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Does Family Size Negatively Affect Child Health Outcomes in the United States?

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This paper explores the relationship between family size and child health outcomes in the United States. More specifically, it attempts to determine if the number of siblings has a causal effect on child health. Becker's Quantity-Quality tradeoff suggests that more children (quantity) results to unhealthier children (quality). The main estimation strategy is the use of instrumental variables, for family size and health outcomes can be jointly determined by parental characteristics unseen and unaccounted for. In addition, a sub-analysis on families below the poverty line is conducted to see the additional effect of another child under more constricted circumstances. Lastly, the relationship between parents' time with their children and family size is explored, since time is assumed to be another way to invest in a child. An econometric analysis of panel data from the U.S. Bureau of Labor Statistic's National Longitudinal Surveys (NLS) points to a positive relationship between family size and health – the more siblings a child has, the healthier the child.

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Does Family Size Negatively Affect Child Health Outcomes in the United States?

1. Introduction

In the United States, one of the main health concerns regarding child health is obesity. In recent years, child and adolescent obesity has more than tripled since the 1970s (Fryar et al. 2014). Furthermore, this condition has devastating consequences, for obese children are at a higher risk of having chronic health conditions and diseases (ie. type 2 diabetes and heart disease) that cost Americans approximately $147-$210 billion a year in healthcare costs alone (Cawley and Meyerhoefer 2009). While there are many financial, social, and biological factors, this paper explores the impact of family size on childhood obesity and other related health outcomes. Despite efforts to determine the effect of family size on health, the topic remains controversial as researchers struggle to reach a consensus on whether or not an increase in family size positively or negatively affects children's wellbeing. On one hand the addition of a sibling will force parents to allocate their resources among more children, resulting to a decrease in investment per child and an eventual decrease in the "quality" of children. On the other hand, parents can take advantage of the economies of scale of children, allowing cost cuts per child in basic needs such as food, clothing, and education. In addition, the interaction between siblings can create positive spillovers—for instance, a sibling can act as a "secondary" parent taking on responsibilities around the house. Therefore, these two opposing forces lead to ambiguous results in determining the effect of family size on children's outcomes. This paper attempts to quantify the impact of family size on health, and will contribute to the literature in threefold:

1) To explore this relationship in a developed country context (United States)
2) To explore not only standardized health scores (ie. BMI-for-Age) but also the level of time investment per child. The amount of time a parent spends per child is an important "input", and can affect health outcomes. As well as filling in the gap in the family size literature, this sub-analysis will provide additional research to the time-use literature.
3) To explore the additional effect of family size by income level

Section 2 provides a literature review. Section 3 elaborates on the Quantity-Quality theory, which will be the theoretical basis for my empirical results. Section 4 introduces the data and provides summary statistics while Section 5 presents the research strategy and empirical model. Section 6 is the empirical results, and lastly, Section 7 provides a discussion as well as areas for further research.

2. Literature Review

2.1 Family Size and Health

The main underlying theory for this topic is the Quantity-Quality (Q-Q) model. In short, the model shows an inverse relationship between family size and child outcomes because a household's limited resources creates a constraint where a trade-off between quantity and quality is necessary (Becker 1960). While there can be many definitions of quality, Becker assumes that quality is a trait that increases as more inputs are invested. For example, the more money towards a child (ie. music lessons, healthful food), the higher human capital and wellbeing (and thus quality) a child will possess. In the case of this paper's research question, the Q-Q theory suggests that an increase in family size decreases the overall health of a child.

One of the main challenges in evaluating the validity of the Q-Q theory is the problem of endogeneity. A simple regression with child outcomes on the left-hand side and family size on the right-hand side would merely confirm correlation (but not causation), since there are unobservable parent and household characteristics that affect both family size and child quality. For instance, parents who are poor planners may have bigger families because they were not prepared with the necessary contraceptives. At the same time, these parents may deteriorate their children's health by neglecting to involve their children in sports. In this case, poor planning is the driver of both family size and child health, not the increase in family size. Now, the question is not only about resource constraints (with an additional child), but also about certain characteristics that parents have. Therefore, many studies have adopted various research methods in an attempt to isolate the causal effect of family size on outcomes. Most utilize instrumental variables (IVs) that are strongly correlated with family size but not with health (Rosenzweig and Zhang 2009; Dasgupta and Soloman 2017; Li et al. 2008; Ponczek and Souza 2012; Lundbord et al. 2013; Glick et al. 2007; Black et al. 2005). Pioneered by Rosenzweig and Wolpin (1980), a very popular IV is twin births due to its random and exogenous nature.[1] However, a limitation of using twin births is that the probability of having twins varies with maternal characteristics such as age and race (Angrist et al. 2010). Nonetheless, the use of twins as an IV still acts as an adequate and exogenous determinant of family size.

[1] Although modern fertility treatments increase the chance of having twins and triplets, these treatments were not prevalent until the mid-1990s (Kulkarni et al. 2013). Since most children in the dataset are born before this period, I do not consider this as a major concern regarding the exogenous nature of twin births.

Another popular IV is sibling-sex composition. It is empirically proven that mothers with children of the same gender are more likely to conceive another child because there is a parental preference for mixed-sibling sex composition (Westoff et al. 1963). Therefore, a binary gender composition of the first two children is utilized to estimate family size (Millimet and Wang 2011; Lee 2008; Iacovou 2001). More recently, studies have used both twin births and gender composition as IVs for robustness checks (Angrist et al. 2010; Angrist and Evans 1998). Aside from two widely-used IVs, some studies cater the IV choice to the cultural, societal, and political context of a particular country or region. For instance, Angrist et al. (2010) assume an ethnic preference for boys in Israeli mothers, and therefore utilize an IV as a binary indicator of whether or not the firstborn is a boy. While this gender bias is evident in countries with the culture, it is likely that this bias is less prevalent and intense in the United States. Furthermore, Zhong (2017) utilizes China's One-Child Policy as an IV to determine family size.

