Collaborative Project on the Seismic Preparedness of Hospitals and Public Health Resilience

US Institutions: Johns Hopkins University and the Pacific Earthquake Engineering Research Institute
NZ Institutions: University of Canterbury and the Natural Hazards Research Center

The continued functionality of critical infrastructure, such as healthcare facilities, is necessary following a major event. The focus of this proposed study is to assess the impact of the Christchurch earthquakes of 2010 and 2011 on acute-care hospitals. The study approach is multi-disciplinary involving engineers, epidemiologists and health and emergency managers. Each of these disciplines is necessary to properly analyze how structural and non-structural damage disrupts essential services provided by hospitals. Given that the building stock in New Zealand is similar to that in the US and that the building code in New Zealand is comparable to current practice in California, the results of this study will have direct applications to the state of California.

In order to provide adequate services to patients, hospitals rely on a wide range of internal and external functions (see Table 1), each of which are part of a complex network of interacting systems. The loss of a single function can severely disrupt the ability to provide care during the critical first hours. The overall goal of this project is to collect and analyze data from recent seismic events to help us better understand the consequence of losing any one or multiple functions in a hospital.

Table 1: Healthcare services and functions.

Healthcare Services	Support Functions
(1) Out-patient services: (a) Emergency department services (b) Out-patient clinics (c) Operative/surgical services	(3) External support/logistics: (a) Electricity (b) Potable water (c) Sewage systems (d) Communications
(2) In-patient services: (a) Intensive care (b) Monitored beds (c) Non-monitored/floor beds (d) Operative/surgical services (e) Rehabilitation services (f) Psychiatric services	(4) Internal support functions: (a) Food/kitchen (b) Laundry (c) Information systems (d) Pharmacy (e) Diagnostic services (f) Medical gases/vacuum systems (g) HVAC (h) Sterilization (i) Blood bank

The Darfield and Canterbury earthquakes that hit Christchurch over a six-month period provide a unique opportunity to assess of the exact mechanisms that disrupt regular services of hospitals, the resilience of the healthcare system provided by redundancies in resources and services of their networked facilities, the performance of this system after several successive strong ground motion events. The practical applications of the lessons learned can be used to improve the safety of hospitals in New Zealand, the US, and other countries by improving planning and better integrate response activities. Although analyzing the impacts on specific facilities, the study seeks to describe the interactions between all the acute-care hospitals.

In addition to similarities between the US and NZ in their existing building stock and building codes, the Coordinated Incident Management Systems (CIMS) for New Zealand is based on California's Incident Command Structure (ICS). Figure 1 below shows a comparison of the two structures for a national health emergency response. Given the agreement of these structures, we expect our project to inform best practices in healthcare system design as well as in emergency response and management.

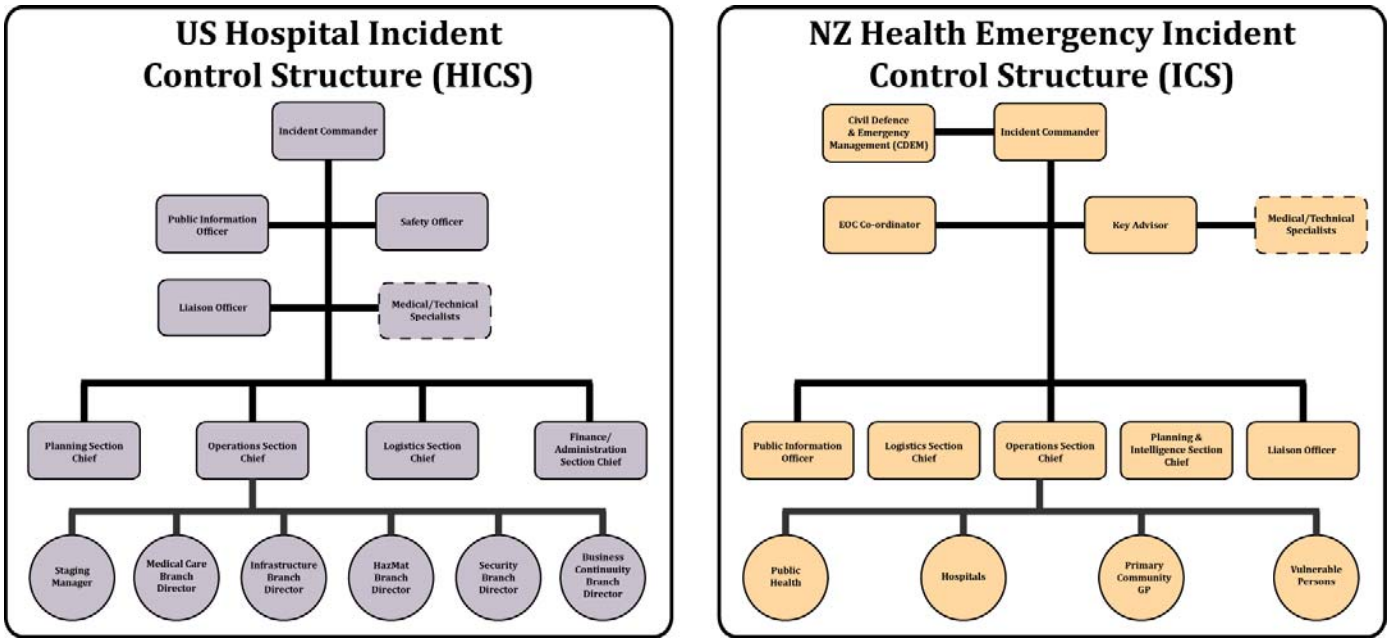

Figure 1. A comparison of the incident command structure for a national health emergency response in the United States (left) and in New Zealand (right).

The research team members conducted a similar pilot study in Chile after the 2010 earthquake and found critical losses of hospital function despite relatively little structural damage in the study area. This has serious implications for planning for healthcare systems, especially hospitals, which tend to take an 'all-hazards', top-down approach. We believe that planning needs to focus more on specific functions and designing systems for performance in terms of continuity. Informal discussions regarding a systematic extension of the work in Chile have been initiated with PAHO.

This study will be useful for:

1. Individual facilities, by analyzing the impact of physical damage on support functions and patient care. This will have serious implications on disaster planning and mitigation activities.
2. CDHB by describing the interactions of the hospitals in their healthcare system during the response, allowing for improved coordination activities.
3. The NZ Ministry of Health to develop strategies and policies that improve hospital and health system planning and mitigation, as well as to better direct future response.
4. A comparative study of the performance of hospitals in El Centro, CA and Mexicali in Baja California, Mexico after the Baja California earthquake of 2010; these results will be useful for Cal EMA to develop strategies and policies that improve hospital and health system planning and mitigation, as well as to better direct future response.
5. A comparison of the performance of the healthcare system in New Zealand to systems in the US and other countries after natural disasters, and the development of hospital safety recommendations as a result of the lessons learned.