Children's Vulnerability to Shocks in Income and Assets: Hurricane Mitch in Nicaragua as a Natural Experiment

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July, 2006
(First draft)

Abstract

In October of 1998 Nicaragua was hit by Hurricane Mitch, the third most powerful hurricane formed in the Tropical Atlantic basin in the 20th century. We exploit this exogenous variation and the trajectory of the hurricane in a quasi-experimental design to evaluate the medium-term effects of a large negative shock on children. We find no significant effect on school enrollment. However, child labor participation among the affected children increased by 45% due to the storm. Similarly, the proportion of children that was simultaneously enrolled in school and working almost doubled, going from 7.5% to 13.5%. In terms of health, we find parallel results. Affected children between six and fifteen years of age were 15% less likely to be taken for medical consultation conditional on being sick, even though there was no significant difference on the prevalence of illness between the affected and non-affected children. In addition, children who suffered the income shock got 0.53 standard deviations further below the weight-for-height Z score reference median and were 5 percentage points more like to be undernourished. Our results are robust to different sub-samples, specifications and estimation methods. We conclude that large income and asset shocks, like natural disasters, can have pervasive medium-run effects on children's well-being, particularly in terms of health, nutrition and labor outcomes.

* The authors are graduate students in Economics and Public Policy, respectively. This paper is still work in progress. Please do not cite without the permission of the authors.

I. Introduction

Households in low-income countries face numerous and diverse risks that cause important fluctuations to their income and generate significant losses of productive assets. Since these economies are highly dependent on agriculture, weather–related shocks are especially relevant for understanding households' welfare and their choices in these settings.

In the last two decades, the literature on microeconomic development has, in fact, devoted growing attention to the consequences of adverse weather for households in poor countries. These studies, however, equate weather shocks with income shocks, ignoring the effects on assets and the future productive capacity of households. Furthermore, previous work in this area has been mostly concerned with consumption smoothing and risk-sharing mechanisms, and does not devote much attention to the consequences of a shock for children.

Investments in children's education and health, in particular, require large cash expenditures, which may be difficult to make in the face of a shock, especially in poor environments where credit and insurance markets do not work well. If this is the case, then, a sufficiently large shock may take children out of school and worsen their health status. For instance, Jacoby & Skoufias (1997) and Jensen (2000) find that income variability has an adverse effect on children's school enrollment and nutrition in environments where formal insurance is limited.

In this paper, we investigate this hypothesis for the case of a very plausible exogenous and large income and asset shock: a natural disaster. In particular, we look at the medium-term effects of Hurricane Mitch on children's schooling and health in Nicaragua. Since some regions of the country were not affected by Mitch, we exploit this exogenous variation as a quasi-experimental design to evaluate the impact of this shock on children. We use a difference-in differences (D-D) approach with panel data from the Nicaragua Living Standards Measurement Study, a household-level survey collected in 1993, 1998, 1999 and 2001 by the World Bank and the National Institute of Statistics of Nicaragua (INEC).

Hurricane Mitch hit Nicaragua in the last week of October of 1998, and it is considered one of the most destructive storms ever to hit Central America. The storm mainly affected the northern and western regions of the country, and left behind more than 50 inches of rain, 3,000 dead and more than 20% of the population in need of new housing. In total, it is estimated that around 45,000 households in 72 municipalities were directly affected. Additionally, close to 300 schools and dozens of health centers were left unusable, and one third of the crops was destroyed (World Bank, 2001). That is, in addition to affecting income, natural disasters often represent an adverse shock to household's assets, existing infrastructure, the health environment, and the macroeconomic conditions of the country. The existing literature on the effects of income shocks on households is, therefore, only partially useful for understanding the total effects of natural disasters.

Without a doubt, natural disasters have captured the attention of policy makers in recent years, especially after Hurricane Katrina in the United States and the tsunami in Asia in 2005. And although some studies exist on the macroeconomic effects and the direct losses associated with natural disasters, the literature on the welfare implications of these phenomena at the household level is rather limited. In particular, work on the consequences of these shocks for children is scarce.

Our preliminary findings suggest that Hurricane Mitch, on average, had no significant effect on school enrollment three years after the shock. However, child labor participation among the affected children increased by 45% due to the storm. Similarly, the proportion of children that was simultaneously enrolled in school and working almost doubled, going from 7.5% to 13.5%. In terms of health, we find parallel results. Affected children between six and fifteen years of age were 15% less likely to be taken for medical consultation conditional on being sick, even though there was no significant difference on the prevalence of illness between the affected and non-affected children. To the extent that disruptions in school enrollment, and nutritional and health deficiencies have long-term effects, these results highlight the need for a more comprehensive agenda when dealing with the consequences of shocks to include the possible effects on children. A one-time flow of aid after a large shock to income and assets may not do enough to prevent the adverse effects of such an event.

The rest of this paper is organized as follows. First, we discuss the existing literature on the consequences of shocks for children and describe the effects of Mitch in Nicaragua. Section III presents a simple conceptual model to frame the effects of a hurricane on children in a setting of imperfect credit and insurance markets. Section IV describes the data used and our empirical strategy, while Section V includes our main results, as well as some refutability tests and robustness checks to our identification approach. Section VI concludes.

II. Background

Natural disasters can adversely affect not only income, but also households' assets, infrastructure, as well as the macroeconomic environment of the affected country. Most of the existing literature on the effects of shocks at the household level, however, restricts its attention to income shocks. This literature suggests that families in poor countries frequently lack the mechanisms needed to efficiently smooth consumption after a shock as credit and insurance markets generally do not work well (Townsend, 1994; Deaton, 1992).

In the case of natural disasters, however, shocks are rather aggregate. Therefore, it becomes difficult to perfectly smooth consumption. Santos (2006) finds that inter-household transfers increased in the aftermath of Hurricane Mitch, but informal resources did not cover all the losses arising from the shock. Since formal markets are largely absent, this evidence suggests that households are not able to fully share risks. Hence, negative shocks can also reduce the resources used towards children's education and health given that significant liquidity is needed to cover the expenses associated with schooling and health care.

The existing literature on the effects of large shocks on children is, nonetheless, surprisingly limited. Behrman (1988), using data from rural India, finds that negative income shocks adversely affected children's health. Similarly, Foster (1995) looks at the effects of an income shock on the nutrition of children, and shows that credit market imperfections influenced the impact of the flood on children's weight in Bangladesh. He shows that, although after the floods 46.2% of the landowning households and 64% of the landless households took out loans, children in the latter households were in worse health conditions since the former were more effective in getting credit.

Similarly, Jacoby & Skoufias (1997), using longitudinal data from 10 villages in India with different climatic characteristics, find that income fluctuations among households lead to variability in school attendance. The authors use a structural dynamic model of human capital accumulation and insurance behavior, and show that in periods of negative income shocks, children are less likely to enroll in school; moreover, they highlight that this insurance strategy has important consequences in the long-run, especially for small – farm households which have a greater response to unanticipated shocks than large-farm units.

In the same way, Jensen (2000) uses cross-sectional data from Cote d'Ivoire to analyze whether children in regions that experienced adverse weather had lower investments in education and health. He looks at inter-regional weather variation between 1985 and 1988, and concludes that the shock was associated with an average decrease in school enrollment of 20%. In addition, he finds that the percentage of sick children taken to receive health services, as well as the nutritional status of the children affected by the shock, worsen significantly.

The existing evidence suggests that negative income shocks tend to be associated with a decrease in the investment on children in terms of education and health. If this is the case, shocks like natural disasters, whose effects go beyond income, can be expected to have an even larger effect on children.

The contributions of this paper to the economic literature are twofold. On the one hand, it analyzes the effects of a large income and asset shock on children, for which the existing evidence is limited. Rarely has there been an opportunity to analyze the microeconomic impact of such a large and exogenous shock like Hurricane Mitch. Additionally, this paper looks at the effects on individuals, and not on regions or groups of affected households, which is often the case in the relevant studies.

Moreover, we explore here the effects of Mitch three years after the event. The persistence of adverse effects on children in the medium term hints at important long-run consequences of income and assets shocks, especially if we take into account that education and health are important determinants of future earnings and welfare.

On the other hand, this paper also contributes to the understanding of natural disasters more specifically. This constitutes valuable information for policy makers, as well as national and international donors, interested in designing comprehensive policies to deal with large negative shocks. Finally, this paper studies households in Central America, a region of the world not only often affected by natural disasters, but also one that is seldom subject of economic research at the micro level.

Description of the Shock: Hurricane Mitch in Nicaragua

Nicaragua is, after Haiti, the poorest country in the Western Hemisphere. When Hurricane Mitch hit Nicaragua in October 1998, the country had a GDP per capita of US$735.84 (constant 2000 US$), 44.71% of the population was living with under US$1 a day and 79.03% under US$2 a day.[1]

Table 1
Microeconomic Effects of Hurricane Mitch

Variable	(%)	Variable	(%)
Did the family move to another house?	17.3	After Mitch, this household benefited from assistance to	
Was this house temporaly unnocupated?	29.4	New school/Reconstruction	5.8
During this time, the family moved to?		New health center/Reconstruction	2.2
Refugee	35.5	Water provision	1.7
Relatives' home	55.8	Sewage	0.0
Temporary home	7.3	Electricity	1.5
Other municipality	1.5	Latrine	7.2
Other state	1.5	Food	45.3
Other country	0.75	Health programs	38.1
The house/basic services were affected by Mitch	45.8	Employment programs	17.1
The structure of ____ in the household was totally/partially destroyed		Donation of clothing	19.7
Walls	56.7	Donation of medicines and/or water	9.2
Floor	19.5	Donation of house	1.7
Roof	58.6	A member of the household died due to Mitch	1.8
Water	41.8	Did not go to the doctor because Mitch destroyed health center	0.3
Toilet	61.7	Did not work because Mitch destroyed you source of employment	3.3
Electricity	24.0	Number of households	595
Distance from your previous house in kms (mean)	4.1		

Mitch mostly affected the Central and Pacific regions, located in the north and west of the country. 19% of the population in Nicaragua (867,752 people) was affected (INEC, 1999). Rural areas were particularly hit, representing 77.4% of the affected households in our sample. *Table 1* includes a summary of some of the immediate effects of the storm.

The 1999 survey of affected households reveals that 45.8% of their dwellings suffered some kind of damage due to the hurricane and, in fact, 29.4% had to temporarily leave their

[1] World Bank. World Development Indicators.

dwelling. Furthermore, 17.3% of the affected households reported having permanently moved to another residence due to Mitch, and 23.53% rebuilt or repaired their house after the disaster.

Households were also asked about the losses related to agriculture. In 56.7% of the affected households at least one member of the household was working on own land when Mitch hit, and 83.5% of those households listed Hurricane Mitch as the main factor that affected their agricultural activity in the 12 months before the survey[2]. When asked about the specific damages caused by Mitch to their agricultural activity, 96.6% of the households reported having lost crops, 10.4% reported having lost productive animals, while 9.2% suffered losses related to their agricultural property. Due to Mitch, the average real agricultural losses per household were $2,932.75 cordobas (US$277.20)[3], representing more than 115% of household's average income in 1998. *Table 2* summarizes the information related to agricultural losses.

