September, 2010

Natural Experiment Evidence on the Effect of Migration on Blood Pressure and Hypertension[1]

John Gibson, *University of Waikato and Motu Economic and Public Policy Research*[*]
Steven Stillman, *Motu, University of Waikato, IZA and CReAM*
David McKenzie, *Development Research Group, World Bank, IZA and CReAM*
Halahingano Rohorua, *University of Waikato*

Abstract

Over 200 million people live outside their country of birth and experience large gains in material well-being by moving to where wages are higher. But the effect of this migration on health is less clear and existing evidence is ambiguous because of the potential for self-selection bias. In this paper, we use a natural experiment, comparing successful and unsuccessful applicants to a migration lottery to experimentally estimate the impact of migration on measured blood pressure and hypertension. Hypertension is a leading global health problem, as well as being an important health measure that responds quickly to migration. We use various econometric estimators to form bounds on the treatment effects since there appears to be selective non-compliance in the natural experiment. Even with these bounds the results suggest significant and persistent increases in blood pressure and hypertension, which have implications for future health budgets given the recent worldwide increases in immigration.

Keywords: Blood pressure, Hypertension, Lottery, Migration, Natural experiment

JEL codes: C21, I12, J61

[1] We thank the Government of the Kingdom of Tonga for permission to conduct the survey there, the New Zealand Department of Labour Workforce Group for providing the sampling frame, audiences at the AHES and ESPE conferences and at the University of New South Wales for helpful comments, and most especially the study participants. Financial support from the World Bank, Stanford University, the Waikato Management School and Marsden Fund grant UOW0503 is gratefully acknowledged. The study was approved by the multi-region ethics committee of the New Zealand Ministry of Health. The paper was written while Gibson was a Visiting Fellow at the Center for Global Development, whose hospitality was much appreciated. The views expressed here are those of the authors alone and do not necessarily reflect the opinions of the World Bank, the New Zealand Department of Labour or the Government of Tonga.
[*] Corresponding author: E-mail: jkgibson@waikato.ac.nz Address: Department of Economics, University of Waikato, Private Bag 3105, Hamilton, New Zealand 3240. Phone: (64-7) 838-4289, Fax (64-7) 838-4331.

1. Introduction

Over 200 million people worldwide live outside their country of birth, with a large proportion having moved from a developing to a developed country. These people generally experience large gains in material well-being by moving to where wages are higher (Clemens and Pritchett, 2008; McKenzie et al., 2010). But the effect of this migration on other dimensions of well-being is less clear. In particular, moving from one cultural and environmental setting to another can be a very stressful process that requires considerable adaptation to new conditions and potentially has negative impacts on health.

In this paper, we use unique survey data on successful and unsuccessful applicants to a migration lottery to experimentally estimate the impact of migration on blood pressure and hypertension. We focus on hypertension for three reasons. First, it is a very prevalent and costly public health problem. Approximately one billion people – just over one-quarter of the world's adults – had hypertension in 2000, and with population aging its prevalence is expected to increase to 1.6 billion by 2025 (Kearney et al., 2005). Globally, it is the leading risk factor for mortality, contributing to almost eight million deaths in 2001, and is ranked second as a cause of disability-adjusted life years (Lopez et al., 2006). The treatment of hypertension is also a major drain on health budgets around the world.[2] If hypertension is indeed affected by migration, the large increase in the number of immigrants worldwide over the last decade can be expected to affect future health budgets in destination countries.

Second, while many health impacts of migration may take decades to materialize, the medical literature notes that blood pressure can respond rapidly to a change in environments (Poulter et al., 1990) and then remain permanently elevated (Salmond et al, 1989). This

[2] For example, in the United States, the direct costs of treatment were about US$37 billion in 2003, with a further $13 billion of indirect costs from lost productivity due to morbidity and mortality (Degli Esposti and Valpiani, 2004). In France, annual per capita treatment costs for patients seen just by general practitioners are approximately €600 (Tibi-Levy et al., 2008), and will be higher for patients requiring more specialized treatment, giving an annual cost of well over €5 billion per year.

makes it ideal for measuring potential health effects of migration in the short run.[3] There are two key pathways through which migration may affect blood pressure. First, hypertension can be triggered by anxiety (Jonas and Lando, 2000) and migration is argued to be stressful (Bhugra and Jones, 2001). Second, diets and physical activity are likely to change after moving to a new country and these are two of the major lifestyle factors affecting hypertension (Geleijnse et al., 2004). In particular, more urbanized diets typically have higher sodium content which is an important cause of high blood pressure (Poulter et al., 1990).

The final reason to focus on hypertension is that Blanchflower and Oswald (2008) claim that it is a good (inverse) indicator of the overall well-being of particular population groups across countries. However, this line of reasoning is based on the untested assumption that hypertension is monotonically decreasing in individual utility for all population groups. Our results in this paper suggest that this is unlikely to be the case for migrants.

While the economic literature on hypertension is sparse, a much larger literature examines the impact of migration on health. Both health economics and public health studies generally conclude that immigrants from developing countries are, on average, healthier than comparable individuals in the host developed countries, which has been called the 'healthy immigrant effect' (Abraido-Lanza et al., 1999). These studies typically make no attempt to control for the potential bias caused by migrant self-selection (Kennedy et al., 2006) so many interpret this finding as evidence that migrants are "positively selected" and thus are in better health than non-migrants (Palloni and Arias, 2004). But there is no way to exclude the possibility that migration itself has had causal impacts on health. In fact, two recent papers that directly examine immigrant self-selection have found no support for the supposition that immigrants are healthier than non-migrants. Rubalcava et al. (2008) use longitudinal data from the Mexican Family Life Survey to compare emigrants from Mexico to similar non-

[3] Other short run health impacts found with the survey used here include improved mental health for adult migrants (Stillman et al., 2009) and both positive and negative impacts on various indicators of anthropometric health for children who migrated (Stillman et al., 2010).

migrants and find no evidence of a "healthy immigrant effect", while Stillman et al. (2009) examine selection of Tongan emigrants into a migration program and find that individuals in worse mental health are more likely to apply to migrate.[4]

To estimate the impact of migration on health without the confounding effect of selection, one must compare the health of immigrants to what their health would have been had they stayed in their home country. This paper does so by examining an immigration flow between the countries of Tonga and New Zealand where the selection into migration is via a random ballot. This randomization allows us to compute experimental estimates of the impact of migration on blood pressure and hypertension by comparing these outcomes for Tongan immigrants to New Zealand who were successful applicants in the migration lottery to outcomes for those Tongans who applied to migrate under this program, but whose names were not drawn in the random ballot and so remained in Tonga.

Importantly, the unique survey used in this paper directly measures the blood pressure of each adult respondent, as well as collecting self-reported data on whether they have ever been diagnosed with high blood pressure. Since hypertension is asymptomatic, it may be especially prone to under-reporting in surveys that rely on self-reported health. Indeed, comparisons of survey self-reports and objective measurements of hypertension find very substantial differences; only seven percent of an English national sample report having hypertension as a chronic illness yet 35 percent of that sample had hypertension based on their measured blood pressure (Johnston et al., 2009). Moreover, this under-reporting was non-random, so the significant income/health gradient in measured hypertension completely disappeared when using the self-reported data.

