HOUSEHOLD CONSTRUCTION KNOWLEDGE ACQUISITION IN POST-DISASTER SHELTER TRAINING

Aaron Opdyke[1]; Amy Javernick-Will[2]; Matthew Koschmann[3]

This is a post-peer-review, pre-copyedit version of an article published in the *International Journal of Disaster Risk Reduction*. The final authenticated version is available online at: https://doi.org/10.1016/j.ijdrr.2018.02.038

To cite this paper, please reference the version of record: Opdyke, A., Javernick-Will, A., and Koschmann, M. (2018) "Household Construction Knowledge Acquisition in Post-Disaster Shelter Training." *International Journal of Disaster Risk Reduction*. 28, 131-139. doi: 10.1016/j.ijdrr.2018.02.038

ABSTRACT

The incorporation of safer building practices into shelter after disasters continues to plague recovery efforts. While limited resources are one potential cause, evidence from case studies suggests that poor adoption of safer construction may stem from a knowledge deficit. Despite these shortcomings, previous research has done little to examine the current state of construction education and training in post-disaster shelter and housing, and there is lacking evidence to support how households acquire new knowledge of construction practice. Examining nineteen shelter projects in the Philippines following Typhoon Haiyan, training methods were categorized using Kolb's experiential learning theory poles. Fuzzy-set qualitative comparative analysis (fsQCA) was then used to analyze the impact of these methods on community construction knowledge. Findings reveal that households acquired knowledge either through a combination of formal training methods that encompassed reflective observation, active experimentation, and concrete experiences or alternatively through observation of on-site construction activities.

Keywords: shelter, training, fuzzy-set qualitative comparative analysis

INTRODUCTION

The principle of 'build back better' has been a driver of humanitarian shelter response for the last two decades. The meaning of this tagline has been explored with rigor (Kennedy et al. 2008; Rahmayati 2016), leading to an ever growing body of research that explores the drivers of improving the quality of shelter rebuilt for, and by, those affected by disaster. In particular, the mantra has resulted in refocused efforts to not only restore building practices, but address underlying knowledge gaps among local building construction stakeholders. In this research we will focus on household knowledge, as they play a key role in commissioning construction efforts after a disaster. Despite new insights, there continues to be disproportionate disaster damage to housing in low-income countries (UNISDR 2016). Further, the scale and frequency of disasters has led to a strained humanitarian system struggling to keep pace in responding with shelter needs (Georgieva et al. 2016).

Given these challenges, there is increasing recognition of the need to transform 'the way reconstruction programs are conceived and implemented' (Turnbull et al. 2015 p. 58). Part of this transformation involves implementing organizations shifting from a focus on delivering products to facilitating processes in disasters. Though such approaches, affected populations are rightfully gaining a central role in shaping their own recovery. Training and education are becoming necessary components of humanitarian shelter assistance, cited as crucial in building capacities that aid hazard mitigation and safer building techniques.

[1] School of Civil Engineering, University of Sydney, Sydney, NSW 2006, Australia; aaron.opdyke@sydney.edu.au

[2] Department of Civil, Environmental, and Architectural Engineering, University of Colorado Boulder, Boulder, CO 80309, USA; amy.javernick@colorado.edu

[3] Department of Communication, University of Colorado Boulder, Boulder, CO 80309, USA; koschmann@colorado.edu

The Sendai Framework goes as far as to, "Promote the incorporation of disaster risk management into post-disaster recovery… through the development of measures such as land-use planning, structural standards improvement and the sharing of expertise, knowledge, post-disaster reviews and lessons learned rehabilitation processes…" (UNISDR 2015).

More broadly, however, we do not fully understand how individuals and households acquire safer construction knowledge after disasters and whether this knowledge is applied in practice. To do so, we need to better understand current construction training methods used for post-disaster shelter, and how these relate to longer term household construction knowledge. Therefore, we ask:

RQ1: What construction training methods are used in post-disaster humanitarian shelter projects?

In the context of the research, we define training as education programs that seek to impart knowledge of safe construction to households. Better understanding of the construction training methods in shelter projects will enable us explore how construction training may influence knowledge outcomes at a community level. Using findings from our first question, we thus ask the question:

RQ2: How does post-disaster construction training impact household construction knowledge?

We begin by discussing previous literature on construction knowledge and training methods in post-disaster contexts. Using interview and survey data collected following Typhoon Haiyan in the Philippines, we analyzed the types of training methods observed across nineteen shelter projects. Using these findings, we next analyzed the impact of training methods on construction knowledge outcomes.

BACKGROUND

We will first review literature on training in disaster contexts, summarizing key developments relating to training on safer construction then review experiential learning theory – one approach which can be applied to categorize educational methods.

Household Knowledge Acquisition after Disasters

The issue of safe shelter construction in post-disaster recovery has been a topic of sustained interest for disaster scholarship (Davis 2011). Recent research has pointed to social norms, self-efficacy, access to resources, perceived risk and severity of consequences, policy, and culture as key influencing factors on household decisions to invest in safer shelter (Turnbull et al. 2015). There is also growing evidence on the importance of secure land tenure, which has been indirectly linked to promoting investments in shelter (NRC and IFRC 2014). While these factors are important, none has received the same level of investment in programming from humanitarian organizations as training.

Past work in the disaster field has focused on the training of first responders (Paton 1994), humanitarians (Rajakaruna et al. 2017), and governments (Chou et al. 2015), however there is a dearth of research on post-disaster training of households, particularly relating to safe shelter construction. Numerous studies have identified training to be important for adoption of improved building practices (Amaratunga and Haigh 2011; Di Gregorio and Soares 2017; Jordan et al. 2015; Lizarralde and Root 2008), yet there remains a need to unpack training to examine how its impact differs across sectors and contexts. While it is understood that there is a positive correlation between training and increased capacity at the community level (Hagelsteen and Becker 2013), the means through which household learning occurs is not well understood. Specifically, calls in the literature highlight the need to study the *effectiveness* of post-disaster training programs (Kumar et al. 2015; Wang et al. 2008).

While training programs are the means through which organizations continue to operationalize knowledge sharing with disaster-affected communities, we lack the ability to compare these differences, in part, because of no standard definition of what is considered 'training.' The term 'training' is often used interchangeably with "information, education, and communication (IEC)," "technical assistance or support," and "guidance." Each of these is often discussed at different scales and each involves a variety of methods that seek to provide access to knowledge on safer building. There is a need to integrate theory of these post-disaster educational programs relating to safe shelter construction, building upon complementary work conducted in other sectors, such as psychosocial preparedness (Elangovan and Kasi 2015) and risk communication (Cole and Murphy 2014).