Table 2
Agricultural Losses Due to Mitch

Type of Loss	% of households [1]	Average Loss (cordobas) [2]	Avergae Loss [3]
A.Agricultural property	9.20%	$8,171.67	$406.55
B. Crops	96.63%	$4,195.97	$2,191.92
C. Agricultural equipment	2.15%	$8,271.43	$96.02
D. Agricultural installations	6.75%	$2,669.36	$97.39
E. Animals for work	10.43%	$432.15	$24.37
F. Other	7.43%	$3,512.35	$116.50
Total agricultural losses		$5,418.17	$2,932.75

Notes: (1) Percentage of households who own land and who were affected by Mitch, (2) Average losses per household in cordobas, conditional on having suffered a loss on the specified category, (3) Average losses per household in cordobas, not conditional on having suffered a loss or owning land (losses=0 if no losses).

In the aftermath of a natural disaster, however, the influx of aid is often very large. After Mitch, large amounts of aid came from international organizations, foreign governments, and the Nicaraguan government. Monetary and in-kind public donations, such as food, housing, construction materials, clothing, and medicines were common. Households were asked about the public programs that benefited them after Mitch. Most households benefited from food and health programs (45.3% and 38.1%), followed by the donations of clothing and employment programs (*Table 1*). While in 1998 only 0.4% of all

[2] The other options included: drought, pest, inundations, robbery, extortion, physical violence, land invasion, kidnapping, fires, or "other".

[3] US$1= 10.58 cordobas in 1998.

households received any public donations, in 1999 52% of the affected households were benefited by this sort of public transfer. The average size per household of the donations was $11.37 cordobas in 1998 and $482.30 cordobas in 1999.

III. Conceptual Framework

Following Skoufias (2001), we present a simple model of household decision-making that stresses the different channels through which a hurricane affects the household's investment in the education and health of children. We use a one-period model with full information and a unitary household.[4]

Parents care about the level of consumption of the household (*C*) and the "quality" of children (*Q*), and maximize the following utility function:

$$\max U = U(C, Q), \tag{1}$$

where $U^{'}(\bullet) > 0$ and $U^{''}(\bullet) < 0$ for both arguments.

For simplicity, we combine education and health in human capital. Human capital has two components: *S*, which represents the stock of human capital at the beginning of the period; and *H*, which is the investment in human capital in the period. We are interested in understanding the effects of the shock on the flow of children's human capital (*H*), rather than on the existing stock (*S*), since the objective is to find out how investment in children changed after the shock. Therefore, in the empirical section, we use school enrollment, short-term nutritional status (indicated by weight for height), use of health facilities (conditional on being sick), and labor supply as our main outcomes of interest.

The "quality" of the children is assumed to be a linear combination of the amount of human capital (*S*+ *H*) and their innate abilities and health endowment (χ), such that:

$$Q = \alpha(S + H) + \beta\chi, \tag{2}$$

where α and β are the contributions of human capital and genetics, respectively.

Human capital investment depends on complementary goods and services, such as books and vaccines, *X*; the time the child spends in school or medical care, t_H^c ; and the time

[4] In this study, we use panel data for a group of households affected by Mitch and for others not affected by the Hurricane; therefore, by using a unitary model, the assumption will be that the balance of power in the household did not change in a differentiated manner for the two specified groups. This seems like a realistic assumption and, thus, we consider the unitary model appropriate for our purposes.

of the parents, t_H^p . The marginal effects of *X*, t_H^c and t_H^p on human capital are assumed to be positive. Similarly, human capital investment depends on a set of observed characteristics of the child, θ (including gender, age, birth order, among others); χ , which refers to unobserved characteristics of the child like his health endowment or innate abilities; and finally, δ , which captures parental education and community characteristics such as the availability of health centers and schools, prices, environmental factors, among others.

The human capital investment in the child can then be represented as follows:

$$H = H(X, t_H^c, t_H^p; \theta, \chi, \delta) \tag{3}$$

At the optimum, household expenditures will equal household income and assets. Expenditures have two components: the consumption of the household (excluding goods and services related to human capital), *C* (numeraire), and the consumption of goods and services related to human capital, $p_x XN$ (where p_x denotes the vector of prices of "human capital" goods and *N* is the number of children in the household).

The resources of the household include assets (*A*) and income. There are three different sources of income: non-labor income of the household (Y_{nl}); labor income of all children ($W^c(T - t_H^c)N$); and labor income of the parents ($W^p(T - Nt_H^m)$). The labor income of each child is equal to his wage (W^c) times the number of time units he dedicates to work out of the total time endowment minus leisure (*T*). An important characteristic of this model is, therefore, that it allows for the possibility of a child be both in school and working; this is going to be relevant given the characteristics of child labor in Nicaragua. The labor income of the parents, similarly, is equal to their wage (W^p) times the number of time units they dedicate to work.

Bringing these elements together, the budget constraint of the household is:

$$C + p_x XN = Y_{nl} + W^c(T - t_H^c)N + W^p(T - Nt_H^m) + A \tag{4}$$

The left hand side of the constraint represents the expenditures while the right hand side corresponds to the resources of the household.

Therefore, households maximize utility (1) subject to restrictions (2) – (4), by choosing the appropriate levels of consumption (*C*), time allocated to human capital ($t_H^c, {}_H^p$), and consumption of goods and services complementary to human capital investment (*X*).

The first-order conditions of this maximization problem are the following:

$$MRS_{CQ} = \frac{U_Q}{U_C} = N\left(\frac{W^C}{\alpha H_1}\right) = MC_{t_H^C} \quad (5)$$

$$MRS_{CQ} = \frac{U_Q}{U_C} = N\left(\frac{W^p}{\alpha H_2}\right) = MC_{t_H^p} \quad (6)$$

$$MRS_{CQ} = \frac{U_Q}{U_C} = N\left(\frac{P_X}{\alpha H_3}\right) = MC_X \quad (7)$$

At the optimum, the marginal rate of substitution between household consumption and child quality equals the marginal cost of investing in the human capital of the child. Combining the first-order conditions yields the solution to this problem: the household will maximize utility by setting the marginal cost associated with the time of the child, the time of the parents and the consumption of "human capital" goods and services all equal.

Let's now use this simple model to think about the effects that a shock like Hurricane Mitch can have on children's investment. These effects fall into three categories. Direct effects include the destruction of schools, health centers or the complementary infrastructure needed, as well as the loss of assets and inventories and the death or illness of members of the family. Indirect effects, on the other hand, reflect the fall in the income of the household due to the loss of crops, jobs or business. Finally, we call secondary effects those related to the slowdown in the economy in general, as a result of inflation, increased debt, fall in production, etc.

The destruction of schools and health centers increases the marginal cost of the goods and services associated with human capital (MC_x). A rise in the price of inputs (P_x), as a result of the destruction of complementary infrastructure, raises MC_x as well.

On the other hand, both the change in assets and in income affects the budget constraint. In that case, the effects are a wealth and income effect that decreases the investment in human capital (assuming human capital is a normal good). The death or illness of a parent enter this model as a decrease in the income of the household and as less time for the parents to dedicate to the investment in children's human capital.

Finally, the slowdown of the economy is expected to decrease the demand for labor and wages. Associated with this change in wages, there is an income and a substitution effect. On the one hand, the latter would predict an increase in children's human capital since the opportunity cost of human capital, the wage, is now lower. However, the income effect would move in the opposite direction. In fact, empirical studies on the relationship between child labor and wages have shown that it is not clear which effect outweighs the other (Basu, 1998). In our model, a decrease in wages lowers the marginal cost of the time that children and parents dedicate to investing in human capital ($MC_{t_H^C}$ and $MC_{t_H^P}$, respectively); this leads to an increase in human capital investment (*H*), which in turn decreases the marginal cost. On the other hand, a decrease in children's wage decreases income and, therefore, human capital.

As can be seen from our model, theoretically, the effect of a shock like a hurricane on children's human capital is ambiguous. Then end result, therefore, is an empirical matter.

IV. Data and Empirical Strategy

We use data from the Nicaragua Living Standards Measurement Studies (LSMS) carried out in 1993, 1998, 1999 and 2001 with the support of the World Bank.[5] The LSMS are panel surveys at the household level, and they gather information on a wide range of topics, including income, expenditure, education, and health. In the aftermath of Hurricane Mitch in October 1998, the World Bank and the government of Nicaragua decided to do a follow up of the 1998 survey in order to assess the effects of Mitch at the household level. Interviewers went back to those households affected by the hurricane and that had been interviewed months earlier in the 1998 round to gather information on the extent of the damages caused by the storm and the different ways in which households had dealt with the disaster. Using information from the 1999 survey, we are able to identify in 2001 those households affected by Mitch.[6] Our panel sample is comprised of 2,764 households, of which 396 were affected by Hurricane Mitch and are part of the treatment or experimental group, whit the remaining representing the control group.

Before our empirical analysis, we present the descriptive statistics for the variables of interest in 1998 and 2001. *Table 3* reports the average values of these characteristics, as well

[5] See INEC (2000). "Comparative Indicators in Zones Affected by Hurricane Mitch, According to Household Surveys" for a detailed explanation of the methodology followed in the LSMS. Field work for the EMNV98 was carried out between April and August 1998; for the EMNV99 in May and June 1999; finally, for EMNV2001, interviews were carried out between June and August of 2001. Values used in this paper are in real values for 1998.

[6] The interviewers followed the households they needed to survey even when they moved out of the household as long as they stayed in the same region as in 1998. Only 2.25% of the households visited in 1999 had permanently moved to another region after the Hurricane.

as the difference in the average changes for the control and experimental groups between the two years. The sample includes households that have at least one child and that were part of both the 1998 and 2001 surveys.

Table 3 shows that households affected by Mitch were poorer on average and a larger proportion of them lived in rural areas before and after Mitch than those households not affected.

