Weather shocks and nutritional status of disadvantaged children in Vietnam

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Abstract

This study uses the Vietnam Young Lives Survey to investigate the impact of small-scale weather shocks on child nutritional status as well as the mechanism through which weather shocks affect child nutritional status. The results show that small-scale weather shocks negatively affect child nutritional status and total household per capita consumption and expenditure (PCCE) but not food PCCE. Disaggregating total food PCCE into consumption of high-nutrient and energy-rich food shows that households protect food consumption by decreasing consumption of high-nutrient food and increasing consumption of affordable but low quality food. This suggests that the impact of small-scale weather shocks on child health is mediated through a reduction in the quality of dietary intake. Finally, this study shows evidence of a differential impact of weather shocks in children from different socioeconomic backgrounds. The impact of weather shocks is observed to be greater amongst children from wealthier households compared to children from poorer households.

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1 Introduction

The increasing frequency of occurrence and the devastating impact of weather shocks represent a growing concern globally, particularly in developing countries where the impact is further exacerbated by the lack of adequate infrastructures and facilities capable of mitigating the immediate impact or aftermaths of weather shocks (Kahn, 2005; UNISDR, 2011b). The enormous human and welfare losses associated with weather shocks are widely documented. For example, in 2011 alone, approximately 332 weather shocks where reported worldwide, affecting 244.7 million and killing over 30,000 with a total economic cost estimated at approximately 366.1 billion US dollars (Guha-Sapir et al., 2012). Other specific examples include the 2010 earthquake in Haiti in which an estimated 250,000 persons were killed or missing, incurring a total damage estimated at approximately 8.1 billion US dollars (Cavallo et al., 2010). The boxing day Indian Ocean tsunami in 2004 caused large-scale destruction with an estimated death toll of over 165,000 in Indonesia alone and over 200,000 deaths across 12 affected countries including Thailand, India and Sri Lanka (Cavallo et al., 2010; Keys et al., 2006). Other weather shocks such as floods and landslides, droughts and volcanic eruptions cause similar large-scale human and economic losses (Guha-Sapir et al., 2012). In addition to the immediate impact, weather shocks often result in huge secondary public health crises resulting from the outbreak of diseases, the disruption of safe drinking water supply and sanitation, the displacement of families and the relocation of survivors into crowded rescue centres, exposing survivors to further health hazards (Watson et al., 2007).

Children are particularly vulnerable and approximately 30-50% of fatalities resulting from the immediate repercussions of weather shocks are reported to be children (UNISDR, 2011a). Furthermore, weather shocks have been implicated in long-term child health outcomes including higher morbidity and mortality amongst children long after they survive the immediate impact. For example, following extreme drought in Zimbabwe, exposed children experienced slower growth rates (Hoddinott & Kinsey, 2001), the 1997 forest fire in Southeast Asia resulted in higher infant and child mortality in Indonesia (Jayachandran, 2009), while the 1998 Hurricane Mitch affecting large parts of Central America was associated with an increase in the prevalence of wasting and malnutrition amongst affected children in Honduras and Nicaragua (Barrios et al., 2000).

There is a growing body of evidence showing links between child stature and future labour market achievements (Case and Paxson (2008), and references therein). Therefore, shocks which

affect child physical development and growth are likely to have long-term economic consequences. For example, Alderman et al. (2006) showed that in addition to childhood stunting, exposure to drought and civil war in early childhood resulted in lower educational attainment in adulthood. Other studies have equally highlighted the long-term health and economic consequences of other forms of early childhood shock. Some examples include higher mortality rates amongst adults born during an economic downturn compared to those born during an economic boom (van den Berg et al., 2006); shorter height at age 20 amongst cohorts whose parents experienced income shocks resulting from a widespread destruction of vineyards in mid-19th century France (Banerjee et al., 2010); lower educational attainment and occupational status amongst adults born during the food crisis in Germany following World war II, compared to those born shortly before or after the crisis (Jürges, forthcoming).

Previous research on weather shocks and child health has focused mainly on the impact of single large-scale weather shocks on child health with fewer studies on the impact of smaller-scale weather shocks. Although the human and economic costs of smaller-scale weather shocks are likely to be less compared to large-scale shocks, recurrent exposure to small-scale weather shocks are likely to have significant impacts on household welfare as well as on children's short- and long-term health outcomes. To the best of my knowledge only two studies have investigated the impact of small-scale weather shocks on child health. Pörtner (2010) showed using three rounds of the Guatemala Demographic and Health Surveys (DHS), that exposure to hydro-metrological disasters (storms, flooding, heavy rainfall, hurricanes and frost) has a negative impact on child's health. After controlling for area and time fixed effects, exposure to small-scale weather shocks in the past year was associated with lower nutritional status in children under 5 years of age (Pörtner, 2010). Similar findings were reported by Datar et al. (2011) in rural India. Using repeated cross-sections of the National Family Health Surveys (NFHS), Datar et al. (2011) showed that exposure to different small-scale weather shocks in the previous year reduced child height-for-age Z-score (HAZ-score) by approximately 0.12-0.15 standard deviations and increased the probability of reporting symptoms of acute illnesses by 9-18% (Datar et al., 2011). HAZ-scores are regarded as a long-run indicator of child nutritional status and are estimated by standardising child height using the median height of a well-nourished child of the same age and gender in a reference population (where the United States National Centre for Health Statistics (US NCHS) sample is used as the reference population). Low HAZ-scores are indicative of past disruptions to child nutritional status resulting from inadequate food nutrient intake and/or recurrent infections and illnesses. The HAZ-score is widely used as a proxy for child health and is an important determinant of child's future health outcomes. For example, childhood

malnutrition and wasting (HAZ-score less that -2) is associated with higher morbidity and mortality in adulthood (Victora et al., 2008).

In addition to fatalities and injuries resulting from the direct repercussions of weather shocks, shock to household income and changes in parental behaviour such as investment decisions in child health represent possible mechanisms through which weather shocks affect child health. In developing countries, the immediate and long-term impact of weather shocks on household welfare is well documented. Significant reductions in both agricultural and non-agricultural wages have been reported several years after the occurrence of a natural disaster (Jayachandran, 2006; Mueller & Osgood, 2009; Mueller & Quisumbing, 2010; T. Thomas et al., 2010). Since child health is a function of a set of inputs such as food nutrients, time and resources invested in caring for the child (Behrman & Deolalikar, 1988; Grossman, 1972; Rosenzweig & Schultz, 1983), shocks to household income are likely to reduce the demand for these inputs, potentially making child health vulnerable. In addition, shocks to household income may increase the opportunity cost of parents time in caring for the child when the need to replenish lost income and for day-to-day subsistence supersedes the need to investment in child health. For example, Datar et al. (2011) showed that in addition to the impact on child's nutritional status, children exposed to small-scale weather shocks are less likely to have full age-appropriate immunization coverage. Similar findings are reported by Miller and Urdinola (2010) who show an association between weather-induced increases in coffee prices and a decline in the use of preventative care and vaccination services during the first year of a child's life. Furthermore, the need to generate extra income may result in children having to contribute to household income and an increase in the supply of child labour, further compromising child health outcomes (O'Donnell et al., 2002; Roggero et al., 2007).

This study contributes to this literature by estimating the impact of small-scale weather shocks on both child health and household income[1]. It differs from previous studies which have either estimated the impact of weather shocks on child health or on household income, by estimating the impact of small-scale weather shocks on both child health and on household income using the same sample. Thus, this study is able to explicitly demonstrate that the adverse impact of weather shocks on child health is mediated through a reduction in household income. It uses the

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[1] Household per capita consumption and expenditure (PCCE) on all goods including food and non-food goods (excluding medical care expenditures) is used as a proxy for household income.

2006 and 2009 panels of the Vietnam Young Lives Surveys (VYLS), which consist of a pro-poor sample of children aged 4 and 12 years in 2006.

