ifo WORKING PAPERS

Sitting on a Volcano: Domestic Violence in Indonesia Following Two Volcano Eruptions

Maximilian Schwefer

ifo INSTITUTE

Sitting on a Volcano: Domestic Violence in Indonesia Following Two Volcano Eruptions*

Abstract

This is the first study to provide pre- and post-treatment family-level data on the impact of volcano eruptions on domestic violence. I use data from 2,024 families in Indonesia, of which a subset has been exposed to two eruptions. Findings confirm an increase in domestic violence of four percent in the treatment group. The proposed channel is an increase in mental distress. This is supported by lower household expenditures, increased rates of alcohol/drug abuse and lowered emotional well-being in affected populations. A subsample of previously displaced families shows higher risk of developing domestic violence. Policymakers should consider the multi-fold non-economic outcomes of natural disasters.

JEL Code: H12, J12, O12, Q54
Keywords: Natural disasters, domestic violence, longitudinal family data

Maximilian Schwefer
ifo Institute – Leibniz Institute for
Economic Research
at the University of Munich
schwefer@alumni.lse.ac.uk

1. Introduction

Natural disasters threaten the well-being of affected individuals and communities.[1] Global warming is expected to augment this threat by increasing the frequency and severity of extreme weather conditions (Van Aalst, 2006; Watson and Albritton, 2001; Cavallo and Noy, 2010). The increasing prevalence of natural disasters and their significant impact make them subject to extensive research. So far, the range of documented outcomes in longitudinal studies has been comparably narrow, and the majority of publications rely on post-disaster data. This is why many scholars have articulated the need for more (longitudinal) evidence on how disasters affect populations (Rezaeian, 2013; Sety, James, and Breckenridge, 2014; Cavallo and Noy, 2010; Parkinson and Zara, 2013; World Health Organization (WHO), 2002; Rosborough, Chan, and Parmar, 2009; Schumacher et al., 2010).

This study contributes to this emerging strand of the literature that documents the association of disasters and violence with novel panel data from Indonesia. It is the first one to provide pre- and post-treatment family-level data on the impact of volcano eruptions on domestic violence. In addition, it offers evidence for the channels by which natural disasters might cause domestic violence.

The causal chain from the occurrence of natural disasters to domestic violence is detailed hereafter. Previous evidence shows that natural disasters cause mental distress in affected populations (Neria, Nandi, and Galea, 2008). The causes of disaster-related distress are multi-fold. They can be psychological (eg existential fear), social (eg loss of social network) or economic (eg loss of livelihood) (see Rezaeian (2013) and Overstreet et al. (2011) for frameworks). Victims' distress symptoms can range from feelings of helplessness to posttraumatic stress disorder (PTSD).[2] The anticipation or experience of recurrent disasters, such as volcano eruptions, can amplify distress (Overstreet et al., 2011). Suffering from mental distress, individuals can develop feelings of aggression and outward, interpersonal violent behavior (Berkowitz, 1993; Curtis, Miller, and Berry, 2000; Denlay and Shrader, 2000). The likelihood of violent behavior is increased

---

1. Geophysical disasters caused economic damage of USD 763 billion between 1995 and 2015. Asia experienced 37 percent of the global economic loss between 1994 and 2015. Volcanic activity accounted for eight percent of all natural disasters globally during this period (Wahlstrom and Guha-Sapir, 2015).

2. For examples of studies documenting increases in symptoms of mental distress, eg PTSD, after natural disasters, see Fernandez et al. (2017), Goenjian et al. (2000), Neria, Nandi, and Galea (2008), Paxson et al. (2012), Rezaeian (2013), Rhodes et al. (2010), Rubonis and Bickman (1991), and Warsini et al. (2014).

by multiple factors, for example, worsened living conditions or a lack of social networks and social control (Curtis, Miller, and Berry, 2000; Rezaeian, 2013). Rezaeian (2013) provides a framework and reviews previous literature that links disaster experience to (interpersonal) violence.

In this study, I estimate the impact of the two eruptions on rates of domestic violence and four alternative outcomes with a difference-in-differences approach. I confirm an increase in domestic violence of four percent in all observed households in the treatment group. Affected communities suffer from lower average household expenditure which is expected to increase distress. Further, increased rates of alcohol/drug abuse and lowered emotional well-being in affected populations point to increased levels of mental distress (alcohol abuse is also associated with IPV).[3] A synthetic control approach allows the verification of these results. A subsample of families with *internally displaced people* (IDP) status displays substantially higher levels of domestic violence after the volcanoes' eruptions. This subsample has previously suffered from natural disasters and proves to be particularly vulnerable to repeated disaster exposure. These families suffer from a loss of livelihood, lack of a social network and augmented feelings of a threat of disaster recurrence. The treatment coefficient estimate suggests an increase of nine percentage points.

Data are provided by an NGO that serves rural and urban communities across Indonesia. I use survey and observational data from 2,024 families. The families receive support based on their vulnerability to family breakdown. In late 2013 and early 2014, some of the families have suffered from the eruption of the two volcanoes Mount Kelud and Mount Merapi. The volcanoes' eruptions caused ashfall, evacuations, and deaths across multiple hundreds of kilometers on Java, Indonesia's main island.

This study's results suggest an increase in domestic violence after natural disasters. It further points to the role of economic conditions, IDP status and social networks of affected communities. Policymakers and emergency response organizations should consider the causes of multi-fold non-economic outcomes of natural disasters when designing interventions.

The remainder of this study is structured as follows. First, I will review related studies

---

3. McFarlane (1998) reviews studies on the association of alcohol abuse and PTSD. Sonne et al. (2009) present evidence on the sequence of the onset of PTSD and alcohol abuse respectively. Bueno and Henderson (2017) explore the association of IPV with alcohol abuse. Bech et al. (2003) discuss the relationship between mental distress and well-being.

that survey the impact of natural disasters and domestic violence separately. I will then discuss how both strains of literature are linked. I will provide an overview of the Indonesian cultural context. Secondly, I will present my empirical strategy and discuss alternative specifications. Afterward, I will present the results that are accompanied by robustness checks. I will conclude by discussing the implications of the findings.

2. The relationship between natural disasters and domestic violence

In the following section, I will first present previous work that surveys the consequences of natural disasters on affected populations. I will then present evidence on the determinants and consequences of domestic violence and its local context in Indonesia. I will conclude by discussing literature linking natural disasters with domestic violence.

2.1. Natural disasters

Natural disasters such as hurricanes, volcano eruptions, earthquakes, and cyclones threaten the well-being of affected communities. Global warming is expected to augment this threat via an increase in the frequency and severity of those disasters that are weather-linked (Cavallo and Noy, 2010; Van Aalst, 2006; Watson and Albritton, 2001).

The strain of studies in economics dedicated to evaluating the impact of natural disasters is comparably novel. Evidence regarding the overall impact on long-term economic growth remains mixed (Loayza et al., 2012). Gignoux and Menéndez (2016) identified public investment in response to natural disasters as a critical moderator that can turn short-run losses in long-term gains. In their study on the welfare impact of earthquakes in rural Indonesia, they found that public investment can lead to local welfare gains within six to twelve years following an earthquake. Arouri, Nguyen, and Youssef (2015) document adverse income effects in rural Vietnam following storms, floods, and droughts while Deryugina, Kawano, and Levitt (2018) find income increases for some communities affected by Katrina.[4] For short-run outcomes, Noy (2009) found that disasters can lead to slowdowns in production and that these are expected to be worse in developing countries. Accordingly, Strobl (2012) estimate an average output drop of .83 percentage points following hurricane strikes in Central America and Caribbean regions.

Apart from macroeconomic evaluations, micro-level assessments have been conducted with respect to human capital accumulation (Caruso, 2017; Baez, Fuente, and Santos, 2010; Janvry et al., 2006; Ferreira and Schady, 2009; Gitter and Barham, 2007), income and expenditure (Arouri, Nguyen, and Youssef, 2015; Deryugina, Kawano, and Levitt, 2018), as well as health and physical growth (Caruso, 2017; Hoddinott and Kinsey,

---

4. In the aftermath of hurricane Katrina, Deryugina, Kawano, and Levitt (2018) find that the incomes of affected individuals outgrow those of unaffected individuals in control communities.

2001; Maccini and Yang, 2009). Caruso (2017) find that the health of young children is particularly susceptible to natural disasters, while Ferreira and Schady (2009) observe lower investment in children in developing countries after droughts.

Despite this wealth of previous publications, few studies address natural disasters as a cause of domestic violence. To my knowledge, there are no longitudinal studies using family level data to observe changes in domestic violence following a natural disaster.[5]

2.2. Domestic violence

2.2.1. Domestic violence as a peril to public health

IPV poses a major peril to public health. In line with previous literature, IPV is defined in the following as violence between intimate partners. Domestic violence is defined as general violence in the household, including IPV as well as violence against children and other household members.[6] IPV can result in stress, fear and physical as well as psychological trauma, and incur the sentiment of loss of control (García-Moreno et al., 2013). Moreover, domestic violence is found to negatively affect children born to mothers exposed to violence during pregnancy (Aizer, 2011). Domestic violence towards children can affect their development and might result in trauma and lower ability, among other things (Reading, 2008). According to estimates by the WHO, 30 percent of ever-partnered women experience intimate partner violence (IPV) in their lifetime. In South East Asia, prevalence rates of IPV are even higher than the global average, at an average rate of 37.7 percent (García-Moreno et al., 2013).

Multiple individual and structural risk factors have been associated with domestic violence in general and IPV in specific. A perpetrator's record of violence in the recent past, drug and alcohol abuse, threatening behavior, previous psychological issues, are some traits that are found disproportionately often in offenders (Dutton and Kropp, 2000).[7] Circumstantial moderators of domestic violence include but are not limited to gender-specific labor market conditions (Aizer, 2010; Anderberg et al., 2015), social welfare transfers (Bobonis, González-Brenes, and Castro, 2013; Hidrobo, Peterman, and Heise, 2016) and adverse emotional cues (Card and Dahl, 2011). Two competing

---

5. An exception is research using rainfall shocks. While one can consider rainfall shocks a natural disaster, their consequences are commonly different from volcano eruptions or earthquakes. They usually pose a non-existential threat, particularly if not accompanied by flooding.

6. For a general discussion of definitions of IPV and domestic violence, please refer to Reading (2008).

7. Both Dutton and Kropp (2000) and Jewkes (2002) provide excellent overviews of this literature and discuss appropriate assessment methods of domestic violence risk.

theories exist on how changes in relative female economic power might change the prevalence of domestic violence. Women might expect to leverage higher economic power to *negotiate* better outcomes in household bargaining. By contrast, one might expect (violent) male backlash as an adverse reaction to a decrease in relative male status (Bueno and Henderson, 2017). In a Sub-Saharan context, Cools and Kotsadam (2017) propose that economic inequality both at the level of the household and at the community is associated with higher IPV rates. With new data from Africa, Alesina, Brioschi, and La Ferrara (2016) argue that ancient cultural norms and current economic conditions interact in a non-trivial way. Empirically, Bueno and Henderson (2017) find that household bargaining based approaches are more predictive of general IPV whereas male backlash theories are so for sexual IPV. The authors also point to the relationship between excessive alcohol consumption and IPV.

2.2.2. Domestic violence in the Indonesian context

There is no systematic, continuous tracking of IPV prevalence on a national level in Indonesia.[8] Both the World Health Organization and the United Nations base their estimates on a SUSENAS (National Census Survey) survey from 2006. In this, 3.07 percent of women reported any lifetime experience of either IPV, non-partner violence or both (UN Women (United Nations Entity for Gender Equality and the Empowerment of Women), 2011; World Health Organization (WHO), 2008). The WHO documents that 66 percent of all reported violence cases are classified as psychological (World Health Organization (WHO), 2008). In contrast, 22 percent of Javanese women of reproductive age that have been part of a pregnancy preparation program reported a "lifetime exposure to sexual and physical violence" (Hayati et al., 2011, p. 1). All numbers deserve cautious interpretation since local norms might lead to biased and possibly understated reporting of IPV.

IPV needs to be understood in the context of norms. For example, in an African context, Alesina, Brioschi, and La Ferrara (2016) show that interaction of ancient norms and female economic power can explain current rates of domestic violence. In Indonesia, IPV has traditionally been considered a personal, private issue that deserves private intervention. This notion prevails until today and might be reinforced by the norm of *harmony* (njaga praja) (Hayati et al., 2013). The norm stresses the protection of the husband's honor towards non-family members. This is likely to result in fewer

---

8. It was not until the mid-1990s that international organizations started raising awareness for the topic, and initial public reactions ranged from surprise to denial (Blackburn, 2004). Reported figures vary greatly depending on time, region and source.

reports of IPV incidences. Fewer and potentially biased reports create an unclear empirical picture and a selective public focus on *out-of-home* violence such as non-marital rape and trafficking. Moreover, victims refrain from reporting as they are typically not convinced that things will change in their favor if they come forward (Blackburn, 2004). In their study, Nilan et al. (2014) found Indonesian men to be reluctant to talk about violence against women. Men tended to engage in victim indictment and overall refutation of the phenomenon of IPV.

Acceptance of IPV is *high* in Indonesia despite political progress.[9] Opposed to global trends, rates of rejection of IPV amongst Indonesian women stayed relatively stable over the recent past (Pierotti, 2013). In the most recent IDHS study, 27 percent of Indonesian women considered wife-beating to be a justified reaction to maternal child neglect (Statistics Indonesia (Badan Pusat Statistik - BPS) National Population and Family Planning Board (BKKBN) Kementerian Kesehatan (Kemenkes—MOH) and ICF International, 2012). Similarly, 24 percent of women considered male violence justified in cases in which women left home without giving notice to their husbands. Both numbers are higher for younger age groups. Compared to women, men report lower levels of acceptance of wife-beating (Statistics Indonesia (Badan Pusat Statistik - BPS) National Population and Family Planning Board (BKKBN) Kementerian Kesehatan (Kemenkes—MOH) and ICF International, 2012) – a finding potentially driven by social desirability.

In the Indonesian context, Hayati et al. (2013) found that female economic independence and conservative values are associated with higher rates of IPV. Hayati et al. (2011) show for this study's treatment area, that female main breadwinners were at particular risk of violence experience yet were particularly unwilling to accept help. Nilan et al. (2014) use interviews and find that one self-reported cause of violence in Indonesia is the (perceived) male inability to satisfy female expectations. In particular, financial difficulties seemed to be predictive of intimate partner violence in the context of Indonesia.[10] In the study, 48 interviewed men, all of whom were considered *community leaders*, expressed a discordance between idealistic, partially religiously informed expectations towards men and a more egalitarian reality resulting in men feeling challenged about their identity (Hayati, 2013).