In humanitarian response, the cluster system is comprised of thirteen sectors that seek to coordinate organizations. Sectors broadly align with humanitarian practice (e.g. health, nutrition) – in the context of this research – the Shelter Cluster is central as they often develop and distribute guidance on construction training. For example, in the aftermath of Typhoon Hiayan in the Philippines, where this research focuses, the Shelter Cluster developed "8 Key Messages" that outlined key learning outcomes for households and builders to understand and apply.

Experiential Learning Theory

The Kolb Learning Styles Inventory (LSI) provides a means to quantitatively assess how individuals learn from experiences. We use LSI, which was first established in 1969 and has become a mainstream and validated instrument, to examine experiential learning theory (Kolb and Kolb 2005), to categorize training methods. LSI has been used across numerous international contexts and is thus a fitting tool to examine the impact of education methods (Joy and Kolb 2009).

The inventory is composed of four discrete learning orientations or poles: (1) concrete experience (CE), (2) reflective observation (RO), (3) abstract conceptualization (AC) and (4) active experimentation (AE). Concrete experiences emphasize personal involvement or connections, relying on feelings rather than logical approaches to a situation. Reflective observation is when a learner relies on their own thoughts to formulate objective and carefully constructed judgements, often through watching. Abstract conceptualization involves logical expressions and systematic planning that links to theoretical perspectives associated with thinking. Active experimentation takes form where the learner is immersed and influenced by changing situations and practical application through doing. Much of Kolb's theory has been explored through the lens of learning styles, yet relatively little research has explored methods that may potentially align with the respective poles.

METHODS

We used a multi-method approach to address the research questions, investigating training in shelter projects in the Philippines following Typhoon Haiyan. Nineteen communities were selected, each receiving shelter assistance from a non-governmental organization (NGO). For this research, we defined a shelter project as any intervention by an organization external to the community that sought to provide shelter assistance. In this context we defined a community as a barangay, the lowest political division of the Philippines. Examples of shelter assistance included in-kind assistance (e.g. construction materials), direct-build construction (e.g. contractor built shelter), conditional cash, and training. Communities were a mix of inland and coastal, urban and rural, but all shared similar levels of damage, approximate size, and presence of external aid. Further, all shelter assistance occurred during approximately the same time period, typically starting 6 months after the typhoon and ending within 2 years. The studied training programs also occurred at similar points in time after the disaster. More information on the specific shelter cases selected can be found in Opdyke (2017).

To answer our first research question of what training methods are used in shelter projects, we used qualitative analysis to analyze the occurrence of various training methods. We then analyzed surveys that assessed construction knowledge and employed ANOVA tests to verify differences in construction knowledge between communities. Finally, using fuzzy-set qualitative comparative analysis (fsQCA) we compared the presence of training methods mapped against Kolb's four learning poles which led to higher construction knowledge scores of households in the identified communities. We selected fsQCA as it is appropriate for cross-case comparisons of moderate case numbers, retains within case complexity, and leverages case knowledge to supplement quantitative data.

Data Collection

Two sets of data were used to address the research questions identified; first we collected interview data, observations, and documentation which was used to assess training formats. We then administered a survey to households to assess construction knowledge.

Qualitative Assessment of Training Methods

In total, 210 interviews were conducted with households, NGO staff, and government officials over four field visits spanning three years. Relevant to training programs, these included local builders, beneficiaries of shelter assistance, local building officials, and training leads for humanitarian organizations.

Organizations were asked to describe any construction training to the communities selected. Examples of interview questions pertinent to training included *'How is training administered?'* and *'What materials do you use to train individuals?'* Follow-up questions were asked during ongoing field visits over the three-year period to assess whether training methods evolved or changed, targeting potential reasons for such modifications. We asked similar questions of community members, including questions that asked them to describe the training they received in order to validate organizational interviews. Example interview questions included, *'Can you describe any training you received?'* and *'What skills or knowledge did you learn?'* A local translator was used to ask questions in the household's native language, either Bisaya or Waray. Households were also asked to compare their new shelter with their home prior to Haiyan. In the event they identified a stronger building practice, they were asked how they acquired this knowledge. This was to account for non-traditional or emergent forms of learning that may not have occurred in formal, organization-led training programs.

Observations included attending eight organization training sessions, five cluster coordination meetings that addressed training strategies, and more than 120 hours of ongoing construction within communities. Field notes included identifying methods that were employed by organizations, such as lectures, and any specific tools that were used during sessions. Other practices observed during construction, such as identifying who was watching or assisting construction activities, were also noted. Documentation collected included material checklists, pre- and post- tests administered by organizations, and Shelter Cluster posters provided to communities on construction recommendations.

Construction Knowledge Survey

A notable output of Shelter Cluster coordination during the Haiyan response was '8 Key Messages' on safer building. These themes included: (1) foundations, (2) tie-downs, (3) bracing, (4) joints, (5) roofing, (6) site selection, (7) building shape, and (8) preparedness. Standards within each category were provided to organizations delivering shelter assistance, resulting in their widespread distribution to communities, either directly through documents that the Shelter Cluster produced or that were adapted and integrated into organizational training efforts. Key message guidance was first distributed in June of 2014, approximately seven months after Haiyan. To assess construction knowledge, we developed a fifteen question survey, which was based on the technical guidance produced by the Shelter Cluster, as this aligned with broad learning outcomes agreed upon by humanitarian organizations. The full survey can be found in Opdyke (2017).

Questions included six multiple choice questions (select one and select all that apply), six rank order questions and three true/false questions. Standards were taken verbatim from Shelter Cluster documentation as we intended to test knowledge that was standardized as best practice across organizations. For example, when asking about tie-downs, four alternatives were listed with a picture and description, and respondents were asked to rank components in order from strongest to weakest. This was then scored based on the distance of ranked items from their correct positions. Each question was weighted equally. The themes of tie-downs, location, slope, preparation, roofing each had one question; foundations, bracing and joints had two questions. Themes with a larger number of questions had more individual recommendations in the original Shelter Cluster guidance or we identified the initial guidance to be more complex than the other themes. The questions sought to test understanding of principles rather than detailed standards, mirroring guidance in the '8 Key Messages.'

In total, we collected 880 surveys from individuals across the nineteen studied communities. Responses were solicited from both those that participated in training as well as those that did not. Surveys were provided in written format and provided in the native language of the household, either Bisaya or Waray. A local research assistant administered the surveys so that any questions could be addressed in the participant's native language. Households were selected using a stratified random selection, using puroks (neighborhoods) as the strata. This geographic approach to sampling was selected in the absence of any database to perform true random selection methods. Minimum sample sizes were determined for each community using known populations and expected variance in test score data. A minimum threshold of 20 surveys per community was determined from sample size calculations.

