Mortality during Landslides, Chuuk, Federated States of Micronesia, 2002

by

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ABSTRACT

Landslides often accompany hydro-meteorological events, such as floods and tropical cyclones, where deaths have been characterized at length. However, little is known about the role of landslides in contributing to resulting mortality. The event of Tropical Storm Chata'an in Chuuk State, Federated States of Micronesia on 2 July 2002 precipitated massive landslides, leading to deaths among islanders long accustomed to the seasonal onslaught of storms. We conducted an epidemiologic investigation to identify preventable risk factors for mortality and formulate public health strategies for future events. Of 43 deaths occurring from twelve landslides on six islands, almost 90% (36/40) died immediately, 56% (24/43) were female, and over half (22/43) were children <15 years of age. Though the landslides occurred over a 12-hour period, nearly 74% (67/91) were unaware of other landslides before being affected. Nearly 83% (76/92) did not know that landslides could accompany tropical storms. Location of the home and building material were not significant. Targeting preparedness to include children and improving communications between and within islands are viable strategies for risk reduction.

KEYWORDS: disasters, natural disasters, landslides, mortality, Micronesia

1.0 INTRODUCTION

Landslides represent a significant geologic hazard worldwide, affecting an estimated 2.1 million people and resulting in approximately 9,500 deaths in the past ten years (IFRCRCS, 2001). Landslides are caused by disturbances in the natural slope stability, have been associated with variations in soil porosity, and can accompany heavy rains or follow drought (Iverson et al., 2000). Although they commonly occur with other major natural disasters such as floods and earthquakes, little is known about the role of landslides in overall mortality, particularly when precipitated by hydrometeorological events.

On July 2, 2002, Tropical Storm Chata'an struck the islands of Chuuk with almost 20 inches of rainfall in a 24-hour period. Of 265 various landslides attributed to the storm, at least 62 massive landslides occurred on July 2 and resulted in 43 deaths and hundreds of injuries on six islands. This event was unique because it occurred in a population long accustomed to the seasonal onslaught of tropical storms and typhoons, but had not experienced landslides in more than two decades. We present descriptive results from an investigation of deaths caused by landslides in Chuuk during Tropical Storm Chata'an to characterize mortality and formulate preventive strategies. For this report, we focused on factors related to the geology of landslides, rainfall, structural characteristics, and behavioral response of case- and comparison subjects.

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2.0 METHODS

We reviewed death certificates from deaths categorized as "landslide-related" by the Chuuk State Hospital to collect demographic information on the decedents. We calculated mortality rates using age-specific population data from the 1994 census of the Federated States of Micronesia (FSM, 1994).

We conducted a descriptive cross-sectional study to identify specific risk factors during landslide events. We administered a questionnaire to study participants to assess knowledge of warning systems, behavioral response, access to medical care, construction material, and possible predisposing conditions such as physical disabilities and alcohol consumption. We defined a case subject as a person who died as a result of suffocation or trauma due to the landslides occurring on July 2, 2002. Family members or individuals familiar with the circumstances of the decedent at the time of the landslide were eligible to be case proxies. We identified a comparison group consisting of injured and non-injured persons who were present at the site of the landslide at the time of the slide. Neighborhood comparison subjects were identified at the site of the landslide and at sites where displaced people were known to have relocated. We compared cases with a comparison group to ascertain risks.

We collected rainfall records from the Weno Weather Station to compare the quantity of rain fallen over a given time with the approximate times when the deaths occurred.

3.0 RESULTS

Forty-three deaths related to the landslides occurred on six islands (Table 1). The first fatality was reported at 2:30 am. Within twelve hours, forty people were killed, and three additional people died from their injuries within the next three days (Figure 1). The overall mortality rate for this event was 1.47 deaths per 1,000 habitants.

Almost 90% (36/40) of the decedents were reported to have died immediately during the landslides. Suffocation (burial) was reported to be the cause of death for 93% (40/43) of the decedents.

