THE IMPACT OF IMMIGRATION ON CHILD HEALTH: EXPERIMENTAL EVIDENCE FROM A MIGRATION LOTTERY PROGRAM

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This paper uses a unique survey designed by the authors to compare migrant children who enter New Zealand through a random ballot with children in the home country of Tonga whose families were unsuccessful participants in the same ballots. We find that migration increases height and reduces stunting of infants and toddlers, but also increases BMI and obesity among 3- to 5-yr-olds. These impacts are quite large even though the average migrant household has been in New Zealand for less than 1 yr. Additional results suggest that these impacts occur because of dietary change rather than direct income effects. (*JEL* J61, I12, F22)

I. INTRODUCTION

Childhood obesity is a major public health problem both globally and in the United States (Institute of Medicine 2004; Troiano et al. 1995). At the same time, extensive immigration to the United States, Canada, Europe, Australia, and New Zealand (NZ) has led to large increases in the number of foreign-born children in these countries, with many, if not most, of these children being born in developing or transition countries. Although economic migrants moving from a developing to a developed country will generally experience large gains in income and increased access to health care and clean water, this migration also potentially introduces unhealthy lifestyle patterns, such as increases in fat and refined sugar-rich diets and decreases in regular physical activity (Clemens, Montenegro, and Pritchett 2008; McKenzie, Gibson, and Stillman 2009; Popkin and Udry 1998). Thus, migration may potentially have negative impacts on health, particularly of still-growing children who are most affected by environmental and dietary changes.[1]

Child health is of intrinsic interest, both as a current measure of well-being and a source of future human capital. Moreover, given the strong economic argument for increasing international migration, it is important for economists to also examine other impacts that migration can have on well-being and whether these impacts lower the net benefit of migrating

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1. For example, see http://vivirlatino.com/2006/03/02/immigration-to-the-us-harmful-to-your-health.php (accessed March 4, 2007).

ABBREVIATIONS

ATT: Average Treatment Effect on the Treated
BMI: Body Mass Index
CDC: Centers for Disease Control
DoL: Department of Labour
ITT: Intention to Treat Effect
LATE: Local Average Treatment Effect
OLS: Ordinary Least Squares
PAC: Pacific Access Category
PINZMS: Pacific Island–New Zealand Migration Survey

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for individuals and for society as a whole. However, identifying the causal impact of migration on child health requires comparing the current health of migrant children to what their health would have been had they stayed in their home country. This counterfactual is typically unobserved, and thus the current literature settles for either comparing the health of immigrant children to that of native-born groups in the destination country (e.g., Bell and Parnell 1996; Frisbie, Cho, and Hummer 2001; Gordon et al. 2003; Institute of Medicine 1998; Kirchengast and Schober 2006) or comparing the health of immigrant children in the destination country to that of similar nonimmigrant children in the source country (e.g., Smith et al. 2003). Both of these approaches assume that there is no selectivity into migration and thus the health of nonmigrant children can be used as an appropriate counterfactual for what the health of migrant children would have been in the absence of migration.[2] These approaches are not very convincing because migrant families are likely to differ from nonmigrant families along a host of unobserved dimensions, some of which are likely to be correlated with both child health and migration.

This paper overcomes this problem by examining the impact of migration on children's health in the context of a unique survey of participants in a migrant lottery program. The Pacific Access Category (PAC) under NZ's immigration policy allows an annual quota of Tongans to migrate to NZ. The other options available for Tongans to migrate are fairly limited, unless they have close family members abroad. Many more applications are received than the quota allows, so a ballot is used by the NZ Department of Labour (DoL) to randomly select from among the registrations. The same survey instrument, designed by the authors, was applied in both Tonga and NZ and allows experimental estimates of the impact of migration on child health to be obtained by comparing the health of immigrant children whose parents were successful applicants in the ballot to the health of those children whose parents applied to migrate under the quota, but whose names were not drawn in the ballot. This survey instrument collected information on both parental-reported health and measured anthropometrics, as well as additional data on household income, diets, and access to health care facilities. Thus, we are able to examine whether migration has a causal impact on child health or whether migration just changes parents' reference points for what "good health" means, and examine the pathways through which changes in child health occur.

In the short-term, migration is found to increase height and reduce stunting of 0- to 2-yr-olds, and increase weight, body mass index (BMI) and obesity of 3- to 5-yr-olds, and have no impact on anthropometrics but lead to better parental-reported health for 6- to 18-yr-olds. The scale of these impacts is quite large even though the average migrant household has been in NZ for less than 1 yr. Additional results suggest these health effects operate through dietary change rather than as direct income effects. It is well known that the first 3 yr of life are when height is most susceptible to nutritional changes, and it is exactly for this age-group that we see migration affecting height. For older children, a richer, higher calorie diet has a limited impact on height, but instead increases body mass.

Tongan migrants to NZ are not atypical of the average developing country migrants elsewhere in the world. For example, the average adult Tongan migrant in our sample has 11.7 yr of education, compared to 11.0 yr for the average 18- to 45-yr-old new arrival in the United States. However, unlike many developing countries, there are already high levels of childhood obesity in Tonga (Fukuyama et al. 2005). Thus, from the standpoint of the worldwide problem with childhood obesity, it is discouraging to find that migration leads to increased obesity even among an already overweight population. This suggests that the increased global movement of people will serve to strengthen the worldwide convergence toward a mostly overweight population. However, this is not meant to imply that migration to NZ has necessarily been bad for the health of the Tongan children in our sample. Previous studies have shown that stunting has a negative association with cognitive development and adult labor market outcomes (Case and Paxson 2008; Colombo, de Andraca, and Lopez 1988; Jamison 1986). Thus, the increased height and reduced stunting of Tongan children in NZ may have a larger positive effect on their lifetime well-being than any negative effects

2. A much smaller literature looks at children who remain in their home countries while a parent migrates (e.g., Hildebrandt and McKenzie 2005; Kanaiaupuni and Donato 1999). These studies can at best determine the impact of having a migrant parent on the health of children, but do not provide information on the health impacts of the child themselves migrating.

from increases in weight and obesity caused by migration.

The next section briefly discusses a simple theoretical model of why migration might affect child health, and summarizes the findings of existing literature on migration and child health. Section III provides background and context on Tongan health and migration, and describes the survey and measures of child health used in this study. Section IV calculates the treatment effect of migration on child health. Section V then explores the mechanisms underlying the measured impacts on child health, and Section VI concludes.

II. HOW MIGHT MIGRATION AFFECT CHILD HEALTH?

A. Theoretical Model

The literature has identified many potential channels through which immigration may affect the health of children. The Grossman (1972) health production function provides a theoretical framework which we use to summarize these various effects. The health of child i at a particular point in time can be written as:

$$H_i = h(M_i, T_i, K_i, B_i, \varepsilon_i) \tag{1}$$

where M_i represents medical and nutritional inputs, T_i encompasses the time inputs of the parent and the time use of the child, K_i is parental health knowledge, B_i represents biological endowments such as genetic factors, and ε_i represents random health shocks. Migration may affect child health through changes in M_i—such as changing diets and changes in access to health care; through changes in T_i—such as less time breastfeeding (Carballo, Divino, and Zeric 1998) and changes in the level of physical activity of children (Unger et al. 2004); and changes in K_i, if parents gain more health knowledge when abroad (Hildebrandt and McKenzie 2005). However, the main challenge to identifying the impact of migration is that the migration decision of a household might be correlated with variables unobserved by the researcher, such as either a child's genetic health status, B_i, or with random health shocks, ε_i.

B. Related Literature

Although there is a large literature on the health of immigrant children, this identification challenge makes it difficult to ascribe most of the findings to the effects of immigration. As noted earlier, the majority of the immigrant health literature compares immigrants to native-born in the destination country. In the United States, much attention has been given to the "healthy immigrant paradox," which has found Hispanic immigrants to be of better health than U.S. natives of similar socioeconomic status (Institute of Medicine 1998). However, there is some evidence that this is in part due to selectivity, with healthier individuals migrating (Rubalcava et al. 2008) and in many other contexts immigrant children have been found to be in poorer health than natives. For example, Kirchengast and Schober (2006) report higher rates of obesity among Turkish and Yugoslav immigrant children in Austria than Austrian children; and Meulmeister, Berg, and Wedel (1990) find higher rates of micronutrient deficiencies and malnutrition among Turkish and Moroccan immigrant children than Dutch children in the Netherlands.