---

9. In the recent past, the country progressed, for example, by introducing a National Commission on Violence Against Women in 1998 and passing of the Domestic Violence Act in 2004 (Hayati et al., 2011).

10. A more detailed account of the concepts of masculinity in Indonesia and female coping strategies in response to IPV can be found in Hayati (2013).

In summary, previous evidence confirms that domestic violence poses a significant threat to public health in Indonesia. Precise measurement of prevalence is complicated by social norms. Household economics and female economic dependence and independence have both been presented as potential risk factors.

2.3. Stress and domestic violence in consequence of natural disasters

This study's findings propose that natural disasters lead to an increase in domestic violence. It thereby relies on previous studies that propose channels through which this happens. Rezaeian (2013) suggests that the psychological, social and economic consequences of natural disasters cause mental distress which in turn causes domestic violence. The following section presents previous evidence on this hypothesis.

The first strand of literature shows how natural disasters cause stress in established populations. A comprehensive account of disaster psychiatry can be found in Usano et al. (2017). Rubonis and Bickman (1991) review 52 empirical studies and find a *small but consistently positive* association of disasters and a subsequent increase in indicators of psychopathology. Goenjian et al. (2000) document higher levels of posttraumatic stress disorder (PTSD) in populations affected by severe earthquakes compared to those exposed to milder trauma. Effects persist without major improvement within 1.5 and 4.5 years following a disaster and that decreases in living conditions, and livelihood can amplify stress. Pre-event conditions such as mental illness predict the later severity of PTSD levels.[11] The recurrent threat of natural disasters, whether anticipated or actual, is expected to augment mental distress further (Overstreet et al., 2011). Two studies have surveyed the impact of Mount Merapi's 2010 eruption on mental health and confirm previous findings for this study's context. Warsini et al. (2014) report higher rates of distress in survivor communities located close to the peak of Mount Merapi for early 2013. Victims attributed distress to *volcanic dust* on roads and *mining and construction* following the events. The same authors also record higher levels of PTSD in affected areas, in particular among women, individuals

---

11. Fernandez et al. (2017) show for a sample in Chile that pre-disaster attributes in patients (such as panic disorders) predict the likelihood of post-disaster PTSD. Rhodes et al. (2010) find a doubling of mental illness prevalence amongst disadvantaged communities post the Katrina Hurricane and estimate PTSD rates at close to fifty percent. In the same context, Paxson et al. (2012) confirm the long-term consequences of natural disasters by finding that rates of post-traumatic stress symptoms did not return to pre-Katrina levels even 43 to 54 months after the event.

of young and middle age and homeowners (Warsini et al., 2014). Further, general evidence suggests that stress is one driver of domestic violence (see for example Runyan et al. (2002) and Bardi and Borgognini-Tarli (2001) for review). Stress is moderated by both, primary and secondary stressors. Primary stressors are immediate consequences of the disaster such as a felt or actual threat to life. Secondary stressors are stressors that have been caused by the disaster, such as the loss of one's job (Overstreet et al., 2011).

The second strand of literature links stress to domestic violence in the context of natural disasters. Rezaeian (2013) offers a systematic review of the literature that documents the link between mental distress and domestic violence. The author finds that most studies document an increase in interpersonal violence after natural disasters. Indeed, outward, interpersonal violence and aggression are often found reactions of humans exposed to mental distress and feelings of helplessness (Berkowitz, 1993; Curtis, Miller, and Berry, 2000; Denlay and Shrader, 2000). For example, Denlay and Shrader (2000) link violence and aggression as one stress-coping mechanism *chosen* by men, based on a study conducted in the aftermath of Hurricane Mitch in Honduras and Nicaragua. Rezaeian (2013) proposes a model for the relationship between natural disasters and violence that includes the multi-fold psychological, social and economic ways by which disasters affect individuals.[12] Worsened living conditions and lack of social networks and social control have been put forward as important moderators of domestic violence (Curtis, Miller, and Berry, 2000; Rezaeian, 2013). Curtis, Miller, and Berry (2000) argue that the social control of antisocial behavior is reduced in the aftermath of disasters permitting increased rates of violence as an otherwise sanctioned behavior. This is supported by evidence on individuals who have lost their social network. Anastario, Shebab, and Lawry (2009) document high rates of gender-based violence in populations who have been internally displaced following Hurricane Katrina.

The third strand of literature links natural disasters to domestic violence. Previous empirical research on the relationship between natural disasters and domestic violence has mostly relied on cross-section data and post-event surveys or police/administrative data. Adams and Adams (1984) were first to empirically link disaster experience on the one and domestic violence on the other hand. The authors argue that stress result-

---

12. Rezaeian (2013, p. 1104) proposes that natural disasters lead to "personal threats to life, loss of loved ones, propertyloss [sic]", "interruption and failure of social systems & services", "collapse of social cohesion & harmony" and "massive destruction, Population [sic] displacement".

ing from disaster manifests in physiological and psychological responses, among them domestic violence. Based on police reports, they document an increase in domestic violence in the aftermath of the eruption of Mount Saint Helens, a volcano located in the United States of America. Sety, James, and Breckenridge (2014) suggest significant increases in domestic violence after disasters in high-income countries. Based on a post-tsunami survey in Sri Lanka, Fisher (2010) propose that disasters amplify pre-event violence patterns. This is confirmed by research on Hurricane Katrina. In a survey during the aftermath of Katrina, Picardo, Burton, and Naponick (2010) found an increase in existing and new abuse of displaced women. Schumacher et al. (2010) confirm this for individuals who lived in affected areas at the time of Katrina's impact. The authors argue that their study is the first one that assesses pre- and post-disaster IPV prevalence but also remark that this information stems from post-event surveys making it subject to potential recall and reporting biases. Curtis, Miller, and Berry (2000) use public reports on child abuse for periods before and after three natural disasters to survey the link between abuse and disasters. They report increased child abuse rates in two of the three observed samples. Parkinson (2017) interviewed women after bushfires and documents an increase in domestic violence.

The only micro-level panel evidence about the impact of natural disasters on domestic violence is on rainfall shocks.[13] While one can consider rainfall shocks a natural disaster, their consequences are commonly different from volcano eruptions or earthquakes. They usually pose a non-existential threat, particularly if not accompanied by flooding.

So far, the range of documented outcomes in longitudinal studies has been comparably narrow, and most publications rely on post-disaster data. Buttell and Carney (2009) point at multiple challenges in measuring changes in gender-based violence. One of them is the lack of baseline information. This is why many scholars have articulated the need for more (longitudinal) evidence on how disasters affect populations (Cavallo and Noy, 2010; Parkinson and Zara, 2013; Rezaeian, 2013; Rosborough, Chan, and Parmar, 2009; Schumacher et al., 2010; Sety, James, and Breckenridge, 2014; World Health Organization (WHO), 2002). The unique panel dataset on individuals employed in this study allows learning about domestic violence and potential risk factors following a disaster.

---

13. Sekhri and Storeygard (2014) find a relationship between rainfall shocks and dowry deaths in India. Chin (2011) associate changing power dynamics following rainfall shocks and spousal violence in the same context. Miguel (2005) identifies extreme rainfall as a reason for economically motivated *witch murders* in Tanzania in which relatives murder elderly women during times of economic scarcity.

3. Context

3.1. Volcano eruptions on Java in 2013 and 2014

Volcano eruptions on Java. With 130 active volcanoes and its location on the *pacific ring of fire*, Indonesia is a country with one of the world's highest rates of seismic activity. In late 2013 and early 2014, it has witnessed two major volcanic eruptions: Mount Kelud and Mount Merapi erupted on its main island Java. The increase in domestic violence in affected areas and its potential causes are subject of this study.

Concerning total evacuations and death toll, Mount Kelud's eruption has been far more severe. However, Mount Merapi's eruption is likely to have been a significant source of stress to surrounding populations. Its eruption in November 2013 caused reminiscence of its last, catastrophic eruption in 2010, which took the lives of 353 individuals. 2013 also marked the end of a three year period in which the volcano displayed a very low level of observable activity.[14] It showed first activity on November 18, 2013, resulting in a 2 km high plume of ash (Wunderman, 2014b). This eruption has been the first significant one, after its 2010 outburst. Following this first incident, Mount Merapi erupted again on multiple occasions in March 2014; creating a 9.8 km high plume on March 27th and affecting neighboring regions and communities in Kemalang and Klaten regency (Wunderman, 2014b). Besides and after one and a half months of increased seismic activity, Mount Kelud erupted on the 13th of February 2014, causing the evacuation of 100,000 people, killing 7 and destroying around 11 thousand buildings in the surrounding communities (Wunderman, 2014a). I observe effects in communities that have not been evacuated but still struck by ashfall.

Assignment to treatment and control groups. Figure 1 maps the location and assignment of treatment and control communities. Treatment communities are marked with a yellow triangle. Communities on Java that are outside the treatment area are selected as the control group and marked with a blue square. Communities outside Java, marked with a green circle, will serve as a control group for a synthetic control robustness check but are not considered for the main analyses. The primary treatment group is identified based on the latest assessment of the International Federation of Red Cross and Red Crescent Societies (see appendix figure 7). This group of districts is named Treatment Kelud on the map's legend. I add two additional treatment areas. The first area, named Additional Ashfall Mount Merapi on the map's legend, is added

---

14. Mount Merapi is an active stratovolcano with a continuous level of activity over time.

based on Wunderman (2014b) and has been exposed to ashfall by Mount Merapi in 2014. This area does not contain any communities in this sample and hence does not affect estimates. A second sub-district named Kabupaten Gunungkidul[15] is included based on the combination of two factors. First, it has been exposed to light ashfall right after Mount Kelud's eruption (The United Nations Office for the Coordination of Humanitarian Affairs (OCHA), 2014). However, it has been excluded from the final assessment of affected areas that have been used for the overall treatment identification (see International Federation of Red Cross and Red Crescent Societies (2014) and map in appendix figure 7). Secondly, and more importantly, the area Daerah Istimewa Yogyakarta (marked as Additional Treatment Mount Merapi) is closely linked to the primary treatment area and is thereby expected to be exposed to the consequences of the treatment shock. Kabupaten Gunungkidul is part of Daerah Istimewa Yogyakarta which is home to all treatment communities. The used regency level economic data are the same for treatment area and this area. Moreover, a social center located in the treatment area administers its support. The light exposure combined with the economic and social dependency on the treatment area recommend its inclusion as opposed to assigning it to a control area or dropping it. Appendix table D.3 runs a robustness check on how exclusion informed results. More detailed information on the eruption is offered by the Red Cross (International Federation of Red Cross and Red Crescent Societies, 2014).

---

15. Also referred to by Gunung Kidul Regency

Figure 1: Overview map of locations of treatment and control groups
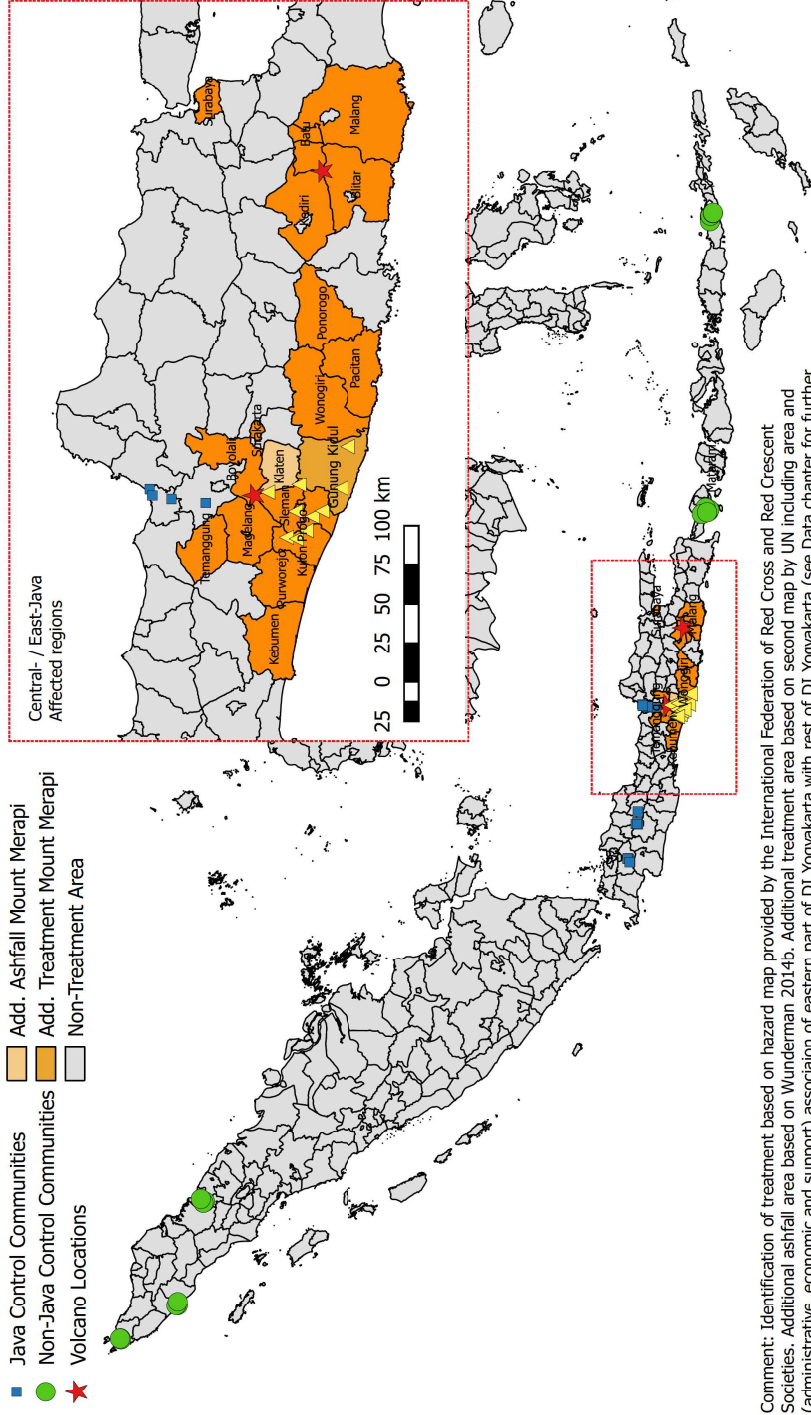
Comment: Identification of treatment based on hazard map provided by the International Federation of Red Cross and Red Crescent Societies. Additional ashfall area based on Wunderman 2014b. Additional treatment area based on second map by UN including area and (administrative, economic and support) associaion of eastern part of DI Yogyakarta with rest of DI Yogyakarta (see Data chapter for further description).

