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The influence of technical assistance and funding on perceptions of post-disaster housing safety after the 2015 Gorkha earthquakes in Nepal

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ABSTRACT

Housing is vital in facilitating a return to normality following a disaster; however, it remains one of the most challenging and problematic areas of post-disaster assistance. There is a pressing need to unpack “Build Back Better” aspirations to understand the drivers of safe housing reconstruction. The objective of this research was to understand the influence of technical assistance and sources of funding on household perceptions of housing safety. Binomial logistic regression was used to analyse survey data collected from 711 households three and half years after the 2015 Gorkha Earthquake in Nepal in two affected districts. We found that only 55% and 60% of households in the selected districts of Gorkha and Okhaldhunga, respectively, felt their home was safe in case of a large future earthquake. The use of demonstration houses in communities resulted in higher odds of safe perceptions, while door-to-door technical assistance was associated with lower perceptions of safety in Gorkha. In contrast, in Okhaldhunga, household reconstruction orientations and short training resulted in lower odds of safe perceptions. The funding source for housing reconstruction did not correlate with perceptions of safety in Gorkha, while government funding and household savings had positive correlations in Okhaldunga. Our findings suggest a possible link between reconstruction financing, technical assistance, and the perceptions household form out of recovery. Organisations seeking to support housing reconstruction can potentially leverage tailored technical assistance and funding sources as points of entry to influence household demand for safer construction.

1. Introduction

Disasters continue to be a major obstacle to sustainable development, hindering social and economic gains. The impact of disasters are detrimental to the safety of communities, effecting economic, social, and environmental wellbeing, accounting for over $2.97 trillion (USD) in economic losses worldwide over the last two decades [1]. In the same period, 1.23 million people were killed and over 4 billion impacted through injury, homelessness, displacement or requiring emergency aid because of disasters. While immediate response plays a crucial role in saving lives after a disaster, the transition to recovery often sees diminishing interest and investment [2]. Disaster recovery is often stated as “the least investigated and most poorly understood of the four phases of disaster management – mitigation, preparedness, response and recovery” [3].

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Housing plays a critical role in supporting livelihoods and successful recovery has often been associated with well-designed, hazard-resistant housing [4,5]. Within disaster studies, there is continued debate over pathways to build back better [6]. Both scholars and practitioners are increasingly calling to define what is “better” in dialogue with those affected [7,8]. It is crucial for the resilience of communities to understand housing related risks and technical opportunities to enhance safety. Household perceptions of safety are important because they form the basis of housing mitigation decisions and potentially actions taken before, during, and after natural hazard events [9,10]. Understanding and applying safer construction can prevent future fatalities and losses [11,12]. However, our understanding of housing safety has largely been defined through engineering evaluations rather than household viewpoints. To enhance safety there is a need to explore safety perceptions of those affected. Re-asserting the knowledge and perspectives of affected communities as a means of assessing recovery outcomes is important if we are to realise the aims of humanitarian assistance.

The nature of post-disaster housing assistance continues to pivot toward homeowner-driven and self-recovery approaches which aim to decentralize power and decision-making in the hands of affected households [13,14]. Historically, post-disaster housing support has been delivered through top-down interventions to communities [15,16]. Currently, we are seeing a movement toward homeowner-driven approaches which decentralize and localize aid [17]. This stands in contrast to post-disaster programming which has historically viewed housing as a product to be delivered centrally by governments and organizations. This shift is important as it holds potential to finally live up to the theorised benefits of people’s participation in disaster risk reduction [18,19].

To understand how to support safer housing construction, there is a need to more systematically analyse the influencing factors at play within housing recovery processes [20,21]. A few notable contributions include, but are not limited to, provision of technical assistance to provide skills and knowledge for construction [22,23] and funding to cover reconstruction costs [24,25]. These two elements, technical assistance and funding, are seen as key-drivers for safer housing and are among the top research needs cited by humanitarian practitioners [26]. There is growing research that has focused on the processes to deliver technical assistance [22]. Evidence on the impact of these interventions on housing outcomes has not kept pace. Similarly, we continue to amass knowledge on the important role of funding to support recovery [27], yet there remain gaps in understanding how the source of funding matters. While there is an abundance of research that has assessed structural improvements to housing, there is comparatively less research that has looked at how households themselves perceive the safety of their reconstructed homes [28].

There is also an abundance of research on perceptions of hazards and risks. These may implicitly focus on housing and not explicitly, for example evacuation behaviour in the Philippines [29] and landslide preparedness in China [30]. In this study, we seek to assess the impact of types of technical and financial assistance on household perceptions of their housing safety.

Toward this goal, we ask: What factors, including technical assistance and funding source, influence household perceptions of post-disaster housing safety? To answer this research question, we surveyed households following the 2015 Gorkha earthquake in Nepal. In Nepal, the government acknowledged the importance of reconstructing seismic resistant housing. Funding was released to affected households if the necessary construction techniques were applied. In addition, humanitarian organizations provided technical assistance to guide affected communities in the reconstruction process. Financial and technical assistance for the reconstruction of houses are common responses to a destructive natural hazard [22]. However, management of the responses vary between countries, including their regulations, types and speed of assistance.

We first review post-disaster housing safety outcomes as well as the associated links to technical assistance and funding. We then describe our methods used to unpack the links between these household-level variables and outcomes, followed by a presentation and discussion of our results. Calls for integrating disaster risk reduction (DRR) methods in recovery have become more prominent, particularly under the Sendai Framework for Disaster Risk Reduction targets, adopted by United Nations member states in 2015. This research seeks to directly contribute to priority 4, through “Enhancing disaster preparedness for effective response and to ‘build back better’ in recovery, rehabilitation and reconstruction” [12].

2. Background

We first review why perceptions of post-disaster housing safety are important before synthesising the two means of assistance – technical assistance and funding – explored in this study.

