Strengthening Public Health and Disaster Resilience in American Samoa: The use of the Precede-Proceed Model

APATU, Emma J. I. a, AGA, Dan b, OSLAND, Echo c, and GREGG, Chris E. d

a Department of Public Health, University of North Florida, Jacksonville, United States of America, e-mail: emma.apatu@unf.edu
b Community and Natural Resources, American Samoa Community College, Pago-Pago, American Samoa, e-mail: danaga98@yahoo.com
c Department of Geosciences, East Tennessee State University, Johnson City, United State of America, e-mail: gregg@etsu.edu
d Department of Public Health, University of North Florida, Jacksonville, United States of America, e-mail: n00843715@unf.edu

Abstract – American Samoa is part of the Samoan Islands located in the South Pacific Ocean about halfway between Hawaii and New Zealand. In 2009, a magnitude 8.1 earthquake occurred between nearby Tonga and American Samoa, creating a regionally destructive tsunami that destroyed coastal infrastructure, killing approximately 34 people in American Samoa. In coordination with the local Territorial Emergency Management Coordinating Office and the Office of Samoan Affairs, we conducted an interview study of 300 adult residents of American Samoa in 2011 to better understand the associations between individual determinants (i.e. health and household characteristics) and household response to the 2009 earthquake and subsequent tsunami. Unlike many areas in the United States, American Samoa has experienced a sustained rise in obesity. Our study confirmed preliminary reports that the people of American Samoa displayed a remarkable adaptive response to the earthquake and tsunami events by evacuating to safe areas between the time they first experience ground motion from the earthquake and the time the tsunami arrived on shore, which was as little as 15 minutes after the earthquake. Despite this overwhelming adaptive response, it was also determined that some individuals were unable to respond appropriately to the earthquake and impending tsunami due to obesity related health conditions, which limited their mobility. This paper applied a modified version of the Precede-Proceed Model to quantitative and qualitative data collected from the interviews in search of innovative ways to improve disaster preparedness and response capabilities for hazards requiring quick response. The aim is to ultimately reduce morbidity and mortality from obesity and obesity related conditions.

Keywords – tsunami preparedness, precede-proceed model, obesity prevention, American Samoa