The next section briefly summarizes the findings of existing literature in health economics on natural experiments and in the public health literature on migration and blood

[4] The higher mortality of Irish immigrants in England compared with the Irish in Ireland was also taken as early evidence of such negative selection (Marmot et al, 1984).

pressure. The current paper is the first that intersects those literatures. Section 3 provides background and context on Tongan health and migration, and describes the survey and measures of blood pressure used in this study. Section 4 reports estimates of the treatment effect of migration on blood pressure and hypertension, using several econometric approaches to place bounds around the true effects. In Section 5, the mechanisms underlying the measured impacts on blood pressure and the persistence of those impacts are explored, while Section 6 contains conclusions.

2. Previous Literature

Natural experiments are increasingly studied in health economics because they provide an opportunity to examine impacts when a potentially endogenous treatment is applied to all or part of a population, without facing some of the ethnical and practical challenges of randomized control trials. The causal effects on health of income shocks have been especially studied, for example, using German reunification (Frijters et al., 2005) or lottery winnings (Lindahl, 2005) as the source of exogenous income variation. However, these types of shocks are relatively rare and the treated population may not be large, making it difficult to generalize from such natural experiments. Moreover, these two previous studies of natural experiments examine a self-reported general health status variable as their main outcome of interest, rather than a detailed measurement of a major health condition as used in this paper.

Another type of natural experiment used to study health comes from changes in compulsory schooling laws. While these law changes in the United States affected only a small fraction of students, making the estimated local average treatment effects potentially uninformative about average treatment effects for the population (Lleras-Muney, 2005), leaving age increases in Britain in 1947 and 1973 affected one-half and one-quarter of the cohorts. This exogenous increase in schooling has been used in a regression discontinuity design by Clark and Royer (2009) to study the effect of schooling on later mortality and on several health outcomes, including measured blood pressure. These authors find no impact of extra schooling on blood pressure (measured almost 50 years later). A later study by Powdthavee (2010) using the same data and approach finds that an extra year of schooling reduced the probability of men subsequently developing hypertension by around ten percentage points, although there was no significant effect for women. However, this study has little to say about the causal pathways leading to this change.

In contrast to the health economics literature, where blood pressure has only recently been studied and where the link between migration and blood pressure remains unexamined, the public health literature contains several longitudinal studies of blood pressure changes of migrants and non-migrants (Salmond et al, 1985; Salmond et al, 1988) and many more cross-sectional comparisons (e.g. Bjerregaard et al, 2002; McGarvey and Baker, 1979). However, these public health studies do not attempt to control for the potential non-random selection of who migrates, and as such their results may not be informative for understanding whether migration has a causal impact on blood pressure. This is clearly the question that needs answering to understand the potential side-effects on health of expanding global migration.

3. Context and Survey

3.1 Background

The Kingdom of Tonga is an archipelago of islands in the South Pacific, about three hours north of New Zealand by airplane. The resident population of Tonga is just over 100,000, with a GDP per capita of approximately US$ 2,200 in PPP terms. One-third of the labor force is in agriculture and fishing, while employment in the manufacturing and services sectors is dominated by the public sector and tourism. Emigration levels are high, with 30,000 Tongan-born individuals living abroad, primarily in New Zealand, Australia and the United States.

Migration to New Zealand began with Tongans arriving on temporary work permits during the 1960s and 1970s. Some stayed on in New Zealand illegally, with a 1976 amnesty granting many of these individuals permanent residence. Migration for work continued in the late 1970s and 1980s, and by 1986 the Tongan population in New Zealand had reached 13,600. However, in 1991, New Zealand introduced a selection system for immigration, in which potential migrants are awarded points for education, skills, and business capital. Few Tongans qualified to migrate under this system, and so most Tongan migration during the 1990s was under family sponsored categories—as the spouse, parent, or child of an existing migrant. For example, in 1997/1998 only 29 Tongans were admitted as principal applicants under the points system, compared to 436 under family categories. With family migration, the Tongan-born population in New Zealand had grown to 19,000 by the 2001 Census.

3.2 The Pacific Access Category

In 2002, another channel was opened up for immigration to New Zealand through the creation of the Pacific Access Category (PAC). This allows for a quota of 250 Tongans to immigrate to New Zealand each year regardless of their skill level or socioeconomic status.[5] Specifically, any Tongan citizens aged between 18 and 45, who are either born in Tonga or born overseas to Tongan-born citizens can register to immigrate to New Zealand.[6] The registration fee is only NZ$50 (US$30) per family, and re-registration in subsequent years is allowed at the lower rate of NZ$20. Many more applications are received than the quota allows, so a ballot is used by the New Zealand Department of Labour (DoL) to randomly select from amongst the registrations. During the 2002-05 ballot years that our sample is drawn from, the odds of having one's name drawn were approximately one in ten.

[5] 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.

[6] 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. Data supplied by the New Zealand Department of Labour for residence decisions made between November 2002 and October 2004 reveals that only four applications were rejected for failure to meet the requirements of the policy.

Once their ballot is selected, applicants then apply for permanent residence in New Zealand, which has two other main requirements. First, they have six months to obtain a job offer in New Zealand that meets an income threshold similar to the adult minimum wage. This is to ensure financial self-reliance since Tongan migrants are not eligible for most forms of welfare until they have resided in New Zealand for two years. Second, they have to undergo a health check (which is the same for all applicants for permanent residence in New Zealand) which is designed to protect public health in New Zealand and to ensure that migrants do not impose excessive costs and demands on the health services. Only four conditions are specified as likely to lead to rejection of a residence application; physical incapacity that requires full time care, requiring dialysis treatment, severe hemophilia, and active pulmonary tuberculosis (based on a chest X-ray). Since these requirements are well publicized, it is unlikely that anyone with these conditions would enter the PAC ballot.

3.3 Survey Data

The data used in this paper are from the Pacific Island-New Zealand Migration Survey (PINZMS), a comprehensive survey designed to measure multiple effects of migration, taking advantage of the natural experiment provided by the PAC.[7] The survey design and enumeration, which was overseen by the authors in 2005-06, covered random samples of four groups of households, surveying in both New Zealand and Tonga.

The first group is a random sample of 102 of the 302 Tongan immigrant households in New Zealand, who had a member who was a successful participant in the 2002-2005 PAC ballots.[8] Administrative data show that none of the ballot winners had returned to live in

[7] See www.pacificmigration.ac.nz for more details of the survey.
[8] A large group of the 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 et al. (2010), we describe in detail the tracking of the sample in New Zealand, showing a contact rate of over 70 percent. The main reasons for non-contact were incomplete name and address details, which should be independent of blood pressure 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.

Tonga for up to two years after the time of the survey, so our analysis does not need to take account of any potential selectivity bias from return migration. 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. These households are therefore non-compliers to the treatment of migration. We sampled 29 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. In forming our experimental estimate, 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 containing unsuccessful participants in these same ballots, who form our experimental control group. The full list of unsuccessful ballots from these years was provided to us by the New Zealand Department of Labour, but the contact details only included a post office box address. We used two strategies to derive a sample of 125 households 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 surveyed households from smaller outlying islands.

The final survey group consists of households living in the same villages as the PAC applicants but from which no eligible individuals had applied for the quota in any of our sample years (e.g. 2002-2005). We randomly selected 120 non-applicant households that met the condition of having at least one member aged 18 to 45 (so as to restrict attention to non-applicant households who could have had a member apply to the PAC if they had been interested in so doing). This group is used to examine whether blood pressure and hypertension differs for Tongans interested in migrating to New Zealand compared with the non-applicant population.