Table 3

Pre-Shock and After-Shock Relevant Characteristics for Households by Treatment Status

Variable	1998: Before Mitch			2001: After Mitch			
	Treatment (Mitch=1)	Control (Mitch=0)	Diff	Treatment (Mitch=1)	Control (Mitch=0)	Diff	Diff-in-diff
Number of members per household	6.19	6.04	0.149	6.29	6.01	0.285	0.136
	[0.144]	[0.056]	[0.154]	[0.137]	[0.055]	[0.148]	[0.214]
Number of children per household	2.65	2.59	0.058	2.49	2.34	0.155	0.097
	[0.100]	[0.039]	[0.107]	[.092]	[0.037]	[0.099]	[0.146]
Age: 0-6 years	1.14	1.11	0.032	0.98	0.92	0.053	0.021
	[0.059]	[0.023]	[0.063]	[0.052]	[0.021]	[0.056]	[0.085]
Age: 6-15 years	1.51	1.48	0.025	1.52	1.41	0.101	0.076
	[0.068]	[0.027]	[0.073]	[0.068]	[0.026]	[0.073]	[0.103]
Proportion of children that are girls	0.522	0.498	0.024	0.502	0.501	0.001	-0.023
	[0.017]	[0.007]	[0.019]	[0.018]	[0.007]	[0.019]	[0.027]
Age of household head	45.46	45.27	0.197	47.51	47.52	-0.010	-0.207
	[0.772]	[0.307]	[0.831]	[0.757]	[0.303]	[0.816]	[1.164]
Age of children	7.70	7.53	0.163	7.78	7.97	-0.187	-0.350
	[0.194]	[0.074]	[0.208]	[0.183]	[0.074]	[0.197]	[0.287]
Years of schooling: head of household	2.93	4.29	-1.359	2.94	3.87	-0.927	0.432
	[0.175]	[0.09]	[0.197]	[0.161]	[0.079]	[0.072]	[0.267]
Years of schooling: spouse	2.89	4.191	-1.303	2.76	3.95	-1.185	0.118
	[0.186]	[0.099]	[0.211]	[0.171]	[0.094]	[0.196]	[0.288]
Female headed households	0.196	0.285	-0.089	0.210	0.303	-0.093	-0.004
	[0.02]	[0.009]	[0.022]	[0.020]	[0.009]	[0.022]	[0.031]
Proportion of rural households	0.722	0.419	0.303	0.709	0.390	0.319	0.016
	[0.022]	[0.010]	[0.024]	[0.022]	[0.010]	[0.024]	[0.035]
Income per capita	3,382	6,279	-2,897	5,076	7,447	-2,371	526.2
	[261.2]	[485.4]	[551.3]	[294.6]	[228.0]	[372.5]	[665.2]
Percent with own house	0.439	0.506	-0.067	0.505	0.525	0.020	0.046
	[0.024]	[0.010]	[0.027]	[0.025]	[0.010]	[0.027]	[0.038]
Distance to closest health center (minutes)	16.58	13.49	3.088	18.55	16.31	2.240	-0.848
	[0.315]	[0.109]	[0.334]	[0.29]	[0.107]	[0.309]	[0.455]
Distance to closest primary school (minutes)	13.57	10.83	2.740	13.09	11.01	2.079	-0.658
	[0.249]	[0.090]	[0.265]	[0.226]	[0.084]	[0.241]	[0.358]
Children no breastfed	0.047	0.041	0.006	0.013	0.030	-0.017	-0.023
	[0.012]	[0.005]	[0.013]	[0.007]	[0.004]	[0.009]	[0.016]
Number of households	396	2,368		396	2,368		

Notes: Standard errors are presented in square brackets. The analysis here includes only households with at least one child under the age of 15. Income per capita expressed in Nicaraguan Cordobas of 1998. See text for definitions of experimental and non experimental households and before and after years.

The average annual per capita income in 1998 was $3,382cordobas (US$281.8) for households affected by Mitch while it was $6,279 cordobas for those not affected (US$523.25). Average income for both groups increased by 2001, but it increased significantly more for the group of households not hit by the hurricane.

The average number of members in the household stayed roughly the same for both the treatment and the control groups from 1998 to 2001, being the average size of the affected households (6.19 members in 1998) not statistically different from that of the non-affected households (6.04 members in 1998).

In terms of household headship, the share of households headed by women is significantly larger in the control group in both 1998 and 2001, with 19.6% and 28.5% of the households being headed by women in the treatment and control groups, respectively. There are no pre-shock differences between the two groups in terms of the educational attainment of the head of the household.

In short, from looking at the initial descriptive statistics, we can see that there are no important differences in the key pre-shock characteristics of our control and treatment groups associated with the number of members in the household or the average age of children. There are, however, statistically significant differences in other relevant measures, namely income. However, once we separate rural and urban households, these differences either disappear or become no significant in statistical sense. *Annex 1* presents selected household characteristics for the control and the treatment groups taking into account whether they are rural or urban.

Empirical Strategy

This paper seeks to measure the effect of a large income and asset shock on the investment of households in the education and health of children. Ideally, we would like to calculate the effect of Mitch on a child's outcome by comparing the actual outcome of the child affected with what that outcome would have been in the absence of the shock. Obviously, we cannot observe this last counterfactual and a construction of a good comparison group is the only option left. In order to do that, we use information on children's and household's characteristics before and after Hurricane Mitch, and exploit the fact that the hurricane was an exogenous event dividing the population into two groups: those affected by Mitch (treatment) and those who were not affected (control). Our approach is based on a difference-in-differences analysis. We compare the differences in nutrition, health, schooling and child labor outcomes between 1998 and 2001 for children in households affected by Hurricane Mitch, relative to the differences present in children of households not affected by the negative shock.

Let's take C_{it} to represent a particular outcome of a child type *i*, where *i* = 0 if the child is in a region not affected by Mitch and *i* = 1 if the child is in a region affected. *t* represents the year: t =1998 (pre-shock) or t = 2001 (after-shock). There are two possible states of the world *r*: *r* = 0 if there is no Mitch, and *r* =1 if there is Mitch.

The conditional mean function for child outcomes is:

$$\mathrm{E}\left[C_{0rt} \middle| i, r, t\right] \text{ if the child is not affected by Mitch; and} \tag{1}$$

$$\mathrm{E}\left[C_{1rt} \middle| i, r, t\right] \text{ if the child is affected.} \tag{2}$$

However, for t = 2001, we only observe (2) when *r* = 1; that is, we cannot observe what the children's outcomes in regions affected by Mitch would have been if the hurricane had not hit them. We can then use similar regions that were not affected by Mitch to estimate this counterfactual:

$$\mathrm{E}\left[C_{0rt} \middle| i = 0, r = 1, t = 2001\right] \tag{3}$$

In the absence of the shock, children's outcomes can be written as:

$$\mathrm{E}\left[C_{i0t} \middle| i, r = 0, t\right] = \alpha + X\beta \tag{4}$$

Further, let's assume that the effect of the shock (*M*) can be captured by a constant (δ). For instance, the nutrition of child *i* in any region would be:

$$C_i = \alpha + \delta M_i + X\beta \tag{5}$$

Under our assumption, the average causal effect of the shock is:

$$\delta = \left\{\mathrm{E}\left[C_{1,2001} \middle| i = 1, t = 2001\right] - \mathrm{E}\left[C_{1,1998} \middle| i = 1, t = 1998\right] - \left\{\mathrm{E}\left[C_{0,2001} \middle| i = 0, t = 2001\right] - \mathrm{E}\left[C_{0,1998} \middle| i = 0, t = 1998\right]\right. \right. \tag{6}$$

Our identifying assumption when using this difference-in-difference approach is that between 1998 and 2001, there would have been no differential change in our measures of health, education and child labor between the two groups of children in the absence of Hurricane Mitch. Given that is not possible to construct the counterfactual of what would have happened to these indicators if Mitch had not hit Nicaragua, we use the 1993 LSMS survey together with the 1998 LSMS to shed some light into this issue. In particular, in implementing this refutability test we are interested in showing that the control and the treatment groups generated by Mitch had not experienced a differential change in our key measures of children's outcomes between 1993 and 1998. We could then use this as indication of the plausibility of our identifying assumption[7].

We are interested in measuring resource flows related to children's outcomes in education, child labor and health. For education, our main indicator is school enrollment, while for child labor participation we look at the probability of either working or looking for a job as well as the number of hours spent at work. For health, we first analyze nutrition, as measured by weight for height; then, we look at the use of health services, conditional on being sick.

It is important to notice that for nutrition we choose to use the weight for height Z score in reference to the median recommended by the World Health Organization. As discussed in Jensen (2000), this measure reflects the short-term or current nutritional status of the child (health investment flow), as opposed to the height-for-age indicator which is more related to long-term nutritional conditions (health stock) of the child.

We use different indicators for the shock. First, we construct a dichotomous indicator equal to one if the household was affected by Mitch (as indicated by having being surveyed in 1999) and zero otherwise. This dummy variable allows us to identify the average effect of the shock among the experimental group.

Our main indicator of the shock, however, is "losses" - a measure of the losses related to agriculture suffered by each household. This measure allows us to create variation in the data since now it is possible to differentiate affected households by the severity of the shock suffered by each one. This variable, as a percentage of the household income in 1998 and in absolute terms, is a measure of the shock.[8]

[7] We have still not done this refutability test.

[8] The construction of this variable "losses" follows recent work from Lazo (2005) and Santos (2005).

In the 1999 survey, as explained in Section II, households were asked whether or not they had suffered any losses in each of seven categories, as well as to quantify those losses. The categories considered are the following: crops, tools, equipment for agriculture, animals for work, facilities, agricultural property, and other. We add up the losses reported, and construct our measure of "losses".

We restrict our sample only to rural areas when using this variable "losses" since urban households are less dependent on agriculture than rural areas, so we would be under-estimating the effect of Mitch on urban households if they are included in the sample.

Furthermore, it is important to recognize that the variable "losses", even if the sample is restricted to rural areas, probably does not fully capture the damages suffered by a household as a consequence of the hurricane. In particular, it does not take into account other effects that may have reduced the welfare of the household, such as damages to the dwelling, provisional displacement, destruction of public infrastructure, among others. In addition, there might be measurement error coming from the self-reporting of the losses[9].

An alternative way of measuring the severity of the shock is by instrumenting with the amount of rain received during the storm. Most of the damages associated with Mitch were caused by the large amounts of rain that the hurricane generated (INEC, 1999). Additionally, the amount of rain received by a given municipality is largely exogenous. We use monthly historical data on precipitations coming from the Nicaraguan National Directory of Meteorology (INETER, by its Spanish acronym) for the period 1990-2000. We use deviations from average precipitations in October 1998, the month of the hurricane, to construct a measure of the shock.

In the section that follows, we present our main empirical results.

VI. Results: Were Children More Vulnerable After the Shock?

Mitch, as discussed in section IV, had very large immediate effects on households. This is evidenced by the large amount of losses, the widespread destruction of dwellings, as well as by the damages caused to businesses. However, it is much less obvious that there would still be significant effects of Mitch in 2001, almost three years after the disaster. To get

[9] See Santos(2005) for further discussion related to the measurement of the shock using the variable "losses".

an idea of the medium-term effects of Mitch, we then first look at the effect of the hurricane on household's consumption by 2001.

