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Child Health in a Post-Flood Period in Bangladesh

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ABSTRACT

In the summer of 1998, Bangladesh was inundated by significant flooding that covered two-thirds of the country and affected more than 30 million people. Although annual flooding is normal and expected in Bangladesh, the 1998 floods caused extraordinary devastation and were considered a "century" flood. Homestead flooding, crop loss and infrastructure damage all compromised food security in rural areas. In this paper I use longitudinal data from the post-flood period in rural Bangladesh to examine children's nutritional status in the post-flood recovery period. I find that parent's human capital (as measured by mother's height and educational attainment of the household head) attenuates the negative effects of flood exposure on children's nutritional status during the post-flood year. Understanding the implications of a post-disaster recovery period for child welfare is vital for future planning and relief efforts. This study contributes to these efforts by exploiting longitudinal data and age differences in growth rates to identify the importance of parental human capital in protecting children during nutritionally vulnerable periods.

INTRODUCTION

In the summer of 1998, Bangladesh was inundated by significant flooding that covered two-thirds of the country and affected more than 30 million people. Although annual flooding is normal and expected in Bangladesh, the 1998 floods caused extraordinary devastation and were considered a "century" flood. Homestead flooding, crop loss, and infrastructure damage compromised household food security and increased disease prevalence in a population with already high rates of poverty and malnutrition.

Unfortunately, this type of scenario has become increasingly common around the world: a significant crisis—whether environmental, economic, or political—devastates a large population of densely-settled households who are already trapped in chronic poverty. How do households anticipate and respond to such crises in the context of ongoing livelihood struggles? Do shocks affect investments in human capital? More specifically, what happens to children in the wake of such shocks? In this paper I use longitudinal data from the post-flood period in rural Bangladesh to examine how children's human capital, as measured by nutritional status, responds in the aftermath of flooding. I emphasize the importance of analyzing these responses in a dynamic context, linking exposure to shocks and nutritional outcomes to longer-term measures of household vulnerability and resources.

I pose two related research questions. First, how were children's nutritional trajectories in the year following the flood affected by exposure to the flooding in the summer of 1998? To address the endogeneity of flood exposure, I use a difference-in-difference-in-difference estimator with individual fixed effects, exploiting the fact that younger children are more vulnerable than older children to nutrition shocks. I next ask whether the relationship between flood exposure and child growth is moderated by parental human and financial capital, hypothesizing that households with lower levels of pre-flood resources are less able to protect children from nutrition shocks.

These analyses help to answer several important policy questions related to crisis and recovery in vulnerable populations. The results reveal the extent to which children were nutritionally compromised by the flood, and which children fared worst. The analyses also contribute specifically to the design and implementation of livelihood interventions, and relief and recovery efforts. Can households use financial and human capital to protect children's nutritional status from significant shocks to income and food security? Given the increasing exposure to shocks and the quantity of resources allocated post-disaster to relief and recovery, these questions are not trivial.

CHILD GROWTH AND GROWTH FALTERING

Infants and young children grow rapidly from birth through age three or four. Nutrition and disease during this stage largely determine the proportion of genetic growth potential that will be achieved by age three (Martorell, 1995, 1999; Martorell & Ho, 1984). Stature achieved by age three is in turn associated with important human capital outcomes, including physical and mental development, school performance, labor productivity, and wages (Alderman, Hoddinott, & Kinsey, 2002; Behrman, 1996; Grantham-McGregor, Fernald, & Sethurman, 1999; Grantham-McGregor, Walker, Chang, & Powell, 1997; Thomas & Strauss, 1997). This suggests that nutritional insults suffered before age three can have lasting consequences throughout life.

Nutritional vulnerability in the preschool years results from several factors. First, younger children require more food relative to their weight than older children and adults in order to maintain rapid growth at this stage (Martorell & Habicht, 1986). Immature immune systems leave children vulnerable to infections that can both lead to and exacerbate inadequate dietary intake (Chen, 1983; Scrimshaw, Taylor, & Gordon, 1968). The transition from breastmilk to table foods, usually occurring between 12 and 24 months, also makes toddlers vulnerable to malnutrition at a time when they are still wholly dependent on caregivers for feeding (UNICEF, 1990).

Nutrition shocks, therefore, most often take the form of inadequate dietary intake, severe or prolonged episodes of diarrheal and other diseases, or both. Abrupt reductions in dietary intake may be the result of child-specific factors such as the arrival of a new sibling or the death of a caregiver; household-specific factors such as crop failure, business loss, eviction, or illness of a primary wage earner; or more macro factors like drought or conflict that may create widespread disruptions in food security. Similarly, diarrheal and infectious disease episodes that contribute to nutrition shocks can be child- , household-, or community-level events.

Growth Trajectories in Bangladesh

Unfortunately, both chronic and acute spells of inadequate dietary intake and infectious diseases are regular occurrences for many children in the developing world, resulting in substantial growth faltering. Growth faltering can be measured by tracking standardized anthropometric measures over time. For example, standardized height-for-age z-scores reflect the deviation from the growth standard for well-nourished children of the same age and sex (Kuczmarski, Ogden, & Guo, 2002).

Across Asia, children are born near the growth reference standard for height-for-age. However, height-for-age z-scores quickly fall from birth to 24 months, and then plateau or continue to fall more slowly (Shrimpton et al., 2001). The situation is particularly dire in Bangladesh where more than half of all of rural children aged two to six are stunted (Bangladesh Nutritional Surveillance Project, 2002). Stunting, defined as a height-for-age z-score of -2.0 or lower, is a pronounced slowing of skeletal growth and stature. Stunting typically results from chronic undernutrition but acute nutrition shocks can also permanently affect growth trajectories.

Estimated stunting rates for rural children in Bangladesh by age and over time are shown in Figure 1. These estimates (results not shown) are calculated from pooled observations from 32 different regional and national anthropometry surveys in Bangladesh from 1982 through 2003 (World Health Organization, 2005). Figure 1 captures two important features of height-for-age trajectories in Bangladesh. First, the steep increase in stunting rates from birth through age two is clear, after which stunting rates improve a bit and then level off. Second, stunting rates in Bangladesh have improved considerably over time. In these estimates, stunting rates improve .74 percentage points each year. This implies a small but significant positive time trend in height-for-age z-scores.

Shocks, Resilience, and Household Coping Responses

How do households respond to a shock large enough to potentially compromise the nutritional status of household members? A rich literature on risk in developing countries (Alderman & Paxson, 1992; Besley, 1995; Cain, 1981; Cox & Jimenez, 1998; Morduch, 1995; Rosenzweig, 1988; Rosenzweig & Wolpin, 1993; Townsend, 1994, 1995; Udry, 1993) suggests that some households attempt to smooth either consumption or assets (or more generally, smooth utility or welfare) across time and across space in the wake of shocks to income. *Ex ante*, households can adopt risk management strategies including income smoothing and diversification, investment in formal and informal insurance arrangements, and asset accumulation, a key form of self-insurance (Alderman & Paxson, 1992; Deaton, 1991; Dercon, 2005). *Ex post*, coping strategies to smooth consumption can include spending down savings, selling assets, borrowing money, and relying on transfers from familial networks or governments (Dercon, 2005; Siegel & Alwang, 1999). Households can also forgo or delay consumption of some items to maintain spending on essential staples like food and shelter (Frankenberg, Smith, & Thomas, 2003).

