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The challenges of impact evaluation: Attempting to measure the effectiveness of community-based disaster risk management

Maria M. Sarabia [a,*], Alfredo Kägi [a], Anthony C. Davison [d], Nicola Banwell [a], Carlos Montes [c], Christina Aebischer [b], Silvia Hostettler [a,**]

[a] EPFL, Cooperation and Development Center, Lausanne, Switzerland
[b] Swiss Red Cross, Bern, Switzerland
[c] Honduran Red Cross, Catacamas, Honduras
[d] EPFL, Chair of Statistics, Lausanne, Switzerland

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ABSTRACT

Although disaster risk management is becoming increasingly important in development cooperation, there is still a lack of robust evidence regarding its effectiveness. Few studies based on a counterfactual have been conducted in the fields of disaster management and disaster risk reduction. This article describes a methodological approach to enabling more rigorous evidence-based decision-making in community-based disaster risk mitigation, and notably for assessing the degree to which it increases preparedness for the adverse effects of hazards in vulnerable communities. The effects of actions designed to reduce disaster-induced loss, damage, injuries, fatalities and resource degradation were evaluated at a Swiss and Honduran Red Cross' intervention area in Honduras. Our results show that the intervention has had a significant positive effect in three important areas of resilience: knowledge and preparedness (e.g., existence of an early warning system); social cohesion (e.g., community institutions); and management of natural assets (e.g., firewood consumption). Our findings indicate that the intervention program has enhanced the capacities of treated communities to prepare for future hazards and to respond in case of an emergency at both household and community levels.

1. Introduction

Between 1998 and 2017, more than 1.3 million people worldwide lost their lives and 4.4 billion were left injured, homeless, displaced or in need of emergency assistance after climate-related or geophysical disasters [1]. The final tally for economic losses was more than $2.9 trillion [1]. In 2015, the Hyogo Framework for Action, which propelled disaster risk reduction (DRR) efforts between 2005 and 2015, was succeeded by the Sendai Framework for Disaster Risk Reduction [2]. This was the first major agreement on the development agenda endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction [2].

The Sendai Framework for Disaster Risk Reduction prioritises the strengthening of governance at the global and regional levels [3]. It upholds stakeholder commitment as the basis for disaster risk-informed sustainable development plans, and strongly advocates the inclusion of community-based perspectives in the planning and delivery of disaster risk reduction (DRR) programs [3]. Community-based approaches have long been used in disaster risk reduction and management, and continue to be of great importance for addressing them [4,5,6]. Yodmani [7] defined community-based disaster risk management (CBDRM) as a participative approach that aims to reduce vulnerability and strengthen people's capacity to cope with disasters by reinforcing resilience at the local level, minimizing human suffering, and accelerating recovery operations. Scholars and practitioners actively promote participatory methods as effective tools for empowering communities and building capacities for disaster risk reduction [8,9,10,11,12]. Within the framework of CBDRM, community members are principal actors and have a major role in designing measures and executing response activities [11, 13]. Following a shift of the resilience paradigm from 'bouncing back' to 'bouncing forward', which implies positive change that reflects transformational resilience, DRR frameworks are now focusing on capitalizing on existing and potential local resources to achieve long-term sustainability [14,15,6].

* Corresponding author.
** Corresponding author.
E-mail addresses: maria.sarabia@etu.unige.ch (M.M. Sarabia), silvia.hostettler@epfl.ch (S. Hostettler).

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Resilience is a multifaceted concept used across numerous fields, including ecology, economics, developmental and trauma psychology, engineering, sustainable development, climate change and disaster risk reduction [16,17,18,19,6]. Resilience within the DRR context often refers to a system's capacity to absorb external shocks and to recover from and adapt to them [20,18,15,6]. Resilience was initially the focus of international DRR initiatives in the Hyogo Framework for Action, which notably emphasized the importance of the community level [21,22]. Since then, resilience literature in DRR has grown [6] and is increasingly marked by efforts to translate resilience from a theoretical concept to an implementable and measurable operational framework [23,24,25,5,26,14].

The true value of making resilience measurable lies in creating indicators and establishing baselines by which progress can be monitored [24,26]. To this end, certain approaches to set a national baseline for resilience by drawing on publicly available data have been adopted in the United States [25]. However, these national frameworks may be inappropriate for inferring such baselines on a sub-national level [25] or impossible to establish when this data is incomplete or unavailable. Furthermore, scholars often remark that there is no 'one-size-fits-all' framework for defining or measuring resilience [24,5,26].

The Honduran Red Cross (HRC) and Swiss Red Cross (SRC) have been jointly implementing a CBDRM program in the department of Olancho, Honduras, with the overall aim of strengthening the resilience of this rural area's most vulnerable communities. For the International Federation of Red Cross and Red Crescent Societies (IFRC), community resilience is defined as communities' and community members' ability to anticipate, prepare for, reduce the impact of, cope with and recover from the effects of shocks and stresses in the face of disasters, crises and underlying vulnerabilities, without compromising their long-term prospects [27,28]. In this framework, resilience has six different dimensions: knowledge and health, economic opportunities, social cohesion, connectedness, well-maintained and accessible infrastructures and services and management of natural assets [27,28].

Knowledge is a key component of resilience, as defined by the IFRC, as it enables communities to understand and address risks, and to build upon past experiences [28]. This definition is supported in other literature on resilience [26]. Health and economic opportunities are said to be important indicators of baseline resilience [24]. As such, socio-economic status [26] and accessibility to health services [25] are included in certain frameworks. Capacities such as social capital, social cohesion and connectedness, and economic, infrastructure and environmental assets, are often cited as common attributes of resilience [24,25,26]. Social cohesion refers to community members' ability to work together to achieve effective DRR [26]. Communities that are cohesive and well-connected know how to self-organise and work together [28]. Establishing plans and procedures are important mechanisms in this process [24,26]. Connectedness involves establishing networks between communities and organizations that enable the sharing of information and access to resources [5]. Finally, a resilient community relies on infrastructure and services that are robust in the face of shocks [16,24,28], and has natural assets that are appropriately managed and protected by the community [25,28,14].

Evidence-based policy has increased significantly in DRR, with the Sendai Framework calling for a stronger evidence base to support implementation [3]. It has also had an important expansion in social policy, education and international development assistance [29], because of the increasing importance of explaining why and how beneficiaries react to interventions, and of ensuring efficient, accountable resource allocation [30]. The goal of an impact evaluation (IE) is to isolate the effect of the program from possible confounders [31,32,33]. To do so, one would ideally evaluate a program or "treatment" by comparing the outcome variables or indicators of interest to the group that received the treatment with what these outcomes *would have been* had this group not received the treatment [34]. This is called the counterfactual, as it cannot be observed. The treatment effect approach consists in estimating this counterfactual, although doing so has its challenges [35].