Consistent with other studies, a negative association is observed between small-scale weather shocks and child HAZ-scores as well as between household total (log) per capita consumption and expenditure (PCCE). The analysis is extended to assess the impact on the quantity (household total PCCE on food) and the quality (household PCCE on high-nutrient and energy-rich food) of dietary intake. No statistically significant difference is observed in total food consumption between exposed and unexposed households. However, the results suggest that exposed households are able to smooth consumption of total food by decreasing the consumption of high-nutrient food (fish, meat, fruits and vegetables) by approximately the same magnitude as their increase in the consumption of low-nutrient, high calorie food (rice and tubers). This is indicative of a fall in quality of households' food intake, thus, providing an explanation for the negative impact of small-scale weather shocks on child nutritional status.

Disadvantaged groups such as children living in poorer households have been shown to more vulnerable to weather shocks (Datar et al., 2011; Hoddinott & Kinsey, 2001), therefore this study also investigates the extent to which differential impact of small-scale weather shocks on household PCCE explains differential impact on child HAZ-score.

The rest of the paper is organized as follows: the conceptual framework and econometric models are outlined in sections 2 and 3, respectively. Section 4 provides a description the VYLS and variables included in econometric models. The results are presented in section 5 and section 6 concludes by summarizing the key findings of the study.

2 Conceptual Framework

Following the literature on the demand for child health[2], the conceptual framework adopted in this study relies on a model of child health production in which child health is embedded in a household utility function. Households are assumed to maximise a utility function at time t given as:

$$U = U(C_t, H_t; K_t) \qquad (1)$$

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[2] Some examples include Pitt and Rosenzweig (1985), Thomas et al. (1990), Alderman and Garcia (1994) Hoddinott and Kinsey (2001) and Behrman and Skoufias (2004)

where C is a vector of goods consumed (health and non-health goods), H is a vector of home-produced commodities such as child health, and K is a vector of household characteristics which may affect utility. Households face two constraints in the production of commodities: a constraint imposed by the technology through which it combines goods to produce commodities (technological constraint) and a budget constraint which determines the bundle of goods it can afford. Thus, the maximization problem facing households is subject to a budget constraint, households' technology and a child health production function.

The child health production function can be described as a function of a set of inputs which can be combined to produce child health. These inputs such as food nutrients, time and resources invested in caring for the child are demanded by parents because they affect parents' utility indirectly through their impact on child health. In this study, child HAZ-score or nutritional status is used as an indicator of child health. Child nutritional status is described as a function of a set of material and environmental inputs which affect child stature:

$$H_t = h(X_t, Z_t, M_t, P_t, K_t, \epsilon_i, \epsilon_h, \epsilon_c) \qquad (2)$$

where H is the child's HAZ-score, X is a vector of observable child characteristics such as age and gender which may affect growth rate, Z is household consumption and expenditure on food nutrients which captures food nutrient input, M is a vector of non-material inputs such as time invested in caring for the child, P is a vector of parental characteristics such as education and age which may affect the technology through which health inputs are combined, K is a vector of household characteristics capturing the health environment facing each child such as good sanitation and availability of safe drinking water, ϵ_i captures time-invariant unobserved child characteristics such as genetic predispositions which are uninfluenced by parental behaviours or preferences but which may affect child health and ϵ_h and ϵ_c are unobserved time-invariant household and community characteristics, respectively, which could also affect child health.

Weather shocks are often associated with economic and welfare losses, particularly in poor households already facing huge budget constraints and limited abilities to smooth consumption. This may in turn affect child's nutritional status through a reduction in household food consumption and expenditure. Household food consumption and expenditure, Z, is described as follows:

$$Z_t = f(D_{t-1}, I_t, K_t, \epsilon_z) \qquad (3)$$

where $D_{t_{-1}}$ represents households' exposure to small-scale weather shocks between time periods t and t -1, I is household income (or total PCCE on all food and non-food goods) and ϵ_z are unobserved time-invariant household and community characteristics that could affect household food consumption and expenditure. Substituting equation (3) into (2), yields a child health production function that includes households' exposure to small-scale weather shocks:

$$H_t = h\left(X_t, D_{t_{-1}}, I_t, M_t, P_t, K_t, \epsilon_i, \epsilon_h, \epsilon_c \right) \qquad (4)$$

3 Empirical Models

In the first instance, the empirical analysis adopted in this study investigates the impact of small-scale weather shocks on child nutritional status. The second part of the empirical analysis investigates the impact of small-scale weather shocks on household total PCCE. The aim of the second part is to explicitly demonstrate that weather-induced negative shocks to household consumption mediate the impact of small-scale weather shocks on child nutritional status. Finally, the analysis is extended to investigate possible differences in the impact of weather shocks between two groups of children defined by their household socioeconomic status: children living in households below and above the sample median household total PCCE.

3.1 The impact of small-scale weather shocks on child HAZ-score

To estimate the impact on child nutritional status, an estimable version of equation (4) is specified to allow the comparison of HAZ-scores of children exposed to small-scale weather shocks to those of unexposed children:

$$H_{ict} = \delta_1 D_{ict_{-1}} + \beta_1 X_{ict} + \beta_2 P_{ict} + \beta_3 K_{ict} + \beta_4 I_{ict} + \gamma Y_t + u_{ict} \qquad (5)$$

$$u_{ict} \sim (0, \sigma_u^2)$$

where H_{ict} is the HAZ-score of the ith child living in community c observed at time t, $D_{ict_{-1}}$ indicates whether a child was exposed to any small-scale weather shock between time periods t and t-1, X, P and K are vectors of child, parent and household characteristics respectively, I is household's monthly (log) total PCCE on all food and non-food goods, Y is a vector of survey year dummies which captures general time trends in child HAZ-score, and u_{ict} is the random error term.

The impact of weather shocks on child HAZ-score (captured by δ_1) estimated from equation (5) will be valid if exposure to weather shocks are randomly assigned. However, communities with higher incidence of small-scale weather shocks are likely to experience less economic growth/development and wealthier households are more likely to migrate from these communities. In addition, households residing in high-risk communities may over time, adopt less risky work or labour strategies in order to minimise the potential impact of weather shocks. This may in turn result in lower average income or returns within these communities. Thus, households living within high-risk communities are likely to face greater constraints in investing in child health, resulting in lower child health outcomes. Failure to control for this will result in an overestimation of the impact of small-scale weather shocks on child health outcomes. A community fixed effect model is specified by decomposing the random error term in equation (5) into two components: $u_{ict} = \alpha_c + \varepsilon_{ict}$. This model controls for community time-invariant characteristics that may be associated with both child health and the probability of exposure to weather shocks:

$$H_{ict} = \delta_2 D_{ict_{-1}} + \beta_1 X_{ict} + \beta_2 P_{ict} + \beta_3 K_{ict} + \beta_4 I_{ict} + \gamma Y_t + \alpha_c + \varepsilon_{ict} \qquad (6)$$

$$\varepsilon_{ict} \sim (0, \sigma_\varepsilon^2)$$

where α_c represents time-invariant community environment common to all children living within the same community and ε_{ict} is the random error term. Due to serial correlation in the random error term, standard errors are estimated to allow for arbitrary variance-covariance structure within communities.

The parameter, δ_2 is estimated using variations in exposure within communities and across time. In other words, equation (6) compares the HAZ-scores of children exposed to small-scale weather shocks to unexposed children within the same community. Identification of δ_2 relies on the assumption that amongst households with similar characteristics living within the same community, exposure to small-scale weather shock is uncorrelated with unobservable household characteristics that could affect child nutritional status. Failure to control for time invariant unobserved household characteristics that are correlated with both the probability of exposure and child nutritional status may result in biased estimates of the impact of small-scale weather shocks on child nutritional status. For example, households may report exposure to weather shocks depending on the extent to which they perceive a fall in household economic welfare, ex-post (Dercon, 2002). Thus, differences in exposure to weather shocks may reflect differences in households' level of preparedness or ability. Lower 'ability' households, for example, may

possess lower adaptive or coping strategies, resulting in 'exposure' to weather shocks and lower 'ability' may also be associated with lower technical efficiency in the combination of child health inputs, resulting in lower child health outcomes. Failure to account for differences in household 'ability' could therefore, result in an overestimation of the impact of small-scale weather shocks.

Due to limitations imposed by the data[3], household fixed effects cannot be explicitly accounted for. Nonetheless, the validity of the assumption that exposure to small-scale weather shocks is uncorrelated with unobservable household characteristics is verified by estimating δ_2, using an alternative specification of equation (6) which excludes parents' (*P*) and household (*K*) characteristics from equation (6). If small-scale weather shocks randomly affect households, inclusion of parents' and household characteristics should not change the estimated effect of small-scale weather shocks on child nutritional status.

