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ABSTRACT

The 2004 Indian Ocean tsunami was an extremely destructive event in Aceh, Indonesia, killing over 160,000 people and destroying infrastructure, homes, and livelihoods over miles of coastline. In its immediate aftermath, affected populations faced a daunting array of challenges. At the population level, questions of how the disaster affected children's and parents' aspirations for education and whether it permanently disrupted schooling progression are critical in understanding how shocks affect human capital in the short and long term. We use longitudinal data from the Study of the Tsunami Aftermath and Recovery (STAR) to examine how disaster exposure affects educational aspirations and eventual attainment. We find that damage to one's community depresses aspirations in the short term but that this weakens with time. With respect to educational attainment 15 years after the event, children's aspirations, parents' education, and family socioeconomic status are more important determinants of whether children complete high school and go on to tertiary schooling than disaster exposure. While these results likely reflect, at least in part, the successful post-tsunami reconstruction program, they also establish enormous resilience among survivors who bore the brunt of the tsunami.

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INTRODUCTION

Disasters such as major floods and fires are increasing in frequency and intensity as a result of climate change, with potentially negative consequences for children. Research on disruption following adverse exposures to children's developmental trajectories and investments in their human capital documents short and long-term consequences for a range of outcomes (Cas et al. 2014; Felitti et al. 1998; Hughes et al. 2017). Understanding how these exposures affect children's educational attainment is critical given education's contributions to economic and social mobility and capacity to weather shocks (Alam, Pörtner, and Simpson 2022; Holloway and Pimlott-Wilson 2011; Muttarak and Lutz 2014). It is important to investigate the full array of factors that drive education outcomes. To this end, we focus on children's educational aspirations and how they are affected by exposure to extreme events. We also consider how aspirations and exposures are related to eventual educational attainment. Educational aspirations are shaped by many internal and external factors (Andrew and Hauser 2011; Vaisey 2010) and have been shown to shape longer-term outcomes including educational and occupational attainment (Frye 2012; Giustinelli 2023; Hitlin 2006; Mare and Maralani 2006; Rothon et al. 2011; Sewell and Shah 1968a). It has been difficult to disentangle the role of background from this process. We leverage exposures to an unanticipated extreme event to provide new evidence on the impacts of exposures on educational aspirations and subsequent educational attainment.

Our paper integrates insights from the aspirations literature and adversity literature, drawing out the implications of adversity for educational goals and attainment. We focus on a large-scale natural disaster that destroyed property, livelihoods, and community. The issues are important. Disasters will continue to occur, and exposures to them are projected to increase as temperatures and sea levels rise, storms intensify, and more people live in vulnerable areas

(Emanuel 2005; Muis et al. 2016; Neumann et al. 2015). From a cohort perspective, Thiery and colleagues (2021) estimate that children born in 2020 will experience somewhere between two and seven times more extreme events than those born in 1960.

Large-scale disasters over the past decades have illustrated the capacity for extreme events to disrupt education through destruction of schools and displacement of children and teachers. The contexts where this has occurred are wide-ranging and include the United States after Hurricane Katrina in Louisiana and wildfires in California (Harris and Larsen 2023; Schulze et al. 2020); China, Haiti, and Indonesia after earthquakes (Green and Miles 2011; Shidiqi, Di Paolo, and Choi 2023; Zifa 2008); Japan and Indonesia after tsunamis (Frankenberg, Friedman, Saadah, et al. 2008; Shiwaku et al. 2016); and Myanmar and the Philippines after typhoons (Julian and Loja 2009; Lateef 2009).

Limited data on attitudes and educational outcomes for individuals followed over the life course poses a challenge. Without longitudinal data, researchers cannot study the evolution of attitudes, behaviors, and economic circumstances after an extreme event, although these factors are important for long-term outcomes. We leverage uniquely rich longitudinal survey data from the Study of the Tsunami Aftermath and Recovery (STAR) to examine how exposure to the 2004 Indian Ocean tsunami impacts educational aspirations in the short and medium term, and ultimately educational attainment of children post-disaster. We focus on children who were ages four to thirteen at the tsunami and differentially exposed to its impacts. We examine educational aspirations one and five years post-tsunami and attainment fifteen years after the event. Our results reveal considerable ambition with respect to education and tenacity in its pursuit, despite the disaster, which had short-term impacts on educational goals. Over the longer term, children's aspirations and economic status are both important in determining educational outcomes.

Outcomes vary by children's sex and socioeconomic status, revealing vulnerabilities for some subgroups and resilience among others.

The 2004 Indian Ocean Tsunami

On December 26, 2004, an undersea earthquake triggered a tsunami that impacted countries bordering the Indian Ocean. Waves reached the Indonesian provinces of Aceh and North Sumatra about 15 minutes later. In the worst hit areas, entire communities were decimated. Damage was more moderate inland and at higher elevations (McAdoo, Richardson, and Borrero 2007). In Indonesia, an estimated 160,000 people died and 700,000 were displaced. Economic losses were calculated at about US\$ 4.5 billion (World Bank 2008).

Infrastructure related to health and human capital suffered. Research has documented impacts on water access (Burrows 2019) as well as health and education services (Frankenberg, Friedman, Saadah, et al. 2008). In the education sector, the disaster destroyed over 2,000 schools, killed 2,500 teachers and left 160,000 students without a school to attend (Dawson 2006). Primary schools closed in the communities with significant disaster damage, and one year later few communities had fully reopened damaged schools (Frankenberg, Friedman, Saadah, et al. 2008). Schools in other areas not directly impacted by the tsunami experienced increases in class sizes. Across the region, administrators reported decreased availability of teachers and supplies and worsened building conditions.

After the tsunami, pledges of financial support from governments, NGOs, and private citizens totaled more than US\$7 billion, which led to expansion of social safety nets including scholarships and large-scale rebuilding of houses, roads, bridges, schools, and government buildings (World Bank 2008). Emergency schools were set up in tents ('school in a box'), which reduced disruption and provided a sense of normalcy for children (UNICEF 2005). In fact, 93% of all children in our sample reported attending school in a box. Emergency schools were more

common in damaged communities, but children from other areas also benefitted (their schools may have suffered earthquake damage).