Counterfactual analysis has gained ground because it provides quantitative evidence on the effects that can be attributed to a program or intervention [36], and has become a standard approach to determining causal effects in most institutions and international organizations, for example the World Bank [37,38]. Counterfactual analysis differs from before vs. after or treated vs. control comparisons, which may provide poor estimates of the counterfactual and of the estimated treatment effects due to confounding factors [37]. The treatment effect approach uses different methods to estimate the counterfactual correctly. Here we employ propensity score matching and weighting to this end. However, depending on the data available and the characteristics of the program/policy, other methods such as regression discontinuity and difference in differences could be applied. Ideally, more than one methodology is used for robustness checks.

Most impact evaluations done by disaster risk reduction programs rely on correlational and/or descriptive approaches. Johnson et al.'s [39] review of evaluations of disaster education programs is an example of this. We only found three studies that used a treatment effect approach in this field [40,41,42], thus revealing an important gap in our knowledge. A recent study used social network analysis to calculate resilience before and after the occurrence of a disaster [43], but it was limited to the assessment of social cohesion and connectedness, and did not evaluate a resilience-building program. Furthermore, evaluating and measuring effects in the context of DRR is particularly challenging, as these evaluations are subject to a disaster occurring. This widens the knowledge gap. Nitschke et al. [44] and Yen et al. [45] thus have proposed retrospective impact evaluations, but the gap in terms of carrying out counterfactual-based impact evaluations without baseline data remains.

The aim of this study is to evaluate the impact of the Swiss Red Cross' current approach to strengthening community resilience by limiting the poverty trap caused by disasters and strengthening community bounce-forward capacities. The definition and components of resilience identified by the IFRC are applied to ensure consistency with the implementation of the CBDRM program, and will enable the lessons learnt to be fed back into future program design. Due to the large scope of resilience, we focus on three aspects: knowledge of natural hazards and preparedness, social cohesion, and management of natural assets. We examine mitigation measures and the degree to which they increase the preparedness of vulnerable communities to respond to the negative effects of hazards.

The present study is an opportunity both to apply a quasi-experimental design and establish a counterfactual and to combine this analysis with qualitative information from semi-structured field interviews. It yields an in-depth understanding of the program's impact and sheds light on possible routes to improving the effectiveness of disaster mitigation. It contributes to the literature by exploring the applicability of the impact evaluation methodology based on the average treatment effect approach, which potentially allows for the retrospective evaluation of a CBDRM program with no pre-existing baseline. Our work supports the implementation of DRR, and thus the Sendai Framework, through two key contributions: its focus on local-level DRR and its effectiveness, and its contribution to a quasi-experimental retrospective methodology that adds to the evidence base for effective DRR.

2. Program background

The HRC/SRC program began in 2005, after the SRC became involved with emergency and relief operations following extreme weather events in Olancho, Honduras, and currently covers 75 communities in three municipalities (Catacamas, San Esteban and Dulce Nombre de Culmí). The target communities were those exposed to hazards but which had not been previously involved in other programs.

Communities were prioritized according to their exposure to hazards and risk level. Table 1 presents demographic and hazard information for the municipalities of the treated communities. These areas have frequently experienced tropical storms and hurricanes from the Atlantic Ocean and most recently from the Pacific Ocean. The main hazards to which they are exposed are flooding, landslides and debris flows.

The three municipalities have a relatively high level of poverty according to the Unsatisfied Basic Needs definition, with over 60% of the population being categorized as poor, compared to the country average of 54%. The rural population exceeds 50% in all three municipalities, with Dulce Nombre de Culmí and San Esteban having higher levels than Catacamas. They rely heavily on agriculture, cattle raising, forestry and fishing, with Dulce Nombre most reliant on these activities. Although this information is important, the key variable of interest for this study is hazard exposure. In the three municipalities, over 370 households are exposed to hazards within the subsample of communities that are part of the program. In all cases, over 40% of households have a high level of exposure to hazards.

The HRC/SRC program focuses on capacity building for preparedness and mitigation. Its key activities are the following:

Elaboration of risk and hazard assessments. This includes geological, hydrological, geomorphological, and meteorological assessments, which are complemented with traditional risk knowledge and coping mechanisms. Based on these assessments, appropriate interventions are defined, prioritized and established through a participatory approach. These include structural interventions (which may be ecosystem-based "green" measures or "grey" infrastructure) and non-structural interventions, which are explained further below.

Elaboration and training on prevention and mitigation plans. In order to be prepared for disasters, communities and key stakeholders are trained and supported in contingency planning, mitigation measures, early warning systems (EWS), search and rescue, evacuation, logistics, emergency health services, and shelter and relief operations. Training is carried out at three different levels. Firstly, at the community level where Disaster Risk Reduction Committees (CODELs) are organized and trained, which link the communities to the National Disaster Management System of Honduras (SINAGER). Secondly, at the household level, where visits are carried out to each household with training on Family Emergency Plans. Thirdly, at the school level, where training is provided on risk management and a School Response and Prevention Plan is elaborated alongside teachers and parents.

Integration of DRR plans into the municipal development plans. Local authorities are associated to this program through capacity building, such as training and support in organizational processes. Risk studies are shared with local authorities in order to serve as decision-making instruments. In keeping with the program's institutional strengthening and up-scaling objectives, these studies are increasingly recognized by local authorities and integrated into municipal development and investment plans. Therefore, it is essential to know which approaches are effective in order to guide development program design and to inform policy.

Identification and construction of green and grey mitigation measures. Based on the risk and hazard assessments described above, the Red Cross works with communities to elaborate specific mitigation measures, such as bridges, drainage systems, reforestation campaigns and soil bioengineering measures. A key element is the active participation of the local population in these activities with a "learning by doing" and "training and action" approach. This increases awareness in the communities and reinforces the sustainability of the training.

The intervention is planned for around two periods of three years. During the first period the Red Cross intervenes directly in almost all activities, setting the basis for community resilience. In the second period the program continues, but with a reduced Red Cross participation leaving more autonomy to the communities and more ownership to the local institutions. The goal is for the committees and their activities to continue after the Red Cross program has ended, in order to guarantee sustainability of the outcomes. In some communities, however, a low presence of the program has lasted longer because the program developed dynamically over the years. The Red Cross added from phase to phase new innovative activities that were first piloted in communities with functional committees.

Table 1
Demographic information of municipalities of treated communities.

Municipality		San Esteban	Dulce Nombre de Culmí	Catacamas
Population (projected for 2016)		27,425	32,163	126,127
Rural Population (projected for 2016)		81%	89%	58%
Illiteracy rate (2013)		18%	23%	18%
Average years of schooling (2013)		5.5	5	5.9
Poverty Index (Unsatisfied Basic Needs - UBN)		66%	75%	65%
Main economic activities: Agriculture, cattle raising, forestry and fishing.		66%	84%	54%
Level of Hazard (Freq.)*	Low	51	48	44
	Medium	165	114	123
	High	160	208	215
Level of Hazard (%) *	Low	14%	13%	12%
	Medium	44%	31%	32%
	High	43%	56%	56%
Total Exposed Households*		376	370	382

*Corresponds to subsample of treated communities. Source: [46]
Source: Instituto Nacional de Estadística (Honduras).