Table 4

Estimates of the Medium-Term Impact of Hurricane Mitch on the Change in Consumption per capita, 1998-2001

Dependent variable in all regressions: Consumption per capita (in Cordobas of 1998)

	OLS			**Fixed Effects**			**Random Effects**			**Maximum Likelihood**		
Variable	**(i)**	**(ii)**	**(iii)**	**(i)**	**(ii)**	**(iii)**	**(i)**	**(ii)**	**(iii)**	**(i)**	**(ii)**	**(iii)**
After treatment (t=1 if 2001, 0=otherwise)	328.4	342.4	389.8	379.0	323.3	337.9	342.6	354.0	347.1	343.6	354.0	366.1
	[125.5]	[105.7]	[104.6]	[95.5]	[107.0]	[101.2]	[98.2]	[96.0]	[99.2]	[96.6]	[95.7]	[98.5]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-98.9	-393.0	-113.3	.....	.....	.....	-188.1	-418.4	-128.3	-193.5	-418.5	-131.0
	[269]	[297.5]	[299.7]				[249.6]	[278.5]	[296.9]	[251.0]	[278.3]	[295.9]
After treatment * Household treated	-656.5	-475.2	-475.3	-454.7	-438.9	-455.5	-583.9	-437.7	-485	-579.4	-437.6	-460.1
	[219.1]	[224.5]	[214.5]	[247.4]	[254.8]	[260.2]	[259.1]	[251.8]	[258.4]	[254.8]	[251.0]	[257.3]
Household located in rural area	-982.1	-1,246.0	-922.3	-1,309.2	-1,287.6	-1,234.3	-1,084.2	-1,337.3	-1,157.5	-1,091.1	-1,337.7	-1,055.1
	[152.2]	[179.1]	[206.9]	[533.6]	[543.0]	[546.5]	[163.3]	[192.5]	[198.3]	[165.1]	[192.4]	[192.3]
Income per capita	0.184	.....	.....	0.054	.....	.....	0.135	.....	.....	0.132	.....	.....
	[0.032]			[0.006]			[0.005]			[0.005]		
Houseownership	.....	-116.3	-131.1	.....	81.0	86.8	.....	-35.7	-34.9	.....	-35.3	-45.3
		[59.4]	[51.6]		[52.7]	[52.9]		[40.8]	[41.1]		[40.9]	[40.8]
Number of children in the household	-305.7	-393.9	-388.5	.....	.....	.....	-328	-393.7	-390.4	-329.4	-393.7	-388.3
	[26.3]	[37.6]	[35.8]				[22.6]	[26.3]	[41.1]	[23.0]	[26.3]	[26.2]
Household head's schooling	377.4	487.2	476.5	.....	.....	.....	407.0	490.0	481.5	408.8	490.1	479.1
	[49.4]	[63.6]	[56.2]				[19.8]	[22.8]	[23.0]	[20.13]	[22.8]	[22.9]
Household head's age	132.5	150.5	145.5	.....	.....	.....	144.5	164.2	155.3	145.2	164.3	160.4
	[37.4]	[37.9]	[32.3]				[30.7]	[36.1]	[35.8]	[31.2]	[36.1]	[35.6]
Household head's age squared	-1.128	-1.240	-1.190	.....	.....	.....	-1.210	-1.350	-1.270	1.220	-1.350	-1.310
	[0.351]	[0.320]	[0.275]				[0.291]	[0.341]	[0.338]	[0.295]	[0.341]	[0.336]
Household head's is a woman	-178.2	-355.8	424.5	.....	.....	.....	-237.7	-354.0	-372.8	-241.3	-353.9	-423.7
	[119.7]	[132.2]	[141.1]				[162.6]	[190.9]	[189.5]	[164.8]	[190.9]	[187.4]
Household has own businesses	19.7	667.9	694.2	-153.1	-66.0	-80.9	36.7	296.0	376.6	35.1	344.5	358.3
	[200.0]	[177.4]	[169.9]	[167.9]	[170.4]	[170.7]	[127.9]	[133.9]	[134.5]	[127.6]	[134.1]	[134.2]
Constant	1,663.9	2,364.9	1,547.7	5,944.5	5,979.8	5,948.3	1,666.8	1,957.7	1,188.8	1,667.3	1,955.8	1,198.0
	[882.2]	[917.9]	[1010.5]	[268.2]	[298.3]	[299.6]	[782.2]	[933.2]	[992.6]	[792.4]	[933.2]	[988.3]
Controls for lands to cultivate	no	yes	yes	no	yes	yes	no	yes	yes	no	yes	yes
Controls for programs of social aid	no	no	yes	no	no	yes	no	no	yes	no	no	yes
Controls for state effects	no	no	yes	no	no	yes	no	no	yes	no	no	yes
H_0: No household effects				2.88	3.70	3.59						
				[0.000]	[0.000]	[0.000]						
R^2	0.447	0.306	0.323									
F	155.82	97.08	43.47	21.08	4.48	3.06						
Number of observations	4,568	4,568	4,568	4,568	4,568	4,568	4,568	4,568	4,568	4,568	4,568	4,568

Notes: Standard errors clustered at the municipality level and p-values of tests on household fixed effects are presented in square brackets. The analysis here includes only households with at least one child under the age of 15. Dummies of programs of social aid include public assistance in terms of provision of water, electricity, employment and donation of food and drugs after the Hurricane. 330 out of 2,326 households in each wave of the survey are part of the experimental group. See text for definitions of experimental and non experimental households and before and after years.

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In order to do this, we contrast the differences in consumption per capita of the treatment households to a set of control households in both urban and rural areas. Identifying this impact requires controlling for any systematic differences between the two groups, thus we include covariates such as location, income per capita, programs of social assistance, production assets, year effects, group effects, state effects and a set of socio-demographics.

The unit of observation for the empirical exercises on consumption corresponds to a household with at least one child below 15 years of age. There are a total of 2,284 households with these characteristics in each wave (327 treatment households and 1,957 controls). *Table 4* illustrates D-D estimates of the effect of Hurricane Mitch on medium-term consumption and includes three different specifications for each method of estimation. The pooled OLS results indicate that there was a (significant) 7.0% to 9.4% fall in the real consumption per capita of the experimental households versus the controls over three years after the disaster. Even though this result is robust to different specifications, we add fixed effects to address a potential bias from specific household effects (e.g. tastes for location, pre-shock insurance mechanisms). Although the joint F-tests suggest the OLS model can suffer from this omitted variable bias, the impact on consumption does not vary much after controlling for these unobservables. Moreover, the D-D estimates from the fixed effects models (FE) are very close to those obtained by implementing random effects (RE). Overall, we can say that the medium-term drop in consumption attributed to the Hurricane lies somewhere between 6.1% and 9%, consistent with a fall in permanent income due to both an income and an asset shock.

Next, we look at our main outcomes of interest related to children. We assess children's well-being in terms of three main subjects: (a) schooling and child labor, (b) illness prevalence, health care utilization (conditional on being ill) and immunization and, (c) nutritional status. In a similar fashion to the methods adopted for the models of consumption, we compare the changes in these variables in 1998 and 2001 for children in households hit by the Hurricane to the analogous difference for non-affected children.

We focus on children aged 6-15 for education and child labor, 0-6 and 6-15 for health measures and 0-4 for nutritional status. We run our specifications separately for boys and girls. This allows us to get at the question of whether girls suffer more than boys from a shock. *Table 5* summarizes the results of simple D-D estimates for education and child labor, using 7,286 and 1,286 treated and control children, respectively.

Regarding school attendance, the enrollment rate increased by 5.7 percentage points in the experimental group (close to 8% of the initial rate) compared to that of the control group. The table also presents the effects of the shock on the likelihood of a child joining the labor market. Overall, the prevalence of child labor increased in the treatment group by 6.4 percentage points (approximately 40% of the original value) compared to the change in the non-experimental group. Thus, in principle, parents gave "affected" children the chance to go to school but were in need of using them as wage earners as well. The results presented in the third panel give to some extent the impression of being confirming this idea. Indeed, the proportion of children jointly attending school and participating increased by 6.9% percentage points in the treated areas, which represents almost an increase of 90%.

The sample variance of the simple D-D estimates can be diminished by incorporating them into a regression analysis. Within this framework we can control for observable characteristics of both groups that can influence the outcome variables of interest, according to the model described above. The regression equation estimated is the following:

$$C_{itd} = \alpha + \beta_1 X_{itd} + \beta_2 \tau_t + \beta_2 Treat_d + \beta_3 (\tau_t \ x \ Treat_d) \quad (6)$$

where i indexes individuals, t indexes years (1 if after 1998, 0 otherwise) and d indexes the treatment and control groups (1 if hit by the hurricane, 0 otherwise). C represents any of the measures associated with children's wellbeing (e.g. whether child is attending school), X is a vector of observable characteristics, τ is a fixed year effect and *Treat* is a dummy for treatment group (1 if treated, 0 if control). The interaction associated with β_3 captures all the variation in children's outcomes specific to the treatments (relative to the controls) in 2001 (relative to before the disaster). The set of covariates includes some demographics of the children and their parents (e.g. age, sex and schooling), some characteristics of the household (e.g. number of permanent members, location and house ownership), productive assets (business ownership, land to cultivate), state effects and dummies for programs of social assistance.

We run two specifications for each method of estimation in order to check both the sensitivity of our results and test for some potential sources of bias. The third row for each of the three panels in *Table 6* presents the estimates of the interaction between the year dummy and the treatment dummy, namely the parameter of interest β_3 in (6). For the pooled linear probability model, the coefficient in the first panel and first specification indicates that children in the treatment group were 3.5% more likely to be attending school (insignificant).

Table 5
D-D Estimates of the Impact of Hurricane Mitch on Schooling and Child Labor

	School Attendance					
	Total Sample			Rural		
Group	Before Mitch	After Mitch	Time difference for group:	Before Mitch	After Mitch	Time difference for group:
Treatments	0.736	0.836	0.100	0.693	0.810	0.117
	[0.016]	[0.013]	[0.021]	[0.019]	[0.016]	[0.025]
Controls	0.781	0.824	0.043	0.669	0.727	0.058
	[0.006]	[0.005]	[0.008]	[0.010]	[0.010]	[0.014]
Difference at a point in time:	-0.045	0.012		0.024	0.083	
	[0.017]	[0.014]		[0.022]	[0.019]	
Difference-in-difference	0.057			0.059		
	[0.022]			[0.029]		

	Child Labor Participation					
	Total Sample			Rural		
Group	Before Mitch	After Mitch	Time difference for group:	Before Mitch	After Mitch	Time difference for group:
Treatments	0.161	0.220	0.059	0.185	0.225	0.040
	[0.013]	[0.015]	[0.020]	0.016	[0.017]	[0.023]
Controls	0.130	0.125	-0.005	0.184	0.169	-0.015
	[0.005]	[0.005]	[0.008]	0.008	[0.008]	[0.012]
Difference at a point in time:	0.031	0.095		0.001	0.056	
	[0.014]	[0.015]		[0.018]	[0.019	
Difference-in-difference	0.064			0.055		
	[0.022]			[0.026]		

	Children Attending School and Participating in the Labor Market					
	Total Sample			Rural		
Group	Before Mitch	After Mitch	Time difference for group:	Before Mitch	After Mitch	Time difference for group:
Treatments	0.075	0.155	0.080	0.085	0.148	0.063
	[0.009]	[0.013]	[0.016]	[0.006]	[0.014]	[0.018]
Controls	0.067	0.078	0.011	0.084	0.088	0.004
	[0.003]	[0.004]	[0.005]	[0.011]	[0.006]	[0.009]
Difference at a point in time:	0.008	0.077		0.001	0.060	
	[0.010]	[0.013]		[0.013]	[0.016]	
Difference-in-difference	0.069			0.059		
	[0.017]			[0.020]		
Number of observations	9,956			4,951		

Notes: Standard errors clustered at the municipality level are presented in square brackets. The analysis here includes only children between 6 and 15 years old. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Table 6

Estimates of the Impact of Hurricane Mitch on School Attendance and Child Labor
(Children between 6 and 15 years of age)

