Research article

Effect of built environment on tsunami related injuries

Dharmarathne SD[1], Osamu K[2], Dehiwala GMC[1], Agampodi SB[3*]

[1]Department of Community Medicine, University of Peradeniya, Sri Lanka.
[2]Institute of Tropical Medicine, Nagasaki University, Japan.
[3]Department of Community Medicine, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka.

Abstract

Background

Built environment is a major determinant in injuries and deaths during natural disasters. Purpose of the present paper was to study the effect of built environment on tsunami injuries.

Methods

A retrospective residential cohort was constructed one month after the tsunami, based on the cross sectional household survey. Household structure was categorised as a binary variable based on the definition used department of census and statistics for the census.

Results

The constructed cohort consisted of 4178 individuals, 2143 (51.3%) males and 2034 (48.7%) females from 1047 households. Mean age of the study sample was 25 years with a standard deviation of 17 years. Out of the 4178 study units studied, 43 (1.1%) died during the acute incidence and 19(0.5%) died later due to complications. Twenty eight (0.7%) people were reported missing at the time of data collection. Moderate to severe injuries were reported by 508 individuals (12.5%). To investigate the injury incidence all tsunami related deaths, missing personals and injuries were classified in to a single group as injuries. Reported number of injuries were 302 (14.4%), and 296 (14.9%) among males and females respectively. In multivariate analysis, living in a temporary shelter (OR=0.259, 95% CI 0.351-0.797) shown a protective effect on injuries whereas, residing within the 100 meter boundary from sea (OR 1.43, 95% CI 1.1-1.8) and destruction of house (OR 1.53 95% CI 1.14-2.07) were predictors of injuries.

Conclusion

Policies on building construction in coastal areas should be done considering these findings to mitigate the effect of future disasters.

Key words: Tsunami; Built environment; Natural disasters

***Correspondence:** sunethagampodi@yahoo.com

How to cite: Dharmarathne SD, Osamu K, Dehiwala GMC, Agampodi SB.Effect of built environment on tsunami related injuries. *Anuradhapura Medical Journal* 2013;**7**(1):5-7.
DOI: http://dx.doi.org/10.4038/amj.v7i1.6134

Introduction

Two tsunamis in Asian region cost more than 80,000 deaths within a span of 7 years. Some of the factors related to tsunami deaths in 2004 were not properly analysed and studying those factors is important in prevention of deaths related to natural disasters. Built environment is a major determinant of injuries and deaths during this type of natural disasters (1) Effect of housing structure and building composition has been studied extensively as a predictor of mortality following natural disaster such as earthquake (2)Epidemiological as well as engineering studies have confirmed the importance of type of structure in preventing deaths and injuries during disasters (3) The Indian Ocean tsunami which hit Asia in 2004 caused massive destruction and loss of more than 60,000 lives. Epidemiology of tsunami related deaths has been studied by several authors.(4,5) These studies showed that being a female, child or elderly person, being indoors at the time of tsunami and level of house destruction was associated with increased mortality. However, the effect of built environment was not adequately described as a determinant of injuries during tsunami disaster in these studies. This is an important area in disaster preparedness and mitigation activities in countries where tsunami poses a major threat. In this paper we studied the factors associated with injuries during tsunami and the effect of built environment on these injuries.

Methods

A community based household survey was conducted in the Kinniya division in the Trincommalee district, Eastern Province of Sri Lanka six months after the tsunami. Kinniya division was severely affected by the tsunami with over 600 reported deaths or missing people and 8,000 affected families (6). A cross sectional study was conducted among all residents of Kinniya who survived the tsunami. Public Health Inspectors visited all households and temporary shelters including "tsunami" camps in this defined area and collected data on all members who lived in households prior to the tsunami. The surviving head of the household was interviewed using an interviewer administered structured questionnaire. Basic demographic data, injuries and deaths occurring from the tsunami and the details of housing structure was collected during this interview. Household structure was categorised as a binary variable; temporary shelters and permanent structures, based on the definition used by the Department of Census and Statistics for the census (7). Informed verbal consent was obtained from all respondents and ethical clearance for the study was obtained from the Ethical Review Committee, Faculty of Medicine, University of Peradeniya, Sri Lanka. To assess the effect of built environment, a logistic regression model was used. Variables were entered in to the model in a backward stepwise approach.

