Natural Hazards and Child Health

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PRELIMINARY

Abstract

This paper examines how the occurrence of various natural disasters affect health status of children using data from Guatemala. Despite a large literature on child health there is relatively little work on how shocks from natural hazards affect the health of children and with climate change it is likely that more and more households will experience changes and possible increases in the risk of natural disasters. Using three rounds of DHS combined with a long time series on hazards the paper controls for both time and area specific effects, while pinpointing when and where a particular shocks occurred. This is done for children between 9 and 59 months with anthropometric information. Child health is proxied by height for age, weight for age and weight for height and direct information on recent illnesses. Except for drought the effect of shocks from these hazards are generally negative and often very large.

1 Introduction

This paper examines how the occurrence of natural disasters affect health status of children using data from Guatemala. The information on the natural hazards come from a report on natural disasters and vulnerability in Guatemala conducted by UNICEF UNICEF (2000). The hazards included cover a large variety of those experienced in Guatemala and many other developing countries. Examples are severe storms, flooding, drought and extreme temperatures.

Despite a large literature on child health there is relatively little work on how shocks from natural hazard affect the health of children. Many natural hazards, such as hurricanes, floods and droughts, occur frequently in many developing countries and are potentially very destructive. Furthermore, with climate change it is likely that more and more households will experience changes and possible increases in the risk of natural disasters. If these changes lead to deteriorations in child health and/or increases in child mortality this will have strong effects on long term growth and social development. This is especially the case since children are often most exposed to shocks that forces the households to focus resources on their most productive members.

[my paper - expand] While the effects of hazards on fertility is an interesting questions this has already been covered in Pörtner (2008).

As discussed in Strauss and Thomas (1995) and Wolpin (1997) there is a large literatue on the determinants of child health and mortality in developing countries. Furthermore, in recent year the effects of conditions early in a child's life on later outcomes have attracted substantial interest.[1] In general the conclusion is that early childhood malnutrition can have significant effects on performance in school, and hence presumably on earnings later in life, although it is difficult to pinpoint an exact period in the child's life that is more critical than others. One paper that looks directly at outcomes in adulthood is Maccini and Yang (2008), which show that the amount of rainfall experienced during early life have statistically significant effects on self-reported adult health for women, but not for men. Women who experience a rainfall that is 20 percent

[1] See, for example, Glewwe and King (2001), Glewwe, Jacoby, and King (2001), Alderman, Hoddinott, and Kinsey (2006) and van den Berg, Lindeboom, and Portrait (2007). In addition there is some evidence that conditions while in utero can affect later outcomes as shown by Behrman and Rosenzweig (2004) and Almond (2006).

above average are also slightly higher (0.57 cm) and tend to be more educated and end up living in household with more assets. [literature on height and wages Strauss and Thomas (1998)]

Despite this large literature, there is surprisingly little that directly deals with the potentially adverse effects of shocks from natural hazards. Foster (1995) showed for Bangladesh that floods lead to substantial lower weight for the children affected and argued that credit market imperfections were the main factor behind the differences in how children's weights responded. More recently Baez and Santos (2007) examined the effects of the hurricane Mitch in Nicaragua on children's health, schooling and labour force participation and found that those affected by the hurricane were more likely to be undernourished and that the distribution of nutritional status worsen, especially for those in the bottom of the distribution.

[advantages / contributions] This paper makes a number of contributions to the literature. First, it covers many different types of hazards rather than focusing on one very large disaster like Mitch as in Baez and Santos (2007) or the floods in Foster (1995). This is important since, as shown by van den Berg and Burger (2008) in a paper also on the effects of hurricane Mitch in Nicaragua, some households appeared to have been harder hit by the preceeding drought than the hurricane itself.[2] Second, by using three rounds of demographic and health surveys combined with the long time series on hazards it is possible to control for both time (year) and area (department) specific effects and therefore better identify the effects of the different hazards. With

[2]Because of data limitations it is not possible for the authors to examine the effect of the drought in details.