3.2 The impact of small-scale weather shocks on household consumption and expenditure

A fall in household total consumption and expenditure, particularly in food consumption is likely to explain the impact of small-scale weather shock on child nutritional status. To investigate this further, the impact of small-scale weather shocks on household total consumption and expenditure, on household food consumption and expenditure and on household food budget shares, are estimated. Similar to section 3.1, a series of community fixed effects models are specified. First, the impact on household (log) total PCCE is modelled controlling for household characteristics and characteristics of the head of household:

$$I_{ict} = \rho D_{ict_{-1}} + \beta_1 Q_{ict} + \beta_2 K_{ict} + \gamma Y_t + \alpha_c + \varepsilon_{ict} \quad (7)$$

$$\varepsilon_{ict} \sim (0, \sigma_\varepsilon^2)$$

Second, the impact on household (log) food PCCE (and household food budget share[4]) is modelled, controlling for household total PCCE, household characteristics and characteristics of the head of household:

$$Z_{ict} = \rho D_{ict_{-1}} + \varphi I_{ict} + \beta_1 Q_{ict} + \beta_2 K_{ict} + \gamma Y_t + \alpha_c + \varepsilon_{ict} \quad (8)$$

$$\varepsilon_{ict} \sim (0, \sigma_\varepsilon^2)$$

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[3] The VYLS collects data on one child per household.
[4] Food budget share is estimated as the sum of households' consumption and expenditure on all food items divided by household total consumption and expenditure on food and non-food items.

where I_{ict} is the ith household's monthly (log) total PCCE on all food and non-food goods, Z_{ict} is household's monthly (log) food PCCE (or household budget share on food). Household monthly food consumption and expenditure constitute all food items obtained from three sources: either bought by the household or obtained from own stock/harvest or received as gift/food aid within the past four weeks. K is a vector of household characteristics including (log) household size, proportion of children less than 6 years old, access to safe drinking water and good sanitation (flush toilet/septic tanks), and Q is vector of the characteristics of the head of household including education, gender and age.

To investigate the impact of weather shocks on the quality of household dietary intake, (log) food PCCE is disaggregated into household consumption and expenditure on micronutrient-rich and energy-rich food. Micronutrient-rich foods are high-nutrient food, rich in trace minerals and vitamins but very low in calories. They are needed by the body in small quantities and are vital for maintaining healthy body functions and in reducing the risk of chronic infections. On the other hand, energy-rich food (carbohydrates, fat and proteins) constitute the major part of a standard diet and are high in calories but have very little micronutrient content. Equation (8) is estimated separately using (log) PCCE on micronutrient-rich food and energy-rich food as dependent variables.

3.3 Differential impact of small-scale weather shocks

The impact of small-scale weather shocks on child health may vary depending of households' capacity to cope with the shock ex post. For example, wealthier households exposed to weather shocks are less likely to experience reductions in absolute consumption if they have access to credit markets or possess assets which can be used to smooth consumption. On the other hand, poorer households often live in more risky environments and children from these households already experience very low levels of consumption and poorer health status, such that exposure to weather shocks may have little impact on child nutritional status. To assess the differential impact of weather shocks across socioeconomic groups, equation (6) – (8) is estimated separately for children living in households above and below the sample median household (log) total PCCE and the coefficients on D_{ict-1} for the two groups are compared. Furthermore, the extent to which differences in the impact of weather shocks on household consumption explains differences in the impact on child HAZ-scores is investigated.

4 Data and Variables

This study uses data from the Vietnam Young Lives Survey (VYLS), an ongoing longitudinal survey of children and households in Vietnam. The first survey was conducted in 2002 and has since followed children and their households for two further rounds in 2006 and 2009. The original sample consists of 2,000 children aged 6-18 months (the younger cohort) and 1,000 children aged between 7.5-8.5 years (the older cohort). Children were selected from 31 communities[5] within five provinces representative of five socioeconomic regions in Vietnam: Lao Cai (North-East region), Hung Yen (Red River Delta), Da Nang (City), Phu Yen (South Central Coast) and Ben Tre (Mekong River Delta). In line with the main aim of the VYLS, which is to track the dynamics of childhood poverty, an over-poor sampling strategy[6] was adopted in the selection of communities, resulting in a purposive over-sampling of poor communities. In each selected community, 150 children were randomly selected from a list of eligible households[7]. In households with more than one eligible child, one child was randomly selected. This study uses only the last two rounds of the survey (2006 and 2009) including both the younger and older cohorts. Round 1 was excluded because information on household food and non-food consumption and expenditure was not collected in 2002.

Households' exposure to small-scale weather shocks are obtained from household questionnaires which include a module on exposure to a range of small-scale hydro-meteorological weather events including droughts, excessive rainfall or floods, erosions, landslides, frosts and storms. $D_{ict_{-1}}$ (in equations (6)-(8)) takes a value of 1 when a household reports experiencing any weather shock between 2002 and 2006 or between 2006 and 2009 and 0, otherwise. In each round, objective measures of child height was collected and age-standardized to a HAZ-score using the World Health Organisation (WHO) recommended US NCHS sample as the reference population. HAZ-scores above 3 and below – 5 are recoded as missing following WHO recommendations which consider HAZ scores outside this range implausible and likely to be due to measurement errors (WHO, 1995).

In rounds 2006 and 2009, the VYLS collected detailed information on household consumption and expenditure on a wide range of food and non-food goods. Household food consumption and expenditure (estimated at 2006 prices) comprise the sum of the value of all food goods

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[5] A community is defined as having a local government, primary school, commune health centre, post office and market.

[6] Tuan et al. (2003) provides a detailed description of the sampling strategy.

[7] Eligibility of households was based on the presence of a child born between January 2001 and May 2002 (for the younger cohort) and between January 1994 and June 1995 (for the older cohort)

bought or obtained from own stock /harvest or received as gift or food aid. Household consumption and expenditure on micronutrient-rich food is estimated as the sum of all high-nutrient food (including fish, meat, eggs, milk, fruits, vegetables, legumes, lentils and beans) consumed within households in the past two weeks[8]. Similarly, household consumption and expenditure on energy-rich food is estimated as the sum of all high-calorie food (including rice, pasta, bread, wheat, cereal, tubers and potato) consumed within households in the past two weeks.

The VYLS collects a wide range of child, parent and household characteristics which are used as controls for observable characteristics that may affect the probability of exposure to weather shocks and child nutritional status. Child characteristics include child's gender (male/female), age categories (younger/older cohort) and ethnicity (ethnic majority group (kinh)/ethnic minority groups); parents' (fathers' and mothers') characteristics include education categories (no education/primary/secondary/high school/degree), age group (≤35 years/ >35 years of age) mothers' religion (religion/no religion) and mothers' height (in centimetres). Controls for household characteristics include (log) household size, proportion of children bellow the age of 6 and access to safe drinking water and good sanitation. For equations (7) and (8), in addition to household characteristics, characteristics of the head of the household (age group, education categories and gender) are included as controls. The final sample across both rounds consists of a total of 4,772 children (2,639 from round 2 and 2,133 round 3).

5 Results and Discussion

Table 1a shows the summary statistics of the full sample and separately for children exposed and unexposed to small-scale weather shocks. Approximately 27% of children were exposed to small-scale weather shocks across both rounds with 40% of these shocks occurring between 2002 and 2006 and 60% between 2006 and 2009. On average children are 1.28 standard deviations shorter than children of the same age and gender within the US reference population, with those exposed to weather shocks statistically significantly shorter than children unexposed by approximately 0.2 standard deviations. Mean household (log) total PCCE, (log) food PCCE and food budget shares are lower in exposed households compared to unexposed households. Table 1a also shows differences in the quality of food consumed between exposed and unexposed households. Household (log) PCCE on micronutrient-rich food is lower while (log)

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[8] In this study, household monthly consumption and expenditure is estimated by multiplying the two weeks consumption values by 2.

