295-0.353)	(0.372-1.00)	(0.360-1.00)	(0.354-1.00)	(0.375-1.00)	(0.364-1.00)	(0.368-0.385)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

Calculated ICCs of 1.00 indicating perfect or near perfect familial aggregation in ages 0-3 and 4-8 can be directly attributed to the low overall prevalence for these age groups. Low prevalence in younger age categories leads to more sibling pairs having similar outcomes and higher aggregation simply because a very small number of individuals in the population have the condition to begin with. The point estimates of 1.00 indicate that a large proportion of the bootstrap samples were calculated to have perfect familial aggregation. This result could suggest that the small proportion of individuals who are defined to have this condition for younger age groups may share the condition with their sibling.

Ages 9-13 had an increase in ICCs across SES groups associated with a decrease in prevalence. The low overall prevalence for this age group (2.7%) may have caused high ICC estimates for several bootstrap samples for these ages as well. The higher overall prevalence in ages 14-18 seemed to result in more stable ICC estimates across SES. Linear and SA vs. Q1-Q5 contrasts were statistically significant ($p<0.001$) for both prevalence and ICCs. The decrease in prevalence across SES groups was associated with an increase in familial aggregation with a prevalence and ICC of 14.9% and 0.324 for the SA group, compared with 6.6% and 0.384 for Q5.

The total prevalence at each age group had a large effect on the confidence limits for the bootstrapped ICCs. The three youngest age categories each had an overall prevalence less than 3%. This low prevalence was directly attributable to the value of the upper confidence limits having a value of 1.00 for overall ICCs. Prevalence increased to 7.7% in ages 14-18, leading to a more stable point estimate and confidence limits.

3.9 ADG 24 – Psychosocial: Other

Other psychosocial conditions (ADG 24) had similar prevalence estimates in ages 0-3 (9.4%), ages 4-8 (10.5%) and ages 9-13 (11.6%) before almost doubling in ages 14-18 (23.1%). Ages 0-3 had a statistically significant SA vs. Q1-Q5 contrast with a prevalence estimate of 12.8% in the SA group compared to Q1 (6.7%), Q3 (9.8%) and Q5 (9.3%). Prevalence in ages 4-8 ranged from 9.6% in Q1 to 15.6% in the SA group, with statistically significant linear and SA vs. Q1-Q5 contrasts ($p<0.001$). Prevalence estimates for ages 9-13 followed a relatively similar pattern ranging from 10.2% in Q1 to 18.2% in the SA group, also with statistically significant contrasts ($p<0.001$). Overall prevalence increased in ages 14-18, however overall SES contrast significance remained similar ($p<0.001$). Prevalence estimates for these ages were highest in the SA group (30.4%), compared to Q1 (21.7%), Q3 (23.7%) and Q5 (22.3%).

Familial aggregation was present for each age and SES group ($p<0.01$). Overall familial aggregation decreased in older ages with estimates of 0.382 in ages 0-3 compared with 0.329 in ages 14-18. A slightly increasing trend in familial aggregation was seen in ages 0-3 with an ICC of 0.375 in the SA group compared to 0.385 in Q5. Linear and SA vs. Q1-Q5 contrasts were also significant for this period. Familial aggregation for ages 4-8 had a significant SA vs. Q1-Q5 contrast with lower aggregation occurring in the SA group (0.359) compared to Q1 (0.390), Q3 (0.371) and Q5 (0.365). The calculated ICCs for ages 9-13 were lowest in the SA group (0.333) and highest in Q1 (0.402), also with significant linear and SA vs. Q1-Q5 contrasts. Adolescent ages had the weakest familial aggregation ranging from 0.319 in Q5 to 0.336 in Q4.