area fixed effects any unobservable area characteristics that might be correlated with both the propensity of getting hit by a specific shock and child health outcomes are eliminated while still retaining a substantial amount of variation in exposure to shocks due to the use of the three surveys. Importantly, it means that the results do not rely on the use of the comparision of areas that may not be entirely comparable as in Baez and Santos (2007), which uses difference-in-difference between areas hit by Mitch and those not hit. The year dummies control for, for example, the economic conditions prevalent at the time of the survey and the level of development. Thirdly, with the detailed information on where and when shocks hit it is possible to both more precisely estimate the effects of the shocks and estimate how quickly the shocks affect child health and how quickly child health recovers if at all. [INCORPORATE INFORMATION ON SICKNESS]

[OUTLINE OF CHAPTER]

2 Natural Hazards and Climate Change

[PULL RELEVANT INFORMATION FROM JENS' PAPER ON SCIENCE BEHIND CLIMATE CHANGE]

[WHICH TYPES OF NATURAL HAZARDS ARE RELEVANT]

3 Data and Estimation Strategy

The data used here come from two sources. Data on health outcomes and characteristics of children and households come from three demographic and health surveys from Guatemala, while the information about shocks are based on data from UNICEF. This section discusses both data set, starting with the latter.

The data on shocks were collected for a report on natural disasters and vulnerability in Guatemala (UNICEF 2000). The raw data is a listing of natural disaster events, mostly drawn from written sources such as newspapers, with information on the type of event, the date, the area hit, the source of the information and a short description of the event. For most of the disasters the information cover very long periods of time. A major advantage of the data is that information is available at departmental level which, together with the long time span, allows a relatively precise measure of the shocks a household is exposed to.

Three major types of hazards are covered in the data: Seismological, hydrometeorological and geophysical. The former includes volcanic eruptions, earthquakes and tremors. While earthquakes and other seismic activity occur frequently in Guatemala it is unlikely that climate change will directly or indirectly affect the rate or severity of these hazards. Included in the geophysical part are crevices formation, land settlement, landslides, erosion and forest fires. These hazards and shocks are all interesting and relevant for the climate change debate and how climate change might affect child health, but unfortunately there is not enough data to reliably estimate the effects of these hazards on health, since these hazards were only included for the later years of the hazard survey. In addition there is also the question of whether these hazards are exogenous events or affected by choices made by people in terms of where they locate and their farming patterns. Hence, focus here is on the hazards included in the hydrometeorological category: Strong winds, overflows (river, etc.), flooding, heavy rain, hurricanes, cold spells and droughts.[3]

Exposure to hazards is measured as the number of shocks that has occurred during a given period preceeding the month the interview took place in.[4] In addition the hazard variable is interacted with a subset of the other explanatory variables (described below) to allow for differences in the effect of the hazards depending on characteristics of the households affected by them.[5]

The data on child health comes from the three rounds of the Guatemalaian Demographic and Health Survey (DHS) conducted in 1987, 1995 and 1998.[6] DHSs are designed to be nationally representative surveys focusing on fertility, contraceptive use and access, and child health and mortality.[7] The main data of interest are the anthropometric measures, such as weight and height, since they provide, at least indirect, information on children's health status through three measures calculated from them: Height for age, weight for age and weight for height. As is standard in most studies of child health these variables are

[3]In addition the category includes thunderstorms, hail storms, tempests and strong currents but there is insufficient information in the data to estimate the effects of these hazards on child health.

[4]The month of the interview is not included both to allow the shocks to affect child health and to ensure that the shock did not occur after the interview date.

[5]An alternative way of measuring shocks is to use a dummy variable for whether one or more shocks occurred during a given time frame. The main advantage of this is that it minimises the risk of double counting a shock which may be listed twice but is really the same shock. The disadvantages are that, especially for longer time frames, it will potentially lead to an overestimate of the effects of shocks and throws away variation. There is, however, relatively little difference between the two measures and the results for the dummy variable estimations are available on request.