2.1. Perceived safety

There is a wealth of literature which has focused on risk perceptions relating to natural hazards [31,32]. For example, past research has shown that risk perceptions are influenced by past disaster experiences and the likelihood of recurrence [29]. However, perceptions of housing safety, which can be considered a subset of these broader views, are distinct and understudied [28]. In this study, we define perceptions of housing safety as household’s expected performance of their home in a future earthquake. As Venable et al. [33] found, there is relatively strong alignment between actual and household perceptions of housing safety. How households perceive the safety of their homes thus plays an important role in shaping investment decisions in safer construction.

Housing safety is particularly complex in the context of non-engineered construction that is the norm in most low- and middle-income countries [5]. As Tanner et al. [34] raise, there has been limited incorporation social expectations into building codes. Most humanitarian programs seek to support ‘safer’ construction, incrementally improving construction practice, such as through simplified design principles. Previous research has noted that top-down programs alone are often not sufficient to reducing disaster vulnerability and there is a need to also consider bottom-up strategies [35]. However, the impact and influence of humanitarian programming on household perceptions of safety has seen limited study to date.

Successful reconstruction is often reported based on rapid completion rates or high application of hazard-resistant measures [36]. However, applied safety features are often mistaken to have long-term impact, overlooking the incremental nature of housing [37].
Household perceptions of safety may offer better insights into longer term changes in safer construction practice. To understand if reconstruction has been successful in the eyes of those affected, the perceived safety of homes is key to understand local disaster risk reduction processes.

2.2. Technical assistance

Technical assistance is the inputs used to inform, guide, and add value to housing recovery undertaken by households, communities and governments [22]. The focus of such programs seek to provide communities with the resources required to recover efficiently [38]. For example, Kotani and Honda [38] found that technical information relating to local materials and techniques provided to builders resulted in an earlier rate of completion. Although technical assistance can come in many forms, we will narrow our focus in this work on the knowledge exchanged to improve construction practice.

As highlighted in previous work by Opdyke et al. [23], there are often multiple pathways through which households acquire knowledge in rebuilding. For example, Hendriks et al. [39] point to the importance using trusted actors in the communication of technical assistance, preferably with a long-term link to the community. There is growing evidence that by including and facilitating access to knowledge, households are more inclined to consider safer solutions [40–43]. Despite the largely positive connotations technical assistance has in the humanitarian and development space, the quality of assistance and training that are provided to communities varies greatly [44]. Unpacking which forms of technical assistance matter is a persistent gap in literature. Understanding the effectiveness of formats is increasingly important as humanitarians back new models to support shelter self-recovery [45].

2.3. Funding

Funding mechanisms, including cash and voucher based assistance, are valued as tool to stimulate resilient housing reconstruction [46–48]. Yet, shelter is often underfunded in crises compared to other humanitarian sectors. This is further complicated by blurred boundaries between humanitarian and development assistance [49,50]. While there is often a surge of funding immediately following crises, long-term reestablishment of housing frequently lags. As Tran et al. [51] raise, building back faster often outweighs the long term benefits of building back safer as organisations tend to focus on quantity over quality. Funding for housing recovery is provided by a number of stakeholders including government authorities, NGO’s, and private entities [52]. While previous research has noted that governments in low-income countries are frequently reliant on outside sources to fund housing reconstruction after disasters [53], other sources of funding, particularly from within communities, have not been adequately examined for their role in housing recovery. Unpacking how the source of funding impacts outcomes holds potential to understand ways to support unique and diverse housing orientations and short mason trainings. The contrast between these two regions allowed further dissection into the role of technical assistance has in the humanitarian and development space, the quality of assistance and training that are provided to communities varies greatly [44]. There is a gap in funding structures that deliver on safety whilst also catering to the financial constraints of each affected household. Households should define their own priorities in reconstruction, and there are increasing calls for more flexible financial models [52].

3. Methods

The aim of this research was to understand the impact of technical assistance and funding on household perceptions of housing safety. Reconstruction in Nepal following the 2015 Gorkha earthquake was selected as a suitable case study, in part, because of the prevalent and interdependent role these variables played in recovery. Fieldwork was conducted during the reconstruction phase between February and May 2018, approximately three and half years after the earthquakes, drawing on a survey of recovering households.

We used binomial logistic regression analysis to unpack the links between the identified housing support mechanisms and household perceptions of housing safety. We considered two groups of independent variables: (1) the type of technical assistance and (2) source of funding for housing. These were regressed against a household’s safety perception of their home in a future earthquake.

3.1. Data collection

Technical housing assistance was provided primarily in the 14 most affected districts, yet coverage differed significantly. Fig. 1 shows the difference in number of interventions. We selected the two districts with the greatest difference in coverage, Gorkha and Okhaldhunga. Gorkha received significant humanitarian technical assistance whilst Okhaldhunga received minimal external aid. Communities in Gorkha district received different intervention types, multiple interventions and often the most intensive assistance types, such as the construction of a demonstration house in the community or door to door assistance. Communities in Okhaldhunga received only a few interventions, few different types of assistance and often the least intensive, such as a short community reconSTRUCTION orientations and short mason trainings. The contrast between these two regions allowed further dissection into the role of housing support in reconstruction.

We collected survey data from 25 communities recovering across two districts – Gorkha (8 communities) and Okhaldhunga (17 communities). A total of 711 household surveys were collected by the research team. This included 271 responses in Gorkha and 440 responses in Okhaldhunga from the male or female head of the household. Household surveys enabled consistency across a large sample of communities, using both multiple-choice and open-ended questions. Questions and consent were asked verbally by local research assistants in Nepali, the native dialects of households, and recorded digitally using tablets.