The tsunami also resulted in major political changes. Before the disaster, Aceh was the site of a long-running violent conflict between the Free Aceh Movement (GAM) and the Indonesian military (Le Billon and Waizenegger 2007). Security remained uncertain in the year after the tsunami, but in August 2005, GAM and the Government of Indonesia signed a peace agreement (the Helsinki Accords), which facilitated the recovery effort and reduced tensions (Evans 2010). Aceh received special autonomy as a province, including the right to a substantially greater share of profits from gas and oil extraction, up to four times what is allowed in other Indonesian provinces.

Children and families were affected in myriad ways by the tsunami and its sequelae. Many lost family, friends, property, and livelihoods. Households across coastal Aceh experienced substantial economic downturns (Lawton et al. 2024). Gradually, rebuilding efforts restored homes and infrastructure, and safety net programs established scholarships. The reconstruction efforts improved housing and infrastructure for some compared to conditions pre-tsunami and resulted in reduced poverty and unemployment overall. Although poverty rates rose immediately following the tsunami in 2005, they fell to below pre-tsunami levels in 2006. In fact, by 2006, poverty levels in tsunami-affected regions largely matched those in regions without direct impacts (World Bank 2008). The psychological, economic, and infrastructural implications of the disaster and its complex aftermath likely affected parents' and children's aspirations regarding education, and perhaps children's abilities to realize those aspirations over the longer term.

We describe the literature on children's formation of aspirations for educational attainment after major disruptions, and provide empirical evidence on how exposure to the

tsunami and its aftermath affects educational ambitions and outcomes. The life course perspective is important, especially the principle of life-span development, which highlights that trauma impacts likely extend past the event itself, modifying children's development trajectories over time (Elder, Johnson, and Crosnoe 2003; Fothergill and Peek 2015). As Elder (2019) described for children of the U.S. Great Depression, who experienced early deprivation, a large-scale shock likely has long-term wide-ranging impacts that are most completely explored with longitudinal data.

Educational Aspirations

Research in psychology, sociology and economics documents the key role of educational aspirations and expectations for achievement. Early work on stratification processes demonstrated both the importance of aspirations for educational and occupational outcomes and the role of parental education and socioeconomic background in establishing aspirations (Andrew and Hauser 2011; Manski 1993; Sewell, Haller, and Portes 1969; Sewell and Shah 1968b; Teachman and Paasch 1998). Sewell and colleagues (1969) developed the Wisconsin status attainment model, positing that aspirations are largely stable, arising from socioeconomic status and ability. High aspirations for the future potentially motivate productive action toward those goals (Mische 2009). Several studies find links between youths' aspirations and later-life education and occupation outcomes (Beal and Crockett 2010; Domina, Conley, and Farkas 2011; Hitlin 2006; Hitlin and Johnson 2015).

Although few papers address the impact of disaster exposures on aspirations, one pathway through which disasters could affect long-term achievement is via depressed aspirations resulting from economic and psychosocial consequences of the event. The COVID-19 pandemic provides a parallel context; in Bangladesh school disruptions are negatively associated with youths' aspirations (Baird et al. 2020). Several studies have considered aspirations across groups

of varying levels of deprivation, documenting that aspirations for education are relatively high among disadvantaged groups, including low-income urban communities (Frostick et al. 2016; Rothon et al. 2011), refugees (Shakya et al. 2010), immigrants (Kao and Tienda 1998), and in poorer rural Indonesia (Parker and Nilan 2013) and Malawi (Frye 2012).

Educational attainment after large scale-shocks

The literature on how exposure to large-scale shocks affects children's education focuses largely either on long-term impacts, where exposure is defined by birth in a region known to be impacted by a disaster, or on short-term impacts on enrollment and performance. Analyses generally find negative exposure impacts on these outcomes, although few have determined the underlying mechanisms (Alam et al. 2022).

Several studies focus on children born around the time and geographic vicinity of earthquakes, comparing their outcomes to those for older cohorts or children living further away. Caruso and Miller (2015) examine the 1970 Ancash earthquake in Peru, using census data from 1993 and 2007 to examine years of education, while Paudel and Ryu (2018) use survey data from Nepal to relate educational attainment as of 2008 to early life exposure to Nepal's 1988 earthquake. Both find that educational outcomes are significantly worse for exposed infants relative to various control groups, and females are more heavily impacted than males. In Nepal, negative impacts are limited to members of lower caste groups, suggesting economic resources may be important. However, no impacts are found for older children suggesting that caste is not only a proxy for economic resources or resources are critical only in early childhood. These studies extend the Barker hypothesis, which posits that in utero exposure to adversity affects health in later life, to investigate impacts on a broader set of human capital outcomes (Barker 1995; Barker et al. 1989). An early analysis concluded that educational attainment of the cohort in utero during the 1918 Spanish Flu epidemic was significantly lower relative to surrounding

cohorts (Almond 2006). Subsequent research highlighted the pitfalls of cohort comparisons, establishing that Almond's conclusions are driven by negative selection of parents (Beach et al. 2022; Brown and Thomas 2018).

Moving beyond in utero exposures, Andrabi, Daniels, and Das (2021) examine educational outcomes following a devastating 2005 earthquake in Pakistan. Five years afterward, they find no effect of disaster exposure on children's enrollment or grade attainment, although test scores are lower for children living in affected areas, particularly for children of women with low levels of education. They attribute the earthquake's modest negative impacts to generous post-earthquake assistance. The importance of economic resources for protecting children's schooling after a shock also emerges from a study of families after Hurricane Mitch in Honduras (Gitter and Barham 2007). In this study, exposure to the hurricane affects educational attainment only for children in families that are credit-constrained. Thomas and colleagues (2004) examine Indonesia after the 1998 financial crisis, finding that household resources and age are important factors in whether children stay in school, with poorer households protecting enrollment for older children at the expense of younger children.