3. Objectives of the impact evaluation and research questions

The main goal of this research project was to test a rigorous, counterfactual-based impact evaluation in the field of disaster risk reduction. This was done by focusing on a community-based disaster risk management program implemented by the Red Cross in Olancho, Honduras.

Main research question:

How can effective impact evaluation be conducted for a DRR program without robust baseline data?

Specific research questions:

a) *Is there a difference in the resilience level of communities that underwent intervention compared to those that did not?*
b) *To what extent are the communities studied prepared to respond appropriately to flooding/landslide events?*

4. Methodology

4.1. Overview

We use a mixed-methods approach, whereby both quantitative data obtained from household surveys and qualitative data from semi-structured interviews were employed to study the effects of the program. The quantitative analysis was based on the average treatment effect approach through propensity score matching and weighting. This was complemented by qualitative domain analysis whereby the responses of semi-structured interviews were transcribed, categorized and coded.

4.2. Definitions of the counterfactual/control groups and matching variables

A community was declared to be treated if it had been included in the Red Cross program, and otherwise declared to be a control community. An ideal study design would initially divide a set of untreated communities into pairs that are as similar as possible, randomly allocate treatment to one community in each pair, and then, after a suitable time, assess the effects of treatment by contrasting the communities in each pair. Any significant effects could then securely be attributed to the impact of the treatment. In the present case, it was impossible to implement such a matched-pair design, as the program was already implemented at the time of the evaluation. Furthermore, no consistent baseline data was available, making it more difficult to match on pre-treatment conditions. Therefore, certain characteristics of the communities that would be unaffected by the treatment were used to identify untreated communities that resembled the treated communities as closely as possible, except for their treatment status [37]. Each treated community was then compared with its counterpart(s) in the control communities.

In order to overcome the lack of randomisation, the present evaluation used the statistical techniques of propensity score matching and propensity score weighting. Both are based on the propensity score, which is the probability that a unit with given observable characteristics received the treatment.[1] Propensity scores were used to ensure comparability between the treated and control groups, thus yielding a reliable estimate of the treatment effect.

The study focused on the Average Treatment Effect on the Treated (ATET), which is the average of the treatment effects over the subpopulation that received the treatment [34,47]. This means that the conclusions apply only to the treated communities and cannot be extended to all communities, as would be the case if the Average Treatment Effect (ATE) had been estimated. Estimation of the ATE requires the sampling weights of the control communities, and this would involve unavailable information regarding the hazard exposure of all the communities in Olancho, Honduras.

4.3. Propensity score matching

Propensity score matching involves finding units in the comparison group with the same characteristics as those in the treated group and that can therefore serve as matches. When only a few characteristics are used, the matching can be directly based on them, but when many characteristics come into play, it is harder to find matches because the number of potential combinations of characteristics increases exponentially. Rosenbaum and Rubin [48] therefore propose matching based on propensity scores and comparing the outcomes for the treated units with their matched untreated counterparts.

In the present case, the program was implemented at the community level, so propensity score matching involved identifying similar communities, using data aggregated over the sampled households in each community, and taking into account the sample design using weights.[2] The use of data aggregated over the sampled households versus all communities introduces measurement error, but a more detailed analysis found its effects on the results to be negligible.[3]

4.4. Propensity score weighting

Propensity score weighting uses propensity scores to weight the observations to account for differences in the treated and control groups. This has the advantage of not discarding certain observations, as is common with matching [49], which was important for our study, as there were only 102 communities. Furthermore, weighting eliminates the need for matching. However, the estimates can have high variances when many of the propensity scores are close to 0 or 1 [50]. The basic idea is that in the treated group, the values of X for which $p(X_i)$ is large may be over-represented in the treated group, while those for which $p(X_i)$ is small may be overrepresented in the control group. These are corrected by using weights based on the propensity scores [50].[4]

4.5. Choice of matching variables

The use of propensity scores for either matching or weighting presupposes that the matching variables X_i satisfy the following assumptions[5]

1) **Conditional independence:** The potential outcomes are independent of the treatment, conditional on the covariates:

$$(Y_{i1}, Y_{i0}) \perp D_i | X_i. \quad (1)$$

or as explained by Heinrich et al. [51]; after controlling for X, the treatment assignment was "as good as random"; and.

2) **Overlap:** For each value of X_i, the probability of receiving treatment is between 0 and 1, i.e.,

$$0 < P(D_i = 1 | X_i) < 1. \quad (2)$$

This pertains to the need for enough overlap in the characteristics of the treated and untreated groups (common support) to find suitable matches.

The matching variables must affect both treatment participation and the outcome, and be unaffected by the treatment [52], so baseline (or pre-treatment) data are extremely useful. As this information was not consistently available for the present study, other variables based on these criteria had to be used, complemented by qualitative information obtained from the interviews. These other variables are presented in Table 2.

As the evaluation mainly focuses on the impact of the program, one of the main matching variables was the level of hazard to which households are exposed.[6] The importance of this variable is the degree to which it affects the potential outcomes in terms of preparedness and knowledge about DRR. In order to fulfil the conditional independence assumption, it was necessary to have level of hazard as a key matching variable. Therefore, 50 communities were selected for the control group following an in-situ analysis to confirm that the following selection criteria were respected:

1) The communities were exposed to natural hazards such as slope instability, or flooding;
2) The communities had not previously received intervention by the SRC or another agency

Other matching variables were selected following the same rationale. Education, wealth and health were selected, since these can affect the result of the training. Interviews with SRC staff and CODEL members suggested that engagement in the program activities and potential outcomes might also be affected by proximity to the city center and whether households owned a television, since interestingly the latter appeared to

[1] For the present evaluation, propensity scores were estimated by a probit regression with the treatment dummy Di as the dependent variable and the covariates in vector Xi as independent variables, i.e.,$P(D_i = 1|X_i) = \phi(\beta' X_i)$, where Φ is the standard normal cumulative distribution function (CDF) and β' is the transpose of the parameter vector.

[2] Kernel matching was employed using the Epanechnikov kernel. The robustness of the results was checked using other procedures, such as the Gaussian kernel and nearest-neighbour matching.

[3] See Tables A3 to A.6 in the annex for the different trials.

[4] For more detail on the weights, see annex.

[5] For the statistical demonstration of this and further explanation please refer to Ref. [50,34].

[6] Ideally, the level of risk - which depends on the level of hazard and vulnerability - would had been used, but the pre-treatment level of vulnerability was not available for all of the treated communities.

Table 2
Outcome and matching variables.