PCCE on energy-rich food is higher in exposed household compared to unexposed households. Similar patterns are observed in households' allocation of the food budget to micronutrient-rich and energy-rich food[9]. The proportion of the food budget allocated to micronutrient-rich food is lower in exposed households compared to unexposed households (51% vs. 49%), while the proportion of the food budget allocated to energy-rich food is higher in exposed households compared to unexposed households (31% vs. 28%).

In Vietnam, agriculture constitute a major, or in some households, the only source of income particularly for poorer households where approximately 75% of households in the lowest income quintile rely solely on agricultural income (Vietnam General Statistics Office, 2010). Therefore weather shocks such as droughts, heavy rainfalls or floods which adversely affect agricultural production are likely to have a negative impact on household income, particularly in poorer regions. A fall in household income will in turn affect the quality of food, exposed households can afford to purchase, resulting in a shift from high-nutrient food to more affordable, but less quality food. This can be seen in Table 1b which shows households' PCCE on food (in Vietnamese Dong) obtained from three different sources: food bought/purchased, food consumed from own stock/harvest or food received as gifts. Purchased food constitutes the major part of households' total PCCE on food compared to food obtained from own stock/ harvest or received as gift.

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[9] Budget shares for micronutrient-rich and energy-rich food are calculated as the sum of household consumption and expenditure on all individual micronutrient-rich and energy-rich food respectively, divided by total food consumption and expenditure.

	Full sample	Unexposed	Exposed	Difference
Table 1a Summary statistics				
Child's Characteristics				
HAZ-score	-1.278	-1.232	-1.404	0.172**
Male	0.505	0.508	0.497	0.011
Kinh (Ethnic majority)	0.891	0.909	0.841	0.067**
Older cohort	0.340	0.328	0.371	-0.042**
Survey year				
2006	0.553	0.608	0.401	0.208**
2009	0.447	0.392	0.599	-0.208**
Father's (F) and Mother's (M) Characteristics				
F age≤35 years	0.393	0.408	0.351	0.057**
F age >35 years	0.607	0.592	0.649	-0.057**
M age ≤35 years	0.548	0.570	0.486	0.084**
M age>35 years	0.452	0.430	0.514	-0.084**
F No education	0.052	0.047	0.064	-0.017*
F Primary	0.231	0.209	0.290	-0.081**
F Secondary	0.461	0.460	0.462	-0.002
F High School	0.178	0.195	0.130	0.065**
F Degree	0.079	0.088	0.054	0.035**
M No education	0.079	0.070	0.102	-0.032**
M Primary	0.265	0.249	0.308	-0.058**
M Secondary	0.475	0.478	0.468	0.011
M High School	0.120	0.133	0.084	0.049**
M Degree	0.061	0.069	0.039	0.030**
M No religion	0.926	0.929	0.916	0.013
M Height (cm)	152.34	152.47	151.97	0.506**
Household Characteristics				
Urban residence	0.203	0.211	0.181	0.030*
Safe drinking water	0.694	0.712	0.644	0.069**
Good sanitation	0.385	0.403	0.336	0.067**
Log household size	1.627	1.622	1.640	-0.017+
Prop. of children≤6 years	0.132	0.141	0.106	0.035**
Log total PCCE	5.958	5.964	5.942	0.022
Log food PCCE	5.378	5.394	5.334	0.059**
Log energy-rich food PCCE	4.007	3.992	4.047	-0.055**
Log nutrient-rich food PCCE	4.642	4.669	4.567	0.101**
Budget share of food	0.590	0.595	0.576	0.018**
Energy-rich food share	0.289	0.281	0.310	-0.029**
Nutrient-rich food share	0.500	0.505	0.487	0.018**
Household Head (H) Characteristics				
H No education	0.058	0.052	0.074	-0.022**
H Primary	0.247	0.227	0.304	-0.076**
H Secondary	0.449	0.450	0.446	0.004
H High School	0.170	0.187	0.122	0.064**
H Degree	0.076	0.084	0.054	0.031**
H age ≤35 years	0.339	0.354	0.297	0.056**
H age >35 years	0.661	0.646	0.703	-0.056**
H Gender (Female)	0.092	0.096	0.080	0.015
PY Observations	4772	3504	1268	

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$. PY: Person-years.

Table 1b Mean household food PCCE from three sources (in 1000 VND)

Sources of food consumed:	(Full sample)	Unexposed	Exposed	Difference
Total food				
Bought	207.35	212.66	192.69	19.97**
Own stock/harvest	38.40	37.09	40.67	-3.58*
Gift	5.65	5.92	4.90	1.02
Energy-rich food				
Bought	38.84	37.58	42.31	-4.74**
Own stock/harvest	21.73	21.72	21.75	-0.03
Gift	0.90	0.74	1.34	-0.60**
Nutrient-rich food				
Bought	111.10	115.27	99.57	15.69**
Own stock/harvest	15.61	14.67	18.22	-3.55**
Gift	2.77	2.97	2.19	0.78*
PY Observations	4772	3504	1268	

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$. PY: Person-years. VND: Vietnamese Dong

However, compared to unexposed households, exposed households consume more from own stock and purchase less food goods, suggesting higher budgetary constraints amongst exposed households and a higher reliance on own stock or harvest to meet dietary needs.
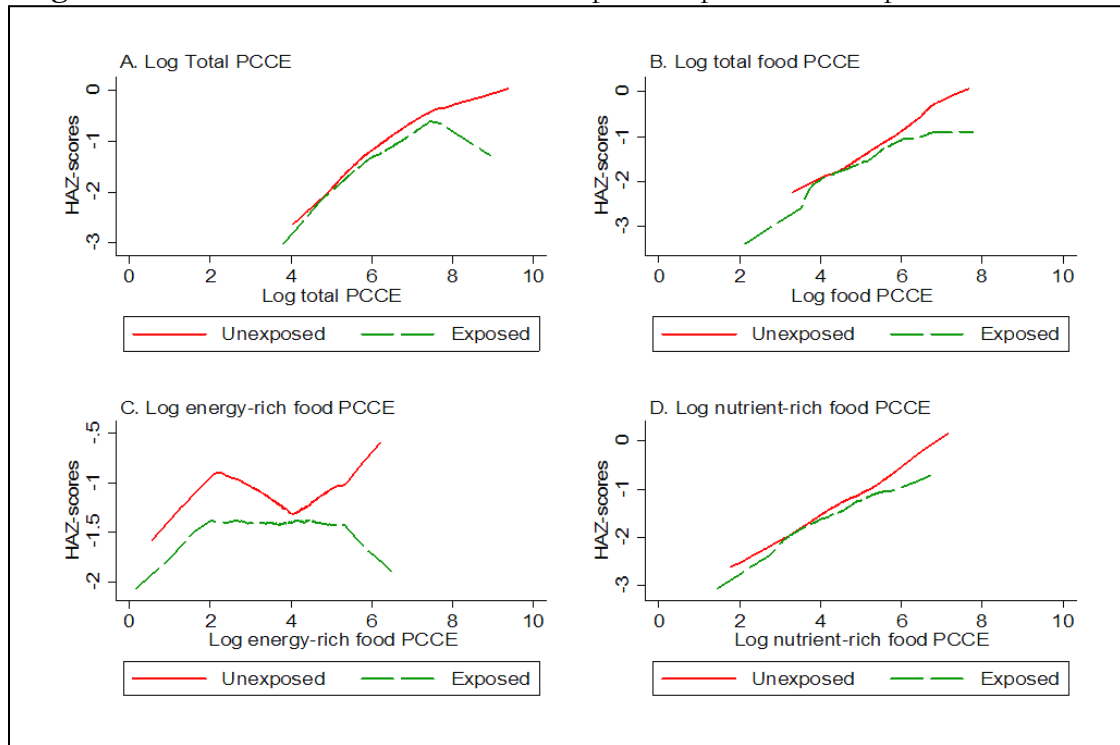
Disaggregating total food PCCE into PCCE on energy- and micronutrient-rich food shows lower expenditure on high-nutrient food and higher expenditure on energy-rich food in exposed households compared to unexposed households. This suggests a shift from purchasing high-nutrient food to perhaps more affordable energy-rich food, by exposed households. Although consumption of high-nutrient food from own stock/harvest is higher in exposed households, this is not high enough to offset the lower expenditure on high-nutrient food.