Results

The study sample consisted of 4,178 individuals, 2,143 (51.3%) males and 2,034 (48.7%) females. Mean age of the study sample was 25 years with a standard deviation of 17 years. Participants were from 1,049 households. Table 1 shows the household level characteristics of the study sample. Of the 4,178 study sample, 43 (1.1%) died during the acute incident and 19 (0.5%) died later due to complications suffered at the tsunami. Twenty eight (0.7%) people were reported missing at the time of data collection. Moderate to severe injuries were reported by 508 individuals (12.5%). To investigate the injury incidence all tsunami related deaths, missing persons and injuries were classified in to a single group as injuries. Of the reported number of injured, 302 (14.4%) were males and 296 (14.9%) were females.

Table 1 **Characteristics of the study sample from 1,049 households in Kinniya, Sri Lanka, affected by the 2004 Tsunami**

	N	%
Ethnicity		
Muslim	964	91.9
Hindu	85	8.1
Highest level of education of the household head/ spouse		
Primary / No schooling	938	89.4
Secondary	111	10.6
Structure		
Temporary	186	17.9
Permanent	853	82.1
Number of family members		
1-2	184	17.5
3-4	451	43.0
5-6	308	29.4
>6	106	10.1
Degree of household damage		
Total	453	43.4
Partial damage with displacement	212	20.3
Damage with no displacement / No damage	379	36.3
Distance to the sea		
<100	461	43.9
101-200	128	12.2
201-300	245	23.4
>300	215	20.5

Household level predictors of injuries during the tsunami was analysed in a logistic regression model. The distance to sea and the degree of household damage were categorised into binary variables (residence location <100m from sea, household destruction with displacement) for the interpretation of results. The number of household members was used not as a predictor but to remove the confounding effect. Initially, a

backward conditional model was used to identify the risk factors. All predictor variables were entered to the model in the first step and non-significant predictor variables were removed from the final model. Predictors of injuries identified from this analysis included; residence location <100m from sea (OR 1.427, 95% CI 1.084-1.877) and household destruction with displacement (OR 1.532, 95% CI 1.137-2.065) .Living in a temporary shelter (OR 0.529, 95% CI 0.359-0.797) was a protective factor for injuries.

Discussion

The main purpose of this analysis was to determine the association between tsunami related injuries and household level risk factors with special emphasis on the built environment. Our study result could have been affected by recall bias, as the construction of the residential cohort and injuries depended on recall. This could have underestimated the injuries rather than overestimating and therefore could not have affected the findings in a negative manner. We tried to overcome the bias reported in previous studies, which were conducted only in "tsunami" camps.

Our analysis revealed that after adjustment for possible confounders and other predictors, living in temporary shelters had a strong protective effect from injuries during the tsunami.The injury pattern during the tsunami was different from the mortality pattern reported in Sri Lanka(5) and elsewhere. Previous studies have reported higher mortality rates in females, children and in elderly age groups. The present analysis did not find a sex differential in the injury incidence, however, increasing age was associated with a higher level of injuries with maximum injury incidence occurring in 50 to 60 year age group. As expected, the distance to the sea had a highly significant association with injuries. This finding together with risk of living in permanent structures in tsunami threatened areas should be an eye opener for policy makers. In 2005, Sri Lankan Government decided to ban building permanent structures within the 100 meter distance from the sea. However, political forces suppressed the implementation of this policy. After eight years of tsunami, large number of permanent structures have built up and being constructed in this danger zone. The present analysis provides strong evidence for re-implementing this policy. The authors urge the decision makers in Sri Lanka to re-implement this policy as a major part of the disaster mitigation plan in tsunami threatened areas for the future.

Acknowledgements

We acknowledge the help given by public health field staff in the Kinniya division.

Funding

None

Competing Interests

None

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