For many households in developing countries, however, the menu of risk management and coping strategies is constrained by access to well-functioning markets, including commodity, credit and insurance markets. Urban households may lack strong kin or social network ties that facilitate informal insurance arrangements. This leaves assets as a critical and flexible tool for welfare smoothing and risk management. The use of assets to manage risk and smooth welfare is context-dependent and varies by wealth levels (Carter, Little, Mogues, & Negatu, 2004). For example, distress sales of jewelry or land will depend on liquidity and prices (Frankenberg et al., 2003). Similarly, livestock may function as a consumption asset to be sold (Rosenzweig & Wolpin, 1993), but may also be an important (and lumpy) productive asset that a poor household will protect at the expense of other assets or consumption (Carter, 1997; Carter et al., 2004; Deaton, 1991).

Several studies in the past decade have documented the effects of shocks on children's human capital. Foster (1995) provides evidence that children were vulnerable to weight loss after the 1988 floods in Bangladesh, particularly in landless households that had no access to credit. Hoddinott and Kinsey (2001) show that children who were 12-24 months old during a severe drought in Zimbabwe were shorter four years later than children of the same age who had not been exposed to the drought. Deolalikar (2004) finds a significant association between the likelihood of being stunted and recent village-level flooding among children in Bangladesh. The effect of village-level flooding on the odds of being stunted is twice as large for children in the lowest wealth quintile relative to the full sample.

THE BANGLADESH CONTEXT

Bangladesh is a densely-populated country situated on the Bay of Bengal in South Asia. Three large river systems run from India, China, Nepal and Bhutan through Bangladesh to empty into the Bay of Bengal: the Ganges, the Brahmaputra, and the Meghna. During the monsoon season in July, August, and September, the rivers reach their peak flows and normally overflow their banks, inundating large parts of the country. This annual flooding cycle is an expected and important event. The floods irrigate the main *aman* monsoon rice crop and improve soil fertility in flood plain areas.

Certain factors, both natural and anthropogenic, can contribute to more severe flooding. Tectonic shifts, heavy snowfalls in the mountains, and cyclones can amplify the annual flooding. When the three rivers reach their peak flows at the same time (which happened five times between 1954 and 1998) flooding is considerably more severe. Changes in land use and land cover have reduced the absorptive capacity of the flood plains, while major flood control structures like embankments and levies can direct massive amounts of flood water towards vulnerable areas. While the evidence is still inconclusive, it does appear that global climate change may be contributing to more frequent and severe floods in the Bay of Bengal and elsewhere (Few, Ahern, Matthiers, & Kovats, 2004). Meanwhile, rapid population growth in Bangladesh in the last half-century has meant that floods affect more people and damage more property. Unstable *char* (floodplain) lands are now settled by an ever-changing population of poor landless households. Industry and agriculture also compete for limited land area.

The health impacts of severe flooding can be enormous (Few et al., 2004). Immediate risks include drowning and injuries from water-borne debris. In the aftermath of flooding, contaminated water and other vectors contribute to elevated rates of diarrheal diseases, respiratory infections, and skin infections. Access to food can be interrupted due to crop loss, road damage, and price swings. Households can suffer damage to housing and other productive assets, disrupting livelihoods. Access to health services may be compromised if health infrastructure is damaged.

The 1998 Floods

The 1998 flood season in Bangladesh was extraordinary in many ways. Several excellent and detailed accounts of the flooding are available elsewhere (see, for example, Beck, 2005; del Ninno, Dorosh, Smith, & Roy, 2001; Few et al., 2004) but a few key points are worth highlighting here. The flood waters starting rising in early July as usual, but by late July heavy flows in all three river basins led to inundation of 30 percent of the country. By the end of the August, this figure was 41 percent. Flooding peaked in September with 51 percent of the country inundated. Both the coverage and duration of the 1998 floods exceeded the most recent severe flooding of 1988 by considerable margins: 100,250 square kilometers inundated in 1998 vs. 89,970 in 1988; and an average of 59 days of water above danger level in the river basins in 1998 vs. 34 in 1988. Peak flood levels in the two years were similar at over 11 meters (del Ninno et al., 2001).

Flood damage in 1998 was commensurately severe as well. Almost 1,000 people were killed, 980,000 homes were affected, and more than one million people were displaced. In all, 30 million people were directly affected by the floods. More than two million tons of rice crops were lost, 15,000 kilometers of roads were damaged, and 26,000 cattle were lost.

Del Ninno and colleagues have produced a thorough account of the 1998 flood at the household level based on the same dataset used in this study (del Ninno et al., 2001). Cross-sectional results from the first survey round indicate that more than half of households lost assets in the flood and almost half suffered housing damage. Employment for day laborers declined abruptly after the floods. A significant portion of households became food insecure after the floods, and diarrheal and respiratory diseases were common. To cope with the floods many household took on debt or purchased food on credit, and many households relied on food aid and cash transfers from the government and from local and national NGOs.

In a separate study, del Ninno and Lundberg (2005) address similar questions to the ones I pose here. Specifically, they seek to demonstrate that the flooding caused growth faltering and that children who faltered post-flood experienced no catch-up growth. Using a sample of children less than five years old at the end of 1999, they find no evidence of catch-up growth by estimating the coefficient on a lagged height-for-age term in a model predicting the change in height-for-age across survey rounds. In other words, flood-exposed children do not grow more quickly after the flood than unexposed children, suggesting that they do not recover their pre-flood growth trajectories. I extend this work in several ways. First, I include a wider age range of children. Few studies of child nutritional status and shocks focus on children older than three years primarily because the slower pace of physical and cognitive development of older children makes the effects of shocks on their developmental outcomes less obvious. Nonetheless, nutritional shocks for older children are important because they can affect the timing and length of pubertal growth, a major determinant of adult stature. Responses to nutritional shocks are also important for school-aged children because they may affect their ability to attend school and their school performance after a shock. Additionally, there is some evidence that older children may suffer disproportionately reduced food consumption after a shock as families try to maintain the consumption of younger siblings (McDonald, Sigman, Espinosa, & Neumann, 1994).

I also extend previous work by directly addressing the issue of endogeneity of flood exposure. Finally, I incorporate pre-flood measures of parental human capital and other household resources into the model, in order to evaluate the potentially protective role these resources may play during a nutritionally vulnerable period.

DATA

The data for this study are drawn from the Coping Strategies in Bangladesh survey, a longitudinal panel survey fielded by the International Food Policy Research Institute (IFPRI) in partnership with the Food Management and Research Support Project of the Bangladesh Ministry of Food. The goal of the survey was to assess household and community responses to the severe flooding in Bangladesh in summer 1998. Complete details of the survey design and sampling are provided in del Ninno et al. (2001). The sampling design sought to represent portions of the country affected by the floods. In the first stage, seven flood-affected *thanas* (subdistricts) were selected to provide a range of both flood exposure and poverty levels: two non-poor severely-affected *thanas*, two poor severely-affected *thanas*, one non-poor moderately-affected *thana*, and two poor moderately-affected *thanas*. Within these categories, specific *thanas* were chosen that had already been included in other IFPRI studies and that would provide adequate coverage across the country's administrative regions.[1]

Within six of the seven selected *thanas*, three unions were randomly selected. Unions are intermediate administrative structures between *thanas* and villages, with an average population of around 27,000 (Commonwealth Local Government Forum, 2005). Within each union, six villages were randomly selected with probability proportional to village size. Two clusters were then randomly selected from each village (using preassigned random numbers), and three households within each cluster were chosen from a complete cluster census. In Saturia *thana*, a random sample drawn from another IFPRI study was used. The resulting sample includes 757 households in 126 villages, from 21 unions in seven *thanas*, drawn without replacement. In the second round of the survey seven households refused to be interviewed or were absent at the time of interview. In the third round, 23 households refused to be interviewed or were absent.