Literature that attempts to empirically examine the Q-Q theory falls into two categories: studies that focus on developing countries and studies that focus on developed countries. In particular, an extensive literature on developing countries focuses on child health and education, and empirically supports the Q-Q model (Rosenzweig and Zhang 2009; Millimet and Wang 2011; Glick et al. 2007; Li et al. 2008; Rosenzweig and Wolpin 1980). For instance, Ponczek and Souza (2012) find that family size negatively affects child education outcomes in Brazil, with a 2.3% decrease in the probability of attending school for firstborn girls after an addition of a sibling. In contrast, Zhong (2017) shows that although the Q-Q model holds for health, it does not hold for education in China— even though an increase in family size decreases children's height-for-weight Z-scores by 0.149, the additional sibling increases the probability of completing elementary school by 3.4%. With these results, Zhong (2017) supposes that while resource constraints inevitably affect health, these constraints are not evident in education. For example, older siblings may help their younger siblings with schoolwork, which may induce the younger siblings to stay in school. On a similar vein, Angrist et al. (2010) do not find a significant effect of family size on the formation of human capital in Israel. They provide a possibility that when there is an exogenous increase in family size, parents may adjust their own resources (ie. parents work longer hours or substitute away from personal consumption) to maintain a certain level of standard for their children.

Although some studies examine the effect of family size and non-health outcomes in developed countries, few consider the effect on child health outcomes in these regions (Dasgupta and Solomon 2017; Lundborg et al. 2012; Hatton and Martin 2010). Out of these, the most relevant to this paper's research question is Dasgupta and Solomon's (2017) examination of the effect of family size on child health in the United States. The authors utilize the National Longitudinal Survey of Youth data to run a probit model to determine how an increase in family size affects the likelihood of different health outcomes such as obesity. In addition, since family size and health outcomes are endogenous, they also run a 2SLS using twin births and same-sex siblings as instruments. Results show that a birth of a younger sibling decreases a child's BMI by 0.344, which results to a 2.1% decrease in the likelihood of being overweight. Assuming that in the United States, children are more likely to be obese rather than underweight from malnourishment, Dasgupta and Solomon's results point to a positive relationship between family size and child health. Therefore, while empirical results from developing countries tend to support the Q-Q model, those from developed countries do not.

2.2 Family Size and Time Investment

Aside from exploring family size on health outcomes, some papers also study the effect of parents' time investment on child outcomes. Other than our main interest in child health, these studies focus on various child outcomes such as education and cognitive skills (De Graaf et al. 2000; Booth et al. 2002; Huston and Aronson 2005). Most of these studies indicate an insignificant overall association between time and child outcomes, if not a positive relationship. More specifically with health outcomes, extensive literature shows a positive relationship between time investment and child health (Hammons and Fiese 2011; Wansink and van Kleef 2013). For instance, Hammons and Fiese (2011) use panel data to find that families who have dinner together 3 or more times a week are 12% less likely to have obese children than families who do not eat together as often. A common justification for this phenomenon is that parents are able to prepare healthier meals and enforce healthier habits to their children. Therefore, the time literature suggests that children's health ameliorates as parents spend more time with them.

Despite the extensive time literature regarding child health, there remains a gap in the research regarding the effect of family size on time investment. Out of the few studies, Hofferth and Anderson (2003) conduct time diary analysis to find that older children spend less time with their parents than their younger siblings, suggesting that parents spend less time with each of their children in bigger families. In addition, Ono et al.

(2013) state that children's time involvement with their mother decreases by an average of 103 minutes per week as the number of children increases. Therefore, the two branches of time literature suggest that parents spend less time on their children as family size increases, which may have either insignificant or positive impacts on child health.

3. Theory

As mentioned before, the most prevalent theory in the family size literature is the Q-Q model (Becker 1960). Many studies have used this model to provide theoretical background and to validate their empirical results (Rosenzweig and Zhang 2009; Millimet and Wang 2011; Glick et al. 2007; Li et al. 2008; Rosenzweig and Wolpin 1980). This theory shows a non-linear inverse relationship between the number of children, and the quality of children. The more children parents have, the lower their average quality will be due to decreased inputs per child. In relation to the research question at hand, as the number of children increases, the health outcomes of each child will be relatively worse than children in smaller households.

This trade-off was introduced by Gary Becker (1960). This theory was first framed in the context of developed countries, because parents were better able to control their fertility decisions with the increase in the knowledge and usage of modern contraceptives in the 1950s. With the ability to better control the number of children parents have, Becker models children as normal consumption goods where the number of children is decided by parents in a way that maximizes their utilities given their preferences and a budget constraint. Currently given that parents in developing countries have access to modern contraceptives assures that the Q-Q model can be applied to all contexts.

Becker makes a distinction between the quantity and quality of children, where quantity is the number of children and quality can be proxied as the amount of parents' resources per child. Although he does not give specific examples of quality, his interpretation of "high-quality" children are that they have more expensive inputs (ie. college education, music lesson etc). It does not necessarily mean that higher-quality children have better character or are ideal citizens. The basic theoretical proof for the inverse relationship between quality and quantity is shown by the first order conditions of the utility maximization problem. An important assumption of this theory is that the quality of children within a family are assumed to be identical—parents invest in the quality of children to the optimal level chosen by the household.

Let the utility function of a household be

$$U = U(n, q, y)$$

where n is the number of children, q is the quality of children, and y represents other consumption goods.

The household's budget constraint is

$$I = nq\pi + y\pi_y$$

where π is the price per unit of n or q. Therefore, $nq\pi$ is the total expenditure on n children all at a quality of q. π_y is the price of consumption goods other than children.