3.2. Increase in domestic violence following the eruptions

Table 2 displays the increase in domestic violence that is at the center of this study. Beginning with the first eruption of Mount Merapi in November 2013, a trend of increasing rates of domestic violence is observable. The main eruption of the two volcanoes occurred in February and March of 2014. The trend of increasing domestic violence continues until late 2014 – a point at which it reached a plateau of around 4 percent of all households in affected regions. Mount Merapi is geographically closer to the sample communities, but its next outbreak in 2014 has not been as impactful as the 2014 outbreak of Mount Kelud. However, it might still have induced significant stress in communities that have been displaced in its last major outbreak in 2010. It is expected that both volcanoes contribute to the increase in domestic violence.

Figure 2: Domestic violence over time by treatment status
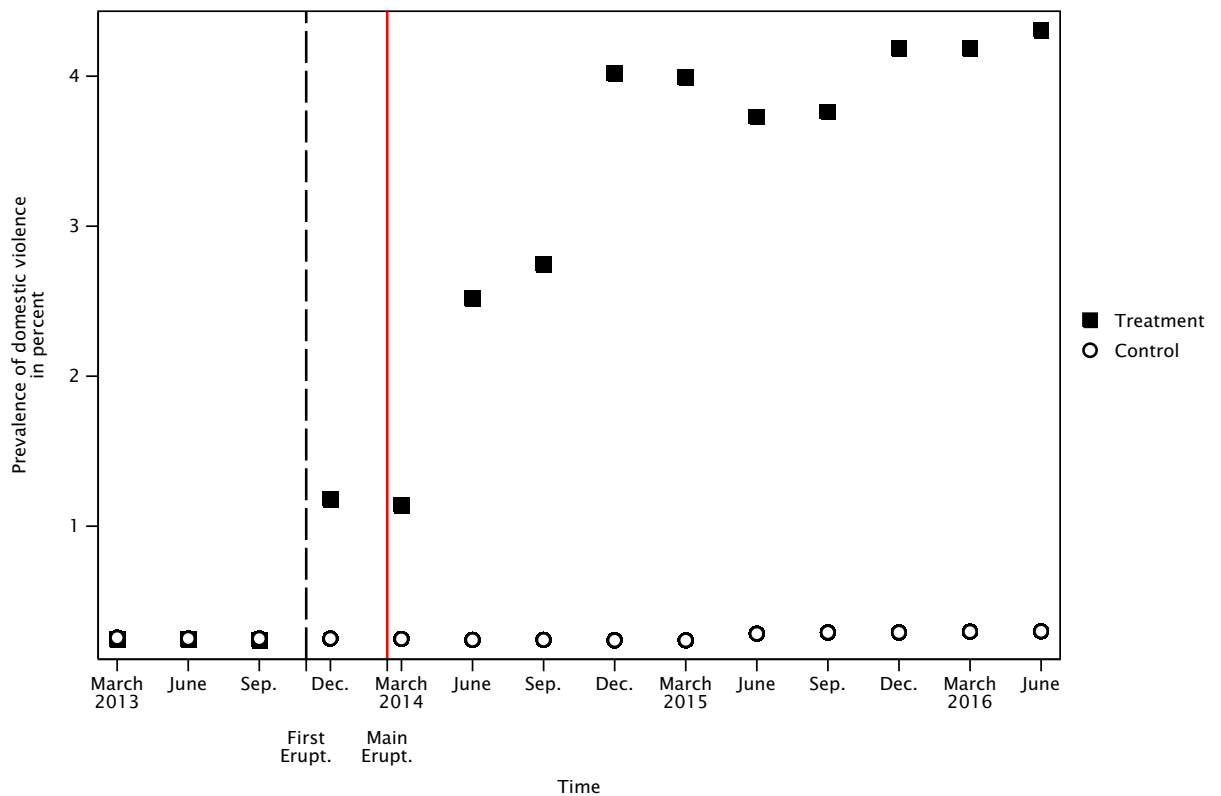
Black squares: treatment areas; White circles: no treatment. First eruption: the first eruption of Mount Merapi, Main eruptions: eruptions of Mount Merapi and Mount Kelud.

3.3. Macro-level decrease of average per capita household expenditure following the eruptions

Nationally, Indonesia's economy grew significantly over the past decades. Despite a recession in the late 1990s, its total GDP has more than tripled between 1995 and 2014. In 2014, it reached a level of 888 billion US Dollar[16] More recently, the country's growth rates have been decreasing: from 8.2 percent in 1995 to 5.0 percent in 2014 (OECD, 2015). 2014, the year of interest to this study, does not mark an exceptional year as such but fits the larger trend of decline in economic growth rates.

Regionally, Indonesia is divided into 34 provinces, which are divided into regencies (*Kabupaten*) and cities (*Kota*).[17] Regencies and cities are divided into subdistricts. In figure 3 the average household expenditure of treatment and control groups are compared. The data are provided by the World Bank Group. Importantly, the data are sometimes provided at regency-level (for example for West Java) and sometimes at city-level (for example for the city of Yogyakarta). The regency-/city-level data are then assigned to the individual. The average values depicted in the figure 3 are thus weighted by the number of observations in each regency and city respectively.

The treatment region exhibits moderate household expenditure growth previous to the eruptions and slows down thereafter. Exact growth figures are found in appendix table 1. The net effect of positive growth in urban areas and negative growth in rural areas results in mildly positive but below average net growth figures for the treatment group.

3.4. Micro-level development of living conditions and interventions following the eruptions

Figure 4 reports the development of living conditions at micro-level. These data are collected by the NGO and are based on the sample used in this study. The observed pattern differs from the macro-level observation of figure 3. Two reasons might drive this. First, universal health care (UHC/JKN) has been formally introduced on first of January of 2014 which might have influenced statements on living conditions and explain the slight uptick observed between 2013 and 2014. Secondly, interventions might have moderated the living conditions of the sample.

---

16. Measured in then-current US Dollar terms.

17. Some regency-sized areas are listed at the level of provinces, eg the Special Region of Yogyakarta or the Special Capital Region of Jakarta.

Figure 3: Weighted regency-/city-level data: development of household expenditure per capita over time (in IDR)
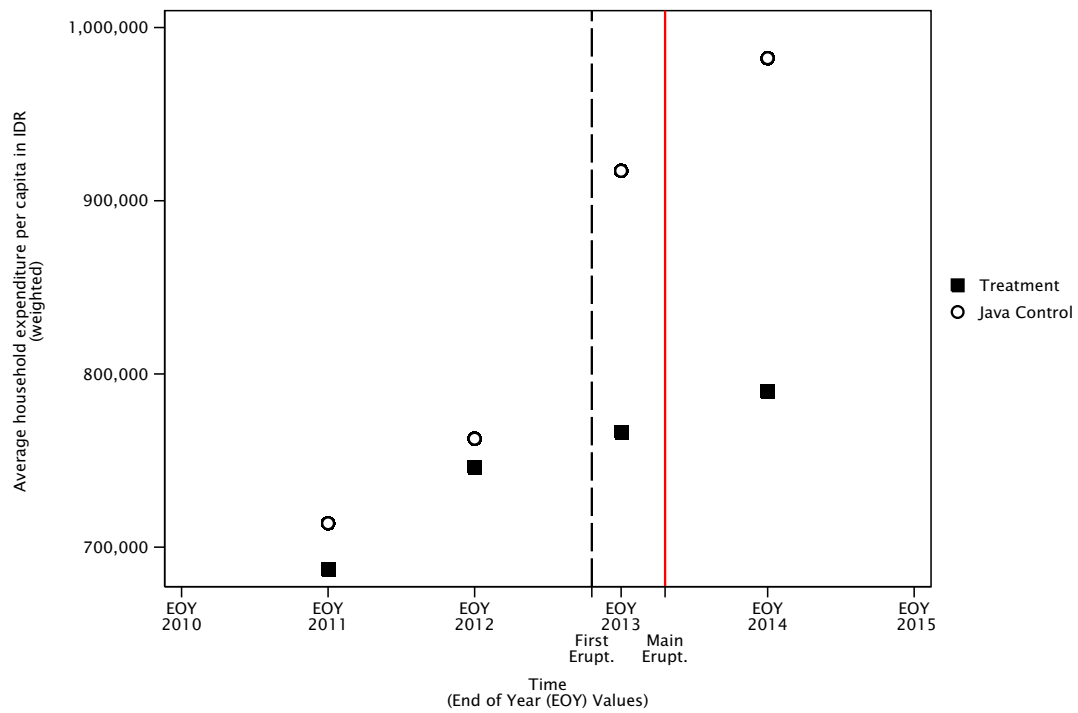
Notes: **Data:** Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank Group; Total household expenditure per capita over time in IDR. EOY = End of year. Data for 2015 is not yet available. Assigning of regencies/cities to Java and Non-Java and treatment and control according to table 1, based on geographical location.

To mitigate the adverse effects of natural disasters, Indonesia has created the National Agency for Disaster Management (BNPB). It orchestrates response activities and all relevant stakeholders in the case of a natural disaster-induced emergency (Jati, 2015). Following Mount Kelud's eruption, the BNPB supported the District's Disaster Management Agency (BPBD) in coordinating all relief efforts (International Federation of Red Cross and Red Crescent Societies, 2014). While all construction-related activities were in the hands of the military, economic and non-economic interventions were carried out by a cluster network of governmental and non-governmental agents such as the Red Cross, the World Food Program, Plan International, World Vision, Catholic Relief Services and the Yakkum Emergency Unit. Inter alia, interventions addressed the psycho-social, economic and nutritional well-being of affected communities (International Federation of Red Cross and Red Crescent Societies, 2014). The sample's treatment and control groups received interventions by the NGO, which also provided the data for this study. Unfortunately, there is no exact record of disaster-specific intervention. Going forward, it is hypothesized that these interventions attenuated the severity of the eruptions' ramifications. All negative changes in livelihood outcomes should hence be understood as an upper bound estimation of outcomes in the counterfactual case of a non-intervention and vice versa for positive changes. How this might affect this study's external validity is discussed in the section on identification concerns, section 6.[18]

---

18. A second concern that will be addressed later on is the multidirectional impact that disaster aid might have on the likelihood of domestic violence. It will also be discussed in the section on identification concerns, section 6.

Figure 4: Development of living conditions over time
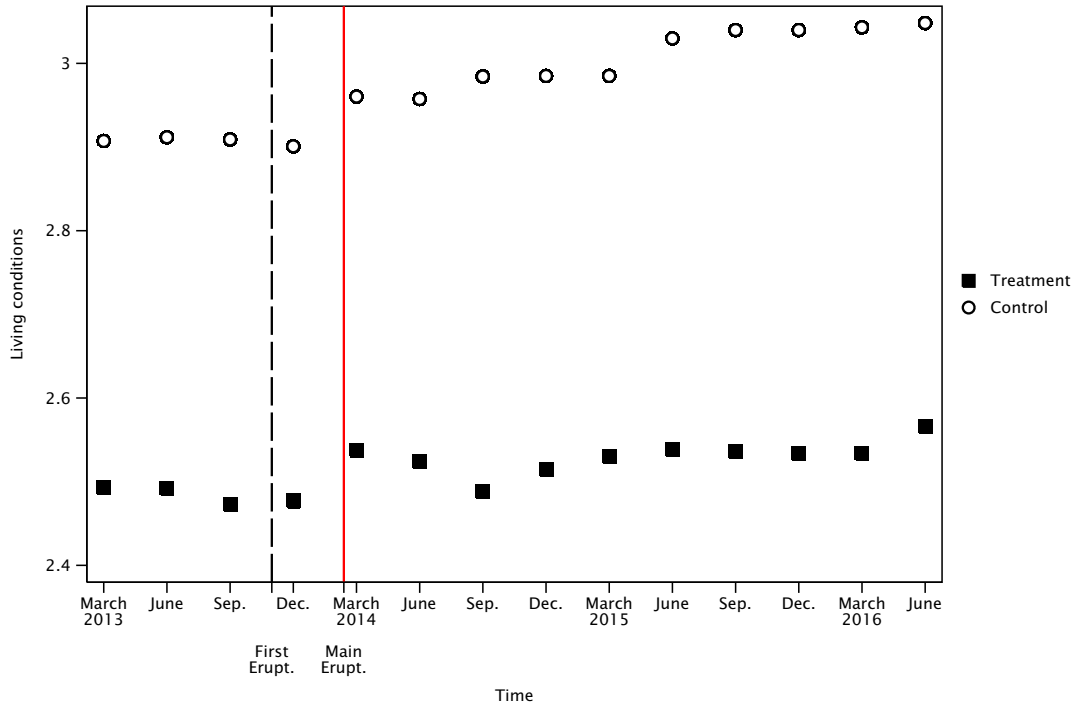
Notes: Black squares: treatment; White circles: no treatment. Y-axis-scale: 4 on the scale equals "Family lives in conditions that are adequate, as per local standards (defined on the level of the community in consultation with key stakeholders)", 1 on the scale equals "Family lives in conditions that are below local standards, and are compromising the personal well-being of individual (and/or family)"; First eruption: the first eruption of Mount Merapi, Main eruptions: eruptions of Mount Merapi and Mount Kelud.

4. Empirical strategy

4.1. Data

Data are provided by a Non-Governmental Organization (NGO), SOS Children's Villages (SOS). The data have been collected on a quarterly basis by social workers via a standardized questionnaire. The social workers are employed by SOS. The unit of analysis is that of a family. I use an unbalanced quarterly panel of 2,029 families in Indonesia from the first quarter of 2013 to the second quarter of 2016 (The number of observations can be found in appendix table 4. The lowest number of observations is given for the last quarter, with 6.1 of all observations, the highest number of observations is given in the third quarter with 2029 observations.) The maximum number of observations is 14. For the average family, I use 13.3 quarters of data.

The families are part of the on-going support program by SOS. They are selected

on the basis of their likelihood of family breakdown. The support program aims at preventing this family breakdown. Interventions comprehend economic, psycho-social, health and legal support. I only consider families that have been admitted to the support program before 2013 and for which reports are given until at least 2015. All observations of families that do not fulfill these prerequisites are dropped. The data are collected by social workers who are interviewing the families on a monthly basis with a structured questionnaire.

The data on domestic violence is collected by a child protection team. The child protection team collects data from two main sources. The first source is community leaders. These are heads of different local administrative levels (Head of Dukuh, Head of Rukun Warga/Rukun Tetangga) or religious leaders. There is a general awareness that incidences of domestic violence should be reported. The second source is the extended family or the nearest party of the victim. Sometimes, there are self-reports of female victims.