3.2. Model variables

Our dependent variable of interest was a household’s perceived safety of their current housing in the event of a large future earthquake. The first independent variables we considered was the type of technical assistance that a household received during
reconstruction. Six different types of technical assistance were considered, drawing on classifications from the Housing Recovery and Reconstruction Platform Nepal (HRRP) to inform the questions that were asked. These included: demonstration house, door-to-door technical assistance, household reconstruction orientation, reconstruction coordination committee, vocational training, and short training. The most substantial assistance was a vocational training for masons and carpenters which took approximately 40–45 days compared to a short training of 7 days primarily aimed at households. Demonstration houses were constructed with community members and remained as an example in the communities. Individual door-to-door assistance was given to households directly, which included tailored rebuilding advice. Household reconstruction orientations were community wide meetings to share general information about the reconstruction process, primarily raising awareness about the procedures and providing some technical knowledge. The reconstruction coordination committee gathered information related to the reconstruction and shared this within a community.

Our second independent set of variables was the source of funding that a household drew on to rebuild their home. People mentioned earnings from members of the household, relatives outside of the household, community members, personal savings, the government, or loans. We were also particularly interested in government sources of funding given the scale of this in Nepal after the earthquake.

We included control variables related to the community that we expected may have influenced perceptions of safety. These included community size, average community damage from the earthquake, accessibility of the community, and the degree of technical assistance provided. Community size data was obtained from HRRP and measured at the ward level, confirmed in conversation with the ward leader. The level of damaged experienced by a community was measured using HRRP’s early damage assessments [55]. This classified average damage in a community according to a five-point scale ranging from (1) negligible or slight non-structural damage; (2) moderate damage with cracks in many walls; (3) heavy damage with large and extensive cracks in most walls; (4) very heavy damage with serious wall failure; (5) destruction. In some cases, communities were also assigned a classification between two levels of damage. The accessibility of a community was delineated whether it was reachable by vehicle traffic or was only serviced by walking tracks. The degree of technical assistance provided to the community was measured through a combination of number, diversity, and type of technical assistance interventions in a community. A high degree of technical assistance was defined by

![Coverage of technical assistance activities of the 14 most affected districts by the earthquake in Nepal (Adapted from Housing Recovery & Reconstruction Platform data on 25 January 2018; with permission).](image-url)
at least 4 types, and 12 interventions, including at least door-to-door assistance. Low intensity assistance is defined by a maximum of 2 types of assistance and not more than 6 interventions in total, not including demonstration houses or door-to-door assistance or vocational training. Moderate assistance was defined between 2 and 4 types and between 6 and 12 interventions.

We also considered control variables for household characteristics that included gender and caste of the respondent as well as the primary household livelihood. While the caste system was formally abolished in Nepal, it continues to play an influence role in society. We considered the three main castes that included Dalit, Janjati, and Brahmin. Brahmin is the highest caste, generally received with respect. Dalit are seen as community outsiders, and other castes often avoid close contact, representing a historically marginalised group. We included an option for “other” for households who stated none of these were applicable. Five types of livelihoods were considered that included agriculture, construction, education, business, or military. More than one livelihood response was possible, if for example, the household’s main source of income came from two family members working in different sectors. A summary of variables and their coding is presented in Table 1.

3.3. Model analysis

Our analysis included one dependent variable – household perceptions of the safety of their housing in a future large earthquake, see Fig. 2. We used binary binomial logistic regression to assess what degree various technical assistance to households and sources of housing funding impacted perceptions of housing safety. Our general regression expression is:

$$\text{Logit (Safety)} = \beta_0 + \beta_1 (\text{Control}) + \beta_2 (\text{TA}) + \beta_3 (\text{Funding}) + \epsilon$$

Where, $\beta_0$ refers to the constant term; $\beta_1$, $\beta_2$, and $\beta_3$ are parameters to be estimated where $i$ is an index for individual variables; $\epsilon$ is the residual; $\text{Control}$ are the community and household control variables; $\text{TA}$ are the types of technical assistance considered; $\text{Funding}$ are the sources of funding used to complete housing reconstruction; and $\text{Safety}$ is the perceived safety in a large future earthquake. Analysis was completed used SPSS statistical analysis software.

4. Results

We first present descriptive statistics of the selected variables and then expand on the results of our binomial logistic regression models for each district.

4.1. Descriptive statistics

In Gorkha, 55.4% of respondents felt their house was safe in a future earthquake, while in Okhaldhunga, 60.0% perceived their house to be safe. On average, damage levels were higher in Gorkha district. Gender of respondents was approximately equally
represented (57.6% female in Gorkha, 43.0% in Okhaldhunga). Our sample in Gorkha contained a more concentrated sample of Janjati caste, while the sample in Okhaldhunga was more evenly distributed.

Both districts are primarily dependent on agriculture, as indicated by 74.5% and 81.1% of respondents in Gorkha and Okhaldhunga who indicated agriculture as their livelihood, respectively. The communities in Okhaldhunga received less technical assistance, with no communities receiving a high level of assistance. In Gorkha, households drew on personal savings and loans more frequently than those in Okhaldhunga.

4.2. Models

We developed two separate models to understand the relationship of technical assistance and funding on safety perceptions – one model for Gorkha and another for Okhaldhunga. The districts were separated to account for other contextual factors, such as differences in previous earthquakes, which may have skewed household perceptions of housing safety. We found no evidence of multicollinearity among our independent variables within each district, validated through a check of variance inflation factors (VIFs). We confirmed that VIFs were less than 10, a common threshold, for all variables. We also confirmed that there was a linear relationship between our only continuous independent variable, community size, and the logit of our dependent variable, safety perception, in each district. This was assessed using the Box-Tidwell [56] procedure. A Bonferroni correction was applied using all terms in the model [57]. Additionally, we also checked for outliers, finding one standardised residual for Gorkha and four standardised residuals for Okhaldhunga above 2.5, which were kept in the analysis (see Table 2).