The studies most closely related to ours in terms of geographic focus have compared anthropometric outcomes for Pacific Island children in NZ to those for other children in NZ. Pacific Island children are taller and heavier for their age than both international reference standards and Caucasian children in NZ. For example, the prevalence of obesity in 3–7-yr-old Pacific Island children ranges from 42% to 49%, depending on the criteria used, versus only 7%–13% for comparable Caucasian children (Gordon et al. 2003). The mean height and weight of Pacific Island children tracks the 95th percentile of international reference charts until about age 10–11, with height then falling back toward the reference median while weight remains high (Salesa, Bell, and Swinburn 1997). Both genetic and dietary differences may account for some of these differences across ethnic groups, with Pacific Island children having significantly higher fat intakes than non-Pacific Island children (Bell and Parnell 1996). However, none of these studies distinguish between immigrant Pacific Island children and those born in NZ and thus have little to say about the impact of migration.

As discussed earlier, immigrants differ from natives in many observable and unobservable dimensions, making it difficult to ascribe any of these differences to the impact of migration per se. A number of other studies explore the impact of acculturation by comparing the health of immigrants who have been abroad for differing amounts of time (see Institute of Medicine 1998,

for a review). But, there are several problems which prevent this strategy from giving us the full impact of immigration on health. First, a number of health effects may occur very soon after migrating (or even during the migration journey in some cases) and thus comparing the health of a child who has been abroad 1 yr to one who has been abroad 5 yr will clearly miss the health impacts which occur during the first year. Second, both because the effect of migration on health is likely to vary with age at arrival, and because the unobservable characteristics of migrants are likely to vary over time, it is not possible to identify the impact of years in the destination country on health (e.g., it is not possible to separately identify age, cohort, and year effects).[3] Third, individuals in either the origin or the destination country may have experienced health shocks (say a drought) during the intervening period which should be accounted for when measuring the impact of immigration.

Overall, the scarcity of surveys which contain information on both migrants in the destination country and nonmigrants in particular source countries, and the challenge of separating the impact of migration from migrant selectivity, limits the ability of the existing literature to identify the health impacts of migration for children. In the next section, we discuss how the unique data used in this paper helps resolve both these problems.

III. CONTEXT AND SURVEY DATA

A. Background and Health Context

The Kingdom of Tonga is an archipelago of islands in the South Pacific, about two-thirds of the way from Hawaii to NZ. The population is just more than 100,000, with a gross domestic product (GDP) per capita of approximately U.S.$2,200 in PPP terms. One-third of the labor force is in agriculture and fishing, with the majority of workers in the manufacturing and services sectors, which are dominated by the public sector and tourism.

Tonga's infant mortality rate is 20 deaths per 1,000 live births, comparable to Ukraine, Brazil, and Paraguay, and much higher than the 5.3 per 1,000 in NZ.[4] Data on malnutrition and stunting is scarce. The World Health Organization (WHO 2005) reports that there is no chronic undernutrition and no important micronutrient deficiencies in Tonga. However, earlier work suggests that malnutrition may occur during infancy and early childhood due to delays in the introduction of supplementary food or lack of nutritionally valuable weaning foods and diets too low in protein among children under 2 yr of age (Bloom 1986; Lambert 1982). Among adolescents and adults, noncommunicable diseases are the most important health problem. The adult obesity rate was 60% in 2004 (WHO 2005), whereas a recent study of 5- to 19-yr-olds also found high rates of childhood obesity, especially among girls (Fukuyama et al. 2005).

B. Migration Context and the PAC

Emigration levels are high, with 30,000 Tongans living abroad, the vast majority in NZ, Australia, and the United States. However, during the 1990s, the opportunities for emigration became more limited, as NZ followed Australia in introducing a points system for migration, with points awarded for education, skills, and business capital. Few Tongans qualified to emigrate under these systems, and so most Tongan emigration was through family reunification categories, as the spouse, parent, or child of an existing migrant. For example, in 2004/2005, only 58 Tongans gained residence to NZ through the business/skilled categories, compared to 549 through family categories. Australia admitted 284 Tongans during the 2004/2005 financial year, whereas the United States admitted 324 Tongans in 2004, of which 290 were under family categories.[5]

In early 2002, another channel was opened up for immigration to NZ through the creation of the PAC, which allows for a quota of 250 Tongans to emigrate to NZ each year regardless of their skill level or socioeconomics status.[6] Specifically, any Tongan citizens aged between 18 and 45, who meet certain English, health, and

3. In addition, selective return migration can cause the characteristics of migrants who have been in the country longer to differ from those who have been in the country for shorter periods.

4. Source: World Bank Central Database, data for 2005.

5. Source: Australian Government Department of Immigration and Multicultural Affairs, U.S. Department of Homeland Security Office of Immigration Statistics, and New Zealand Department of Labour.

6. The Pacific Access Category also provides quotas for 75 citizens from Kiribati, 75 citizens from Tuvalu, and, prior to the December 2006 coup, 250 citizens from Fiji to migrate to New Zealand. There have been some changes in the conditions for migration under the Pacific Access Category since the period we examine in this paper (see Gibson and McKenzie 2007 for details)—here we describe the conditions that applied for the potential migrants studied in this paper.

character requirements,[7] can register to migrate to NZ.[8] Many more applications are received than the quota allows, so a ballot is used by the NZ Department of Labour (DoL) to randomly select from among the registrations. During the 2002–2005 period we study, the odds of having one's name drawn were approximately one in ten. Individuals whose names are not selected can apply again the next year.

Once their ballot is selected, applicants must provide a valid job offer in NZ within 6 mo in order to have their application to migrate approved. This offer can be for essentially any full-time job, and most of the migrants began work in typical entry level occupations, such as packing groceries in supermarkets and working in construction. After a job offer is filed along with their residence application, it typically takes 3–9 mo for an applicant to receive a residence decision. Once receiving approval, they are then given up to 1 yr to move. The median migrant in our sample moved within 1 mo of receiving their residence approval. At the time of our survey, the median migrant child had spent 6 mo in NZ (mean of 7.6 mo). Thus, this paper examines the short-term impact of migration on child health.

C. *Pacific Island–NZ Migration Survey*

The data used in this paper are from the first wave of the Pacific Island–NZ Migration Survey (PINZMS), a comprehensive household survey designed to measure multiple aspects of the migration process and take advantage of the natural experiment provided by the PAC.[9] The survey design and enumeration, which was overseen by the authors in 2005–2006, covered random samples of four groups of households, surveying in both NZ and Tonga.

The first group consists of a random sample of 101 of the 302 Tongan immigrant households in NZ, who had a member who was a successful participant in the 2002–2005 PAC ballots.[10] Administrative data show that none of the ballot winners had returned to live in Tonga at the time of the survey, nor had any of them after a further 2 yr. There are 171 children aged ≤18 in these households. The second group consists of a sample of households of successful participants from the same random ballots who were still in Tonga at the time of surveying. We sampled 26 of the 65 households in this group, focusing our sampling on households located in villages from which the migrants in our first survey group had emigrated. Most of this group consists of individuals whose applications were still being processed at the time of surveying. There are 56 children aged ≤18 in these households. In forming all of our experimental estimates, we weight the sample so that it reflects the actual ratio of migrants to successful ballots still in Tonga at the time of the survey.