In addition to testing construction knowledge, we also collected data on respondents' gender, education level, age, previous construction experience, English proficiency, and place of birth. Educational levels were assessed as: (a) no formal education; (b) some elementary; (c) elementary graduate; (d) some high school; (e) high school graduate; (f) some college; and (g) college graduate. English proficiency levels were selfassessed by households as: (a) beginner; (b) intermediate; (c) advanced; and (d) fluent. Finally place of birth was categorized as either: (a) within barangay; (b) within municipality; (c) within province; or (d) outside of province.

Analysis

Our analysis consisted of first characterizing the types of training observed, verifying differences in construction knowledge across communities using ANOVA, and then calibrating our data for use in fsQCA to examine causal conditions that led to higher construction knowledge.

Categorizing Training Methods

To answer our first research question of what types of training methods are used in shelter projects, interviews were translated, transcribed, and then imported into QSR NVivo software for qualitative coding. We adopted a deductive coding structure derived from experiential learning theory in order to classify observed training methods into the four Kolb poles – concrete experience, reflective observation, abstract conceptualization, and active experimentation. These were selected in order to categorize the underlying delivery mechanisms of training, affording more detail and generalizability. For example, one household described training they received on construction techniques as follows, *"We were given photocopies of the picture of the house and a poster was posted in the barangay. There was an illustration of the house plan and the picture of a completed house."* This was coded under reflective observation as households presented these learning modalities noted the visualization of knowledge in a reflexive manner. Coding definitions and examples are presented in Table 1.

Table 1: Training Qualitative Coding Structure

Kolb Pole	Coding Definition	Examples
Concrete Experience (CE)	Tangible, felt qualities of the world through immersion of hypothetical situations	Community stories; historical experiences
Reflective Observation (RO)	Passive participation involving listening or visualization	Pictures; lectures
Abstract Conceptualization (AC)	Thinking about, analyzing, or systematically planning, rather than using sensation as a guide	Diagrams; maps
Active Experimentation (AE)	Ability to engage with objects or materials through testing or trial and error	Material demonstration

A second coder independently coded a sample of 42 interviews (two interviews from each project case and four cross-cutting interviews) and inter-rater reliability scores, in the form of Cohen's Kappa coefficient, were calculated in order to ensure robust construct validity. Kappa values of 0.4 were used as a threshold for acceptable agreement (Landis and Koch 1977). In the case that any interview did not meet this threshold, both coders revisited coding until consensus could be reached. Using interview codes, in combination with documentation and observations, we developed a typology of construction training methods used across shelter projects.

Linking Training Methods to Construction Knowledge

We first sought to verify that there were differences in construction knowledge across different communities using ANOVA. A significance level of 0.05 was assumed for statistical testing. Each of the individual 15 construction knowledge questions were scored from zero to one and summed for an overall test score for each individual surveyed. Some question types only had zero or one values, such as true/false questions, while others such as rank order, were scored based upon partial correctness. Individual scores were then averaged for each community, resulting in comparable numerical scores of construction knowledge. We found that there were statistical differences leading us to move to our next phase that explored these differences using fuzzy-set Qualitative Comparative Analysis (fsQCA). A discussion of the differences found using ANOVA is discussed below in our findings.

In the second phase of our research, we built on the identified training methods to examine which types of methods were more likely to lead to higher construction knowledge using fsQCA. Qualitative comparative analysis presents a middle ground between qualitative and quantitative methods, leveraging a set-theoretic approach to understand how combinations of conditions, equivalent to independent variables in conventional statistical analysis, in isolation or combination, lead to outcomes, or dependent variables in conventional analysis (Ragin 1987). Set theory is well suited to analyzing mixed-media data (such as training methods) and understanding the importance of conditions in isolation as well as in combination. An outcome of interest is first selected, in this case construction knowledge, and conditions are identified that are posited to influence this outcome. We hypothesized based upon theory that Kolb's four experiential learning poles in construction training would impact the outcome of construction knowledge, building upon our earlier analysis. From our previous qualitative analysis, households commonly discussed obtaining knowledge outside of formal post-disaster training, thus we included on-site observations as an additional variable. We also observed through participant accounts that experience with past typhoons was a key means of acquiring knowledge over time. Further, we also wanted to assess whether if formally structuring training had an impact on knowledge outcomes. Here, we defined 'formal' as whether the organization recognized the methods as constituting training and integrated these efforts into broader shelter programming. For example, if an organization intentionally built a pilot shelter to show concepts resulting in the ability of households to reflectively observe construction, this was considered formal training. Whereas, unplanned observations of neighbor construction would not be considered formal training. This resulted in six conditions being selected for analysis.

Variable Calibrations

The calibration of conditions is an important step in fsQCA as it provides theoretical context to measurement (Ragin 2009). The calibration process involves defining membership (1), non-membership (0), and fuzzy values in-between (if any are present). For each of the six conditions identified – training methods (concrete experience, reflective observation, abstract conceptualization, active experimentation), on-site observations, and formal training – we opted to use an indirect method of calibration that relied on qualitative data to structure sets. In contrast, we used a direct method of calibration for our outcome, construction knowledge, as the data was quantitative.

We calibrated our outcome variable, construction knowledge, based on the community average for each shelter project, drawing from survey data collected. After averaging test scores within each project community, we transformed the raw test score data using log-odds into fuzzy-set values for each community where projects were located. Anchors points were used to establish theoretical membership in the set; specifically, we set membership as 11 questions answered correctly or higher on our construction knowledge test and non-membership as 10 or less questions. While the difference between these two values is small, practically, we observed differences between cases in interviews. A crossover point was selected at 10.5, between the two anchors. This meant that all communities where average scores were 11 or above were assigned a value of 1, while communities with average scores below 10 were assigned a value of 0. Communities that fell between were assign values between 0 and 1, based upon transformed scores.

For our training conditions, we drew from Kolb's four learning 'poles' to structure our training conditions that included: (a) concrete experience; (b) reflective observation; (c) abstract conceptualization and; (d) active experimentation. While we could have alternatively selected individual training methods, this would have increased our logic space by growing the number of conditions considered, whereas Kolb's four poles provide greater parsimony toward underlying characteristics of training methods. Thus, for each of the four conditions corresponding to each respective pole, we opted to use a crisp set that was defined by the presence or absence of content in that given area (either 0 or 1). For example, if a shelter project was previously coded as including reflective observation in the training methods observed, this case was assigned a set score of 1. In order for a case to be scored as having membership in a given learning pole, there had to be consistent mention across interviews for that given case. Methods within each of the four Kolb poles were evaluated and scored based on the presence or absence of training formats in each respective area.