[6]A DHS type survey was collected in 2002, but since the hazard data only runs to 1999 that survey is not used here.

[7]The 1987 DHS did not cover the Petén, which is the northernmost department in Guatemala.

converted into Z-scores, which is the deviation of a child's value from the median value of the reference population divided by the standard deviation of the reference population.[8] Height for age is the best indicator of whether a child is growing as it should and is therefore considered a good measure of long-term health.[9] Children with low heights for their age are considered stunted. Weight for height, which is a measure of wasting, is better seen as an indicator of current health since low weight for height is often associated with acute starvation or severe disease, although it is also possible that it can result from chronicly unfavourable conditions. Weight for age is more difficult to interpret since it is influenced by both height for age and weight for height, but in the absense of significant wasting the results for height for age and weight for age should be relatively similar. Hence, focus here will be on height for age and weight for height. Generally, Z-scores two standard deviations below the reference median is considered severly stunted or wasted (Gorstein, Sullivan, Yip, de Onis, Trowbridge, Fajans, and Clugston 1994).

[DIRECT INFORMATION ON ILLNESS]

The 1987 DHS collected anthropometric information for all children of women who were permanent residents of the household and between three and 36 months of age. The two later surveys measured all children present in the

[8] The creation of the reference population is described in detail in World Health Organization (2006). Children from USA, Ghana, Norway, Oman and Brazil were used for the construction of the growth standard and an important difference between the old and new growth standard is that it shows that there is little difference in how children grow in different countries if they are exposure to a healty diet and environment and good health care. Specifically, only about 3% of variability in length is due to differences among sites compared to 70% due to differences among individuals (World Health Organization 2006, p. 1).

[9] The discussion of the health measures in this paragraph is based on de Onis and Blössner (1997).

household who were between zero and 59 months of age, but to ensure consistency across rounds all children who did not have their permanent residence in the house were dropped. Furthermore, since the hazards are most likely to affect children in rural areas due to exposure and living conditions all children from urban areas are excluded. After dropping observation missing one or more of the anthropometric measures the samples consist of 1,578, 6,429 and 2,928 children in the 1987, 1995 and 1998 surveys, respectively.

Since children who are twins or triplets have substantially different health and mortality experiences than singletons and 92 children are therefore excluded. Furthermore, children being breastfed are generally less affected by changing circumstances than those weaned and to focus on shocks that occured during the children's life time only children older than eight months are used here, which lead to a reduction in the sample of 1763 children. In addition, 360 children with extreme measures of either weight or height are dropped as well. In practice extreme is taken to be above or below five standard devaitions from the comparison sample's means (an absolute Z-score above five).[10] Finally, 14 children from households with missing observation on the other explanatory variables (see below) are dropped. This leaves a final sample of 8,706 children between the ages of nine and 59 months of age at the time of the interview.[11]

The household and individual level explanatory variables used here are the sex of the child, the age of the mother at the time of the child's birth, her education and literacy levels, the father's education level and ethnicity of the

[10]For comparision, the WHO study sites used to create the child growth standards had relatively few that were below (or above) a Z-score of three.

[11]There are 1,200 from the 1987 DHS, 5,131 from the 1995 DHS and 2,375 from the 1998 DHS.

child. For both age and education levels the squared of the variables are also included. Unfortunately the data does not have direct information on land ownership, which was shown in Pörtner (2008) to have important implications for responses to risk and shocks. To proxy as best as possible for this a dummy variable is included which is one if either the mother or the father respond that they work on own or family land. The problem is that there may be land-holding households that are show up as not having land with this definition and that there is no information about the size and quality of the land. For the 1995 and 1998 surveys a wealth index is calculated for all households surveyed, but is not available for the 1987 round. To provide enough variation in exposure to the hazards this variable is therefore excluded.[12]

To capture differences between areas that may directly or indirectly affect child health department dummies are included together with a fourth-order polynomial in the altitude of the municipality.[13] Furthermore, dummies for the survey rounds are included to allow for differences in economic development over time that might affect child health. Ideally, dummies for the month of the survey should be included as well to allow for seasonal difference in health outcomes for children, but there is not enough overlap between the surveys to allow for this and still estimate the effects of the hazards.