Deuchert and Felfe (2015) use longitudinal data to analyze the impacts of typhoon Mike on schooling outcomes over a fifteen-year period in Cebu, Philippines. Housing damage is a proxy for the intensity of the shock. They find that damage negatively affects children's education. The impact increases with time since the event and is greatest for girls, children without older siblings, and children from families that are poor or lack strong kin or social networks.

Studies in higher-income countries have focused more on the processes through which disasters affect schooling. Several papers examine Hurricane Katrina in the United States, documenting the disruption this event caused for school systems and the children they serve. In

New Orleans, the disaster displaced a tremendous number of families and disrupted schools for a median of 5 weeks (Sacerdote 2012). Fothergill and Peek (2015) note that youth lost instruction time, changed schools, and had difficulty concentrating in class due to trauma. Teachers were also reported to be overwhelmed and upset and unable to perform their jobs optimally. As a result, children were launched into negative and unstable trajectories after the hurricane. Over time some found a new equilibrium and recovered (Pane et al. 2008; Sacerdote 2012).

Considering a longer time frame and focusing only on students who remain in or return to New Orleans, Harris and Larsen (2023) document substantial improvements in test scores, high school graduation rates, and college enrollment after a massive school reform (results contrast changes over time for New Orleans students to changes over time students in other parts of Louisiana).

The papers discussed above focus on outcomes related to *achievements* in terms of enrollment, attainment, and test performance, in most cases based on one cross-sectional survey or census. Taken together they suggest that the shocks that accompany natural disasters can affect children's educational outcomes, even years later, and that the poor and females are often at greater risk. They also document the importance of background characteristics that shape human capital investment even absent a disaster and of economic resources after a disaster. Importantly, some suggest that post-disaster financial support and programs to strengthen educational infrastructure can address the negative impacts of disaster exposure.

METHODS

Data and sample

The Study of the Tsunami Aftermath and Recovery (STAR) is a longitudinal survey of individuals, households, and communities in the tsunami-affected provinces of Aceh and North Sumatra, Indonesia. The baseline sample comes from the 2004 National Socioeconomic Survey (SUSENAS), an annual survey conducted by Statistics Indonesia 10 months before the tsunami.

It is representative of the population at the district (*kabupaten*) level (BPS 2019). The STAR survey targeted thirteen districts in Aceh and North Sumatra, all with coastlines potentially vulnerable to inundation from the tsunami. All SUSENAS enumeration areas (EAs) within these districts were eligible for the STAR survey in 2005. Together the EAs capture wide variation in the severity of the disaster. The STAR data provide information pre- and post-tsunami about respondents living in areas directly affected by the tsunami, as well as areas where impacts were indirect, allowing for comparisons across time, place, and circumstances.

The first wave of STAR (STAR Y1) sought to re-interview all individuals who were members of 6,490 households interviewed in the selected districts as part of SUSENAS in 2004. Fieldwork began five months post- tsunami (May 2005) and lasted for 12 months. Four additional follow-ups were conducted annually, concluding in November 2010. A ten-year follow-up took place between September 2014 and June 2016 and a fifteen-year follow-up began in 2020 (Frankenberg et al. 2022). Attrition rates in all waves are low, reflecting the survey team's persistence in tracking respondents. Of the 26,919 individuals who were members of baseline households in 2004, 24,752 survived the tsunami. Follow-up rates with the individual panel exceed 92% in every post-tsunami wave. In each wave, we interviewed both panel respondents and new members of households.

We focus on children who survived the tsunami and were between the ages of 4 and 13 at the time of the disaster. We analyze children who participated in STAR Y1 and leverage the longitudinal design of this survey to follow this cohort of children at two additional time points: 5 years (STAR Y5, 2009-2010) and 15 years (STAR Y15, 2020) post-tsunami, at which point children are past the age at which high school is typically completed. We examine the short and medium-term effects of exposure to the tsunami on children's educational aspirations, and how exposure and aspirations affect educational attainment over the long term.

Educational aspirations and attainment variables

In each post-tsunami survey wave, we asked respondents “What is the highest level of schooling you hope to attend?” Because over 90% of respondents hope to attain a degree from secondary or post-secondary school, we collapsed the response categories into a dichotomy indicating desire for post-secondary education (including an “academy” diploma, associate’s degree, university/bachelor’s degree, or above) or for a lower level of education. We measure aspirations at approximately one year (STAR Y1) and again at five years (Y5) post-tsunami.¹ Our analytical sample includes 5,429 children with valid observations for the aspirations variable one year after the tsunami, and 5,150 children with valid observations five years post-tsunami (5% attrition).²

To examine changes in aspirations, we created a variable combining respondents’ aspirations from STAR Y1 and STAR Y5. This variable takes on four values: (1) no aspirations for higher education in *either* year, (2) transition *into* aspirations for higher education by year five, (3) transition *out of* aspirations for higher education by year five, and (4) aspirations for higher education at *both* years. For children under 11 years of age, parents answered questions on behalf of their offspring. Children aged 11 to 14 years could answer for themselves if parents consented. About 48% of children aged 11-14 opted to be interviewed directly in STAR Y1, while 62% of children of the same age range did so in STAR Y5.³

Because we followed this cohort for 15 years, we can examine the link between aspirations for education and eventual educational outcomes measured in STAR Y15. We

¹ For 253 respondents who were not interviewed in STAR Y5, we used information about them from STAR Y4 (collected roughly a year earlier). This is about 5% of the analysis sample of STAR Y5.

² Attrition between STAR Y1 and Y5 is unrelated to disaster exposure measures or to parental education. We were less likely to interview children in year 5 if they were from households that were economically better off in the year after the tsunami.