Outcome Variables (Y)	Matching Variables (X)
Knowledge of natural hazards and preparedness	Type of hazard (% of households exposed to landslides)
Knowledge of what a hazard is	Level of hazard (% of households exposed to a high level of hazard)
Signal in case of a hazard	**Education**
Knowledge of when to evacuate	% of respondents with at least one year of education
Subjective level of preparation at the HH Level	Average number of adults with primary education in the household
Subjective level of preparation at the Community Level	**Proximity**
Household level measure: List of telephone numbers	Average amount of time it takes to reach the community center (community shelter, center of emergency coordination)
Household level measure: Important documents stored in one place	**Wealth and income**
Household level measure: Emergency food	Average household expenditures per capita (as proxy for income)
Household level measure: Emergency bag	% of households exposed to some type of deprivation (flooring, assets, sanitation)
Household level measure: Safe meeting point	**Entertainment/Distractions**
Household level measure: Evacuation route	% of households who owned a TV at the baseline
Household level measure: Defined shelter	**Health**
Household level measure: Insurance policy	Average subjective level of health
Household level measure: Family emergency plan	
Knowledge of bioengineering measures	
Implementation of bioengineering measures	
Social Cohesion	
Availability of community preparation plan	
Community reaction in case of emergency.	
Emergency committees (CODELs) active in the community	
Community participation in drills	
Organization at the community level in response to hazards.	
Management of natural assets	
Use of firewood per person per day	
Adequate waste management	

reduce participation in program activities and hence might affect its potential outcomes.

Hazard assessments were carried out before the interventions, so the level of hazard was available for all the treated communities. This was not the case for the control communities, so considerable time and effort was spent both in determining the level of hazard to which households in the control communities were exposed and in ensuring consistency with the methodology used for the treatment group. This was done using the *Local Analysis of Natural Hazards and Risks Methodology* (MET-ALARN), which helped in determining the hazard levels in the treatment group.[7] Moreover, the geologist who had assessed the hazards in the treated communities performed the same role in the control communities.

[7] In 2005, the Swiss Agency for Cooperation and Development (SDC) and the Center for Territorial Studies of Nicaragua (INETER) developed the MET-ALARN methodology in order to standardize hazard map criteria and legends for slope instability.

4.6. Choice of outcome variables

Outcome variables are those used to study the effect of the program. The program was intended to improve resilience, so the impact evaluation would ideally assess the effect of the program on resilience. However, resilience is too broad in scope for the effects of the program to be captured on all of its dimensions; moreover these dimensions are interrelated, and some may be affected by factors exogenous to the program, such as health and economic opportunities. Hence, the evaluation concentrated on a set of indicators pertaining to knowledge of natural hazards and preparedness, social cohesion and management of natural assets. In order to capture the treatment effect, it was necessary to compare the control communities with the treated ones, so outcome variables pertaining to both groups of communities (described in Table 1) were selected. Further analyses were performed on other variables pertaining only to treated communities, though the treatment effect was not estimated.

4.7. Quantitative data collection

Data collection was performed within the framework of this evaluation and consisted of both quantitative data (questionnaires) and qualitative data (key informant interviews). In early 2018, during the first phase of this research project, 87 questionnaires (23 from control communities and 64 from treated communities) were piloted, and eight expert interviews were conducted. The survey was then refined, and the final version consisted of 120 questions on demographic information, household characteristics, living conditions, natural hazards, preparedness, training, mitigation measures, social cohesion, income, connectivity and health. The second phase of fieldwork was carried out between January 14, 2019 and February 9, 2019. Three field coordinators and nine enumerators collected data from 102 communities in seven municipalities in Olancho, yielding a final sample of 810 households.

Matched sampling [53] was used to ensure balance in the hazard variable in the treated and control groups. Thus, the proportions of level of hazard of the treated and control communities were similar. The steps taken to select the sample were:

Step 1: Selection of 50 communities from the 74 treated communities.

This phase involved selecting communities with more exposed households, versus communities with fewer exposed households, which was too costly in terms of time and resources. Security concerns and HRC/SRC regulations were also taken into consideration.

Step 2: Selection of households in the treated communities.

Stratified random sampling with strata representing the different levels of hazard (high-medium-low) [54] was used to select 400 out of 805 exposed households in treated communities, giving a sampling rate of almost 50%. The final sample consisted of 380 households in the treated communities, due to the lack of availability of some households. The hazard exposure of this sample is described in Table 3.

Step 3: Selection of 50 control communities.

A geologist and a GIS specialist undertook field visits to identify and select 50 control communities that were both exposed to hazards and

Table 3
Level of hazard of sample of treated group.

Hazard Level		San Esteban	Dulce Nombre de Culmí	Catacamas	Total
Low	Frequency	18	20	18	56
Medium		66	35	39	140
High		52	58	74	184
Total		**136**	**113**	**131**	**380**
Low	Percentage	18%	13%	14%	15%
Medium		31%	49%	30%	37%
High		51%	38%	56%	48%

Table 4
Demographic information of municipalities in control group.

Municipality	Campamento	Esquipulas del Norte	Gualaco	San Francisco de La Paz	Catacamas
Population (projected for 2016)	21,815	11,749	23,320	20,388	126,127
Rural Population (projected for 2016)	71%	100%	80%	69%	58%
Illiteracy rate (2013)	17%	31%	22%	21%	18%
Average years of schooling (2013)	5.8	4.5	5.4	5.9	5.9
Poverty Index (UBN)	67%	76%	81%	71%	65%
Main economic activities: Agriculture, cattle raising, forestry and fishing.	63%	86%	76%	75%	54%

Table 5
Level of hazard of sample of control group.

Hazard Level		Campamento	Catacamas	Esquipulas del Norte	Gualaco	San Francisco de La Paz	Total
Low	Frequency	18	24	8	3	2	55
Medium		30	91	39	8	3	171
High		47	91	43	16	7	204
Total		95	206	90	27	12	430
Low	Percentage	19%	12%	9%	11%	17%	13%
Medium		32%	44%	43%	30%	25%	40%
High		49%	44%	48%	59%	58%	47%

comparable with the 50 treated communities. Once these control communities had been identified, the specialists used the methodology previously applied to the treated communities by the HRC/SRC to obtain the hazard level of the households in the control communities. Table 4 contains demographic information of the municipalities corresponding to the control communities, which are comparable to those in Table 1. However, the most important variable for comparability is hazard exposure, which was the main criteria for the selection of control communities. Catacamas has both treated and control communities. The control communities in this municipality were selected carefully to ensure that they were distant enough from the treated communities to avoid contamination.

Step 4: Selection of households in the 50 control communities.

These households were selected by stratified random sampling using the proportions of level of hazard and type of hazard from the treated communities in order to ensure matches. The final sample of households in the control communities was 430. The level of hazard of these households is described in Table 5. As its last column shows, the exposure levels are comparable to those in the treated group.