Estimation is done using standard OLS, which with the department dummies corresponds to a standard department fixed effects model. One potential issue here is that it is not possible to reliably calculate risk measures for most

[12] Even if the wealth index was available for the 1987 survey round there is a potential issue of endogeneity with including the variable.

[13] There are 22 departments in Guatemala with a total of 331 municipalities.

of the hazards since the time series available are not long enough, which may bias the results (Pörtner 2008).[14] In that case the level of risk will be included in the error term and hence create a correlation between the error term and the shock variable. Which direction the bias will take depends on how risk affects child health directly. If household respond to higher risk by having more children we might expect that effect to be negative for the anthropometric measures because of closer spacing of children and a more binding resource constraint. Obviously, there is a positive correlation between risk and the number of shocks that occur in a department, which means that the bias in this case will be downwards.

The extent to which this bias is a problem depends on the size of the direct (unobserved) effect of risk and how large the correlation between risk and the number of shocks is. This bias is unlikely to be a serious concern here for a number of reasons. First, while higher fertility is often thought to lead to lower child quality this standard interpretation ignores the role of risk. As shown in Pörtner (2008) household with land who face higher hurricane risk have both more children *and* higher human capital investments in the form of schooling, while household without land facing higher risk tend to have fewer children and invest more in education than similar households in lower risk areas. Hence, it is not at all clear that the effect of risk on child health is actually negative. Secondly, if the current level of child health and its response to shocks is the results of decisions made by parents in the face of a known level of risk it is entirely possible that higher levels of shocks as a result of climate change will

[14] Pörtner (2008) also used department dummies and the fourth-order polynomial and still found that both hurricane risk and shocks had significant effects on fertility and education.

put additional stress on the already limited resources of households. In that case, the estimates of previous natural hazards' effect on child health is likely to be too low (closer to zero) compared to the actual effect of hazards with climate change.

Table 1: Descriptive Statistics

Variable	Mean	SD	Min	Max
Height for age (Z-scores)	−2.59	1.24	−5.00	4.62
Weight for age (Z-scores)	−1.34	1.05	−4.94	4.33
Weight for height (Z-scores)	0.16	1.10	−4.78	4.64
Girl	0.50	0.50	0.00	1.00
Mother's education	1.68	2.44	0.00	18.00
Mother's education^2/100	0.09	0.23	0.00	3.24
Mother reads with difficulty	0.26	0.44	0.00	1.00
Mother cannot read	0.53	0.50	0.00	1.00
Mother's age at child's birth	28.97	7.14	15.00	49.00
Mother's age at child's birth^2/100	8.90	4.40	2.25	24.01
Father's education	2.41	2.94	0.00	19.00
Father's education^2/100	0.14	0.33	0.00	3.61
Father's education missing	0.05	0.21	0.00	1.00
Land	0.35	0.48	0.00	1.00
Indigenous	0.51	0.50	0.00	1.00
1995 survey	0.59	0.49	0.00	1.00
1998 survey	0.27	0.45	0.00	1.00
Altitude (by municipality)	1,168.60	806.55	1.00	3,200.00
Altitude^2/1000	2,016.08	2,067.07	0.00	10,240.00
Altitude^3/1000000	3,963.18	5,088.68	0.00	32,768.00
Altitude^4/1000000000	8,336.84	12,673.50	0.00	104857.60
Number of Observations		8,706		

[INCLUDE THIS IN DISCUSSION] The problem with weight for height here is that we expect the shocks examined here to have longer term impacts, which means that we are more likely to see effects on height for age and weight for age than for weight for height, which can respond much more quickly to changes.