We calibrated on-site observations similar to the previous training methods, using a crisp set. Where households could observe construction, a set score of 1 was assigned, whereas the absence of this was assigned a value of 0. A common example of not being able to observe construction was through relocation or direct-build shelter projects. Our earlier calibration of training methods, did not explicitly include whether these methods were formal, or delivered through the implementing organization. As such, we also included a condition of whether the training was delivered through a formal training program associated with the shelter project. Further details of the condition and outcome calibrations can be found in Opdyke (2017).

Pathway Analysis

After assigning membership for each condition to the project cases, we compiled our truth table used for analysis of causal pathways. In total six conditions were selected for analysis. The final truth table is shown below in Table 2. Our truth table was then imported into fsQCA software for analysis (Ragin et al. 2008). Pathways were assessed using consistency and coverage measures. Consistency measures the degree to which cases with a given set of factors or conditions exhibit the outcome, where a consistency score of 0.8 is required, and coverage measures the degree to which a given pathway explains the cases analyzed, indicating the relevancy of each pathway (Rihoux and Ragin 2009). During this analysis, we also determined which individual conditions were *necessary* or *sufficient* to produce the outcome, where necessity is a measure of the degree to which the outcome is a subset of the causal condition and sufficiency provides a measure of the degree to which the causal condition is a subset of the outcome.

Table 2: Training Truth Table

Case	Community	CE	RO	AC	AE	Observations	Formal Training	Construction Knowledge
1	Okoy	1	1	1	1	0	1	0.56
2	Maricaban	1	1	0	1	1	0	0.94
3	Poblacion	1	1	0	1	0	0	0.34
4	Sungko	1	1	0	1	1	1	0.99
5	Sillon	0	0	0	0	0	0	0.07
6	Kangkaibe	1	1	0	1	1	0	0.98
7	Tagpuro	0	0	0	0	0	0	0.17
8	Pago	1	1	1	1	0	1	0.53
9	New Kawayan (101)	0	1	1	0	0	1	0.03
10	Bagacay (93)	1	1	1	1	1	1	0.88
11	San Agustin	1	1	0	1	1	1	1.00
12	San Jose (83C)	0	1	0	0	1	0	0.86
13	Magallanes (52)	1	1	1	1	0	1	0.09
14	San Jose (85)	1	1	1	1	1	1	0.9
15	Hiabangan	1	1	0	1	0	1	0.94
16	Sagkahan (62)	0	1	1	0	0	1	0.41
17	Sulangan	1	1	1	1	1	1	0.17
18	Cogon	0	0	0	0	0	0	0.59
19	Cantahay	1	1	1	1	1	1	0.89

FINDINGS

To answer our research question of what factors account for differences in household construction knowledge, three sections are presented below. The first outlines a typology of training types that emerged from the context of the Philippines. We then present a summary of construction knowledge test scores by community. Finally, we discuss causal pathways that led to higher construction knowledge.

Training Methods and Delivery

Of the nineteen communities studied, seven lacked any formal construction training programs. To reiterate, we considered any direct method of sharing knowledge between an organization and a household as formal training. Of the shelter programs that employed training, a typology of training formats emerged from our analysis. Of those projects that employed formal training, we found that six formal methods of providing construction training were used by organizations. More than one method of training could, and often did, appear in a single project. For example, it was common for organizations to combine a lecture, while also distributing posters with key messages in a community. In order of frequency of use, these included: (1) diagrams, (2) lectures, (3) demonstrations, (4) hand-out materials, (5) posters, and (6) photos. Frequencies of use are presented in Table 3.

Table 3: Training Methods Applied

Kolb Poles	Training Method	Frequency of Use
AC	Diagrams	75%
RO	Lecture	58%
AE	Demonstration	58%
RO	Hand-outs	50%
RO	Posters	25%
RO	Photos	25%
		N=12

RO – Reflective Observation;
AC – Abstract Conceptualization; AE – Active Experimentation

Diagrams were the most widely used method to provide training to households and consisted of housing blueprints or construction details drawn using two dimensional plans. For several organizations observed, this was the only means used to transfer knowledge to households on safer building practice. Lectures and demonstrations were the next most used training methods. These were commonly paired together in single day seminars, as one NGO staff member described, *"The morning was a lecture and then in the afternoon we actually built the little model house."* Lectures ranged in size from 20 individuals to more than 100 individuals in size and proved one of the simplest means of rapidly conveying information to large audiences. Demonstrations afforded the ability to test component and concepts and frequently made use of model shelters or scaled components. Hand-out materials, such booklets and flyers, were common in about half of programs providing training; however, interviews suggest that these were infrequently read by households. Posters and photos were the least observed methods of transferring knowledge.

In contrast to formal training, two other formats of learning emerged from our analysis. A number of shelter programs either required or recommended that households participate in the construction of their own shelter. This involvement was found to be a source of learning for many households, who, in some cases, took on construction tasks for the first time. Working alongside skilled laborers, lessons on safer building were often transferred from hired labor to households. One female household member described her husband's involvement in assisting with their shelter construction, *"No, they didn't really train him. They did not specifically teach us how things should be done. He just learned from them somehow, picked up a few ideas by assisting them during the construction."* In addition to household participation in construction, the second method of household learning that surfaced was watching construction, either on their own house or their neighbors' houses. Even in the absence of formal training methods, the observation of construction provided a means to examine and learn new construction methods, such as strapping and bracing.

Difference in Community Construction Knowledge

We next verified that there were differences in community construction knowledge. The average score on the construction knowledge test was found to be 10.62 (out of a possible 15) with a standard deviation of 1.59. This suggests that, on average, households answered questions correctly for about two-thirds of concepts targeted by recognized standards. Here we aggregated household knowledge scores, but recognize this represents only one component of community construction knowledge – builder's knowledge being the other primary contributor. We found that there were statistically significant differences in construction knowledge between communities ($F=3.293$, $p<0.01$). This verified that training programs were a potential variable in knowledge differences. A comparison of construction knowledge test score boxplots is shown below in Figure 1. This plot suggests that there are community-level factors that influence construction knowledge (e.g. training methods) and variation within communities suggests that there are also individual level attributes that influence construction knowledge. Specific training methods employed in respective communities shown in Figure 1 can be found in Table 2.