The third survey group consists of households of unsuccessful participants in these same ballots. The full list of unsuccessful ballots from these years was provided to us by the NZ DoL, but the details for this group were less informative than those for the successful ballots, as only a post office box address was supplied and there were no telephone numbers. We used two strategies to derive a sample of 119 households with a member with an unsuccessful ballot from this list, with this sample size again dictated by our available budget. First, we used information on the villages where migrants had come from to draw a sample of unsuccessful ballots from the same villages (implicitly using the village of residence as a stratifying variable). Second, we used the Tongan telephone directory to find contact details for people on the list. To overcome concerns that this would bias the sample to the main island of Tongatapu, where people are more likely to have telephones, we deliberately included in the sample households from

7. Data supplied by the New Zealand Department of Labour for residence decisions made between November 2002 and October 2004 reveals that out of 98 applications only 1 was rejected for failure to meet the English requirement and only 3 others were rejected for failing other requirements of the policy. See McKenzie, Gibson, and Stillman (2009) for more details on this policy.

8. The person who registers is a Principal Applicant. If they are successful, their immediate family (spouse and children under age 24) can also apply to migrate as Secondary Applicants. The quota of 250 applies to the total of Primary and Secondary Applicants and corresponds to about 90 migrant households each year.

9. Further details about this survey and related papers produced from these data can be found at http://www.pacificmigration.ac.nz.

10. A large group of the 302 immigrant households were unavailable for us to survey because they had been reserved for selection into the sample of the Longitudinal Immigrant Survey, conducted by Statistics New Zealand. In McKenzie, Gibson, and Stillman (2009), we describe in detail the tracking of the sample in New Zealand, showing a contact rate of more than 70%. The main reasons for noncontact were incomplete name and address details, which should be independent of child health and therefore not a source of sample selectivity bias. There was only one refusal to take part in the survey in New Zealand and none in Tonga.

the Outer Islands of Vava'u and 'Eua'. There are 281 children aged 18 and under in these households.

The final survey group consists of households living in the same villages as the PAC applicants but from which no eligible individuals applied for the quota in any of our sample years (e.g., 2002–2005). We randomly selected 90 nonapplicant households with at least one member aged 18–45. There are 271 children aged ≤18 in these households. These households will be used to look at the process of health selection into migration, and for examining the cross-sectional correlates of child health in Tonga.

The fact that a random ballot was used to select among applications gives us a group of migrants and a comparison group who are similar to the migrants in both observable and unobservable dimensions, but remain in Tonga only because they were not successful in the ballot. This allows experimental estimates of the impact of migration on child health to be obtained by comparing the health of children whose parents were successful applicants in the ballot to the health of those children whose parents applied to migrate under the quota, but whose names were not drawn.

D. Measuring Child Health

Our analysis focuses on nine interrelated measures of child health. The first two are *parent-reported measures of each child's health status in the current year* and their *health status compared to 1 yr ago* on 5-point scales. Self-reported health status has the virtue of being quick to collect, making it a common question on multipurpose surveys, such as the New Immigrant Survey in the United States (Jasso et al. 2004), despite evidence of systematic differences in responses by socioeconomic status (Sindelar and Thomas 1991). These questions provide an indication of the level of and changes in overall health status; however, there are reasons to worry that parental responses to these questions may change with migration, regardless of whether health actually changes. For example, when reporting whether or not their child is in good health, migrant parents may compare their children to a reference group of NZ children, rather than to the health standards of children in Tonga.

Physical indicators of nutrition are not subject to respondent-specific reporting error and are of direct interest themselves as they have been shown to be indicative of health status and correlated with economic prosperity. The remaining seven measures of child health are derived from height and weight data. These measurements were directly collected by trained interviewers during the in-person surveys, and are adjusted for whether the child is measured lying down or standing, whether they are wearing shoes, and the type of clothing being worn.[11] We examine three continuous measures of child anthropometry: *height*, *weight* and *BMI*, each *standardized by age in months and gender*.[12] These measures are each expressed as z-scores which show how many standard deviations each child is away from the age- and gender-specific median height, weight, or BMI in a reference population of well-nourished children.[13]

Our final four measures are threshold measures derived from the standardized height and BMI z-scores and based on U.S. Centers for Disease Control (CDC) recommendations: *stunting* is defined as having standardized height below the 5th percentile of the reference population and indicates chronic undernutrition and poor health, *underweight* as having standardized BMI below the 5th percentile, *overweight* as having standardized BMI between the 85th and 95th percentiles, and *obese* as having standardized BMI above the 95th percentile of the reference population (Kuczmarski, Ogden, and Grummer-Strawn 2000).[14]

11. Height was measured to the nearest 0.1 cm using a portable stadiometer (Schorr Height Measuring Board, Olney, Maryland) and weight was measured to the nearest 0.1 kg on a digital scale (Model UC-321; A&D Medical, Milpitas, California).

12. BMI refers to the body mass index which is measured as weight in kilograms divided by height in meters squared. This has been shown by nutritionists to best measure energy intakes net of energy output.

13. We use the 1990 reference standards for the United Kingdom, as derived in Cole, Freeman, and Preece (1998), for each of these measures as they are available for children of all ages. We find similar results using nonstandardized measures of height, weight, and BMI, but focus on the standardized results for comparability with the literature.

14. There is considerable debate about the validity of using universal BMI cutoff points for comparing obesity prevalence across ethnic groups. Rush, Plank, and Davies (2003) show that for the same BMI, the percent body-fat for Pacific Island children is lower than that for NZ children of European origin. Rush et al. (2004) report similar findings for young adults, for example, they find that the average body-fat for a young adult Pacific Islander with a BMI of 33 is the same as that for a young adult of European origin with a BMI of 30. However, because we are comparing BMI for Tongan children in New Zealand to Tongan children in Tonga, as opposed to comparing immigrant children to natives, as is common in much of the literature, this debate about using ethnic-specific BMI cutoffs should not be a concern.

Child height (or stature) is generally known to be a sensitive indicator to the quality of economic and social environments (Steckel 1995), whereas child weight and, more typically, BMI have been demonstrated to be good measures for identifying short-run effects on health (Strauss and Thomas 1998). A number of studies have shown that the relationship between socioeconomic status and child health varies with the age of the child (Case, Lubotsky, and Paxson 2002; Sahn and Alderman 1997). Thus, we stratify our analysis of the impact of migration on child health into four age-groups across which impacts are likely to differ: 0–2, 3–5, 6–12, and 13- to 18-yr-olds.

Environmental factors are especially important determinants of child height in early childhood. Therefore, the World Health Organization recommends focusing analysis of height measures to 0- to 5-yr-olds (WHO 1986). The stature of infants and children is particularly vulnerable to nutritional stresses and, in our example, these children changed environments during this vulnerable stage in life (all 0- to 2-yr-olds in our sample were born in Tonga, because they had to be included in the ballot application to be included in our sample, and thus were mainly brought to NZ as infants). Thus, we further split the 0–5 age-group. Teenagers are often dropped when examining child health, because the onset of puberty is thought to be weakly related to underlying health status, thus making it difficult to measure the true relationship between other covariates and health status. Instead of dropping teenagers, we examine their outcomes separately.

E. Migration Selection and Child Health

The PAC randomizes among the group of households interested in migrating to NZ under the PAC. It is thus of interest to examine whether children in households which apply to migrate under the PAC have different health than children in households which do not apply to migrate. Table 1 compares the characteristics of children and their parents in the unsuccessful ballot households to those for the nonapplicant children. We see positive selection into the PAC applicant pool in terms of parental education and household income. However, there is no significant difference in any of our nine child health measures between children in nonapplicant households and children in households with unsuccessful ballots. This is consistent with the lack of a strong income gradient in child health in Tonga, which we show later in the paper.

Nevertheless, even in the absence of migration selectivity in terms of child health, the results from a nonexperimental study still will be biased either if the migration decision of adults depends on their underlying desires for investing in their children's futures, including making future investments in child health, or if households experience shocks (such as a drought) which drive both their migration decision and directly affect future child health. The PAC ballot allows us to produce an unbiased experimental estimate of the causal impact of migration on child health, regardless of potential unobservables that are correlated with a household's desire to emigrate.