For the difference-in-differences approach, I use a subsample of the full Indonesian sample. I limit the sample for the difference-in-differences analysis to communities located on Java. This is done in order as the Java communities (control and treatment) show similar trends prior to the eruptions and hence comply with the common trend assumption.

The main descriptive statistics are summarized in table 1 for the pre- and post-treatment period. The treatment group is younger and better educated than the control group. Reported household expenditure and living conditions are higher in the control group than in the treatment group during the pre-treatment period. The gap between the two groups widens over time. Pre-treatment, domestic violence and reported alcohol abuse rates are low and below one percent in both control and treatment. For the pre-treatment period, the treatment group's average well-being score is 2.6 whereas the control group's score is 3.1 on a scale where four is good, and one is bad (Please refer to the appendix for a description of scales).

The share of biological children is comparably high in both the control and treatment group at rates of 100 percent and 98 percent respectively. There is a shrinking but statistically significant difference between the two groups in this respect. The average family has been part of the program for around six years. The treatment group receives more interventions and has been part of the program for a shorter duration of time than the control group. However, both groups receive a similar level of psychosocial and childcare support. Levels of received support do not increase significantly over time.

The descriptive statistics in table 1 show that pre- and post-treatment levels of key variables are different. This does not violate the assumptions of a difference-in-differences estimation per se. However, one might question whether these groups, that are different from each other, really would have developed in the same way if it was not for the treatment. To check the robustness, we conduct a synthetic control analysis. We will also use communities outside of Java for this analysis as described in section 6.

Table 1: Descriptive statistics by treatment status

	Pre-treatment			Post-treatment		
	Control	Treatment	Diff.	Control	Treatment	Diff.
Outcome variables:						
Share of fam. with domestic vio.	0.002	0.002	0.000	0.002	0.029	-0.026***
Log household expenditure per capita	13.610	13.555	0.054***	13.699	13.580	0.119***
Living conditions (1 to 4=good)	2.909	2.486	0.424***	2.976	2.509	0.467***
Emotional well-being (1 to 4=good)	3.097	2.611	0.486***	3.181	2.657	0.524***
Share families with alcohol/drug abuse	0.007	0.004	0.003	0.007	0.009	-0.002
Cargegiver characteristics:						
Caregiver education (1 to 4)	2.547	2.670	-0.123***	2.544	2.701	-0.157***
Age female caregivers	47.355	44.881	2.474*	47.858	41.563	6.295***
Age male caregivers	45.527	43.751	1.776***	47.020	44.181	2.839***
Share biological children	0.998	0.979	0.018***	0.998	0.986	0.012**
Support variables:						
Time since program admission in years	6.491	5.391	1.099***	6.555	5.484	1.070***
Support: Food	0.425	0.653	-0.228***	0.423	0.653	-0.230***
Support: Healthcare	0.547	0.798	-0.252***	0.544	0.798	-0.254***
Support: Material	0.195	0.304	-0.109***	0.194	0.304	-0.110***
Support: Economic	0.288	0.650	-0.362***	0.288	0.650	-0.362***
Support: Living conditions	0.440	0.578	-0.138***	0.437	0.573	-0.136***
Support: Psychosocial	0.783	0.788	-0.005	0.780	0.782	-0.002
Support: Childcare	0.757	0.763	-0.006	0.754	0.764	-0.010
Support: Legal	0.337	0.461	-0.124***	0.336	0.453	-0.117***

Notes: **Data:** Pre-treatment statistics based on pooled data from first three quarters of 2014; Post-treatment statistics based on pooled data from three last quarters of 2013; Age and education data might vary within-family over time based on responding primary caregiver; **Definition variables:** Education caregiver on scale 1 to 4 indicates 1) no formal education, 2) primary education, 3) lower secondary education, and 4) higher achievement than lower secondary education respectively; Support domains indicate support given by SOS in respective domains; See appendix section A for exact other scales and definitions of variables.

4.2. Difference-in-differences identification strategy

I employ a difference-in-differences estimation. The method is frequently employed to study the ramifications of natural disasters (Caruso, 2017; Gignoux and Menéndez, 2016; Jensen, 2000; Shah and Steinberg, 2017). Specifically, and following Gignoux and Menéndez (2016), I am using a fixed effects model to account for unobserved between-family variation. I estimate the model for five outcomes. The main outcome variable is domestic violence. The four alternative outcomes are average household expenditure (based on macro-level data), household living conditions (based on micro-level data), emotional well-being and alcohol/drug abuse.[19]

4.2.1. Domestic violence

I estimate the following equation to identify the effect of two volcano eruptions on domestic violence prevalence.

$$y_{j,t} \quad = \quad \alpha_j \quad + \quad \beta_t \quad + \quad \gamma T_{j,t} \quad + \quad +\delta' X_{j,t} \quad + \quad \epsilon_{j,t} \quad (1)$$

, where $y_{j,t}$ describes a binary outcome variable for household j at time t that is one if domestic violence is reported and zero otherwise. α_j is a fixed effect accounting for time-invariant household attributes (A non-reported Hausman test supports the fixed effects approach). β_t is a time dummy-vector with dummies for all quarters to capture general time trends. $T_{j,t}$ is a dummy that is 1 for all affected areas post-treatment and 0 otherwise. γ is the coefficient of interest and measures the increase in domestic violence attributable to the event.

$X_{j,t}$ is a vector of family attributes that are determined in the pre-treatment period but time-variant. It includes the following variables: age-group of primary caregiver[20], number of children in the household as well as time since program admission and a binary indicator for whether a family received support. ϵ is an idiosyncratic, time-varying error term. Standard errors are clustered at a regional level (Results are robust to clustering at family level).

To describe the treatment effect over time, I report a series of dummies by interacting a binary *living in a treatment region* indicator with time fixed effects. The coefficients

---

19. Alcohol/drug abuse is reported at low rates, which might be either due to underreporting or low rates or both. Irrespective of this, the models will provide suggestive evidence towards the plausibility of the proposed channel – stress as a cause of domestic violence.

20. Age groups are created based on the decade of parental birth: 2000-10, 1990-99, 1980-1989, etc.

of this indicator vector capture the increased likelihood of development of domestic violence for individuals living in treated regions compared to individuals living in control regions. This also allows testing the common trend assumption. It shows that there is no pretreatment difference between control and treatment groups with regard to the dependent variable.

4.2.2. Alternative outcomes

For the alternative outcomes, I estimate the previously specified difference-in-differences equation 1 and replace outcome $y_{j,t}$ by the respective alternative outcome variable. I will estimate the baseline equation of the previous specification. Opposed to the previous specification, I employ a random-effects model as suggested by Hausman test results.

I estimate four outcomes. The first two are economic outcomes. A threat to livelihood would be expected to increase mental distress and act as a secondary stressor (Overstreet et al., 2011). The latter two outcomes are emotional well-being and alcohol/drug abuse. Emotional well-being is considered a proxy for the state of mental well-being of the sample. Previous research has documented the comorbidity of alcohol abuse and PTSD.[21]

The first outcome is household expenditure per capita in Indonesian Rupiah (IDR) as reported by the Indonesia Database for Policy and Economic Research.[22] This value does not vary by household but by region. The data per region can be found in appendix tables 1 and 2.

The second outcome is living conditions. Living conditions of a household are measured on a scale from one to four, with four indicating a positive outcome. The survey defines value four as "Family lives in conditions that are adequate, as per local standards (defined on community level in consultation with key stakeholders)", while the definition for value one is "Family lives in conditions that are below local standards, and are compromising the personal well-being of individual (and/or family)". The full scale is to be found in appendix section A.

---

21. McFarlane (1998) reviews studies on the association of alcohol abuse and PTSD. Sonne et al. (2009) present evidence on the sequence of the onset of PTSD and alcohol abuse respectively. Bueno and Henderson (2017) explore the association of IPV with alcohol abuse.

22. See Indonesia Database for Policy and Economic Research (INDO-DAPOER) by the World Bank Group.

The third outcome is emotional well-being. This variable takes on values from one to four, with four being *good*. The survey defines value four as "Care-giver is pro-active in addressing the situation of her/his family, and is emotionally stable, with a generally positive outlook". The definition for value one is "Care-giver is passive (not taking any action to address the situation of her/his family) and/or is emotionally unstable (showing signs of anger, irritability, aggression or depression)". Appendix section A provides the full scale. One potential issue with this outcome is that the reporting care-giver sometimes changes over time. The threat to identification will be discussed later.

The fourth outcome is alcohol/drug abuse. Social workers report whether alcohol and/or drug use affect the family in a negative way. If either one of the two caregivers abuses alcohol or drugs, it is coded as 1, if none of the two abuse alcohol or drugs, it is coded as 0.

4.3. Heterogeneity analysis

Based on conversations with experts of the local situation and previous literature (Anastario, Shebab, and Lawry, 2009), I hypothesize that households with IDP status (internally displaced people) are particularly likely to develop domestic violence after the eruption. Households with IDP status had to resettle in the past due to natural disasters. These households were forced to migrate and often suffer on multiple dimensions in their new environment. In the setting of the sample, many families from the Huntap community had to move due to the 2010 major outbreak of Mount Merapi. A family is classified with IDP status if the family has IDP status at any given point in time during the observational period.

It is hypothesized that they will develop higher rates of domestic violence for three reasons. First, they are likely to suffer from a reduced livelihood even before treatment. This is because their previous sources of income have either been destroyed or the displacement forced them to create a new livelihood (While some studies on Katrina show that this might be beneficial for some, local experts suggest that overall living conditions suffer from displacement). These families are thereby likely to suffer from reduced income, reduced home size and a loss of their previous environment. Secondly, individuals with IDP status are expected to suffer from a loss of their social network and thereby social control. Thirdly, the volcano eruptions could act as traumatic reminders. Although I am not able to show this, I hypothesize that a *re-eruption* of Mount Merapi will cause significant trauma to this subpopulation.

Overstreet et al. (2011) summarizes literature that shows that even anticipation of a recurrent disaster threat can induce distress. I, therefore, estimate the baseline specification for both individuals with IDP and without IDP status in two separate models.

4.4. Proposed channel of causality

As outlined in the introduction and literature review sections, previous studies found that the psychological, social and economic consequences of natural disasters cause mental distress in affected populations. Outward, interpersonal violence and aggression are one type of reaction of humans exposed to distress. Worsened living conditions and lack of social networks and thereby social control act as important moderators.

This study follows this proposed causal chain. To test these predictions, I first estimate the impact of treatment on domestic violence. I then survey four alternative outcomes. I estimate the treatment effect on two economic outcomes. This is to test whether the affected population also suffers from economic loss. Secondly, I estimate the treatment effect on alcohol/drug abuse and emotional well-being. I argue that both are associated with mental distress (Alcohol abuse has also been associated with IPV).[23] A heterogeneity analysis with a subsample of individuals with IDP status estimates the treatment effect of people that lack a social network.

5. Results

5.1. Change in domestic violence prevalence

I estimate the change in the prevalence of domestic violence with a difference-in-differences model using fixed effects estimates (A Hausman test rejects the equivalence of random effects). Column 1 of table 2 presents the results of a fixed effects model without controls. Column two shows fixed effects estimates with a minimum set of controls, including quarter and village as well as caregiver age group dummies. Column three shows estimates from a fixed effects model with full controls, adding an indication of received types of NGO support, time since admission to SOS and number of children living in the household. Treatment is defined as living in an exposed community during and post the first volcano eruption. Results suggest an increase of approximately 2.2

---

23. Bech et al. (2003) discuss the relationship between mental distress and well-being. Bueno and Henderson (2017) explore the association of IPV with alcohol abuse.

percentage points in domestic violence after the event of an earthquake. Compared to the low baseline level, this is a very meaningful increase. The effect size does vary slightly between estimation approaches and is found in random effects as well as fixed effects models. Figure 5 shows treatment coefficients over time.

Table 2: Baseline model: effect of volcano eruptions experience on domestic violence

	Dependent variable: domestic violence		
	(1)	(2)	(3)
	No controls	Minimum controls	Full controls (Baseline model)
Treatment	0.030***	0.022***	0.022***
	(0.000)	(0.002)	(0.002)
Constant	0.002***	-0.077**	-0.217***
	(0.000)	(0.017)	(0.026)
Time dummies		✓	✓
Programme dummies		✓	✓
Age group dummies		✓	✓
Support dummies			✓
Time since admission and no. of children			✓
Observations	12,169	12,128	12,128
$Adj.R^2$	0.016	0.058	0.067
Clusters	4	4	4
Family level fixed effects	Yes	Yes	Yes
Standard erros clustered at regional level	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family fixed-effects; **Dependent variable:** domestic violence (yes = 1/no = 0); Robust standard errors are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

Figure 5: Baseline model:
effect of volcano eruptions experience on domestic violence over time
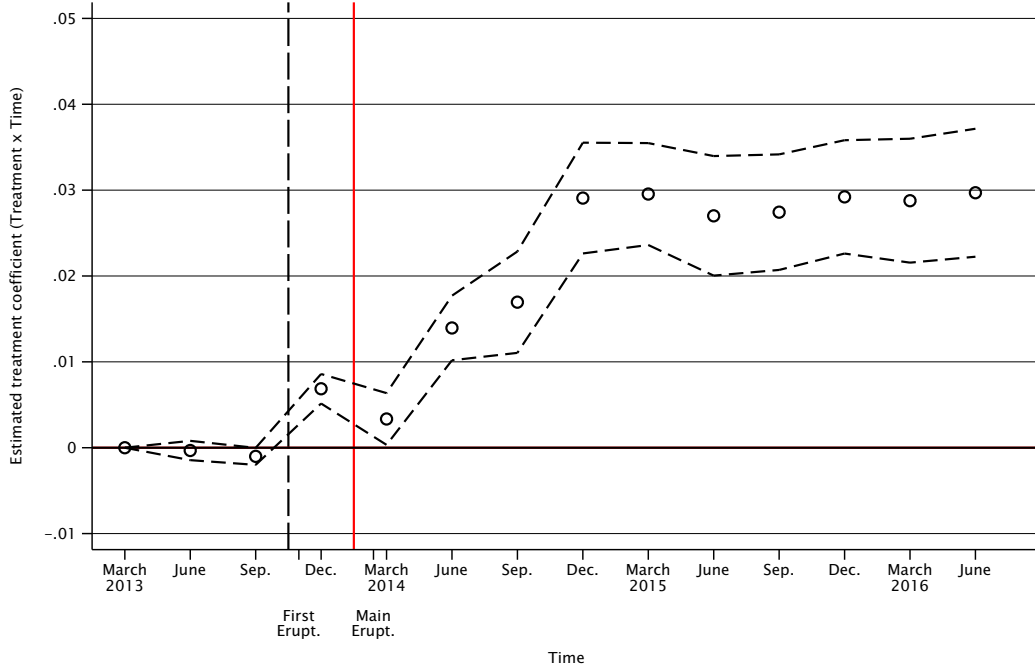
Difference-in-differences estimate with family fixed-effects; **Dependent variable:** *domestic vio-lence in treated vs. non-treated regions. Estimated coefficient: interaction of treatment and time. Controls: caregiver age group, regional control, number of children, support, time since admission; Robust standard errors in parentheses are clustered at regional level; First Eruption: marking the first eruption of Mount Merapi; Main Eruption: main eruptions of Mount Merapi and Mount Kelud; Lines indicate 95 percent confidence interval.*

5.2. Change in alternative outcomes

Changes in the four alternative outcomes support the hypothesis that the volcano eruptions lead to a decrease in material and emotional well-being. I find an adverse effect of treatment on average household expenditure while the individual living conditions do not change. The latter result might also be influenced by the fact that the sample receives economic interventions (See discussion in section 6). Importantly, the first outcome variable is measured on macro-level, while the latter is measured on household level. The treatment coefficient is negative for emotional well-being. It is positive and significant for alcohol/drug abuse negatively affecting families. The small effect of the latter outcome has to be interpreted in light of the overall low rates of alcohol/drug abuse in the overall sample.

