Evacuation Travel Demand Analysis – Haifa 2016 Wildfire

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Introduction

Over the past decades we have experienced an increase in the intensity and frequency of both natural and man-made disasters (Smith, et al., 2009). These events have dramatic implications in terms of loss of human lives, well-being, and economic costs (Pel, et al., 2012; Newkirk, 2001). In Israel, similarly to other Mediterranean countries, we see a rise in the frequency of forest fires and a subsequent expansion of the affected area (Tessler, 2012).

When planning the response for any type of disaster, efficient management of the transportation systems is vital in order to allow for an effective evacuation of the affected population, and the mobilization of equipment and relief and response personnel (Perry & Lindell, 2003; Brachman & Church, 2009).

The unpredictability of the circumstances of disaster means that proposed evacuation and transportation plans need to be adaptable for the changing situation. This may include physical failures of the transportation network which lead to a reduction in network capacity as well as a significant change in travel patterns. Therefore, understanding the demand for travel during disaster, particularly when evacuations take place, is critical for the efficient management of the event (Van der Gun, et al., 2016).

Despite the importance of modeling travel demand during evacuations, existing literature tends to explore the actual decision to evacuate, or evacuation during hurricanes; or derives data from stated preferences (SP): The most studied behavior is the actual choice whether to evacuate or not, in particular in hurricane situations. For example, Baker (1991), and Dow and Cutter (2002) studied RP data from past hurricanes. Several researchers used SP and combined the study of evacuation choices with the timing of evacuation or number of intermediate stops and other decisions (Alsnih, et al., 2005; Auld, et al., 2012).

Haifa November 2016 Wildfire

A wildfire took place in Haifa, Israel, on November 24, 2016. On that day, starting at 10AM, a series of wildfires occurred in various locations at the southern part of the city, a primarily residential area. The residents of several neighborhoods in this area were asked to evacuate. In total, about 40,000 inhabitants (approximately 15% of Haifa's population) were evacuated. The fires were extinguished on the following day and residents were able to return to their homes.

After the fire events, a web survey was developed and administered (March to June 2017) in order to collect data on the activities that residents of the affected areas took part in that day – in total data from 516 individuals was collected. The information collected includes all the locations they stopped at, the activities they participated in at these locations, and their durations of stay. Travel

modes, travel times and the identity of other individuals that traveled with them, were reported for each trip between stops.

Research Objectives

The aim of our research is to employ the revealed preference (RP) data collected after the Haifa 2016 fire to shade light on travel activities undertaken by individuals and households during disaster evacuation, and to propose an activity-based model for such events.

The information collected in the web survey includes all the locations where respondents and all their household members stopped at: the activities they undertook in these locations (respondents were able to report more than one activity per stop) and the durations of stay. Travel modes, travel times and the identity of other individuals that traveled with them, were reported for each trip between stops. Data was collected for all trips until evacuation from the area affected by the wildfires, or until the last stop was made that day if the respondent remained at the affected area.

Methodology and results

Evacuation rates and propensity
To date, we have examined the factors influencing the decision to evacuate or stay put, both in literature and in the data collected after the Haifa 2016 fire. A comprehensive literature review that compares between factors influencing the decision to evacuate or 'stay put' was conducted. Unsurprisingly the clearest factors influencing the decision to evacuate are those relating to the characteristic of the event: higher risk level, regardless of measurement method, increases the chance of individual evacuating. Other contributing factors relating to the include: guidance provided by authorities, evacuation of others around the individual. Another category of factors includes individual and household characteristics, the result for which are less consistence in their affect and among the contributing factors are: past experience with evacuation or having an evacuation plan, living in a mobile home. When examining household characteristics, most studies agree that having children in the household increase the chance of evacuation, while few studies show that the presence of those in need for assistance increases the chance of evacuation. Presence of pet shows little negative or no effect whatsoever. Other factors examined which shows significant affect include having work obligation which negativity affecting the chance of evacuation and gender.