The survey was fielded in three waves: Round 1 in November-December 1998, Round 2 in March-April 1999, and Round 3 in November 1999. The household questionnaire included modules on flood exposure, individual employment and other income sources, individual

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[1] See Appendix for a detailed discussion of the possible selection biases related to the choice of *thanas*. It appears that households sampled from "severely-affected" *thanas* had a much lower odds of flood exposure than households in moderately-affected *thanas*. One possible reason for this is that exposed households in severely-affected areas were displaced by the flooding and had not returned to their residence by the time of the first survey round in November 1998. If this is the case, then the sampled households represent either less severely-affected households or those with greater resilience to the flood who avoided displacement or had recovered from it by the fall.

borrowing, household expenditures and assets, receipt of transfers, and allocation of food to individuals in the day prior to the survey. Morbidity for all household members in the past two weeks was reported, and anthropometric data for all women and for children under 12 years old were collected. Community information was collected at three levels: village, union, and *thana*. Village data for Rounds 1 and 3 include local wages, prices, cropping, and NGO and food distribution activity. Union data (collected in all rounds) includes demographics, flood exposure, infrastructure, prices, and program interventions at the union level. *Thana* data includes historical agricultural production and *thana*-level program interventions.

For this study I define an analytic subsample consisting of children who were 6-107 months old in July 1998 when flooding commenced. This sample includes 915 children with complete individual and household data in at least one of the three survey rounds. Of 984 children who appear on the household roster in at least one survey round, I include 779 children from Round 1 (November 1998), 798 children from Round 2 (April 1999), and 760 children from Round 3 (November/December 1999). Only three children included in the sample in Round 1 are reported to have died by Round 3, although it could be the case that other children whose data are missing by Round 3 have also died. In addition, the sample may be biased by the absence of children who died between the floods and Round 1 of the survey. These children are unfortunately not captured in the household roster. Another subset of children are excluded due to missing data on one or more household characteristics used in the analysis, including mother's height, the education of the household head, or the landholding of the household. For the most part, it is the mother's height that is missing. Missing household characteristics exclude 77 observations in Round 1, 30 observations in Round 2, and 25 observations in Round 3.

The majority of excluded cases are due, therefore, to missing height measurements. The anthropometry module recorded the reason why children were not measured, and these reasons vary substantially by age. Many of the school-aged children are recorded “absent.” For example, 43 of the 47 children age 6-9 with missing height measurements in Round 1 were marked “absent.” In the younger cohorts, children are more likely to be reported as sick or refusing measurement. A small proportion of children who were measured fell below the height-for-age z-score cutoff of -6, and another small group had weight but not height data. In multivariate analysis of pooled observations from all three surveys rounds (results not shown), a missing height-for-age z-score is significantly associated with older age, an educated household head, and greater landholdings, but not with household flood exposure. There are no significant predictors of missing anthropometry in Round 3 conditional on having a height-for-age z-score in Round 1. Both household-level attrition across survey rounds and missingness of height-for-age z-score within survey round are clustered within Derai *thana*, suggesting perhaps less rigorous survey work in this area

The outcome of interest in these analyses is child nutritional status. I operationalize nutritional status using height-for-age, a well-established anthropometric indicator of nutritional well-being. Height-for-age can be used both to track an individual’s linear growth trajectory and as an index of the nutritional status of a population (Gibson, 1990). Height-for-age measures can be easily compared across children of different ages and across populations by use of standardized z-scores, which use a well-nourished population of children as the reference (Kuczmarski et al., 2002). The height-for-age z-score indicates by how much a child deviates from this reference population. A height-for-age z-score of -2.0 implies that the child is two standard deviations below the median of the reference population. Children with z-scores of -2.0 or lower are considered stunted, suggesting chronic malnutrition. I calculate z-scores using the "zanthro" command in STATA, Version 8.3.

The predictor variables in these analyses are household flood exposure and three measures of household vulnerability. IFPRI constructed two measures of household flood exposure (del Ninno et al., 2001). The first is a summed index of three separate measures of flood exposure: depth of water on the homestead, depth of water in the home, and number of days of water in the home. This yields a score ranging from 0 to 16. This index was also aggregated into a categorical measure of flood exposure, defined as no exposure (index score of zero), moderate exposure (index score 1-5), severe exposure (6-10), and very severe exposure (11-16). Del Ninno and Lundberg (2005) then create a dichotomous measure of flood exposure, equal to 0 if the household had no exposure and equal to 1 if the household was moderately, severely, or very severely exposed. I argue that the moderate exposure category includes the type of flooding normally experienced by households during regular seasonal flooding in Bangladesh, so my measure of flood exposure is a dichotomous measure equally to 0 if the household had no or moderate exposure, and 1 if the household was severely or very severely exposed.

I hypothesize in this study that the effect of flood exposure on child nutritional status depends on the household's pre-flood level of vulnerability. Here I operationalize vulnerability in three variables, chosen both for their prominence in the literature on vulnerability and for their availability as pre-flood measures in the Coping Strategies in Bangladesh dataset. The first measure is the height of the child's mother, which represents the investments made in her health and nutrition as a child. The second variable is a dichotomous measure indicating whether the household head lacks any formal education, and the third variable is another dichotomous measure indicating that the household owns no or very little farmland.

The child's age is an important variable in the analysis, both for calculating the height-for-age z-score and for stratifying the sample by cohort. Age in years and months is reported in all three survey rounds. However, the months measure is missing for many children, particularly at older ages. This has implications for height-for-age z-scores which are calculated based on the child's age in months. In addition, consistency in age reporting across survey rounds is only moderately high (see Bairagi, Aziz, Chowdhury, & Edmonston, 1982; Bairagi, Edmonston, & Hye, 1991; and Bairagi, Edmonston, & Khan, 1987 for helpful discussions of age misstatement problems in Bangladesh). To address these problems, I chose to add six months to the age in completed years for children missing age in months.[2] Where ages across survey rounds were inconsistent, I assumed that age in Round 1 was the most accurate data point. Month of birth was then calculated by subtracting age in months from the month of the survey, and birth cohorts were then assigned based on month of birth.

METHODS

In this paper I estimate the growth trajectories of children in a post-flood period in order to evaluate whether flood exposure and pre-flood resources affect growth faltering during a vulnerable time. Specifically, I test the hypothesis that children in households with fewer pre-flood resources faltered more than children in more resilient households. My measure of growth

[2] I also conducted the analyses using age in completed years for all children and using age in completed years only for children with missing age in months. Evidence from Bairagi (Bairagi et al., 1982; Bairagi et al., 1991) suggests that the most appropriate solution may vary by age of child.

faltering is a decline in height-for-age z-score that exceeds the typical age-specific height-for-age z-score decline for rural children in Bangladesh.