³ Other work documents the close alignment between educational aspirations of parents and children (Kirk et al. 2011; Trusty 2000).

constructed a variable for educational attainment using the question “What is the highest school level you attended/are currently attending?” We classify respondents as to whether he or she attends or has attended an institution for post-secondary education (some college), completed high school but went no further, or left school before completing high school. By STAR Y15 all but 58 respondents were at least 19 years old and thus beyond the regular age for high school attendance. We excluded 30 respondents who were still attending high school at the time of the Y15 survey. There were 5,234 valid observations for this variable, for an attrition rate of only 3.6% of those who provided information about aspirations 15 years earlier in STAR Y1.⁴

Tsunami exposures

We characterize exposure to the disaster at the community and at the household level. At the community level, we use two variables. One is an indicator of general damage to the community, which we constructed by triangulating across information from knowledgeable community informants, direct observations by field supervisors, and high-resolution satellite imagery from which we assessed the degree of change in landcover to a reflection pattern consistent with bare earth in the period just after the tsunami (Gray et al. 2014). The measure is closely correlated with levels of tsunami mortality, injuries, post-traumatic stress, and damage to the built and natural environments (Frankenberg et al. 2011; Frankenberg, Friedman, Gillespie, et al. 2008). In addition to our measure of general damage, we constructed an indicator of whether the community’s schools were damaged in the disaster, as reported in interviews with

⁴ Attrition in STAR Y15 is significantly lower among those who aspired to higher education in STAR Y1 (by 0.2%) but not related to education aspirations in STAR Y5. Attrition is 0.6% lower among those whose father died in the tsunami but not significantly related to the other tsunami exposures (which are described below), parental education, child’s age, or levels of economic resources. For 303 respondents who were not interviewed in STAR Y15, we used information about them from STAR Y10 (collected roughly 5 years earlier). This is about 6% of the analysis sample of STAR Y15. We conducted sensitivity analyses excluding observations from STAR Y10 which yielded similar results.

the village leader and his or her staff. This measure addresses a very direct route through which the disaster might alter educational goals and outcomes.

At the household level, we construct two dichotomous variables. The first indicates whether the tsunami or earthquake damaged or destroyed the house the child lived in at the time of the disaster. We focus on housing damage for several reasons. First, housing is a major economic asset, often accounting for a large share of family wealth. Second, housing and residential location may be important sources of identity and connection with community (Barakat 2003). Third, housing disruptions are directly stressful and may also disrupt family and social networks and livelihoods (Sutley and Hamideh 2020). We believe that the experience of housing damage provides a sensitive indicator of disaster impacts because much research documents the costs to psychosocial health of damage and destruction of housing and the ensuing disruption to individual and community life (World Bank 2008).

The second measure indicates whether the child's father was killed in the disaster. The loss of a parent typically implies the end of a child's relationship with someone who is central to emotional well-being. Moreover, parental death may reduce economic resources, create pressure for children to assume additional responsibilities, and interfere with friendships, all of which may affect ideas about future pathways and trajectories (Stokes, Reid, and Cook 2009; Tremblay and Israel 1998; Worden and Silverman 1996). Our earlier work with slightly older children documents changes in children's schooling enrollment associated with parental loss (Cas et al. 2014).

Other covariates

Socioeconomic status We consider the roles of maternal and paternal years of education, as parental education has a close relationship with children's educational outcomes. Because mothers' and fathers' involvement in parenting varies over a child's life course, we analyze the

education of both parents (Black, Devereux, and Salvanes 2005; Thomas 1994). We assume parental education is fixed, as the youngest parents in the analysis sample were 20 and 24 years old in STAR Y1 and STAR Y5, respectively, and had likely completed their education.

We also include measures of mean monthly household expenditure per capita measured before the tsunami and, in the attainment models, at one and five years after the tsunami. These measures are log transformed to address skewness. Measures of expenditure level are widely used to measure household welfare in low- and middle-income countries and rural settings (Deaton and Zaidi 2002; Filmer and Pritchett 2001). They are less vulnerable to measurement error than income, and they capture a more precise picture of economic status over a longer period, as households often maintain spending levels even when income fluctuates (Frankenberg, Thomas, and Beegle 1999).

Respondent characteristics Analyses also control for basic demographic characteristics: the child's sex, indicators for single years of age, and urban/rural residence at the time of the tsunami. In the analysis of educational aspirations over time we include an indicator of whether the children responded for themselves, rather than a parent or guardian answering for them.

Analytical methods

We stratify our analyses of aspirations in Y1 and Y5 by whether parents or children were reporting. We estimate logistic regression models of low aspirations (less than college) relative to higher aspirations. Robust standard errors account for clustering at the community level. To examine changes in children's aspirations over time we use multinomial logistic regression models. We ask how tsunami exposures and other factors limit children's goals, pushing them towards lower aspirations. Aspirations for higher education at *both* one and five years post-tsunami serves as the base category. Our outcome categories are no aspirations for higher

education at *either* year, transition *out of* aspiring to higher education, and transition *into* aspirations for higher education. Robust standard errors account for clustering at the community level. We also conducted Wald tests to determine whether groups of covariates were jointly significant.

Lastly, to examine attainment of aspirations we estimate two logistic regressions, where the outcomes are (1) whether the respondent was able to complete at least high school education in the fifteen years after the tsunami and (2) whether the respondent went beyond high school to enroll in post-secondary education. We include measures of exposure to the disaster, aspirations over time, and demographic and economic attributes. We estimate a second specification that includes a community-level fixed effect to control for features that are constant within a community (such as damage from the disaster) for children from the same pre-tsunami location.

RESULTS

Descriptive statistics

Table 1A presents the weighted summary statistics of educational aspirations and attendance in the five years after the earthquake and tsunami. As shown in Panel A1, at the first post-tsunami interview, 38% of respondents report they do not aspire to attend higher education. Five years later, that percentage has fallen to 22%, which is a substantial change indicating increased aspirations generally.

Turning to the stability of aspirations over time (Panel A2), across the post-tsunami period 67% of respondents express consistent aspirations, most of whom hope to attend college at both one and five years after the tsunami. For those whose aspirations change, it is more common to develop college aspirations (24%) than to give them up (9%).

Panel B of the table presents statistics on educational attainment by the 15-year follow-up. A little less than one-fifth of children left school without attaining a high school degree,

while 42% completed high school and enrolled in tertiary education. These figures match data from Indonesia's SUSENAS survey, which puts the post-secondary participation rate in Aceh at 44.5% in 2019 (BPS 2021). At 42%, the fraction going on to college is half the share of those who hoped to go on to college at some point in the five years after the tsunami.