Table 3: Alternative outcomes: effect of volcano eruptions experience on alternative outcomes

	Alternative outcomes:			
	(1)	(2)	(3)	(4)
	Household expenditure	Household living conditions	Emotional well-being	Alcohol/ drug abuse
Treatment	-0.054***	-0.059	-0.067***	0.005***
	(0.019)	(0.053)	(0.017)	(0.000)
Time s. Prog. Adm.	-0.002	0.010	0.004	0.001
	(0.001)	(0.013)	(0.019)	(0.001)
Constant	13.553***	0.000	0.000	-0.006
	(0.020)	(.)	(.)	(0.011)
Time dummies	✓	✓	✓	✓
Programme dummies	✓	✓	✓	✓
Age group dummies	✓	✓	✓	✓
No. of children	✓	✓	✓	✓
Observations	7,207	11,134	11,583	12,128
$Adj.R^2$				
Clusters	4	4	4	4
Family level random effects	Yes	Yes	Yes	Yes
Standard erros clustered at regional Level	Yes	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family random-effects; **Dependent variable:** column 1: log of household expenditure in IDR (measured at regency-/city-level), column 2: living conditions (measured at micro level, scale of 1 to 4, where 4 is good), column 3: emotional well-being (scale of 1 to 4, where 4 is good), column 4: alcohol/drug abuse affects family (yes = 1/no = 0) respectively, see appendix section A for exact scales and definitions of variables; Robust standard errors in parentheses are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

5.3. Heterogeneity analysis: domestic violence prevalence among internally displaced people (IDP)

I find that households that are classified as internally displaced people (IDP) have a significantly larger chance of displaying domestic violence. The estimated effect size is roughly four to five times that of non-IDP households. This suggests that IDP families are at more substantial risk of developing domestic violence. Unobserved pretreatment heterogeneity of IDP vs. Non-IDP households is accounted for by fixed effects.

6. Identification concerns and robustness checks

Multiple concerns potentially threaten the validity of correct identification of the treatment effect. In the following section, I will discuss them and several robustness checks to address the concerns where possible.

Sample selection and attrition. The sample is particularly vulnerable to family breakdown compared to the general population. Its selection into a programme by SOS Children's Villages happens based on its assessed risk of family breakdown. While this renders the sample not representative of the Indonesian population, it is of particular relevance for policymakers. Due to its vulnerability, the sample is often the primary target group for emergency programs. Reactions of this group hence remain relevant for policy design. We only use individuals that have been present for the core of the observational period. Selective attrition from the program can upward bias the estimates. However, only 5.3 percent of all observations are omitted because they left the program before the end of the observational period. This indicates that selective attrition is not responsible for the observed effects. The remaining number of observations is comparably stable over time (see appendix table 4). Throughout the years 2013 and 2014 the number of families remains at around 900 and gradually decreases thereafter.

Interviewer behavior. By definition, a natural disaster is a visible event. This event might affect interviewer behavior as well. The thoroughness by which interviews were conducted and the attention of social workers to signs of violence might have been influenced. This would upward bias reporting of domestic violence as discussed in Sekhri and Storeygard (2014). I cannot entirely reject this hypothesis. However, two arguments increase the likelihood that the results are not entirely driven by observational sensitivity. First, the identified results in domestic violence fit the overall

Table 4: Heterogeneity analysis: effect of volcano eruptions experience on domestic violence prevalence by internally displaced people (IDP) status

	Dependent variable: domestic violence			
	(1) No IDP status no controls	(2) IDP status no controls	(3) No IDP status full controls	(4) IDP status full controls
Treatment	0.020*** (0.000)	0.091*** (0.000)	0.014*** (0.001)	0.092** (0.018)
Constant	0.002*** (0.000)	-0.003*** (0.000)	-0.150*** (0.023)	-0.520** (0.119)
Quarter dummies			✓	✓
Programme dummies			✓	✓
Age group dummies			✓	✓
Support dummies			✓	✓
Time since admission and no. of children			✓	✓
Observations	10,763	1,084	10,740	1,066
$Adj.R^2$	0.0091	0.062	0.042	0.23
Clusters	4	3	4	3
Family fixed effects	Yes	Yes	Yes	Yes
Standard erros clustered at regional level	Yes	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family fixed-effects; **Dependent variable:** domestic violence (yes/no); sample split by previous IDP experience; Robust standard errors in parentheses are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

development of related variables. In addition to domestic violence, I also find increases in alcohol/drug abuse prevalence rates and reductions in emotional well-being. Furthermore, the full sample is restricted to families who have been admitted previously to the event. This implies that the same questionnaire has been filled for on average 5 to 6 years before the eruption happened. I expect that this long-term exposure to the organization and interviewers will increase the likelihood of accurate, trust-based reporting and detection of domestic violence.

Related to this is a concern associated with the main outcome variable. Domestic violence is indicated by a simple binary variable reflecting the overall presence of domestic violence within a family. This issue limits the overall depth of insight that can be gained from this study, apart from potential backlash identification issues. However, as Reading (2008) point out, there is a high correlation between different forms of domestic violence. From a humanitarian point of view, it is also relevant to detect and prevent violence in general, irrespective of the actor and victim.

Caregiver attributes. Most variables of interest are collected at the household level (for instance domestic violence, alcohol/drug abuse, living conditions). However, variables like caregiver age and emotional well-being are collected at the level of the caregiver. In some cases, the *primary caregiver* changes. It is hypothesized that this occurs (mostly) not due to death or divorce but dependent on which parent has been interviewed. To test the relevance of *switching caregivers*, the baseline model is only estimated for households that report a male primary caregiver (This does neither imply, that excluded households are led by female singles, nor that the primary male caregivers are single). I find a positive treatment effect suggesting an increase in domestic violence. This effect is smaller compared to the one found when using the full sample. See appendix table 8 for the model.

Simultaneous treatment (eruption and support). A related concern is associated with the disaster and regular support programs that the sample has received. Interventions might bias outcomes. While other opinions exist, Cavallo et al. (2013) posit that post-disaster aid commonly covers only a minor share of real damages in affected communities. Nonetheless, the data on living conditions might be upward biased. That is, compared to other vulnerable groups, due to sample selection, the sample might benefit from more (disaster) support than otherwise equally vulnerable groups that do not receive support. It is not observed how families behaved that received no support at all. It is also not possible to distinguish between disaster and

regular support. However, even these outcomes are informative. It is of interest what happens in light of intervention, as scenarios with intervention are more common in most countries than non-intervention. MYet, this study cannot comment on whether this specific set of interventions increased domestic violence due to male backlash. Observing overall economic and family-level data suggests that domestic violence is associated with worsening economic conditions. However, the data *remain blind* as to relative income shares within families and their association with domestic violence.

Assignment to treatment group. Assignment to treatment is identified via maps provided by disaster aid organizations and additional reasoning. I do not have GPS location information on single households but identify via the location of the community the household is assigned to. The communities are then located as single points on the map and matched to disaster data. Certain villagers might live further away outside of the treatment area and thereby experience *less* treatment. This could downward bias the results. To check the robustness of the results to the exclusion of mildly affected treatment areas, the communities located in Kabupaten Gunungkidul are excluded. Results are robust to limiting the treatment sample to the resulting smaller sample size (see appendix table 10).

Pre-treatment differences of control and treatment group. As argued, compared to the control group, the treatment group is on average less educated and suffers from lower living conditions, inter alia (see table 1). While overall household expenditure per capita is at a similar level (see figure 3), the variation in observables might cast doubt on the adequacy of the comparison of treatment and control group. As pointed out earlier, pre-treatment differences would only threaten difference-in-differences identification if they lead to a violation of the common trend assumption.

I run a synthetic control approach to testing whether the post-treatment trends are rooted in the worse socioeconomic position of the treatment group compared to the control group. The approach has been pioneered by Abadie and Gardeazabal (2003) and Abadie, Diamond, and Hainmueller (2010) to evaluate the effects of policy interventions and civil conflict. Cavallo et al. (2013) were first to employ it for the identification of natural disaster effects. It creates a weighted average of control units to create a new synthetic control group, which then parallels the treatment group in its pretreatment features.

The results suggest that the negative post-treatment development of the treatment

region is not founded on pretreatment differences of control and treatment groups. The synthesized control groups that have been created based on the pre-treatment trends of the treatment group develop more positively than the treatment group in all cases. Results are reported in the in appendix figure 6.

7. Discussion

This study does not allow to comment on whether male backlash theories or bargaining models provide a better explanation for violence in the aftermath. However, a net increase in violence is observed. The overall rates of observed violence are in line with the previous literature. Domestic violence does not level off over time. This is in accordance with previous reviews that have shown a mixed picture with respect to the persistence of PTSD in the aftermath of disasters (Neria, Nandi, and Galea, 2008).

The overall results tie in with previous research that suggests an increase in PTSD following disasters and propose violence as one channel of how individuals react to existential stress and a challenged livelihood (Rezaeian, 2013). The four alternative outcomes support this theory. Previous hypotheses by Nilan et al. (2014) who point out the association between violence and the (self-perceived) male inability to satisfy female (economic) expectations are supported as well.

Families who have been displaced in the past are facing a particular risk of developing domestic violence. This longitudinal observation confirms previous post-disaster cross-sectional observations in a hurricane-related IDP context (Anastario, Shebab, and Lawry, 2009). It also alludes to the findings by Berkowitz (1993) who propose that a lack of social control will lead to higher rates of domestic violence (Curtis, Miller, and Berry (2000) discuss this in the specific context of natural disasters). Individuals with IDP status live outside of their previous social environment and are hence subject to less social control. The findings also confirm with Warsini et al. (2014), who documented higher rates of distress in survivor communities around Mount Merapi, which are the communities that individuals with IDP status come from. The high rates of domestic violence suggest that individuals with IDP status should be tracked closely following their displacement.

Appendix table 6 supports the previous findings. The table offers a comparison of families in the treatment region by their domestic violence status. Families that show domestic violence in the aftermath of the disaster also report below average emotional

well-being. We also find significantly higher rates of documented alcohol/drug abuse at a rate of 15 percent. These differences within the treatment group hint at the validity of the previously proposed channels.

8. Conclusion

This study's results suggest an association between natural disasters and domestic violence. In the aftermath of two volcano eruptions, I find an increase in domestic violence, a reduction in emotional well-being and a strong relationship between domestic violence and IDP status. A synthetic control approach supports the robustness of findings. The unique data thereby offer a longitudinal perspective on a particularly vulnerable group. As such, it is the first family level panel dataset from a developing country. Causal identification might suffer from multiple shortcomings in the data. While there is no final causal certainty that domestic violence has been caused by the stress induced by volcano eruptions, I argue that one has good reason to investigate the relationship further and act *preemptively* from a policy perspective. This could also result in providing (further) special assistance to families with IDP status. Findings should encourage the collection of more evidence and a potential increase in sensitivity of disaster aid workers for a prevalence of domestic violence in post-disaster areas.

A. Definitions and coding of variables

Living conditions variable scale
The scale is reversed from the original scaling in the raw data to offer a more intuitive interpretation.

4 = Family lives in conditions that are adequate, as per local standards (defined on community level in consultation with key stakeholders).

3 = Family lives in conditions that are fairly adequate, as per local standards.

2 = Family lives in conditions that are below local standards, but not compromising the personal well-being of individual (and/or family).

1 = Family lives in conditions that are below local standards, and are compromising the personal well-being of individual (and/or family).

Emotional well-being scale
The scale is reversed from the original scaling in the raw data to offer a more intuitive interpretation.

4 = Care-giver is pro-active in addressing the situation of her/his family, and is emotionally stable, with a generally positive outlook.

3 = Care-giver often takes action to address the situation of her/his family, but is struggling to cope with stress or is emotionally unstable.

2 = Care-giver rarely takes action to address the situation of her/his family, and is struggling to cope with stress or is emotionally unstable.

1 = Care-giver is passive (not taking any action to address the situation of her/his family) and/or is emotionally unstable (showing signs of anger, irritability, aggression or depression).

Alcoholism variable

Social workers report whether alcohol and/or drug use negatively affects the family. If either one of the two caregivers abuses alcohol or drugs, it is coded as 1, if none of the two abuse alcohol or drugs, it is coded as 0.

B. Auxiliary tables

B.1. Household expenditure data and treatment status by regency/city

Table 1 shows total household expenditure figures in IDR of all regencies/cities considered in the study. Table 2 shows the development of household expenditure figures in IDR over time and the assignment of regions to treatment and control status.

Table 2 displays household expenditure growth over time in columns one and two. Numbers are based on World Bank data. In column three the table indicates whether a given regency/city is located on Java or not. Column four shows whether a regency is part of the treatment group. The treatment group is located in the areas of DI Yogyakarta and Yogyakarta. Regencies that are on Java but not in the treatment group form the control group. Regencies that are neither on Java nor in the treatment group are not part of the main analysis but part of the synthetic control approach. Regencies and cities on Java (see column 3 for information on location) display a bandwidth ranging from -14 percent to positive 13 percent for 2013 on 2014. The rural DI Yogyakarta region around the city of Yogyakarta (Yogyakarta, Kota) displays the lowest overall growth figure of negative 14 percent. It is also the region in which a large share of the treatment group is located.