Dependent variable: School attendance

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.043	0.032	0.041	0.031	0.557	0.507	0.489	0.415
	[0.010]	[0.010]	[0.010]	[0.010]	[0.104]	[0.113]	[0.088]	[0.095]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.010	0.020	0.008	0.019	…..	…..	0.180	0.254
	[0.022]	[0.022]	[0.015]	[0.014]			[0.172]	0.182
After treatment * Household treated	0.035	0.016	0.027	0.012	0.096	0.126	0.267	0.160
	[0.024]	[0.026]	[0.018]	[0.020]	[0.232]	[0.242]	[0.215]	[0.220]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	8,873	8,873	8,873	8,873	3,254	3,254	8,873	8,873

Dependent variable: Child labor participation

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.001	-0.003	-0.001	-0.003	-0.274	-0.174	-0.080	-0.086
	[0.010]	[0.010]	[0.010]	[0.009]	[0.115]	[0.104]	[0.095]	[0.091]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.005	-0.008	0.000	-0.012	…..	…..	-0.009	-0.185
	[0.019]	[0.017]	0.016	[0.012]			[0.202]	[0.201]
After treatment * Household treated	0.071	0.075	0.068	0.071	0.930	0.944	0.841	0.841
	[0.023]	[0.021]	[0.028]	[0.025]	[0.235]	[0.226]	[0.218]	[0.209]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	9,059	9,059	9,059	9,059	3,625	3,625	9,059	9,059

Dependent variable: School attendance and child labor participation

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.005	0.001	0.005	0.001	-0.185	-0.323	0.043	-0.050
	[0.010]	[0.010]	[0.009]	[0.008]	[0.131]	[0.148]	[0.111]	[0.122]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.003	-0.010	-0.002	-0.008	…..	…..	-0.018	-0.208
	[0.014]	[0.016]	[0.013]	[0.012]			[0.251]	[0.263]
After treatment * Household treated	0.074	0.061	0.061	0.048	0.956	0.962	0.962	0.855
	[0.021]	[0.024]	[0.027]	[0.025]	[0.278]	[0.283]	[0.261]	[0.265]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,568	4,568	4,568	4,568	2,376	2,376	4,568	4,568

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Random effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of 15. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of schools, health centers, housing, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Table 7

Estimates of the Impact of Hurricane Mitch on Illness Prevalence and Health Care Utilization
(Children between 6 and 15 years of age)

	Did Child Get Sick?					
	Total Sample			Rural		
Group	**Before Mitch**	**After Mitch**	**Time difference for group:**	**Before Mitch**	**After Mitch**	**Time difference for group:**
Treatments	0.319	0.335	0.016	0.320	0.337	0.017
	[0.017]	[0.017]	[0.024]	[0.019]	[0.019]	[0.027]
Controls	0.334	0.303	-0.031	0.351	0.318	-0.033
	[0.007]	[0.007]	[0.010]	[0.011]	[0.010]	[0.015]
Difference at a point in time:	-0.015	0.032		-0.031	0.019	
	[0.018]	[0.018]		[0.022]	[0.022]	
Difference-in-difference	0.047			0.050		
	[0.026]			[0.031]		
Number of observations	9,930			4,943		

	Health Care Utilization (conditioned on being sick)					
	Total Sample			Rural		
Group	**Before Mitch**	**After Mitch**	**Time difference for group:**	**Before Mitch**	**After Mitch**	**Time difference for group:**
Treatments	0.271	0.261	-0.010	0.240	0.233	-0.007
	[0.029]	[0.027]	[0.040]	[0.031]	[0.030]	[0.043]
Controls	0.323	0.436	0.113	0.264	0.363	0.099
	[0.012]	[0.015]	[0.019]	[0.016]	[0.019]	[0.026]
Difference at a point in time:	-0.052	-0.175		-0.024	-0.130	
	[0.031]	[0.174]		[0.035]	[0.036]	
Difference-in-difference	-0.123			-0.106		
	[0.044]			[0.050]		
Number of observations	3,168			1,644		

	Percentage of Children Immunized: Measles					
	Total Sample			Rural		
Group	**Before Mitch**	**After Mitch**	**Time difference for group:**	**Before Mitch**	**After Mitch**	**Time difference for group:**
Treatments	0.879	0.428	-0.451	0.871	0.393	-0.478
	[0.015]	[0.026]	[0.030]	[0.017]	[0.030]	[0.034]
Controls	0.838	0.518	-0.320	0.830	0.490	-0.340
	[0.007]	[0.011]	[0.0133]	[0.010]	[0.016]	[0.019]
Difference at a point in time:	0.041	-0.090		0.041	-0.097	
	[0.010]	[0.013]		[0.020]	[0.034]	
Difference-in-difference	-0.131			-0.138		
	[0.033]			[0.039]		
Number of observations	3,369			1,794		

Notes: Standard errors clustered at the municipality level are presented in square brackets. The analysis here includes only children between 6 and 15 years old, except sample used to assess immunization that contains only children six years old or younger. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Table 8

Estimates of the Impact of Hurricane Mitch on Illness Prevalence and Health Care Utilization (Children between 6 and 15 years of age)

Dependent variable: Did child get sick?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.028	-0.025	-0.025	-0.025	-0.139	-0.088	-0.139	-0.128
	[0.017]	[0.019]	[0.018]	[0.020]	[0.066]	[0.086]	[0.058]	[0.071]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.017	-0.009	-0.012	-0.005	.....	.....	-0.088	-0.043
	[0.028]	[0.030]	[0.027]	[0.031]			[0.120]	[0.128]
After treatment * Household treated	0.050	0.053	0.047	0.051	0.258	0.247	0.263	0.26
	[0.037]	[0.036]	[0.039]	[0.038]	[0.165]	[0.168]	[0.151]	[0.152]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	8,690	8,690	8,690	8,690	5,715	5,715	8,690	8,690

Dependent variable: Health care utilization (conditioned on being sick)

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.100	0.063	0.100	0.063	0.495	0.351	0.621	0.397
	[0.023]	[0.028]	[0.023]	[0.028]	[0.170]	[0.226]	[0.134]	[0.165]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.005	-0.025	-0.006	-0.028	.....	.....	-0.304	-0.518
	[0.034]	[0.036]	[0.038]	[0.040]			[0.286]	[0.309]
After treatment * Household treated	-0.151	-0.157	-0.144	-0.153	-0.519	-0.482	-0.817	-0.864
	[0.046]	[0.046]	[0.042]	[0.042]	[0.431]	[0.440]	[0.362]	[0.367]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	2,755	2,755	2,755	2,755	814	814	2,755	2,755

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Random effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of 15. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

This estimate falls to 1.6% and becomes not statistically different from zero once we control for the beneficiary status of households in terms of programs of social aid aimed to alleviate the impact of the hurricane. Comparable results are reached using pooled Probit models, FE Conditional Logit (FECL) and Generalized Logit Random Effects (LRE). The Hausman specification tests favor the FECL model over the others (e.g. household fixed effects are not negligible) but the results are still very alike among these different models.

The second panel in *Table 6* confirms the previous findings concerning child labor. Overall, the four models predict an increase three years after the shock in the proportion of children under the age of 15 either working or looking for a job. On average, we find that the proportion of working children raised by 45% in the experimental regions, going from 16.1% to nearly 23.0%. These estimates are robust to different specifications and econometric methods. The findings summarized in the third panel confirm our previous hypothesis: children stayed in school but a relatively higher proportion of those affected by the hurricane had to work at the same time. In fact, due to the shock, the proportion of children both enrolled in school and engaged in work related activities almost doubled from 7.5% to approximately 13.5%.

The next set of results is presented in *Table 8* and includes two main dimensions: sickness prevalence and utilization of medical services for children between the age of 6 and 15. On the one hand, we find no systematic differences in children's illness incidence between treated and controls. Even though the point estimates are positive in all the regressions, they are not statistically significant at any standard level of confidence. On the other hand, conditioned on being ill, children in the experimental sample were about 15% less likely to be taken for consultation. All the estimates of this effect are statistically significant different from zero except those under the FCLE, which is comprehensible given the loss in efficiency characteristic of models that use only observations switching the status from one wave to another. Equivalent calculations (presented in *Table 9*) are carried out for children under 6 years old. In most cases the results of these exercises match those obtained for the first group of children analyzed, even though they are less precise because of the size of the sub-sample used.

Seeking to examine other consequences of the shock on health issues, we look at the percentage of children between 0 and 6 years old that were immunized. The D-D estimates presented in *Table 10* suggest that children in the treatment group were between 11% and 15% relatively less likely to be receiving shots against measles, approximately a 16% reduction from the original prevalence of immunization. We find no evidence of significant differences regarding vaccination to prevent other diseases such as tuberculosis, diphtheria and tetanus.

Table 9
Estimates of the Impact of Hurricane Mitch on Children's Vaccination
(Children between 0 and 6 years of age)

Dependent variable: Child immunized against tuberculosis?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.017	0.009	0.012	0.004	0.862	0.484	1.004	0.615
	[0.005]	[0.006]	[0.004]	[0.002]	[0.421]	[0.506]	[0.338]	[0.404]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.004	-0.004	0.001	-0.004	…..	…..	0.292	-0.332
	[0.012]	[0.012]	[0.005]	[0.005]			[0.481]	[0.506]
After treatment * Household treated	-0.003	-0.001	-0.005	0.000	0.101	0.366	0.288	0.383
	[0.017]	[0.018]	[0.016]	[0.006]	[1.131]	[1.167]	[0.870]	[0.839]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,587	4,587	4,587	4,587	263	263	4,587	4,587

Dependent variable: Child immunized against tetanus and difteria?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.247	-0.257	-0.202	-0.208	-4.131	-4.253	-3.998	-4.119
	[0.011]	[0.015]	[0.016]	[0.018]	[0.380]	[0.434]	[0.261]	[0.281]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.005	-0.015	-0.008	-0.015	…..	…..	-0.230	-0.419
	[0.015]	[0.014]	[0.020]	[0.018]			[0.353]	[0.363]
After treatment * Household treated	-0.013	-0.012	0.009	0.008	0.647	0.720	0.405	0.371
	[0.031]	[0.029]	[0.013]	[0.011]	[0.691]	[0.695]	[0.424]	[0.424]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,579	4,579	4,579	4,579	1,528	1,528	4,579	4,579

Dependent variable: Child immunized against measles?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.312	-0.302	-0.407	-0.399	-3.210	-2.881	-3.102	-3.025
	[0.017]	[0.019]	[0.024]	[0.023]	[0.240]	[0.270]	[0.162]	[0.178]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.034	0.026	0.053	0.039	…..	…..	0.496	0.375
	[0.018]	[0.017]	[0.030]	[0.028]			[0.242]	[0.251]
After treatment * Household treated	-0.114	-0.111	-0.166	-0.163	-1.354	-1.299	-1.170	-1.144
	[0.038]	[0.036]	[0.062]	[0.061]	[0.405]	[0.411]	[0.316]	[0.317]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,579	4,579	4,579	4,579	2,338	2,338	4,579	4,579

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. The analysis here includes only households with at least one child under the age of six. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane.