Table 1B presents summary statistics for exposure to the disaster, for all respondents and stratified by whether respondents lived at baseline in a community that was moderately or heavily damaged by the disaster. The event brought sweeping damage and destruction to many. At the time of the tsunami, 82% resided in a community that was moderately to heavily damaged, and almost 50% lived in a community where schools were damaged. About 69% of the children experienced damage or destruction of their home, and just under 2% lost their father in the disaster.

Background characteristics that were established before the tsunami are reported in panel B of Table 1B. They are the percentage of children who are male, their age, maternal and paternal education, and (the logarithm of) monthly per capita expenditures. A little over half the respondents are male. Mothers, on average, have almost seven years of education, versus 7.7 years for fathers. The measure of pre-tsunami expenditure (from 2004) indicates the log of per capita monthly spending was 11.9 (roughly USD 18 per month at 2004 exchange rates).

In columns 2 and 3 of Table 1B, we present summary statistics by whether the community was damaged. Damage to schools and to homes was far more common among children from damaged communities, and for these indicators, the differences are statistically significant at a 1% size of test. Loss of a father was also more common for children in heavily damaged communities, but in both areas, this exposure is relatively rare because a child was unlikely to survive if their father died (Frankenberg et al., 2011).

An empirical test of whether the exposure measures based on tsunami damage in the community are related to pre-existing differences is to compare these pre-tsunami characteristics among respondents who were living in communities that were damaged by the tsunami with the characteristics of those who were living in communities that were not directly damaged. The means are reported in columns 2 and 3 respectively, and the differences are reported in column 4. The child characteristics and measure of household resources are, on average, identical and the differences in parental education are small and in opposite directions. None of the differences is statistically significant. We conclude that our measure of community damage from the disaster is not likely to be confounded by pre-existing differences between residents of the two groups of communities, and we interpret its relationship to education aspirations and attainment as causal in the multivariate models that follow. We also examined whether our other exposure measures are related to pre-tsunami characteristics; because they are, we do not interpret the relationships as causal.⁵

Effects and associations of tsunami exposures on educational aspirations

Table 2 presents results from logistic regressions, where the outcome is aspiring to less than a college education at years 1 and 5, relative to hoping to attend college (columns 1-4). We also present results from a multinomial logit specification of the evolution of aspirations over time (columns 5-7). Coefficients are presented as odds ratios for the logistic regressions and relative risk ratios for the multinomial logit models. Our key questions are whether children exposed to the disaster express reduced hopes for the future and what role family background

⁵ We report results from models that include both general damage to the community (which we argue is plausibly exogenous) and other exposure measures. If the other exposure measures are not exogenous, and thus correlated with unobserved factors in the models, then the estimates of the effects of general damage to the community will be biased. To assess the importance of this concern, we have compared the coefficients of the general community damage measure when it is the only exposure measure in the models, to the coefficient on that covariate when all exposure measures are included in the models. The differences in the estimated effects of general damage to the community are very small, not substantively important, and not statistically significant. We therefore interpret the community-level damage estimates as causal in the models with the extended set of exposure measures.

plays in shaping educational goals. As noted above, we interpret the relationships between tsunami exposures and outcomes as associations.

We begin with results from cross-sectional analyses. With respect to exposure to the disaster, focusing on parental reports in the first year after the disaster (column 1), the odds of reporting low aspirations for children are 1.47 times higher for those from damaged communities compared to those from undamaged communities. School damage is also associated with higher odds (the ratio is 1.31) of low aspirations. Loss of a father, however, is associated with *lower* odds of no college aspirations (albeit at a 10% size of test) providing suggestive evidence that mothers who are recent widows are determined that their children will continue in school despite their loss. Turning to children reporting for themselves (column 2), only damage to the home is associated with educational aspirations. Children whose home was damaged or destroyed are more likely to express low aspirations for their education, with an odds ratio of 1.79.

At year five, the exposure measures continue to display associations with aspirations, although the effects are mostly somewhat attenuated and estimated with less precision. When parents report (column 3), school damage is associated with increased odds of low aspirations. The coefficient for whether the community sustained damage more generally, is no longer statistically significant. Five years after the disaster, when children report, the association between low aspirations and housing damage is no longer statistically significant at conventional levels. General community damage increases the odds of low aspirations at a level just short of statistical significance. As a group, the exposure measures are jointly significant ($p < 0.05$), apart from parental reports in year 5, where $p = 0.09$.

Turning to demographic and economic status, aspirations are more likely to be low for male children, particularly at year 5, when children report for themselves (column 4). Increasing levels of maternal and paternal education are all associated with reduced odds of expressing low

aspirations, and this relationship holds in both years and regardless of who reports. Higher per capita spending levels before the tsunami are associated with reductions in the odds of low aspirations. This result is statistically significant only in year 1 when parents report, although it is marginally significant ($p=0.07$) in year 5 when children report.

For the most part, the relationships that emerge in the cross-section hold in the multinomial logit models where the outcome is transitions in aspirations over time (columns 5-7). Here, the base category is aspirations for higher education at both one and five years post-tsunami, and results (expressed as relative risk ratios) are interpreted with reference to this base category (Wulff 2015). General damage to the community exerts a positive impact on expressing low aspirations in both years (column 5), and on transitioning from low aspirations to high aspirations (column 7), relative to high aspirations in both years. These results suggest that the disaster depressed aspirations in the year after the tsunami, but that for some, the impact was temporary. There are no differences in the effect of general damage to the community for those who aspired to higher education in the year after the tsunami, whether or not their aspirations changed 5-years post-tsunami (column 6).⁶

For the other exposure measures, damage to schools and damage or destruction of a child's home are both positively associated with low aspirations in both years. Home damage is also positively associated with transitioning from low to high aspirations. Death of a father is not related to the evolution of aspirations, and none of the exposure measures is related to transitioning from high to low aspirations (column 6).

⁶ We have tested whether the effect of community damage differs for those who never aspired to higher education (column 5) and those who transitioned from aspiring to higher education and then not (column 6). We found that it does indeed differ: those who were living in communities damaged by the tsunami are 32 percentage points less likely to transition from aspiring to not aspiring to higher education relative to those who did not aspire to higher education in both years. The difference is statistically significant at a 5% size of test.