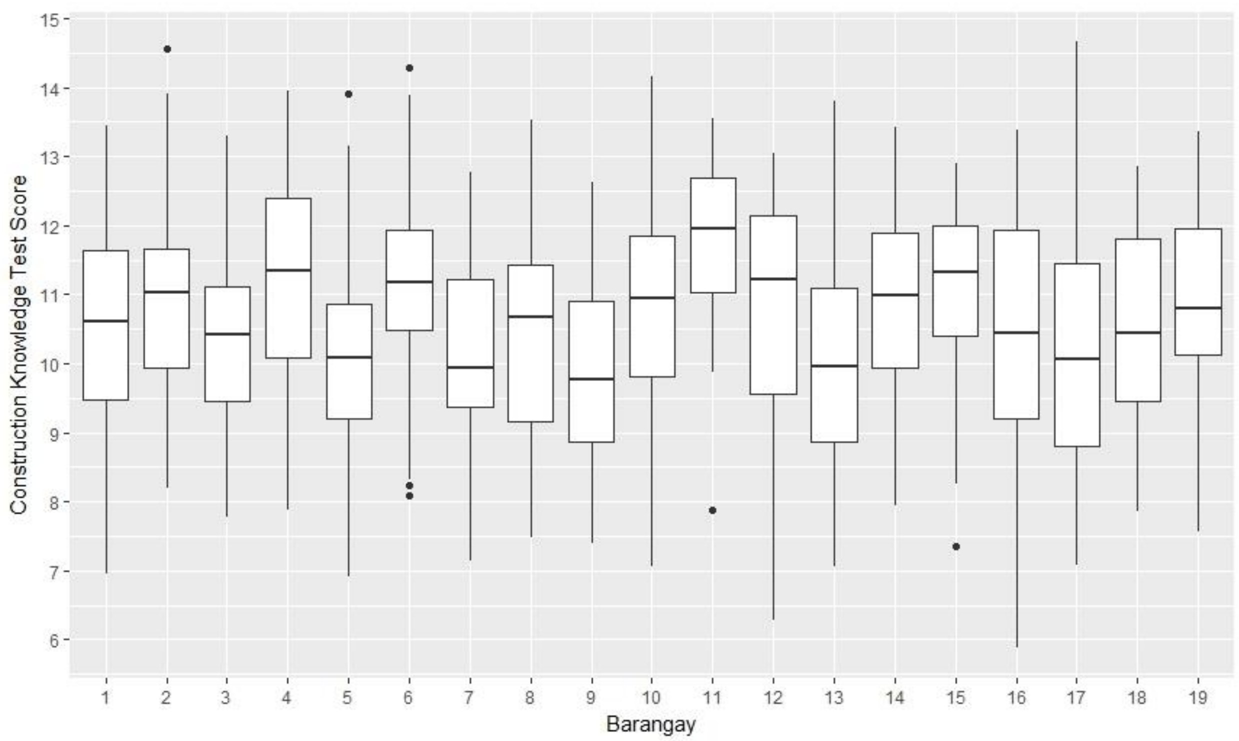


Figure 1: Construction Knowledge Scores by Community[4]

In total, 53% of respondents were female and 47% were male, approximating population gender demographics of the selected communities. The average respondent age was 38 with a standard deviation of 14 years. Across demographic attributes, we found that respondents with differing education levels had statistically significant differences in construction knowledge ($F=4.896$, $p<0.01$). Further investigation revealed that this was a positive correlation between the education and construction knowledge. We did not find differences in construction knowledge among different genders, levels of English proficiency, ages, or previous construction experience (either before or after the typhoon).

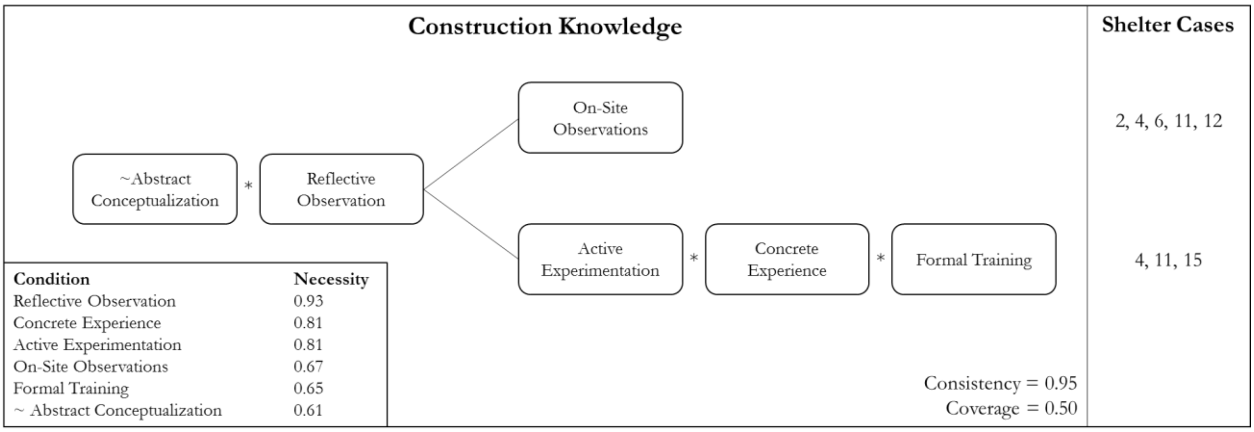
While many organizations emphasize the importance of transferring knowledge on safer building principles to households, implementing agencies typically assumed that this had to occur through direct and intentional learning activities or materials. In our analysis of construction knowledge across projects, t-test results showed a statistically significant difference between communities where households were present during construction and communities where households were not present during construction to observe construction methods and ask questions. We found that the households within communities that included on-site observation had an average construction knowledge score of 10.88, and those without on-site observations had an average construction knowledge score of 10.36; ($t(880)=4.99$, $p<0.01$). This suggests observation during construction plays an important role in learning.

Our interview data from households supported these findings and suggest that, in addition to intentional training activates, households acquired new knowledge through observation of new construction techniques applied. As such, we included on-site observations as a condition of interest in our analysis. To calibrate this condition for fsQCA, we defined membership as the presence of the households during construction, where households had the ability to observe new techniques being used and ask questions to carpenters and masons. In contrast, out of set membership was defined as the lacking presence of the household during construction. This was most common for relocation programs where households did not witness construction and moved after completion of the shelters.

[4] The median test scores are shown in the middle bar; the first and third quartiles are denoted by the top and bottom of the boxes, respectively; and the whiskers end at either the minimum or maximum values. In the event any outliers were present, the whiskers terminate at 1.5 times the inter-quartile range (IQR).

Pathways to Construction Knowledge

Our analysis of causal conditions showed two pathways that led to the presence of construction knowledge. Our solution had an overall consistency of 0.95 and a coverage of 0.5. A summary of the two pathways identified can be found in Figure 2. The use of "*" denotes the Boolean "and" operator to signify combinations of conditions. A "~" denotes the absence, or lack of, a condition. Finally, common conditions are shown on the left, with unique pathways separated by split lines. Reflective observation training methods were found to be a necessary condition with a necessity value of 0.93. This suggests that households required at least some passive education formats in order to internalize knowledge. For the other six cases that had high household construction knowledge but were not covered by the two pathways identified, five of the six cases included formal training that covered all four types of training methods, differing from the first pathway only by the presence of abstract conceptualization training methods. These cases were primarily 'core' shelters that relied on simple designs – a potential reason they possessed higher construction knowledge. The simpler designs may have allowed for more ease in acquiring concepts.