4.8. *Qualitative data collection and analysis*

Qualitative data was used to help to define matching variables, and to provide greater depth and context for the results of the impact evaluation. Seventeen semi-structured interviews were conducted with community members (women and men), members of the emergency committees (CODELS), and Red Cross staff. These provided additional information that could not be captured in the surveys. The transcripts of the semi-structured interviews were coded according to a node-list created in a dialectic process between the information acquired from the interviewees and the main components of the household survey. The main nodes explored were 'risk reduction', 'community involvement', 'gender and generational participation', 'capacity building' and 'migration'.

5. Findings

5.1. *Overview*

The ATET was estimated using propensity scores. Weighting and matching approaches both gave similar results. The findings are structured below as follows: the dimension of knowledge and preparedness was established by studying the subjective level of preparedness, followed by specific measures of preparedness at the household and community levels. Social cohesion and involvement of households in the treated communities were then analysed. Finally, the effect on the management of natural assets was investigated based on the use of firewood, waste management and bioengineering measures.

5.2. *Knowledge on preparedness and protection at the household level*

Households in the treated communities reported feeling more prepared both at the household and community levels than their non-treated counterparts. The subjective level of preparedness was assessed using a question regarding how prepared respondents felt in the case of an event (landslide or flooding) on a scale from 1 (not prepared at all) to 10 (completely prepared). Table 6 illustrates how more respondents from the control communities had the lowest levels of preparedness, with 50% of respondents saying they were in one of the bottom three levels compared to 30% in the treated group. A positive and statistically significant effect was found for the ATET for level of preparedness, corresponding to an increase of slightly over one point on the scale. Similar results were found when households were asked about the level of preparedness of their communities.[8]

Specific measures of knowledge regarding preparedness were analysed as these were part of the program training sessions. Table 7 shows a positive and significant difference between the treated and control communities in their ability to correctly identify the hazards to which their community was exposed, in terms of knowledge about existing EWS and regarding evacuation.

Within the treated communities, 66% of the individuals responded that they knew what hazards were, versus 43% in the control communities. For those who answered positively, a follow-up question asked

Table 6
Subjective level of preparedness of treated and control groups.

Level	Control		Treated	
	Freq.	%	Freq.	%
Low	216	50	113	30
Medium	168	39	214	56
High	46	11	53	14
Total	**430**	**100**	**380**	**100**

[8] See Table A3 in the annex.

Table 7
Knowledge and preparedness measures in treated and control households.

	Hazard Knowledge				EWS Presence				Evacuation knowledge			
	Control		Treated		Control		Treated		Control		Treated	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
No	272	63	151	40	427	100	299	79	199	47	76	20
Yes	158	37	229	60	2	0	79	21	221	53	300	80
Total	430	100	380	100	429	100	378	100	420	98	376	100

what a hazard was, in order to determine whether the respondent truly knew. After correcting for this, 60% of households treated communities and 37% of control communities the percentage of households appeared to clearly know what a hazard was. When respondents were asked about the type of hazard to which they were exposed, 65% identified the hazard correctly in the treated communities, compared to 59% in the control communities.[9] Though small, this difference is statistically significant.

This difference increased when individuals were asked whether they had EWS in place. None of the households in the control communities reported having EWS, versus 21% in the treated communities. This captures whether the households had knowledge of EWS presence and not the actual presence of these systems in the community. For the subsample of respondents who had a family member belonging to the CODEL, 32% responded that there were EWS in place. For the smaller subsample of respondents that reported having participated in the elaboration of the Community Prevention and Preparation Plan, 40% responded having EWS presence. This was also reflected in the qualitative interviews for several of the CODEL members. When asked about Red Cross' main contribution in the community, a member of the CODEL in the San José del Guano community explained:

"For us, the impact of the Red Cross has been very important because they have come to provide us with training to build shelters and create early warning systems in case of disasters, for us to know how to communicate in case of an emergency … We now know where to go and what to do."

Finally, 80% of the households from the treated communities reported knowing when to evacuate, compared to 53% of those in the control communities. Additionally, respondents were asked whether there could be a reason they or a member of their family would not evacuate if were a hazard warning and recommendation to evacuate issued. 93% of the respondents from the treated communities reported that there was no reason and that they would all evacuate, compared to 82% in the control communities. This suggests that households in treated communities may take hazards more seriously and show a high acceptance of the early warning and evacuation systems, as they are defined in a participatory way and regularly tested.

Concerning the program's impact, the ATET was 23 percentage points for knowledge of hazards and 24 percentage points for the presence of EWS and evacuation knowledge. Among the treated communities, treatment increased the percentage of households with hazard knowledge, EWS presence and evacuation knowledge by over 20 percentage points.

For specific household preparedness measures, a positive and significant treatment effect was identified; see Table 8. The most significant treatment effects were having a defined shelter (an ATET of 47 percentage points), having a safe meeting point and important documents stored in one place (with an ATET of 31 percentage points), and having an evacuation route (an ATET of 24 percentage points). Emergency food, a bag containing emergency supplies, and an emergency family plan

Table 8
ATET, standard error and 95% confidence intervals for household preparedness measures.

Measure	ATET (percentage points)	Std. Err.	[95% Conf. Interval]	
List of telephone numbers	2	6	−10	15
Important documents stored in one place	31	9	14	48
Emergency food	9	3	4	14
Emergency bag	4	1	2	7
Safe meeting point	31	4	22	39
Evacuation route	24	5	14	34
Shelter	47	4	39	55
Family emergency plan	6	2	2	9

measures were also statistically significant, but the magnitude of the ATET was quite small. The ATET for having a list of emergency telephone numbers was not statistically significant, as 34% of the households in the control group said they already had one (see Table 9).

These results suggest which topics the training sessions should emphasise and that thus could feed back into the HRC/SRC program. During the fieldwork, it was observed that not all household members participated in the training; the answers of heads of households and non-heads of households differed, as heads of households or their spouses were more likely to be involved in the training sessions. Within the treated communities, 73% of the heads of households reported knowing what a hazard was, compared to 57% among non-heads of households. These results captured only whether or not the respondent knew about these measures, and do not imply that they had been adopted by the household. For example, measures may have been implemented of which the respondent was unaware. However, the results remain valid because of the importance of assessing whether the household members knew about these measures and could react accordingly if need be.

A key finding for preparedness measures at the community level was a positive and significant ATET for the percentage of households reporting that the emergency committees (CODELs) were active (79 percentage points). A key component of CBDRM programs is to support the organization, training, equipping and recognition of the CODELs and working closely with them. These results reflect the fact that individuals within the community knew of the existence of these emergency committees and considered that they played a key role in preparing against disasters. When asked with whom they would coordinate response measures in the event of an emergency, only 2% from the control communities considered the emergency committees, whereas 43% of respondents in the treated communities answered that they would either coordinate with the local, municipal or national emergency committees (CODEL, CODEM or COPECO).