Table 1: Household expenditure by year and by regency/city

| Regency/city | Household expenditure per capita in IDR | | | |
	2011	2012	2013	2014
Aceh Barat, Kab.	540,932	638,680	632,962	684,435
Aceh Besar, Kab.	634,162	713,185	648,954	713,994
Bogor, Kab.	600,637	738,744	683,325	774,349
Bogor, Kota	763,232	816,762	811,084	883,508
DI Yogyakarta, Prop.	649,901	721,349	692,732	748,303
Jawa Barat, Prop.	587,951	674,459	680,911	781,065
Medan, Kota	717,967	861,019	976,107	957,268
Semarang, Kab.	522,294	661,918	630,186	739,148
Semarang, Kota	749,405	760,646	1,023,720	1,058,218
Sikka, Kab.	332,327	379,175	447,326	462,701
Tabanan, Kab.	755,171	830,672	838,093	993,577
Yogyakarta, Kota	913,793	904,525	1,088,371	940,194
Observations	26,879	26,879	26,879	26,879

Notes: **Data:** Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank Group; Total household expenditure per capita over time in IDR; Abbreviations Kab and Kota refer to regencies (*Kabupaten*) and cities (*Kota*); Prop. refers to areas with available province-level data, only.

Table 2: Household expenditure growth (in IDR)
and treatment/control status by regency/city

Regency/city	Household expenditure per capita		Treatment status	
	Growth 2011 to 2014	Growth 2013 to 2014	Share of group living on Java	Share of group in treatment group
	in percent	in percent	in percent	in percent
Aceh Barat, Kab.	0.27	0.08	0.00	0.00
Aceh Besar, Kab.	0.13	0.10	0.00	0.00
Bogor, Kab.	0.29	0.13	1.00	0.00
Bogor, Kota	0.16	0.09	1.00	0.00
DI Yogyakarta, Prop.	0.15	0.08	1.00	1.00
Jawa Barat, Prop.	0.33	0.15	1.00	0.00
Medan, Kota	0.33	-0.02	0.00	0.00
Semarang, Kab.	0.42	0.17	1.00	0.00
Semarang, Kota	0.41	0.03	1.00	0.00
Sikka, Kab.	0.39	0.03	0.00	0.00
Tabanan, Kab.	0.32	0.19	0.00	0.00
Yogyakarta, Kota	0.03	-0.14	1.00	1.00
Total	0.29	0.05	0.45	0.25
Observations	26,879	26,879	26,879	26,879

Notes: **Data:** Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank Group; Assignment to Java / Non Java groups and treatment group according to geographical location; Abbreviations Kab and Kota refer to regencies (*Kabupaten*) and cities (*Kota*); Prop. refers to areas with available province level data, only.

B.2. Household expenditure data and treatment status by SOS Children's Villages community

Table 3 shows the development of household expenditure at the level of SOS Children's Villages communities. The first letter indicates the programme with which a community is associated (see also table notes).

Table 3: Java only: Household expenditure growth over time by
SOS Children's Villages community and by treatment status

| SOS Children's Villages community name | Household expenditure per capita | | | Treatment status |
	Household expend. 2014 in IDR	Growth 2013 to 2014 in percent	Growth 2011 to 2014 in percent	Share of group in treatment group in percent
J: Bogor (Summarized)	854,322.24	0.10	0.19	0.00
L: Andesde	748,303.42	0.08	0.15	1.00
L: Cakrawala	748,303.42	0.08	0.15	1.00
L: Huntap	748,303.42	0.08	0.15	1.00
L: Huntap Glagaharjo	748,303.42	0.08	0.15	1.00
L: Jayagiri	781,065.46	0.15	0.33	0.00
L: Jogoluhur	748,303.42	0.08	0.15	1.00
L: Kota Jogja	940,194.33	-0.14	0.03	1.00
L: Pakridhan Yogawidagdo	748,303.42	0.08	0.15	1.00
L: Puri Manunggal B.A.B.	748,303.42	0.08	0.15	1.00
L: Pusaka	748,303.42	0.08	0.15	1.00
L: Sapa Jiwa	748,303.42	0.08	0.15	1.00
L: Seputar	781,065.46	0.15	0.33	0.00
L: Sumedang	781,065.46	0.15	0.33	0.00
L: Turus Becik	748,303.42	0.08	0.15	1.00
L: Wangunsari	781,065.46	0.15	0.33	0.00
S: Ambarawa	739,147.83	0.17	0.42	0.00
S: Sayung	1058217.76	0.03	0.41	0.00
S: Tambak Rejo	1058217.76	0.03	0.41	0.00
Total	843,459.94	0.06	0.22	0.55
Observations	12,169	12,169	12,169	12,169

Notes: **Data:** Indonesia Database for Policy and Economic Research (INDO-DAPOER), World Bank Group;
Total household expenditure per capita over time in IDR; The first letter indicates the SOS Children's Village
programme with which a programme is associated. J for SOS Social Centre Jakarta, L for SOS Social Centre
Lembang, S for SOS Family Strengthening Programme Semarang; Abbreviations Kab and Kota refer to
regencies (*Kabupaten*) and cities (*Kota*); Prop. refers to regions on province level.

C. Descriptive statistics

C.1. Number of observations by quarter (full sample and Java only)

Table 4 presents the total number of observations over time for the full sample. This sample is used for the synthetic control approach. Table 5 presents the subsample of communities on Java. This sample is used for the difference-in-differences estimation.

Table 4: Number of observations by quarter: full sample

Quarters	Number total observations	Relative share in percent	Cumulative share in percent
1	1,989	7.4	7.4
2	2,024	7.5	14.9
3	2,029	7.5	22.5
4	2,027	7.5	30.0
5	2,025	7.5	37.6
6	2,024	7.5	45.1
7	2,019	7.5	52.6
8	2,018	7.5	60.1
9	2,018	7.5	67.6
10	1,931	7.2	74.8
11	1,737	6.5	81.3
12	1,715	6.4	87.6
13	1,685	6.3	93.9
14	1,638	6.1	100.0
Observations	26,879		

Notes: One observation is one family; Quarter 1/2/3/4 = data collected during first, second, third, fourth quarter of 2013 respectively; Quarter 5/6/7/8 = data collected during first, second, third, fourth quarter of 2014 respectively; Quarter 9/10/11/12 = data collected during first, second, third, fourth quarter of 2015 respectively; Quarter 13/14 = data collected during first and second quarter of 2016 respectively; For the estimations, I only consider families that have been admitted to the support program before 2013 and for which reports are given until at least 2015; All observations of families that do not fulfill these prerequisites are dropped.

Table 5: Number of observations by quarter: Java only

Quarters	Number observations Java only	Relative share in percent	Cumulative share in percent
1	897	7.4	7.4
2	906	7.4	14.8
3	910	7.5	22.3
4	909	7.5	29.8
5	908	7.5	37.2
6	906	7.4	44.7
7	901	7.4	52.1
8	900	7.4	59.5
9	900	7.4	66.9
10	831	6.8	73.7
11	813	6.7	80.4
12	815	6.7	87.1
13	808	6.6	93.7
14	765	6.3	100.0
Observations	12,169		

Notes: Java only. One observation is one family; Quarter 1/2/3/4 = data collected during first, second, third, fourth quarter of 2013 respectively; Quarter 5/6/7/8 = data collected during first, second, third, fourth quarter of 2014 respectively; Quarter 9/10/11/12 = data collected during first, second, third, fourth quarter of 2015 respectively; Quarter 13/14 = data collected during first and second quarter of 2016 respectively; For the estimations, I only consider families that have been admitted to the support program before 2013 and for which reports are given until at least 2015; All observations of families that do not fulfill these prerequisites are dropped.

C.2. Descriptive statistics for treatment group by domestic violence status

Table 6 presents descriptive statistics for those families living in the treatment area. The treatment group is divided into whether there are domestic violence reports or not.

Table 6: Descriptive statistics for treatment group by presence of domestic violence

	Families of treatment group with:		
	no domestic violence	domestic violence	Diff.
Outcome variables:			
Share of fam. with domestic vio.	0.00	1.00	-1.00
Log household expenditure per capita	13.58	13.60	-0.02
Living conditions (1 to 4=good)	2.51	2.49	0.02
Emotional well-being (1 to 4=good)	2.67	2.27	0.40***
Share families with alcohol/drug abuse	0.01	0.15	-0.14***
Caregiver characteristics:			
Caregiver education (1 to 4)	2.71	2.49	0.22
Age female caregivers	41.86	37.35	4.52*
Age male caregivers	44.22	41.45	2.77
Share biological children	0.99	1.00	-0.01
Support variables:			
Time since program admission in years	5.52	4.27	1.25***
Support: Food	0.65	0.83	-0.18*
Support: Healthcare	0.79	0.93	-0.13*
Support: Material	0.30	0.56	-0.26***
Support: Economic	0.65	0.66	-0.01
Support: Living conditions	0.57	0.68	-0.11
Support: Psychosocial	0.78	0.93	-0.15*
Support: Childcare	0.76	0.93	-0.17*
Support: Legal	0.45	0.66	-0.21**

Notes: **Data:** Only treatment area; Only data for three last quarters of 2014 (post-treatment); Treatment group divided into families without report of domestic violence (column 1) and with report of domestic violence (column 2) during this period; **Definition variables:** Education caregiver on scale 1 to 4 indicates 1) no formal education, 2) primary education, 3) lower secondary education, and 4) higher achievement than lower secondary education respectively; Support domains indicate support given by SOS in respective domains; See appendix section A for exact other scales and definitions of variables.

C.3. Descriptive statistics by location on Java

Table 7 presents descriptive statistics for those families that live on Java and those that live not on Java. Communities on Java are used for all difference-in-differences estimates. The families that are not living on Java are only used for the synthetic control approach (together with families living on Java).

Table 7: Descriptive statistics by location on Java

	Java		Non-Java		Full sample	
	Mean	SD	Mean	SD	Mean	SD
Outcome variables:						
Share of fam. with domestic vio.	0.002	0.047	0.002	0.049	0.002	0.048
Log household expenditure per capita	13.581	0.19	13.241	0.32	13.394	0.32
Living conditions (1 to 4=good)	2.677	0.63	2.368	0.49	2.496	0.57
Emotional well-being (1 to 4=good)	2.843	0.61	2.910	0.30	2.882	0.46
Share families with alcohol/drug abuse	0.006	0.074	0.016	0.13	0.011	0.11
Cargegiver characteristics:						
Caregiver education (1 to 4)	2.609	0.75	2.317	0.52	2.443	0.65
Age female caregivers	46.449	11.0	41.319	9.24	42.723	10.0
Age male caregivers	44.529	10.2	44.759	11.4	44.644	10.8
Share biological children	0.988	0.11	0.997	0.052	0.993	0.083
Support variables:						
Time since program admission in years	5.901	1.99	6.265	1.57	6.101	1.78
Support: Food	0.547	0.50	0.561	0.50	0.555	0.50
Support: Healthcare	0.682	0.47	0.926	0.26	0.816	0.39
Support: Material	0.254	0.44	0.150	0.36	0.196	0.40
Support: Economic	0.482	0.50	0.609	0.49	0.552	0.50
Support: Living conditions	0.514	0.50	0.207	0.41	0.345	0.48
Support: Psychosocial	0.785	0.41	0.434	0.50	0.592	0.49
Support: Childcare	0.760	0.43	0.615	0.49	0.680	0.47
Support: Legal	0.404	0.49	0.305	0.46	0.349	0.48
Observations	2,713		3,329		6,042	

Notes: **Data:** Statistics based on data from first three quarters of 2013; **Definition variables:** Education caregiver on scale 1 to 4 indicates 1) no formal education, 2) primary education, 3) lower secondary education, and 4) higher achievement than lower secondary education respectively; Support domains indicate support given by SOS in respective domains; See appendix section A for exact other scales and definitions of variables.

D. Robustness checks

D.1. Alternative outcomes estimated with male primary caregivers only

Table 8: Treatment effects on alternative outcomes with male primary caregivers only

	Dependent variable: domestic violence		
	(1)	(2)	(3) Full controls (Baseline model)
	No controls	Minimum controls	
Treatment	0.012*** (0.000)	0.011*** (0.000)	0.011*** (0.000)
Constant	0.002*** (0.000)	-0.001 (0.001)	-0.011* (0.004)
Time dummies		✓	✓
Programme dummies		✓	✓
Age group dummies		✓	✓
Support dummies			✓
Time since admission and no. of children			✓
Observations	8,773	8,732	8,732
$Adj.R^2$	0.0081	0.015	0.015
Clusters	4	4	4
Family fixed effects	Yes	Yes	Yes
Standard erros clustered at regional level	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family fixed-effects; **Dependent variable:** domestic violence (yes = 1/no = 0); Robust standard errors in parentheses are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

D.2. Alternative outcomes estimated with fixed effects

Table 9: Treatment effects on alternative outcomes with fixed effects

	Alternative outcomes: (fixed effects)			
	(1)	(2)	(3)	(4)
	Household expenditure	Household living conditions	Emotional well-being	Alcohol/ drug abuse
Treatment	-0.054*	-0.060	-0.067**	0.005***
	(0.019)	(0.053)	(0.018)	(0.000)
Time s. Prog. Adm.	-0.007***	0.021	0.003	0.004*
	(0.001)	(0.010)	(0.018)	(0.002)
Constant	13.651***	2.595***	2.953***	-0.031*
	(0.015)	(0.054)	(0.200)	(0.012)
Time dummies	✓	✓	✓	✓
Programme dummies	✓	✓	✓	✓
Age group dummies	✓	✓	✓	✓
No. of children	✓	✓	✓	✓
Observations	7,207	11,134	11,583	12,128
$Adj.R^2$	0.37	0.018	0.057	0.010
Clusters	4	4	4	4
Family level fixed effects	Yes	Yes	Yes	Yes
Standard erros clustered at regional level	Yes	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family fixed-effects; **Dependent variable:** column 1: log of household expenditure in IDR (measured at regency-/city-level), column 2: living conditions (measured at micro level, scale of 1 to 4, where 4 is good), column 3: emotional well-being (scale of 1 to 4, where 4 is good), column 4: alcohol/drug abuse affects family (yes = 1/no = 0) respectively, see appendix section A for definitions of variables; Robust standard errors in parentheses are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

D.3. Omission of Kabupaten Gunungkidul region from baseline model

Table 10: Omission of Kabupaten Gunungkidul region from baseline model

	Fixed effects model			
	(1)	(2)	(3)	(4)
	No controls with smaller sample	Minimum controls with smaller sample	Full controls with smaller sample	Full controls with full sample (Baseline Model)
Treatment	0.033***	0.024***	0.024***	0.022***
	(0.000)	(0.003)	(0.002)	(0.002)
Constant	0.002***	-0.098**	-0.282**	-0.217***
	(0.000)	(0.028)	(0.049)	(0.026)
Quarter dummies		✓	✓	✓
Programme dummies		✓	✓	✓
Age group dummies		✓	✓	✓
Support dummies			✓	✓
Time s. Adm. and No. of Children			✓	✓
Observations	10,305	10,270	10,270	12,128
R^2	0.016	0.077	0.091	0.069
$Adj.R^2$	0.0160	0.0750	0.0888	0.0673
Clusters	4	4	4	4
Family FE	Yes	Yes	Yes	Yes
SEs clustered at regional level	Yes	Yes	Yes	Yes

Notes: Difference-in-differences estimate with family fixed-effects; **Dependent variable:** domestic violence (yes = 1/no = 0); Columns one to three without Kabupaten Gunungkidul. Column four presents baseline model with full sample; Robust standard errors in parentheses are clustered at regional level; ***/**/* indicate significance at the 1%/5%/10% level.