My analysis must account for the fact that household flood exposure is likely to be correlated with unobserved household characteristics that are also associated with poor nutritional status. For example, if poorer households are more likely to live on marginal lands that are vulnerable to flooding, and also more likely to have stunted children, then estimates of the effects of flood exposure on nutritional status will be biased if household wealth is not observed or is measured with considerable error. While I have attempted to control for some of these characteristics through the household vulnerability measures, it is likely that I have not controlled for all of them. In their analysis del Ninno and colleagues contend that flood exposure can be considered an exogenous shock, correlated neither with community wealth nor with household landholdings (del Ninno et al., 2001; del Ninno & Lundberg, 2005). I take two different approaches here.

Difference-in-Difference-in-Difference

To evaluate the growth trajectories of children in the post-flood year, I first exploit the age difference in vulnerability to nutrition shocks with a difference-in-difference-in-difference approach. I compare the difference in height-for-age z-scores (HAZ) between exposed and unexposed children in the three survey rounds for each of three birth cohorts of children based on their age in months in July 1998 when the flooding started. The "young" cohort is 6-35 months in July 1998, the "middle" cohort is 36-71 months, and the "old" cohort is 72-107 months.

The triple difference equation can be built up from three separate differences. First, I compare the height-for-age z-scores in unexposed and exposed children of the same cohort and survey round:

$$\text{Difference 1} = [HAZ^{E} - HAZ^{U}]$$

where E and U denote exposed and unexposed children. The second comparison is the difference in Difference 1 (of the height-for-age z-scores between unexposed and exposed children, of the same cohort) across survey rounds:

$$\text{Difference 2} = [HAZ^{E} - HAZ^{U}]_{t=0} - [HAZ^{E} - HAZ^{U}]_{t=1}$$

where t=0 and t=1 indicates two different time periods or survey round. Finally, Difference 2 is differenced across cohorts:

$$\begin{aligned}\text{Difference 3} = {} & ([HAZ^{E} - HAZ^{U}]_{t=0} - [HAZ^{E} - HAZ^{U}]_{t=1})_{\text{cohort} = 0} - \\ & ([HAZ^{E} - HAZ^{U}]_{t=0} - [HAZ^{E} - HAZ^{U}]_{t=1})_{\text{cohort} = 1}\end{aligned}$$

For the old cohort I expect a minimal difference-in-difference. That is, even if flood-exposed children are shorter than unexposed children at the beginning of the post-flood period (due to observed and unobserved differences in resources as well as flood exposure), the *gap* in HAZ between exposed and unexposed children should not grow much wider over time because children at this age are less vulnerable to a nutrition shock. For the young cohort, however, for whom the post-flood period is already a nutritionally vulnerable time, I expect the difference-in-difference to be large and significant if the flood exposure negatively affected linear growth. The middle cohort may accumulate some additional deficits in height-for-age, but they should not be as severe as the young cohort.

To execute the difference-in-difference-in-difference analysis, I first regress height-for-age z-scores on flood exposure, survey round dummies for Round 2 and Round 3, and the interaction of flood exposure and time dummies. The interaction terms are the coefficients of interest, indicating whether the change in height-for-age z-scores across time is different for exposed vs. unexposed children. In a typical OLS regression, the zero-order flood exposure term would represent the baseline (Round 1) difference in z-scores between exposed and unexposed children. However, the OLS model is vulnerable to endogeneity concerns, as flood exposure is a potentially endogenous variable.

To address this, I estimate instead an individual fixed-effects model, still controlling for flood exposure, the time dummies, and the exposure * time interaction terms. The fixed-effects model is a difference estimator that sweeps out of the model any time-invariant characteristics (observed or unobserved) at the individual, household or community level. Because 1998 flood exposure is constant within individual across survey rounds, it cannot be estimated in a fixed-effects approach, and so this term is dropped from the fixed-effects models. The flood exposure * time interaction terms remain the coefficients of interest.

To incorporate the triple difference, I then estimate a separate fixed-effects model that includes cohort and a complete set of interactions: cohort * time, cohort * flood exposure, and the three-way interaction of exposure, time and cohort. The cohort and cohort * flood terms are again constant within individual over time and are dropped from the model. The coefficients on the three-way interactions reveal whether growth trajectories in the post-flood year depend on flood exposure and whether this association differs by cohort as hypothesized above.

Pre-Flood Vulnerability

A second research aim of this study is to evaluate the role of pre-flood household resources in determining growth trajectories in the post-flood period. To do this, I adopt a similar approach to the triple difference analysis described above. The household resources variables I use are mother's height, household head's education, and the household's landholding. These variables are all presumably fixed prior to the flood, although a young mother could potentially continue to grow over the course of the post-flood year. Sales of land are very rare in this population.

I first regress height-for-age z-score on survey round, the round * exposure interactions, and then a complete set of interactions of the household resource variables and survey round, and the three-way interactions of household resource variables, survey round, and flood exposure. The zero-order terms for the household resource variables and the interactions of resources and flood exposure are time-invariant and are dropped from the model. The coefficients on the survey round * resources interactions reveal whether these resources make a difference in children's linear growth at different stages of the post-flood recovery period. The three-way interactions reveal whether these associations vary by flood exposure. For example, is available farmland a more important protective asset for households that experienced severe flooding than for households that did not?

To account for the different nutritional vulnerability by cohort, I stratify the analysis by cohort after estimating the model on the pooled sample of all three cohorts. While this approach does not allow me to compare the statistical significance of the differences by cohort, it is a more straightforward set of analyses to interpret.

A final observation about the interpretation of the change in height-for-age z-scores is warranted here. Note that I am not attempting to identify a causal link from flood exposure to growth faltering as in del Ninno (2005). This would require a pre-flood measure of height-for-age to truly identify. Instead, I take the Round 1 survey in November 1998 (five months after peak flooding) as a baseline measure, and then observe the different growth trajectories experienced by children from that point based on the their flood exposure and other household characteristics.

RESULTS

Descriptive statistics for the analytic sample by survey round are provided in Table 1. It is clear that this population of children is severely nutritionally compromised, with an average height-for-age z-score of -2.25 in Round 1, declining further to -2.37 in Round 2 and rebounding slightly again in Round 3. Approximately half of the children are in households that experienced severe or very severe flooding in 1998, with an average flood exposure index of 5.9 (on the 0-16 scale). The mothers' average height is around 150 centimeters, or just under five feet. More than half live in households where the household head has no education, and more than a third live in households with no or very little available farmland. Three time-varying characteristics of the households suggest the pattern of recovery in the post-flood year: the Body Mass Index of mothers improves from Round 1 to Round 3, while per capita expenditures decline slightly and food share (as a percentage of household expenditures) increases.

Differential growth trajectories by cohort and flood exposure

Table 2 shows the unadjusted differences (and double and triple differences) in height-for-age z-scores (HAZ) by flood exposure, survey round and cohort. In Round 1, HAZ scores are lower by more than half of a standard deviation among flood exposed children relative to unexposed children. As discussed above, I cannot attribute this causally to the flooding, but instead I use this a baseline for comparisons across time and cohorts. By Round 2, the gap between exposed and unexposed children has widened for the youngest cohort. In other words, the HAZ scores of the young cohort declined for both exposed and unexposed children, but they declined *more* for the flood exposed group. The gap stayed fairly stable for the middle cohort (exposed and unexposed groups both declined slightly), and closed for the oldest cohort, as unexposed children faltered more than exposed children. The differences by survey round are summarized in the three right-hand columns of the top panel. The largest difference is seen among the young cohort from Round 2 to Round 3. While the unexposed children show little change in HAZ, the exposed children actually improve by 0.25 standard deviations, reversing almost all the faltering observed from Round 1 to Round 2. Over the course of the full survey year, both the young and the old cohorts end up with narrower differentials between exposed and unexposed children than at the start of the post-flood period.