Table 10
D-D Estimates of the Impact of Hurricane Mitch on Children's Vaccination
(Children between 0 and 6 years of age)

Group	Before Mitch	After Mitch	Time difference for group:
	Percentage of children immunized: Tuberculosis		
Treatments	0.963	0.984	0.021
	[0.008]	[0.006]	[0.011]
Controls	0.968	0.986	0.018
	[0.003]	[0.002]	[0.004]
Group difference at a point in time:	-0.005	-0.002	
	[0.009]	[0.007]	
Difference-in-difference	0.003		
	[0.011]		
	Percentage of children immunized: Tetanus & Diphteria		
Group	**Before Mitch**	**After Mitch**	**Time difference for group:**
Treatments	0.947	0.663	-0.284
	[0.01]	[0.025]	[0.027]
Controls	0.952	0.703	-0.249
	[0.004]	[0.010]	[0.011]
Group difference at a point in time:	-0.005	-0.040	
	[0.011]	[0.027]	
Difference-in-difference	-0.035		
	[0.029]		
	Percentage of children immunized: Measles		
Group	**Before Mitch**	**After Mitch**	**Time difference for group:**
Treatments	0.879	0.428	-0.451
	[0.015]	[0.026]	[0.030]
Controls	0.838	0.518	-0.320
	[0.007]	[0.011]	[0.0133]
Group difference at a point in time:	0.041	-0.090	
	[0.010]	[0.013]	
Difference-in-difference	-0.131		
	[0.033]		
Number of observations	4,507	785	

Notes: Standard errors clustered at the municipality level are presented in square brackets. The analysis here includes households with at least one child under 15. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

In terms of nutrition, results are similar to the ones obtained for schooling, labor and use of health care; that is, Hurricane Mitch had a large and negative effect on children's nutritional status. As explained before, we use the child's weight-for-height (WFH) Z score, a summary measure of current nutrition. The Z score is calculated as standard deviations from the NCHS reference median, recommended by the WHO. Estimates for the effect of Hurricane Mitch on nutrition are obtained for children between 0 and 4 years of age since we have no nutritional information for older members of the household.

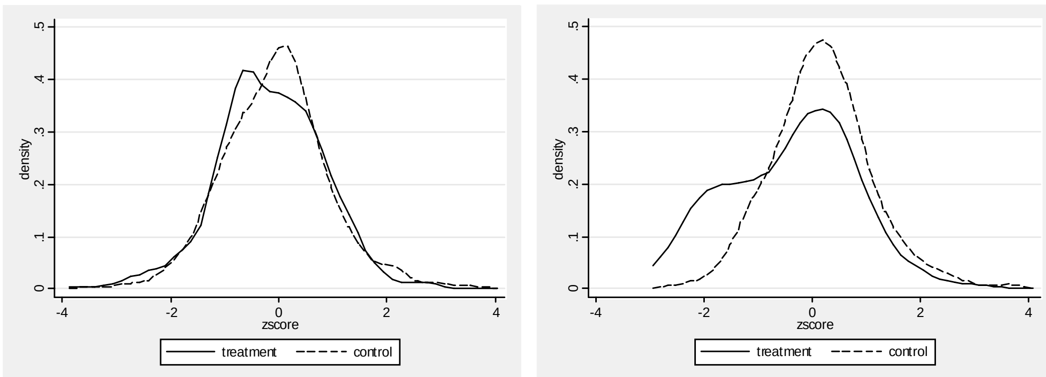
Figure 1

Z-score Weight-for Height Densities

(Children between 0 and 4 years of age)

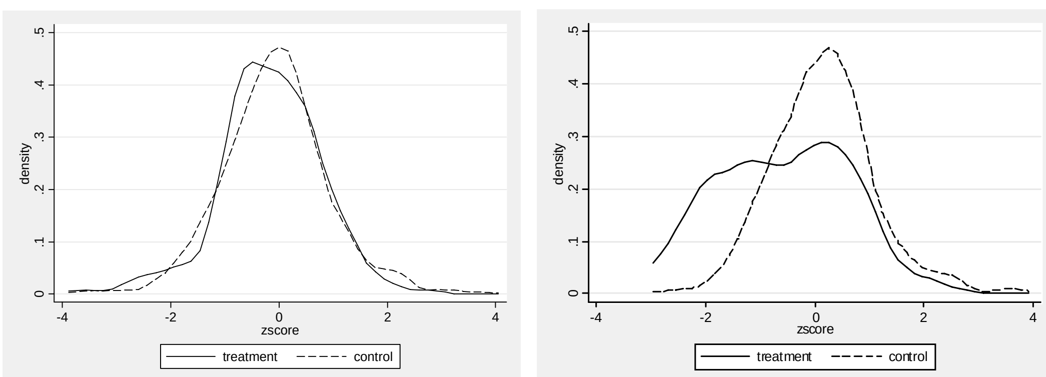
Z-SCORE: TREATMENT VS CONTROL (ALL KIDS)

1998 **2001**



Z-SCORE: TREATMENT VS CONTROL (BOYS)

1998 **2001**



Z-SCORE: TREATMENT VS CONTROL (GIRLS)

1998 **2001**

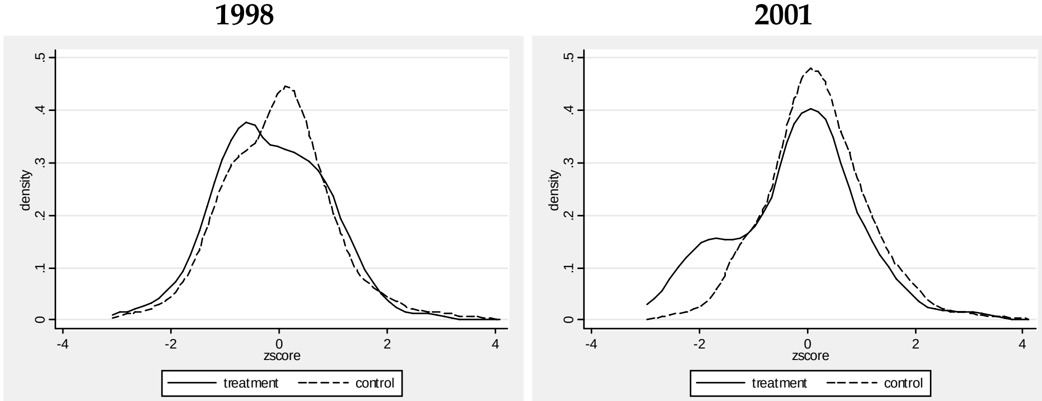
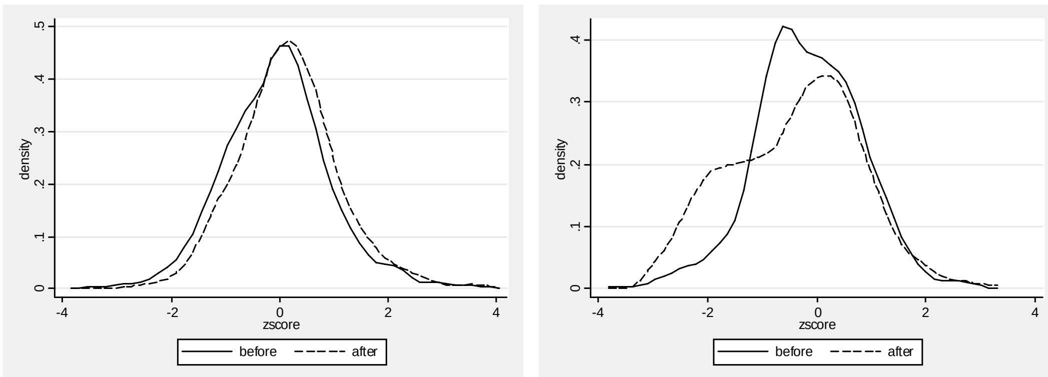
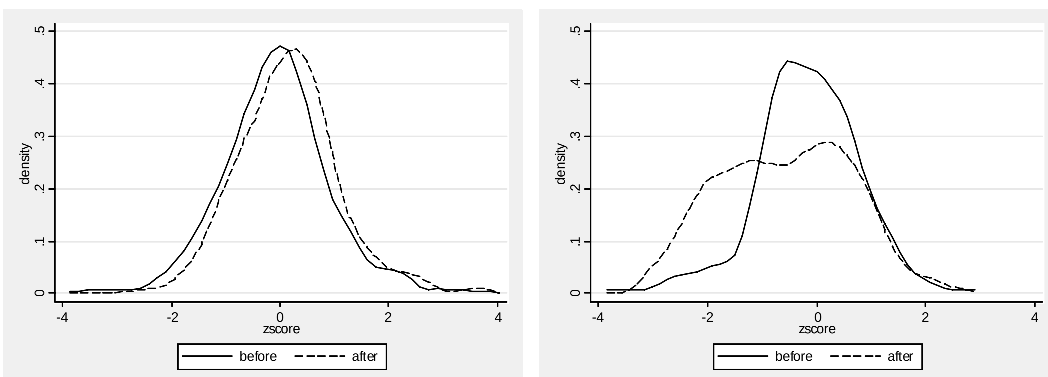


Figure 2
Z-score Weight-for Height Densities
(Children between 0 and 4 years of age)

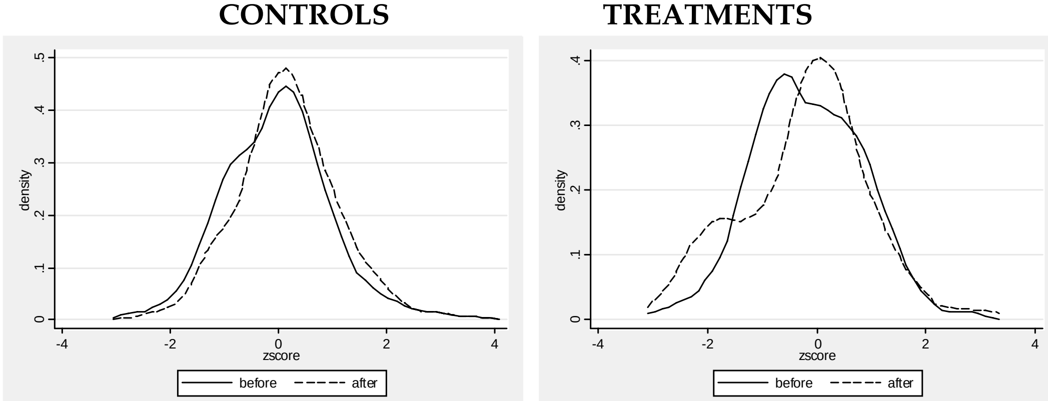
Z-SCORE: TREATMENTS AND CONTROLS BEFORE VS AFTER (ALL KIDS)
CONTROLS **TREATMENTS**



Z-SCORE: TREATMENTS AND CONTROLS BEFORE VS AFTER (BOYS)
CONTROLS **TREATMENTS**



Z-SCORE: TREATMENTS AND CONTROLS BEFORE VS AFTER (GIRLS)
CONTROLS **TREATMENTS**



In terms of undernourishment, we analyze two related indicators. We analyze both the Z-score itself and the probability of being severely undernourished- more than two standard deviations below the reference median.