Figures 1-3 presents a series of nonparametric locally weighted regressions, showing the impact of small-scale weather shocks on child HAZ-scores, on (log) food PCCE and on household food budget shares[10]. Figure 1A and 1B plots child HAZ-score as a function of (log) total PCCE and (log) food PCCE, splitting the sample by exposed and unexposed households. Both graphs show a positive relationship between household PCCE and child nutritional status, with child HAZ-scores increasing as household total PCCE and total food PCCE increases. However, across the entire PCCE distribution, the HAZ-scores of children exposed to small-scale weather shocks are lower than the HAZ-scores of unexposed children. The gap between the 'exposed' and 'unexposed' lines is indicative of the magnitude of the impact of weather shocks on child nutritional status and a widening of the gap between the two lines going up the (log) total PCCE distribution is indicative of a differential impact of small-scale weather shocks at different

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[10] These plots are obtained using the pooled sample across both years.

quantiles. The gap between the two lines is greatest at higher quantiles, suggesting a greater impact of weather shocks on wealthier households[11]. A similar positive relationship is observed between child HAZ-score and the consumption of micronutrient-rich food (Figure 1D), while no clear relationship is observed between child nutritional status and PCCE on energy-rich food (Figure 1C), suggesting a more important role of micronutrient-rich food in predicting nutritional status.

Figure 1 HAZ-scores and household consumption: exposed vs. unexposed households

Given the positive relationship between the quality of food and child HAZ-score, lower HAZ-scores in exposed children is likely to be due to a reduction in household food PCCE, particularly PCCE on high-nutrient food. Figure 2 and 3 presents nonparametric Engel curves showing differences between exposed and unexposed households in terms of household budget share on food (Figure 2A-C) and household (log) food PCCE (Figure 3A-C). Figure 2A-C plots food budget share as a function of (log) total PCCE, splitting the sample by exposed and unexposed households. A negative relationship is observed between (log) total PCCE and household food budget share (Figure 2A) suggesting that food is a necessity for both groups[12]. However, food budget share in exposed household is lower across the entire distribution of (log)
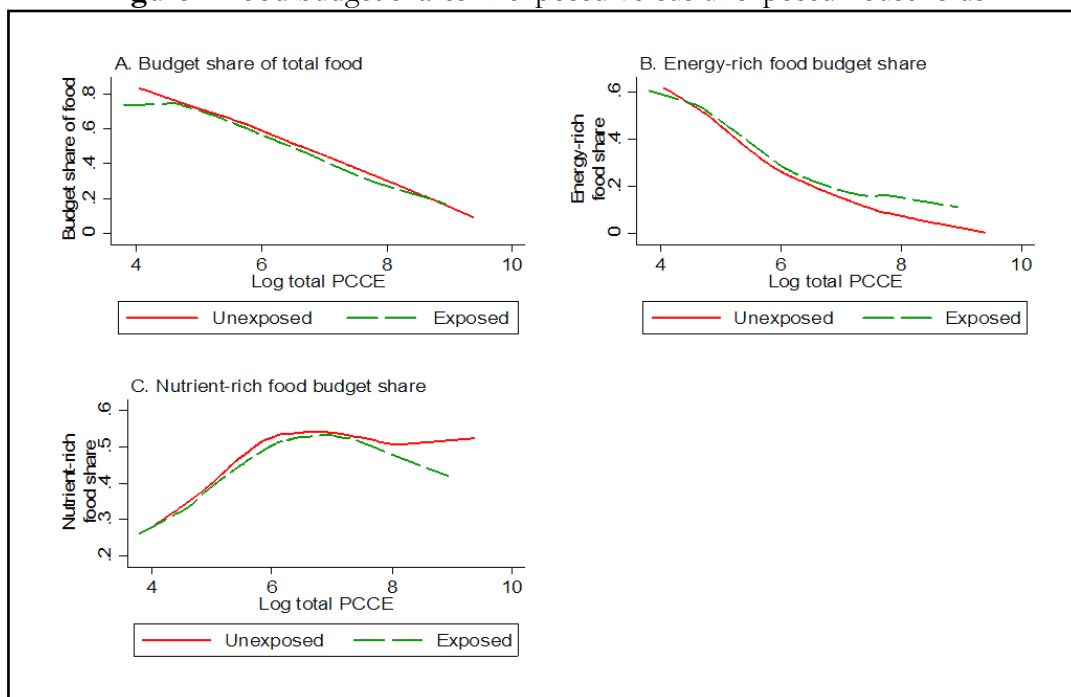
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[11] This effect is discussed in more detail in section 5.3 which examines the differential impact of small-scale weather shocks using parametric modelling.

[12] This implies that household PCCE on food grows more slowly than household total PCCE.

total PCCE compared to the food budget shares of unexposed households. Similarly, energy-rich food is a necessity for both groups (Figure 2B), but exposed household allocate a higher proportion of their food budget to energy-rich food compared to unexposed households. On the other hand, the share of the food budget allocated to high-nutrient food is lower in the exposed households compared to unexposed households (Figure 2C) suggesting a reduction in the quality of dietary intake. Similar results are observed when household (log) food PCCE is plotted as a function of (log) total PCCE (Figure 3A-C). Compared to unexposed households, exposed households consume less high-nutrient food and more energy-rich food.
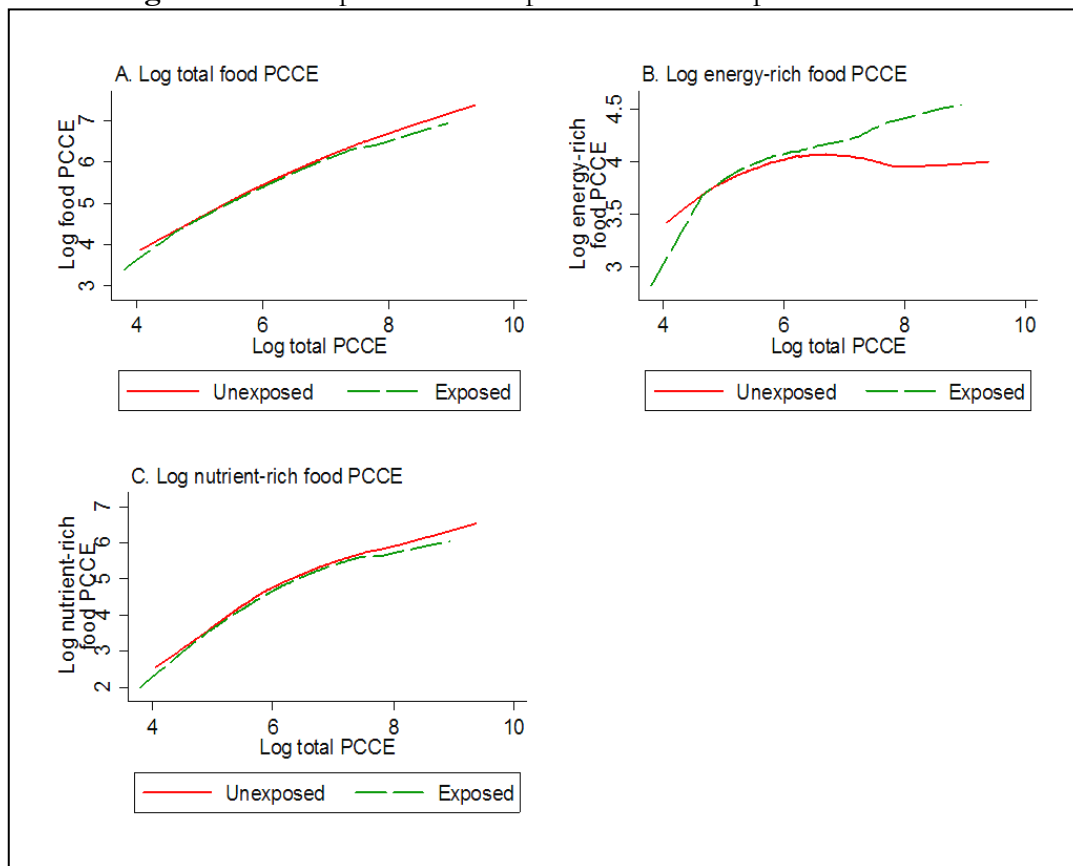
Figure 2 and 3 provides some explanation for the observed differential impact of small-scale weather shocks on child HAZ-scores at different quantiles of the (log) total PCCE distribution. The gap in household budget share and (log) PCCE on energy-rich food (Figure 2B and 3B, respectively) observed between the 'exposed' and 'unexposed' lines is widest at higher quantiles of the (log) total PCCE distribution compared to lower quantiles. Similarly, the gap in household budget share and (log) PCCE on micronutrient-rich food (Figure 2C and 3C), although smaller than the gap observed with energy-rich food, appears to be larger at the higher quantiles compared to lower quantiles. This suggests that the differential impact of small-scale weather shocks on child HAZ-scores may be mediated by the differential impact on the quality of dietary intake.