IV. THE EFFECT OF MIGRATION ON CHILD HEALTH

This section focuses on estimating the impact of migration to NZ on the health of Tongan children. We rely on the fact that the PAC ballot, by randomly denying eager migrants the right to move to NZ, creates a control group of children that should have the same outcomes as what the migrant children would have had if they had not moved. Evidence that the control group of nonmigrants is statistically identical to the successful ballots in terms of ex-ante characteristics is reported in Table 2. We cannot reject equality of means for any variable among all children (0- to 18-yr-olds), which is consistent with the random selection of ballots among applicants to the PAC.[15]

A. Sample Means and Intent-to-Treat Effects

Table 3 presents the proportion of parents reporting their children are in very good health, as opposed to good or average health; the proportion of parents reporting their children are in much better health now compared to 1 yr ago, as opposed to somewhat better now, about the same now, or somewhat worse health now; the mean z-score for each anthropometric measure; and the proportion of children that are stunted, underweight, overweight, and obese among children in each of the four age-groups whose parents were either successful or unsuccessful in the PAC ballot (and standard errors for each which

15. McKenzie, Gibson, and Stillman (2009) provide further evidence that the PINZMS captures a random sample of both successful and unsuccessful PAC ballots and that winning the ballot is properly randomized.

TABLE 1
Selection of Families into the Pacific Access Category Ballot
(Comparison of Characteristics of Children ≤18 in Nonapplicant and Unsuccessful Ballots)

	Sample Means in Tonga		
	Unsuccessful Ballots	Nonapplicants	*t*-test of Equality of Means *p* Value
Proportion children 0–2 yr old	0.15	0.22	.05
Proportion children 3–5 yr old	0.20	0.25	.10
Proportion children 6–12 yr old	0.41	0.35	.11
Proportion children 13–18 yr old	0.23	0.17	.13
Age in months	104.2	89.1	.03
Proportion female	0.46	0.45	.77
Proportion living with both parents	0.93	0.93	.98
Number of children in household	4.8	4.3	.38
Father's age	38.9	38.9	1.00
Father's years of education	11.6	10.8	.01
Father's height	170	163	.28
Mother's age	37.0	36.9	.94
Mother's years of education	11.3	10.6	.03
Mother's height	164	165	.65
Total real household cash income	17,553	9,348	.00
Total real household own production	10,427	7,399	.06
Very good parent-rated health	0.51	0.55	.57
Much better health since last year	0.34	0.38	.54
Standardized height for age	−0.25	−0.19	.76
Standardized weight for age	1.05	0.93	.55
Standardized BMI for age	1.50	1.35	.47
Stunted—height for age ≤ 5th percentile	0.17	0.17	.95
Underweight—BMI for age ≤ 5th percentile	0.04	0.05	.58
Overweight—BMI for age 85th–95th percentile	0.16	0.16	.89
Obese—BMI for age ≥ 95th percentile	0.44	0.42	.77
Total sample size	281	271	—

Note: Test statistics account for clustering at the household level and survey stratification.

account for clustering at the household level and survey stratification and weighting).

Consider first children in households where the parent had been unsuccessful in the PAC ballot. These children remain in Tonga, and their health indicates what health conditions would be like in the absence of migration. Infants and toddlers (aged 0–2) are generally short in stature compared to the reference population, with 36% defined as stunted. Mean standardized height is closer to the reference population for older children but, in each age-group, a larger proportion than expected are stunted (12%, 13%, and 17%, respectively for 3–5, 6–12, and 13- to 18-yr-olds versus 5% in the reference population by definition). This is consistent with the findings in early studies such as Lambert (1982) and Bloom (1986) that suggested malnutrition could be an issue in the early years.

However, in concordance with the high levels of obesity in Tonga as a whole, children are on average heavier than the reference population, with 39% of 0- to 2-yr-olds, 48% of 6- to 12-yr-olds, and 64% of 13- to 18-yr-olds classified as obese. For the children ≥6 yr, mean weight for age and BMI for age are over one standard deviation higher than the reference population. The exception is 3- to 5-yr-olds, which are only slightly heavier than the reference population. One explanation of these different patterns among 0- to 2-yr-olds compared to 3- to 5-yr-olds may be that Tongan children have growth (height) spurts at slightly older ages than British children under 5 who form the reference population. However, because our analysis only uses this reference group for standardization purposes, this only affects interpretation of the levels of obesity and stunting, and

TABLE 2
Test for Randomization
(Comparison of Ex-ante Characteristics of Children ≤18 in Successful and Unsuccessful Ballots)

	Sample Means Applicants		t-test of Equality of Means p Value
	Successful Ballots	Unsuccessful Ballots	
Proportion children 0–2 yr old	0.12	0.15	.21
Proportion children 3–5 yr old	0.21	0.20	.72
Proportion children 6–12 yr old	0.43	0.41	.68
Proportion children 13–18 yr old	0.24	0.23	.84
Age in months	107.5	104.2	.63
Proportion female	0.47	0.46	.83
Proportion living with both parents	0.98	0.93	.12
Number of children in household	4.3	4.8	.27
Father's age	39.6	38.9	.47
Father's years of education	11.7	11.6	.86
Father's height	162	170	.24
Mother's age	37.9	37.0	.34
Mother's years of education	11.6	11.3	.47
Mother's height	159	164	.30
Proportion in New Zealand	0.80	—	—
Months in New Zealand	7.6	—	—
Total sample size	247	281	—

Note: Test statistics account for clustering at the household level and survey stratification and weighting.

not of the changes in these variables driven by migration.

Simple comparison of means between the successful and unsuccessful ballots identify whether there are significant intention-to-treat effects, that is, whether getting a successful ballot leads to changes in child health outcomes.[16] For 0- to 2-yr-olds, we see that winning the ballot causes significantly greater height and less stunting, with no changes in weight or parental perceptions of health. Only 5% of 0- to 2-yr-old children in households with a winning ballot are stunted, compared to 36% of 0- to 2-yr-old children in households with unsuccessful ballots. For 3- to 5-yr-olds in contrast, we see winning the ballot results in no significant changes in height, but increases in weight, leading to higher BMI and a much higher proportion obese. There are no significant changes in either height or weight for older children, but parents of both 6- to 12-yr-olds and 13- to 18-yr-olds are more likely to say their children are in very good health in winning ballot households.

B. The Impact of Migration on Child Health

In a perfect randomized experiment, the impact of the treatment (here, migration) on each outcome can be obtained through a simple comparison of means or proportions in the control group (unsuccessful ballots) with the treatment group (successful ballots), as done in the previous subsection. However, as discussed in Heckman et al. (2000), this simple experimental estimator of the treatment effect on the treated is biased either if control group members substitute for the treatment with a similar program or if treatment group members drop out of the experiment. In our application, *substitution* bias will occur if PAC applicants who are not drawn in the ballot migrate through alternative means and *dropout* bias will occur if PAC applicants whose name are drawn in the ballot fail to migrate to NZ.

We do not believe that substitution bias is of serious concern in our study, as individuals with the ability to migrate via other arrangements will likely have done so previously given the low odds of winning the PAC ballot.[17] Furthermore,

16. These t tests account for clustering at the household level and survey stratification and weighting.

17. We did not come across any incidences where remaining family members told us that the unsuccessful applicant had migrated overseas during our fieldwork.