Given the utility function and budget constraint, the first-order conditions are as follows:

$$L = U(n, q, y) + \lambda(I - nq\pi - y\pi_y)$$

$$\frac{\partial L}{\partial n} = \frac{\partial U}{\partial n} - \lambda q\pi = 0 \rightarrow \frac{\partial U}{\partial n} = \lambda q\pi \rightarrow MU_n = \lambda q\pi$$

$$\frac{\partial L}{\partial q} = \frac{\partial U}{\partial q} - \lambda n\pi = 0 \rightarrow \frac{\partial U}{\partial q} = \lambda n\pi \rightarrow MU_q = \lambda n\pi$$

$$\frac{\partial L}{\partial y} = \frac{\partial U}{\partial y} - \lambda\pi_y = 0 \rightarrow \frac{\partial U}{\partial y} = \lambda\pi_y \rightarrow MU_y = \lambda\pi_y$$

$$\frac{\partial L}{\partial \lambda} = I - nq\pi + y\pi_y = 0$$

Denoted by λ, the marginal utility of income is the additional utility from a unit increase of income. Therefore, the marginal utility of *n*, *q*, and *y* can broken down into two components: the additional utility of income (λ) and the respective marginal costs ($q\pi$, $n\pi$, π_y), which indicates the increase in utility per unit times the number of units.

The first-order conditions provide the relationships between the factors and their respective marginal costs. In family size decision-making, parents will hold these conditions to choose an equilibrium/optimal consumption bundle that maximizes their utility. From here, the marginal costs *n*, *q*, and *y* are

$$MC_n = q\pi$$

$$MC_q = n\pi$$

$$MC_y = \pi_y$$

For instance, $q\pi$ is the cost associated with having one additional child at a quality level of q. Conversely, $n\pi$ is the cost associated with increasing one unit of quality for n children in the family (since the theory assumes all children have the same level of q). It is important to note that the marginal costs of n and q are proportional to q and n respectively. Therefore, there is an inverse relationship between n and q. For instance, an increase in the number of children ($n\uparrow$) increases the marginal cost of quality ($MU_q\uparrow$), which decreases and amount of quality ($q\downarrow$). Intuitively, an increase in quantity (quality) results in a decrease in quality (quantity) due to a household's limited amount of resources. This relationship does not change even when additions are made to the theory, such as incorporating health endowment at birth in determining q (Becker 1960).

This theory examines how the decision for parents to have more children affects the quality of, or the amount of inputs allocated in each child. For the purpose of the research question, as family size increases, the investment in each child decreases due to the fact that parents allocate their constrained resources among the number of children. Quality is represented by the wellbeing of the children. Because activities that improve health typically require more money from parents, having more children reduces health. For instance, children who eat expensive organic meals are likely to be healthier than those who eat cheap fast food. The decrease in investment per child will result in the exacerbation of children's health outcomes. So, children in bigger households will have worse health outcomes (ie. more obese, shorter etc) than those in smaller households because their parents have provided them with fewer resources (Kesse-Guyot, et al. 2017).

4. Data Description and Summary Statistics

4.1 Data Description

I extract my data from the National Longitudinal Survey (NLS), a country-wide longitudinal survey run by the United States Bureau of Labour Statistics. The paper will utilize two different sections of the survey: the National Longitudinal Survey of Youth 1979 (NLSY) and the National Longitudinal Survey of Youth 1979 Children and Young Adults (NLSY79-CYA). The U.S. Bureau of Labour Statistics first initiated the NLSY to track tens of thousands of Americans born in the years 1957-64. The NLSY has biennial data from 1979 to 2014. The NSLY79-CYA is a survey that tracks the biological children of the women in the NLSY section. Throughout its 15 biennial rounds (1986-14), the survey keeps track of 11,521 children, of which 250 are twins, and 6 are triplets. This distribution is reflective of the U.S. twin population of about 2%. For the purpose of this paper, the analysis will limit to children younger than 18 years old.

Since this paper aims to explore child health outcomes, the main survey of interest is the NLSY79-CYA. However, the NLSY will provide extensive information on the mothers, allowing for better controls for mother characteristics. In addition, the NLSY79-CYA provides variables such as the number of siblings, weight, and height to calculate health outcomes, as well as those that can be used for control variables (income, education, race etc).

It is important to note that the survey was conducted on a subsample of the population every round. Therefore, it is impossible for an individual child or mother to have all information across all years. Although the data spans long enough that almost all

(11,223 children) are evaluated at least once, this methodology limits the number of observations. In order to conduct panel analysis, it is essential to have information across at least two different years. While this is true for most of the data, the survey year of these observations may not correspond to the desired age of the child. For example, a child may get an additional sibling when he/she is 5 years old, but all of the observations may be in the teenage years. In addition to limiting the sample data, this inconsistency can provide empirical results that are less valid.

The main health outcomes of interest are health z-scores from the World Health Organization. The WHO Anthro software calculates standardized scores of children from birth to 18 years that are considered as child growth standards. These outcomes are: BMI-for-Age, Height-for-Age, Weight-for-Age, and Weight-for-Height. These scores give information on a child's relative position in the population of the same age and gender, because they provide the standard deviations away from the mean. For the context of the U.S. where obesity is more prevalent than malnourishment, I will assume that parents would prefer their children to have lower BMI, Weight-for-Age, and Weight-for-Height. Table 1 provides a brief description for each. It is important to note that -2 is the threshold for underweight or malnourishment (WHO 2011).

Table 1: Description of Health Outcomes

Health Outcomes	
BMI-for-Age	Indicator for overweight and obese children. A score of at least 2 indicates overweight and below -2 indicates underweight. In the case of this study, a decrease in this score usually indicates an improvement in health outcomes
Height-for-Age	Indicator for height. A score below -2 indicates stunted height
Weight-for-Age	Indicator for weight. A score below -2 is underweight and may have growth problems. However, this is better assessed from BMI-for-Age or Weight-for-Height
Weight-for-Height	Indicator for overweight and obese children. Should show similar trends like BMI-for-Age

Aside from these main health outcomes, an extension of the research question will utilize a behavioural variable. Recognizing that time is a very important but limited resource, I made an investment score that measures the amount of time parents invest in their children. In the context of the United States, it may be that parents keep their children healthy even with an increase in family size, but may not be able to input the same amount of time per child with an addition. The exploration of this relationship is certainly relevant and is also an indication of the wellbeing of a child (as shown in the time-use literature). An explanation of this variable is provided in Table 2. Table 3 provides an extensive summary of independent variables.