Figures 1 & 2 show the Z score weight-for-height kernel densities for the whole sample of children before and after the shock, as well as separated by gender. This exercise is useful because it allows us to understand the effects of Mitch on the distribution of nutritional status, as opposed to just focusing on the probability of being malnourished. The graphs show that there was a large change in the shape of the distribution among children affected by Mitch, in particular among those already below the reference median (the distribution became much bulkier on the left hand side). Results are very similar for boys and girls separately, although for boys the effect seems to be a bit larger.

This interpretation is confirmed when analyzing the densities by group, as in *Figure 2*. While the distribution of weight for height Z scores among children not affected by Mitch shifted a little bit to the right (improvement in overall nutrition) between 1998 and 2001 for the whole sample, as well as for girls and boys separately, the situation is different for affected children. In particular, on the right hand side, the distribution seems to have marginally even shifted to the left, while on the left hand side, the distribution becomes significantly denser. That is, there was a large increase in the number of children severely malnourished among those affected by the natural disaster.

Table 11, on the other hand, includes the results for the multivariate analysis. It shows a change in the percentage of children, boys and girls, who are severely malnourished – that is, those with a Z score that is more than two standard deviations below the reference median.

Focusing on the Probit results, we find that children who suffered the income and asset shock are 5 percentage points more like to be undernourished vis a vis non-affected children. Results are statistically significant even after controlling for fixed effects, as revealed by the conditional fixed effects Logit results.

Similarly, the first part of *Table 11* presents the estimates for the effect of Mitch on the weight-for-height standardized index. We find that, on average, being affected by Mitch meant that a child got 0.53 standard deviations further below the WFH reference median.

Results are similar in magnitudes and still highly significant for rural households (*Annex 6*).

Table 11

Estimates of the Impact of Hurricane Mitch on Nutritional Status

(Children between 0 and 4 years of age)

Dependent variable: Z-score Weight-for-height

Variable	Pooled OLS (i)	Pooled OLS (ii)	Fixed Effects OLS (i)	Fixed Effects OLS (ii)	Random Effects (i)	Random Effects (ii)	Maximum Likelihood (i)	Maximum Likelihood (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.193	0.193	0.189	0.190	0.190	0.191	0.190	0.191
	[0.042]	[0.043]	[0.043]	[0.044]	[0.034]	[0.034]	[0.034]	[0.034]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.097	-0.051	…..	…..	-0.077	-0.042	-0.077	-0.043
	[0.083]	[0.093]			[0.067]	[0.071]	[0.066]	[0.071]
After treatment * Household treated	-0.459	-0.471	-0.553	-0.529	-0.49	-0.488	-0.489	-0.487
	[0.115]	[0.117]	[0.110]	[0.115]	[0.088]	[0.092]	[0.088]	[0.092]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	no	no	yes	no	yes
Number of observations	3,512	3,512	3,512	3,512	3,512	3,512	3,512	3,512

Dependent variable: Children under Severe Undernutrition (<-2 Z)

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.014	-0.016	-0.016	-0.015	-1.270	-1.383	-0.866	-0.927
	[0.005]	[0.005]	[0.006]	[0.005]	[0.502]	[0.532]	[0.313]	[0.317]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.014	0.012	0.012	0.010	…..	…..	0.465	0.418
	[0.012]	[0.013]	[0.010]	[0.009]			[0.345]	[0.385]
After treatment * Household treated	0.072	0.055	0.080	0.049	3.230	3.087	1.839	1.503
	[0.026]	[0.022]	[0.038]	[0.026]	[0.797]	[0.826]	[0.485]	[0.520]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	no	no	no	yes
Number of observations	3,512	3,512	3,512	3,512	230	230	3,512	3,512

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Logit Random Effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of four. Household and individual demographics in several specifications include child's age, gender and breastfeeding records, school attainment of both household head and spouse, number of members within the household, log of income per capita, area of location, and distance to closest health center. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of drinking water, sewage, electricity, employment, health campaigns and donation of food, vitamins and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Results from Alternative Methods and Samples

In what follows we present a set of checks in order to assure that our identification strategy is in fact extracting the causal effect of the shock on investments on children. To do so, we perform a series of empirical exercises in two directions. On one hand, we construct other possible counterfactuals in an attempt to account for possible biases due to systematic differences between the initial experimental and non-experimental groups. Thus, we recalculate our previous estimates comparing treated and control units, first focusing separately on rural and urban areas and second in those cultivating similar crops. On the other hand, we test the trends between the two groups using a National Household Survey from 1993 to simulate a pseudo D-D, in which our treated households are not exposed to the shock (i.e. all the units taking a placebo).

The results comparing only experimental and non-experimental rural units are very close to those obtained using the complete sample, although obviously they are slightly less precise. In short, we find no differences in school attendance, a significant increase in children's attachment to the labor market, similar illness prevalence, lower health care utilization and, to some extent, less vaccination against some common diseases when the analysis is restricted to rural households.

VII. Concluding Remarks

The results of this paper suggest that households reduce the investment in their children after an asset and income shock like a natural disaster given the large cash expenditures required for children's education and health. The absence of more efficient mechanisms to deal with natural disasters puts households in a situation where they need to make difficult choices: which expenditures or investments to cut? From a policy perspective, it is relevant to know what these choices are. This study indicates that children may be significantly affected after the reallocation of resources needed when assets and income drastically fall after a disaster.

There are three areas in which we are still working for this paper. First, we are going to construct different control groups to test our main hypotheses and verify the plausibility of our identifying assumption. In particular, we are going to compare rural households that grow the same crops (to control for shocks, i.e. price fluctuations, and insurance mechanisms) and also those located in the same regions. Second, we are going to introduce different measures of the shock, as described on the text – whether the dwelling was destroyed or suffered significant damages. In addition, we are going to instrument for Mitch using historical rain data available for Nicaragua. Finally, a section on the implications of our results and the external validity of this study is still pending.

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Annex 1

Means of Some Relevant Characteristics in Rural Households by Treatment Status

Variable	1998: Before Mitch Treatment (Mitch=1)	1998: Before Mitch Control (Mitch=0)	1998: Before Mitch Diff	2001: After Mitch Treatment (Mitch=1)	2001: After Mitch Control (Mitch=0)	2001: After Mitch Diff	Diff-in-diff
Number of members per household	6.56	6.34	0.220	6.64	6.48	0.160	-0.060
	[0.173]	[0.089]	[0.195]	[0.166]	[0.092]	[0.190]	[0.272]
Number of children per household	2.90	2.94	-0.037	2.71	2.79	-0.078	-0.041
	[0.123]	[0.066]	[0.140]	[0.114]	[0.065]	[0.131]	[0.192]
Age: 0-6 years	1.28	1.32	-0.039	1.07	1.16	-0.088	-0.049
	[0.074]	[0.030]	[0.083]	[0.065]	[0.037]	[0.075]	[0.112]
Age: 6-15 years	1.62	1.62	0.006	1.64	1.64	0.009	0.003
	[0.082]	[0.045]	[0.094]	[0.083]	[0.046]	[0.095]	[0.133]
Proportion of children that are girls	0.517	0.491	0.026	0.498	0.483	0.015	-0.011
	[0.019]	[0.010]	[0.022]	[0.020]	[0.011]	[0.023]	[0.032]
Age of household head	45.46	44.56	0.903	47.17	46.85	0.320	-0.583
	[0.929]	[0.484]	[1.048]	[0.912]	[0.499]	[1.039]	[1.475]
Age of children	7.63	7.23	0.395	7.68	7.65	0.033	-0.362
	[0.215]	[0.110]	[0.242]	[0.208]	[0.112]	[0.236]	[0.338]
Years of schooling: head of household	2.18	2.52	-0.346	2.24	2.36	-0.120	0.226
	[0.165]	[0.105]	[0.196]	[0.147]	[0.099]	[0.178]	[0.265]
Years of schooling: spouse	2.40	2.60	-0.202	2.25	2.445	-0.197	0.005
	[0.187]	[0.112]	[0.198]	[0.165]	[0.109]	[0.198]	[0.294]
Female headed households	0.153	0.192	-0.039	0.210	0.303	-0.093	-0.054
	[0.021]	[0.012]	[0.024]	[0.020]	[0.009]	[0.022]	[0.036]
Income per capita	2,613	3,391	-777.9	4,251	5,097	-845.8	-67.9
	[275.1]	[341.2]	[438.3]	[246.4]	[345.7]	[424.5]	[610.1]
Percent with own house	0.388	0.442	-0.054	0.444	0.449	-0.005	0.049
	[0.028]	[0.015]	[0.032]	[0.029]	[0.016]	[0.033]	[0.047]
Distance to closest health center (minutes)	16.93	14.00	2.930	20.62	22.62	-2.003	-4.933
	[0.375]	[0.200]	[0.426]	[0.364]	[0.211]	[0.421]	[0.599]
Distance to closest primary school (minutes)	14.95	13.65	1.302	14.64	15.12	-0.480	-1.782
	[0.301]	[0.165]	[0.343]	[0.283]	[0.162]	[0.326]	[0.474]
Children no breastfed	0.031	0.032	-0.001	0.016	0.016	0.000	0.001
	[0.011]	[0.006]	[0.013]	[0.009]	[0.005]	[0.010]	[0.017]
Number of households	286	993		286	993		

Notes: Standard errors are presented in square brackets. The analysis here includes only households with at least one child under the age of 15. Income per capita expressed in Nicaraguan Cordobas of 1998. See text for definitions of experimental and non experimental households and before and after years.

Annex 2

Estimates of the Impact of Hurricane Mitch on School Attendance and Child Labor in Rural Households (Children between 6 and 15 years of age)

Dependent variable: School attendance

	LPM - OLS Pooled		Probit Pooled		Conditional Logit Fixed Effects		Logit Random Effects	
Variable	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**
After treatment (t=1 if 2001, 0=otherwise)	-0.012	-0.014	-0.011	-0.012	-0.436	-0.291	-0.179	-0.166
	[0.017]	[0.016]	[0.018]	[0.015]	[0.159]	[0.135]	[0.132]	[0.121]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.006	0.000	0.000	-0.008	…..	…..	-0.090	-0.155
	[0.023]	[0.022]	[0.023]	[0.021]			[0.222]	[0.227]
After treatment * Household treated	0.065	0.067	0.077	0.078	0.993	0.981	0.731	0.725
	[0.030]	[0.028]	[0.040]	[0.036]	[0.283]	[0.270]	[0.252]	[0.242]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,421	4,643	4,421	4,643	2,300	2,497	4,421	4,643

Dependent variable: Child labor participation

	LPM - OLS Pooled		Probit Pooled		Conditional Logit Fixed Effects		Logit Random Effects	
Variable	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**
After treatment (t=1 if 2001, 0=otherwise)	0.071	0.068	0.075	0.067	0.660	0.658	0.574	0.557
	[0.020]	[0.022]	[0.021]	[0.022]	[0.145]	[0.156]	[0.118]	[0.128]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.010	0.014	0.004	0.007	…..	…..	0.129	0.103
	[0.028]	[0.028]	[0.026]	[0.025]			[0.189]	[0.207]
After treatment * Household treated	0.028	0.013	0.041	0.026	0.076	0.104	0.269	0.189
	[0.033]	[0.033]	[0.032]	[0.032]	[0.252]	[0.263]	[0.234]	[0.240]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	4,244	4,244	4,244	4,244	2,076	2,076	4,244	4,244

Dependent variable: School attendance and child labor participation

	LPM - OLS Pooled		Probit Pooled		Conditional Logit Fixed Effects		Logit Random Effects	
Variable	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**
After treatment (t=1 if 2001, 0=otherwise)	-0.004	-0.005	-0.003	-0.004	-0.499	-0.633	-0.155	-0.243
	[0.017]	[0.016]	[0.016]	[0.014]	[0.186]	[0.213]	[0.156]	[0.175]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.006	0.003	-0.005	0.002	…..	…..	-0.162	-0.125
	[0.020]	[0.021]	[0.019]	[0.018]			[0.267]	[0.290]
After treatment * Household treated	0.068	0.049	0.064	0.044	0.994	1.067	0.867	0.728
	[0.028]	[0.030]	[0.037]	[0.032]	[0.329]	[0.336]	[0.296]	[0.301]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	9,070	9,070	4,415	4,415	1,429	1,429	4,415	4,415

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Random effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of 15. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of schools, health centers, housing, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Annex 3

Estimates of the Impact of Hurricane Mitch on Illness Prevalence and Health Care Utilization in Rural Households

(Children between 0 and 6 years of age)

Dependent variable: Did child get sick?