The lower panel of Table 2 shows the cohort differences, with the triple differences in the three right-hand columns. These nine statistics summarize the difference in height-for-age between exposed and unexposed children in two different cohorts at two different points in time.

For example, the largest difference is from Round 1 to Round 2 between the old and young cohorts: 0.36 standard deviations in height-for-age z-score. This positive difference indicates that the disparity in the difference in height-for-age z-scores between exposed and unexposed children has widened for these two cohorts from November 1998 to April 1999. In the first survey round, the young and old cohorts had similar differences in mean height-for-age z-score by flood exposure: -.53 for the young cohort and -.61 for the old cohort. In both cohorts, flood exposed children had lower height-for-age. By the second survey round, five months later, the flood exposure gap for the young cohort had widened to -.68 while the same gap or the old cohort has shrunk to -.41, as the unexposed children in this age group falter more quickly than the exposed children. Therefore, the double differences are -.68 - (-.53) = -.16 for the young cohort and -.41 - (-.61) = .20 for the old cohort, and the triple difference (old-young) is .20 - (-.16) = 0.36. As expected, the young cohort has accumulated more of a deficit in height-for-age z-scores between exposed and unexposed children over time than has the old cohort. However, this result is almost entirely reversed by the third survey round, with a triple difference of -.32, driven primarily by the rebounding height-for-age z-scores among the young flood exposed children from Round 2 to Round 3 (from -2.72 to -2.47). For the entire post-flood year, then, the triple difference for the old and young cohort is almost zero (.04). A similar analysis comparing the old and middle cohorts suggests a widening gap (.23) from Round 1 to Round 2, followed by little change from Round 2 to Round 3 (-.01). This yields a triple difference at the end of the survey of year of 0.22, suggesting that recovering from flood exposure is harder for the middle cohort relative to the older age group. Comparing the middle cohort to the younger group yields similar results, suggesting that the middle cohort, age 3-5 during the flooding, may have been the most vulnerable to the effects (or aftermath) of flood exposure during the post-flood year. While the HAZ gap in exposed vs. unexposed children in the middle cohort widens slightly from Round 1 to Round 3 (from -.60 to -.67), the gap narrows considerably for the young cohort over the same time period (from -.53 to -.41). The triple difference at the end of the year is -.18 (middle-young), again suggesting that the flood exposed children in the middle cohort have had a more difficult recovery period.

Regression analysis can confirm whether these descriptive results are statistically significant. Estimates from the differenced models are shown in Table 3. Recall that this model cannot estimate the zero-order cohort or flood exposure effects, but allow an estimation of the secular change in height-for-age by cohort, and the change associated with flood exposure over time. The model shown in the first column includes only survey round dummies and the round by flood exposure interactions, pooling all three cohorts together. The notable decline in height-for-age z-scores from Round 1 to Round 2 is evident in the significant coefficient on the Round 2 dummy. The change from Round 1 to Round 3 is not statistically distinguishable from zero, suggesting that overall the children have recovered their growth trajectory by the end of the survey year. The survey round * flood exposure interactions are not significant, suggesting that the secular decline in HAZ is not different for flood exposed children relative to exposed children.

The fully saturated model is shown in the second column. Here the differences in the secular decline by cohort are clear: while the young cohort falters by .259 standard deviations in HAZ from Round 1 to Round 2, the gap is significantly smaller for the middle and old cohorts, as shown by the large and positive interaction terms of survey round and cohort. Similar results are seen for the change from Round 1 to Round 3 as well. However, none of the two-way or three-way interactions involving flood exposure are individually or jointly significant in this model. Again, this suggests that the growth trajectories of exposed and unexposed children do not diverge, for any of the cohorts, in the post-flood period.

Household vulnerability

The second set of analyses is this study investigates the role of (pre-flood) household resources as potential moderators of the relationship between flood exposure and growth trajectories over time. In Table 4 I present results from four individual fixed-effects models. In the first column, the three cohorts are pooled. While there are no significant effects of landlessness or lack of education, the role of mother's height in predicting change in child's height-for-age does appear to vary by flood exposure status. (Note that the size of the coefficients here is influenced by the scale of the mother's height, which is measured in centimeters.) There is a secular increase in height-for-age of .406 standard deviations for all children from Round 1 to Round 2, and a decline of -2.534 standard deviations for flood exposed children. There is also a very small decline in height-for-age z-score for each centimeter of mother's height for all children of -.003 standard deviations for every centimeter of height, but a significant increase in height-for-age z-score associated with taller mothers among flood exposed children only. It could be argued that we would expect children of taller mothers to grow more quickly, as they are likely to have greater growth potential and will likely achieve taller stature. However, the fixed-effects specification has already removed the child's time-invariant endowments including genetic growth potential from the model. It has also removed the baseline differences in height-for-age between flood exposed and unexposed children. One interpretation of this finding is that the human and other capital represented by mother's height plays a protective role for the health of children during the vulnerable post-flood period, but this protective role is only meaningful in flood-exposed households.

In the next three columns of Table 4, I present results for the same model stratified by cohort. As discussed above, I expect to see stronger effects of flood exposure and household resources on younger children who are in a rapid growth phase and are most vulnerable to nutritional insults at this point. The results for the youngest cohort in the second column reveal that this cohort is driving the results related to mother's height for all children shown in the first column. Again, there is a steep decline in height-for-age among flood-exposed children, which is compensated in part by a strong positive effect of .069 standard deviations in height-for-age for each centimeter of mother's height for flood exposed children.

These effects are summarized in Figure 2, which shows the marginal change in height-for-age from Round 1 to Round 2 by mother's height and flood exposure for the young cohort, net of differences in landholding and educational attainment of the household head. The range of mother's heights shown in the chart includes 90 percent of the distribution of mother's heights in the sample. The relative flatness of the line for unexposed children suggests that mother's height (again, as a proxy for her human capital) does not have a large influence on the nutritional trajectory for unexposed children from the first to the second survey rounds. The downward slope indicates the relationship is inverse. The very steep positive line for exposed children suggests that for this group, the human capital represented by mother's height makes a very large difference in the Round 1 to Round 2 change in children's height-for-age.

In the third and fourth columns of Table 4, I show results of the same model for the middle and old cohort. Mother's height has no significant influence for these two age groups. There is one marginally significant result for the middle cohort that suggests that children in flood-exposed households where the head had no education show less decline in height-for-age then children in flood-exposed households where the head does have some formal education. The set of three-way interactions and the education * survey round interactions are not jointly significant in this model, so I do not interpret these results. For the old cohort, the household head's educational status does appear to influence the association between flood exposure and changes in height-for-age, particularly over the full survey period from Round 1 to Round 3. The coefficient on the three-way interaction (of survey round 3 * no formal education * flood exposure) of -.284 indicates that growth faltering in the post-flood year among flood-exposed children in the old cohort is worse among households with an uneducated head.

I summarize these results in Figure 3. On the left side of the graph, the difference in faltering is shown for flood exposed and unexposed children in this cohort in households where the household head has no education. The difference is approximately 0.8 standard deviations in height-for-age z-score. On the right side of the graph, the same difference is shown for children in households with an educated head. Here the difference is smaller, only 0.5 standard deviations, due both to less faltering among the exposed children and more faltering among the unexposed children. This result is consistent with the results for mother's height among the young cohort – in both of these cases, more parental human capital is associated with better health outcomes among flood exposed children and slightly worse outcomes among unexposed children.