With respect to demographic and economic factors, for males, all three outcomes (low aspirations in both years, or transitions over time) are more likely than the reference category of consistently high aspirations. Parental education and pre-tsunami resources are consistently associated with a lower likelihood of any category other than high aspirations in both years, indicating a strong positive influence of socioeconomic status on children's intentions for higher education in the aftermath of a disaster. This positive association between family socioeconomic status and higher aspirations is also echoed in the cross-sectional results (columns 1-4), especially for parental education.

Associations of tsunami exposures, aspirations, and economic status with educational attainment

The next questions we address are how exposures to the disaster, educational aspirations in its aftermath, and socioeconomic status influence outcomes 15 years post-tsunami. Because the outcomes we construct are dichotomous, we estimate logistic regressions, with odds ratios displayed in Table 3. The first column (1) shows results for whether students complete at least high school. The second column (2) shows the results for whether those who complete high school enroll in higher education.

Fifteen years after the disaster, general community damage does not affect educational attainment. Children who were from damaged communities at the time of the disaster are just as likely to complete high school and (given high school completion) to go on to college, as those who were from undamaged communities. Damage to schools, on the other hand, is positively associated with completing high school and going on to college. We interpret this counter-intuitive result as arising because areas where schools were damaged were targeted for assistance—so the coefficient is indicative of endogenous program placement. Neither the

experience of losing a home nor father's death is a significant predictor of high school completion or continuation to college.

We also include aspirations measures and economic status—variables that are important in longitudinal analyses of educational outcomes, though studied mostly in non-disaster settings. The reference category for our measure of aspirations is children who express a desire to attend college at both years 1 and 5 post-tsunami. Relative to those children, all other children are significantly less likely to complete high school and significantly less likely to go on to enroll in higher education.

Earlier we saw that males expressed lower aspirations for college than females. Here we see that males are significantly less likely to graduate from high school or enroll in college than females.

Turning to economic status, both maternal and paternal education are positively associated with completing high school and with enrolling in college. Higher levels of economic resources are not associated with completing high school, but they are associated with enrolling in college given high school completion. Resource levels five years after the tsunami are more closely associated with college than resources one year after the tsunami or in the year before the tsunami (pre-tsunami resources are only marginally significant).

As discussed above, the tsunami's impacts varied enormously across communities, but idiosyncratically within relatively small geographic areas. To allow for the possibility that the impact of the tsunami varied in ways that are correlated with unobserved features of the community that affect educational outcomes, we estimate models that include community-level fixed effects, based on location of residence at the time of the tsunami (columns 3 and 4 of Table 3). In these models, features that are fixed at the community level (including general damage to the community, damage to schools, and urban status) are absorbed into the fixed effects so that

estimates reflect contrasts drawn between people in the same communities at the time of the tsunami. These estimates leverage variation within communities, rather than between communities.

Including community fixed effects has little impact on the estimates and inferences. It does not change the associations of measures of aspirations or parental education on the outcomes. The economic measures are somewhat more strongly associated with attendance in higher education in the models with community fixed effects than the models without. Interestingly, when comparisons are restricted to within communities, the pre-tsunami measure of resources emerges as important for attending college, even with measures of post-tsunami resources included.

Attrition is a potential source of bias in any long-term longitudinal study and is a particular concern in this context if attrition is related to tsunami exposure, education aspirations or education outcomes, all of which may be linked to marriage and child-bearing. In these data, attrition is higher among male and female married respondents, but lower among females who have ever born a child. As a result, attrition is only higher among those females who are not yet mothers. Neither marriage nor childbearing is related to the community-level measures of tsunami exposure, but those whose homes were damaged or destroyed in the tsunami are more likely to be married by year 15. Marriage and child-bearing are not related to education aspirations in the year after the tsunami but married respondents had lower aspirations in year 5. Married respondents attained lower levels of education by year 15. Child-bearing is not related to education aspirations or attainment, conditional on marriage. (Childbearing out of wedlock is extremely rare in the study area.)

As noted, STAR is designed to follow all respondents, including those who marry and move away, and educational attainment in year 15 is not known for only 3.6% of the respondents

in this study. To assess the implications of attrition for our estimates and conclusions, we have re-estimated the models in Table 3 assigning those who were not followed up the lowest aspirations and lowest levels of educational attainment to place a lower bound on the estimates. All of these estimates are essentially indistinguishable from those in Table 3 and are all well within a standard error of the Table 3 estimates and none of the inferences is affected. For example, the largest differences are for the odds ratios on low aspirations in years 1 and 5 and attendance in higher education, conditional on completing high school. In the model without community fixed effects (in column 2 of Table 3) the odds ratio is 0.35 and in the lower bound estimates it is 0.33. In the model with community fixed effects (column 4) the odds ratios are 0.38 and 0.35, respectively. The t statistics in the lower bound models are slightly larger than those in Table 3. (Upper bound estimates in which those who attrit are assigned high expectations and high education outcomes are also indistinguishable from the estimates in Table 3.) We conclude that attrition is not a source of bias in these analyses and that attrition related to marriage and child-bearing does not affect our conclusions.

DISCUSSION

The 2004 Indian Ocean tsunami was extremely destructive, killing roughly 5% of the population of Aceh province and destroying infrastructure, homes, and livelihoods over miles of coastline. In its immediate aftermath, affected populations faced daunting challenges in rebuilding their lives. For families, decisions about education for school-age children were front and center. At the population level, questions of how the disaster affected children's and parents' education aspirations and whether it permanently disrupted schooling progression are critical in understanding how shocks affect human capital. Interestingly, despite the devastating disaster, aspirations remained quite high even one year after the tsunami, with more than 60% of children in the sample reporting aspirations to attend higher education. These high aspirations also grew

more widespread over time, with more than three-quarters of the sample expressing aspirations to attend higher education five years post-tsunami.