Figure 2 Food budget shares in exposed versus unexposed households

Differences in parent and household characteristics observed between exposed and unexposed children (Table 1a) suggests that exposure to small-scale weather shocks are not randomly distributed. On average, households exposed to small-scale weather shocks are of lower socioeconomic status compared to unexposed households (Table 1a). For example, compared to unexposed household, parents in exposed households are less educated, fewer proportions of households exposed to small-scale weather shocks have access to safe drinking water (64% versus 71%), flush toilet/septic tank (34% versus 40%) and have larger (log) household sizes (1.64 versus 1.62). Parental education, access to safe drinking water, and good sanitary conditions has been shown to be important determinants of child health and nutritional status in developing countries (Behrman & Deolalikar, 1988; Fewtrell et al., 2005). For example, higher education is associated with higher income and children with more educated parents are likely to have better health outcomes compared to children with less educated parents[13]. The following sub-sections present results of the parametric analyses that accounts for differences in observable characteristics between exposed and unexposed children.

Figure 3 Food expenditure in exposed versus unexposed households

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[13] Currie (2009) provides an excellent review of the literature on child health and parental socioeconomic status.

5.1 Impact of small-scale weather shocks on child nutritional status

The parametric strategy adopted here estimates the impact of small-scale weather shocks on child HAZ-scores controlling for observable characteristics correlated with both exposure to small-scale weather shocks and child HAZ-scores. Exposure to small-scale weather shocks is assumed to be randomly distributed amongst households living within the same community, conditional on observable parent and household characteristics. Two community fixed effect models are specified to test this assumption; the first excludes parent and household characteristics and the second accounts for parent and household characteristics. Table 2 shows results of the parametric estimation of the impact of small-scale weather shocks on child HAZ-scores. In the first specification (first column, Table 2), after controlling for only child characteristics, HAZ-score of children exposed to small-scale weather shocks are on average approximately 0.15 standard deviations lower than those of unexposed children. This finding is consistent with other studies that have reported similar estimates of the impact of small-scale weather shocks on child nutritional status (Datar et al., 2011; Pörtner, 2010).

An indication of the magnitude of this impact can be deduced using the World Health Organisation (WHO) growth reference charts[14] which shows corresponding height differences (comparable to the US NCHS sample) for a given age and gender for a one standard deviation in HAZ-scores. For example, a one standard deviation in the HAZ-score of a 4 year old male child is equivalent to a 4.25cm difference in height. Similarly, for a male child aged 8, 12 and 16 year old, the equivalent height difference is approximately 6.25cm, 6.75cm and 7.5cm, respectively. Equivalent approximations for girls of similar ages (i.e. 4-16years old) are 4cm, 6cm, 6.5cm and 7cm, respectively. Therefore a reduction in HAZ-scores by 0.15 standard deviation is equivalent to a reduction in height by approximately 0.6 -1.125cm. Given the potential for future catch-up growth in children who experience temporary growth retardation in childhood (Adair, 1999)[15], the functionally small height differences estimated here may disappear in late childhood/adolescence. However, repeated exposure to shocks, such as small-scale weather shocks, throughout childhood is likely to impede any catch-up growth that may have occurred in late childhood or early adolescence (Martorell et al., 1994).

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[14] These charts are downloadable from the WHO webpage:
http://www.who.int/growthref/who2007_height_for_age/en/index.html
[15] The potential for future catch-up growth in children has been disputed by some authors. Some examples include Martorell et al. (1994) and Hoddinott and Kinsey (2001).

Table 2 Impact of weather shocks on child HAZ-score

	(1)		(2)		(3)	
Exposed	-0.146**	(0.0439)	-0.102*	(0.0391)	-0.0775*	(0.0364)
Male	-0.0352	(0.0332)	-0.0436	(0.0341)	-0.0311	(0.0347)
Kinh (Ethnic majority)	0.576**	(0.107)	0.409**	(0.103)	0.242**	(0.0818)
Older cohort	-0.208**	(0.0439)	-0.228**	(0.0446)	-0.201**	(0.0399)
Year=2009	0.189**	(0.0433)	0.0357	(0.0427)	0.0997*	(0.0397)
Safe drinking water			-0.0428	(0.0424)	-0.0303	(0.0371)
Good sanitation			0.155**	(0.0537)	0.106*	(0.0427)
Log household size			-0.0172	(0.0705)	0.00287	(0.0687)
Prop. of children≤6 years			-0.0630	(0.134)	-0.0988	(0.112)
Urban residence			0.232	(0.240)	0.169	(0.324)
Log total PCCE			0.303**	(0.0478)	0.174**	(0.0387)
M No religion					0.0110	(0.0658)
M Height (cm)					0.0525**	(0.00264)
F age >35 years					-0.0334	(0.0559)
F Primary					0.0425	(0.0915)
F Secondary					0.120	(0.0996)
F High School					0.113	(0.126)
F Degree					0.290*	(0.131)
M age>35 years					-0.0467	(0.0436)
M Primary					0.100	(0.0731)
M Secondary					0.123	(0.0742)
M High School					0.224**	(0.0781)
M Degree					0.325**	(0.100)
Constant	-1.749**	(0.104)	-3.375**	(0.325)	-10.72**	(0.488)
PY Observations	4772		4772		4772	

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$; Cluster-robust standard errors in parentheses.   Base categories: F and M ≤35years for parents' age, F and M with no education for parents' education. PY: Person-years. All models control for community fixed effects.

In the second specification (second column, Table 2), a set of observable household characteristics are included while the third specification includes the full set of child, household and parent characteristics (third column, Table 2). If small-scale weather shocks randomly affect households, the inclusion of observable household and parent characteristics should have little or no effect on the magnitude of the estimated impact of small-scale weather shocks on child HAZ-score. After controlling for household characteristics including (log) total household PCCE, household size, access to safe drinking water and good sanitation, the magnitude of the estimated effect of small-scale weather shocks on child HAZ-scores reduces slightly to approximately 0.1 standard deviations. The inclusion of parent characteristics further reduces the magnitude of the estimated impact.

The reduction in the magnitude of the impact of small-scale weather shocks suggest that small-scale weather shocks are disproportionately distributed amongst those whose observed

characteristics are correlated with a higher probability of malnourishment, resulting in an overestimation of the impact of small-scale weather shocks of child nutritional status. For example, consistent with the literature on child health and parental education, higher parental education is associated with higher child HAZ-scores (Table 2). Since exposed children, on average, have parents with lower levels of education (Table 1a), the reduction in the magnitude of the estimated impact of small-scale weather shocks after controlling for parents education suggests that part of this impact can be explained by the impact of parent education on child HAZ-scores. Overall, the estimated impact of small-scale weather shocks on child nutritional status remain statistically significant after controlling for the full set of child, parent and household characteristics.

5.2 Impact of small-scale weather shocks on household consumption

The second part of the empirical analysis estimates the impact of small-scale weather shocks on household consumption and expenditure. Consistent with the literature on child health and parental socioeconomic status (Cameron & Williams, 2009; Case et al., 2002; Currie, 2009) a significant positive correlation is observed between child HAZ-scores and household (log) total PCCE. An increase in household (log) total PCCE is associated with an increase in child HAZ-scores (Table 2). Similar effects on child HAZ-scores are observed with (log) food PCCE and (log) micronutrient-rich food PCCE (results shown in Table A1 of the Appendix). Although energy-rich food has a positive effect on child HAZ-scores, the magnitude of this effect is considerably less and estimated with less precision, compared to the effect of micronutrient-rich food on child HAZ-scores[16]. The greater effect of high-nutrient food on child nutritional status is unsurprising given that micronutrients are more important for maintaining normal body physiological functions and micronutrient deficiencies could result in higher rates of infection and stunting as well as higher mortality rates in children (Black et al., 2008; Dewey & Begum, 2011).