TABLE 12. Prevalence and ICC Figures: ADG 24 – Psychosocial: Other

Unadjusted ADG 24- Psychosocial Other	**Measure**	**Social Assistance (SA)Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**	**Overall Linear Trend**	**Contrast SA vs. Q1-Q5**
0-3	Prevalence	12.8%	6.7%	8.9%	9.8%	9.0%	9.3%	9.4%		****
	ICC	0.375	0.381	0.384	0.375	0.387	0.385	0.382	****	****
		(0.347-1.00)	(0.350-0.417)	(0.357-1.00)	(0.160-1.00)	(0.252-1.00)	(0.087-1.00)	(0.374-0.391)		
4-8	Prevalence	15.6%	9.6%	10.3%	10.3%	9.9%	9.6%	10.5%	****	****
	ICC	0.359	0.390	0.369	0.371	0.378	0.365	0.371		****
		(0.335-0.385)	(0.356-0.425)	(0.341-1.00)	(0.347-1.00)	(0.057-1.00)	(0.196-0.773)	(0.362-0.38)		
9-13	Prevalence	18.2%	10.2%	10.7%	11.4%	11.0%	10.5%	11.6%	****	****
	ICC	0.333	0.402	0.378	0.355	0.377	0.370	0.365	****	****
		(0.305-0.362)	(0.362-0.435)	(0.348-1.00)	(0.332-1.00)	(0.357-1.00)	(0.348-1.00)	(0.356-0.373)		
14-18	Prevalence	30.4%	21.7%	21.7%	23.7%	21.5%	22.3%	23.1%	****	****
	ICC	0.331	0.326	0.329	0.325	0.336	0.319	0.329	****	****
		(0.303-0.361)	(0.289-0.363)	(0.302-0.355)	(0.303-0.348)	(0.316-0.353)	(0.304-0.337)	(0.319-0.338)		

*p < 0.05 ; **p < 0.01; ***p < 0.005; ****p < 0.001

Prevalence and ICCs both had significant SA vs. Q1-Q5 trends for ages 0-3 ($p<0.001$). These significant SES gradients worked in opposite directions with higher prevalence and lower familial aggregation occurring in the SA group. Findings were similar for ages 4-8 with the largest prevalence (15.6%) and smallest ICC (0.359) in the SA group. Similarly, ages 9-13 had high prevalence (18.2%) and low familial aggregation (0.333) in the SA group as compared to income quintiles. The prevalence trend remained similar in ages 14-18, but the ICC trend appeared to slightly change directions with the second highest ICC occurring in the SA group (0.331).

The ICC trend across SES changes from an overall increasing trend in younger ages to a slight decreasing trend at ages 14-18. This suggests that those who grow up in households that required social assistance have higher prevalence, but may not be as similar to their siblings on behavioural outcomes as families in higher income groups at younger ages, but the within family relationship reverses in older ages.

In ages 4-8 and 9-13, Q1 had typically lower prevalence and higher familial aggregation than all other income groups. This result suggests that children residing in low income neighbourhoods whose families do not require any social assistance have lower rates of non-chronic psychosocial conditions and higher familial similarity as compared to the rest of the population.

3.10 Comparison between ADGs

Prevalence trends largely varied across different age and ADG combinations. With the exception of asthma (ADG 6) and chronic conditions related to the eye (ADG 14) there appeared to be a lower prevalence for those living in areas of high SES. These trends are confirmed with many of these prevalence estimates having significant linear and SA vs. Q1-Q5 contrasts. Asthma had a slight SES gradient in younger ages, but this prevalence trend disappears in ages 9-13 and 14-18. Chronic conditions related to the eye had statistically significant linear and SA vs. Q1-Q5 contrasts across SES groups for all four age groups, with those in higher SES groups experiencing a higher prevalence.

Familial aggregation differed noticeably across both SES groups and age. *Figure 5* provides a visual summary of the ICC magnitude experienced for different ADGs across SES groups in ages 4-8. Estimates from chronic psychosocial conditions (ADG 23) were excluded from this figure because of unstable prevalence and ICC measures. Chronic specialty conditions related to the eye appeared to have the strongest familial aggregation across all SES groups, with the exception of the SA group. Minor primary infections had the highest ICC in the SA group, and second highest for Q1-Q5. Asthma had the next highest familial aggregation, followed by non-chronic psychosocial conditions and major primary infections. Minor and major injuries had low ICC estimates relative to all other conditions.