TABLE 3
Summary Statistics—Sample Means

	Very Good Parent-rated Health	Much Better Health Since Last Year	Standardized Height for Age	Standardized Weight for Age	Standardized BMI for Age	Stunted Height for Age ≤ 5th Percentile	Underweight BMI for Age ≤ 5th Percentile	Overweight BMI for Age	Obese BMI for Age ≥ 95th Percentile
				Children 0–2 yr old					
Unsuccessful ballots	0.70	0.27	−0.91	0.09	1.35	0.36	0.06	0.16	0.39
Successful ballots	0.70	0.44	0.63	0.43	0.58	0.05	0.21	0.05	0.34
Raw intent to treat	0.00	0.17	1.54	0.34	−0.77	−0.32	0.14	−0.11	−0.05
t test of ITT = 0 (*p* value)	.97	.28	.00	.63	.23	.00	.15	.18	.72
Subsample size	65	47	51	53	49	51	49	49	49
				Children 3–5 yr old					
Unsuccessful ballots	0.66	0.36	0.04	0.47	0.52	0.12	0.08	0.13	0.13
Successful ballots	0.69	0.40	0.09	1.32	1.50	0.19	0.02	0.22	0.42
Raw intent to treat	0.03	0.05	0.05	0.86	0.97	0.07	−0.06	0.10	0.29
t test of ITT = 0 (*p* value)	.76	.66	.73	.02	.01	.36	.20	.20	.00
Subsample size	106	106	96	98	90	96	90	90	90
				Children 6–12 yr old					
Unsuccessful ballots	0.47	0.34	0.09	1.39	1.76	0.13	0.02	0.16	0.48
Successful ballots	0.70	0.43	0.04	1.40	1.64	0.12	0.00	0.17	0.42
Raw intent to treat	0.23	0.09	−0.05	0.01	−0.11	−0.01	−0.02	0.00	−0.06
t test of ITT = 0 (*p* value)	.00	.30	.62	.97	.67	.91	.16	.97	.49
Subsample size	220	220	204	210	208	204	208	208	208
				Children 13–18 yr old					
Unsuccessful ballots	0.35	0.35	0.43	1.46	1.87	0.17	0.03	0.16	0.64
Successful ballots	0.69	0.34	0.36	1.66	2.07	0.12	0.02	0.26	0.67
Raw intent to treat	0.34	−0.02	−0.07	0.20	0.20	−0.05	−0.02	0.09	0.03
t test of ITT = 0 (*p* value)	.00	.87	.79	.48	.50	.45	.67	.30	.81
Subsample size	123	123	108	112	111	108	111	111	111
Total sample size	514	496	459	473	458	459	458	458	458

Note: Test statistics account for clustering at the household level and survey stratification and weighting. ITT, Intention to treat effect.

as discussed earlier, the other options available for Tongans to migrate are fairly limited, unless they have close family members abroad. However, as shown in Table 2, dropout bias is a more relevant concern; only 80% of ballot winners (weighted by the number of their children) had migrated to NZ at the time of our survey. Many of the other ballot winning households were still in the process of moving, whereas the others either decided not to move, or were unable to move due to the lack of a valid job offer in NZ for the household principal applicant.

Instrumental variables provide an approach for estimating average treatment effects with experimental data. In our application, the PAC ballot outcome can be used as an excluded instrument because randomization ensures that success in the ballot is uncorrelated with unobserved individual attributes which might also affect child health, and that success in the ballot is strongly correlated with migration.[18] This estimate is called the local average treatment effect (LATE) and can be interpreted as the effect of treatment on individuals whose treatment status is changed by the instrument. Angrist (2004) demonstrates that in situations where no individuals who are assigned to the control group receive the treatment (e.g., there is no substitution), the LATE is the same as the average treatment effect on the treated (ATT).

Table 4 presents three sets of results using the ATT estimator for each outcome and age-group. The first row presents linear instrumental variables estimates with no control variables, and the second row presents linear instrumental variables estimates with controls added for each child's gender, age in months, age in months squared, birth order position, and their parent's age and height. Including controls for these predetermined variables should increase the efficiency of our estimates. In almost all cases, the point estimates are very similar when adding these controls, which is consistent with randomization balancing these covariates. Finally, the third row presents marginal effects from bivariate probit models for each discrete outcome, with no control variables added.[19] In all three cases, whether an individual has migrated to NZ is instrumented by whether their household was successful in the PAC ballot. All standard errors use the appropriate survey weights to account for the sampling rates for each group and are clustered at the household level.

For 0- to 2-yr-olds, we find that migration causes a significant increase in height and reduction in stunting. Immigrant children of this age are 1.8 to 1.9 standard deviations taller as a result of migration, and 36–42 percentage points less likely to be stunted.[20] This greater height is associated with lower BMI for age, but despite large magnitudes, the effect on BMI is not significant, although there is a greater tendency to be underweight for age and a reduced likelihood of being overweight for age. For 3- to 5-yr-olds, we find strong and significant evidence that migration increases weight. Migration leads to a significant 0.9 to 1.0 standard deviation increase in weight for age, a 0.9 to 1.2 standard deviation increase in BMI for age, a 10–18 percentage point increase in the likelihood of being overweight (only significant when including control variables), and a 32–36 percentage point increase in the likelihood of being obese. For neither 0- to 2-yr-olds nor 3- to 5-yr-olds is there any significant difference in the likelihood that a parent views the child's health as very good, or being better than last year as a result of migration, although the point estimates for better health than last year show a positive, but insignificant, effect of approximately 20 percentage points for 0- to 2-yr-olds.

For older children, migration is found to have no significant impact on anthropometric measures. Moreover, most of the point estimates are relatively small in size; however, in contrast to younger children, parents are significantly more likely to view their 6- to 18-yr-olds as being in very good health after migration. For 6- to 12-yr-olds, parents are 28–29 percentage points more likely to view them as having very good health, whereas for 13- to 18-yr-olds parents the corresponding figure is 33–41 percentage points.

Overall, the results appear consistent with children receiving more food intake with

18. Validity of the instrument also requires that the ballot outcome does not directly affect child health conditional on migration status. It seems unlikely to us that winning the ballot and not being able to migrate would impact the health status of children in the household.

19. Bivariate probit results using controls were generally similar in magnitude and significance, but the bivariate probit had trouble converging in a few cases when the controls were added. Furthermore, unlike in a linear model, adding a balanced covariate to a nonlinear model such as a probit can change the point estimates (Raab et al. 2000).

20. Although the size of these impacts are quite large, previous research has suggested that, if the circumstances of undernourished children change at a young enough age, almost a complete reversal of stunting is possible (Golden 1994).

TABLE 4

IV Estimates of Experimental Impact of Migration on Child Health

	Very Good Parent-rated Health	Much Better Health Since Last Year	Standardized Height for Age	Standardized Weight for Age	Standardized BMI for Age	Stunted Height for Age ≤ 5th Percentile	Underweight BMI for Age ≤ 5th Percentile	Overweight BMI for Age 85th–95th Percentile	Obese BMI for Age ≥ 95th Percentile
Children 0–2 yr old									
Linear IV: No control variables	−0.007	0.230	1.795***	0.438	−1.180	−0.369***	0.220	−0.171	−0.077
	(0.169)	(0.203)	(0.579)	(0.868)	(1.046)	(0.101)	(0.174)	(0.126)	(0.216)
Linear IV: Control variables	0.011	0.194	1.855**	0.370	−1.092	−0.424***	0.334*	−0.042	−0.186
	(0.181)	(0.219)	(0.787)	(0.762)	(1.060)	(0.147)	(0.191)	(0.156)	(0.243)
Bivariate probit: No controls	−0.008	0.220				−0.364***	0.278**	−0.161**	−0.073
	(0.200)	(0.212)				(0.078)	(0.113)	(0.068)	(0.199)
Subsample size	65	47	51	53	49	51	49	49	49
Children 3–5 yr old									
Linear IV: No control variables	0.039	0.059	−0.161	1.012**	1.195***	0.083	−0.072	0.119	0.362***
	(0.126)	(0.134)	(0.462)	(0.440)	(0.459)	(0.090)	(0.057)	(0.090)	(0.126)
Linear IV: Control variables	0.069	0.032	−0.052	0.901**	0.878*	0.077	−0.019	0.183**	0.317**
	(0.117)	(0.138)	(0.453)	(0.456)	(0.465)	(0.089)	(0.046)	(0.082)	(0.135)
Bivariate probit: No controls	0.040	0.058				0.071	−0.059	0.097	0.357***
	(0.134)	(0.134)				(0.079)	(0.046)	(0.076)	(0.100)
Subsample size	106	106	96	98	90	96	90	90	90
Children 6–12 yr old									
Linear IV: No control variables	0.285***	0.111	0.169	0.013	−0.138	−0.009	−0.023	0.003	−0.078
	(0.090)	(0.105)	(0.342)	(0.317)	(0.323)	(0.076)	(0.016)	(0.071)	(0.113)
Linear IV: Control variables	0.275***	0.113	0.666*	0.402	0.041	−0.046	−0.037	0.003	−0.057
	(0.098)	(0.101)	(0.388)	(0.354)	(0.351)	(0.083)	(0.026)	(0.077)	(0.120)
Bivariate probit: No controls	0.290***	0.109				−0.009	−0.018	0.003	−0.078
	(0.092)	(0.105)				(0.081)	(0.013)	(0.067)	(0.114)
Subsample size	220	220	204	210	208	204	208	208	208
Children 13–18 yr old									
Linear IV: No control variables	0.410***	−0.022	0.081	0.241	0.242	−0.064	−0.018	0.111	0.032
	(0.111)	(0.136)	(0.299)	(0.333)	(0.351)	(0.082)	(0.043)	(0.107)	(0.134)
Linear IV: Control variables	0.330***	−0.106	0.186	0.340	0.249	−0.090	−0.021	0.089	0.055
	(0.089)	(0.123)	(0.285)	(0.323)	(0.325)	(0.089)	(0.044)	(0.120)	(0.130)
Bivariate probit: No controls	0.386***	−0.019				−0.073	−0.033	0.120	0.033
	(0.096)	(0.122)				(0.087)	(0.033)	(0.118)	(0.139)
Subsample size	123	123	108	112	111	108	111	111	111
Total sample size	514	496	459	473	458	459	458	458	458