Table 2: Description of Behavioural Outcomes

Time Investment	
Investment score	Score for the amount of time invested in the child. The score is a compilation of 4 different actions done with the children: (1) Parent help with homework often (2) Parent and child eat dinner often (3) Parent and child go shopping often (4) Parent and child go out often These questions are asked to the children to avoid biased answers by the parents. The score is the percentage of actions that were true for the parent (0 to 1)

Table 3: Summary of Independent and Control Variables Used

Variable	Description
Independent Variables of Interest	
Number of Children	Number of children a mother has in a single HH
Twin HH	Indicator for HH with twins *0= Non-twin HH; 1=Twin HH*
Gender Composition	Indicator for HH with same-gender composition *0=Not same; 1= Same*
Control Variables	
Race	Categorical for race of child *1= Hispanic; 2= Black; 3= Other*
Sex	Indicator for gender of child *0= Male; 1= Female*
Adjusted Family Income (1000s)	Annual family income in 1000s, CPI (base 1984)
Mother Education	Categorical for mother education *1= Not finish HS; 2= Finish HS;* *3= Some college; 4= Post-college*
Marital Status	Categorical for mother marital status *1= Married; 2= Separated;* *3= Divorced; 4= Widowed*
Residence	Categorical for type of HH child lives in *1= with mother; 2= with other family;* *3= other or living independently*
Poverty	Indicator for children living under the poverty line *0= over poverty line; 1= under poverty line*

4.2 Summary Statistics

The summary statistics presented below are information for individual children from ages 4 to 9. This is primarily because most of the population was surveyed during these years.

Table 4: Summary Statistics (Continuous)

	mean	sd	min	max
Health Outcomes				
BMI	16.28	4.50	1	137
BMI-for-Age	0.23	1.50	-5	5
Height-for-Age	-0.07	1.48	-6	6
Weight-for-Age	0.14	1.14	-4	5
Weight-for-Height	0.24	1.47	-5	5
Right-hand Side Variables				
Number of Children	2.64	1.38	0	11
Adj Family Income (1000s)	26.92	37.75	0	598
Mother Education (yrs)	12.91	2.57	0	20
Investment Score	0.81	0.36	0	1

Table 4 shows the summary statistics for continuous variables so that the statistics provide context on the general makeup of the child population. *Number of Children*, which is on average 2.6 children per mother, will be our main independent variable to represent family size. *Investment Score* indicates that on average, parents score about 81% in spending time with their children, or fulfill about 81% of the activities that were asked about in the survey. Table 5 summarizes information about categorical variables.

Table 5a: Distribution of Race

	pct
Hispanic	19.34
Black	27.22
Other	53.43

Table 5b: Distribution of Gender

	pct
Male	50.71
Female	49.29

Table 5c: Distribution of Residence

	pct
With mother	96.26
With other family	2.89
Other/Independent	0.85

Table 5d: Dist of Mother Marital Status

	pct
Married	77.54
Separated	9.27
Divorced	12.35
Widowed	0.84

Tables 6 and 7 provide summary statistics for gender and race. It is important to note that while most statistics are similar within different categories, family income is on average significantly higher for non-Hispanic/Black children.

Table 6: Summary Statistics by Race

	Hispanic		**Black**		**Other**	
	mean	sd	mean	sd	mean	sd
Health Outcomes						
BMI	15.81	2.14	15.79	2.32	15.78	2.05
BMI-for-Age	0.25	1.43	0.22	1.55	0.25	1.40
Height-for-Age	-0.20	1.27	0.11	1.36	-0.17	1.28
Weight-for-Age	0.05	1.13	0.22	1.12	0.06	1.01
Weight-for-Height	0.22	1.43	0.18	1.57	0.21	1.41
Independent Variables						
Number of Children	2.96	1.56	2.82	1.33	2.41	1.23
Adj Family Income (1000s)	24.27	23.12	22.87	32.19	36.26	47.22

Table 7: Summary Statistics by Gender

	Male		**Female**	
	mean	sd	mean	sd
Health Outcomes				
BMI	15.85	2.10	15.72	2.14
BMI-for-Age	0.31	1.49	0.17	1.37
Height-for-Age	-0.05	1.30	-0.20	1.30
Weight-for-Age	0.17	1.09	-0.00	1.02
Weight-for-Height	0.26	1.47	0.15	1.41
Independent Variables				
Number of Children	2.57	1.30	2.64	1.39
Adj Family Income (1000s)	31.39	39.88	31.18	42.49
Mother Education	2.72	0.95	2.67	0.93

Table 8 shows a t-test that compares child health outcomes of households with at least two children and households with single children. As shown from the table, there is a significant difference between most health outcomes except for Height-for-Age. Households with at least two children have significantly lower outcomes, indicating an improvement in health since they are both still higher than the WHO’s -2 threshold for being underweight (2011). Therefore, preliminary data analysis insinuates that the Q-Q tradeoff may not be supported.

Table 8: T-test for Number of Children

	2+ Children	1 Child	diff	t stat
BMI	16.16896	16.68326	-.5143025***	-11.52748
BMI-for-Age	.2023455	.2143781	-.0120326	-.5265423
Height-for-Age	-.0599493	-.0203472	-.0396021**	-1.802005
Weight-for-Age	.11537	.2144927	-.0991227***	-6.08746
Weight-for-Height	.1994911	.2535776	-.0540865**	-2.368731

Since comparing health outcomes by the number of children still allows for endogeneity, I also run a t-test between households who have twins and those who do not. More specifically, Table 9 tests for significant changes in health outcomes for first-borns who have twin siblings and those who do not. By comparing these, we may be able to see the additional difference in outcomes when siblings randomly gain another sibling (1 birth vs. 2 births).

Table 9: T-test for First-borns (no twin vs. twin)

	No Twin Siblings	Has Twin Siblings	diff	t stat
BMI	16.26271	16.03845	.2242586	1.541798
BMI-for-Age	.1877648	.28	-.0922352	-1.058571
Height-for-Age	.0925525	.1883955	-.095843	-1.133149
Weight-for-Age	.1896615	.2105782	-.0209168	-.3234916
Weight-for-Height	.1914303	.2479104	-.0564801	-.6598286

Compared to the previous t-test results, there is no significant difference between the health outcomes of interest, although the outcomes of first-borns with no twin siblings tend to be a little lower for BMI-for-Age, Height-for-Age, Weight-for-Age, and Weight-for-Height. This implies there is no significant effect of family size.