5.3. Social cohesion and preparedness at the community level

As part of the social cohesion dimension, the CODELs were analysed

[9] As the present study focuses only on flooding and landslides, these figures show only the percentage of households that correctly identified their exposure to flooding and/or landslides.

Table 9
CODEL participation and drills within the treated communities.

	CODEL Family Member		Community participation in drill		HH participation in drill	
	Freq.	%	Freq.	%	Freq.	%
No	134	45	194	59.7	249	68.6
Yes	164	55	131	40.3	114	31.4
Total	298	100	325	100	363	100

with regard to the level of involvement and participation within the treated communities.[10] 55% of households reported having a family member who was part of a CODEL. As for the participation in drills over the past 10 years, 40% of the respondents indicated that the community had participated in a drill, and 31% reported that someone in their household had done so. This is in keeping with the results and reveals that some measures may have been implemented at the community level without the participation of all the household members, as it depended on their role in the committee.

As for the Community Preparation and Prevention Plan the Red Cross elaborated with the communities, 52% of the households affirmed that this plan existed, and 46% of this subsample recalled at least one topic addressed by the plan. Moreover, 73% of this subsample indicated that a family member had participated in its elaboration, and 53% indicated that it had been implemented to face a hazard (see Table 10). Again, this supports our findings on the participation of the households in community-level activities and measures.

The qualitative interviews suggest that the HRC/SRC has reinforced organizational structures within the community not only to face disasters, but also to confront other health or education challenges the community faces. This was further confirmed by the responses of households when asked how the community would react in the event of an emergency (see Table 11). 26% of the respondents from the control communities, but only 8% of those from the treated communities, believed they would only help their family members. Furthermore, only 38% of respondents from the control communities believed the community members would help one other in an orderly manner, while this percentage was significantly higher (61%) in the treated communities. The corresponding ATET was also positive and statistically significant.

5.4. Management of natural resources

The final component of resilience in the framework of this study, the management of natural resources, concerned the use of ecological and economic stoves, waste management and soil bioengineering measures.

As part of the HRC/SRC program, ecological and economic stoves ("ecofogones") were built in many houses in order to reduce the firewood required for cooking, thus contributing to reducing deforestation as well as yielding better health indicators by reducing respiratory diseases and accidents linked to the use of traditional woodstoves. The descriptive statistics yield the following insights: in control communities, the average number of logs used per person per day to cook was 6.8, versus 4.9 logs in the treated communities. The estimated ATET, a decrease of 1.91 logs per person per day (or 558 fewer logs per person per year in the treated communities) was statistically significant, as well as economically and ecologically important.

There was also a small but positive statistically significant effect for waste management. The HRC/SRC raises awareness at household level to reduce and recycle waste, and to bury the remaining garbage. However, only 6% of the households in the treated communities reported doing so. No formal waste collection systems exist in this rural setting, and the cheapest and most practical approach is to burn waste, or to

[10] Since CODELS are not active in the control communities, this analysis focuses only on the treated communities.

Table 10
Community prevention and preparation plan awareness, involvement and implementation.

	Community Prevention and preparation plan awareness		Subsample of HHs who answered "Yes" to having a Community Prevention and Preparation Plan					
			Recall of plan		Participation of family member in elaboration of plan		Implementation of plan	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
No	134	48.0	75.0	53.6	39	26.9	64	46.7
Yes	145	52.0	65.0	46.4	106	73.1	73	53.3
Total	279	100	140.0	100	145	100	137	100

Table 11
Perception of community collaboration in case of a disaster in sample of treated and control communities.

Community collaboration	Control		Treated		Total	
	Freq.	%	Freq.	%	Freq.	%
People in the community will only help their family members.	106	26.2	32	8.5	138	17.6
People will work together to help each other, but not in a very organized manner.	147	36.3	114	30.2	261	33.4
People will work together to help each other in an organized and well planned manner.	152	37.5	231	61.3	383	49.0
Total	**405**	**100**	**377**	**100**	**782**	**100**

throw it away, with 79% and 13% of the total sample using these techniques respectively.

As mentioned earlier, another key aspect of the HRC/SRC's intervention consisted in protecting households through "green" and "grey" measures. The "green" measures (soil bioengineering) are of special interest as they are a practical, low-cost solution for controlling soil erosion that can be quite easily replicated by other households.[11] A significant positive ATET of 13% points was found in terms of the percentage of people that knew about soil bioengineering measures, but the effect was not statistically significant for implementation because measures such as the use of izote plants to stabilize the soil were quite common in the study area, and several households in the control group reported using them. However, the HRC/SRC bioengineering measures were tailored to the level of exposure of each household and combined different measures, which differed from simply using izote plants. A higher percentage of households reported carrying out maintenance to the bioengineering measures in the treated communities than in the control communities (85% and 71% respectively). In general, the bioengineering measures were better conserved in the treated communities (93% versus 65%) [55].

6. Discussion

The authors identified only one other study on the design of effective impact evaluations in disaster management and disaster risk reduction that has used propensity scores [41]. The present study proposes a methodology for conducting such an empirical impact evaluation in these fields, thereby adding to the knowledge base on evidence-based decision-making.

The present study explored a methodology to measure the impact of a CBDRM Program on the resilience of communities in Olancho, Honduras, through a counterfactual-based evaluation of its impact.

[11] Downs (Swiss Development Cooperation) personal communication.

There seem to be overall positive and significant effects on different dimensions of resilience as defined by the IFRC framework, but the contribution of this paper is broader than these specific conclusions.

The results show that the chosen methodology allowed for the evaluation of a positive impact in terms of knowledge on preparedness, meaning that the program's training sessions were effective. There is a positive and significant effect on social cohesion, which highlights the effectiveness of the community-based approach adopted by the Red Cross and promoted by the Sendai Framework [3]. Finally, the findings reveal a positive and significant effect on the management of natural resources, to the benefit of other elements of resilience.

A major challenge was the lack of consistent baseline data, which is common due to the cost of data collection and the nature of such programs. Data collection cannot be the first priority of development and humanitarian agencies, which must above all focus on assisting affected populations. This notwithstanding, the integration of data collection into program design from the beginning would both reduce the cost and improve the robustness of later impact evaluations. Several approaches for establishing baseline data on resilience are being applied at a national level in the United States [25], but they may be unsuitable for community-based programs such as that evaluated above, as available data may not be on the appropriate scale and inadequate proxy measures may be used [25,26]. Furthermore, the design of appropriate indicators and means for collecting the appropriate data are context-specific [24,5,26]. Humanitarian and development organizations should therefore take this into account during the design and field implementation phases of their programs.