Notes: Standard errors account for clustering at household level and use survey weights. Control variables are child's gender, age in months, age in months squared, birth order, parent's age, and parent's height. Ballot success is used to instrument migration to New Zealand in each regression.

*Significant at 10%; **Significant at 5%; ***Significant at 1%.

migration, and with this greater food intake having differential effects depending on the age of children.[21] As noted earlier, there is some evidence that a late transition to solid food and inadequate nutritional content of weaning foods has resulted in malnutrition during early childhood in the Pacific. International evidence has shown nutritional supplementation to only have an impact on stunting and height under the age of 3 (Branca and Ferrari 2002; Schroeder et al. 1995). Beyond this age, additional nutrition is unlikely to have much impact on height. However, excess energy intake through an increase in calories can of course still lead to weight increases, as has happened here with the 3- to 5-yr-olds. Interestingly, the large increase in the propensity of being underweight for 0- to 2-yr-olds is entirely driven by the large increase in average height, because it is not accompanied by any change in the average weight of these children. In the next section, we examine in more detail the evidence for greater resource intake.

V. HOW MIGHT MIGRATION BE AFFECTING CHILD HEALTH?

In this section, we attempt to understand some of the channels through which these effects may operate. Returning to Equation (1), we see that health outcomes may change as a result of changes in material inputs, time inputs, and health knowledge. Our data only allow us to examine the impact of changes in material inputs, although we will discuss how changes in the other two types of factors could relate to our results.

Increases in income alter the ability of a household to purchase food and medical inputs that affect child health production. As shown in McKenzie, Gibson, and Stillman (2009), migration from Tonga to NZ results in large increases in earned income among principal applicants. Re-estimating the main treatment effect model from that paper to examine the impact on total household income among migrant households with children, we find that migration increases annual total household income by approximately 14,990 NZ dollars for these households relative to an average annual total household income of 19,840 NZ dollars among unsuccessful lottery applicants in Tonga.[22] A number of studies find a strong relationship between household income and child health (Case, Lubotsky, and Paxson 2002), thus we first examine whether these income increases are likely to be related to the estimated impacts of migration on child health.

In Table 5, we present results from estimating the relationship between child health and child and parent characteristics,[23] log total household cash income,[24] log total household imputed value of own-production,[25] and log distance from the nearest doctor[26] among all children in all households in Tonga (e.g., a combined sample of unsuccessful ballot applicants, successful ballot applicants still in Tonga, nonapplicants and previous household members of successful migrants now in NZ that are still in Tonga). We estimate ordinary least squares (OLS) models for each of the continuous outcomes and probit models for the discrete outcomes and present marginal effects and their associated standard errors which account for clustering at the household level. The results are only associations, not causal relationships. Nonetheless, if income has a strong causal impact on child health, we would expect to see a significant association in these regressions. However, we see there is only a weak relationship between income and most measures of child health.[27] The exceptions are height for age, where children are significantly taller in households with higher cash incomes and income from own-production, and stunting, where children in households with higher cash incomes are less likely to be stunted. However, the magnitude of these effects are quite small

21. In unreported results, we also examined whether impacts are related to the amount of time the children lived in New Zealand. We find migration has significant impacts on the same outcomes and that the magnitude of these impacts grow linearly with time spent in New Zealand (e.g., the average monthly impact equals the total impact reported in Table 4 divided by the mean number of months living in New Zealand for children in each age-group).

22. Total household income includes labor earnings, agricultural income, pension and investment income, the receipt of social benefits, and the imputed value of own-produced foods that are consumed by the household.

23. We include all of the covariates from the treatment effects regressions as well as controls for the total number of children in the household, whether the child lives with both of their parents, and each parent's years of education.

24. We also estimate the same models controlling for a quadratic in income. The models using log income best fit the data and results are qualitatively the same in each case.

25. The value of own-production is imputed using self-reported valuations of own produce consumed in the week before the survey. We control for this separately because own-production is likely to be directly related to child anthropometrics due to the different foods consumed by households with crops versus those without own production.

26. This is calculated using GPS data on the location of each household and of each medical center.

27. This is the case even if we do not control for parent characteristics in the regression model.

TABLE 5

Correlates of Health Status in Tonga (Probit Marginal Effects for Outcomes (1)–(2), (6)–(9), OLS for Remainder)

	Very Good Parent-rated Health	Much Better Health Since Last Year	Standardized Height for Age	Standardized Weight for Age	Standardized BMI for Age	Stunted Height for Age ≤ 5th Percentile	Underweight BMI for Age ≤ 5th Percentile	Overweight BMI for Age 85th–95th Percentile	Obese BMI for Age ≥ 95th Percentile
Log total household cash income	−0.0200**	−0.011	0.0595*	−0.046	−0.052	−0.0147**	0.004	0.013	−0.002
	(0.010)	(0.017)	(0.034)	(0.045)	(0.050)	(0.007)	(0.003)	(0.010)	(0.019)
Log total household own-production	0.012	−0.001	0.111***	0.004	−0.055	−0.009	0.001	−0.011	−0.019
	(0.017)	(0.016)	(0.042)	(0.053)	(0.048)	(0.008)	(0.003)	(0.007)	(0.019)
Log distance from nearest doctor	0.009	0.023	−0.014	−0.032	−0.057	0.007	0.008	0.021	−0.020
	(0.024)	(0.024)	(0.100)	(0.092)	(0.095)	(0.019)	(0.006)	(0.016)	(0.027)
Female dummy	−0.034	−0.028	0.096	0.420***	0.399***	−0.015	−0.0301***	0.012	0.115***
	(0.044)	(0.040)	(0.147)	(0.113)	(0.133)	(0.033)	(0.012)	(0.029)	(0.039)
Age in months/12	0.000	−0.001	0.0144**	0.0180***	0.0140**	−0.00357***	−0.00108***	0.001	0.001
	(0.001)	(0.002)	(0.006)	(0.006)	(0.006)	(0.001)	(0.000)	(0.001)	(0.002)
Age squared/144	0.000	0.000	−0.00815***	−0.00642***	−0.00391*	0.00166***	0.000428***	0.000	0.000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)
Birth order position	−0.025	0.004	0.071	0.038	0.006	−0.009	−0.007	−0.024	0.031
	(0.023)	(0.020)	(0.076)	(0.079)	(0.075)	(0.014)	(0.007)	(0.017)	(0.025)
Number of children in household	0.005	0.002	−0.059	0.007	0.008	0.007	−0.002	−0.005	−0.014
	(0.014)	(0.016)	(0.053)	(0.059)	(0.054)	(0.010)	(0.004)	(0.011)	(0.017)
Lives with both parents	0.110	0.066	−0.006	−0.422	−0.015	0.027	−0.006	0.039	0.024
	(0.080)	(0.075)	(0.353)	(0.376)	(0.375)	(0.057)	(0.025)	(0.039)	(0.106)
Father's age	−0.003	−0.008	−0.011	−0.004	0.003	0.002	0.000	−0.005	0.009
	(0.005)	(0.006)	(0.021)	(0.020)	(0.019)	(0.003)	(0.001)	(0.004)	(0.006)
Mother's age	0.006	0.0109*	0.021	0.029	−0.003	−0.003	0.000	0.003	−0.001
	(0.006)	(0.006)	(0.027)	(0.020)	(0.022)	(0.004)	(0.002)	(0.004)	(0.007)
Father's years of education	0.010	0.008	−0.012	0.056	0.058	0.010	0.0112***	−0.014	0.020
	(0.017)	(0.016)	(0.060)	(0.053)	(0.060)	(0.014)	(0.004)	(0.011)	(0.019)
Mother's years of education	0.013	−0.003	0.108*	0.124**	0.042	−0.0222*	−0.00947**	0.009	0.006
	(0.014)	(0.015)	(0.057)	(0.049)	(0.062)	(0.012)	(0.005)	(0.011)	(0.021)
Father's height	0.000	−0.001	0.005	0.000	−0.002	0.000	0.000	−0.001	0.000
	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)	(0.000)	(0.000)	(0.001)
Mother's height	−0.001	0.002	0.009	0.007	0.004	−0.001	0.001	0.001	0.002
	(0.002)	(0.002)	(0.006)	(0.004)	(0.005)	(0.001)	(0.001)	(0.001)	(0.002)
Observations	609	568	540	561	542	540	542	542	542
R-squared	0.09	0.03	0.10	0.17	0.08	0.07	0.17	0.04	0.06