	LPM - OLS Pooled		**Probit Pooled**		**Conditional Logit Fixed Effects**		**Logit Random Effects**	
Variable	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**
After treatment (t=1 if 2001, 0=otherwise)	0.063	0.030	0.043	0.000	0.233	-0.013	0.280	-0.009
	[0.031]	[0.044]	[0.024]	[0.032]	[0.199]	[0.264]	[0.155]	[0.196]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.001	0.015	0.000	0.015	…..	…..	0.042	0.151
	[0.033]	[0.034]	[0.035]	[0.035]			[0.213]	[0.230]
After treatment * Household treated	-0.056	-0.065	-0.028	-0.035	-0.426	-0.448	-0.215	-0.256
	[0.057]	[0.058]	[0.049]	[0.048]	[0.384]	[0.392]	[0.316]	[0.318]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	2,204	2,204	2,204	2,204	916	916	2,204	2,204

Dependent variable: Health care utilization (conditioned on being sick)

	LPM - OLS Pooled		**Probit Pooled**		**Conditional Logit Fixed Effects**		**Logit Random Effects**	
Variable	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**	**(i)**	**(ii)**
After treatment (t=1 if 2001, 0=otherwise)	0.149	0.119	0.153	0.128	1.471	1.180	1.284	1.411
	[0.073]	[0.076]	[0.074]	[0.080]	[0.565]	[0.695]	[0.408]	[0.601]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.060	0.106	0.061	0.112	…..	…..	0.648	1.301
	[0.081]	[0.090]	[0.082]	[0.090]			[0.538]	[0.842]
After treatment * Household treated	-0.198	-0.198	-0.203	-0.204	-2.143	-2.921	-1.871	-2.823
	[0.126]	[0.132]	[0.121]	[0.131]	[1.244]	[1.697]	[0.812]	[1.098]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	553	553	553	553	115	115	982	982

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Random effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of 15. Household and individual demographics include age, gender and school attainment for both children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Annex 4

Estimates of the Impact of Hurricane Mitch on Illness Prevalence and Health Care Utilization in Rural Households

(Children between 6 and 15 years of age)

Dependent variable: Did child get sick?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.032	-0.017	-0.027	-0.013	-0.040	0.009	-0.136	-0.072
	[0.023]	[0.020]	[0.023]	[0.028]	[0.121]	[0.146]	[0.099]	[0.117]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.026	-0.028	-0.020	-0.020	…..	…..	-0.157	-0.141
	[0.034]	[0.033]	[0.034]	[0.035]			[0.144]	[0.160]
After treatment * Household treated	0.062	0.069	0.057	0.067	0.260	0.299	0.297	0.325
	[0.044]	[0.043]	[0.046]	[0.046]	[0.212]	[0.219]	[0.190]	[0.192]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	3,827	3,827	3,827	3,827	2,519	2,519	3,827	3,827

Dependent variable: Health care utilization (conditioned on being sick)

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.103	0.039	0.100	0.035	0.492	0.221	0.700	0.285
	[0.040]	[0.043]	[0.040]	[0.043]	[0.321]	[0.398]	[0.241]	0.291
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.014	-0.051	-0.014	-0.055	…..	…..	-0.430	-0.819
	[0.048]	[0.052]	[0.049]	[0.052]			[0.376]	0.433
After treatment * Household treated	-0.155	-0.157	-0.139	-0.143	-0.341	-0.157	-0.819	-0.874
	[0.061]	[0.063]	[0.050]	[0.050]	[0.606]	[0.638]	[0.486]	[0.498]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	1,285	1,285	1,285	1,285	345	345	1,285	1,285

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Random effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of 15. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.

Annex 5

Estimates of the Impact of Hurricane Mitch on Children's Vaccination in Rural Households
(Children between 0 and 6 years of age)

Dependent variable: Child immunized against tuberculosis?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.028	0.012	0.020	0.007	1.636	1.001	1.234	0.756
	[0.010]	[0.010]	[0.006]	[0.004]	[1.177]	[1.147]	[0.576]	[0.644]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.006	0.002	0.001	-0.002	…..	…..	0.050	-0.116
	[0.015]	[0.016]	[0.009]	[0.007]			[0.616]	[0.656]
After treatment * Household treated	-0.010	-0.001	-0.013	-0.005	0.123	0.339	-0.447	-0.116
	[0.025]	[0.025]	[0.029]	[0.017]	[1.604]	[1.594]	[1.018]	[0.656]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	2,189	2,189	2,189	2,189	162	162	2,189	2,189

Dependent variable: Child immunized against tetanus and difteria?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.255	-0.274	-0.233	-0.247	-4.161	-4.625	-4.569	-4.819
	[0.016]	[0.023]	[0.027]	[0.033]	[0.627]	[0.718]	[0.467]	[0.530]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.011	-0.026	-0.010	-0.021	…..	…..	-0.404	-0.602
	[0.019]	[0.016]	[0.027]	[0.021]			[0.481]	[0.504]
After treatment * Household treated	-0.027	-0.012	0.000	0.007	0.548	0.402	0.422	0.402
	[0.040]	[0.038]	[0.022]	[0.016]	[0.852]	[0.849]	[0.582]	[0.583]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	2,186	2,186	2,186	2,186	710	710	2,186	2,186

Dependent variable: Child immunized against measles?

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.330	-0.332	-0.434	-0.452	-3.445	-3.207	-3.369	-3.366
	[0.024]	[0.029]	[0.036]	[0.038]	[0.379]	[0.421]	[0.271]	[0.292]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.024	0.013	0.046	0.028	…..	…..	0.372	0.226
	[0.023]	[0.021]	[0.039]	[0.035]			[0.297]	[0.309]
After treatment * Household treated	-0.136	-0.124	-0.193	-0.174	-1.264	-1.224	-1.333	-1.247
	[0.042]	[0.042]	[0.071]	[0.072]	[0.526]	[0.531]	[0.408]	[0.404]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	yes	yes	no	yes
Number of observations	2,186	2,186	2,186	2,186	1,108	1,108	2,186	2,186

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. The analysis here includes only households with at least one child under the age of six. Household and individual demographics include age, gender and school attainment for children and household head and the number of members, log of income per capita and area of location. Other controls include dummies of households owning businesses and land to crop. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of water, sewage, electricity, employment, health campaigns and donation of food and drugs after the Hurricane.

Annex 6

Estimates of the Impact of Hurricane Mitch on Nutritional Status in Rural Households
(Children between 0 and 4 years of age)

Dependent variable: Z-score Weight-for-height

Variable	Pooled OLS (i)	Pooled OLS (ii)	Fixed Effects OLS (i)	Fixed Effects OLS (ii)	Random Effects (i)	Random Effects (ii)	Maximum Likelihood (i)	Maximum Likelihood (ii)
After treatment (t=1 if 2001, 0=otherwise)	0.148	0.140	0.089	0.089	0.134	0.127	0.134	0.127
	[0.067]	[0.070]	[0.066]	[0.066]	[0.051]	[0.052]	[0.051]	[0.052]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	-0.091	0.000	…..	…..	-0.074	-0.002	-0.074	-0.002
	[0.093]	[0.112]			[0.078]	[0.086]	[0.078]	[0.085]
After treatment * Household treated	-0.400	-0.392	-0.486	-0.448	-0.421	-0.392	-0.42	-0.392
	[0.137]	[0.141]	[0.128]	[0.134]	[0.104]	[0.109]	[0.104]	[0.109]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	no	no	yes	no	yes
Number of observations	1,833	1,833	1,833	1,833	1,833	1,833	1,833	1,833

Dependent variable: Children under Severe Undernutrition (<-2 Z)

Variable	LPM - OLS Pooled (i)	LPM - OLS Pooled (ii)	Probit Pooled (i)	Probit Pooled (ii)	Conditional Logit Fixed Effects (i)	Conditional Logit Fixed Effects (ii)	Logit Random Effects (i)	Logit Random Effects (ii)
After treatment (t=1 if 2001, 0=otherwise)	-0.017	-0.019	-0.022	-0.022	-1.180	-1.264	-1.050	-1.167
	[0.007]	[0.007]	[0.010]	[0.008]	[0.742]	[0.767]	[0.474]	[0.490]
Household treated (d=1 if household hit by Mitch, 0=otherwise)	0.021	0.014	0.017	0.011	…..	…..	0.635	0.491
	[0.014]	[0.015]	[0.012]	[0.010]			[0.386]	[0.451]
After treatment * Household treated	0.071	0.052	0.083	0.050	2.693	2.522	1.855	1.554
	[0.030]	[0.025]	[0.041]	[0.029]	[0.926]	[0.941]	[0.614]	[0.664]
Household and individual demographics	yes	yes	yes	yes	yes	yes	yes	yes
Controls for programs of social aid	no	yes	no	yes	no	yes	no	yes
Controls for state effects	no	yes	no	yes	no	no	no	yes
Number of observations	1,833	1,833	1,833	1,833	139	139	1,833	1,833

Notes: Standard errors clustered at the municipality level are presented in square brackets. Probit coefficients reported correspond to marginal effects. Logit Random Effects models computed using Gauss-Hermite quadrature. The analysis here includes only households with at least one child under the age of four. Household and individual demographics in several specifications include child's age, gender and breastfeeding records, school attainment of both household head and spouse, number of members within the household, log of income per capita, area of location, and distance to closest health center. Dummies of programs of social aid include public assistance in terms of construction and reconstruction of health centers, provision of drinking water, sewage, electricity, employment, health campaigns and donation of food, vitamins and drugs after the Hurricane. Approximately 15% of the total number households represent the experimental group. See text for definitions of experimental and non experimental households and before and after years.