DISCUSSION

Vulnerability to natural disasters and other severe income and asset shocks is multidimensional and dynamic. Exposure to a disaster, even a widespread one, is rarely distributed randomly across a population, but is determined by proximate and distal factors ranging from household poverty to land tenure systems and other political institutions. Similarly, resilience in the face of disaster will also depend on capital of many forms, prior exposure to shocks, and safety nets and recovery efforts provided by communities and governments.

This analysis of the nutritional trajectories of children after severe regional flooding in Bangladesh in 1998 floods suggests that the flood exposure *per se* may not have caused marginal growth faltering in children. Specifically, I find that household exposure to severe flooding (beyond the normal seasonal flooding) had no significant association with children's growth trajectories, net of secular changes in height-for-age and cohort effects; and net of differences in height-for-age between exposed and unexposed children at the start of the post-flood recovery period in November 1998.

When pre-flood measures of household human and physical capital are incorporated into the models, however, a distinct pattern emerges. Higher levels of capital (or resources) appear to minimize the differences in changes in height-for-age between flood exposed and unexposed children. In the analysis of mother's height in the young cohort, children in flood exposed households grow faster from the first to the second survey rounds if they have taller mothers; children in unexposed households actually falter slightly with increasing maternal height. In the analysis of educational attainment in the old cohort, parental education narrows the gap in changes in height-for-age by flood exposure. These findings are consistent with human capital playing a protective role for children in households experiencing a vulnerable period such as the post-flood recovery period.

It is less clear why higher levels of human capital are associated with worse child health outcomes among unexposed households, as was the case for both mother's height (for the young cohort) and parental educational attainment (for the old cohort). One possible explanation for these counterintuitive findings centers around the role of food aid and transfers. If food aid in flood-affected areas was targeted at households based on household resources but not on household flood exposure, then children with no household flood exposure but low levels of parental resources or capital may have received more food aid than unexposed children with higher levels of household resources. This hypothesis could be tested in future analysis that incorporates receipt of food aid at the household level.

Given the challenges of this dataset, sensitivity analyses are warranted here. I estimated all of the models with a different age specification, using age in completed years where no months were reported instead of adding six months as described above. Results were substantively similar. In addition, I estimated all of the models using a different cut-off point for flood exposure: I divided the sample into households with no exposure and those with any exposure, following del Ninno et al. (2001). Again, results were substantively very similar. I also incorporated different specifications of the household vulnerability measure, including an index of vulnerability based on a summed score of different aspects of vulnerability.

The results presented here suggest several future directions for this research. While del Ninno and Lundberg (2005) investigated the role of food aid, a more detailed examination of which households received food aid and how these transfers influenced household expenditures is warranted. Similarly, the dynamic role of household physical and financial assets (in addition to the time-invariant human capital measures presented here) seems important. Future analyses could incorporate detailed measures of household assets, looking at pre-flood holdings, the degree of asset loss, asset sales post-flood, and the pace of asset recovery over the post-flood year. This analysis should expand understanding of the asset- and consumption-smoothing strategies that were available and attractive to households with differing levels of resources. Another human capital asset that could be analyzed is the change in maternal BMI. As discussed above, poor households have both few coping strategies available after a severe weather shock and a strong incentive to hold onto assets that may be difficult to replace later. An examination of the implications of these asset allocation and disposition decisions for children's health and development would be very relevant for policy makers.

Poor, densely-settled populations in developing countries will continue to experience devastating environmental disasters and other shocks, perhaps with increasing frequency and intensity. Considerable aid monies and development projects are focused on protecting these vulnerable populations before such events, and assisting with their relief and recovery in the wake of major catastrophes. It is important to understand exactly which groups and individuals are most at risk of experiencing permanent negative effects during the post-disaster recovery period in order to craft effective and well-targeted interventions. This study suggests that pre-flood household resources play an important role in moderating nutrition shocks for small children. More work is needed to pinpoint the exact role of food aid and other coping strategies, and to determine which resources contribute most to resilience from shocks.

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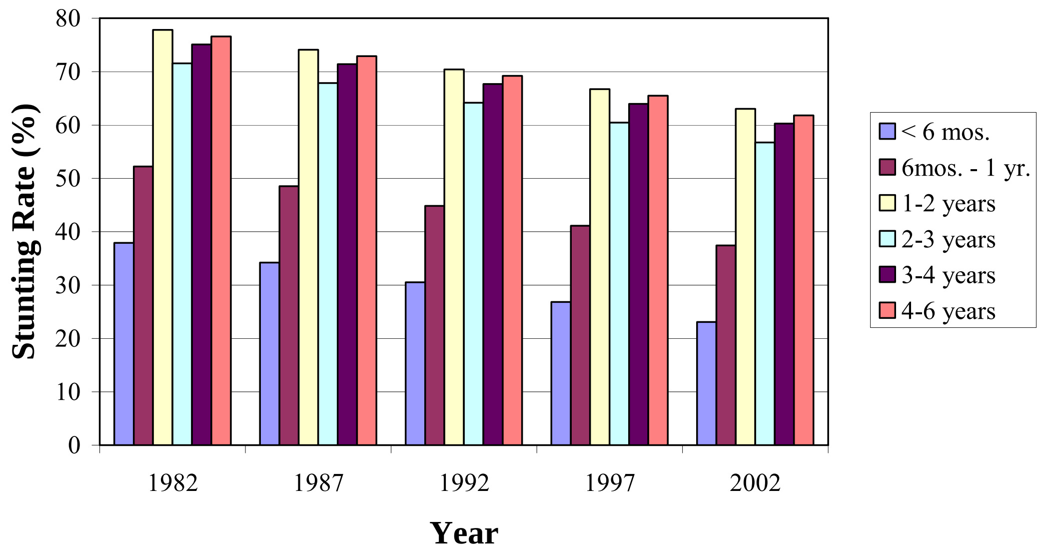
FIGURES AND TABLES

Figure 1: Estimated stunting rates by age and year, rural children in Bangladesh, 1982-2002



Source: WHO Global Database on Child Growth and Malnutrition

Figure 2: Change in height-for-age z-score from November 1998 to April 1999 by mother's height and flood exposure, children born 1995-1997 in rural households in flood-affected *thanas*, Bangladesh [N=255].