Again, it is important to note that summary statistics and t-tests do not guarantee causation. Endogeneity still exists between family size and health outcomes, and there are no control variables. In order to better determine the sole effect of family size on health outcomes, an IV estimation with control variables is necessary.

5. Research Strategy and Empirical Model

The main empirical model is a two-stage least squares regression. The first stage regression will use the IVs to estimate the number of children in a household.

$$numchild^* = a_0 + a_1 IV_h + a_2 X_{ht} + e \quad (1)$$

where *numchild** is the number of children, IV is a vector of two IV variables, twin births and gender composition for household *h*, and *X* is a vector of control variables of households *h* at time *t*. The IVs will be dummy variables: 0 for non-twin households and same-sex composition, and 1 for twin households and different-sex composition. As mentioned before, one of the conditions for an adequate IV is for it to be strongly correlated with the endogenous dependent variable of interest. An evaluation of this requirement is provided in the empirical results section. When the first stage is calculated, the estimated *numchild** is stored for the second stage. The second stage is a regression between the estimated family size and a health outcome of interest.

$$health\ outcomes = b_0 + b_1 numchild^* + b_3 X_{ht} + e \quad (2)$$

Since *numchild** is an estimated variable from an exogenous IV, the glaring problem of endogeneity between health outcomes and actual family size is ameliorated. This allows the coefficient of interest (b_1) to be less biased and more likely to determine causality rather than mere correlation. In addition to the two individual IVs, another IV that incorporates both twin households and gender composition will also be used. Aside from exploring health outcomes, I also look at the effect of family size on parent investment with the IV models.

6. Empirical Results

6.1 Validity of Instrumental Variables

One simple way to check for the adequacy of the proposed IVs is to look at the first-stage regression results (with control variables). Although not a formal test, if the results show a significant relationship between family size and the IVs, then the IV would meet one of the conditions of correlation. In addition, the Cragg-Donald Wald F statistics indicate that both IVs are adequate to use in the 2SLS.

Table 10: First Stage Regressions for IVs

	(1)	(2)	(3)
VARIABLES	Twins	Gender Composition	Both
Twin Household	2.323***		2.042***
	(0.0344)		(0.0306)
Gender Composition		-1.122***	-1.087***
		(0.00815)	(0.00792)
Controls	Yes	Yes	Yes
F Statistic	363.454	1733.400	1088.908
Observations	79,136	79,136	79,136
R-squared	0.094	0.242	0.287
Number of Children	9,541	9,541	9,541

6.2 Preliminary Regressions

Before utilizing the IV research strategy, I run two longitudinal regressions: a random effects model and a fixed effects model at the child level. Although a fixed effects model is more appropriate, the random effects results can show the general relationship between child health outcomes and time-invariant variables such as race and sex.

Table 11: Preliminary Results (Panel Random Effects)

VARIABLES	(1) BMI-for-Age	(2) Height-for-Age	(3) Weight-for-Age	(4) Weight-for-Height
Number of Children	-0.0432**	-0.0461***	-0.0711***	-0.0521***
	(0.0176)	(0.0178)	(0.0126)	(0.0174)
Race (Hispanic)				
Black	-0.136**	0.134**	0.0871*	-0.0627
	(0.0674)	(0.0679)	(0.0488)	(0.0663)
Other	-0.133**	0.118**	-0.0592	-0.110**
	(0.0538)	(0.0543)	(0.0391)	(0.0529)
Gender (Male)	-0.126***	-0.0546	-0.162***	-0.137***
	(0.0405)	(0.0410)	(0.0297)	(0.0399)
Adj Family Income	0.000684	-0.000623	0.000144	0.000409
	(0.000454)	(0.000463)	(0.000253)	(0.000447)
Mother Education (< HS)				
High School	-0.166*	0.0377	-0.0642	-0.160*
	(0.0883)	(0.0892)	(0.0628)	(0.0870)
Some college	-0.0560	-0.00330	-0.0530	-0.0586
	(0.0911)	(0.0921)	(0.0649)	(0.0897)
College+	-0.191**	0.155	-0.00936	-0.192**
	(0.0935)	(0.0944)	(0.0665)	(0.0920)
Marital Status (Married)				
Separated	-0.0685	0.0557	-0.0897	-0.0741
	(0.0858)	(0.0863)	(0.0569)	(0.0845)
Divorced	0.110	-0.108	0.0141	0.104
	(0.0730)	(0.0738)	(0.0498)	(0.0718)
Widowed	0.594**	-0.291	0.230	0.590**
	(0.258)	(0.261)	(0.178)	(0.255)
Residence (w/ Mother)				
With other family	0.146	0.217	-0.0354	0.0907
	(0.337)	(0.335)	(0.224)	(0.332)
Other/Independent	0.569	0.560	0.871**	0.577
	(0.688)	(0.712)	(0.415)	(0.678)
Constant	0.924***	-0.138	0.767***	0.960***
	(0.121)	(0.122)	(0.0869)	(0.119)
Observations	7,864	8,220	9,450	7,881
Number of Children	4,871	4,973	5,165	4,875

Table 11 shows the preliminary results for the random effects, and Table 12 shows the preliminary results for the panel fixed effects. It is important to note that these results could be biased. The simple regressions allow for unobservable parent characteristics to partially drive the relationship between number of children and health outcomes. Therefore, the empirical results would overestimate the actual effect of family size, resulting in coefficients with greater magnitudes. However the regressions may be able to show the general direction of family size and health outcomes.