1. Introduction and background

On September 29th, 2009 at 06:48 AM local time, a M8.1 earthquake occurred about 190 km south of the US Territory of American Samoa in the South Pacific Ocean. The earthquake produced a destructive tsunami that reached up to 17m above sea level (Fritz et al., 2011) and over 600m inland (Jaffe et al., 2010), damaged coastal infrastructure and locally claimed 34 lives in American Samoa alone (United States Geological Survey, 2009). The islands of American Samoa are located 200 km north of the Tonga trench, an active convergent tectonic boundary marking the collision of the Pacific and Australian plates where earthquakes are common. The geographic location of the islands of American Samoa leaves its residents exposed to future earthquake and tsunami hazards. Residents cannot necessarily influence the earthquake or tsunami hazards, but can only limit their exposure to tsunamis in the coastal zone and take precautionary measures to reduce their vulnerability to both hazards. Though worrisome because most people live, recreate and work in the coastal zone, of specific interest to public health researchers and practitioners is the ability of at risk people exposed to tsunami hazards to effectively respond to strong ground motion from an earthquake, since this is the quickest warning that a tsunami may be imminent. In American Samoa, the tsunami may impact shores in as little as 10 minutes (it took 15 minutes for the first tsunami wave to reach...
In 2007, in collaboration with the Department of Health, World Health Organization and Monash University, Australia published the results of an investigative study on personal risk factors in the population of American Samoa. Some 1,871 residents aged 25 to 64 years agreed to have their body mass index evaluated. Of those persons, it was determined that 74.6% were obese. Factors identified as contributing to this obesity epidemic included sedentary life styles, movement away from traditional food practices, and reliance on imported goods (Davison, Fanolua, Roaine, and Vargo, 2007; World Health Organization, 2007). It is well known that obesity has negative consequences on individual and community health. Obesity can lead to other diseases such as Type II diabetes and cardiovascular disease (Marinou et al., 2010). In addition, it can hinder peoples’ ability to respond to natural hazards such as earthquakes, tsunamis, flash flooding and storm surge, all of which are common in coastal settings of tropical islands. American Samoa is located in such an area where earthquakes and tsunamis are a persistent threat; therefore, ensuring that individuals can physically reach safety areas (i.e. high ground) by foot is imperative. Road networks may become unusable due to earthquake damage and traffic congestion (Wood and Schmidtlein, 2012), but steep topography, uneven or wet and slick ground and other environmental factors such as having to physically break through dense tropical vegetation can make even short evacuation distances physically and mentally challenging. Furthermore, unless residents reach an area sufficiently inland or above sea level that has been pre-determined to be a safe area by emergency management authorities, during an earthquake and tsunami evacuees may be uncertain as to how far inland or above sea level they need to evacuate. This uncertainty means that people may over evacuate, which could further complicate the stress and strain of evacuation on foot. Therefore, having the physical ability to seek safety on foot may become a lifesaving necessity. Good public health and a capability to meet the demands of protective actions for natural hazards such as pre-determined evacuation areas and sheltering is an important intersection for health program planning. Besides the trade-off between the short-term cost of maintaining good physical fitness and the benefit of maintaining a capacity to respond to tsunamis in the long-term presented in this paper, there are obvious short-term benefits of good physical fitness that can be realized before surviving the next tsunami. These would include improved energy to participate in work and recreation without the discomfort of shortness of breath, fatigue and sedentary lifestyle often associated with obesity. With the building of a new Nutrition, Exercise, Health and Wellness Community Research Center at the American Samoa Community College (ASCC) and the existence of the local Territorial Emergency Management Coordinating Office (TEMCO), public health practitioners, medical personnel, nutritionists, and emergency managers are in an exciting position to develop system approaches to improving health outcomes and even greater levels of disaster resilience in American Samoa. Interdisciplinary teamwork aimed to improve population health and safety is of paramount importance in order to maximize resources and save lives. The purpose of this study was to apply a modified version of the Precede-Proceed Model to quantitative and qualitative data collected from the interviews to develop a theoretical framework to improve disaster preparedness and response capabilities for hazards requiring quick response in American Samoa.
2. Methodology

2.1. The case study

In July 2011, the East Tennessee State University (ETSU) natural hazards and society program in the Department of Geosciences conducted a study with TEMCO and the Office of Samoan Affairs to better understand the associations between individual determinants (i.e. health and household characteristics) and household response to the 2009 earthquake and tsunami. The main goal of the project was to test components of the Protective Action Decision Model (PADM) of Lindell and Perry (2012) — a leading behavioral model in the USA— to see how the model performed for predicting response to tsunamis and in a non-US-based culture. Findings from the PADM study were initially published in Apatu et al. (2013), but additional articles are in review. In general, it was found that among study participants, individual and household response to the 2009 earthquake and tsunami was good; though some of the population reported health related barriers to evacuation during the event. Respondents expressed the need for village safety zones and better evacuation routes to help facilitate household evacuation during future earthquakes and tsunamis. A minority of the respondents (13.8%) indicated that health problems hindered their ability to evacuate. Of these respondents, obesity related health problems such as diabetes, high blood pressure and foot problems were reported. The evacuation and health related data were incorporated into an adapted health promotion planning framework called the Precede-Proceed Model to illustrate an integrative plan for obesity prevention and tsunami preparedness.