7. Conclusion

The program implemented by the Red Cross in Honduras aims to strengthen community resilience by improving risk knowledge and preparedness, increasing community cohesion and limiting existing resource degradation. The study sought to address the following question: *What methodological approach could be taken to evaluate the impact of community-based disaster risk reduction programs, which come with a host of challenges?*

An impact evaluation was conducted based on an average treatment effect for the treated communities using propensity score matching. The results were validated via robustness checks that employed different matching algorithms and propensity score weighting, all of which yielded similar effect estimates and levels of significance.

The Red Cross's intervention had a positive and significant effect on the treated communities in three important areas of resilience: knowledge and preparedness (e.g., existence of an EWS); social cohesion (e.g., community institutions); and management of natural assets (e.g., firewood consumption). This impact evaluation indicates that the intervention program enabled treated communities to enhance their capacity to prepare for future hazards and to respond in case of an emergency at both the household and community levels.

The community-based focus of the program is central for reinforcing community cohesion through the establishment of community committees. Stronger organizational structures as well as training on how to run community institutions have allowed the communities to connect to the municipal level and to engage in related community development programs in fields such as health and education, thereby further strengthening overall community resilience.

This study illustrates the value of combining quantitative and qualitative methods to deepen the analysis and increase the robustness of the results. As financial resources will always be limited in the development and humanitarian fields, it is important to guide development programs and policy towards the most effective interventions and design. Impact evaluations based on methodologies, such as the propensity score matching tested in the present study, have proven feasible and may be extremely valuable for supporting decision-making, especially in contexts with limited resources.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2020.101732.

9. Annexe

A.1. Propensity score weights.

The weights for each observation are

$$Weight_i = \frac{D_i}{\widehat{p}(X_i)} + \frac{(1-D_i)}{(1-\widehat{p}(X_i))}. \tag{3}$$

where $\widehat{p}(X_i)$ represents the propensity score and D_i represents the treatment status. This means that the observations in the treated groups have weights $1/\widehat{p}(X_i)$ and those in the control groups have weights $1-1/\widehat{p}(X_i)$. The simplest estimate of the average treatment effect on the treated (ATET) compares the mean outcome of the treated group with their potential outcomes had they not been treated, and is [50].

$$\frac{1}{n_1}\sum_{i=1}^{n} Y_i D_i - Y_i(1-D_i)\frac{\widehat{p}(X_i)}{1-\widehat{p}(X_i)}. \tag{4}$$

However, since the weights may not sum to unity in each subsample, a preferable estimate is

$$\frac{\sum_{i=1}^{n} Y_i D_i}{\sum_{i=1}^{n} D_i} - \frac{\sum_{i=1}^{n} Y_i(1-D_i)\frac{\widehat{p}(X_i)}{1-\widehat{p}(X_i)}}{\sum_{i=1}^{n}(1-D_i)\frac{\widehat{p}(X_i)}{1-\widehat{p}(X_i)}}. \tag{5}$$

A.2. Propensity score weights

Probit regression				Number of obs = 102		
					LR chi2(9) = 49.71	
					Prob > chi2 = 0	
Log likelihood = −45.83				Pseudo R2 = 0.3517		
Treatment	**Coef.**	**Std. Err.**	**z**	**P > |z|**	**[95 Conf. Interval]**	
% of respondents that had at least 1 year of education	−0.16	0.77	−0.20	0.84	−1.67	1.35
Average no. of adults per HH with at least 1 year of education	0.23	0.22	1.01	0.31	−0.21	0.67
Proximity (average amount of time it takes to arrive to community center)	−0.06	0.02	−2.42	0.02	−0.10	−0.01
Average expenditure per capita	−0.35	0.24	−1.46	0.15	−0.82	0.12
% of HH with some type of deprivation (flooring, assets or sanitation)	−1.29	0.64	−2.01	0.05	−2.54	−0.03
% of HH who owned a TV at the baseline	0.00	3.54	0.00	1.00	−6.93	6.94
Average subjective level of health	0.50	0.41	1.23	0.22	−0.30	1.30
Level of hazard: % of HHs exposed to a high level of hazard	0.02	0.01	2.64	0.01	0.00	0.03
Type of hazard: % of HHs exposed to landslides	−0.02	0.01	−3.48	0.00	−0.04	−0.01
_cons	1.38	1.29	1.07	0.29	−1.16	3.91

Table A.3
ATET using community level propensity score kernel matching with Epanechnikov Kernel

Outcome (Y)	Reps	ATET	Bias	Std. Err.	[95% Conf. Interval]	
Knowledge of what a hazard is	100	0.23	−0.01	0.06	0.11	0.35
Signal in case of a hazard	100	0.24	0.00	0.04	0.16	0.31
Knowledge of when to evacuate	100	0.24	−0.01	0.06	0.12	0.36
Subjective level of preparation at the HH Level	100	0.85	0.01	0.32	0.22	1.47
Subjective level of preparation at the Community Level	100	1.16	0.01	0.08	0.99	1.32
List of telephone numbers	100	0.02	−0.01	0.06	−0.10	0.15
Important documents stored in one place	100	0.31	0.01	0.09	0.14	0.48
Emergency food	100	0.09	0.00	0.03	0.04	0.14
Emergency bag	100	0.04	0.00	0.01	0.02	0.07
Safe meeting point	100	0.31	0.00	0.04	0.22	0.39
Evacuation route	100	0.24	0.00	0.05	0.14	0.34
Defined shelter	100	0.47	0.00	0.04	0.39	0.55
Insurance policy	100	0.00	0.00	0.00	0.00	0.01
Family emergency plan	100	0.06	0.00	0.02	0.02	0.09
Does your community have a prevention and preparation plan?	100	0.41	0.00	0.03	0.34	0.47
Community reaction: will only help family members	100	−0.12	0.00	0.04	−0.20	−0.04
Community reaction: will help each other but not very organized	100	−0.08	0.01	0.06	−0.20	0.05
Community reaction: will help each other in an organized manner	100	0.24	0.00	0.07	0.11	0.37
Is the CODEL active?	100	0.79	0.00	0.04	0.72	0.87
Community participation in drill	100	0.39	0.00	0.04	0.31	0.47
Coordination of response with someone from CODEL, CODEM or COPDECO	100	0.41	0.00	0.04	0.33	0.50
Logs per person per day	100	−1.91	0.11	0.41	−2.73	−1.09
Adequate waste management	100	0.05	0.00	0.02	0.00	0.09
Knowledge of bioengineering	100	0.13	0.01	0.05	0.03	0.22
Implementation of bioengineering	100	0.04	0.01	0.05	−0.07	0.14

Table A.4
ATET using community level propensity score N-nearest neighbour matching with N = 3