Each ADG had a somewhat unique shape to its ICC distribution across SES groups. Familial aggregation in Q1 appeared to be consistently higher than in the SA

group for many ADGs in ages 4-8. Asthma, non-chronic psychosocial conditions, major primary infections and minor injuries all had slight jumps in familial aggregation between SA and Q1, followed by a gradual decline across remaining income quintiles. Major primary infections had the largest overall change between the income groups with the highest and lowest ICC for a particular ADG in ages 4-8. Major injuries had the lowest overall change between the highest and lowest ICC for this age group.

There was a large difference in ICC magnitude between minor primary infections (0.445) and major primary infections (0.309) in the SA group for ages 4-8. This difference appeared to get smaller in middle income quintiles, before getting slightly larger in Q5. Minor and major injuries did not share this effect, with ICC estimates remaining almost identical across all income groups.

Figure 6 provides a visual description of total ICCs for different ADG conditions at different age groups. Again, chronic psychosocial conditions were not included in this figure. Chronic specialty conditions related to the eye were strongest at each age group, with a slight decrease at older ages. Major and minor primary infections largely differed at younger groups, before approaching almost identical values in ages 14-18. Asthma and non-chronic psychosocial conditions slightly decreased across age groups and approached the same magnitude of primary infections. Familial aggregation remained the lowest in major and minor injuries for all age groups, with a slight increase occurring in older ages for minor injuries. The decreases in overall aggregation for most conditions likely reflect members of the same family having a more similar environment in early years as compared with adolescence.