D.4. Synthetic control approach: verifying robustness of previous results

I employ a synthetic control approach to create a control group that allows evaluating how the treated region could have developed if it would not have been affected by a volcano eruption. To conduct the analysis, the sample is collapsed on the regency/city level. The primary caregiver's age group, the level of primary caregiver education, the primary caregiver sex, living conditions and household expenditure are used as pre-treatment regressors to approximate a synthetic control group. Synthetic control estimations are run for all outcome variables, except for the household expenditure macro data (This is only available on annual level). The pre-treatment period is defined as the first 3 quarters of 2013. The treatment period is defined as the first quarter of 2014 (The last quarter of 2014 is spared due to its exposure to the first eruption of Mount Merapi). The finding is confirming the hypothesis, that there was indeed an adverse development caused by the eruption.

Figure 6: Synthetic control approach based estimation of outcomes
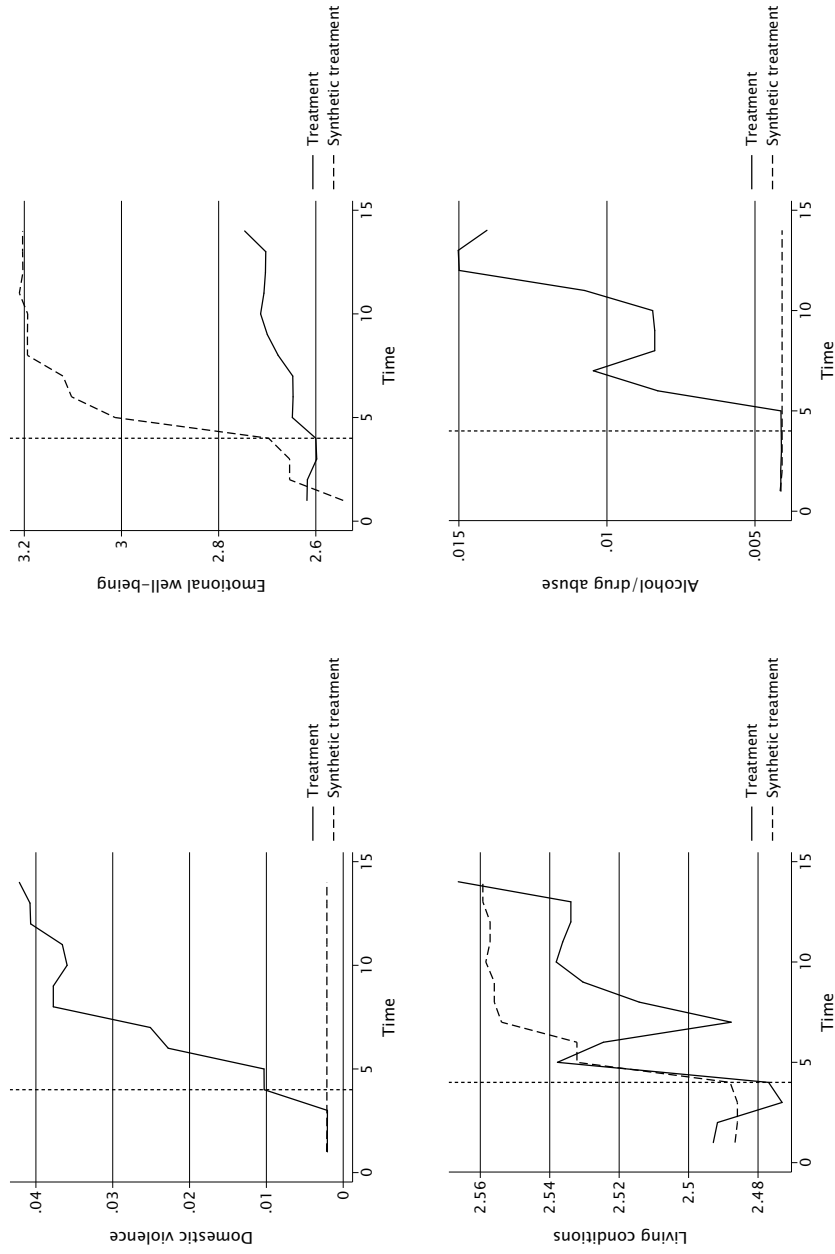
Notes: Synthetic control results. Synthetic treatment (control group) marked by dashed line; treatment group marked by black line; **Dependent variable:** upper left graph: domestic violence (yes = 1/no = 0), upper right graph: emotional well-being (scale of 1 to 4, where 4 is good), lower left graph: living conditions (measured at micro level, scale of 1 to 4, where 4 is good), lower right graph: alcohol/drug abuse affects family (yes = 1/no = 0); Time expressed in quarters. Quarter 1 equals first quarter of 2013.

E. Disaster map

Figure 7: Hazard map of Mount Kelud eruption in 2014
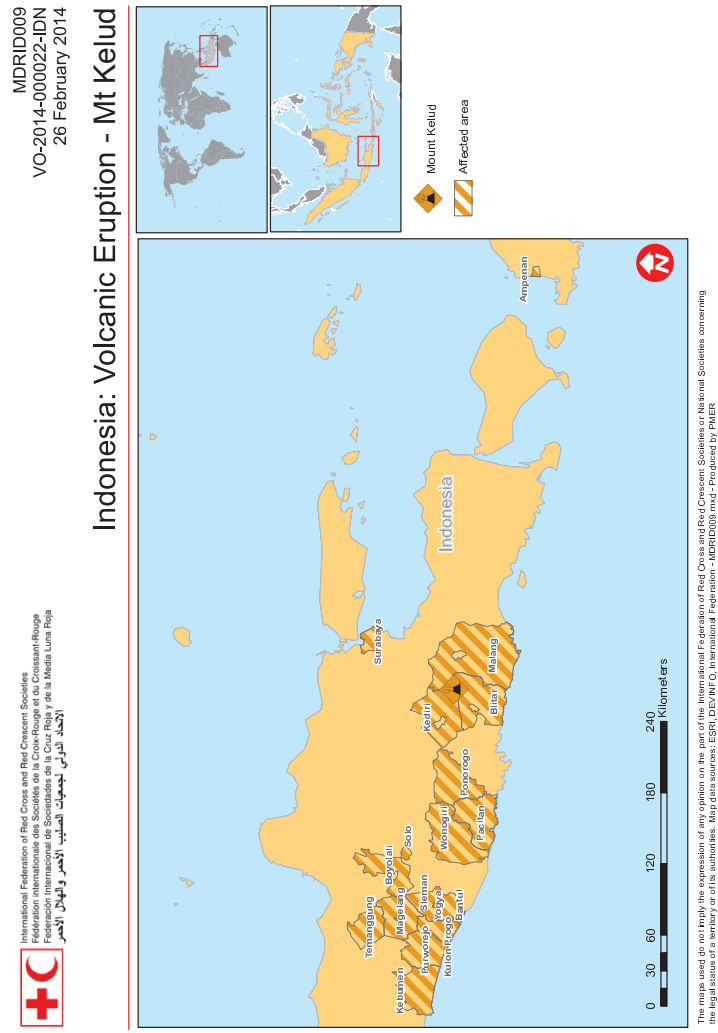
Notes: Map describes Mount Kelud eruption in 2014. Source is International Federation of Red Cross and Red Crescent Societies (2014).

References

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 2010. "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program." *Journal of the American Statistical Association* 105 (490): 493–505.

Abadie, Alberto, and Javier Gardeazabal. 2003. "The economic costs of conflict: A case study of the Basque country." *American Economic Review* 93 (1): 113–132.

Adams, Paul R., and Gerald R. Adams. 1984. "Mount Saint Helens's ashfall. Evidence for a disaster stress reaction." *The American Psychologist* 39 (3): 252–260.

Aizer, Anna. 2010. "The Gender Wage Gap and Domestic Violence." *American Economic Review* 100 (4): 1847–59.

———. 2011. "Poverty, Violence and Health: The Impact of Domestic Violence During Pregnancy on Newborn Health." *The Journal of Human Resources* 46 (3): 518–538.

Alesina, Alberto, Benedetta Brioschi, and Eliana La Ferrara. 2016. "Violence Against Women: A Cross-cultural Analysis for Africa." *NBER Working Paper Series* 21901.

Anastario, Michael, Nadine Shebab, and Lynn Lawry. 2009. "Increased gender-based violence among women internally displaced in Mississippi 2 years post–Hurricane Katrina." *Disaster Medicine and Public Health Preparedness* 3 (1): 18–26.

Anderberg, Dan, Helmut Rainer, Jonathan Wadsworth, and Tanya Wilson. 2015. "Unemployment and Domestic Violence: Theory and Evidence." *The Economic Journal* 126 (597): 1947–1979.

Arouri, Mohamed, Cuong Nguyen, and Adel Ben Youssef. 2015. "Natural Disasters, Household Welfare, and Resilience: Evidence from Rural Vietnam." *World Development* 70:59–77.

Baez, Javier, Alejandro *de la* Fuente, and Indhira Santos. 2010. "Do natural disasters affect human capital? An assessment based on existing empirical evidence." *IZA Discussion Paper Series* 5164.

Bardi, Massimo, and Silvana M. Borgognini-Tarli. 2001. "A survey on parent-child conflict resolution: Intrafamily violence in Italy." *Child Abuse and Neglect* 25 (6): 839–853.

Bech, Per, Lis Raabaek Olsen, Mette Kloller, and Niels Kristian Rasmussen. 2003. "Measuring well-being rather than the absence of distress symtoms: a comparison of the SF-36 Mental Health subscale and the WHO-Five Well-Being Scale." *International Journal of Methods in Psychiatric Research* 12 (2): 85–91.

Berkowitz, Leonard. 1993. *McGraw-Hill series in social psychology. Aggression: Its causes, consequences, and control.* New York, NY: Mcgraw-Hill Book Company.

Blackburn, Susan. 2004. "Violence." Chap. 8 in *Women and the State in Modern Indonesia,* 194–219. Cambridge: Cambridge University Press.

Bobonis, Gustavo J., Melissa González-Brenes, and Roberto Castro. 2013. "Public transfers and domestic violence: The roles of private information and spousal control." *American Economic Journal: Economic Policy* 5 (1): 179–205.

Bueno, Cruz Caridad, and Errol A. Henderson. 2017. "Bargaining or Backlash? Evidence on Intimate Partner Violence from the Dominican Republic." *Feminist Economics* 23 (4): 90–116.

Buttell, Frederick P., and Michelle Mohr Carney. 2009. "Examining the Impact of Hurricane Katrina on Police Responses to Domestic Violence." *Traumatology* 15 (2): 6–9.

Card, David, and Gordon B. Dahl. 2011. "Family violence and football: The effect of unexpected emotional cues on violent behavior." *Quarterly Journal of Economics* 126 (1): 103–143.

Caruso, Gérman Daniel. 2017. "The legacy of natural disasters: The intergenerational impact of 100 years of natural disasters in Latin America." *Journal of Development Economics* 127:209–233.

Cavallo, Eduardo A., Sebastian Galiani, Ilan Noy, and Juan Pantano. 2013. "Catastrophic Natural Disasters and Economic Growth." *Review of Economics and Statistics* 95 (5): 1549–1561.

Cavallo, Eduardo A., and Ilan Noy. 2010. "The Economics of Natural Disasters: A Survey." *IDB Working Paper Series,* no. 124.

Chin, Yoo Mi. 2011. "Male backlash, bargaining, or exposure reduction?: Women's working status and physical spousal violence in India." *Journal of Population Economics* 25 (1): 175–200.

Cools, Sara, and Andreas Kotsadam. 2017. "Resources and Intimate Partner Violence in Sub-Saharan Africa." *World Development* 95:211–230.

Curtis, Thom, Brent C. Miller, and E. Helen Berry. 2000. "Changes in reports and incidence of child abuse following natural disasters." *Child Abuse and Neglect* 24 (9): 1151–1162.

Denlay, Patricia L., and Elizabeth Shrader. 2000. *Gender and post-disaster reconstruction: The case of Hurricane Mitch in Honduras and Nicaragua.* Washington, DC: LCSPG / LAC Gender Team - The World Bank.

Deryugina, Tatyana, Laura Kawano, and Steven D Levitt. 2018. "The Economic Impact of Hurricane Katrina on Its Victims: Evidence from Individual Tax Returns." *American Economic Journal: Applied Economics* 10 (2): 202–233.

Dutton, Donald G., and Randall P. Kropp. 2000. "A Review of Domestic Violence Risk Instruments." *Trauma, Violence & Abuse* 1 (2): 171–181.

Fernandez, Cristina A., Benjamin Vicente, Brandon D. L. Marshall, Karestan C. Koenen, Kristopher L. Arheart, Robert Kohn, Sandra Saldivia, and Stephen L. Buka. 2017. "Longitudinal course of disaster-related PTSD among a prospective sample of adult Chilean natural disaster survivors." *International Journal of Epidemiology* 46 (2): 440–452.

Ferreira, Francisco H G, and Norbert Schady. 2009. "Aggregate economic shocks, child schooling, and child health." *World Bank Research Observer* 24 (2): 147–181.

Fisher, Sarah. 2010. "Violence Against Women and Natural Disasters: Findings From Post-Tsunami Sri Lanka." *Violence Against Women* 16 (8): 902–918.

García-Moreno, Claudia, Christina Pallitto, Karen Devries, Heidi Stöckl, Charlotte Watts, and Naeemah Abrahams. 2013. *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence.* Geneva, Switzerland: World Health Organization (WHO).

Gignoux, Jérémie, and Marta Menéndez. 2016. "Benefit in the wake of disaster: Long-run effects of earthquakes on welfare in rural Indonesia." *Journal of Development Economics* 118:26–44.

Gitter, Seth R., and Bradford L. Barham. 2007. "Credit, Natural Disasters, Coffee, and Educational Attainment in Rural Honduras." *World Development* 35 (3): 498–511.