Outcome (Y)	ATET	Std. Err.	z	P>|z|	[95 Conf. Interval]	
Knowledge of what a hazard is	0.22	0.05	4.56	0.00	0.13	0.32
Signal in case of a hazard	0.24	0.03	8.39	0.00	0.18	0.29
Knowledge of when to evacuate	0.19	0.07	2.71	0.01	0.05	0.33
Subjective level of preparation at the HH Level	1.08	0.34	3.17	0.00	0.41	1.75
Subjective level of preparation at the Community Level	1.22	0.02	59.14	0.00	1.18	1.26
List of telephone numbers	0.03	0.05	0.58	0.56	−0.07	0.13
Important documents stored in one place	0.33	0.10	3.49	0.00	0.15	0.52
Emergency food	0.08	0.03	2.74	0.01	0.02	0.14
Emergency bag	0.04	0.01	3.79	0.00	0.02	0.06
Safe meeting point	0.33	0.03	10.32	0.00	0.27	0.39
Evacuation route	0.21	0.03	6.60	0.00	0.15	0.28
Defined shelter	0.47	0.04	11.37	0.00	0.39	0.55
Insurance policy	0.00	0.00	1.06	0.29	0.00	0.01
Family emergency plan	0.06	0.02	3.65	0.00	0.03	0.09
Does your community have a prevention and preparation plan?	0.39	0.01	41.90	0.00	0.37	0.41
Community reaction: will only help family members	−0.04	0.03	−1.51	0.13	−0.09	0.01
Community reaction: will help each other but not very organized	−0.22	0.03	−7.55	0.00	−0.28	−0.17
Community reaction: will help each other in an organized manner	0.29	0.04	7.20	0.00	0.21	0.37
Is the CODEL active?	0.77	0.05	16.71	0.00	0.68	0.86
Community participation in drill	0.38	0.04	9.43	0.00	0.30	0.46
Coordination of response with someone from CODEL, CODEM or COPDECo	0.41	0.02	23.01	0.00	0.38	0.45

(*continued on next page*)

(*continued*)

Outcome (Y)	ATET	Std. Err.	z	P>|z|	[95 Conf. Interval]	
Logs per person per day	−1.97	0.33	−5.87	0.00	−2.62	−1.31
Adequate waste management	0.04	0.02	1.71	0.09	−0.01	0.08
Knowledge of bioengineering	0.11	0.06	1.98	0.05	0.00	0.23
Implementation of bioengineering	0.08	0.07	1.16	0.25	−0.05	0.21

Table A.5
ATET using community level propensity score N-nearest neighbour matching with N = 1

Outcome (Y)	ATET	Std. Err.	z	P>|z|	[95 Conf. Interval]	
Knowledge of what a hazard is	0.24	0.04	5.57	0.00	0.16	0.32
Signal in case of a hazard	0.24	0.03	8.20	0.00	0.18	0.29
Knowledge of when to evacuate	0.04	0.13	0.29	0.77	−0.22	0.30
Subjective level of preparation at the HH Level	1.39	0.20	7.07	0.00	1.01	1.78
Subjective level of preparation at the Community Level	1.17	0.10	11.87	0.00	0.98	1.37
List of telephone numbers	0.00	0.10	0.02	0.99	−0.19	0.19
Important documents stored in one place	0.15	0.19	0.82	0.41	−0.21	0.52
Emergency food	0.03	0.04	0.79	0.43	−0.05	0.12
Emergency bag	0.04	0.01	3.18	0.00	0.01	0.06
Safe meeting point	0.33	0.03	10.67	0.00	0.27	0.39
Evacuation route	0.24	0.04	6.10	0.00	0.16	0.31
Defined shelter	0.47	0.04	11.22	0.00	0.39	0.55
Insurance policy	0.00	0.00	1.07	0.29	0.00	0.01
Family emergency plan	0.06	0.02	3.25	0.00	0.02	0.09
Does your community have a prevention and preparation plan?	0.35	0.04	7.95	0.00	0.26	0.43
Community reaction: will only help family members	−0.02	0.03	−0.54	0.59	−0.08	0.04
Community reaction: will help each other but not very organized	−0.32	0.08	−3.79	0.00	−0.49	−0.15
Community reaction: will help each other in an organized manner	0.37	0.06	6.38	0.00	0.26	0.48
Is the CODEL active?	0.67	0.08	8.73	0.00	0.52	0.82
Community participation in drill	0.40	0.04	10.68	0.00	0.33	0.47
Coordination of response with someone from CODEL, CODEM or COPECO	0.37	0.05	8.11	0.00	0.28	0.46
Logs per person per day	−2.23	0.56	−3.97	0.00	−3.32	−1.13
Adequate waste management	0.06	0.03	2.17	0.03	0.01	0.11
Knowledge of bioengineering	0.03	0.10	0.30	0.77	−0.16	0.22
Implementation of bioengineering	0.13	0.09	1.54	0.12	−0.04	0.30

Table A.6
ATET using propensity score weights

Outcome (Y)	ATET	Std. Err.	z	P>|z|	[95 Conf. Interval]	
Knowledge of what a hazard is	0.21	0.06	3.47	0.00	0.09	0.33
Signal in case of a hazard	0.24	0.03	7.10	0.00	0.17	0.30
Knowledge of when to evacuate	0.22	0.07	2.89	0.00	0.07	0.36
Subjective level of preparation at the HH Level	1.01	0.29	3.47	0.00	0.44	1.59
Subjective level of preparation at the Community Level	1.17	0.08	14.77	0.00	1.01	1.32
List of telephone numbers	0.02	0.06	0.40	0.69	−0.09	0.14
Important documents stored in one place	0.28	0.09	3.19	0.00	0.11	0.45
Emergency food	0.09	0.03	3.04	0.00	0.03	0.14
Emergency bag	0.04	0.01	3.50	0.00	0.02	0.07
Safe meeting point	0.30	0.04	7.20	0.00	0.22	0.39
Evacuation route	0.22	0.05	4.25	0.00	0.12	0.33
Defined shelter	0.47	0.04	10.94	0.00	0.39	0.55
Insurance policy	0.00	0.00	1.01	0.31	0.00	0.01
Family emergency plan	0.06	0.02	3.51	0.00	0.03	0.09
Does your community have a prevention and preparation plan?	0.40	0.04	10.66	0.00	0.33	0.47
Community reaction: will only help family members	−0.09	0.04	−2.17	0.03	−0.18	−0.01
Community reaction: will help each other but not very organized	−0.13	0.07	−1.92	0.06	−0.26	0.00
Community reaction: will help each other in an organized manner	0.26	0.07	3.93	0.00	0.13	0.39
Is the CODEL active?	0.78	0.04	20.57	0.00	0.70	0.85
Community participation in drill	0.39	0.04	9.96	0.00	0.31	0.47
Coordination of response with someone from CODEL, CODEM or COPECO	0.41	0.04	10.13	0.00	0.33	0.49
Logs per person per day	−1.90	0.47	−4.01	0.00	−2.83	−0.97
Adequate waste management	0.04	0.02	2.00	0.05	0.00	0.09
Knowledge of bioengineering	0.12	0.05	2.41	0.02	0.02	0.22
Implementation of bioengineering	0.05	0.05	1.03	0.31	−0.04	0.14

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