3.1 Demographics

More than one-half (24/43) of the fatalities were female. The median age of the decedents was 14 years, with ages ranging from 3 months to 84 years. Children less than 15 years of age accounted for over one-half (22/43) of the fatalities in this event.

The relative risk for children under 15 years of age was 1.32. Compared with crude death rates for the landslides by age groups to estimates from all causes for previous years, mortality increased slightly among the 5-14 age group, not noted in previous years (Figure 2).

3.2 Knowledge and Awareness of Landslides

Almost 70% (36/52) of the comparison group reported knowing about the incoming tropical storm at least one day in advance, mostly by radio, but only 4% (2/52) reported knowing about the landslides by radio. Retrospectively, 85% (44/52) of the comparison group reported not knowing that landslides could accompany heavy rain, and 75% (33/44) of these also reported that they had not considered landslides a hazard.

Although the landslides occurred over a 12-hour period, almost 70% (35/51) of the comparison group reported being unaware of other landslides in Chuuk that day and less than 10% (5/51) reported knowing about occurring landslides more than an hour before being affected. Of those who faced the landslide with little anticipation (35/52), only 31% (11/35) reported noticing natural warning signs such as rushing water and rumbling earth.

3.3 Location and Activities during the Landslide

The proportion of subjects reporting being inside a structure at the time of the landslide was higher among case subjects [59% (23/39)] than among injured comparison subjects [36% (14/39)], and

similar to that among non-injured comparison subjects [62% (8/13)]. Among those who were not aware of the possibility of landslides, the proportion of decedents inside a structure during the landslide [56% (18/32)] is similar to that of injured subjects [58% (15/26)] and both are lower than the proportion for non-injured [67% (6/9)].

Only 17% (3/17) of the case subjects who were outside during the landslides were in the midst of preparations for a possible typhoon. Most (10/17) were performing activities such as walking on the road, picking breadfruit and bananas, or bringing down laundry.

3.4 Structural Characteristics

Among the fatalities reporting being inside a structure (23/39) when the landslide occurred, 80% (18/23) occupied a structure located at the bottom of a slope or by the sea, and almost 70% (16/23) reported having concrete walls. Of those inside concrete structures, at least half (8/15) left their homes and sought shelter from the tropical storm.

3.5 Rainfall

During the last four decades, the islands of Chuuk received on average 7 to 14 inches of rainfall for any given month, with highest values recorded between May and October. The Weather Station on Weno Island documented a record monthly rainfall (34.34 inches or 858.5 mm) during July, 2002 (Personal communications, September 2002). Monthly pecipitation levels had not been that high since July, 1962 (32.99 inches or 824.75 mm).

On July 2nd, 2002, the islands received almost 20 inches (500 mm) of precipitation in 24 hours, with a peak reaching over 3 inches (75 mm) per hour, resulting in at least 265 landslides during the tropical storm. Although some landslides continued to occur the following days, most of the more massive landslides and all fatalities occurred on this day. (The last landslide reported in Chuuk occurred in 1976, when monthly precipitation levels peaked at 28.4 inches, or 709.75 mm.)

The hourly amounts of rainfall and the reported times of the fatal landslides appeared to peak on or about the same time (Figure 3). Rainfall data was available only for Weno, the capital and site of the only meteorological station in the state.

4.0 DISCUSSION

This investigation showed that although landslides struck during a 12-hour period, most people were unaware that deadly landslides also were occurring in different villages on the same island and on other islands throughout Chuuk. This highlights an immediate need to improve the state's infrastructure for communications and to sensitize warning systems in emergency situations within and between islands.

Although the affected community appeared to be prepared and knowledgeable about tropical storms and typhoons, few knew that even tropical storms could trigger deadly landslides. Thus, their choice of shelter was probably inappropriate for the hazards that they perceived. In this event, a typhoon watch was issued on Sunday, June 30 in anticipation that winds of 74 miles per hour (mph) or greater possibly would hit the area within the next 48 hours (Weno Weather Station, 2002; Pielke, Pielke, 1997). Two days later, at tropical storm status (maximum sustained winds of 60 mph), some people moved to storm shelters, usually concrete structures belonging to relatives, while continuing to prepare for the advancing typhoon. For example, all decedents in the landslide in Penia were siblings between 6 and 13 years of age who were left in a concrete storm shelter while their mother returned home to prepare food in advance of a typhoon.