2.2. The Precede-Proceed Model

The Precede-Proceed Model is a theoretical framework that consists of two series of phases. The first series, termed PRECEDE, is used to generate information regarding specific factors that may influence the health status of the target population (this series was the focus of this research study). Precede consists of four foundational phases that are designed to collect information that will be used to inform subsequent decision making. PROCEED encompasses the second series of phases and is concerned with implementation and evaluation of an appropriately researched and informed public health program. The Precede-Proceed model has been used by public health interventionists as an organizational tool to identify relevant factors that influence health, determine which factors are most modifiable, and guide the logical development of program goals, objectives and targets while setting program planners up for successful evaluation (Green and Kreuter, 2005). The four foundational phases and four implementation and evaluation phases guide the formulation of ecological approaches to health program planning. The first phase, Sociological Assessment, is dedicated to engaging the priority population in dialogue to gather feedback on gaps, strengths, social concerns, future directions and cultural contexts relevant to a given health outcome and quality of life. The second phase, Epidemiological Assessment, focuses on which behavioral, environmental and genetic factors may lead to the health problem. Phase three encompasses Educational and Ecological Assessment, which examines factors that affect behavior such as knowledge, attitudes and beliefs. Additionally, factors that predispose, enable and reinforce favorable environments or behaviors are explored in Phase three. The fourth phase is an Administrative and Policy Assessment and Intervention Alignment. This is the time when the study area is assessed and specifics regarding necessary resources are determined. Phase five is Implementation, which is as straightforward as it reads. Here, the developed program or intervention is implemented. The final three phases deal with Evaluation, which include Process, Impact and Outcome evaluations (Fertman and Allensworth, 2010). After an outcome evaluation is performed, the eight phases of the Precede-Proceed model would be considered completed. This paper input relevant primary assessment data into the first two phases of the PRECEDE series and offered Precede-Proceed model appropriate suggestions for future brainstorming during Phases three and four; the intention was to apply the qualitative and quantitative data collected through interviews to an evidence based model and lay the foundation for appropriately informed tsunami preparedness and obesity prevention public health programs in American Samoa.

<table>
<thead>
<tr>
<th>Village Name</th>
<th>Questionnaires Sold</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fagali‘i</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>Maloata</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Fagamalo</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Pala’a</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>Asili</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>Se’etaga</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Amanave</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>Tula*</td>
<td>47</td>
<td>15</td>
</tr>
<tr>
<td>Fagasa*</td>
<td>82</td>
<td>27</td>
</tr>
<tr>
<td>Agugulu</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Afa’o</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Amaulia</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
<td>100</td>
</tr>
</tbody>
</table>

* Eastern district villages, all other villages are in the Western district

We surveyed 300 adult residents in 12 villages on Tutuila Island in July 2011. Formal approvals from the Institutional Review Board (IRB) at East Tennessee State University (ETSU) as well as from the American Samoa Office of Samoan Affairs and TEMCO were obtained prior to data collection in July 2011. The sampling frame consisted of all households in the Western and Eastern Districts on Tutuila (figure 1). We conducted surveys in nine villages in the Western District (Fagamalo, Maloata, Fagali‘i, Poloa, Amanave, Agugulu, Se’etaga, Afa’o, Asili, and Amaulia) and two villages in the Eastern District (Fagasa and Tula). These villages were selected in order to obtain diversity in households’ experience of tsunami run-ups (the highest...
In the Western District, we attempted to conduct a census because of the small size of the villages. In the larger villages in the Eastern District, we used systematic sampling (an equal-probability method). A team of bilingual interviewers, who spoke both English and Samoan, obtained informed consent and then conducted the interviews. The study villages were selected based on varying warning or response times and tsunami run-up heights (the maximum height above the referenced sea level to which waves reach). Villages on the west side of the island and closest to the source of the tsunami had experienced greater run-up (up to 17m) and shorter response times, while villages on the eastern and northern sides of the island had longer times and lower run-ups (up to 9 m) (Fritz et al., 2011).

All interviewers attended a two-day training session lead by the research team to ensure understanding of the project, survey material and standardization of interviews in the field. Two separate research team Coordinators from ETSU performed follow-up visits with randomly selected respondents in each study village to confirm quality and accuracy of interviews. Additionally, interviewers met with the study Coordinators at a central location on a weekly basis to submit completed questionnaires, and to report any problems encountered with interviews. The study questionnaire was created in English, translated into Samoa and then back-translated into English to ensure the Samoan translation captured the essence and integrity of the original questionnaire.

We collected socio-demographic data on individuals and households. These included, but are not limited to: age, sex, and years of household residence, household size (e.g. number of persons in household during the 2009 earthquake), education and marital status (Table 2). Moreover, we sought to understand respondents thoughts on what could be done to improve village readiness for future earthquakes and tsunamis. In addition, a descriptive measure of whether persons evacuated after the earthquake and before the tsunami was collected. Also, any self-reported health and physical mobility issues experienced during their attempt to evacuate were documented. All quantitative data were tabulated in aggregate form. Means, frequencies, and ranges are provided. Qualitative data were coded and general themes are presented.