FIGURE 5. Familial Aggregation of ADGs – Ages 4-8

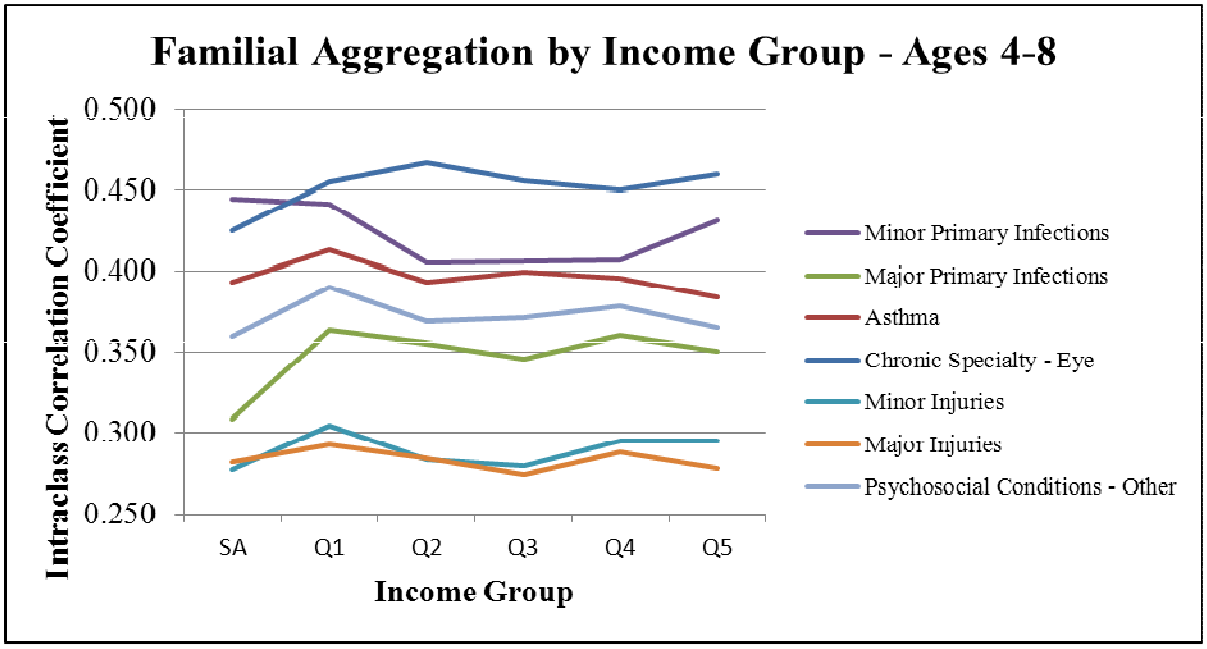
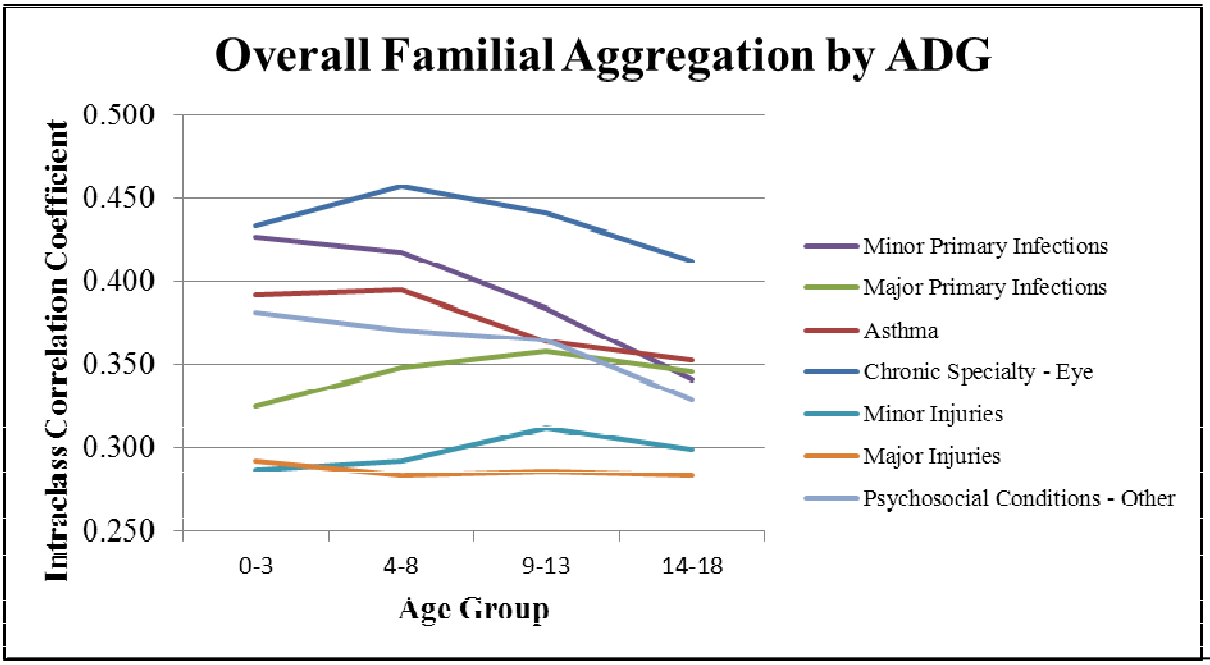


FIGURE 6. Overall Familial Aggregation by ADG – All Ages



The absolute difference between the weakest and strongest ICC is smallest in the oldest age group (0.129) and largest in ages 4-8 (0.173). These differences were relatively similar in ages 0-3 (0.146) and ages 9-13 (0.155). Chronic specialty eye conditions had noticeably stronger familial aggregation at older age groups. The ICCs for chronic specialty eye conditions were 0.441 in ages 9-13 and 0.413 in ages 14-18. The ICCs for the next highest familial aggregation was 0.384 for minor primary infections at ages 9-13, and 0.353 for asthma at ages 14-18. The differences between the highest and second highest ICC at ages 0-3 and 4-8 were much smaller, 0.006 and 0.039 respectively.