According to the United States Geological Survey (USGS), slopes where debris flows have occurred in the past are likely to experience them in the future, and that people should be located away from steep slopes, streams and rivers, intermittent-stream channels, and the mouths of mountain channels USGS, 2000). In settings like those of Chuuk, this may be difficult to accomplish because villages are

often located on a coast at the base of a slope and near a source for fresh water.

Descriptive and consistent warning signs can assist in prompting appropriate behavioral response. In this event, preliminary rumbling and mud were reported as natural warning signs for incoming debris flow. In Meseiku, where the landslide occurred at approximately 2:30 a.m., the rumbling of the creek woke the parents of the only two fatalities in the village, and probably contributed in saving the other five children in this home. In Mwalitw at 7 a.m., the landslide also came down the course of a creek, and different reports agreed that water and mud came first, shortly followed by debris. In Nechap, the village with the greatest destruction and casualties, a wave described as a "wall of water" preceded the landslide. In Nepukos, people were unable to distinguish mud from landslide and reported them as simultaneous. The USGS cautions that a trickle of flowing or falling mud or debris may precede larger flows (USGS, 2000) and recommends that people near a stream or channel be alert for any sudden increase or decrease in water flow and for a change from clear to muddy water, which may indicate debris flow activity upstream.

One striking finding of this descriptive work was that children under 15 years of age were vulnerable in this landslide event. Among the study population, the increased mortality rate for those less than 15 years of age and those 35 years and over is consistent with previous reports on other natural disasters, where the risk of serious or fatal injury was found to be greatest among children and older adults (Glass et al., 1977; Osaki, Minowa, 2001).

Although construction material has been linked to a higher risk of death during earthquakes (Glass et al., 1977), our study found no association between the risk of becoming a fatality and the construction material of the house. Other factors might play a more important role than construction material, such as construction type and reinforcement, but these were not evaluated.

Structures at the base of steep slopes have been described to be at risk from landslides (Harp, Reid, 2002), but our investigation did not verify this. The volcanic formation of most islands in Chuuk results in the establishment of villages at the bases of slopes. Further, landslides are highly localized, and their size and speed depend on many factors in addition to the orography of the area.

Being outside a structure appeared to be protective against death and injury in this event. Most (15/22) of the case subjects were inside a structure with concrete floor and walls just before the landslide. The other seven case subjects were reported to be inside wooden walls, but five of these come from a single family in Kuchua, where the entire house was swept away by the landslide. The other two decedents inside were reported to be asleep at the time of the landslide.

Landslides, often regarded as secondary to major disaster events, can be naturally triggered by earthquakes, floods, volcanic eruptions, or hurricanes, and can result in more damage and life loss than the primary event. To date, the public health consequences of hurricanes and tropical storms result mainly from torrential rains and floods, rather than from high winds. The catastrophic death toll (10,000) after Hurricane Mitch in 1998 was primarily attributed to widespread flooding and thousands of landslides following heavy rainfall in Honduras, Nicaragua, and Guatemala, and became the most deadly hurricane in the Atlantic Ocean in 200 years (Crone et al., 2001). Floods and landslides in Venezuela during December 1999, considered one of the most severe disasters in the Americas this century, sustained precipitation levels that peaked at 410 mm and led to the deaths of over 300 people (Pan American Health Organization, 1999).

Human deforestation is also known to increase the probability of landslides in certain slopes. According to a report by the United Nations Disaster Assessment and Coordination Team that addressed landslide sites other than those with fatalities, many landslides occurred in gardens and plantation areas cultivated for taro, cassava, banana, sweet potato and breadfruit above the villages (Higgins, Teleni, Jayaprakash, 2002.)

Because our investigation concerned only twelve landslide sites with fatalities, we did not address deforestation as a contributor to mortality.