3.4 Measuring Blood Pressure and Hypertension

One of the authors and her assistants interviewed respondents in their homes. In addition to asking about a set of standard socio-economic indicators and self-reported health status, a feature of the PINZMS is that direct measurements were also taken of blood pressure and anthropometrics. Blood pressure was measured using the standard approach of placing an inflated cuff around the upper arm with the subject in a sitting position after five minutes of rest, using an oscillometric digital sphygmomanometer (Model UA-767; A&D Medical, Milpitas, CA).[9] Readings come as a pair, with systolic blood pressure (SBP) measuring pressure when the heart beats and diastolic blood pressure (DBP) measuring pressure between beats. Both are reported in units of millimeters of mercury (mmHg). Following standards used in the medical literature, hypertension was defined as either systolic blood pressure 140 mmHg or greater or diastolic blood pressure 90 mmHg or greater (Kearney et al, 2005). In addition, the survey also asked respondents if they had ever been informed by a doctor that they had high blood pressure (other than during pregnancy) and when their blood pressure had last been measured.

3.5 Verifying Randomization

Blood pressure was measured for each individual aged 19 and over in the household. However, since the only household members who can immigrate with the PAC ballot winners are their spouse and dependent children (of age up to 24 years), our experimental estimates restrict the comparisons of blood pressure between the migrants and the PAC ballot entrants still in Tonga just to the migrant/principal applicant and their spouse and children aged 19-24.

[9] A validation study on the use of this particular electronic blood pressure monitor is provided by Rogoza et al., (2000).

This results in sample sizes of 161 migrants, 63 members of households with ballot winners still in Tonga, 198 members of households with ballot losers in Tonga, and 216 non-applicants in Tonga. All statistical results reported below are clustered at the household level and weighted to represent the population of PAC ballot entrants.

The random lottery should ensure that characteristics of the ballot winners and losers are the same on average, but since we do not have data for the entire population of ballot applicants we need to check that randomization holds in our sample. Table 1 compares the means of ex-ante characteristics for 19-48 year old ballot winners and ballot losers in our sample, and shows that the two groups are similar in most respects.[10] In particular, they have the same average age, birth location, education, gender, height, and income in the year prior to when most migrants left Tonga. However, the ballot winners reported higher previous employment rates, on average, than did the ballot losers in our sample. Thus, in some specifications of our regression estimates we will control for these observed ex-ante characteristics to control for any differences in blood pressure arising from baseline differences in observed variables.

(Table 1 about here)

Table 1 also shows that the average migrant in our sample had spent 11 months in New Zealand when we measured their blood pressure. Previous evidence suggests that blood pressure may change within months of migrating (Poulter et al., 1990) so the duration of exposure to the migration treatment in our sample should be sufficiently long to detect effects if they exist. Moreover, these effects are likely to persist since the evidence from longitudinal surveys is that once the blood pressure of migrants is elevated it remains so permanently (Salmond et al., 1989).

[10] We use the cut-off of 48 years, since for some sample members up to three years had elapsed from the time of ballot entry (for which people aged more than 45 years are ineligible) until the time when we measured blood pressure.

4. Methods and Results

4.1. Descriptive Comparisons

To estimate the impact of international migration on blood pressure and hypertension we want to compare these outcomes for migrants with what they would have been in their home country had they not migrated. Typically, it is not possible to readily identify this unobserved counterfactual health outcome. However, the PAC lottery system, by randomly denying eager migrants the right to move to New Zealand, creates a control group of individuals who should have the same outcomes that migrants would have had if they had not moved. If there were no self-selection into migration amongst ballot winners, simply comparing mean blood pressure and hypertension rates for the ballot-winning migrants with the same variables for the ballot losers might be expected to provide experimental estimates of the treatment effect. However, if there is only selective compliance to the migration program, then more econometrically sophisticated approaches to estimating treatment effects are required.

We start therefore by examining the means for the various sub-groups in our sample, of systolic and diastolic blood pressure, and of the incidence of measured and self-reported hypertension (Table 2). The unweighted count of the number of observations in each sub-group, and the results of tests of hypotheses for equal means across the various sub-groups are also reported.[11] The average blood pressure of the migrants is higher than it is in the control group of ballot losers in Tonga, by between 2.4 mm.Hg (diastolic) and 3.6 mm.Hg (systolic). The incidence of hypertension is also higher, by 9.1 percentage points when using measured blood pressure and by 3.2 percentage points using the self-report on diagnosed hypertension. All of these differences between the migrants and the control group are statistically significant at levels between p=0.03 and p=0.08. As in Rubalcava et al. (2008),

[11] The hypothesis tests take account of weighting and clustering.

we find no evidence of positive selection amongst would-be migrants, with non-applicants having almost identical blood pressure and hypertension rates as unsuccessful applicants.

(Table 2 about here)

We next examine the overall distribution of systolic and diastolic blood pressure readings, for the three sub-samples of main interest; the migrants, the non-compliers and the ballot losers. The cumulative distribution functions (CDFs) in Figure 1 pool together males and females, since the econometric results reported below show no gender differences in the effects of migration on blood pressure. The pooled samples are larger, giving smoother CDFs that allow the differences between the treatment groups to be seen more clearly.

The entire distribution of systolic blood pressure readings is shifted to the right for migrants compared with ballot losers. Above the 5th percentile there is no overlap of the two distributions, with the increase being approximately the same at all percentiles. Hence, estimates of treatment effects for measured hypertension based on a threshold of 140 mmHg should be robust and there is no need to use other thresholds. There is also a shift to the right in diastolic blood pressure readings for migrants, evident from above the 10th percentile, although it is not as large as the increase in systolic blood pressure.

(Figure 1 about here)

There appear to be more complex changes (or selection effects) in blood pressure for non-compliers. Those with the lowest blood pressure have a distribution that follows the same pattern as the ballot losers, who also remain living in Tonga. However, from about the 40th percentile onwards the distribution of non-complier blood pressures increases sharply, to exceed that of even the migrants. Even with only a small sample of non-compliers, the differences between the ballot loser and non-complier distributions are statistically significant according to Kolmogorov-Smirnov tests (p=0.01 for systolic and p=0.09 for diastolic).

4.2 Treatment Effects Estimators

The simple experimental estimator of the treatment effect on the treated (SEE-TT) given by comparing the means in Table 2 for the migrants and the unsuccessful ballots may be biased if treated individuals drop out of the experiment or if control group members substitute for the treatment with a similar program (Heckman et al., 2000). In the context of the current study, there is little likelihood of *substitution bias* where PAC applicants with unsuccessful ballots still manage to migrate to New Zealand through alternative means. The reason is that individuals desiring to emigrate from Tonga who had access to migration channels other than the PAC would likely already have used those channels, since the odds of success in the PAC lottery are so low (McKenzie et al., 2010). But, there is considerable *dropout* bias, as can be seen from Table 1 with 24 percent of those holding a winning ballot still living in Tonga at the time of the survey.