We use longitudinal data from multiple time points before and after the tsunami to examine how exposure to the disaster is related to short- and medium-term aspirations for education, and how exposures, aspirations, and socioeconomic status are related to eventual educational attainment. With respect to disaster impacts, we find that general damage to one's community depresses aspirations for higher education. Over time, aspirations rise, but community damage continues to exert a somewhat negative impact. Other aspects of exposures are also negatively associated with aspirations, although we do not attribute a causal role to these factors. Interestingly, which exposure factors are important and in what way varies as a function of whether aspirations are reported by parents or by children. For example, in the short term, aspirations expressed by parents are more susceptible to school damage in the community compared to children, and aspirations expressed by children themselves are more susceptible to housing damage. This points to the importance of collecting data directly from children as well as their parents when possible.

Turning to attainment fifteen years later, general damage to one's community of residence at the time of the tsunami is not a statistically significant predictor of completing high school or going on to college. Damage to or destruction of one's home is negatively related to completing high school, but the coefficient is not precisely estimated in models that address unobserved heterogeneity across communities by including community-level fixed effects. Damage to schools is actually positively associated with attending college (among those who complete high school), which almost certainly reflects the multiple strategies undertaken after the tsunami to encourage households to continue to invest in education for children and young adults, which were focused in areas with worse damage.

Indeed, interpreted in conjunction with intensive efforts that individuals, communities, the government, and NGOs devoted to setting up temporary schools, reducing fees and providing scholarships, and to more general recovery in the five years after the disaster, the results are encouraging. Even a disaster of a magnitude of the tsunami need not inevitably derail investment in human capital in the form of long-term educational attainment. Our results are broadly similar to findings of recent work on educational outcomes in New Orleans after a large-scale post-Katrina school reform program, which showed improvements across multiple dimensions (Harris and Larsen 2023).

Likely also important was the end of the long-running civil war. The peace arrangements created a more positive outlook for many in the province. Moreover, in addition to the emergency provisions implemented immediately after the tsunami, a 2008 provincial bylaw on education mandated the government to spend at least 30% of its budget on education to improve quality and access, using financial reserves from natural resource extraction amassed as part of the peace deal. This commitment resulted in Aceh having the second-highest per-capita education expenditure in Indonesia (World Bank 2008), leading to higher than average participation rates across all levels of education and markedly improved test scores (Shah and Lopes Cardozo 2014). The combination of these efforts may underlie the sizable proportions of respondents (24%) who switched from expressing lower aspirations at one year after the tsunami, to expressing aspirations for postsecondary education four years later.

Although tsunami exposures do not appear to permanently dampen educational attainment, it is not clear that all subgroups fare equally well in the tsunami's aftermath. In particular, males are less likely to aspire to higher education, and less likely to complete high school or go on to college. These sex differences mirror the rising attainment of females observed in many settings, but differ from findings of other research on post-disaster settings

where females are at greater disadvantage (Caruso and Miller 2015; Paudel and Ryu 2018). In other work, we show that boys who lost parents in late adolescence and young adulthood complete fewer years of education than boys whose parents survive (Cas et al. 2014).

With respect to educational attainment, more important than the measures of exposure to tsunami damage, both in terms of impact on the odds ratios and levels of statistical significance, are levels of parental education and household resources. As research outside disaster contexts documents, family background is strongly influential in who attains relatively high levels of education (Sewell and Shah 1968a, 1968b).

Background exerts its influence in part by promoting high levels of aspirations even immediately after the tsunami. Consistent aspirations for tertiary education are strongly associated with eventual enrollment. Relatively little is known about how aspirations shape educational outcomes in lower- and middle-income contexts, but our results match research in wealthier settings. For example, among US youth, long-term stable expectations are more predictive of enrollment in higher education than wavering expectations (Bozick et al. 2010).

To conclude, after a catastrophic disaster, we find that exposure to the event in the form of general damage to one's community, depresses educational aspirations in the short term (we interpret this as a causal effect), but the impact is relatively short-lived and it is not related to educational attainment fifteen years later. Other exposure measures are negatively associated with aspirations, but not, ultimately, with lower attainment.

Family socioeconomic background plays a strong role in shaping aspirations. In turn, both aspirations and background are strongly related to educational attainment. Our results suggest a more minor role for disaster exposures than in much of the literature. This likely reflects the extensive and successful effort to rebuild infrastructure, implement safety nets quickly, and sustain them for multiple years. It likely also reflects the fact that we are better able

to control for the factors found to be important for educational attainment in non-disaster settings than is typically possible with census data or data from one cross-sectional survey as in most previous research. In a world where disasters are increasingly severe and frequent, our research provides important insights into how such events may affect short- and long-term educational trajectories, an important measure of human capital and social mobility.

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Table 1A. Educational aspirations and attainment over time

			Percentage
<u>A. Educational aspirations</u>			
A1. No aspirations to attend higher education			
Time since tsunami	1 year		38
	5 years		22
A2. Transitions of aspirations to attend higher education			
Time since tsunami	<u>1 year</u>	<u>5 years</u>	
	No	No	13
	Yes	No	9
	No	Yes	24
	Yes	Yes	54
 <u>B. Educational attainment by 15 years since tsunami</u>			
B1. Completed high school			81
B2. Completed high school, attend(ed) higher education			42

N = 5,429 (STAR Y1); 5,150 (STAR Y5); 5,234 (STAR Y15)
 Results are weighted to account for survey design.