We measured the predictive value of the models. Models for both districts were statically significant, $X^2 = 120.1$ (Gorkha) and $X^2 = 126.5$ (Okhaldhunga). Results are shown in Table 3. The Gorkha model explained 48% (Nagelkerke $R^2$) of the variance in perceptions of safety and correctly classified 71% of cases. The Okhaldhunga model explained 34% (Nagelkerke $R^2$) of the variance in perceptions of safety and correctly classified 74% of cases. For Gorkha, sensitivity was 80.8%, specificity was 72.7%, positive predictive value was 78.7% and negative predictive value was 72.5%. For Okhaldhunga, sensitivity was 81.1%, specificity was 62.3%, positive predictive value was 77.0% and negative predictive value was 69.1%.

In Gorkha, five variables were found to be significant which included: community size, households who experienced complete destruction of their home (as compared to those who experienced heavy damage), community access, demonstration houses, and door to door technical assistance. Households who observed a demonstration house had 2.6 times higher odds of perceiving their house to be safe. Conversely, households who received door to door technical assistance had 8.47 lower odds of perceiving their house as safe. Of the controls found to be significant, smaller communities had narrowly higher odds of perceiving their house as safe. Conversely, households who received door to door technical assistance had 8.47 lower odds of perceiving their house as safe. Of the controls found to be significant, smaller communities had narrowly higher odds of perceiving their house as safe. Conversely, households who received door to door technical assistance had 8.47 lower odds of perceiving their house as safe. While there were no differences between heavy and very heavy damage, those whose house was completely destroyed had 34.48 higher odds of perceiving their current housing as...
safe. However, the exact strength of this relationship may be questionable as we found a high standard error. We did not find a relationship between funding and safety perceptions, nor influence of caste, gender, or livelihood.

In Okhaldhunga, access and community size were again found to be significant. Similar to Gorkha, caste, gender and livelihood were not significant. Household reconstruction orientations and short training were significant with 3.58 lower odds of households describing their house as safe as compared to those that did not receive technical assistance through one of these formats. We also found a significant, positive correlation between the use of government funding and personal savings and safety perceptions. These resulted in odds ratios of 2.67 and 2.41, respectively.

4.3. Validity

We also sought to assess the accuracy of our models and how well they discriminate between perceptions of safe and unsafe housing. We used Receiver Operating Characteristic (ROC) curves to examine prediction accuracy. The area under the ROC curves for Gorkha and Okhaldhunga were 0.856 (95% CI, 0.812 to 0.899) and 0.807 (95% CI, 0.766 to 0.849), respectively, which both represent an excellent level of discrimination corresponding to equivalent accuracies of 85.6% and 80.7%. Areas above 0.7 are typically considered acceptable, while areas above 0.8 are excellent [58].

5. Discussion

This section discusses the two district models, unpacking what types of funding and technical assistance were identified as predictors of perceived safety.

5.1. Feeling safe and unsafe because of technical assistance

Our results on the relationship between technical assistance and perceptions of housing safety reveal two potentially contrasting

| Table 2
| Descriptive statistics of variables. |
|-------------------------------------|
| Variable                           | Frequency (%)                      |
| Control                            |                                     |
| Perceived safety                   | Gorkha (N = 271) | Okhaldhunga (N = 440) |
| Safe                               | 55.4 | 60.0 |
| Unsafe                             | 46.6 | 40.0 |
| Size of community                  |                                     |
| Number of people                   | Mean = 134.4 | Mean = 81.6 |
| SD                                | 74.3 | 28.2 |
| Average damage level in community  |                                     |
| Destruction (5)                    | 65.7 | – |
| (4–5)                              | 11.8 | – |
| Very heavy damage (4)              | 27.7 | 22.7 |
| (3–4)                              | 32.5 | – |
| Heavy damage (3)                   | 6.6  | 25.9 |
| Moderate damage (2)                | 4.3  | – |
| Negligible or slight damage (1)    | 2.7  | – |
| Community access                   |                                     |
| Vehicular                          | 45.8 | 77.5 |
| Walking only                       | 54.2 | 22.5 |
| Community assistance               |                                     |
| High                               | 83.4 | – |
| Medium                             | 6.6  | 43.0 |
| Low                                | 10.0 | 57.0 |
| Gender                             |                                     |
| Female                             | 57.6 | 43.0 |
| Male                               | 42.4 | 57.0 |
| Caste                              |                                     |
| Dalit                              | 7.4  | 10.2 |
| Janjati                            | 77.5 | 55.5 |
| Brahmin                            | 5.2  | 27.0 |
| Other                              | 10.0 | 7.3  |
| Livelihood                         |                                     |
| Agriculture                        | 74.5 | 81.1 |
| Construction                       | 25.1 | 20.5 |
| Education                          | 2.2  | 4.1  |
| Business                           | 8.9  | 6.1  |
| Military                           | 3.7  | 3.6  |
| Technical assistance               |                                     |
| Demonstration house                | 44.3 | 8.6  |
| Door to door technical assistance  | 22.1 | 8.6  |
| Household reconstruction orientation| 8.5  | 8.0  |
| Reconstruction coordination committee | 6.3  | 0.5  |
| Vocational training                | 2.2  | 7.4  |
| Short training                     | 20.3 | 14.5 |
| Funding                            |                                     |
| Household earnings                 | 16.6 | 7.7  |
| Relatives                          | 8.5  | 1.8  |
| Community                          | 2.2  | 6.4  |
| Savings                            | 53.1 | 20.7 |
| Government                         | 83.8 | 75.2 |
| Loan                               | 66.8 | 37.7 |
mechanisms. On one hand, the provision of technical assistance in the form of training allows knowledge sharing and education relating to hazard resistant techniques and their implementation. On the other hand, training programs, if effective, enable households to have greater capacity to identify deficient construction. Our results show that 40% of households in Okhaldhunga and 46.6% in Gorkha still felt their reconstructed house would be unsafe in case of a big earthquake. We hypothesize that awareness of safety risks was raised, yet abilities to address safety issues in practice were not sufficiently facilitated.