Tables 1 - 3 show various descriptive statistics for the sample. Table 1 shows the dependent variables and the individual and household characteristics. Clearly, for both height for age and weight for age the children in the sample are substantially below the WHO baseline for child growth. As mentioned above height for age is a good indicator of longer term health status and here the children in the sample do particularly poorly with a mean Z-score of -2.6. This means that, on average, children in the sample are 2.6 standard deviations shorter than the comparison population for their age and sex. A similar trend holds for weight for age, although the results are relatively better. Interesting, weight for height, which is sometimes considered a good indicator of current health status the children appear to do well although this is mainly a result of height for age performing so poorly compared to weight for age.[15] Since there might be difference by sex and by survey Table 3 shows how many children are two standard deviations or more below the growth standard by sex and by survey. Generally, girls do better than boys (about half the sample are girls) and there is an improvement in both height for age and weight for age over time.

Education levels for both parents are low on average: Average years of schooling for mothers is only 1.7 and 2.4 for fathers. This low human capital also shows up in the literacy numbers for mothers. More than half of the mothers cannot read and more than a quarter can only read with difficulty. For

[15] As described in World Health Organization (2006) one finding of the new growth standard study was that race and country of origin has little effect on how children grow if they are fed and cared for to the best standard.

Table 2: Ratio of Children with Z-scores below Two

	Survey Round		
Sex of child	1	2	3
	Height for Age		
Boy	0.76	0.74	0.70
Girl	0.69	0.71	0.66
	Weight for Age		
Boy	0.29	0.28	0.23
Girl	0.28	0.26	0.19
	Weight for Height		
Boy	0.02	0.05	0.03
Girl	0.02	0.03	0.02
Number of Observations	1,200	5,131	2,375

about five percent of the fathers there is no information on years of education or the mother does not know. These are coded as zero education and a dummy is added to allow these observations to remain in the data set. The land variable indicates that 35 percent of the children live in households with land.[16] Finally, just over half the children are indigenous.

Table 3 shows how many children experienced a given number of shocks by survey round. Clearly, the 1995 survey round was conducted after a relatively quite period. None of the children had experience hurricanes, dought, frost or overflowing rivers or lakes in the six months period prior to the month they were surveyed in and the prevalence of no heavy rain fall or strong winds were lower than for the other two survey rounds. Only flooding seemed more prevalent for the 1995 survey than the other surveys. Hence, while there appear

[16] As mentioned above this variable is one if either of the parents respond that they work on own or family land.

Table 3: Percentages Who Experienced Shocks by Survey

Number of Shocks	Survey Round 1	2	3
	Desbordamiento		
0	77.17	100.00	85.43
1	16.33	0.00	14.57
2	6.50	0.00	0.00
	Helada		
0	100.00	100.00	67.83
1	0.00	0.00	27.16
2	0.00	0.00	5.01
	Huracan		
0	94.92	100.00	1.47
1	5.08	0.00	98.53
	Inundacion		
0	67.92	42.72	85.43
1	19.00	41.24	2.53
2	3.33	9.06	12.04
3	9.75	0.00	0.00
4	0.00	6.98	0.00
	Lluvias		
0	81.83	91.17	0.00
1	5.08	8.83	99.71
2	13.08	0.00	0.29
	Sequia		
0	77.42	100.00	76.63
1	22.58	0.00	23.37
	Ventarron		
0	85.67	95.21	26.48
1	14.33	0.68	72.51
2	0.00	4.11	1.01
Observations	1,200	5,131	2,375

NOTE: By number of the different types of shocks in the six months prior to the month of the survey.

to be a fair amount of variation in shocks experienced it has to be kept in mind that almost sixty percent of the children in the sample were surveyed in the 2nd (1995) round. This means that it will be more difficult to identify the effect of these shocks. An additional related issue is that for hurricanes there is little variation within survey rounds: No hurricanes in 1995, just over five percent experienced a hurricane for the 1987 survey and almost everybody in the 1998 survey. Given that survey dummies are included as described above this makes is harder to identify the effect of hurricanes.