Table 12: Preliminary Results, no IVs (Panel Fixed Effects at the Individual Level)

VARIABLES	(1) BMI-to-Age	(2) Height-to-Age	(3) Weight-to-Age	(4) Weight-to-Height
Number of Children	-0.202***	-0.0236	-0.284***	-0.229***
	(0.0744)	(0.0753)	(0.0396)	(0.0731)
Adj Family Income (1000s)	0.000904	-0.00145*	-6.63e-05	0.000723
	(0.000732)	(0.000743)	(0.000345)	(0.000720)
Marital Status (Married)				
Separated	-0.197	0.185	-0.251***	-0.104
	(0.195)	(0.191)	(0.0964)	(0.191)
Divorced	0.177	-0.103	0.0376	0.196
	(0.186)	(0.188)	(0.0972)	(0.184)
Widowed	0.465	1.065	0.968**	0.444
	(0.871)	(0.875)	(0.427)	(0.998)
Residence (w/ Mother)				
With other family	-1.094	1.166	0.0459	-1.029
	(1.204)	(0.979)	(0.507)	(1.183)
Other/Independent	-0.193	0.622	1.513**	-0.374
	(1.438)	(1.480)	(0.636)	(1.413)
Constant	0.890***	-0.107	1.001***	0.969***
	(0.186)	(0.189)	(0.0993)	(0.183)
Observations	7,864	8,220	9,450	7,881
R-squared	0.004	0.003	0.016	0.005
Number of Children	4,871	4,973	5,165	4,875

Looking at the fixed effects results, as the number of children increases, BMI-for-Age, Weight-for-Age, and Weight-for-Height change by -0.2, -0.28, and -0.23

respectively, at 1% level of significance. Given that even with the decrease the scores remain above -2 (since the mean scores are near 0 from the summary statistics table), the decrease indicates an improved health outcome. Other than the number of children, control variables such as the mother's marital status, family income, and residence are significant. These preliminary results show that the Q-Q tradeoff does not hold, and this finding is consistent with the literature on developed countries, as Dasgupta and Solomon (2017) also find an advantageous effect of family size on child health outcomes.

6.3 IV Regressions

I run three main IV regressions of fixed effects at the child level: with the IV as twin households, gender composition, and a combination of the two IVs.

When using twin households as an IV, the directions of the coefficients on *Number of Children* are mixed. Furthermore, the coefficients on family size are all insignificant. This ambiguous result may be because the IV depends on a small sample size of twin households. Therefore, the twin IV results do not agree with or deny the Q-Q tradeoff.

Table 13: Twin Households IV (Panel FE at the Child Level)

VARIABLES	(1) BMI-for-Age	(2) Height-for-Age	(3) Weight-for-Age	(4) Weight-for-Height
Number of Children	0.208	-0.328	-0.0788	0.101
	(0.382)	(0.355)	(0.187)	(0.374)
Adj Family Income (1000s)	0.000750	-0.00135*	-0.000130	0.000605
	(0.000749)	(0.000754)	(0.000351)	(0.000734)
Marital Status (Married)				
Separated	-0.201	0.187	-0.248**	-0.108
	(0.196)	(0.192)	(0.0967)	(0.192)
Divorced	0.161	-0.0851	0.0328	0.182
	(0.187)	(0.189)	(0.0976)	(0.185)
Widowed	0.463	1.066	0.968**	0.444
	(0.876)	(0.877)	(0.429)	(1.001)
Residence (w/ Mother)				
With other family	-1.098	1.056	0.101	-1.033
	(1.210)	(0.990)	(0.511)	(1.187)
Other/Independent	-0.483	0.838	1.442**	-0.609
	(1.469)	(1.504)	(0.641)	(1.442)
Constant	-0.115	0.640	0.497	0.163
	(0.935)	(0.872)	(0.460)	(0.916)
Observations	7,864	8,220	9,450	7,881
Number of Children	4,871	4,973	5,165	4,875

Table 14 presents empirical results for the gender composition IV. Unlike results from the twin household IV, the coefficients on *Number of Children* in these regressions are all negative. In terms of significance, an increase in the number of children suggests a decrease of 0.39, 0.31, and 0.37 for BMI-for-Age, Weight-for-Age, and Weight-for-Height. Since a decrease in these outcomes indicates better health in the developed world context, the gender composition IV shows that the Q-Q theory does not hold. All control variables (family income, mother marital status, and child residence) are significant in some health outcomes. For example, for every $1000 increase in adjusted family income, Height-for-Age decreases by -0.0015 on average. In addition, in comparison to children with married mothers, Weight-for-Age is on average 0.25 less for children whose mothers are separated and 0.97 higher for children whose mothers are widowed. The magnitudes of *Widowed* (marital status) and *Other/Independent* (residence) are 0.97 and 1.52 respectively for Weight-for-Age, which indicates that on average, children whose mothers are widowed or live independently have a much higher health outcome. Although these results are significant, this may be driven by outliers within an already small sample size. In the data, only 0.85% of children live independently and only 0.84% children have widowed mothers, and it may be that there are certain outliers that drive the significance.

Table 14: Gender Composition IV (Panel FE at Child Level)

VARIABLES	(1) BMI-for-Age	(2) Height-for-Age	(3) Weight-for-Age	(4) Weight-for-Height
Number of Children	-0.387***	-0.0111	-0.313***	-0.373***
	(0.121)	(0.123)	(0.0653)	(0.119)
Adj Family Income (1000s)	0.000973	-0.00146**	-5.72e-05	0.000774
	(0.000734)	(0.000744)	(0.000346)	(0.000721)
Marital Status (Married)				
Separated	-0.195	0.185	-0.251***	-0.103
	(0.195)	(0.191)	(0.0964)	(0.191)
Divorced	0.185	-0.104	0.0383	0.202
	(0.186)	(0.188)	(0.0972)	(0.184)
Widowed	0.465	1.065	0.968**	0.445
	(0.872)	(0.875)	(0.427)	(0.998)
Residence (w/ Mother)				
With other family	-1.092	1.171	0.0381	-1.028
	(1.205)	(0.980)	(0.508)	(1.184)
Other/Independent	-0.0616	0.613	1.523**	-0.272
	(1.441)	(1.482)	(0.636)	(1.416)
Constant	1.343***	-0.138	1.073***	1.321***
	(0.300)	(0.303)	(0.162)	(0.294)
Observations	7,864	8,220	9,450	7,881
Number of Children	4,871	4,973	5,165	4,875

Lastly, Table 15 summarizes results from both gender composition and twin household IVs. For an increase in the number of children, BMI-for-Age, Weight-for-Age and Weight-for-Height decreases by 0.37, 0.28 and 0.33, indicating better health outcomes in the context of the United States, and therefore in contrast to the Q-Q theory. It is important to note that this regression is a combination of the two IVs, of which gender composition by itself had very significant results while twin households did not. Therefore, it is reasonable to see that results with both IVs are more similar to those of the gender composition IV.