The impact of dropout bias can be illustrated by writing an equation for the hypertension (or blood pressure) of applicant *i* as:

$$Hypertension_i = \alpha + \beta * BallotSuccess_i + \nu_i, \text{ where } E(\nu_i)=0, \quad (1)$$

where $BallotSuccess_i$ is a dummy variable taking the value one if the PAC applicant's ballot is drawn in the lottery and zero otherwise. An equation for hypertension can alternatively be written as:

$$Hypertension_i = \mu + \lambda * Migrate_i + \varepsilon_i, \text{ where } E(\varepsilon_i) = 0, \quad (2)$$

where $Migrate_i$ is a dummy variable taking the value one if person *i* migrates and zero otherwise, and λ is the average treatment effect on the treated. The SEE-TT of the change in hypertension from migration is calculated as the difference in mean hypertension rates between lottery winners who migrate and unsuccessful ballots:

$$SEE\text{-}TT = E[Hypertension_i \mid Migrate_i=1] - E[Hypertension_i \mid BallotSuccess_i=0] \quad (3)$$

However, from equation (2), we can see that:

$$\text{SEE-TT} = \lambda + E[\varepsilon_i \mid Migrate_i=1] - E[\varepsilon_i \mid BallotSuccess_i=0] \quad (4)$$

Thus, the SEE-TT will only be an unbiased estimate of λ if the last two terms in equation (4) sum to zero. Because ballot success is determined randomly via a lottery we can replace $E(\varepsilon_i|BallotSuccess=0)$ with $E(\varepsilon_i|BallotSuccess=1)$ and rewrite (4) to show that the SEE-TT is an unbiased estimate of the treatment effect on the treated if and only if:

$$E[\varepsilon_i \mid Migrate_i=1] = E[\varepsilon_i \mid BallotSuccess_i=1] \quad (5)$$

The SEE-TT gives a consistent estimate of the change in hypertension from migration if and only if there is no selection as to who migrates amongst those successful in the lottery.

It is easy to think of mechanisms by which there is non-random selection of who migrates amongst the lottery winners (eg., those more easily able to get a job in New Zealand, those whose health does not constrain travel), so there are grounds to suspect that the condition is not met in practice. As long as individuals who are expected to have lower blood pressure are more likely to move to New Zealand, the SEE-TT will give a lower bound to the true treatment effect. For example, if those best adapted to New Zealand move, they likely have a less stressful time than would the average lottery winner, causing less elevation of blood pressure from migration than would occur for the average lottery winner.

Therefore, we also use another approach for estimating treatment effects, the instrumental variables estimate of the local average treatment effect (IV-LATE).[12] Returning to equation (2), we can consistently estimate λ if an excluded instrument exists that is correlated with whether an individual migrates, $Migrate_i$, and is uncorrelated with the error term in this equation, ε_i. This estimate of λ is the local average treatment effect and can be interpreted as the effect of treatment on individuals whose treatment status is changed by the

[12] Note that we could also estimate the intent to treat (ITT) effect, which compares outcomes for subjects *assigned* to a treatment with outcomes for those assigned to the control group, without regard to who actually received the treatment. The regression specification in equation (1) yields the ITT effect. While the ITT is frequently reported in randomized studies that suffer noncompliance it does not provide bounds in the way that the SEE-TT and IV-LATE are likely to in the current case.

instrument. In our application, this is the effect of migration on the blood pressure of individuals who migrate after winning the lottery. Angrist (2004) demonstrates that in situations where no individuals who are assigned to the control group receive the treatment (i.e., there is no substitution) then the IV-LATE is the same as the treatment effect on the treated (IV-TT).

In our application, the PAC lottery outcome can potentially be used as an excluded instrument. Randomization ensures that success in the lottery is uncorrelated with unobserved individual attributes that might also affect hypertension and success in the lottery is strongly correlated with migration (the first stage F-statistic is over 250). Validity of the instrument also requires that the lottery outcome does not directly affect blood pressure conditional on migration status (the exclusion restriction). However, the results presented in Figure 1 suggest that some individuals winning the lottery and not being able to migrate may have elevated blood pressure levels. Two possible causes of this pattern are that perhaps there is frustration from having won the ballot but not then fulfilling the further conditions needed to migrate and this stress causes elevated blood pressure, or that there is self-selection among ballot winners with those having the highest blood pressure not migrating.

If being a non-complier has a direct effect on blood pressure, the IV-LATE estimate will be biased upwards because high blood pressure and hypertension among the non-compliers will be interpreted as signs of positive selection among ballot winners who migrate (i.e., that they have lower blood pressure and hypertension than would the entire sample of ballot winners have if they had all moved to New Zealand).[13] Of course, this estimate will be unbiased if positive selection among ballot winners is the correct explanation for the higher blood pressure and hypertension observed among non-compliers. Unfortunately, there is no way to identify whether this is the cause, rather than the alternative of winning the ballot and

[13] This is negative selection in the sense of having less blood pressure or less hypertension. In the general health context these would be thought of as positive selection since they are associated with being healthier.

not moving having a direct impact on blood pressure and hypertension because of the frustration created in such a situation. Hence, the IV-LATE estimates should be considered as an upper bound on the true treatment effect on the treated. Conversely, the SEE-TT estimates are a lower bound estimate since they assume that there is no selection among ballot winner versus non-compliers (i.e., that migrants in New Zealand can be viewed as a random sample of ballot winners).

4.3 Empirical Results

Column 1 of Table 3 reports systolic blood pressure impacts using the SEE-TT estimator, while Column 2 adds controls for pre-existing characteristics that are potentially correlated with blood pressure and with the incidence of hypertension. This pattern of first reporting results without and then with controls is repeated for diastolic blood pressure, measured hypertension and self-reported hypertension. The controls include age, sex, marital status, years of education, place of birth, height, and employment and income in the year prior to the migrants leaving Tonga (and the corresponding year for ballot losers). In general, the controls make little difference to the point estimates for the SEE-TT, although they do alter levels of statistical significance in three of the four regressions.

(Table 3 about here)

According to the SEE-TT results, migration increases mean systolic blood pressure by 3.7 mm.Hg and mean diastolic blood pressure by 2.4 mm.Hg (or by 4.1 and 2.2 mm.Hg when controls are used). The incidence of measured hypertension rises by nine percentage points and of self-reported hypertension by three percentage points.[14] These estimates pool the effect on males and females, whose blood pressure and rates of hypertension are largely the

[14] The results for hypertension are marginal effects from linear probability models (OLS on a binary dependent variable). Estimates of marginal effects from probit models are available from the authors and have similar magnitudes and statistical significance. We focus on the linear probability estimates, and their instrumental variables equivalents in Table 4 below, because they are more robust to specification changes, they do not have convergence problems when covariates are added and unlike in a linear model, adding a balanced covariate to a non-linear model, such as a probit, can change the point estimates (Raab et al., 2000).

same (except for a weakly significant lower systolic blood pressure for females). In unreported results the dummy variables for migration and females were interacted and a test of equal treatment effects by gender produced no statistically significant rejections.[15] Similarly, very few of the other control variables showed significant effects.