Minor primary infections had the largest difference in ICCs across age groups with a change from 0.427 in ages 0-3 to 0.341 in ages 14-18. Major injuries had the smallest change in familial aggregation across age groups, with a difference of 0.008 between the highest (ages 0-3) and lowest (ages 4-8 & 14-18) ICCs. All ADGs had a drop in familial aggregation between ages 9-13 and 14-18. Non-chronic psychosocial conditions and minor primary infections had the two largest drops in familial aggregation at these ages. This result suggests certain ADG conditions become noticeably less dependent on family as children make the transition from middle years schooling to high school.

CHAPTER FOUR: DISCUSSION

4.1 Clinical Relevance of ICCs

The required sample size for detecting changes across groups is dependent on the overall variability within the groups being compared, the power and level of significance to be achieved and the desired clinical relevance to be detected (Cohen, 1992). ICC linear and SA vs. Q1-Q5 contrasts were statistically significant ($p<0.05$) for most ages and ADGs. The large sample size (N=3000; N_{SA}=500....N_{Q5}=500) allowed for small overall differences in ICCs to be detected at low levels of significance and high levels of power. This result becomes clear when examining the absolute differences in ICCs across SES for certain ADGs. An example of this can be seen in minor injuries (ADG 21) at ages 0-3. There was a statistically significant SA vs. Q1-Q5 contrast ($p<0.001$) but only a maximum difference of 0.011 between the observed ICC in the SA group (0.279) and Q1 to Q5 (ranging from 0.273 to 0.290).

Strong familial aggregation may suggest that the implementation of programs associated with a particular ADG may best be implemented at the family level. Similarly, large differences in ICCs across SES groups could suggest that family-level programs may best be implemented in particular neighbourhoods. The decision as to exactly what absolute changes in ICC across SES groups should be deemed clinically relevant is not easily answered.

As outlined in the methodology section of this research, the determination of whether or not an ICC is statistically significant was determined by simulating multiple

ICCs under the null hypothesis of no aggregation. Absolute differences in ICCs may not appropriately determine the relative strength of familial aggregation that is present for a particular condition. The debate over exactly what should be considered a large or small change in ICC may be best determined for each unique study context. Methodology that involves outcome simulation at different probability levels could prove essential for the proper comparison of ICCs between groups.

4.2 Eye Care and Private Insurance

Chronic conditions related to the eye (ADG14) are primarily funded under private insurance plans in Manitoba. According to CIHI (2005), approximately 54% of Manitobans aged 12 and over have public or private insurance for eye care. The observed overall ICCs for ages 9-13 of 0.441 suggest relatively high familial aggregation compared to other conditions of similar prevalence. The high aggregation for this ADG may be largely attributed to the strong genetic component that is often present in conditions related to the eye (Klein et al., 2005).

High-income earners are four times more likely than low-income earners to have some kind of coverage related to eye care (CIHI, 2005). Results from ADG 14 show increasing familial aggregation in higher SES groups for all ages. Intuitively this suggests that those in higher SES groups have concurrently higher coverage rates and familial aggregation. Administrative data housed at MCHP provides information on physician claims that are covered through Manitoba Health, but not private insurance claims. Inclusion of these claims in the assessment of chronic specialty conditions related to the eye may have shown even larger disparity of prevalence and familial aggregation in

higher income groups. Even without the inclusion of these claims, families with private insurance are likely experiencing more public claims than those without coverage because of higher overall referral rates to publically covered physician offices.

4.3 Familial Aggregation Comparisons between ADGs

Familial aggregation comparisons between ADGs must be interpreted with caution. *Table 2* showed that the significance of ICCs depends in part on the prevalence of the outcome in the population and structure of the population. This finding suggests that drawing conclusions about the magnitude of ICCs may be difficult if the family structure and outcome prevalence differ between the two groups being compared. Proper comparisons of ICCs with binary outcomes would likely have to be made by simulating a situation-specific set of confidence levels for the null hypothesis of no aggregation, then comparing the p-values obtained.