Goenjian, Armen K., Alan M. Steinberg, Louis M. Najarian, Lynn A. Fairbanks, Madeline Tashjian, and Robert S. Pynoos. 2000. "Prospective Study of Posttraumatic

Stress, Anxiety, and Depressive Reactions After Earthquake and Political Violence." *The American Journal of Psychiatry* 157 (6): 911–916.

Hayati, Elli Nur. 2013. "Domestic violence against women in rural Indonesia: Searching for multilevel prevention." Medical Dissertations, Umea University.

Hayati, Elli Nur, Malin Eriksson, Mohammad Hakimi, Ulf Högberg, and Maria Emmelin. 2013. "Elastic bands strategy: women's lived experience of coping with domestic violence in rural Indonesia." *Global Health Action* 6 (1): 18894.

Hayati, Elli Nur, Ulf Högberg, Mohammad Hakimi, Mary C. Ellsberg, and Maria Emmelin. 2011. "Behind the silence of harmony: risk factors for physical and sexual violence among women in rural Indonesia." *BMC Women's Health* 11 (1): 52.

Hidrobo, Melissa, Amber Peterman, and Lori Heise. 2016. "The effect of cash, vouchers, and food transfers on intimate partner violence: Evidence from a randomized experiment in Northern Ecuador." *American Economic Journal: Applied Economics* 8 (3): 284–303.

Hoddinott, John, and Bill Kinsey. 2001. "Child growth in the time of drought." *Oxford Bulletin of Economics and Statistics* 63 (4): 409–436.

International Federation of Red Cross and Red Crescent Societies. 2014. *Emergency Plan of Action (EPoA) Indonesia: Volcanic Eruption – Mt Kelud.* Online Report. Accessed September 4, 2018. `https://reliefweb.int/sites/reliefweb.int/files/resources/MDRID009dref.pdf`.

Janvry, Alain *de*, Frederico Finan, Elisabeth Sadoulet, and Renos Vakis. 2006. "Can conditional cash transfer programs serve as safety nets in keeping children at school and from working when exposed to shocks?" *Journal of Development Economics* 79:349–373.

Jati, Raditya. 2015. *National progress report on the implementation of the Hyogo Framework for Action (2013-2015).* Progress Report 2013-2014. The Indonesian National Agency for Disaster Management (BNPB). Accessed September 4, 2018. `https://www.preventionweb.net/files/41507%7B%5C_%7DIDN%7B%5C_%7DNationalHFAprogress%7B%5C_%7D2013-15.pdf`.

Jensen, Robert. 2000. "Agricultural volatility and investments in children." *American Economic Review* 90 (2): 399–404.

Jewkes, Rachel. 2002. "Intimate partner violence: causes and prevention." *The Lancet* 359 (9315): 1423–1429.

Loayza, Norman V., Eduardo Olaberría, Jamele Rigolini, and Luc Christiaensen. 2012. "Natural Disasters and Growth: Going Beyond the Averages." *World Development* 40 (7): 1317–1336.

Maccini, Sharon, and Dean Yang. 2009. "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review* 99 (3): 1006–1026.

McFarlane, Alexander C. 1998. "Epidemiological evidence about the relationship between ptsd and alcohol abuse: The nature of the association." *Addictive Behaviors* 23 (6): 813–825.

Miguel, Edward. 2005. "Poverty and witch killing." *Review of Economic Studies* 72 (4): 1153–1172.

Neria, Yuval, Arijit Nandi, and Sandro Galea. 2008. "Post-traumatic stress disorder following disasters: a systematic review." *Psychological Medicine* 38 (4): 467–480.

Nilan, Pam, Argyo Demartoto, Alex Broom, and John Germov. 2014. "Indonesian Men's Perceptions of Violence Against Women." *Violence Against Women* 20 (7): 869–888.

Noy, Ilan. 2009. "The macroeconomic consequences of disasters." *Journal of Development Economics* 88 (2): 221–231.

OECD. 2015. *OECD Economic Surveys: Indonesia 2015.* Paris: OECD Publishing.

Overstreet, Stacy, Alison Salloum, Berre Burch, and Jill West. 2011. "Challenges Associated with Childhood Exposure to Severe Natural Disasters: Research Review and Clinical Implications." *Journal of Child & Adolescent Trauma* 4 (1): 52–68.

Parkinson, Debra. 2017. "Investigating the Increase in Domestic Violence Post Disaster: An Australian Case Study." *Journal of Interpersonal Violence.*

Parkinson, Debra, and Claire Zara. 2013. "The hidden disaster: Domestic violence in the aftermath of natural disaster." *Australian Journal of Emergency Management* 28 (2): 28–35.

Paxson, Christina, Elizabeth Fussell, Jean Rhodes, and Mary Waters. 2012. "Five years later: Recovery from Post Traumatic Stress and Psychological Distress Among Low-Income Mothers Affected by Hurricane Katrina." *Social Science & Medicine* 74 (2): 150–7.

Picardo, Carla W., Shirley Burton, and John Naponick. 2010. "Physically and Sexually Violent Experiences of Reproductive-Aged Women Displaced by Hurricane Katrina." *The Journal of the Louisiana State Medical Society* 162 (5): 282–290.

Pierotti, Rachael S. 2013. "Increasing Rejection of Intimate Partner Violence: Evidence of Global Cultural Diffusion." *American Sociological Review* 78 (2): 240–265.

Reading, Richard. 2008. "The impact of exposure to domestic violence on children and young people: A review of the literature." *Child Abuse & Neglect* 32:797–810.

Rezaeian, Mohsen. 2013. "The association between natural disasters and violence: A systematic review of the literature and a call for more epidemiological studies." *Journal of Research in Medical Sciences* 18 (12): 1103–1107.

Rhodes, Jean, Christian Chan, Christina Paxson, Cecilia Elena Rouse, Mary Waters, and Elizabeth Fussell. 2010. "The Impact of Hurricane Katrina on the Mental and Physical Health of Low-Income Parents in New Orleans." *American Journal of Orthopsychiatry* 80 (2): 237–247.

Rosborough, Stephanie, Jennifer L. Chan, and Parveen Parmar. 2009. "Responding to Gender-based Violence in Disasters: Grappling With Research Methods to Clear the Way for Planning." *Disaster Medicine and Public Health Preparedness* 3 (1): 8–10.

Rubonis, Anthony V., and Leonard Bickman. 1991. "Psychological Impairment in the Wake of Disaster: The Disaster-Psychopathology Relationship." *Psychological Bulletin* 109 (3): 384–399.

Runyan, Desmond, Corrine Wattam, Robin Ikeda, Hassan Fatma, and Laurie Ramiro. 2002. "Child abuse and neglect by parents and other caregivers." Chap. 3 in *World report on violence and health,* edited by Etienne G. Krug, Linda L. Dahlberg, Mercy James A., Anthony B. Zwi, and Lozano Rafael, 57–86. Geneva: World Health Organization.

Schumacher, Julie A., Scott F. Coffey, Fran H. Norris, Melissa Tracy, Kahni Clements, and Sandro Galea. 2010. "Intimate Partner Violence and Hurricane Katrina: Predictors and Associated Mental Health Outcomes." *Violence and Victims* 25 (5): 588–603.

Sekhri, Sheetal, and Adam Storeygard. 2014. "Dowry deaths: Response to weather variability in India." *Journal of Development Economics* 111:212–223.

Sety, M., K. James, and J. Breckenridge. 2014. "Understanding the Risk of Domestic Violence During and Post Natural Disasters: Literature Review." Chap. 5 in *Is-*

sues of Gender and Sexual Orientation in Humanitarian Emergencies, edited by Larry W. Roeder, 99–111. Cham: Springer International Publishing Switzerland.

Shah, Manisha, and Bryce Millett Steinberg. 2017. "Drought of Opportunities: Contemporaneous and Long Term Impacts of Rainfall Shocks on Human Capital." *Journal of Political Economy* 125 (2): 527–561.

Sonne, Susan C., Sudie E. Back, Claudia Diaz Zuniga, Carrie L. Randall, and Kathleen T. Brady. 2009. "Gender Differences in Individuals with Comorbid Alcohol Dependence and Post-traumatic Stress Disorder." *American Journal on Addictions* 12 (5): 412–423.

Statistics Indonesia (Badan Pusat Statistik - BPS) National Population and Family Planning Board (BKKBN) Kementerian Kesehatan (Kemenkes—MOH) and ICF International. 2012. *Indonesia Demographic and Health Survey 2012.* Jakarta, Indonesia: BPS, BKKBN, Kemenkes, ICF International.

Strobl, Eric. 2012. "The economic growth impact of natural disasters in developing countries: Evidence from hurricane strikes in the Central American and Caribbean regions." *Journal of Development Economics* 97 (1): 130–141.

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA). 2014. *Indonesia: Mt. Kelud Eruption.* Online report. Accessed September 4, 2018. `https : / / reliefweb . int / map / indonesia / indonesia - mt - kelud - eruption-14-february-2014`.

UN Women (United Nations Entity for Gender Equality and the Empowerment of Women). 2011. *Violence against Women Prevalence Data: Surveys by Country.* Online report. Accessed September 4, 2018. `http : / / www . endvawnow . org / uploads/browser/files/vaw%7B%5C_%7Dprevalence%7B%5C_%7Dmatrix%7B% 5C_%7D15april%7B%5C_%7D2011.pdf`.

Usano, Robert J., Carol S. Fullerton, Lars Weisaeth, and Beverley Raphael. 2017. *Textbook of disaster psychiatry.* Cambridge: Cambridge University Press.

Van Aalst, Maarten K. 2006. "The impacts of climate change on the risk of natural disasters." *Disasters* 30 (1): 5–18.

Wahlstrom, Margareta, and Debarati Guha-Sapir. 2015. *The human cost of weather-related disasters 1995-2015.* Geneva, Switzerland: UNISDR.

Warsini, Sri, Petra Buettner, Jane Mills, Caryn West, and Kim Usher. 2014. "The Psychosocial Impact of the Environmental Damage Caused by the MT Merapi Eruption on Survivors in Indonesia." *EcoHealth* 11 (4): 491–501.

Watson, Robert T., and Daniel L. Albritton, eds. 2001. *Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

World Health Organization (WHO). 2002. *Gender and Health in Disasters.* Information Sheet. Accessed September 4, 2018. `http://www.who.int/gender/gwhgendernd2.pdf`.

————. 2008. *Country policies and strategies for combating GBV.* Factsheet. Accessed September 4, 2018. `www.searo.who.int/entity/gender/data/indonesia.pdf?ua=1`.

Wunderman, Richard, ed. 2014a. "Global Volcanism Program, 2014. Report on Kelut (Indonesia)." In *Bulletin of the Global Volcanism Network,* 39:02. Washington, DC: Smithsonian Institution.

————, ed. 2014b. "Global Volcanism Program, 2014. Report on Merapi (Indonesia)." In *Bulletin of the Global Volcanism Network,* 39:10. Washington, DC: Smithsonian Institution.

ifo Working Papers

No. 251   Barrios, S., M. Dolls, A. Maftei, A. Peichl, S. Riscado, J. Varga and C. Wittneben, Dynamic scoring of tax reforms in the European Union, January 2018.

No. 250   Felbermayr, G., J. Gröschl and I. Heiland, Undoing Europe in a New Quantitative Trade Model, January 2018.

No. 249   Fritzsche, C., Analyzing the Efficiency of County Road Provision – Evidence from Eastern German Counties, January 2018.

No. 248   Fuest, C. and S. Sultan, How will Brexit affect Tax Competition and Tax Harmonization? The Role of Discriminatory Taxation, January 2018.

No. 247   Dorn, F., C. Fuest and N. Potrafke, Globalization and Income Inequality Revisited, January 2018.

No. 246   Dorn, F. and C. Schinke, Top Income Shares in OECD Countries: The Role of Government Ideology and Globalization, January 2018.

No. 245   Burmann, M., M. Drometer and R. Méango, The Political Economy of European Asylum Policies, December 2017.

No. 244   Edo, A., Y. Giesing, J. Öztunc and P. Poutvaara, Immigration and Electoral Support for the Far Left and the Far Right, December 2017.

No. 243   Enzi, B., The Effect of Pre-Service Cognitive and Pedagogical Teacher Skills on Student Achievement Gains: Evidence from German Entry Screening Exams, December 2017.

No. 242   Doerrenberg, P. and A. Peichl, Tax morale and the role of social norms and reciprocity. Evidence from a randomized survey experiment, November 2017.

No. 241   Fuest, C., A. Peichl and S. Siegloch, Do Higher Corporate Taxes Reduce Wages? Micro Evidence from Germany, September 2017.

No. 240   Ochsner, C., Dismantled once, diverged forever? A quasi-natural experiment of Red Army misdeeds in post-WWII Europe, August 2017.

ifo Working Papers

No. 251   Barrios, S., M. Dolls, A. Maftei, A. Peichl, S. Riscado, J. Varga and C. Wittneben, Dynamic scoring of tax reforms in the European Union, January 2018.

No. 250   Felbermayr, G., J. Gröschl and I. Heiland, Undoing Europe in a New Quantitative Trade Model, January 2018.

No. 249   Fritzsche, C., Analyzing the Efficiency of County Road Provision – Evidence from Eastern German Counties, January 2018.

No. 248   Fuest, C. and S. Sultan, How will Brexit affect Tax Competition and Tax Harmonization? The Role of Discriminatory Taxation, January 2018.

No. 247   Dorn, F., C. Fuest and N. Potrafke, Globalization and Income Inequality Revisited, January 2018.

No. 246   Dorn, F. and C. Schinke, Top Income Shares in OECD Countries: The Role of Government Ideology and Globalization, January 2018.

No. 245   Burmann, M., M. Drometer and R. Méango, The Political Economy of European Asylum Policies, December 2017.

No. 244   Edo, A., Y. Giesing, J. Öztunc and P. Poutvaara, Immigration and Electoral Support for the Far Left and the Far Right, December 2017.

No. 243   Enzi, B., The Effect of Pre-Service Cognitive and Pedagogical Teacher Skills on Student Achievement Gains: Evidence from German Entry Screening Exams, December 2017.

No. 242   Doerrenberg, P. and A. Peichl, Tax morale and the role of social norms and reciprocity. Evidence from a randomized survey experiment, November 2017.

No. 241   Fuest, C., A. Peichl and S. Siegloch, Do Higher Corporate Taxes Reduce Wages? Micro Evidence from Germany, September 2017.

No. 240   Ochsner, C., Dismantled once, diverged forever? A quasi-natural experiment of Red Army misdeeds in post-WWII Europe, August 2017.