Table 15: Both IVs (Panel FE at the Child Level)

VARIABLES	(1) BMI-for-Age	(2) Height-for-Age	(3) Weight-for-Age	(4) Weight-for-Height
Number of Children	-0.341***	-0.0389	-0.292***	-0.336***
	(0.118)	(0.118)	(0.0630)	(0.116)
Adj Family Income (1000s)	0.000956	-0.00145*	-6.37e-05	0.000761
	(0.000734)	(0.000743)	(0.000346)	(0.000721)
Marital Status (Married)				
Separated	-0.196	0.185	-0.251***	-0.103
	(0.195)	(0.191)	(0.0964)	(0.191)
Divorced	0.183	-0.102	0.0378	0.200
	(0.186)	(0.188)	(0.0972)	(0.184)
Widowed	0.465	1.065	0.968**	0.445
	(0.872)	(0.875)	(0.427)	(0.998)
Residence (w/ Mother)				
With other family	-1.092	1.161	0.0436	-1.028
	(1.204)	(0.980)	(0.508)	(1.184)
Other/Independent	-0.0940	0.633	1.516**	-0.298
	(1.440)	(1.482)	(0.636)	(1.415)
Constant	1.231***	-0.0697	1.022***	1.232***
	(0.291)	(0.293)	(0.156)	(0.285)
Observations	7,864	8,220	9,450	7,881
Number of Children	4,871	4,973	5,165	4,875

Overall, IV estimations generally point to positive health outcomes as family size increases. Although there is always the possibility of stunted growth or malnutrition, the magnitudes of these coefficients are low enough that the average effect of family size still keep children above the -2 Z-score cut-off (an indicator of malnutrition by designated by the World Health Organization). Therefore, the IV estimations provide evidence against the Q-Q theory. Aside from the main coefficients of interests, mother marital status consistently has significant effects. More specifically for Weight-for-Age, the mother being separated (compared to being married) induces a decrease in Weight-for-Age while widowed mothers induces an increase in the health outcome.

One main concern about the IV regression results is its interpretability for larger families. The coefficients indicate a constant increase or decrease in health outcomes per each child. Although the average effect of one additional child does not push kids beyond the -2 Z-score cut-off, the results imply that their health may cross this threshold once they have 4 or 5 more siblings. Therefore, I ran a basic IV model that looks at the marginal effect of a new sibling. As indicated in Table 16, the coefficients on all health outcomes except Height-to-Age for single children gaining a sibling ("1 to 2") are significant and negative, while other groups are not significant. In addition, all of the magnitudes are different. These results may point to an effect of family size on health outcomes for only smaller families. However, it is important to note that these are naïve results, and important control variables must be incorporated in order to estimate a more accurate relationship. For instance, the employment status of the mother is a crucial factor. It is more likely for a mother of 4 children to give up work and stay home than a mother of 1. If going from 2 to 3 children makes mothers give up their full-time job, then the health outcomes of children would definitely be different from those whose mothers are still working. Therefore, differentiating the two types of mothers can better estimate the true effect of family size on health outcomes. Nonetheless, in line with the Q-Q's assumption of a non-linear relationship, these regression results point to a non-linear or at least a trailing effect of family size on health outcomes.

Table 16: Marginal Effect of a Child

VARIABLES	(1) 1 to 2	(2) 2 to 3	(3) 3 to 4
BMI-to-Age			
Number of Children	-0.445***	-0.332	-0.466
	(0.159)	(0.280)	(0.593)
Observations	4,727	5,186	2,709
Number of Children	3,045	3,420	1,803
Height-to-Age			
Number of Children	0.107	-0.313	0.279
	(0.167)	(0.272)	(0.529)
Observations	4,923	5,406	2,838
Number of Children	3,102	3,475	1,847
Weight-to-Age			
Number of Children	-0.351***	-0.356**	-0.196
	(0.0848)	(0.145)	(0.316)
Observations	5,655	6,239	3,278
Number of Children	3,264	3,666	1,947
Weight-to-Height			
Number of Children	-0.482***	-0.182	-0.440
	(0.156)	(0.273)	(0.581)
Observations	4,747	5,204	2,710
Number of Children	3,052	3,423	1,803

6.4 Additional IV Analysis: Poverty Interaction

In addition to the traditional IV regressions in the previous section, I also run IV regressions that specifically attempt to pry out the effect of family size on families below the poverty line. In more technical terms, these regressions incorporate a *Poverty Interaction*, an interaction term between the number of children and an indicator for whether or not a family is above or below the poverty line (0 for above and 1 for below).

The purpose of including a poverty interaction is the fact that the coefficient on *Adj. Family Income* merely provides the average effect of family income on health outcomes. This coefficient does not necessarily give information about how families of different income levels react to an increase in family size. By including a poverty interaction term, the regressions allow for an additional effect of family size for poor families, whose reactions may be more extreme due to a tightening of already-constrained resources.