Even though the inferences drawn on ICCs should depend on other factors, the literal interpretation of an ICC remains the same. Comparing the absolute ICCs measures of two ADGs that do not have identical prevalence estimates is still useful. The ICC estimates in this study context essentially provide point estimates of familial similarity based on the proportion of total outcome variation accounted for by the family level intercept. A larger ICC does not necessarily represent a more statistically significant value, but it does characterize a larger family level random intercept implying greater within group similarity.

4.4 Low and High Prevalence Related to ICC Calculation

Some ADG outcomes had relatively low (<10%) or high (>90%) prevalence estimates for a given age and SES group combination. For these conditions, there were likely some bootstrap samples that contained families who had perfect similarity on a particular outcome. This would result in a calculated ICC of 1.00 if all families contained within a bootstrap sample had identical disease characteristics. Histograms of the 500 calculated ICCs for each condition, age and SES combination would sometimes have a second spike in the distribution at 1.00, indicating that multiple bootstrap samples would have "perfect" familial aggregation. This result suggests that the sensitivity in ICC estimation on binary outcomes may be dependent on the actual prevalence of a particular condition.

As mentioned above, ICC estimation with binary outcomes is inherently different than working with continuous outcomes. Since binary outcomes only take on two values, there is a high degree of likelihood that members in the same group will take on the same value, even with random assignment to each study subject. *Table 2* showed that even when 500 simulations were made with the assumption of no familial aggregation, ICCs still took on relatively high values for the 95% and 99% confidence levels at low outcome probabilities.

Heo & Leon (2005) looked at the effects of changing between-cluster variation, the number of clusters, cluster size equality and average cluster size on type I error and power in a simulated mixed effects logistic regression model with binary outcomes. This

study found that between-cluster variation and the number of clusters both had an effect on the type I error rate and statistical power. More studies which simulate the effect that different outcome rates have on ICC estimation would be beneficial for optimizing the methodology in calculating familial aggregation in this context, particularly if a bootstrap selection methodology was utilized.

4.5 Effect of Age Range on Prevalence and ICC Estimation

The presence of a particular ADG was determined based on various medical and hospital claims of an individual occurring within a certain age range, and independent of all other claims throughout childhood. The definition of age ranges could potentially have a large effect on the results obtained for both prevalence and familial aggregation. Widening the age ranges would naturally increase the prevalence of a particular ADG since more medical claims would be available for the assessment of each individual. This increase in prevalence however, would not necessarily be associated with a similar effect on familial aggregation.

Tables 7, 9 and 10 provided an illustration of this effect for minor and major injuries (ADG 21 & 22) and asthma (ADG 6). The overall prevalence estimates at previously defined age groups ranged from 35.0% to 51.2% for minor injuries; and from 35.1% to 40.3% for major injuries. Combining all four age ranges and defining an ADG from ages 0-18 leads to overall prevalence estimates of 84.2% and 79.3% for minor and major injuries respectively. The linear and SA vs. Q1-Q5 contrasts at ages 0-18 were significant for minor and major injuries ($p<0.001$). These trends were similar to contrast estimates obtained at each age range, only linear trends for minor injuries at ages 9-13 &

14-18 were not statistically significant. Familial aggregation also increased with the newly defined age range. Total minor injury ICCs ranged from 0.287 to 0.312 across age groups, compared to an estimate of 0.356 for ages 0-18. Total major injury ICCs ranged from 0.284 to 0.292 across age groups, compared to an estimate of 0.329 for ages 0-18. The effect of widening age groups for asthma had a similar effect on prevalence estimates. Prevalence ranged from about 10-20% at each age group, but increased to 36.3% from ages 0 to 18. Familial aggregation however, remained relative similar in ages 0-18 (0.368) as compared to each age group (0.353 to 0.392).

These figures illustrate that wider age groups of particular ADG outcomes will undoubtedly lead to much higher estimates of prevalence. Widening the age range did not change the ICC estimates for asthma, a more chronic condition, but noticeably increased in both minor and major injuries. Further assessment of familial aggregation for conditions that are acute in nature may require a wider assessment period to account for the unsystematic distribution of outcomes throughout childhood.