Condition	Necessity
Reflective Observation	0.93
Concrete Experience	0.81
Active Experimentation	0.81
On-Site Observations	0.67
Formal Training	0.65
~ Abstract Conceptualization	0.61

Figure 2: Pathways to Construction Knowledge

The first pathway covered five of the twelve cases that showed the presence of construction knowledge. These cases lacked abstract conceptualization training methods, but included the presence of reflective observation methods and on-site observations by households during construction. For all of the cases that fell into the first pathway, skilled labor was employed by the implementing organization and all the projects were in-situ, allowing households to observe construction of their neighbor's shelters. The importance of observations in this pathway was demonstrated by one individual, *"First, I was able to watch the group that built the bigger houses, and I learned a lot of techniques from the builders. So, when it was time for our house, smaller compared to the first, I was vocal in airing my observation based on my previous experience. Every now and then I make suggestions on how to construct a specific portion. One time I called them out when I saw that they didn't install the posts properly because I've seen how it was seamlessly set up by the builders from the bigger house."* We saw that this inclusion of reflective observation acted as a catalyst for households to internalize knowledge. Further, the connection of these observations through established social ties build trust in the knowledge being acquired.

The second pathway covered three cases and lacked abstract conceptualization methods, but included reflective observation methods, similar to the first pathway, but also included active experimentation methods and concrete experience methods. This pathway was also unique from the first in that the cases showed the presence of formal training. In contrast to the first pathway, which relied on information, education, and communication (IEC) materials, projects in this pathway had formal workshops. Further, all of the projects in this pathway were material distributions, which supplied a core set of building supplies such as posts, sheets of plywood, and framing members to homeowners, in combination with technical support.

In interpreting our pathway results, the most obvious distinction was that the first pathway relied on observation as a means of learning, while the second relied on formal training that drew from multiple methods. There has been a traditional focus on formal training, but our results show that more cases that achieve construction knowledge actually do so through passive means. While we hypothesize that this may in part be due to cultural differences in learning, in particular a high power distance between the role of educators and learners (Hofstede 2003), it none the less reinforces the important role of demonstrations, lectures, photographs, and other methods that allow for reflective observation of building concepts.

Additionally, an intriguing finding was absent abstract conceptualization methods were central to both pathways. This pole aligned with the use of maps and technical diagrams; many households expressed difficulty understanding these and were unable to visualize two dimensional representations and architectural plans. The absence of abstract conceptualization in the pathway reinforces that the presentation of overly detailed information was detrimental to household acquisition of concepts.

DISCUSSION

In exploring construction knowledge after Haiyan, several cross-cutting themes emerged from our analysis and findings. Fundamentally, all training programs emphasized a reliance on principles, rather than standards. An emphasis on principles aimed to transfer knowledge that could be readily accessible by individuals. There is important distinction from other types of professional training that seek to transfer process oriented knowledge. In other words, the knowledge needed by households did not require them to build a shelter themselves, but rather recognize deficient construction. This was summarized by an NGO staff member:

> "It is all about capacity building. If you just build people's houses and leave, the next time a storm happens you have to come back because they don't know how to do logistics, they don't know how to do it properly, they don't know how to design a house, but if you teach people, and again this is the difference I think between my philosophy and the Filipino philosophy, I don't teach standards, I teach principles. The difference being the standards is like down to the point, has to be four millimeter GI [galvanized iron sheets], has to be this, has to be that, really nitty gritty, so my philosophy and all of our philosophy is when we leave we never have to come back – people have the skills and knowledge. Now that isn't a six-month commitment that is a three to five, to seven-year commitment like we started with a three-year commitment, most people start with a three year, we were speaking to people in Haiti most of them made three or five and lasted seven."

Our construction knowledge test results showed that, on average, individuals were able to demonstrate proficiency in recognizing about two-thirds of the messages targeted by shelter organizations. This final number is higher than earlier monitoring conducted by organizations involved in this research. In surveys during construction by an organization in one of the higher performing communities, an NGO staff members noted the following, *"Unfortunately, our data is saying that only 27% of the people remember any five of the eight key messages. Our target is about 90% to remember."* While we lacked pre-training data on construction knowledge, qualitative evidence suggests that overall construction knowledge of households improved during recovery. Formal training programs resulted in the presence of high construction knowledge of households, but our findings suggest that those learning through informal methods may actually gain equal proficiency of safer building principles.

In examining differences in acquired knowledge within the '8 Key Messages" more closely, we found that preparedness concepts had the highest acquisition with an average test score of 12.98. Other concepts, in order of test scores included: tie-downs (11.83), joints (11.80), foundations (11.79), roofing (10.96), bracing (8.76), site location (8.23), and building shape (6.91). The range of these scores demonstrates that learning was not equal across topics and that, while some new applications were picked up (notably strapping and tie-downs), other important messages were not retained to the same degree. Lower scores in retention of bracing concepts and building shape are particularly troubling and merit more attention in future responses. The lower scores for site selection can be explained by most households selecting an answer choice on exposed higher terrain, far away from storm surge which was the primary cause of fatalities during Haiyan. In reality, such locations may be more prone to wind, reflecting the importance of emphasizing multiple hazards when discussing site selection with communities. More discussion of which messages were applied in shelter projects can be found in Opdyke et al. (2016).

Another theme that emerged from our study was the time and resource intensive nature of successful training, as repeatedly noted by NGO staff.. We saw that a minimum threshold of resources needed to be allocated to training in order to realize the benefits. A training advisor to the Shelter Cluster expressed this theme:

> "If you want to make effective learning in training, you have to get people participating in your learning process. That is time intensive, that is cost intensive, that is human resource intensive and that is something which isn't there. Unfortunately, what is happening is that you have got road shows where you have got 80 people sitting there in a barangay [community], 30 degrees with humidity in the middle of the day, and you've got one big 'build back safer' banner out there and somebody talking and nobody beyond the second row is listening to what is going on."

The contact time spent engaged in specific training methods could further explain our findings. Notably, the use of some methods may necessitate more contact hours. While our results point to the need to include a combination of reflective observation, concrete experiences, and active experimentation, anecdotal evidence suggests that the time demands of each may be different. For example, communities may need more time to absorb abstract formats, such as building drawings. Despite the need for time-intensive training methods, our findings also point to informal methods that place learning outside of structured training. Implications of this are immense, as it suggests that lower cost informal methods may hold equal ability to transfer knowledge.