We were unable to conclude whether the intensity of assistance played a role in feelings of safety, possibly due to the wide variation in methods applied. However, we did find specific methods of assistance that showed impact. As would be expected, demonstration houses and short trainings of masons correlated with higher odds of feeling safe. We also expect that some assistance methods make people feel capable of taking action, apart from raising awareness. Demonstration houses and short mason trainings are more hands-on and show “how” to build back safer, covering tacit procedural knowledge [59,60]. In contrast, door-to-door assistance and household orientations may not be sufficient for households to act and mitigate risks. In both districts, we see the same trend, although with mixed statistical significance to confirm this uniformly.

Surprisingly, some assistance methods were negatively correlated with feelings of safety. In Gorkha, feelings of unsafe housing correlated with door-to-door assistance and household orientations. These are both communication methods that rely on two-way exchanges, often tailoring knowledge to receiver. Studies have repeatedly stressed the benefits of such exchange based communication, emphasising the importance of knowledge interactions to find appropriate solutions [61,62]. We argue that this knowledge exchange has raised awareness and understanding of seismic risks that could impact an individual’s house. As individuals acquire knowledge of building safer housing, this creates a high standard of construction within the community. If there is the inability to meet this set standard, households may question the safety of their home. Their feelings of unsafe construction might be explained by their

Table 3
Binomial logistic regression results.

| Variable | Gorkha | | | | | | Okhaldhunga | | | |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|          | OR      | S.E.    | Lower   | Upper   | OR      | S.E.    | Lower   | Upper   |
| Control  | 0.991*** | 0.003   | 0.985   | 0.997   | 1.014*  | 0.007   | 1.000   | 1.029   |
|          | 95% CI for OR | | | | | | 95% CI for OR | | | |
| Average damage levels in community (ref: Heavy damage (3)) | | | | | | | | | |
| Negligible or slight damage (1) | – | – | – | – | 1.312 | 0.787 | 0.281 | 6.130 |
| Moderate damage (2) | – | – | – | – | 0.982 | 0.614 | 0.295 | 3.270 |
| (3–4) | – | – | – | – | 1.072 | 0.394 | 0.496 | 2.321 |
| Very heavy damage (4) | 2.759 | 1.345 | 0.198 | 38.495 | 1.317 | 0.422 | 0.576 | 3.010 |
| (4–5) | – | – | – | – | 0.422 | 0.678 | 0.112 | 1.594 |
| Disaster (5) | 0.029** | 1.415 | 0.002 | 0.465 | – | – | – | – |
| Access (ref: Vehicular) | | | | | | | | | |
| Walking path only | 3.757** | 0.581 | 1.204 | 11.730 | 2.704*** | 0.429 | 1.166 | 6.272 |
| Assistance intensity (ref: Low) | | | | | | | | | |
| Moderate | – | – | – | – | 0.598 | 0.379 | 0.628 | 2.773 |
| High | 0.856 | 0.618 | 0.255 | 2.873 | – | – | – | – |
| Gender (ref: Male) | | | | | | | | | |
| Female | 1.294 | 0.359 | 0.640 | 2.617 | 0.920 | 0.251 | 0.562 | 1.504 |
| Caste (ref: Other) | | | | | | | | | |
| Dalit | 0.952 | 1.043 | 0.123 | 7.359 | 1.049 | 0.565 | 0.347 | 3.171 |
| Janjati | 0.943 | 0.669 | 0.254 | 3.497 | 1.637 | 0.509 | 0.603 | 4.460 |
| Brahmin | 0.220 | 0.977 | 0.032 | 1.492 | 0.651 | 0.520 | 0.235 | 1.804 |
| Agriculture | 1.348 | 0.398 | 0.618 | 2.938 | 1.320 | 0.379 | 0.628 | 2.773 |
| Construction | 0.661 | 0.432 | 0.284 | 1.541 | 0.747 | 0.341 | 0.383 | 1.459 |
| Education | 5.229 | 1.210 | 0.488 | 56.020 | 2.336 | 0.656 | 0.646 | 8.449 |
| Business | 1.739 | 0.620 | 0.516 | 5.859 | 0.587 | 0.529 | 0.208 | 1.655 |
| Military | 0.287 | 0.827 | 0.057 | 1.450 | 0.996 | 0.660 | 0.274 | 3.629 |
| TA | | | | | | | | | |
| Demonstration house | 2.600** | 0.416 | 1.150 | 5.876 | 1.802 | 0.435 | 0.768 | 4.226 |
| Door to door technical assistance | 0.118** | 0.522 | 0.042 | 0.329 | 1.083 | 0.448 | 0.450 | 2.609 |
| Household reconstruction orientation | 0.477 | 0.699 | 0.121 | 1.876 | 0.279*** | 0.484 | 0.108 | 0.721 |
| Reconstruction coordination committee | 2.271 | 0.789 | 0.484 | 10.658 | 0.057 | 1.532 | 0.003 | 1.147 |
| Vocational training | – | – | – | – | 0.782 | 0.484 | 0.303 | 2.018 |
| Short training | 0.869 | 0.476 | 0.342 | 2.209 | 0.279*** | 0.386 | 0.131 | 0.595 |
| Funding | | | | | | | | | |
| Household earnings | 1.708 | 0.462 | 0.691 | 4.222 | 1.460 | 0.458 | 0.595 | 3.580 |
| Relatives | 0.678 | 0.596 | 0.211 | 2.181 | 0.744 | 0.931 | 0.120 | 4.611 |
| Community | 0.617 | 1.051 | 0.079 | 4.844 | 1.364 | 0.550 | 0.464 | 4.004 |
| Savings | 1.416 | 0.378 | 0.675 | 2.973 | 2.673*** | 0.350 | 1.346 | 5.309 |
| Government | 0.751 | 0.457 | 0.306 | 1.839 | 2.410*** | 0.321 | 1.284 | 4.522 |
| Loan | 0.758 | 0.377 | 0.362 | 1.588 | 1.053 | 0.300 | 0.585 | 1.895 |
| Constant | 24.126** | 1.508 | 1.050 | 126.456 | 0.213* | 0.918 | | |
| Chi² (X²) | 120.196 | 126.456 | 0.478 | 0.338 | | | | |