Notes: Robust standard errors in parentheses, clustered at household level. Regressions also control for survey year.
*Significant at 10%; **Significant at 5%; ***Significant at 1%.

with a 100% increase in cash income (income from home production) associated with a 0.06 (0.11) standard deviation increase in height for age and a 1.5 percentage point decrease in the likelihood of being stunted. However, children whose parents earn more cash income are significantly less likely to be reported in very good health.

We then ask whether there is any relationship between the health of Tongan children who have recently immigrated to NZ and the change in income that their families experienced as a result of migrating. Table 6 shows that the magnitude of the change in earnings experienced from moving to NZ and the number of months they have lived in NZ have almost no relationship with the health of immigrant children.[28] The only significant associations are that a 100 NZD increase in weekly earnings is associated with a 2.3% point *reduction* in the likelihood of parents reporting their children as having much better health than 1 yr ago and 0.9 percentage point *increase* in the likelihood of children being stunted.

Taken together, these results suggest that, even with the large income gains experienced by migrant households, changes in income explain little of the estimated impact of migration on child health. Dietary change is another pathway through which migration is likely to affect child health. Not only is the availability of foods hugely different between Tonga and NZ, the relative prices of foods available in both countries also differ immensely. Existing literature also suggests that major dietary changes occur for Pacific Islanders following migration to NZ (Harding et al. 1986). Thus, we next examine whether changes in diet are likely to be related to the estimated impacts of migration on child health.

Table 7 presents results from estimating the ATT of migration on diet. Specifically, we collect information from all households on whether any of 30 different foods were eaten by any member of the family during the day prior to the interview. For 27 of these foods, we also asked during how many meals were these foods eaten. The list of foods is identical in Tonga and NZ making a direct comparison of diet composition possible. To focus our analysis, we examine the cumulative number of meals in which eight foods are consumed, five of which are composites. These foods are: rice, roots, fruits, and nonroot vegetables, fish, fats, meats, milk, and sweets.[29] We estimate linear instrumental variables models for each using whether the household was successful in the PAC ballot to instrument for whether the individual has migrated to NZ. These models are estimated with one observation per-child to allow all covariates from the second specification of the child health regression models to be included in these regressions as well (results are presented both with and without covariates), and thus the results can be interpreted at the impact of migration on the diet of the average child in the sample.[30] We also estimate a third specification that includes additional controls for the number of male and female adults in the household and the number of other children. As discussed below, migration leads to significant changes in household composition which could have a mechanical impact on the number of daily meals consumed by a household. Although we cannot jointly identify the impact of both migration and changes in household composition on diet, if the estimates of the direct impact of migration are unchanged in this specification, we can rule out that changes in household composition are responsible for our findings.

These results indicate that migration leads to a significant increase in the consumption of meats, fats, and milk. These changes in diet are large—consumption of meats and fats both almost double while consumption of milk quadruples—and are robust to including controls for household composition. Although we cannot directly relate changes in diet to changes in child health because we do not know which household members are consuming which food, these results suggest that dietary change is directly related to changes in child health.

28. Only one Tongan immigrant child is underweight, thus this outcome is dropped from this analysis. Again, the results are robust to not controlling for parent characteristics besides household income.

29. Roots include taro (swamp taro), taro taruas (chinese taro), kumara (sweet potato), taamu/kape, yams, cassava/manioc, and potato. Fruits and nonroot vegetables include other vegetables, coconut (fresh and dry), banana, mango, pawpaw, and other fruits. Fish includes tinned fish and fresh fish. Fats include corned beef, mutton, and coconut (fresh and dry). Meats include corned beef, mutton, fresh beef, chicken, pork, and other meat (e.g., sausage). Sweets are one of the foods where the number of meals is not recorded, thus this is a discrete outcome.

30. Again, standard errors are presented which account for clustering at the household level and all regressions use the appropriate survey weights to account for the sampling rates for each group. We also include day of the week fixed effects in the regressions with covariates to account for temporal patterns in food consumption.

TABLE 6

Correlates of Health Status in New Zealand (Probit Marginal Effects for Outcomes (1)–(2), (6)–(8), OLS for Remainder)

	Very Good Parent-rated Health	Much Better Health Since Last Year	Standardized Height for Age	Standardized Weight for Age	Standardized BMI for Age	Stunted Height for Age ≤ 5th Percentile	Overweight BMI for Age 85th–95th Percentile	Obese BMI for Age ≥ 95th Percentile
Change in total household	−0.002	−0.0229*	−0.025	−0.014	−0.004	0.009***	−0.009	0.000
earnings (00s NZD)	(0.008)	(0.013)	(0.023)	(0.036)	(0.036)	(0.004)	(0.004)	(0.013)
Months in New Zealand/12	0.114	0.046	0.009	0.174	0.179	0.017	−0.024	0.065
	(0.080)	(0.125)	(0.307)	(0.243)	(0.196)	(0.039)	(0.039)	(0.085)
Female dummy	0.009	0.060	0.028	0.405**	−0.032	−0.002	−0.047	0.002
	(0.052)	(0.084)	(0.285)	(0.153)	(0.217)	(0.035)	(0.051)	(0.092)
Age in months/12	−0.030	0.013	−0.040	0.081	0.028	0.010	0.017	−0.051
	(0.026)	(0.044)	(0.127)	(0.148)	(0.129)	(0.020)	(0.022)	(0.046)
Age squared/144	−0.037	−0.075	0.400	0.276	0.456	−0.097	−0.057	0.479**
	(0.118)	(0.180)	(0.587)	(0.668)	(0.575)	(0.103)	(0.109)	(0.235)
Birth order position	0.053	−0.027	−0.285	−0.168	0.019	0.026	−0.036	0.024
	(0.033)	(0.060)	(0.188)	(0.141)	(0.147)	(0.024)	(0.028)	(0.052)
Number of children in household	−0.017	0.037	0.004	0.104	0.077	0.001	0.028	−0.011
	(0.026)	(0.049)	(0.151)	(0.148)	(0.104)	(0.014)	(0.021)	(0.043)
Lives with both parents	Perfect	Perfect	2.102	−0.389	−2.373***	−0.438*	Perfect	Perfect
	Predictor	Predictor	(1.437)	(0.682)	(0.521)	(0.369)	Predictor	Predictor
Father's age	−0.0240*	−0.016	−0.020	−0.036	0.054	−0.001	0.000	0.024
	(0.014)	(0.022)	(0.046)	(0.052)	(0.045)	(0.006)	(0.008)	(0.019)
Mother's age	0.0527***	0.018	0.016	−0.036	−0.110**	0.000	0.004	−0.033
	(0.016)	(0.024)	(0.046)	(0.047)	(0.048)	(0.007)	(0.009)	(0.020)
Father's years of education	−0.020	−0.014	−0.007	0.063	0.001	0.004	−0.0224***	0.008
	(0.024)	(0.023)	(0.043)	(0.048)	(0.037)	(0.007)	(0.007)	(0.016)
Mother's years of education	−0.010	0.033	−0.031	0.114	0.101	0.012	−0.0347**	0.046
	(0.021)	(0.042)	(0.069)	(0.080)	(0.062)	(0.011)	(0.016)	(0.029)
Father's height	0.000	0.000	0.000	0.004	0.001	0.001**	0.000	0.000
	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
Mother's height	0.00248*	0.0181*	0.004	0.002	0.002	0.000	0.009***	−0.002
	(0.001)	(0.011)	(0.005)	(0.004)	(0.003)	(0.001)	(0.002)	(0.001)
Observations	184	180	166	169	161	166	158	158
R-squared	0.26	0.31	0.11	0.17	0.26	0.22	0.14	0.16