The IV-LATE estimates, using ballot success as the instrumental variable for migration, are reported in Table 4. The results are reported first without, and then with controls for pre-existing characteristics, to allow easy comparison with the SEE-TT estimates in the same format in Table 3. The estimates for the impact on hypertension come from instrumental variables estimates of linear probability models.[16]

(Table 4 about here)

According to the IV-LATE results, migration increases mean systolic blood pressure by 4.8 mm.Hg and mean diastolic blood pressure by 3.6 mm.Hg, with both statistically significant at the five percent level. The addition of the controls changes these estimates only slightly, to 5.2 mm.Hg and 3.3 mm.Hg. Similarly, migration causes the incidence of measured hypertension to rise by 13 percentage points (by 11 points, with controls) and of self-reported hypertension to rise by 3.5 percentage points.

These IV-LATE estimates are, on average, 30 percent higher than the corresponding SEE-TT estimates in Table 3. This margin is the same whether or not controls are used, with the lack of impact from adding controls consistent with the randomization balancing the covariates. Thus, the bounds around the true treatment effect on the treated are reasonably narrow, in spite of the complication from potentially selective non-compliance. Migration from Tonga to New Zealand appears to have caused the rate of measured hypertension to increase by between 9.1 and 12.5 percentage points. This increase is equivalent to

[15] The *p*-values were 0.25, 0.63, 0.15 and 0.83 for the four outcome variables in Table 3.

[16] Marginal effects from bivariate probit models are available from the authors and have similar values. These bivariate probits are more appropriate than IV-probits because the dependent variable in the first stage equation (migration) is a discrete variable.

approximately one-third of the mean rate of measured hypertension amongst the unsuccessful ballots in Tonga.

5. How Might Migration Be Affecting Blood Pressure?

In this section, we attempt to understand the channels through which migration is impacting blood pressure. There are at least two hypothesized pathways for migration to cause blood pressure to be elevated; from stress and anxiety (Jonas and Lando, 2000), or from the increased sodium content of a more urbanized diet (Poulter et al., 1990). In terms of stress and anxiety, the PINZMS asks each adult respondent about how much of the time during the previous month they felt "calm and peaceful" with responses captured using a 5-point Likert scale, ranging from 5="all of the time" to 1="none of the time". In terms of dietary sodium, the survey asks whether any of thirty different foods were eaten by the family during the day prior to the interview and the number of meals with that particular food.[17] These data are combined with information from the Pacific Islands Food Composition Tables on the milligrams (mg) of sodium in a typical serving of each of these foods.[18] These data then allow a test of whether the sodium content of diets has risen with migration to New Zealand.

Table 5 presents SEE-TT and IV-LATE estimates of the impact of migrating to New Zealand on measured calmness and on dietary sodium. Results are presented with and without controls, but in no case do the control variables change the point estimates. There is a significant reduction in calmness amongst migrants compared with ballot losers, with a decline of about 0.4 points on the 5-point scale. Relative to the mean calmness score of ballot losers in Tonga $(\bar{x} = 2.4)$ the impact of migration represents a reduction in calmness of about

[17] This is a family diet question rather than an individual diet question, so there was no information on who was present at each meal. Since the average number of diners in migrant households may differ from the average for households in Tonga, all the regressions for the sodium content of the family diet condition on household size.
[18] Available online at: http://www.fao.org/docrep/007/y5432e/y5432e00.htm

one-sixth.[19] There is also a significant increase in dietary sodium, of approximately 450 mg per day, equivalent to just under two-thirds of the mean $(\bar{x} = 720)$ sodium content of household diets for ballot losers in Tonga. Therefore, both dietary change and higher levels of stress are likely to be contributing to the increase in blood pressure and hypertension that accompanies migration from Tonga to New Zealand.

(Table 5 about here)

We can also examine whether these impacts on blood pressure and hypertension persist, using two different tests. First, we exploit the variation in time spent in New Zealand at the time of our baseline survey, which ranged from one month to three years. Second, for a subset of the immigrants (approximately 80 percent) we have data from a retest of their blood pressure in 2008, approximately three years after the main survey.[20] This should be long enough for blood pressure to decrease if all that was measured in the main survey in 2005/06 was a transitory effect caused by the migration process.

The basis of the first test is that if the higher blood pressure of immigrants was just a transitory effect, blood pressure should decline the longer the time between arriving in New Zealand and having blood pressure measured. Yet as panel A of Table 6 shows, amongst the immigrants, there is no statistically significant effect of time in New Zealand on blood pressure readings in the main survey in 2005/06. Indeed, the coefficients on time are positive rather than negative so there is no evidence that an initial rise in blood pressure during the migration process is then countered by a subsequent decline as migrants acclimate.

(Table 6 about here)

[19] Calmness is one of the five components in the Mental Health Inventory 5 (MHI-5) of Veit and Ware (1983). The impact on the overall MHI-5 of migration from Tonga to New Zealand was previously examined by Stillman et al. (2009), who found large positive impacts. However, the individual components have not previously been examined, and this exercise reveals that the only negative impact is on stress.

[20] Of the 102 immigrant households in the baseline survey, 13 were not revisited either because they had re-emigrated (mainly to Australia or the U.S.) or had moved to outer areas of New Zealand where it was too expensive to travel for fieldwork. Of the 89 households that were revisited, some members who had blood pressure measured in 2005/06 were unavailable for retesting or had moved to other households, giving a sub-sample of 125 of the 161 immigrants with two observations on their blood pressure.

The second test compares the means of the measured blood pressure and hypertension rates in 2005/06 and 2008 (Table 6, panel B). Amongst the subset of immigrants with blood pressure measured twice, there is no decline over time in blood pressure or hypertension rates (*p*-values for rejecting equal means range from 0.37 to 0.84). Moreover, the immigrants who had their blood pressure measured twice appear to be representative of the full sample of immigrants,[21] so this evidence of no decline in blood pressure after three or more years in New Zealand is not tainted by attrition bias. Therefore, it appears that the significant rise in blood pressure and hypertension caused by migration from Tonga to New Zealand persists over time and is not just a transitory effect caused by the immediate stress of moving.

6. Conclusions

Hypertension is the world's leading risk factor for premature mortality and the cost of treating high blood pressure is a major drain on health budgets around the world. While past research has examined the impact of migration on hypertension, none so far has adequately controlled for potential self-selection among migrants. In fact, many have explicitly assumed that migrants are healthier than non-migrants. In this paper, we overcome the selection problems affecting these previous studies by examining a migration program which uses a random ballot to choose amongst excess number of applicants.

We find that migrating from Tonga to New Zealand leads to significant and persistent increases in blood pressure. The incidence of hypertension rises by about ten percentage points, which is equivalent to over one-third of the baseline rate in the non-migrant population. We have to place bounds around our estimates because of potentially selective non-compliance to the migration treatment, but these bounds are relatively tight and do not weaken any of the substantive results. Migration also leads to significant increases in both stress and the sodium content of diets, which are two hypothesized causes of hypertension.

[21] The comparison between blood pressure at baseline for the attritors and those whose blood pressure was re-tested shows no significant differences, with *p*-values ranging from 0.77-0.92 (Table 6, panel C).

It is also notable that the estimated impact of migration on measured hypertension is approximately three times larger than the estimated impact on self-reported diagnosed hypertension. Thus, the current study adds to earlier findings that hypertension may be especially prone to under-reporting in surveys that rely on self-reported health. Since economists have only recently started to study hypertension, and in some cases rely on self-reported measures, there may be grounds for caution in interpreting results from such studies.

