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Do wave heights and water levels increase ocean lifeguard rescues?☆

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ABSTRACT

Objective: To investigate the association of wave height and tidal water level changes with the frequency of ocean lifeguard rescues.
Methods: All ocean lifeguard rescues recorded by Newport Beach Lifeguards in 2015 and 2016 were linked by time and location to weather and ocean variables contained in other historical databases. We performed separate multivariable analyses using mixed effects negative binomial regression to evaluate the total effects of wave height, mean water level (primarily set by tidal elevation), and rising vs. falling water level, on the frequency of ocean rescue in the study location, controlling for confounding variables.
Results: Newport Beach Lifeguards made 8046 rescues during the study period. In all areas of the beach, rescue frequency increased as waves got larger (IRR: 3.25; 95%CI: 2.91–3.79) but then decreased in large surf (IRR: 0.52; 95%CI: 0.37–0.73). In two sections of beach, lifeguards made more rescues during lower water levels, but in the third section of beach, made more rescues during higher water levels. Rescue frequency increased in two sections of beach with rising water levels, but did not in the other section.
Conclusions: Wave height, water level, and water level direction were associated with rescue frequency, but the environmental factors included in the analysis did not fully account for most variation in rescue frequency. Other factors need to be evaluated to identify major determinants of rescue frequency.

1. Introduction

Lifeguards are one of the layers of protection in drowning prevention at open water surf beaches [1,2]. Environmental hazards at ocean beaches, along with social dynamics and other demographic risk factors, contribute to drowning risk [3-5]. Lifeguards often prevent the need for rescue or injury by recognizing specific environmental hazards usually unidentified by the typical beach patron. For example, lifeguards protect members of the public by warning about rip currents, pointing out the location of submerged rocks at high tide, or informing parents with small children about in-shore holes where water depth changes suddenly. A recent study from California indicated the majority (54.85%) of lifeguard activity consists of preventative contacts, while aquatic rescues represented only 1.9% of activity, first aid events represented 0.94%, and major medical events represented 0.12% [6].

Multiple factors in the coastal environment lead to both preventative actions and rescues by lifeguards [7]. While, knowledge of physical variables of the coastal environment has expanded, it has mostly focused on rip currents. These concentrated flows of water move away from shore to varying distances beyond the surf zone [8], have been estimated to account for most surf lifeguard rescues in the United States and other locations [9-12], and have dominated the literature on hazards in the beach environment [10,13]. Other ocean and beach factors have been assessed for their contribution to surf zone injuries [14]; and although their role in lifeguard rescue has not been evaluated in the literature, backwash, lateral currents, sandbars, inshore holes, and other hydrodynamic and morphologic beach factors have been included as determinants of rescue for lifeguard training programs [9,15]. These processes arise from the interaction between different environmental variables, such as wave height or varying water levels, to form hazardous conditions that cause rescue. Both wave height and tidal water level are thought to be determinant of rescue frequency due to risk they present directly to bathers, their association with rip current frequency and velocity [16-18], and their role in exacerbating risk from other hazards in the ocean environment. However, the extent of their contribution to rescue and lifeguard activities has not been evaluated. Such information could help front line lifeguards anticipate and prevent rescues, benefiting the lifesaving community and their patrons.

The objective of this study was to investigate the association of wave height and tidal water level changes with the frequency of ocean lifeguard rescue occurrence in Newport Beach, California, using lifeguard

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rescue records collected in real-time from a Computer-Aided-Dispatch (CAD) system. This data collection method allows linkage of detailed lifeguard activity records to other sources for the analysis of lifeguard rescues and various other factors. Further analysis of oceanic and other environmental variables that affect rescue could provide new knowledge for use in lifeguard training programs, and information beneficial to supervisors and managers preparing staff and allocating resources. We believe the findings of this study could be used to improve lifeguard effectiveness via earlier intervention in the drowning process, resulting in fewer rescues and ultimately a safer experience for the beach patron.

2. Methods

This observational retrospective study linked records collected between January 1, 2015 and December 31, 2016 on the following variables from related sources: (1) Newport Beach lifeguard rescue data recorded in real-time with a Computer Aided Dispatch (CAD) System, (2) weather measurements from a nearby weather station, (3) wave data measured by three offshore buoys near the study location, (4) tidal water level information from sensors at the Los Angeles Harbor entrance, and (5) visual near-shore wave estimates from Surfline forecasters.