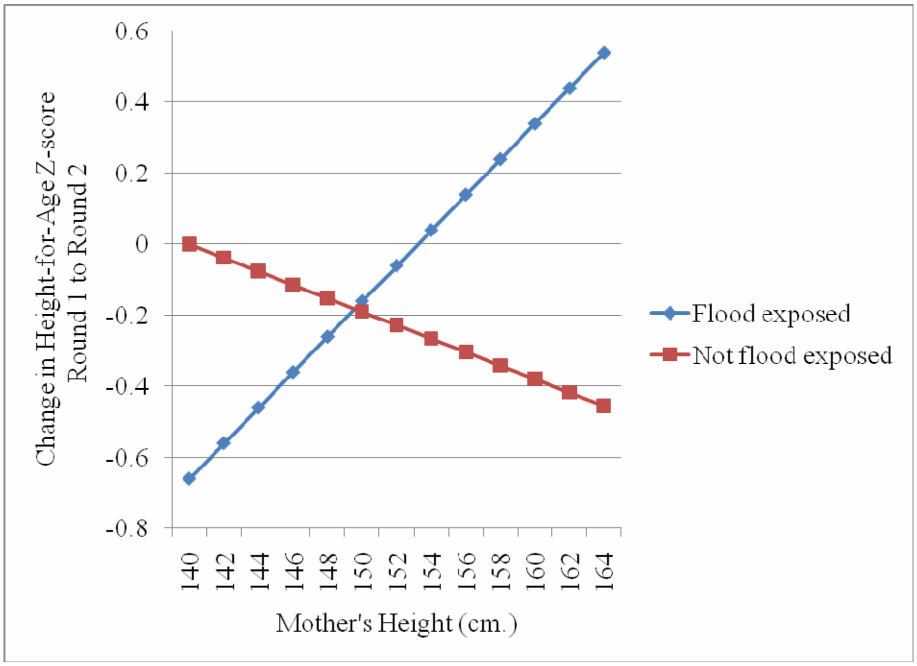
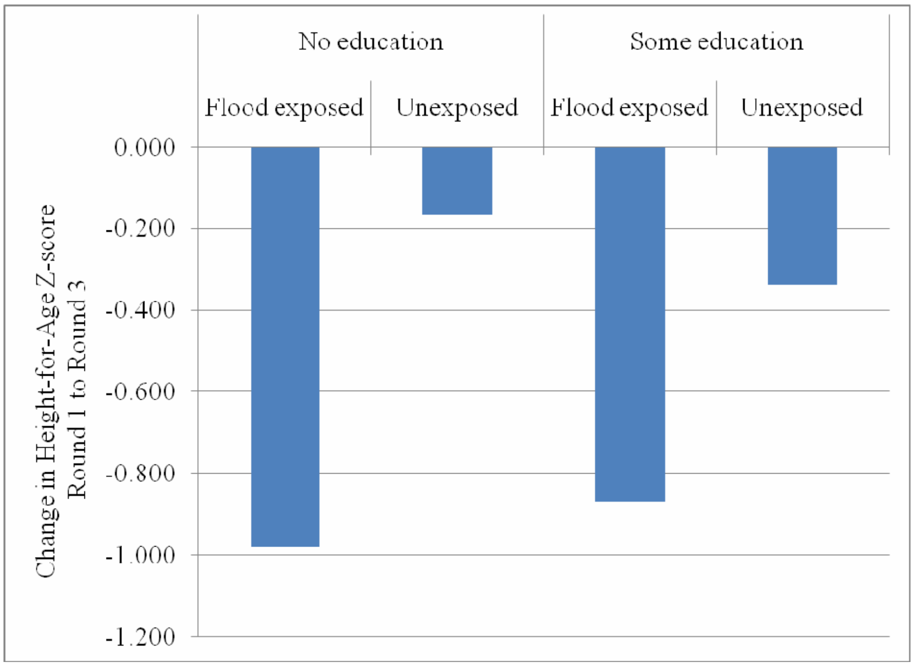


Figure 3: Change in height-for-age z-score from November 1998 to April 1999 by educational attainment of household head and flood exposure, children born 1989-1992 in rural households in flood-affected *thanas*, Bangladesh [N=336].



	Round 1		Round 2		Round 3	
	Mean	SD	Mean	SD	Mean	SD
Child						
Age in Months	62.66	28.68	68.15	28.62	73.10	28.08
Height for age z-score	-2.25	1.36	-2.37	1.32	-2.26	1.37
Household time invariant						
1998 flood exposure = 1	0.53	--	0.55	--	0.56	--
1998 flood exposure index	5.91	4.34	6.16	4.43	6.16	4.37
Mother's height (cm.)	149.86	5.07	149.91	5.04	149.89	5.20
Household head has no education	0.58	--	0.54	--	0.53	--
Household owns little or no farmland	0.37	--	0.39	--	0.38	--
Household time varying						
Mother's Body Mass Index	18.32	2.16	18.47	2.25	18.77	2.29
Logged per capita expenditures	6.37	0.47	6.29	0.47	6.27	0.47
Food share (percentage)	71.21	13.94	79.08	10.50	78.80	11.62
N	779		798		760	

in flood-affected *thanas* in Bangladesh, 1998-1999 [N=757].

Cohort	Age at onset of 1998 flooding	Round 1: Fall 1998			Round 2: Spring 1999			Round 3: Fall 1999		
		No Flood	Flood	Δ	No Flood	Flood	Δ	No Flood	Flood	Δ
Young	6-35 mths	-1.88	-2.41	-0.53	-2.04	-2.72	-0.68	-2.06	-2.47	-0.41
Middle	36-71 mths	-1.86	-2.47	-0.60	-1.91	-2.54	-0.63	-1.80	-2.47	-0.67
Old	72-107 mths	-1.53	-2.15	-0.61	-2.22	-2.63	-0.41	-2.07	-2.54	-0.46
Cohort Differences										
Middle-Young		0.02	-0.06	-0.08	0.13	0.18	0.05	0.26	0.00	-0.26
Old-Middle		0.33	0.32	-0.01	-0.31	-0.09	0.22	-0.28	-0.07	0.21
Old-Young		0.35	0.26	-0.09	-0.18	0.09	0.27	-0.02	-0.07	-0.05

Table 3: Determinants of change in height-for-age z-scores from individual fixed-effects models, rural children in flood-affected *thanas* in Bangladesh, 1998-1999 [N=2,337 observations].

	(1)	(2)
Survey round (Ref = Round 1)		
Round 2	-0.118	-0.259
	[3.21]***	[3.74]***
Round 3	-0.018	-0.163
	[0.48]	[2.28]**
Flood exposed X Survey Round (ref. = Round 1)		
Round 2 x Flood exposed	0.006	-0.011
	[0.13]	[0.11]
Round 3 x Flood exposed	0.024	0.067
	[0.47]	[0.68]
Cohort X Survey Round (ref. = Round 1)		
Round 2 X Middle		0.168
		[1.80]*
Round 2 X Old		0.222
		[2.42]**
Round 3 X Middle		0.158
		[1.65]*
Round 3 X Old		0.240
		[2.55]**
Flood exposed X Cohort X Survey Round		
Flood exposed X Round 2 X Middle		0.037
		[0.29]
Flood exposed X Round 2 X Old		-0.002
		[0.02]
Flood exposed X Round 3 X Middle		-0.025
		[0.19]
Flood exposed X Round 3 X Old		-0.100
		[0.77]
Constant	-2.252	-2.252
	[128.03]***	[128.37]***
Number of observations	2337	2337
Number of respondents	915	915
R-squared	0.02	0.03

Absolute value of t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Estimates of the effect of flood exposure, cohort, and household vulnerability measures on change in height-for-age z-score, children born 1988-1997 in rural households in flood-affected *thanas*, Bangladesh, 1998-1999 [N= 2,337 observations].