Finally, our results call into question the claim of Blanchflower and Oswald (2008) that self-reported hypertension may be used as an (inverse) indicator of overall well-being across countries. Along with the problem of bias in self-reported measures, the current study provides an example where overall well-being of the affected group is likely to have increased substantially, even as blood pressure and hypertension have risen. In addition to the revealed preference argument that migrants would only move if they expected to become better off (and would return if those expectations were wrong) there are also the results of previous studies on these Tongan migrants which showed that their incomes rose by over 250 percent (McKenzie et al, 2010) and that their overall levels of mental health also significantly improved (Stillman et al, 2009). There are good reasons for economists to study hypertension but using it as a proxy indicator of well-being is probably not one of them.

References

Abraido-Lanza, A., Dohrenwend, B., Ng-Mak, D., Turner, J. 1999 The Latino mortality paradox: a test of the salmon-bias and healthy migrant hypotheses. *American Journal of Public Health* 89, 1543-48.

Angrist, J. 2004. Treatment effect heterogeneity in theory and practice. *Economic Journal* 502, C52-C83.

Angrist, J., Imbens, G., Rubin, D., 1996. Identification of causal effects using instrumental variables. *Journal of the American Statistical Association* 91, 444-55.

Bhugra, D., Jones, P., 2001. Migration and mental illness. *Advances in Psychiatric Treatment* 7, 216-33.

Bjerregaard P., Jorgensen, M., Lumholt, P., Mosgaard, L., Borch-Johnsen, K., and the Greenland Population Study, 2002. Higher blood pressure among Inuit migrants in Denmark than among the Inuit in Greenland. *Journal of Epidemiology and Community Health* 56, 279-284.

Blanchflower, D., Oswald, A., 2008. Hypertension and happiness across nations. *Journal of Health Economics* 27, 218-233.

Clark, D., Royer, H., 2009. The effect of education on adult mortality and health: Evidence from Britain. *Mimeo* University of Florida.

Clemens, M., Pritchett, L., 2008. Income per natural: Measuring development for people rather than places. *Population and Development Review* 34, 395-434.

Degli Esposti, L., Valpiani, G., 2004. Pharmacoeconomic burden of undertreating hypertension. *Pharmacoeconomics* 22, 907-928.

Frijters, P., Haisken-DeNew, J.P., Shields, M., 2005. The causal effect of income on health: evidence from German reunification. *Journal of Health Economics* 24, 997–1017.

Geleijnse, J., Kok, F., Grobbee, J., 2004. Impact of dietary and lifestyle factors on the prevalence of hypertension in Western populations. *European Journal of Public Health* 14, 235-239.

Heckman, J., Hohmann, N., Smith, J., Khoo, M., 2000. Substitution and dropout bias in social experiments: A study of an influential social experiment. *Quarterly Journal of Economics* 115, 651-694.

Johnston, D., Propper, C., Shields, M., 2009. Comparing subjective and objective measures of health: Evidence from hypertension for the income/health gradient. *Journal of Health Economics* 28, 540-552.

Jonas, B., Lando, J., 2000. Negative affect as a prospective risk factor for hypertension. *Psychosomatic Medicine* 62, 188-96.

Kearney P., Whelton, M., Reynolds K., Muntner P., Whelton P., He, J., 2005. Global burden of hypertension: analysis of worldwide data. *Lancet* 365, 217-223.

Kennedy, S., McDonald, J., Biddle, N. 2006. The Healthy Immigrant Effect and Immigrant Selection: Evidence from Four Countries. *SEDAP Research Paper* No. 164, McMaster University.

Lindahl, M., 2005. Estimating the effect of income on health and mortality using lottery prizes as an exogenous source of variation in income. *Journal of Human Resources* 40, 144–168.

Lleras-Muney, A., 2005. The relationship between education and adult mortality in the United States. *Review of Economic Studies* 72, 189-221.

Lopez A., Mathers, C., Ezzati M., Jamison, D., Murray C., 2006. Global and regional burden of disease and risk factors, 2001: Systematic analysis of population health data. *Lancet* 367**,** 1747–57.

Marmot, M., Adelstein, A., Bulusu, L., 1984. Lessons from the study of immigrant mortality. *Lancet* 323, 1455-58.

McGarvey, S., Baker, P., 1979. The effects of modernization and migration on Samoan blood pressures. *Human Biology* 51, 461-479.

McKenzie, D., Gibson, J., Stillman, S., 2010. How important is selection? Experimental vs non-experimental measures of income gains from migration. *Journal of the European Economic Association* 8, 886-908.

Palloni, A., Arias E., 2004. Paradox lost: explaining the Hispanic adult mortality advantage. *Demography* 41,385-415.

Poulter N., Khaw, K., Hopwood, B., Mugambi, M., Peart, W., Rose, G., Sever, P., 1990. The Kenyan Luo migration study: observations on the initiation of a rise in blood pressure. *British Medical Journal* 300, 967-972.

Powdthavee, N., 2010. Does education reduce the risk of hypertension? Estimating the biomarker effect of compulsory schooling in England. *IZA Discussion Paper* No. 4847.

Raab, G., Day, S., Sales, J., 2000. How to select covariates to include in the analysis of a clinical trial. *Controlled Clinical Trials* 21, 330-42.

Rogoza A., Pavlova, T., Sergeeva, M., 2000. Validation of A&D-767 device for the self-measurement of blood pressure. *Blood Pressure Monitoring* 5, 227-231.

Rubalcava, L., Teruel, G., Thomas, D., Goldman, N., 2008. The healthy migrant effect: New findings from the Mexican Family Life Survey. *American Journal of Public Health* 98, 78-84.

Salmond C., Joseph, J., Prior, I., Stanley, D., Wessen, A., 1985. Longitudinal analysis of the relationship between blood pressure and migration: the Tokelau Island migrant study. *American Journal of Epidemiology* 122, 291-301.

Salmond C., Prior, I., Wessen, A., 1989. Blood pressure patterns and migration: A 14-year cohort study of adult Tokelauans. *American Journal of Epidemiology* 130, 37-52.