4 Results

This section presents the results for the effect of shocks from natural hazards on children's height for age, weight for age and weight for height. Table 4 presents the baseline determinants of child health excluding any of the hazards. The girls do on average substantially and statistically significantly better than boys.[17] For both mothers' and fathers' more education lead to better child health. This effect can also be seen from mother's literacy: Children whose mothers can read only with difficulty is 0.15 standard deviations below children with mothers that can read, while the effect for mothers that cannot read is -0.21. Land has little effect on the three health measures which may be an indication that the variable does not completely adequately capture whether the household owns land.

Table 5 combines the estimated effects of the different hazards on child

[17] This is not as unusual as one might expect. See Ejrnæs and Pörtner (2004) for an example.

Table 4: Baseline Determinants of Child Health

	Height for Age	Weight for Age	Weight for Height
Girl	0.164***	0.081***	0.047**
	(0.025)	(0.022)	(0.023)
Mother's education	0.011	−0.000	−0.012
	(0.018)	(0.016)	(0.017)
Mother's education^2/100	0.404***	0.450***	0.329**
	(0.155)	(0.136)	(0.146)
Mother reads with difficulty	−0.144***	−0.078**	0.005
	(0.043)	(0.038)	(0.041)
Mother cannot read	−0.205***	−0.165***	−0.064
	(0.058)	(0.051)	(0.055)
Mother's age at child's birth	−0.040***	−0.041***	−0.009
	(0.014)	(0.012)	(0.013)
Mother's age at child's birth^2/100	0.072***	0.072***	0.023
	(0.022)	(0.020)	(0.021)
Father's education	0.032***	0.033***	0.019**
	(0.010)	(0.009)	(0.009)
Father's education^2/100	0.070	−0.018	−0.087
	(0.091)	(0.080)	(0.086)
Father's education missing	0.019	0.030	0.025
	(0.061)	(0.054)	(0.057)
Land	0.010	0.006	0.003
	(0.028)	(0.024)	(0.026)
Indigenous	−0.314***	−0.103***	0.108***
	(0.037)	(0.032)	(0.035)
1995 survey	0.084**	0.025	0.082**
	(0.039)	(0.034)	(0.037)
1998 survey	0.079*	0.166***	0.298***
	(0.045)	(0.040)	(0.042)
Altitude (municipality)	−0.002***	−0.001***	0.000
	(0.000)	(0.000)	(0.000)
Altitude^2/1000	0.002***	0.001***	0.000
	(0.000)	(0.000)	(0.000)
Altitude^3/1000000	−0.001***	−0.001***	−0.000
	(0.000)	(0.000)	(0.000)
Altitude^4/1000000000	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)
Constant	−1.447***	−0.679***	−0.262
	(0.236)	(0.209)	(0.223)
Department dummies	Yes	Yes	Yes
Observations	8706	8706	8706
R-squared	0.15	0.08	0.04
Adj. R-squared	0.15	0.08	0.04

NOTE: Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: The Effect of Number of Shocks on Child Health

	Height for Age	Weight for Age	Weight for Height
Desbordamiento	−0.039	−0.061	−0.054
	(0.050)	(0.044)	(0.047)
Helada	−0.097**	−0.111**	−0.062
	(0.049)	(0.043)	(0.046)
Ventarron	−0.082**	−0.030	0.021
	(0.038)	(0.033)	(0.036)
Sequia	0.069	0.089**	0.083*
	(0.049)	(0.043)	(0.046)
Lluvias	−0.146***	−0.115***	−0.039
	(0.048)	(0.043)	(0.046)
Inundacion	−0.069***	−0.016	0.035*
	(0.022)	(0.019)	(0.021)
Huracan	−0.124	−0.132	−0.111
	(0.134)	(0.118)	(0.126)