***, **, and * refer to p < 0.01, p < 0.05, and p < 0.1, respectively.
feeling of urgency to improve their house. Therefore, we question if feeling unsafe is a negative outcome, as it may indicate higher awareness of risks. Households might be more inclined to consider future investments in housing safety and leave buildings in case of an earthquake. Despite the positive connotations of additional training, the consequence of being risk aware may instil greater fear within communities.

5.2. Which type of technical assistance is most effective?

Technical assistance should be accessible and adaptable to communities whilst complementing the recovery process. Across each of the six types of technical assistance provided to communities, we pose a series of observations and implications as follows:

- **Demonstration houses** were widely provided in both Gorkha and Okhaldhunga (5 out of 8 communities in Gorkha and 6 out of 13 in Okhaldhunga). In these communities, demonstration houses were clearly visible. In both districts, there was a positive relationship between demonstration houses and safety perceptions. We stress that demonstration houses are the only type of assistance that show a clear positive impact on safety perceptions. Learning through a visual medium, requires limited pre-existing knowledge from individuals. Households could easily recognise visual similarities of their house with the demonstration house. Like other studies [22,63,64], we hypothesize that, demonstration houses enable applicability of technical knowledge, contributing to feelings of safety. The communities often participated in the construction of demonstration houses, enabling people to observe less visible techniques. Therefore, we found that being exposed to a demonstration house was positively correlated with higher safety perceptions in Gorkha. Due to sample size restrictions, we cannot confirm a causal relationship in Okhaldhunga. However, this does not necessarily indicate that demonstration houses are not important. We hypothesize that the lower reconstruction pace, and the relatively late construction of the demonstration houses in Okhaldhunga might have slightly reduced its impact on perceptions of safety. We believe that the timing of the introduction of demonstration houses may have come during a time when reconstruction was losing its momentum. Furthermore, how demonstration houses were presented and applied communities did vary for respondents, often blending with other forms of technical assistance that made it difficult to theoretically isolate for the impact of this type of technical assistance. This hypothesis is supported by a relatively low recollection of the demonstration houses in Okhaldhunga.

- **Door to door assistance** was associated with lower perceived safety, only significant in Gorkha. In our sample, in 5 out of 8 communities in Gorkha door to door assistance was provided. In Okhaldhunga, only 1 community had received door to door assistance. The small sample size in Okhaldhunga, explains the lack of significance. We explain the negative impact on perceived safety in Gorkha due to raised awareness. This program relied heavily on verbal communication and interaction. One possible explanation is that households obtained a more profound understanding of structural risk enabling them to identify crucial deficiencies. This lower perception of safety might indicate a learning process and growth.

- **Reconstruction coordination committee** showed ambiguous impact on safety perceptions. These committees enhanced feelings of safety in Gorkha, potentially explained by the strong network and links to other interventions that these reconstruction coordination committees. The negative impact in Okhaldhunga can possibly be explained by limited possibilities for aid in that district.

- **Vocational training** was only found in Okhaldhunga (in 5 communities) and showed an insignificant negative impact on feelings of safety. We hypothesize that this hands-on training was too short to fully cover reconstruction techniques in practice, or that

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**Fig. 3.** Positive (green) and negative (red) impact on perceived housing safety in case of a large earthquake, with the lower and upper bounds of the 95% confidence intervals.

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| Technical assistance typologies               | Gorkha          | Okhaldhunga       |
|-----------------------------------------------|-----------------|-------------------|
| Demonstration house                           | 1.150 - 5.876   | 0.266 - 4.226     |
| Door to door technical assistance             | 0.042 - 0.329   | 0.450 - 2.609     |
| Reconstruction orientation committee          | 0.484 - 10.658  | 0.005 - 1.147     |
| Vocational training                           | 0.342 - 2.209   | 0.303 - 2.018     |
| Short training                                | 0.121 - 1.876   | 0.131 - 0.595     |
| Household reconstruction orientation          | 0.104 - 0.721   |                   |

The numbers indicate the 95% confidence interval of odds ratio.
households were not in the possibility to implement the techniques in practice due to financial limitations or other needs. During our field work, masons mentioned not to be able to implement everything they had learned because they were not the ones paying.

- **Short trainings** for masons, were given in all communities in Gorkha, compared to 11 out of 13 in Okhaldhunga. Short trainings resulted in lower perceptions of safety in both models, yet only significant in Okhaldhunga. We again explain the negative impact on safety perceptions due to the raised awareness, and inability to fully address them in practice.

- **Household reconstruction orientations** were not widely provided in both districts (only 3 communities in Gorkha and 1 community in Okhaldhunga). Household reconstruction orientations showed lower perceptions of safety, only significant in Okhaldhunga. Despite the lack of significance in Gorkha, we see the same trend in both models. We hypothesize that, orientations primarily raised awareness without giving hands-on assistance in the implementation. This could have therefore increased perceived lack of safety.

In our analysis, we step away from purely binary explanations of the impact of technical assistance. Fig. 3 summarized the main impact of technical assistance on perceptions of safety, stressing the positive or negative direction of the impact. Our case knowledge also explains the feeling of unsafety through the lack of suitability of housing design and the lack of construction progress. Many households were not (yet) living in the new house as it did not meet their family needs or was not yet finished. Some households were found to accept the risk of living in their larger damaged house over living in the smaller safer house.