4.6 Lower Familial Aggregation in Injuries

Familial aggregation was relatively weak in major and minor injuries compared to all other conditions explored in each age group. There is likely a large difference in the genetic effect between having an injury related medical or hospital claim versus for example, chronic specialty conditions related to the eye (ADG 14). Sibling relationships have been shown to exist for childhood injuries. These similarities are typically attributed to environmental factors such as domestic conflict, lack of social supports, parental behaviours and child-parent relationships (Rhodes & Iwashyna, 2007; Schwebel &

Brezausek, 2010). Higher familial aggregation, for example in conditions related to the eye, may include environmental factors such as insurance coverage and parental smoking, along with documented genetic similarities among family members (Lee, Klein, Klein & Fine, 2001; CIHI, 2005; Stone et al., 2006).

The acute nature of childhood injury may in part underestimate familial aggregation at each individual age group. Siblings may have similar disease patterns across age groups for conditions that are more chronic in nature, whereas injuries may be more randomly distributed throughout childhood. The combination of all age groups led to much higher ICC estimates for both minor and major injuries. As previously mentioned, the ability to determine whether or not certain families have more "injury prone" children may involve the selection of wider assessment periods.

4.7 ICC Estimation for Binary Outcomes

The interpretation of ICCs in this study context is difficult because of the inherent differences that exist between binary outcomes and normally distributed outcomes. The simulated ICCs that were calculated under the null hypothesis of no familial relationship (*Table 2)* was used to determine whether or not a particular health measure had statistically significant aggregation. This methodology proved essential to truly determine whether or not an ICC should be considered important for this unique population.

Each member of a family can either be assigned a 0 (health measure is not present) or a 1 (health measure is present). Even with random assignment of a binary outcome, there will undoubtedly be families in which each member has identical values.

This would not be the case however for random assignment of an outcome from a continuous distribution. Values for all members of a particular family may be similar in this situation, but never identical. Calculating ICCs and their confidence limits for poisson and negative binomial distributions has been previously explored, but not been well established in practice (Lui & Kuo, 1996; Carrasco & Jover, 2005). Continuous outcomes that quantify illness severity may be beneficial in calculating within-group aggregation for a sample of individuals who have a particular condition.

4.8 Future Research

The research conducted in this thesis primarily focused on the relationships between SES and both the prevalence of health conditions and familial aggregation. Further exploring the effect of individual and family level factors contributing to familial aggregation may help identify certain characteristics that contribute to stronger or weaker relationships. Aggregation may also depend on the gender of the children within a family. Stratifying the analysis and re-calculating ICCs by different family types (two boys, one boy and one girl, etc.) may help further identify where the majority of aggregation is occurring. Exploring families with multiple boys may be particularly relevant in future research on childhood injuries because of the higher prevalence rates in males. Calculating family aggregation of those living in different areas of rural and northern Manitoba may also be useful.

For this research, simulation analysis has proven to be a useful tool in making statistical inferences on ICCs calculated on binary outcomes. Various factors including outcome prevalence and population structure have proven in this research to influence the

"null hypothesis ICC" at different levels of significance. More in-depth analyses on the identified factors that affect ICC estimation on binary outcomes would be useful for future research in a similar subject field.

4.9 Limitations to Research

The research conducted in this thesis addressed the objectives as intended. Limitations exist in both the methodology and how the results should be interpreted. The calculation of ICCs for ADG conditions with very high or low prevalence estimates would sometimes result in a value of 1 for a given bootstrap sample. The histograms of these bootstrapped ICCs would not look normally distributed, but rather have a bimodal looking distribution with a lower peak occurring at a value of 1, and a higher peak at approximately the median of the distribution. The high values in this distribution may have had an effect on the contrast results for certain ICCs. Generally the ICCs cited in this thesis did not have this property; however an alternative methodology may need to be explored for future research of this type to account for low and high prevalence conditions.