Statistical analysis of the data collected in the web survey shows that overall, 83% of the respondents evacuated from the area of the fires. The Factors of age and presence of children and elderly persons in the household are associated with the evacuation rates. 91% of the children under 18 years old in the sample evacuated. Among adults, 86% of those in households with children evacuated, but, only 72% of adults in households without children. Individuals in the older age groups, and those in households with elderly persons are significantly less likely to evacuate. Individuals in household with pets are also less likely to evacuate. As expected, individual's whose home was at high risk were more likely to evacuate.

In addition, a binary choice model that incorporate multivariate explanatory variables was developed for the decision whether or not to evacuate. The results show an effect for factors

related to all of the characteristics of the individual the household and the event itself. Children, and especially younger ones, are more likely to evacuate. Older adults, ages 55 or over are also more likely to evacuate. Differences were also not found between males and females and based on education or car ownership levels. The results regarding children and the elderly are consistent with earlier studies, and so are the lack of effect of education and car ownership. But, the results regarding gender contradict the majority of studies that found that females are more likely to evacuate. Presence of children in the household increases the probability of evacuation. These results are more conclusive than the ones found in the literature. Individuals in households with pets were less likely to evacuate, but the magnitude and significance of this result is lower. This is in line with earlier results that mostly shows a small negative or no effect on evacuation rates. Finally, as with all previous studies, higher levels of risk for the home was related to a higher probability of evacuation.

Evacuation characteristics
In addition to the choice whether or not to evacuate, there are other decisions that individuals make during an evacuation event.

Lindell and Prater (2007) distinguish between the proximate and ultimate evacuation destinations. The former is defined as the first stop that evacuees make outside the affected area, while the latter is their final destination. In the current survey, in order to simplify and shorten the questionnaire, only information on the proximate destination was collected. Among the individuals that evacuated (N=446), for 57% the proximate destination was someone else's house, 17% travel to public places. In terms of the locations of destinations, 52% of evacuees stopped within the boundary of the city of Haifa, 20% outside the city, but within the metropolitan area and 28% traveled further away.

The vast majority of individuals (N=440) evacuated using private vehicles. 38% drove themselves and 54% were passengers. the results highlight the dependence on the private vehicle in such unplanned events. These results are consistent with those reported by Dow and Cutter (2002) and Kang et al. (2007). The expected number of vehicles used per household for the evacuation is 0.89, which is substantially lower than values reported in the literature for hurricane events (e.g. 1.62 in Kang et al. 2007). This may be explained by the nature of the evacuation which was expected to be short-termed and by lower car ownership rates in Israel compared to the US. The high fraction of individuals that evacuate with private vehicles, and the relatively low number of vehicles used, means that many individuals evacuate together with others. Only 10% of individuals evacuate on their own. The average size of groups that evacuate together is almost three persons. Furthermore, it increases with the household size. This results further demonstrates the tendency of households to evacuate together, which was also pointed out in the literature.

About 60% of individuals make at least one intermediate stop. Individuals that evacuate make an average of 1.10 intermediate stops. Children under 18 make 0.80 stops. Adults in households with and without children make 1.51 and 0.83 intermediate stops, respectively. These results suggest not only that the travel patterns of children differ from that of adults, but also that their presence in the household affects the behavior of the adults. Counter to expectations, there is little difference in the number of stops between individuals that evacuated and those that did not.

Future and Current Works

At the present time the main focus of research is on analyzing the data regarding activities at stops during an evacuation scenario. An initial examination of the percentage of stops where activities took place, illustrates the previously studied need to pick-up others during a disaster, and the increased need to do so for adults with children in their household. Moreover, it demonstrates how the socio-demographic groups differ from one another regarding pick-up locations. Other activities that have been discussed in the past have to do with taking care of pets and picking up belongings; however, in our survey, these were found to be less significant. Furthermore, very little attention has been given in the literature to the time people spend 'waiting' until they grasp the extent of the disaster and its implications, which was noted in approximately 25% of the stops, with tendencies to do so in particular places correlated to the final decision to evacuate.

Further analysis and discussion regarding these findings is presently conducted, with the prospect of developing an activity-based model for disaster originated evacuation. Future work will include incorporating intra-household interaction, evident in the data and in literature, into a household activity-based model for disaster originated evacuation.

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