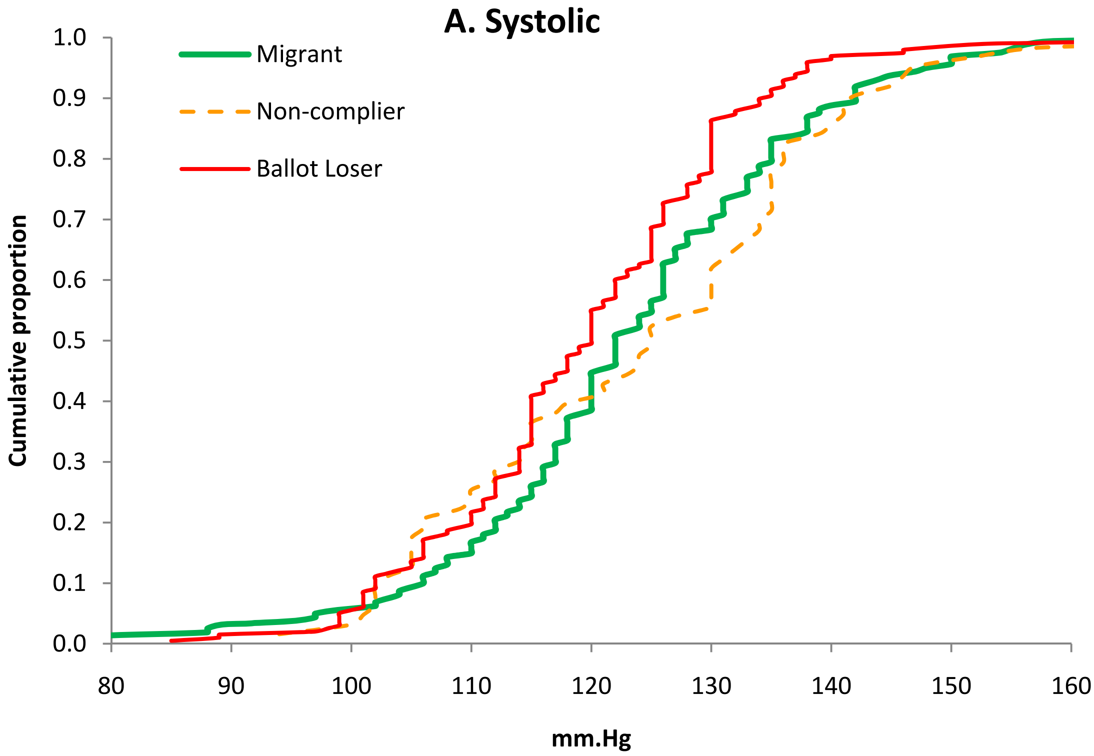
Stillman, S., McKenzie, D., Gibson, J., 2009. Migration and mental health: evidence from a natural experiment. *Journal of Health Economics* 28, 677–87.

Stillman, S., Gibson, J., McKenzie, D. 2010. The impact of immigration on child health: experimental evidence from a migration lottery program. *Economic Inquiry*, forthcoming.

Tibi-Levy, Y., de Pouvourville, G., Westerloppe, J., Bamberger, M., 2008. The cost of treating high blood pressure in general practice in France. *European Journal of Health Economics* 9, 229-236.

Veit, C.T., Ware, Jnr, J.E. 1983. The structure of psychological distress and well-being in general populations. *Journal of Consulting and Clinical Psychology* 51, 730-742.

FIGURE 1: CDFs OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE BY SAMPLE GROUP



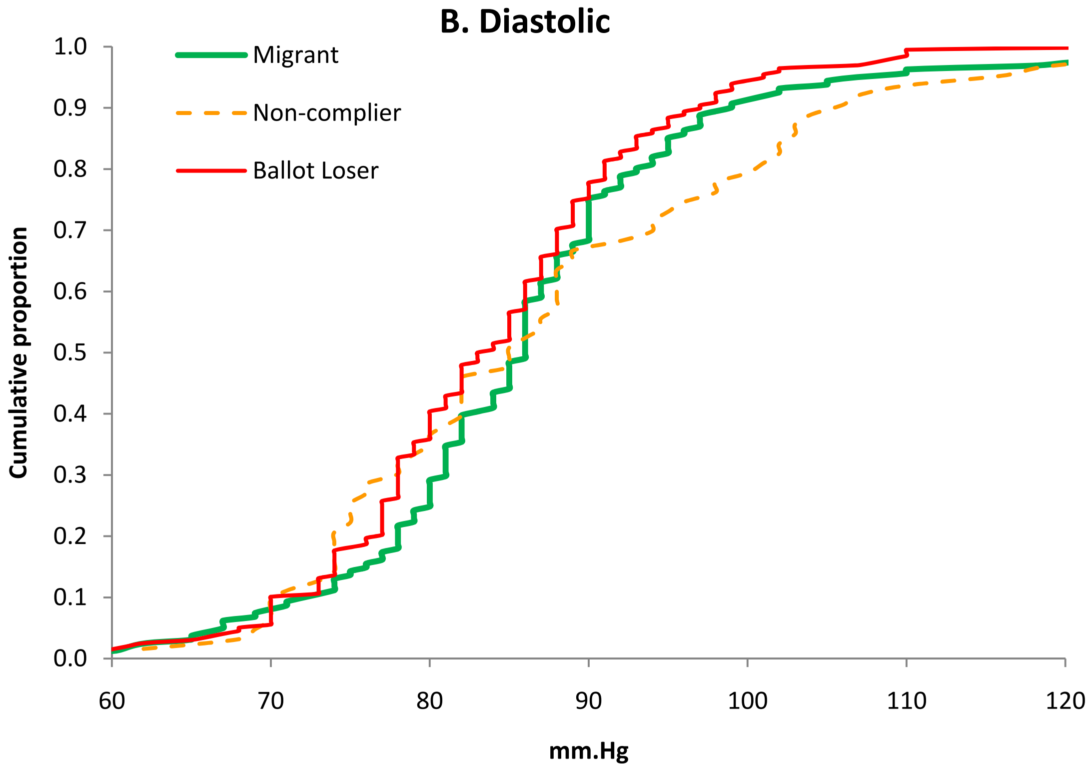


TABLE 1: TEST FOR RANDOMIZATION

Comparison of ex-ante characteristics of principal applicants, spouses and children (> 18 years) with successful and unsuccessful ballots

	Sample Means APPLICANTS Successful Ballots	Sample Means APPLICANTS Unsuccessful Ballots	T-test of equality of means p-value
Proportion female	0.54	0.56	0.73
Proportion who are married	0.70	0.76	0.15
Age	33.12	33.70	0.44
Years of schooling	11.82	11.66	0.47
Height	170.22	168.93	0.31
Proportion born on Tongatapu	0.77	0.74	0.43
Employment in prior year/before moving	0.60	0.47	0.01
Income in prior year/before moving	93.25	99.57	0.62
Percent in New Zealand	0.76		
Months in New Zealand	11.34		
Total Sample Size	**224**	**198**	

Note: Test statistics account for clustering at the household level

TABLE 2:
SAMPLE MEANS OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE AND HYPERTENSION RATES

	Observations	Systolic mm.Hg	Diastolic mm.Hg	Measured Hypertension	Reported Hypertension
APPLICANTS	422	119.89	84.07	0.270	0.007
Successful Ballots	224	123.53	86.58	0.357	0.032
Migrants	161	123.17	86.29	0.354	0.037
Non-migrants	63	124.67	87.54	0.365	0.016
Unsuccessful Ballots	198	119.60	83.86	0.263	0.005
NON-APPLICANTS	216	118.60	83.11	0.282	0.037
p-values for tests of equality of means					
Successful ballots vs unsuccessful ballots		0.010	0.035	0.050	0.037
Migrants vs non-migrant successful ballots		0.570	0.605	0.894	0.322
Migrants vs unsuccessful ballots		0.034	0.083	0.080	0.041
Non-applicants vs unsuccessful ballots		0.467	0.521	0.664	0.125

Note: *p*-values of hypothesis tests account for clustering at the household level.