The Nepalese government approached housing reconstruction both as a privilege and an obligation. Funding was based on damage assessments and received with gratitude. Yet, strict designs needed to be followed to assure seismic resistance to accessing funding. In addition, funding was insufficient to cover the cost and not reconstructing at all was not an acceptable option for the government. In other countries, more liberty was given to the affected households after major disasters events. Literature has stressed the importance of building back “better” in the eyes of those affected as opposed to building back “safer”, acknowledging that affected households know what is best for their own development. For example, in the Philippines construction materials or financial assistance were provided based on the damage assessment after typhoon Haiyan, yet application of hazard-resistant construction techniques was not enforced [42]. Although freedom in the decision making is indeed crucial to enhance resilience, housing safety was not always improved, for example after the 2004 Indian Ocean tsunami [6,65]. Therefore, recovery approaches are heavily discussed in literature [4,8,43,66,67].

Earlier studies also claimed the positive role of demonstration houses as a tool to understand reconstruction techniques [68,69]. Yet, they were not earlier connected to perceptions of safety. Personal conversations, such as door-to-door assistance were earlier identified as effective method to select appropriate techniques together with the affected households [22]. Our interpretation acknowledges the value of door-to-door assistance as tool for effective knowledge exchange and learning. Repeatedly, substantial funding is invested in vocational training and short carpenter trainings in the aftermath of disasters. Working alongside local carpenters is seen as one of the main pathways for fundamental change of the construction practice [70,71]. Our results show a negative side effect of training, raising awareness and understanding of where safety is not fully obtained. Our results show that training is only useful if there are possibilities to apply the acquired knowledge and skills in practice.

5.3. Funding – a critical resource?

Previous research has pointed to the importance of funding to supporting housing recovery [47,48,72]; our analysis sought to more closely examine how the potential source impacts perceived outcomes. Government funding is often the primary mechanism of supporting permanent housing reconstruction [52]. Our analysis of funding sources leads to three main take-aways: 1) if funding is sufficient, feelings of safety can be enhanced, 2) low perceptions of safety are not necessarily a negative outcome, 3) conditional funding stimulates risk awareness that can have both positive and negative impact of feelings of safety.

Insufficient funding can lead to poor resource procurement, ineffective training, and a quality of aid that does not meet minimum standards [43,52]. Our results indicate that, sufficient recovery funding can have a positive impact on safety perceptions, as people are able to meet safety standards. We found that only two funding sources, government funding and household savings, were significantly correlated to safer housing perceptions, only in the district where limited assistance was given (Okhaldhunga). Governmental funding itself was insufficient to meet the required seismic resistant guidelines and to cover the complete construction costs. Our fieldwork uncovered complaints implying a considerable discrepancy between the amount they received and their actual costs of reconstruction. People were placed in a position where they had to use their life savings to receive financial support, needing to prioritise housing safety over other development needs. In Okhaldhunga districts, savings were crucial to establish safety feelings. Sourcing funding from household earnings, the local community, and loans had positive correlations with safety perceptions, while sourcing from relatives was negatively correlated, however none of these were found to be statistically significant. As compared to government and savings, these other sources constituted a relatively smaller portion of construction costs.

The provision of funding can also be seen as an opportunity for communities, especially in low- and middle-income countries to progress and implement sustainable change. However, studies have shown that, early reconstruction that lacks resourcing can lead to unsafe and unsustainable construction as agencies are under time pressures to show primarily visible results [73]. We also question the long-term impact of government funding in Nepal. Reconstructed houses were generally built according to seismic resistant guidelines. However, households showed dissatisfaction with the design of the governmental houses and revealed intentions to change their house. Design alternations, adding additional rooms or floors, can seriously harm the seismic resistance of the newly built houses. Households also mentioned plans to improve future safety of their house. This may be indicative that households recognise that the government funding processes need improvement. However, it could also denote that through government funding programs households develop awareness for areas where they still lack safety. The funding procedure integrates an opportunity for knowledge
transfer and learning. We suggest developing incremental housing strategies that align with the timeline of household development, assuring a more sustainable solution. Although we have not analysed the interaction between funding and technical assistance, earlier studies have shown that awareness of risks and abilities to take action are connected [40,42,69]. In the model for Gorkha, we believe that highly intensive technical assistance alongside funding raised safety ambitions.

Funding can act as incentive for communities to participate and inform a more sustainable recovery. We believe conditions to funding were crucial to raise awareness of seismic risks and enhance safety perceptions in Okhaldhunga. In Nepal, tranches were only received after households demonstrated to a credited engineer that they had built to design standards specified by the National Reconstruction Authority [74]. Complying with these strict guidelines, and receiving a financial reward, could explain the impact on perceived safety in Okhaldhunga. However, we also question if this the significant pressure placed by the government to comply with safety standards was justified. Households felt forced to meet reconstruction standards, threatened with exclusion from future governmental support. Forcing the use of household savings and creating a necessity to take loans just to comply with national standards, can have a negative impact on household development. In addition, the governmental funding showed inefficiencies, and due to accessibility and a complex system, applications for the tranches caused significant delays [74]. We recommend limiting conditions for the recovery funding to grant households their own priorities aligned with contextual possibilities.