While training is widely recognized as an important part of reconstruction programs, in many cases, the implementation of training programs is treated as something that is necessary to do, which can be 'checked off', without focusing on the process and long term learning. Household responses echoed this phenomena and it was common for organizationally defined criteria for 'training' to be absent from local perspectives. As Field (2017) notes in the Philippines context, different cultures can often result in different understandings of effectiveness and even what constitutes programming. The lesson that should be taken from this finding is that there is a need to align training with the learner's perspective, not that of donor or organizational objectives.

As our findings suggest, formal training does not require targeting all households, thus organizations should focus their resources on ensuring that training is well structured and provides an adequate diversity of methods. Further, as well-developed construction craft worker apprentice programs in developed countries demonstrate, the use of formal and informal training methods need not be exclusive of each other. While organizations may view training as a costly endeavor, our findings point to the potential to leverage multiple types of methods. Such an approach obviously comes with challenges, such as the ability to monitor and evaluate learning through informal methods such as observation, but also comes with greater scalability. To this end, the issue of scaling training solutions remains one of the largest challenges for humanitarian organizations. The importance on-site observations yields importance in future thinking in this area.

Complementing our findings focused on training methods, we also found differences in construction knowledge between different individual education levels – the only statistically significant attribute of individuals studied. More broadly, higher construction knowledge among higher education groups suggests that long-term investments in education may lead to a population that is capable and skilled in building infrastructure. The absence of gender, past construction experience, age, and language proficiency as individual factors that impact knowledge acquisition further cements the potential role of education in a population that can support settlements. Further research is needed to explore causation and whether higher knowledge acquisition is a byproduct of education systems or individuals.

LIMITATIONS

There are several limitations of our study that merit attention. Notably, we did not have the ability to provide a pre-test before training programs as we were unable to identify participants prior to their training. As a result, we were unable to measure changes in construction knowledge directly. Such data, while difficult to collect, should be attempted in future research to more fully explore changes in construction knowledge. However, through extensive qualitative data, which asked trained and un-trained individuals about their experience and construction knowledge, we did triangulate data sources to validate our findings. Further, select communities may have possessed a stronger grasp of the tested construction principles before the disaster. We attempted to mitigate this by covering a relatively large number of communities and diversity of training programs.

We also examined training methods at the community level, rather than individual level, and we acknowledge that some individuals may not have received the training methods used by organizations within their community. While an individual unit of analysis would have afforded greater comparison of formal training methods, it would have neglected the ability to capture informal knowledge acquisition outside of documented training due to sampling of only trained individuals. We also did not have a measure for explicitly addressing the quality of training afforded and quantifying differences in the same type of method between two organizations. We did, however, rely on the Shelter Cluster '8 Key Messages' standardized content and we attempted to mitigate any impacts of differing quality by selecting a relatively large number of case communities. The '8 Key Messages' integrated significant local building customs and practices – they were not just imposed external standards. Thus, our assessment of knowledge is defined not just from an external, technical expertise view, but also from local best building practices. We do however recognize that the development of these guidelines does likely give disproportionate weight to humanitarian organization's perspectives.

Lastly, in assessing knowledge of safer construction, we relied upon the '8 Key Messages' as a reference to define learning outcomes. Community average test scores had small differences – approximately 10% of the total possible score. Altering our cutoff for possessing safe construction knowledge could have resulted in differing findings. Because defining what constitutes sufficient knowledge of safe construction is a grey area, future work is needed to connect life-safety standards in building to adequate knowledge levels.

Future Work

Our research has taken the first step to operationalize construction training in humanitarian shelter programs. This is a ripe and needed area of research, and future work should continue expanding our understanding of training methods and learning outcomes. We investigated training through the lens of experiential learning theory, but the application of other education theories can aid in explaining appropriate formats to convey safer construction knowledge. There has also been much debate about whether learning styles, such as those proposed in Kolb, are valid and can explain differences in skill and knowledge acquisition. The testing of such theories in practical contexts, such as following disasters, can provide additional evidence to move beyond traditional studies in university settings.

While we relied on survey responses to test construction knowledge, another area of future research should be practical tests – expanding and validating what we have found in this research. Households' acquisition of safe construction knowledge is imperative, but only the first step in understanding how and why some households chose to employ this knowledge and others do not (e.g. Turnbull et al. 2015). Future research should continue to explore the drivers of safe construction, both in formal shelter assistance programs as well as those that self-recover without humanitarian assistance.

CONCLUSION

Answering calls for the study of training in post-disaster recovery (Ginige and Amaratunga 2011; Jordan et al. 2016), we have sought to categorize and operationalize what constitutes construction training in post-disaster shelter. Further, we have taken a step toward understanding how training leads to the acquisition of construction knowledge. In this research, we analyzed training programs administered as part of shelter projects in nineteen communities within the Philippines following Typhoon Haiyan. We first identified training formats, and then categorized types of training methods using Kolb's experiential learning theory poles. Next, we used Kolb's learning poles, along with formal training and on-site observations, to analyze how households acquired construction knowledge using fsQCA. Our approach identified on-site observation as a key means of household learning which challenges conventional methods of delivering education through structured training.

There is a telling gap that surfaced between how training was delivered and how households acquire construction knowledge. While reflective observational methods were required in both pathways discovered to construction knowledge, there was significantly fewer methods that drew upon concrete experiences, despite the latter's presence in leading to construction knowledge. In 75% of projects, abstract conceptualization poles were touched upon through maps and other technical diagrams, however the absence of this pole was found in both pathways to higher construction knowledge. The absence of abstract conceptualization methods challenges previous experiential learning theory (Kolb 1984), which suggest that all four poles are necessary. Our findings expand experiential learning to a new domain, disaster recovery, and provide new insights into the specific experiences that ground learning of construction knowledge. Our findings also point to several practical contributions for organizations. Foremost is the need to leverage on-site observations of construction activities. The most successful example of how this was operationalized into programming was through pilot shelters. By allowing households to visually examine shelters prior to construction of their own, organizations can provide an opportunity to instill the needed skills to assess whether safe construction techniques are understood. If on-site observations cannot be used, such as in the case of relocation projects, there is need to invest sufficient resources and time in formal training programs that use a set of diverse methods. Based on our findings, a combination of lectures and material demonstrations is sufficient if conducted over multiple sessions. To embed content in local practices, historical reflections and stories can ground new content in experiences – particularly where community members are not just participants in training but asked to deliver content and considered equal partners. Organizations also should tailor training to targeted learning outcomes. A few well delivered messages can go further than poorly delivered training that seeks to cover every dimension of building construction.