TABLE 3:
REGRESSION ESTIMATES OF SEE-TT, WITH CONTROLS FOR EX ANTE CHARACTERISTICS

	Systolic		Diastolic		Measured Hypertension		Self-reported Hypertension	
Migration dummy	3.666	4.105	2.421	2.229	0.091	0.077	0.032	0.030
	(2.21)*	(2.36)*	(1.73)+	(1.49)	(1.74)+	(1.36)	(2.08)*	(1.84)+
Female dummy		-3.224		-1.903		0.017		0.012
		(1.86)+		(1.29)		(0.26)		(0.96)
Married dummy		0.224		2.891		0.163		0.006
		(0.11)		(1.27)		(1.98)*		(1.18)
Age		-0.670		-0.998		-0.072		-0.002
		(0.62)		(0.96)		(1.88)+		(0.67)
Age squared		0.016		0.020		0.001		0.000
		(1.02)		(1.34)		(2.08)*		(0.69)
Years of education		0.434		0.638		0.011		0.000
		(0.73)		(1.78)+		(0.72)		(0.46)
Dummy for born on Tongatapu		-4.339		-2.697		-0.104		-0.022
		(2.25)*		(1.58)		(1.48)		(1.20)
Height		-0.081		0.071		0.003		0.000
		(1.25)		(1.20)		(0.96)		(0.87)
Past employment dummy		-2.508		-1.004		-0.017		0.018
		(1.19)		(0.57)		(0.22)		(1.17)
Past income		0.006		-0.012		0.000		0.000
		(0.72)		(1.74)+		(0.94)		(1.01)
Constant	121.491	139.102	83.846	77.712	0.253	0.718	0.009	-0.013
	(117.49)**	(6.18)**	(109.07)**	(4.26)**	(7.10)**	(1.07)	(1.15)	(0.26)
R-squared	0.05	0.14	0.00	0.12	0.00	0.08	0.01	0.04

Notes: *N* =359. Robust t statistics in parentheses, + significant at 10%; * significant at 5%; ** significant at 1%.
Linear probability model used for measured hypertension and self-reported hypertension.
SEE-TT (simple experimental estimator of the effect of the treatment on the treated) compares migrants to unsuccessful ballots.

TABLE 4:
INSTRUMENTAL VARIABLES ESTIMATES OF LOCAL AVERAGE TREATMENT EFFECTS

	Systolic		Diastolic		Measured Hypertension		Self-reported Hypertension	
Migration dummy	4.758	5.202	3.561	3.329	0.125	0.107	0.035	0.031
	(2.43)*	(2.58)**	(2.15)*	(1.91)+	(2.01)*	(1.61)	(2.06)*	(1.76)+
Female dummy		-3.169		-1.734		0.020		0.011
		(1.89)+		(1.22)		(0.32)		(0.94)
Married dummy		0.154		2.817		0.157		0.006
		(0.08)		(1.29)		(1.98)*		(1.26)
Age		-0.588		-0.940		-0.068		-0.003
		(0.57)		(0.95)		(1.86)+		(0.98)
Age squared		0.015		0.019		0.001		0.000
		(0.99)		(1.35)		(2.08)*		(1.00)
Years of education		0.365		0.587		0.010		0.000
		(0.64)		(1.71)+		(0.67)		(0.38)
Dummy for born on Tongatapu		-4.385		-2.697		-0.104		-0.022
		(2.35)*		(1.63)		(1.53)		(1.20)
Height		-0.078		0.072		0.003		0.000
		(1.23)		(1.24)		(0.99)		(0.88)
Past employment dummy		-2.390		-0.788		-0.013		0.017
		(1.17)		(0.46)		(0.17)		(1.15)
Past income		0.007		-0.012		0.000		0.000
		(0.80)		(1.83)+		(0.98)		(0.83)
Constant	121.511	137.954	83.876	76.930	0.254	0.663	0.009	0.003
	(119.16)**	(6.36)**	(110.62)**	(4.37)**	(7.22)**	(1.02)	(1.17)	(0.06)

Notes: *N* =422. Robust z statistics in parentheses, + significant at 10%; * significant at 5%; ** significant at 1%.
Ballot success dummy is used as the instrument for migration.
IV-linear probability model used for measured hypertension and self-reported hypertension.

TABLE 5:
SEE-TT AND IV-LATE ESTIMATES OF IMPACTS OF MIGRATION ON STRESS LEVELS AND DIETARY SODIUM

	Calmness (5=always, 1=never)				Sodium Content of Diet mg/day			
	SEE-TT		IV-LATE		SEE-TT		IV-LATE	
Migration dummy	-0.440	-0.421	-0.454	-0.428	440.174	449.086	457.407	458.729
	(5.43)**	(5.02)**	(4.39)**	(4.07)**	(5.83)**	(5.76)**	(5.70)**	(5.57)**
Female dummy		-0.070		-0.069		25.091		26.052
		(0.64)		(0.65)		(0.80)		(0.86)
Married dummy		0.112		0.104		-162.307		-161.716
		(0.71)		(0.69)		(2.26)*		(2.35)*
Age		0.016		0.019		47.000		45.151
		(0.24)		(0.30)		(1.25)		(1.26)
Age squared		0.000		0.000		-0.592		-0.567
		(0.21)		(0.28)		(1.05)		(1.06)
Years of education		-0.026		-0.026		-19.812		-19.455
		(0.90)		(0.92)		(1.68)+		(1.71)+
Dummy for born on Tongatapu		0.103		0.108		-36.780		-34.086
		(0.92)		(0.99)		(0.77)		(0.74)
Height		-0.007		-0.007		3.449		3.453
		(1.39)		(1.42)		(1.49)		(1.55)
Past employment dummy		0.051		0.042		54.895		51.709
		(0.35)		(0.30)		(0.94)		(0.91)
Past income		0.001		0.001		0.310		0.314
		(1.43)		(1.51)		(1.53)		(1.61)
Household size					-7.654	-7.957	-7.697	-7.646
					(0.91)	(0.89)	(0.93)	(0.89)
Constant	2.377	3.319	2.377	3.293	668.923	-480.536	669.260	-456.316
	(28.95)**	(2.30)*	(29.35)**	(2.35)*	(11.08)**	(0.70)	(11.42)**	(0.69)
R-squared	0.02	0.06			0.18	0.26		

Notes: *N* =359 for SEE-TT and *N* =422 for IV-LATE.
Robust t or z statistics in parentheses, + significant at 10%; * significant at 5%; ** significant at 1%.
Ballot success dummy is used as the instrument for migration.

TABLE 6:
TESTS OF THE PERSISTENCE OF THE BLOOD PRESSURE IMPACTS

	Systolic Blood Pressure	Diastolic Blood Pressure	Measured Hypertension
A. EFFECT OF TIME IN NZ (months) AT BASELINE SURVEY (*n* =161)			
Without covariates	0.109	0.088	0.007
	(0.136)	(0.103)	(0.005)
With covariates (the same ones as in Tables 3-5)	0.091	0.051	0.007
	(0.142)	(0.116)	(0.005)
B. COMPARISON WITH BLOOD PRESSURE THREE YEARS LATER (*n* =125)			
Baseline (2005/6)	123.24	86.15	0.360
	(1.41)	(1.24)	(0.043)
Retest (2008)	122.91	85.02	0.344
	(1.54)	(1.13)	(0.043)
p-value for t-test of equal means	0.84	0.37	0.75
C. COMPARISON OF BLOOD PRESSURE AT BASELINE BETWEEN THOSE RETESTED AND ATTRITORS			
Individuals subsequently retested (*n* =125)	123.24	86.15	0.360
	(1.41)	(1.24)	(0.043)
Attritors (*n* =36)	122.94	86.75	0.333
	(1.93)	(1.78)	(0.080)
p-value for t-test of equal means	0.92	0.81	0.77

Notes: Standard errors in parentheses, + significant at 10%; * significant at 5%; ** significant at 1%.