2.1. Study location and lifeguard service

Newport Beach is a suburban beach city in Southern California, USA, with approximately 90,000 permanent residents. The city experiences mild weather conditions and year-round tourism. With approximately 10 million people visits per year, peak summer beach visitation can exceed 100,000 patrons per day [19]. The Newport Beach Fire Department provides robust Emergency Medical Services (EMS) for the city: the department has an average response time of 4 min and 22 s from one of eight fire engines staffed by Emergency Medical Technicians and/or three ambulances with paramedics [20]. Professional lifeguards in Newport Beach are also employed by the Newport Beach Fire Department, and integrated into the city's EMS system. Lifeguards patrol year-round, and are responsible for eight miles (12.8 km) of Pacific Ocean surf beach divided into three operational divisions (Divisions 1, 2, 3) with fixed towers, vehicles, and boats (Fig. 1).

2.2. Variables and data sources

Data from various sources were linked according to an exact deterministic process (Fig. 2). We created a dataset with three records (one each for Division 1, Division 2, and Division 3) for every hour between 7:00 AM and 8:00 PM, for 2015 and 2016 resulting in a panel frame with 28,509 records. Hourly data for each division included a count of rescues and public contacts, the hourly mean of continuous environmental variables, and the hourly mode of categorical environmental variables. Institutional Review Board approval was not required for this study; previously collected de-identified data did not meet the regulatory definition of human subjects research.

2.2.1. Lifeguard activity variables

Newport Beach lifeguards recorded the time and location of all rescues and other interventions (preventative action, first aid, rule enforcement, etc.) in real-time via SunGard Systems Computer Aided Dispatch (CAD) Integrated Public Safety Software (Lake Mary, Florida, USA). Lifeguards in towers and vehicles called dispatch using closed circuit telephones or radios if required to intervene in a situation. The dispatcher recorded the time, location, and type of call into the computer system,

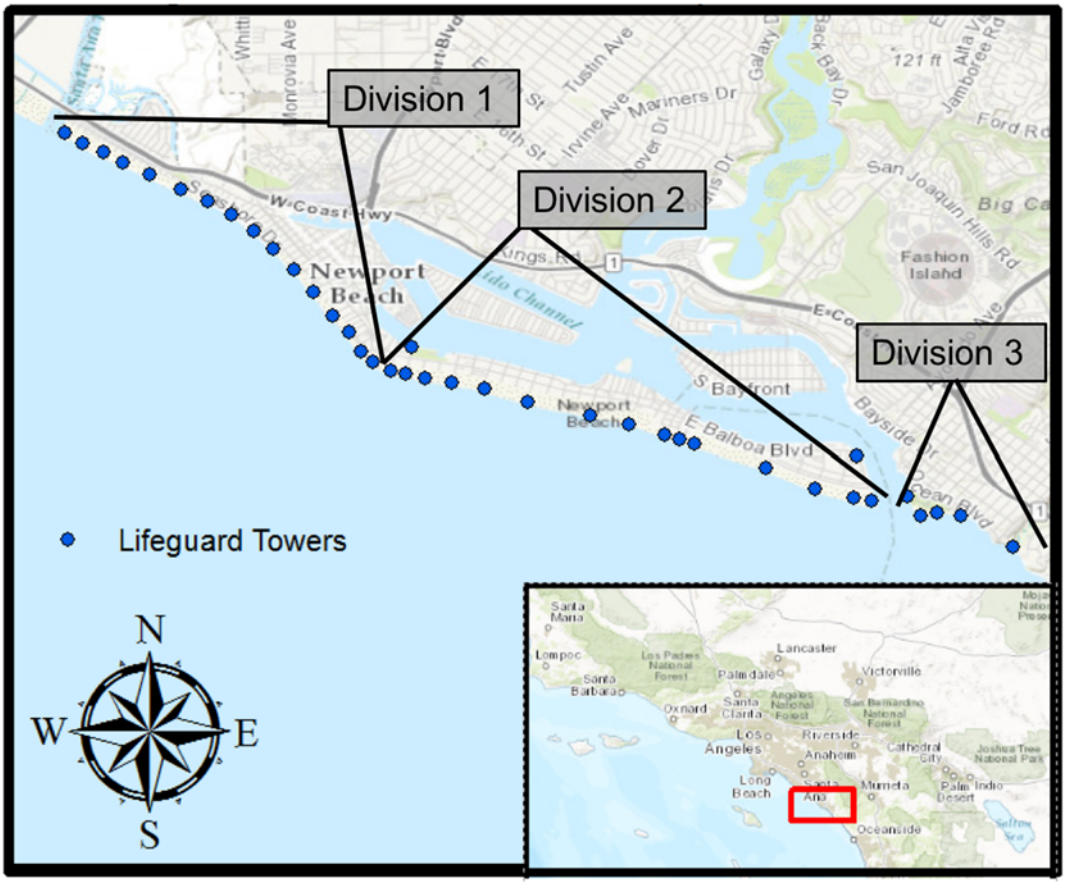

Fig. 1. Map of Newport Beach with operational divisions and lifeguard towers.

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