5.0 CONCLUSIONS

A greater proportion of people who died during landslides triggered by Tropical Storm Chata'an were unaware of the hazards of landslides and were children under 15 years. Viable risk reduction strategies should focus on 1) improving communication systems during tropical storms between and within the islands; 2) enhancing community knowledge and preparedness for landslides and other hazards; and 3) targeting health and disaster education to groups, especially children. Being outside or inside a structure during a landslide should be further evaluated for appropriate safety seeking behavior.

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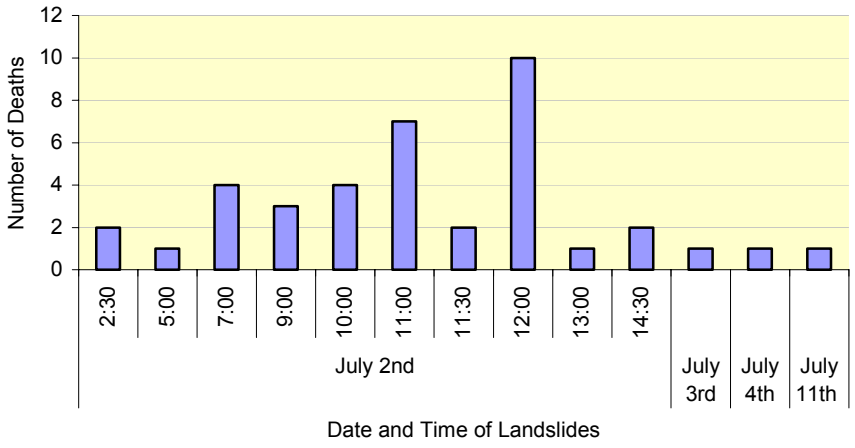
Table 1. Mortality by island, Chuuk, Federated States of Micronesia, July 2002

Island	Cases (%)	Cases not accounted for	Mortality rate (per 1,000)
Tonoas	21 (52.5)	3	6.08
Udot	5 (12.5)	0	3.13
Siis	1 (2.5)	0	2.10
Fefen	8 (20.0)	0	1.98
Uman	1 (2.5)	0	0.33
Weno	4 (10.0)	0	0.25
Total	40	3	1.37

Figure 1. Case subjects by reported time of death*, Chuuk, Federated States of Micronesia, 2002



* unknown time of death for 4 case-subjects

Figure 2. All cause crude death rates (1990-1993) and landslide-related death rates by age group,
Chuuk, Federated States of Micronesia, 2002

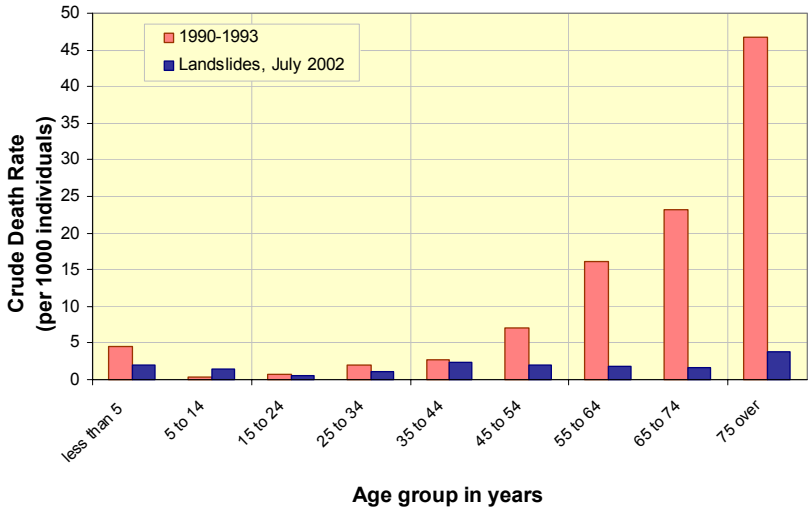


Figure 3. Total hourly rainfall, and total number of fatalities and landslides by time of landslide, Chuuk, Federated States of Micronesia, July 2, 2002