NOTE: Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

health.[18] As expected the most substantial effects are on height for age and weight for age and the effects of most chocks are negative and large. The discussion here focuses on height for age, but the results are mostly similar for weight for age. The largest effect is for heavy rain (lluvias) where each shocks leads to a decline in height for age of close to 0.15 standard deviations, and this effect is also strongly statistically significant. Hurricanes appear to have an almost as strong effect, but it is not statistically significant, which is probably due to the distribution of hurricanes shocks across the survey rounds as discussed above. The third highest effect is frost (helada) with an

[18]The underlying full results are available on request. In general the effects of the other explanatory variables are very similar to those presented in Table 4.

estimated effect of 0.1 standard deviations reduction in height for age for each shock. Finally, strong winds (ventarron) has a slightly lower effect than frost, but is still statistically significant.[19] The only hazard that appears to have a positive effect is drought, although the effect is not statistically signficant for height for age. This hazard is also the one that is hardest to quantify and capture in this frame work, especially since it is hard to define exactly what one occurance is.

While Table 5 can provide a first indication of the effects of the different hazards on child health it is likely that these effects will vary with individual and household characteristics. Hence, Table 6 presents the estimated direct effects of the hazards and their interactions with being a girl, land and indigenous. This means that the direct effect is now the estimated effect for ladino boys in households without land. The introduction of interactions leads to some very interesting changes in the estimated effects of the different hazards.

The direct negative effect of overflowing rivers and lakes is now substantial and statistically significant. The reason for the small statistically insignificant effect in Table 5 appear to be that the effect for girls and those children living in households with land is essentially zero. For indigenous boys without land the effect is relatively large at -0.13, but it is not statistically significant. Flooding has almost the same direct effect as above, while the effect for girls is very small. On the other hand, those with land and those who are indigenous are most more severely affected by flooding than what one would expect based on the simple estimation in 5. Heavy rain appear to be an "equal opportunity"

[19]It is a nice consistency check on the results that the effect of strong winds is substantially lower than the effect of hurricanes.

Table 6: The Effect of Number of Shocks on Child Health

	Height for Age	Weight for Age	Weight for Height		Height for Age	Weight for Age	Weight for Height
desbordamiento	−0.145*	−0.157**	−0.099	inundacion	−0.070**	−0.011	0.040
	(0.075)	(0.066)	(0.071)		(0.029)	(0.025)	(0.027)
X girl	0.127	0.160**	0.127*	X girl	0.051**	0.030	0.003
	(0.081)	(0.072)	(0.077)		(0.025)	(0.022)	(0.023)
X land	0.110	0.096	0.038	X land	−0.021	−0.057**	−0.057**
	(0.089)	(0.079)	(0.084)		(0.027)	(0.024)	(0.026)
X indigenous	0.018	−0.056	−0.113	X indigenous	−0.043	−0.007	0.027
	(0.098)	(0.086)	(0.092)		(0.028)	(0.025)	(0.027)
ventarron	−0.044	−0.014	0.029	huracan	−0.140	−0.140	−0.102
	(0.055)	(0.049)	(0.052)		(0.142)	(0.125)	(0.134)
X girl	−0.049	−0.067	−0.073	X girl	−0.030	−0.043	−0.051
	(0.049)	(0.043)	(0.046)		(0.055)	(0.049)	(0.052)
X land	−0.068	0.044	0.093*	X land	−0.061	0.036	0.081
	(0.051)	(0.045)	(0.048)		(0.058)	(0.051)	(0.055)
X indigenous	0.029	0.010	−0.003	X indigenous	0.091	0.034	−0.013
	(0.057)	(0.050)	(0.053)		(0.057)	(0.050)	(0.053)
sequia	−0.034	−0.003	0.058	helada	−0.286**	−0.217**	−0.068
	(0.085)	(0.075)	(0.080)		(0.112)	(0.099)	(0.106)
X girl	−0.092	−0.162**	−0.171**	X girl	0.083	0.020	−0.050
	(0.084)	(0.074)	(0.079)		(0.072)	(0.063)	(0.068)
X land	0.212**	0.120	−0.017	X land	0.078	0.082	0.045
	(0.088)	(0.077)	(0.083)		(0.079)	(0.069)	(0.074)
X indigenous	0.137	0.256***	0.234***	X indigenous	0.141	0.083	0.022
	(0.087)	(0.077)	(0.082)		(0.105)	(0.092)	(0.099)
lluvias	−0.144**	−0.069	0.029				
	(0.061)	(0.054)	(0.057)				
X girl	0.013	−0.032	−0.071				
	(0.047)	(0.042)	(0.045)				
X land	−0.019	0.022	0.029				
	(0.052)	(0.046)	(0.049)				
X indigenous	−0.007	−0.067	−0.076				
	(0.050)	(0.044)	(0.047)				