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1434791 and the United States Agency for International Development Office for Foreign Disaster Assistance and Habitat for Humanity International under Award No. Award No. AID-OFDA-G-16-00048. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, the United States Agency for International Development Office for Foreign Disaster Assistance, or Habitat for Humanity International.

REFERENCES

Amaratunga, D., and Haigh, R. (2011). *Post-Disaster Reconstruction of the Built Environment: Rebuilding for Resilience*. John Wiley & Sons, Chichester.

Chou, J.-S., Yang, K.-H., and Ren, T.-C. (2015). "Ex-post evaluation of preparedness education in disaster prevention, mitigation and response." *International Journal of Disaster Risk Reduction*, 12, 188–201.

Cole, J. M., and Murphy, B. L. (2014). "Rural hazard risk communication and public education: Strategic and tactical best practices." *International Journal of Disaster Risk Reduction*, 10, 292–304.

Davis, I. (2011). "What have we learned from 40 years' experience of Disaster Shelter?" *Environmental Hazards*, 10(3–4), 193–212.

Di Gregorio, L. T., and Soares, C. A. P. (2017). "Post-disaster housing recovery guidelines for development countries based on experiences in the American continent." *International Journal of Disaster Risk Reduction*, 24, 340–347.

Elangovan, A. R., and Kasi, S. (2015). "Psychosocial disaster preparedness for school children by teachers." *International Journal of Disaster Risk Reduction*, 12, 119–124.

Field, J. (2017). "What is appropriate and relevant assistance after a disaster? Accounting for culture(s) in the response to Typhoon Haiyan/Yolanda." *International Journal of Disaster Risk Reduction*, 22, 335–344.

Georgieva, K., Shah, N., Ibrahim, H., Jafar, B., Macnee, W., Manuel, T., Mohohlo, L., Sriskandarajah, D., and Wallstrom, M. (2016). *Too important to fail - addressing the humanitarian financing gap*. High-Level Panel on Humanitarian Financing Report to the Secretary-General.

Ginige, K., and Amaratunga, D. (2011). "Capacity Development for Post-Disaster Reconstruction of the Built Environment." *Post-Disaster Reconstruction of the Built Environment: Rebuilding for Resilience*, D. Amaratunga and R. Haigh, eds., John Wiley & Sons, Chichester, 13–29.

Hagelsteen, M., and Becker, P. (2013). "Challenging disparities in capacity development for disaster risk reduction." *International Journal of Disaster Risk Reduction*, 3, 4–13.

Hofstede, G. (2003). Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations. SAGE Publications, Thousand Oaks.

Jordan, E., Javernick-Will, A., and Amadei, B. (2015). "Post-disaster reconstruction: lessons from Nagapattinam district, India." *Development in Practice*, 25(4), 518–534.

Jordan, E., Javernick-Will, A., and Tierney, K. (2016). "Post-tsunami recovery in Tamil Nadu, India: combined social and infrastructural outcomes." *Natural Hazards*, 84(2), 1327–1347.

Joy, S., and Kolb, D. A. (2009). "Are there cultural differences in learning style?" *International Journal of Intercultural Relations*, 33(1), 69–85.

Kennedy, J., Ashmore, J., Babister, E., and Kelman, I. (2008). "The meaning of 'build back better': evidence from post-tsunami Aceh and Sri Lanka." *Journal of Contingencies and Crisis Management*, 16(1), 24–36.
Kolb, A. Y., and Kolb, D. A. (2005). "The Kolb Learning Style Inventory - Version 3.1 2005 Technical Specifications."
Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Prentice-Hall, Englewood Cliffs.
Kumar, S., Diaz, R., Behr, J. G., and Toba, A.-L. (2015). "Modeling the effects of labor on housing reconstruction: A system perspective." *International Journal of Disaster Risk Reduction*, 12, 154–162.
Landis, J. R., and Koch, G. G. (1977). "The Measurement of Observer Agreement for Categorical Data." *Biometrics*, 33(1), 159–174.
Lizarralde, G., and Root, D. (2008). "The informal construction sector and the inefficiency of low cost housing markets." *Construction Management and Economics*, 26(2), 103–113.
NRC and IFRC. (2014). *Security of Tenure in Humanitarian Shelter Operations*. Norwegian Refugee Council and International Federation of Red Cross and Red Crescent Socieites.
Opdyke, A. (2017). "Resilient and Sustainable Infrastructure Systems: A Comparative Analysis of Post-Disaster Shelter Coordination, Stakeholder Participation, and Training." Dissertation, University of Colorado Boulder, Boulder, CO.
Opdyke, A., Javernick-Will, A., Koschmann, M., and Moench, H. (2016). "Characterizing Post-Disaster Shelter Design and Material Selections: Lessons from Typhoon Yolanda in the Philippines." *Construction Research Congress*, San Juan, 1475–1485.
Paton, D. (1994). "Disaster relief work: An assessment of training effectiveness." *Journal of Traumatic Stress*, 7(2), 275–288.
Ragin, C. (1987). The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies. University of California Press, Berkeley.
Ragin, C. (2009). "Fuzzy sets: calibration versus measurement." *The Oxford Handbook of Political Methodology*, Box-Steffensmeier, H. Brady, and D. Collier, eds., Oxford University Press, Oxford.
Ragin, C., Strand, S., and Rubinson, C. (2008). *Fuzzy-Set / Qualitative Comparative Analysis 2.0*. Department of Sociology, University of Arizona, Tuscon.
Rahmayati, Y. (2016). "Reframing 'building back better'for post-disaster housing design: a community perspective." *International Journal of Disaster Resilience in the Built Environment*, 7(4), 344–360.
Rajakaruna, S., Wijeratne, A. W., Mann, T. S., and Yan, C. (2017). "Identifying key skill sets in humanitarian logistics: Developing a model for Sri Lanka." *International Journal of Disaster Risk Reduction*, 24, 58–65.
Rihoux, B., and Ragin, C. C. (2009). Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques. SAGE Publications, Thousand Oaks.
Turnbull, M., Sterrett, C., Hirano, S., and Hillebose, A. (2015). Extending Impact: Factors Influencing Households to Adopt Hazard-Resistant Construction Practices in Post-Disaster Settings. Catholic Relief Services, Baltimore.
UNISDR. (2015). Sendai Framework for Disaster Risk Reduction 2015 - 2030. Geneva.
UNISDR. (2016). The Human Cost of Weather Related Disasters 1995-2015. Geneva.
Wang, Y., Goodrum, P. M., Haas, C. T., and Glover, R. W. (2008). "Craft training issues in American industrial and commercial construction." *Journal of Construction Engineering and Management*, 134(10), 795–803.