Table 17: Both IVs with Poverty Interaction (Panel IV FE at the Child Level)

VARIABLES	(1) BMI-for-Age	(2) Height-for-Age	(3) Weight-for-Age	(4) Weight-for-Height
Number of Children	-0.353***	-0.0218	-0.301***	-0.356***
	(0.118)	(0.119)	(0.0633)	(0.116)
Poverty Interaction	0.212	-0.207	0.187*	0.310
	(0.209)	(0.200)	(0.112)	(0.205)
Poverty Indicator	-0.478	0.638	-0.629*	-0.756
	(0.604)	(0.581)	(0.330)	(0.592)
Adj. Family Income	0.000966	-0.00141*	-0.000102	0.000759
	(0.000737)	(0.000747)	(0.000347)	(0.000724)
Marital Status (Married)				
Separated	-0.238	0.171	-0.219**	-0.139
	(0.200)	(0.196)	(0.0987)	(0.197)
Divorced	0.183	-0.126	0.0794	0.209
	(0.189)	(0.190)	(0.0994)	(0.186)
Widowed	0.473	1.066	0.989**	0.445
	(0.874)	(0.876)	(0.428)	(1.001)
Residence (w/ Mother)				
With other family	-1.080	1.086	0.0957	-1.014
	(1.206)	(0.984)	(0.509)	(1.186)
Other/Independent	-0.0974	0.616	1.511**	-0.294
	(1.442)	(1.484)	(0.637)	(1.419)
Constant	1.231***	-0.104	1.040***	1.244***
	(0.292)	(0.294)	(0.156)	(0.286)
Observations	7,864	8,220	9,450	7,881
Number of Children	4,871	4,973	5,165	4,875

The poverty interaction regressions are panel fixed effects IV models at the child level on health outcomes. Like the IV results, *Number of Children* has a significant and advantageous effect on BMI-for-Age, Weight-for-Age, and Weight-for-Height. As for the poverty variables, the only significant poverty and poverty interaction variables are for Weight-for-Age. For instance, children from poor families have a Weight-for-Age that is on average 0.63 smaller than children from richer households. However, their Weight-for-Age increases by 0.19 for every additional sibling. Therefore in the case of poor families, the Q-Q tradeoff holds since an extra sibling increase Weight-for-Age.

6.5 Behavioural Regressions

In addition to evaluating the effect of family size on health outcomes, I explore the effect of family size on the time investment of parents in children. Although the amount of time parents put into their children does not directly translate to children's health outcomes, the ideal still deals with the broader concept of parents' reactions to an additional child in a resource constraint. Moreover, while it may be easier for parents to keep their children relatively healthy in the United States, the amount of time invested per child may change dramatically as a new child comes along.

For this section, I run an ordered probit IV model. The main dependent variable for this regression is an investment score that ranges from 0 to 1. In a more technical sense, it is the proportion of questions that indicate time investment. This score consists of 4 main questions that proxy for different ways in which parents can spend time with their children (refer to Table 2). A 0 indicates no time investment and a 1 indicates full time investment.

Table 18 indicates that while *Number of Children* is insignificant, poverty is a significant factor in determining the amount of time parents spend on their children. For both regressions, the margins coefficient on *Poverty Indicator* is negative, which suggests that poorer parents spend less time with their children. However, as poor families have more children, parents are likely to spend more time with their children. This phenomenon may be attributed to the fact that parents may give up their jobs to stay at home to watch the kids, and thus spending more time with them.

Table 18: Behavioural Score Regressions

VARIABLES	(1) IV: Both (Poverty Int)	(2) IV: Both
Number of Children	-0.303	-0.007
Poverty Interaction	0.053**	
Poverty Indicator	-0.282***	-0.188***
Adj Family Income	0.002***	0.001***
Marital Status (Married)		
Separated	-0.154***	-0.123***
Divorced	-0.131***	-0.118***
Widowed	-0.090	-0.066
Residence (w/ Mother)		
With other family	-0.211***	-0.211***
Other/Independent	-0.585***	-0.586***
Margins		
Number of Children	-0.030	-0.017
Poverty Indicator	-0.282***	-0.116***
Poverty Interaction	0.053**	
Observations	79,136	79,136

7. Discussion and Policy Implications

7.1 Discussion

Most regressions with child health outcomes show that as the number of children in a household decreases, the health outcomes of the children improve. Although there is a risk of the children being underweight, a look at the means of each of health score indicate that the additional decrease will not push most children into the -2 threshold. Therefore, in terms of the United States, a decrease in these outcomes indicates better health outcomes. These results are contrary to what the Q-Q theory postulates. Other than the main coefficients on *Number of Children*, a significant control variable is mother marital status. Surprisingly, adjusted family income and the poverty interaction do not have a significant effect on both health outcomes and behavioural outcomes. Based on the empirical results that bigger families point to better child health, some policy implications may be programs that encourage more children. However, it is important to note that this is the *average* effect of an additional sibling, rather than the *marginal* effect of a new child. As seen from the marginal effects analysis, is it likely for family size to have a trailing effect rather than a constant effect on health outcomes.

7.2 Further Research

Further research is needed in a variety of areas. As mentioned above further analysis of the marginal effect by birth order is necessary, especially since the Q-Q theory maps a non-linear relationship between family size and child health outcomes. In addition, further analysis on the behavioural changes in parents' investment in their children needs attention. The investment score utilized is very rudimentary and therefore may not fully reflect the parents' investment. Next, more time-varying controls variables are necessary, especially those that reflect parents characteristics and preferences in fertility and child-raising. These variables can serve as nice controls that may further help in controlling for endogeneity between family size and health outcomes since they also affect both variables. In addition, the models do not examine the same children, due to missing data in health outcomes and other variables. Due to this, not all analyses made can be applied to a general population since they are conclusions made about different subsets of the sample. Lastly, my models fail to acknowledge any interaction between siblings that may affect child health. For instance, older siblings may take on the some parental roles for the younger children. Although physical resources may be constrained by an additional child, having an older sibling supervise the younger child while being active outside may have a positive externality on health outcomes. This aspect of the family must be taken accounted in the regressions in order to pry out the causal effect of family size more accurately.

Nonetheless, this paper explores the effect of family size on health outcomes. In addition, this paper places the Q-Q tradeoff in a more developed world context by also exploring the effect of family size on parents' time investment. Lastly, a sub-analysis on families below the poverty line sheds light on the differential impact of family size on health. These three analyses help fill the gap in the family size literature as well as the time-use literature in the developed world context.

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