As documented in Table 2, the mean age of the study population was 42.3 years. Half (50.7 %) of the interviewees were female and the average household size during the 2009 earthquake was approximately 5 persons. Just over 50 % of respondents reported a high school diploma and nearly three fourths (70.0 %) were married. All data were classified into the previously discussed first two
phases of the Precede-Proceed Model and provided foundational insight into the social and epidemiological assessments. Where necessary secondary data obtained from primary literature was used to develop the logic model illustrated in Figure 2.

3. Results

3.1. Precede-Proceed Phase 1 - social assessment, for future earthquakes and Tsunamis

Respondents were asked what they believe could be done to improve their village’s readiness for future earthquakes and tsunamis. Five major themes emerged from the qualitative data and are discussed below.

3.1.1. Having a village safety zone(s)

Many respondents communicated a desire for an identified area to where villagers can evacuate during a tsunami. This central safety area is envisioned to be a place where emergency supplies can be stored. There appeared to be a great sense of community among the respondents and they would like to be able to come together and help one another during a disaster.

3.1.2. Evacuation routes and improved infrastructure

Respondents stated they would like to have more evacuation routes to high ground. Improved trails that support expedient evacuation was vocalized as a needed key change.

3.1.3. Readiness through village meetings and awareness

More meetings discussing village readiness was communicated as an important part of tsunami preparedness. These meetings are seen to be an opportunity for tsunami education. Schools were also identified as a suitable venue to educate children about tsunami response.

3.1.4. Mass media campaigns

Radio and television were identified to be culturally appropriate outlets for public service announcements regarding tsunami preparedness and other disaster relevant information.

3.1.5. Preparedness

“Being prepared at all times” was noted by many respondents as an essential task for American Samoan residents living in an active earthquake and tsunami area. Knowledge of the nearest route of evacuation and knowing how to help others in the community during a crisis was of paramount concern to many respondents.

3.2. Precede-Proceed Phase 2 - epidemiological assessment, evacuation behavior and health

Overall, over three fourths (77.1%) of respondents reported that their household evacuated after the earthquake and before the tsunami (see Table 3). Some respondents noted that delays in evacuation after the earthquake and before the tsunami were due to health problems. Approximately 13.8% of respondents indicated that their ability to evacuate during the 2009 Samoa earthquake and tsunami was hindered by a household member that had health problems (mostly associated with obesity related diseases). Also, 9.3% of respondents mentioned that their ability to evacuate was affected by persons that had physical mobility issues due to being overweight, disabled, or problems with their joints (see Table 4).

Table 3: Health Problems that Affected Evacuation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household evacuation (n = 231)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>77.1</td>
</tr>
<tr>
<td>No</td>
<td>22.9</td>
</tr>
<tr>
<td>Health Related Barriers to Evacuation (n = 297)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13.8</td>
</tr>
<tr>
<td>No</td>
<td>85.9</td>
</tr>
<tr>
<td>Physical Mobility Problems (n = 298)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9.2</td>
</tr>
<tr>
<td>No</td>
<td>90.3</td>
</tr>
<tr>
<td>Household Evacuation Plan (n = 251)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>35</td>
</tr>
<tr>
<td>No</td>
<td>65</td>
</tr>
</tbody>
</table>

Table 4: Health Problems that Affected Evacuation

<table>
<thead>
<tr>
<th>Health Problem</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>15</td>
</tr>
<tr>
<td>Hypertension</td>
<td>14</td>
</tr>
<tr>
<td>Foot problems</td>
<td>4</td>
</tr>
<tr>
<td>Asthma</td>
<td>3</td>
</tr>
<tr>
<td>Gout</td>
<td>3</td>
</tr>
<tr>
<td>Heart attack</td>
<td>2</td>
</tr>
<tr>
<td>Ulcer</td>
<td>1</td>
</tr>
<tr>
<td>Cancer</td>
<td>1</td>
</tr>
<tr>
<td>Mental Disorder</td>
<td>1</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
</tr>
<tr>
<td>Filarisis</td>
<td>1</td>
</tr>
<tr>
<td>Total count of problems identified</td>
<td>47</td>
</tr>
</tbody>
</table>