Table 1B. Exposures and background characteristics by damage in community at time of tsunami

	All respondents	Community damaged in tsunami	No direct tsunami damage	Difference: Damaged-no direct damage
	[1]	[2]	[3]	[4]
<u>A. Exposures</u>				
Any damage in community	82			
% had some damage to schools	49	57	14	43***
% houses damaged/destroyed	69	73	52	21***
% father killed in tsunami	1.9	2.0	1.3	0.8
<u>B. Background characteristics</u>				
% male	54	54	54	0.0
Age 1 year post-tsunami (years)	9.7	9.7	9.7	0.0
Mother's education (years)	6.9	6.7	7.6	-0.8
Father's education (years)	7.7	7.6	7.9	-0.3
Monthly per capita spending (log), pre-tsunami	11.9	11.9	11.9	0.0
Sample size	5,429	4,179	1,250	

*** indicates significantly different at 1% size of test.

Table 2. Regressions of not aspiring to go to higher education at 1 and 5 years post-tsunami and of changes in aspirations over time

Covariates	<u>Aspirations:</u>				years post- tsunami 1 year 5 years	<u>Change in aspirations</u>		
	<u>Does not aspire to attend higher educ</u>					Aspire to attend higher educ as reported		
	1 year post-tsunami reported by		5 years post-tsunami reported by			No No	Yes No	No Yes
	Parent	Child	Parent	Child				
	[1]	[2]	[3]	[4]		[5]	[6]	[7]
Community sustained damage	1.47	1.29	1.07	1.26		1.64	1.12	1.36
	[2.84]	[1.21]	[0.26]	[1.81]		[2.34]	[0.82]	[2.25]
Schools damaged in community	1.31	1.05	1.67	1.05		1.41	0.99	1.22
	[2.17]	[0.27]	[2.29]	[0.36]		[1.95]	[0.08]	[1.49]
House destroyed or damaged	1.12	1.79	0.95	1.23		1.38	1.18	1.24
	[1.11]	[3.31]	[0.20]	[1.80]		[1.98]	[1.17]	[2.09]
Father died in tsunami	0.52	1.55	0.30	1.56		1.03	0.96	0.68
	[1.86]	[1.01]	[1.52]	[1.29]		[0.07]	[0.11]	[1.23]
(1) if male	1.14	1.22	1.07	1.30		1.31	1.42	1.22
	[1.74]	[1.67]	[0.34]	[2.95]		[2.52]	[3.30]	[2.63]
(1) if urban area at time of tsunami	1.21	0.98	1.04	1.19		1.44	1.09	1.11
	[1.35]	[0.13]	[0.12]	[1.18]		[1.69]	[0.56]	[0.71]
Years of education: mother	0.88	0.87	0.85	0.87		0.79	0.88	0.89
	[8.25]	[6.63]	[4.10]	[9.65]		[11.10]	[7.97]	[7.99]
Years of education: father	0.92	0.94	0.91	0.91		0.87	0.90	0.92
	[6.09]	[3.56]	[2.64]	[6.16]		[7.04]	[5.77]	[6.50]
Monthly ln(per capita expenditure) pre-tsunami	0.76	0.95	1.30	0.80		0.78	0.74	0.76
	[2.14]	[0.37]	[1.12]	[1.83]		[1.50]	[1.93]	[2.13]
Intercept	42.19	2.72	0.01	10.02		35.01	22.80	28.29
	[2.48]	[0.55]	[1.53]	[1.61]		[1.77]	[1.70]	[2.23]
Sample size	4,026	1,403	1,076	4,074			5,150	
Joint significance (p-value of χ^2 statistic)	0.000	0.003	0.089	0.029			0.014	

Columns 1-4: Odds ratios from logit regression with dependent variable taking a value of 1 if respondent does not aspire to go to college and 0 otherwise.

Columns 5-7: Relative risk ratios from multinomial logit regression. Reference group: those who reported college aspirations in both years 1 and 5.

[Asymptotic t statistics] in parentheses take into account clustering at the community level. Community is the enumeration area of residence in the pre-tsunami survey. Models also include indicator variables for years of age, whether father was alive before the tsunami, and indicator variables for missing values (parental education, per capita expenditures).

Table 3. Regressions of educational attainment 15 years post-tsunami

Attainment 15 years post-tsunami:	Include community fixed effects			
	Completed at least high school	Attend(ed) higher educ given completed high school	Completed at least high school	Attend(ed) higher educ given completed high school
Covariates	[1]	[2]	[3]	[4]
Community sustained damage	1.04 [0.35]	0.83 [1.60]		
Schools damaged in community	1.20 [1.69]	1.49 [3.78]		
House destroyed or damaged	0.81 [1.87]	1.02 [0.17]	0.85 [1.37]	0.89 [1.15]
Father died in tsunami	1.38 [0.90]	0.84 [0.65]	1.04 [0.09]	0.79 [0.68]
Change in aspirations about going to college				
No (1 year), No (5 years post-tsunami)	0.18 [12.58]	0.35 [5.02]	0.18 [11.92]	0.38 [4.67]
No (1 year), Yes (5 years post-tsunami)	0.78 [2.17]	0.70 [3.59]	0.79 [1.94]	0.73 [3.10]
Yes (1 year), No (5 years post-tsunami)	0.23 [11.00]	0.32 [7.05]	0.26 [9.95]	0.38 [5.65]
Yes (1 year), Yes (5 years post-tsunami)	(Reference)	(Reference)	(Reference)	(Reference)
(1) if male	0.62 [5.43]	0.47 [9.68]	0.62 [5.48]	0.43 [10.82]
(1) if urban area at time of tsunami	1.12 [0.83]	0.68 [3.70]		
Years of education: mother	1.10 [6.12]	1.11 [8.12]	1.08 [5.02]	1.11 [7.63]
Years of education: father	1.09 [5.42]	1.10 [7.61]	1.07 [4.36]	1.10 [7.35]
Monthly ln(per capita expenditure)				
Pre-tsunami	1.05 [0.43]	1.17 [1.66]	1.01 [0.08]	1.55 [3.31]
1 year post-tsunami	1.10 [1.06]	1.31 [3.29]	1.38 [3.16]	1.58 [5.06]
5 years post-tsunami	1.13 [1.38]	1.64 [6.23]	1.22 [2.13]	1.60 [5.52]
Intercept	0.04 [1.95]	0.00 [8.73]		
Sample size	5,234	4,310	4,284	4,181
Joint significance (p-values of χ^2 statistic)				
Damage variables	0.145	0.002	0.000	0.000
Aspirations variables	0.000	0.000	0.000	0.000
Number of community fixed effects			300	370

Odds ratios from logit regressions. [Asymptotic t statistics] in parentheses take into account clustering at the community level. Community is the enumeration area of residence in the pre-tsunami survey. Models also include indicator variables for years of age, whether father was alive before the tsunami, and indicator variables for missing values (parental education, per capita expenditures).