Notes: Robust standard errors in parentheses, clustered at household level. One individual is underweight. One individual is dropped from each discrete model where lives with both parents are a perfect predictor. NZD, New Zealand Dollar.

*Significant at 10%; **Significant at 5%; ***Significant at 1%.

TABLE 7
Linear IV Estimates of Experimental Impact on Diet Composition

	No. of Meals Rice	No. of Meals Roots	No. of Meals Fruits/Vegs	No. of Meals Fish	No. of Meals Fats	No. of Meals Meats	No. of Meals Milk	Anyone Ate Sweets
Mean unsuccessful ballots	0.224	1.733	2.477	0.580	0.705	1.053	0.448	0.146
Relative price (Pa'anga/NZD)	1.966	0.504	0.769	0.567	0.654	1.262	1.657	NA
No control variables	−0.097	0.221	1.013**	−0.264**	0.640***	0.911***	1.121***	0.034
	(0.095)	(0.191)	(0.414)	(0.113)	(0.185)	(0.161)	(0.140)	(0.089)
Main control variables	−0.084	0.319	0.424	−0.183	0.649***	0.960***	1.210***	0.047
	(0.098)	(0.207)	(0.433)	(0.121)	(0.172)	(0.170)	(0.133)	(0.083)
Added controls for household size	−0.050	0.404*	0.098	−0.173	0.611***	0.972***	1.212***	0.009
	(0.100)	(0.215)	(0.450)	(0.124)	(0.170)	(0.170)	(0.133)	(0.093)
Total sample size	528	528	528	528	528	528	528	528

Notes: Standard errors account for clustering at the household level and all regressions use survey weights. Models with main control variables include controls for the child's gender, age in months, age in months squared, birth order position, their parents' age and height, and day of the week fixed effects. The final specifications include additional controls for the number of male and female adults in the household and the number of children. Ballot success is used to instrument for being in NZ in each regression. The market exchange rate is 1.372 Pa'anga per NZD. Roots include taro (swamp taro), taro taruas (chinese taro), kumara (sweet potato), taamu/kape, yams, cassava/manioc, and potato. Fruits and vegetables include other vegetables, coconut (fresh and dry), banana, mango, pawpaw, and other fruits. Fish includes tinned fish and fresh fish. Fats include corned beef, mutton, and coconut (fresh and dry). Meats include corned beef, mutton, fresh beef, chicken, pork, and other meat (e.g., sausage). NZD, New Zealand Dollar.

*Significant at 10%; **Significant at 5%; ***Significant at 1%.

Increased consumption of meats and milk would lead to increased protein and other micronutrient intake, which have been shown to increase the stature of infants and toddlers (Branca and Ferrari 2002). However, increased consumption of these goods along with fats would lead to an increase in overall calorie and fat intakes, which is directly related to weight gain.

A number of factors could contribute to changing diets. As mentioned earlier, relative food prices are quite different in NZ versus Tonga and most migrant households have experienced large increases in income. Table 7 also displays the relative Tongan to NZ market price for each food item. The estimated changes in diet are somewhat consistent with relative prices also being a factor—for example, meats and milk are relatively cheaper in NZ than in Tonga compared to other foods (in particular, roots and fish). However, we find low cash income elasticities for most foods in Tonga.[31] Perhaps, more importantly, the marketing of foods and the availability of different foods is likely to be vastly different between these countries. Furthermore, many Tongan households grow or raise some of their own food, whereas none of the Tongan migrant households in our survey do so.

Overall, these results suggest that dietary change is an important channel through which migration impacts child health and that changes in income, both the direct effect of these changes and their impact on diet, are of limited importance. Differences in relative prices may explain some of this dietary change, but it seems likely that other important mechanisms are also driving this. Another potentially important channel is changes in household structure. For example, ATT estimates indicate that the share of adult women in migrant households declines by 19 percentage points following migration. We suspect that having fewer female extended family members around to help prepare meals could be a large contributor to a shift toward less healthy diets. It is also important to note that there are a number of other channels through which migration may affect child health that our data do not allow us to examine. For example, changes in antenatal practices, such as breastfeeding, might explain the increased stature of infants in NZ, whereas reductions in physical activity might play an important role in explaining the increased BMI of pre-teens. It is also possible that maternal health knowledge about nutrition during early childhood may improve in NZ.

31. Households with higher cash incomes are not consuming significantly different amounts of fruits, vegetables, milks, or meat. In contrast, consumption patterns do vary with the level of own food production, which does not take place among Tongan households in New Zealand.

VI. CONCLUSIONS

This paper overcomes the selection problems affecting previous studies of the impact of migration on child health by examining a migrant lottery program. The PAC under NZ's immigration policy allows an annual quota of Tongans to migrate to NZ in addition to those approved through other migration categories, such as skilled migrants and family streams. Many more applications are received than the quota allows, so a ballot is used to randomly select from among the registrations. A unique survey designed by the authors allows experimental estimates of the impact of migration on child health to be obtained by comparing the health of immigrant children whose parents were successful applicants in the ballot to the health of those children whose parents applied to migrate under the quota, but whose names were not drawn in the ballot.

Migration is found to affect child health in a manner consistent with increased food intake. Infants and toddlers suffer less stunting after migration, whereas 3- to 5-yr-olds gain weight. Older children show no change in anthropometric measures, but have better parental reported health. Dietary change appears to be an important channel through which migration impacts child health, whereas changes in income, both the direct effect of these changes and their impact on diet, are of limited importance. Differences in relative prices may explain some of this dietary change, but it seems likely that other important mechanisms, such as changes in household structure, are also driving this.

It is important to note that there are a number of other channels through which migration may affect child health that our data do not allow us to examine. For example, changes in antenatal practices, such as breastfeeding, might explain the increased stature of infants in NZ, whereas reductions in physical activity might play an important role in explaining the increased BMI of pre-teens. Further research is needed to examine these effects, as well as to determine interventions which can help lower the rate of obesity among older children in immigrant households.

It also must be emphasized that these results reflect the short-run impacts of migration on child health and therefore it will be important to continue monitoring these children to see whether the increases in BMI and obesity persist for the cohort of 3- to 5-yr-olds and whether similar changes occur for the younger cohort of 0- to 2-yr-olds once they are too old for additional food intakes to impact their height.

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