5.4. Limitations and future research

To validate the levels of technical assistance received by households, we compared the types of assistance that a household reported against activities reported by HRRP to have occurred in a respondent’s community. We would not expect to see all households in a community to have reported receiving some types of technical assistance. For example, not all households were offered the opportunity to participate in a vocational training. However, comparing individually reported rates of receiving technical assistance allows us to examine whether households who may have indeed received technical assistance had omissions in their survey response. The percent of households who reported receiving technical assistance in communities where activities were reported by HRRP were low. Generally, less intensive types of technical assistance had lower reporting in household surveys where we know activities occurred. The technical assistance variables are thus likely to more strongly correlate with households who had higher recall. For example, demonstration houses were recalled 35.4% in Gorkha and 18.4% in Okhaldhunga. Door to door assistance were often recalled in Gorkha (20.8%), and little in Okhaldhunga (8.3%). Similarly, short trainings were more recalled in Gorkha (20%) than in Okhaldhunga (16.1%). Vocational trainings were most recalled in Gorkha (45.1%) and very little in Okhaldhunga (7.3%). As a result, we note that there were potential concerns over recall of technical assistance activities by households. This was expected given the time during which data was collected (nearly three and half years into recovery).

Future research should make additional attempts to consider combinations of variables beyond just their influence as standalone factors, better contextualising the intersection of housing support mechanisms. This systematic deconstruction of combinations of housing assistance holds potential to more efficiency utilise resources in recovery programs. For example, our study constructed high, medium and low intensities of technical assistance to explore the joined influence of assistance. We believe further exploration of the intensity of assistance merits additional study as well as more passive types of technical assistance.

In Gorkha, humanitarian assistance showed the strongest correlations with feelings of safety, whereas in Okhaldhunga, governmental assistance had the strongest impact. Therefore, we question if resources and knowledge empower. Knowledge provided by NGOs generates understanding yet does not always enable and facilitate action and implementation. Resources, primarily governmental funding for materials, has generated positive safety perceptions in Nepal. These resources seem to take away a crucial barrier and enable action. Although many studies have already stressed the value of cash-based interventions, this study calls to explore causal relationships between resources, knowledge, and reconstruction decisions.

As we highlighted earlier, two-way exchange of knowledge is often cited in literature as more effective over unidirectional communication. However, our study has shown that this may also lead to negative safety perceptions. There is a need to further explore the implications of these negative perceptions. Additional work is also needed to define and operationalise safety outcomes in humanitarian response. In this study, we have represented safety outcomes through household perceptions, situating and measuring this outcome through local perspectives, but recognise that longer term assessments are needed to definitively comment on impacts of the support mechanisms considered. In this study, we only measured perceptions of safety and not a household’s actual understanding. Perceptions might explain understanding, yet this needs to be explored in further research.

We also only focused on two districts in Nepal, and further research will be needed to understand long term recovery trajectories of other districts after the Gorkha earthquakes. We assessed a moment within the reconstruction phase yet did not control for pre-existing knowledge or changes of understanding and safety perceptions over time. Communities with higher damage levels might have a stronger trauma. It is unclear how personal experiences of disasters influence future construction decisions. Further research is needed to explore if and how traumas stimulate building back safer housing. Remoteness, identified by access through a walking path only, shows to correlate with higher perceptions of safety. This might be explained by a lack of knowledge, (false) confidence in community support, or other priorities that overshadow the importance of housing safety.

6. Conclusions

Achieving safe housing outcomes continues to be a complex task in post-disaster recovery. This research explored two support mechanisms – technical assistance and funding – to understand their impact on household perceptions of the safety of housing construction practice in the aftermath of the 2015 Gorkha earthquakes in Nepal. We call to rethink how recovery outcomes are assessed, measuring the impact of support on household-defined metrics. By exploring safety perceptions, our results raise continued debate...
over how scholars have measured and conceptualised safety standards, including acceptable limits and by who. Those affected by disasters are often the most marginalised, having to balance daily crises with the need for safe housing. Our study takes an initial step toward understanding how assistance mechanism shape these outcomes.

Influencing perceptions, and thereby awareness of safer construction, is an important proposition to build more resilient recovery practices. We selected Gorkha where assistance was higher, and Okhaldhunga where assistance was lower, to compare potential differences in recovery funding. We found that both funding and technical assistance do correlate with perceptions of safety, yet only certain types, and not in all cases. In Gorkha we found that 55% of households felt their current house was safe in the event of a large future earthquake, while 60% of households in Okhaldhunga felt safe. This study contributes to the evolving discourse of post-disaster housing assistance, providing new insights on the types of support to lead to locally understood safety outcomes.

We found four types of technical assistance that were correlated with household perceptions of safety, which included demonstration houses, door to door technical assistance, household reconstruction orientations, and short trainings. The first of these, demonstration houses resulted in higher odds of safe perceptions, while the latter three all had an inverse relationship. The lower perception of safety is hypothesised to be explained by household recognition of safer construction practices, or the lack thereof. However, further research is needed to understand and unpack these specific formats and their impact on how households understand the safety of their homes. The limited, lacking, and negative correlations of technical assistance and safety perceptions raise questions as to the efficacy of some training and information formats.

Funding sourced from government programs and personal savings in Okhaldhunga correlated with higher perceived safety. This could be a result of closer oversight in how resources are used and the quality of construction, which past research has shown to be important. No relationship was found between funding and perceptions in Gorkha, although we expect this may be because government funding was so widespread in the sample. Our findings point to leveraging household financial resources where possible, supplemented by government funding, to incentivise awareness of building safety. Importantly, our findings point to the importance in future research to examine the potential role of funding as a prerequisite for technical assistance and the linkages between these two inputs.

Our results make important contributions to scholarship of post-disaster housing studies by deconstructing two factors – technical assistance and funding – that are often claimed to be important, but with limited nuance in whether this is consistent across format and source, respectively. Practically, this knowledge offers governments and organisations an opportunity to more strategically consider how they support communities to improve risk awareness. To promote safer building outcomes, care must be taken to understand what type of aid is prioritised by those in need of housing reconstruction instead of generalising and creating blanket solutions. As our research shows, the format of early recovery assistance has the potential to shape longer term community views of housing. With a community-centred approach, household priorities towards reconstruction can be placed in the hands of households who are best positioned to manage risk [75,76].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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