NOTE: Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

hazards in the sense that the point estimates for the interactions are very small. For all types of individuals and households the effect is strong and statistically significant at between -0.13 to -0.16 standard deviations per shock.

For frost shocks the direct effect is also substantially larger at close to -0.3 standard deviations. Girls and those with land show an effect of frost on height for age around -0.2, which is statistically significant at the ten percent level. The effect for indigenous children is lower at -0.15, but the effect is more statistically significant than the two other interactions.

Hurricanes continue to have an statistically insignificant direct effects and none of the interactions change that picture. The estimated effects of hurricanes are still substantial, however, except for indigenous children where the effect is only a reduction of 0.05 standard deviations. For strong winds the two groups most affected are girls and children in households with land both of which show a negative and statistically significant effect of around 0.1 standard deviations. The direct effect and the effect for indigenous children is much smaller and not statistically significant.

The results for drought provide partly an explanation of the small positive effect in the basic estimations: Children in households with land are substantially better off than other households. This effect is statistically significant and is equal to 0.18 standard deviations. For indigenous household the effect is also positive but smaller and not statistically significant. The direct effect is now negative, but far from being statistically significant, while girls show a substantial negative effect which is close to be statistically significant. These results make sense if crop yield is lower because of the drought, but prices increases sufficiently to compensate the agricultural households for the reduced yield.[20] It is, however, still difficult to reconsile this explanation with the negative effect of other hazards that likely affect crops such as hurricanes and strong winds, which show negative and often large negative effects.

4.1 Hazards and Illness

[SECTION ON NATURAL HAZARDS' EFFECTS ON DIRECTLY OBSERVED ILLNESS]

5 Conclusion

Climate change is likely to lead to increased risk in a number of different natural hazards. These changes will affect many different aspects of the economy and the prospect for development. This paper attempts to quantify what the effects will be on a particular area: Child health. As found in the previous literature healthier children are both more likely to survive, do better in school and earn higher wages when adults for a given level of schooling (Strauss and Thomas 1998). Hence, if climate change has substantial negative effects on child health this will reverberate through the society both in the short and long run.

This paper use the three rounds of the Demographic and Health Survey from Guatemala together with data on natural hazards that allows us to pinpoint when and where particular shocks occurred. For each hazard we estimate

[20] This requires that the landed households are net producers of the crops affected by the drought.

the effect of the number of shocks that hit the area in the six months prior to the survey month on child health. This is done for children between 9 and 59 months for whom there is anthropometric information. Child health is proxied by height for age, weight for age and weight for height with most of the focus on the first outcome. The hazards analysed are strong winds, overflows (river, etc.), flooding, heavy rain, hurricanes, frost and droughts.

Except for drought the effect of shocks from these hazards are generally negative and often very large.[21] Many of the estimated effects are reduction in height for age of between 0.1 and 0.2 standard deviations which is substantial given the already dismal level of child health with, on average, children in Guatemala 2.6 standard deviations below the WHO growth standard for height for age. Hence, it will not take large increases in the risk of these hazards to severely disrupt the prospect for long run social development.

[21] As discussed above, drought is likely difficult to measure correctly and is the hazard that fits the worst into the framework employed here.

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