Table 3 shows that exposure to small-scale weather shocks is associated with a statistically significant reduction in (log) total PCCE as well as a reduction in (log) food PCCE (although statistically insignificant). Differences in the magnitudes of the impact on household (log) total PCCE and on (log) food PCCE (9 vs. 2 percent) suggest that although small-scale weather shocks are associated with a reduction in the overall consumption, exposed households appear to protect food consumption.

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[16] The full results are shown in Table A1 of the Appendix.

Table 3 Impact of weather shocks on household consumption and budget share on food

Explanatory Variables	Log Per Capita Consumption& Expenditure on:				Budget Share on food:		
	Total PCCE	Total Food	Energy-rich	Nutrient-rich	Total Food	Energy-rich	Nutrient-rich
Exposed	-0.0907**	-0.0161	0.0549*	-0.0569**	-0.00311	0.0213**	-0.0137**
	(0.0194)	(0.0154)	(0.0232)	(0.0203)	(0.00746)	(0.00602)	(0.00498)
Log total PCCE	-	0.753**	0.235**	0.880**	-0.107**	-0.127**	0.0652**
	-	(0.0195)	(0.0273)	(0.0292)	(0.00735)	(0.00693)	(0.00865)
H Primary[‡‡]	0.247**	0.0217	0.0286	0.0641+	0.00223	-0.0131	0.0110
	(0.0316)	(0.0218)	(0.0432)	(0.0330)	(0.0119)	(0.0103)	(0.00876)
H Secondary	0.419**	0.00859	0.00245	0.0778*	-0.00728	-0.0184+	0.0220*
	(0.0355)	(0.0209)	(0.0422)	(0.0316)	(0.0117)	(0.0106)	(0.00947)
H High School	0.536**	-0.00735	-0.0384	0.0961**	-0.0207	-0.0265*	0.0352**
	(0.0351)	(0.0229)	(0.0461)	(0.0306)	(0.0124)	(0.0118)	(0.00981)
H Degree	0.790**	0.0158	-0.0788	0.149**	-0.0123	-0.0310*	0.0523**
	(0.0503)	(0.0278)	(0.0479)	(0.0390)	(0.0135)	(0.0116)	(0.0119)
H age >35 years[‡]	-0.0466+	0.105**	0.139**	0.1000**	0.0450**	0.00584+	-0.00150
	(0.0233)	(0.0158)	(0.0217)	(0.0166)	(0.00676)	(0.00332)	(0.00312)
H Gender (Female)	0.0364	-0.0144	-0.0552+	-0.0318	-0.00778	-0.00350	-0.00248
	(0.0363)	(0.0181)	(0.0278)	(0.0239)	(0.00871)	(0.00600)	(0.00675)
Prop. of children≤6years	-0.373**	0.262**	-0.393**	0.574**	0.145**	-0.160**	0.153**
	(0.0537)	(0.0446)	(0.0562)	(0.0613)	(0.0191)	(0.0123)	(0.0174)
Log household size	-0.302**	-0.473**	-0.555**	-0.462**	-0.214**	-0.0137*	0.00654
	(0.0335)	(0.0227)	(0.0292)	(0.0236)	(0.00992)	(0.00579)	(0.00618)
Urban residence	0.260	-0.0874+	-0.0978	-0.0546	-0.0550**	-0.000794	0.00941
	(0.160)	(0.0454)	(0.0696)	(0.0750)	(0.0156)	(0.0220)	(0.0199)
Year=2009	0.394**	-0.104**	-0.141**	-0.100**	-0.0705**	-0.0131*	-0.00684
	(0.0231)	(0.0160)	(0.0242)	(0.0211)	(0.00835)	(0.00605)	(0.00874)
Constant	5.922**	1.620**	3.546**	0.00283	1.580**	1.103**	0.0644
	(0.0670)	(0.130)	(0.180)	(0.180)	(0.0502)	(0.0434)	(0.0511)
PY Observations	4772	4772	4772	4772	4772	4772	4772

[+] $p < 0.1$, [*] $p < 0.05$, [**] $p < 0.01$; Cluster-robust standard errors in parentheses. Base categories: [‡]H ≤35years, [‡‡] H no education. PY: Person-years.

Disaggregating food consumption into consumption of micronutrient- and energy-rich foods shows that exposed households are able to protect total food consumption by reducing the consumption of high-nutrient food and increasing the consumption of energy-rich food. Similar results are observed with the impact of weather shocks on household allocation of the food budget to high-nutrient and energy-rich food (Table 3, column 5-7). The concomitant decrease and increase in high-nutrient and energy-rich food respectively, is indicative of poorer dietary intake, thus providing a strong explanation for lower HAZ-scores in children exposed to small-scale weather shocks.

5.3 Differential impact of small-scale weather shocks

The nonparametric analyses discussed above suggest that the impact of small-scale weather shocks is greater amongst children living in wealthier households. In this section, this effect is further investigated by modelling the impact of small-scale weather shocks using two sub-groups defined by household (log) total PCCE: children living in households below and above the sample median (log) total PCCE.

Similar to the results seen with nonparametric modelling, small-scale weather shocks has a higher impact on the stature of children living in wealthier households compared to children from poorer households (Table 4, column 1). Table 4 (columns 2-6) also provides some explanation for this observed differential impact and shows that the impact of weather shocks on household (log) total PCCE is greater in households above the median compared to household below the median (approximately 8 percent vs. 2 percent). Although the impact on the quantity of food consumed (log food PCCE) is approximately similar for both sub-groups, the impact on the quality of food is greater in households above the sample median. In both sub-groups, exposure to weather shocks is associated with approximately similar magnitudes of reduction in the consumption of high-nutrient food. However, compared to households below the median, in households above the median, exposure to weather shocks is associated with a higher increase in the consumption of energy-rich food (7 percent vs. 3 percent).

As alluded to in section 3.3, the impact of small-scale weather shocks may depend on households coping strategies or the availability of credit or savings to smooth consumption. This means that wealthier households may be better equipped to cope with the aftermath of small-scale weather shocks, thereby, resulting in a lower impact on child nutritional status. For example, Hoddinott and Kinsey (2001) showed that exposure to droughts adversely affects the height of only

children living in poorer households possessing fewer livestock holdings, with no significant effect on the height of children living in wealthier households. However our results suggest that wealthier households are not better able to compensate the adverse effects of small-scale weather shocks and experience greater reductions in household (log) total PCCE as well as in the quality of dietary intake and hence, lower child HAZ-scores.

This result should be interpreted with caution given the pro-poor sampling strategy adopted by the VYLS resulting in a sample largely consisting of poorer households compared to a nationally representative sample[17]. For example, in a nationally representative sample such as the Vietnam Household Living Standard Survey (VHLSS), average household monthly total PCCE in 2006, 2008 and 2010[18] was estimated at 511, 792 and 1,211 thousand Vietnamese Dong (VND), respectively (Vietnam General Statistics Office, 2010). Estimates from this study sample are 546 and 817 thousand VND in 2006 and 2009 respectively for household above the sample median (log) PCCE and 207 and 327 thousand VND, respectively for household below the median. Thus, 'wealthier' households within the VYLS are unlikely to be true representatives of an average (in terms of a national average) rich household and therefore may not truly reflect the ability of wealthier households to smooth consumption following weather-induced income shocks.

On the other hand, failure to observe a significant impact of small-scale weather shocks on the nutritional status of children from poorer households within this study, may be a reflection of the wider adverse environmental and living conditions to which children from poorer households are exposed, which may in turn, pose more risks to child health.

Taken together, this may explain the higher impact of small-scale weather shocks on children living in 'wealthier' households compared to those living in poorer households. Although direct extrapolations on the heterogeneity of the impact of small-scale weather shocks cannot be made to a nationally representative sample, this result further strengthens the main findings of this study on the mechanisms through which small-scale weather shocks affect child HAZ-scores.