3.3. Towards health program planning: an adapted Precede-Proceed Model

Figure 2 presents a visualization of a logic-based Precede-Proceed Model for tsunami preparedness that integrates obesity prevention and management. Relevant background and interview data were applied to the first two phases of the Precede-Proceed Model. Salient behavioural, environmental and health related factors that inform tsunami preparedness and obesity are identified in
Phases 1 and 2. Potential predisposing, enforcing, and reinforcing factors are suggested in Phase 3, which operates on the factors identified in the social and epidemiological assessments of Phases 1 and 2. Phase 4 would guide an assessment of organizational and political support and barriers for the program. In this phase the program planner would establish a time line for implementation, develop a budget, and assign responsibilities; this phase would be used to identify the specific setting in which the program is to be implemented as well as engage community organizations for collaboration. Figure 2 suggests several educational strategies and policies that could be targeted to both aid in the prevention of obesity and strength emergency preparedness and disaster resilience. The four phases of the Proceed series would be specific to the goals, objectives and targets of the planned program.

4. Discussion and conclusion

This study suggests that TEMCO and the ASCC Health and Wellness Center are in a unique position to create a systems approach to improving tsunami preparedness and evacuation capabilities in conjunction with obesity prevention and reduction. The survey respondents indicated a need for additional disaster preparedness and suggested a public health program designed to enhance disaster response would be welcomed. In addition to the target population being ready for a public health program, TEMCO and ASCC Health and Wellness Center Outreach have a mission to enhance disaster preparedness/ obesity prevention and a program of this nature would support organizational goals. Needs expressed by respondents regarding improved tsunami preparedness included: creating tsunami safety areas where village members have an identified space where they can be safe from the effects of a tsunami, developing and maintaining better and more numerous evacuation routes, facilitating village readiness and awareness meetings, and being prepared in the face of disaster and able to aid others in need (i.e. if a fellow village member has injuries). Overall, evacuation response to the 2009 earthquake and tsunami was good as evidenced by the reported evacuation response of 77.1% among study participants. East Tennessee State University tsunami researchers are currently analyzing additional findings from the survey data to understand which factors explain this remarkable response. Although the overall evacuation response to the 2009 event was positive, household preparedness for future earthquakes and tsunamis is poor with only 35% of respondents indicating that they have a household plan (Table 3). Additionally, for a small portion of the sample, health and physical mobility related barriers to evacuation were reported at 13.8% and 9.0%, respectively. As the American Samoan population ages, and passes through the epidemiological transition from communicable disease to chronic disease, the health implications of obesity for tsunami preparedness should not be overlooked. Inputting ecological and epidemiological data into the Precede-Proceed model showed that it is possible to develop a concerted health promotion strategy to improve tsunami preparedness and obesity related health outcomes in American Samoa. The Precede-Proceed model builds on earlier phases. This research established the first two phases of the model and set American Samoa public health interventionists up to develop a logic based public health program for tsunami preparedness. Such a strategy would also benefit preparedness for other geographically related hazards such as typhoons, flooding and sea-level rise, since each of these, like tsunamis, affect coastal areas where most people live, work and recreate. Possible health promotion strategies could include developing foot paths surrounded by community gardens to serve as fitness trails that support healthy lifestyles as well as locations that lead to safety zones where temporary emergency centres would be located during a disaster. Also, educational counselling about diabetes and high blood pressure prevention and management, as well as nutrition sessions emphasizing healthy eating habits could serve as important obesity prevention efforts offered by the American Samoa Wellness Center. This healthy lifestyle education could be reinforced by the use and promotion of fitness trails to and through village safety zones (i.e. higher ground). Around the safety zones community gardens with fruits and vegetable crops could be planted to promote healthy eating habits, a trend popular in many countries, even in urban settings. Ongoing research will seek to understand enabling, predisposing, and reinforcing factors that motivated community members to respond so effectively to the 2009 event and to understand how to motivate persons of this culture to adopt healthier lifestyle behaviours that improve obesity related health outcomes that could contribute to an even greater level of adaptive response to the next earthquake and tsunami.

5. Acknowledgements

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