Another limitation of this research exists within the exclusion criteria used to develop the final study sample. Excluding individuals living outside of Winnipeg at any point along with those without an identifiable sibling considerably reduces the sample from the overall Manitoba birth cohort. The structure of the population that resided outside of Winnipeg at some point during childhood was explored to determine whether or not family composition was consistent for the entire Manitoba population.

The family size structure of those who lived outside of Winnipeg from birth to age 18 (N=48824) was found to be quite similar to that of the final study sample. The average family size was slightly lower in the Winnipeg population (2.19) than the population that resided outside of Winnipeg (2.36). There were a high percentage of families containing either two or three siblings in both the Winnipeg population (98.2%) and the population that resided outside of Winnipeg (93.7%).

Despite the fact that family composition is somewhat similar between the two populations, the results obtained on familial aggregation and prevalence for the Winnipeg population cannot directly apply to the non-Winnipeg population. Comparable family sizes is one similarity between non-Winnipeg siblings and Winnipeg siblings, however dissimilarities such as levels of physical activities, residential stability, etc. also exist. This limitation has an effect on the overall external validity of the research study since study results cannot be directly generalized to all children/families residing in Manitoba.

CHAPTER FIVE: CONCLUSIONS

The research conducted in this thesis investigated childhood health in a unique study context at the population level. Prevalence and familial aggregation was calculated at four age periods and six levels of SES for eight different health outcomes. The proposed methodology addressed the research questions as intended, while bringing up new issues surrounding the appropriate analysis of ICCs calculated on binary outcomes.

Strong SES prevalence gradients were present for most ADGs with the exception of ADG 6 (Asthma). Injury, primary infection and psychosocial ADGs generally had higher prevalence estimates in lower SES groups, particularly in those requiring social assistance. Chronic specialty conditions related to the eye (ADG 14) had the opposite trend, with those in the upper SES groups experiencing higher prevalence rates. The prevalence trends found for all ADGs remained relatively similar at each age group studied.

The significance of family ICCs was determined through a simulation of the null hypothesis of no aggregation for outcomes of differing prevalence. Familial aggregation was present at each age and SES group combination for the eight ADG conditions explored. Chronic specialty conditions related to the eye had the highest absolute familial aggregation at each age group. Major and minor injuries were found to have the lowest absolute familial aggregation at each age group. Injury ICCs increased when the age range of ADG assessment was widened to include all of childhood (ages 0 to 18). A similar expansion of age range for asthma also led to higher prevalence, but no increase in familial aggregation was detected.

The majority of SA vs. Q1-Q5 and linear contrasts performed on bootstrapped ICC estimates ended up being statistically significant, even though there were small absolute differences across SES groups. The direction of the SES gradient differed depending on the ADG and age. Typically familial aggregation became weaker in older age groups, particularly in high school years. The simulation of the null hypothesis implying no familial aggregation for outcomes of differing prevalence proved that statistical significance of ICCs does in fact depend on prevalence. The prevalence of most ADGs varied across SES groups. This suggests that comparing absolute ICC values across cohorts of differing prevalence may not reflect the true differences in familial aggregation.

The estimation of ICCs for binary outcome was found to depend on several aspects of the study population and research methodology. The factors identified in this research included the outcome prevalence, bootstrap replication size and the definition of age ranges. Clinical relevance of aggregation may best be determined through simulation of a null hypothesis ICC in each unique context. Future research that focuses on ICC calculation should take these ideas into consideration.

This research demonstrated that a wide range of childhood health conditions have some degree of similarity within families. The strength of these within family similarities appears to vary across SES groups and depend on the prevalence of the health outcome being investigated. Despite the fact that childhood injury does not intrinsically have a strong genetic component, significant familial aggregation was present. This suggests that there are likely genetic and environmental contributions that are playing a role in overall

child health and wellbeing for Winnipeg siblings. Future policy discourse would best be focused on addressing both of these family level components for prevention, detection and management of these health conditions.

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