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[17] Nguyen (2008) compares the VYLS to two nationally representative samples: the VHLSS and the Demographic Health Survey (DHS). Average household wealth index is significantly lower in the VYLS compared to the VHLSS and the DHS (Nguyen, 2008).

[18] No survey was conducted in 2009.

Table 4 Differential Impact of small-scale weather shocks on child HAZ-scores, household consumption and budget share on food

	HAZ-scores	Log Per capita Consumption& Expenditure on:				Budget share on:		
		Total PCCE	Total Food	Energy-rich Food	Nutrient-rich Food	Total Food	Energy-rich Food	Nutrient-rich Food
Below sample median log total PCCE (*N=2283*)	-0.0324	-0.0214	-0.0186	0.034	-0.0677**	-0.00584	0.0217**	-0.0166*
	(0.0431)	(0.0144)	(0.0137)	(0.0232)	(0.0212)	(0.00765)	(0.00688)	(0.00684)
Above sample median log total PCCE (*N=2486*)	-0.126*	-0.0800**	-0.0255	0.0653+	-0.0590+	-0.00397	0.0230**	-0.0111
	(0.0527)	(0.0127)	(0.0238)	(0.0337)	(0.0293)	(0.0104)	(0.00791)	(0.00665)

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$; Cluster-robust standard errors in parentheses.
Column 1 includes the full set of child, parent and household characteristics and community fixed effects. Columns 2-8 include the full set of household characteristics, characteristics of the head of household and community fixed effects.

6 Conclusion

Small-scale weather shocks are unlikely to be accompanied by an immediate or extensive loss of lives or wide-spread destruction of social infrastructures often seen in cases of large-scale natural disasters. However, repeated exposure to small-scale weather shocks is likely to have important long-term adverse economic consequences on households, potentially making child health vulnerable.

This study uses the Vietnam Young Lives Survey to investigate the impact of small-scale weather shocks on household welfare and on the nutritional status of children living in households within disadvantaged communities of Vietnam. Similar to previous studies, this study confirms that both child health and household welfare are compromised by weather shocks. After controlling for a wide range of observed characteristics and community fixed effects, children living in households exposed to weather shocks are statistically significantly more malnourished than children living in unexposed households.

This study focuses mainly on investigating the role weather-induced shocks to household income (using household total PCCE as a proxy for household income) plays in mediating the adverse impact of small-scale weather shocks on child health. This is because shocks to household income is likely to represent a major mechanism through which small-scale weather shocks affects child health, either directly (for example, through a reduction in household consumption of high-nutrient food which are crucial for child physical development), or indirectly (for example, through inducing changes in parental behaviour such as reducing the time spent caring for the child or increasing the supply of child labour).

The results show that small-scale weather shocks are associated with a reduction in total household consumption and expenditure on all food and non-food goods as well as a reduction in the quality of dietary intake. Since child nutritional status is a function of the quality of dietary intake, this result shows that weather shocks impacts on child nutritional status through a reduction in household economic welfare which in turn, results in a fall in the quality of child dietary intake.

Finally, the results show evidence of a differential impact of weather shocks in children from different socioeconomic backgrounds. However, contrary to previous studies, a greater impact of small-scale weather shock is observed in children from wealthier backgrounds due to a larger reduction in quality of household dietary intake. However, this result should be interpreted with

caution given that this study sample consists predominantly of disadvantaged households. Therefore 'wealthier' households are likely to still face high budget constraints with limited capacities to smooth consumption in response to household consumption shocks. On the other hand, for poorer households, weather shocks may be one of a host of other risky environmental conditions which are perhaps more important in determining the nutritional status of children living within these environments. This may explain the failure to observe a significant impact of weather shocks in children from poorer backgrounds.

Malnutrition in children remains a leading public health concern globally particularly in developing countries, not least because it has been implicated in 53% of the 10.6 million preventable deaths in children each year (Black et al., 2008; Hosseinpoor et al., 2006). In addition, childhood malnutrition has been linked to adverse health, lower education and labour market outcomes in adulthood (Case & Paxson, 2008; Currie, 2009). Given the increasing frequency of natural disasters and the vulnerability of children when exposed, there is the need to investigate the extent and mechanisms through which weather shocks impact on child health as well as to identify particular groups of children who are most at risk. This will in turn inform policy responses aimed at protecting vulnerable households and children against the impact of weather shocks. Overall, this study highlights the importance of insuring household consumption as a means of protecting long- and short- term health outcomes of vulnerable children.

Appendix

Table A1 Impact of small-scale weather shocks on child HAZ scores, controlling for Total PCCE and Food PCCE

	(1)		(2)		(3)		(4)	
Exposed	-0.0775*	(0.0387)	-0.0793*	(0.0359)	-0.0891*	(0.0364)	-0.0761*	(0.0357)
Log total PCCE	0.174**		-		-		-	
Log food PCCE	-		0.143**	(0.0324)	-		-	
Log energy-rich food PCCE	-		-		0.0483+	(0.0282)	-	
Log nutrient-rich food PCCE	-		-		-		0.117**	(0.0219)
Male	-0.0311	(0.0347)	-0.0281	(0.0351)	-0.0271	(0.0353)	-0.0272	(0.0352)
Kinh (Ethnic majority)	0.242**	(0.0818)	0.260**	(0.0829)	0.275**	(0.0824)	0.256**	(0.0808)
Older cohort	-0.201**	(0.0399)	-0.209**	(0.0404)	-0.210**	(0.0412)	-0.208**	(0.0404)
Year=2009	0.0997*	(0.0397)	0.138**	(0.0405)	0.164**	(0.0401)	0.137**	(0.0405)
Safe drinking water	-0.0303	(0.0371)	-0.0302	(0.0367)	-0.0194	(0.0367)	-0.0297	(0.0361)
Good sanitation	0.106*	(0.0427)	0.120**	(0.0411)	0.144**	(0.0418)	0.115**	(0.0417)
Log household size	0.00287	(0.0687)	0.0495	(0.0715)	-0.0170	(0.0733)	0.0341	(0.0690)
Prop. of children≤6 years	-0.0988	(0.112)	-0.168	(0.104)	-0.163	(0.106)	-0.198+	(0.102)
Urban residence	0.169	(0.324)	0.192	(0.329)	0.197	(0.323)	0.189	(0.328)
M No religion	0.0110	(0.0658)	0.0115	(0.0663)	0.00993	(0.0663)	0.00833	(0.0652)
M Height (cm)	0.0525**	(0.00264)	0.0530**	(0.00259)	0.0533**	(0.00267)	0.0531**	(0.00265)
F age >35 years	-0.0334	(0.0559)	-0.0458	(0.0561)	-0.0487	(0.0558)	-0.0455	(0.0561)
F Primary	0.0425	(0.0915)	0.0514	(0.0929)	0.0672	(0.0932)	0.0475	(0.0914)
F Secondary	0.120	(0.0996)	0.135	(0.101)	0.159	(0.102)	0.129	(0.100)
F High School	0.113	(0.126)	0.133	(0.128)	0.161	(0.128)	0.125	(0.127)
F Degree	0.290*	(0.131)	0.314*	(0.131)	0.366**	(0.131)	0.307*	(0.133)
M age>35 years	-0.0467	(0.0436)	-0.0482	(0.0432)	-0.0520	(0.0438)	-0.0441	(0.0434)
M Primary	0.100	(0.0731)	0.110	(0.0735)	0.112	(0.0742)	0.106	(0.0736)
M Secondary	0.123	(0.0742)	0.136+	(0.0722)	0.151*	(0.0725)	0.133+	(0.0723)
M High School	0.224**	(0.0781)	0.248**	(0.0776)	0.274**	(0.0790)	0.240**	(0.0782)
M Degree	0.325**	(0.100)	0.358**	(0.0984)	0.395**	(0.0975)	0.348**	(0.0978)
Constant	-10.72**	(0.488)	-10.66**	(0.479)	-10.10**	(0.454)	-10.40**	(0.411)
PY Observations	4772		4772		4772		4772	

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$; Cluster-robust standard errors in parentheses. All models control for community fixed effects

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