	All cohorts	Young	Middle	Old
Survey round (ref. = Round 1)				
Round 2	0.406	2.66	0.47	-0.763
	[0.37]	[1.02]	[0.25]	[0.54]
Round 3	-0.846	-0.444	-1.185	-0.34
	[0.76]	[0.17]	[0.62]	[0.24]
Flood exposed X Survey Round (ref. = Round 1)				
Round 2	-2.534	-10.321	-0.977	0.846
	[1.69]*	[2.92]***	[0.39]	[0.43]
Round 3	-1.472	-8.438	1.878	-0.529
	[0.98]	[2.38]**	[0.74]	[0.27]
Mother's height X Round (ref. = Round 1)				
Round 2 X Mother's height	-0.003	-0.019	-0.003	0.004
	[0.47]	[1.12]	[0.25]	[0.44]
Round 3 X Mother's height	0.005	0.002	0.007	0.002
	[0.66]	[0.09]	[0.59]	[0.17]
Mother's height X Round x Flood exposed (ref. = Round 1)				
Round 2 X Mother's height x Flood exposed	0.017	0.069	0.006	-0.005
	[1.70]*	[2.92]***	[0.34]	[0.38]
Round 3 X Mother's height x Flood exposed	0.011	0.057	-0.012	0.005
	[1.09]	[2.40]**	[0.70]	[0.37]

(continued on next page)

Table 4: (Continued from previous page) Estimates of the effect of flood exposure, cohort, and household vulnerability measures on change in height-for-age z-score, children born 1988-1997 in rural households in flood-affected *thanas*, Bangladesh, 1998-1999 [N= 2,337 observations].

	All cohorts	Young	Middle	Old
Landless X Round (ref. = Round 1)				
Round 2 x Landless	0.055	0.087	-0.019	0.136
	[0.71]	[0.49]	[0.14]	[1.31]
Round 3 x Landless	0.114	-0.165	0.177	0.261
	[1.41]	[0.88]	[1.27]	[2.46]**
Landless X Round x Flood exposed (ref. = Round 1)				
Round 2 x Landless x Flood exposed	-0.164	-0.287	-0.011	-0.213
	[1.56]	[1.19]	[0.06]	[1.50]
Round 3 x Landless x Flood exposed	-0.117	0.045	-0.156	-0.191
	[1.08]	[0.18]	[0.87]	[1.31]
No education X Round (ref. = Round 1)				
Round 2 x No education	-0.04	-0.103	-0.137	0.088
	[0.53]	[0.59]	[1.06]	[0.87]
Round 3 x No education	0.104	0.194	-0.005	0.172
	[1.34]	[1.05]	[0.04]	[1.69]*
No education X Round x Flood exposed (ref. = Round 1)				
Round 2 x No education x Flood exposed	0.119	0.21	0.293	-0.057
	[1.16]	[0.86]	[1.72]*	[0.41]
Round 3 x No education x Flood exposed	-0.148	-0.053	-0.044	-0.284
	[1.41]	[0.21]	[0.25]	[2.02]**
Constant	-2.253	-2.141	-2.197	-2.383
	[127.94]***	[53.02]***	[75.38]***	[100.22]***
Number of observations	2337	639	845	853
Number of respondents	915	255	324	336
R-squared	0.03	0.11	0.03	0.05

Absolute value of t statistics in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX: SAMPLE SELECTION CONCERNS

The sampling methodology for the Coping Strategies in Bangladesh dataset is described in detail in del Ninno et al. (2001). The first stage involved selecting seven *thanas* to "give a fair representation of the parts of the country affected by flooding" (del Ninno et al., 2001, p.10). To do this, the IFPRI team first categorized *thanas* by flooding severity, based on criteria set by the Bangladesh Water Development Board. Only moderately affected and severely affected *thanas* were included for purposes of the data collection effort. *Thanas* were then also categorized by poverty level using the 1998 Bangladesh Household Expenditure Survey. A "poor" *thana* was one in which more than 70 percent of the population lived below the poverty line. From this dual classification, seven *thanas* were selected that had been included in other IFPRI studies and that would represent a wide range of geographical regions across the country. The seven selected *thanas* are shown in Table A2.

To verify the validity of this categorization process, I calculated the household flood exposure, landholding and household expenditures for each *thana*. The results are are also shown in Table A2. A brief review of the table suggests some serious problems with the categorization based on flood exposure. The four "severely affected" *thanas* (as designated by the Bangladesh Water Development Board) have a lower proportion of flood-affected households and lower mean flood exposure index than the moderately-affected *thanas*. In Saturia *thana*, a severely-affected region, only 17 percent of households meet the criteria for flood exposure used in this study, while 97 percent of households in Madaripur meet these criteria. The poverty classification is also not particularly robust: the mean of the log per capita expenditures in "poor" *thanas* is 6.37, vs. 6.38 in "nonpoor" *thanas* (as measured in the first survey round), and 40 percent of households in poor *thanas* are landless vs. 32 percent in the nonpoor *thanas*.

If the classifications based on the Bangladesh Water Development Board and the 1998 Household Expenditure Survey are assumed to be correct, this suggests a potentially serious sample selection problem with the Coping Strategies in Bangladesh dataset. I would expect to find a higher proportion of flood-exposed households and a higher mean flood exposure index in the severely-affected *thanas* relative to the moderately-affected *thanas*. However, I find the opposite to be true. One explanation for this is that many households that were severely affected by flooding were displaced from their homes during the flooding and had not returned to their original (pre-flood) residence by the time of the first round survey in November 1998, and were therefore not available to be sampled. In moderately affected areas, the overwhelming majority of households report flood exposure, but may not have been so severely affected that they were still displaced by fall 1998.

To assess the bias in a different way, I calculate the odds of reporting household flood exposure as a function of the two *thana* characteristics: degree of flood exposure, and poverty. The results are shown in Table A2 and confirm the descriptive results: relative to living in a non-poor, moderately affected *thana*, living in a poor, severely affected *thana* reduces the odds of flood exposure by 93 percent. Odds of flood exposure for residents of non-poor severely-affected *thanas* are 73 percent lower.

This analysis confirms that households most affected by flooding may not appear in the CSB dataset. Results from this study and others using this dataset should be interpreted with caution in light of this potential bias. The CSB sample is representative of households in the seven selected *thanas who were still residing in the area five months after the floods*; it is reasonable to assume that this group differs from the population that had left the region in important ways. This analysis of potential bias reminds us of the difficulties inherent in drawing a population representative sample in a post-disaster setting. A more accurate but decidedly more difficult sampling strategy in this situation would have used an existing pre-flood population-representative sample (e.g. a sample drawn for a Demographic and Health Survey or for a household expenditure survey). In this way, an estimate of the missing households could be made, and households potentially could be tracked to new locations.

Table A1: Charactersitics of *thanas* selected for inclusion the Coping Strategies in Bangladesh survey sample.

	Severely Affected	Poor	Proportion of flood-affected households	Mean flood exposure index	Mean log (per capita expenditures)	Landless households
Mohammadpur	√	√	0.27	3.02	6.37	0.29
Saturia	√	√	0.17	2.91	6.43	0.21
Muladi	√		0.68	7.44	6.22	0.21
Shibpur	√		0.41	4.14	6.55	0.46
Derai		√	0.33	4.72	6.26	0.63
Madaripur		√	0.97	10.04	6.41	0.48
Shahrasti			0.82	8.34	6.37	0.30

Table A2: Odds ratios for a model predicting household flood exposure from *thana* characteristics, rural households in flood-affected *thanas*, Bangladesh, 1998-1999 [N=779]

	Odds ratio, household exposed to flood
Thana characteristics (ref. = Non-poor, moderate flooding)	
Poor, moderate flooding	0.347
	[2.06]**
Non-poor, severe flooding	0.272
	[2.73]***
Poor, severe flooding	0.067
	[4.89]***
Observations	779

Robust z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%