International Journal of Disaster Risk Reduction 17 (2016) 137–153

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Putting people at the centre of tornado warnings: How perception analysis can cut fatalities

Richard Michael Stokoe [1]

University of South Wales, Glyntaff Campus, Pontypridd, Rhondda Cynon Taff CF37 4BE, United Kingdom

ARTICLE INFO

Article history:
Received 17 November 2015
Received in revised form
10 April 2016
Accepted 10 April 2016
Available online 23 April 2016

Keywords:
Tornado
Facebook
Early warning systems
Risk perception
White Male Effect
Smartphone apps

ABSTRACT

Despite improvements in tornado Disaster Risk Reduction (DRR), since the 1990s the number, and proportion, of people dying in tornadoes in America has increased. This paper examines how people rely, understand and trust tornado alerts and the Early Warning Systems (EWS) that disseminate them, if socio-demographics cause specific groups to experience greater risk, whether these factors have affected the rise in fatalities and what mitigation measures could reverse this.

Ford County, Kansas, was selected as a case study. Interviews were conducted with officials and an online survey marketed through Facebook was undertaken, receiving 547 responses. Results showed white men were particularly vulnerable to tornadoes as they were more likely to ignore warnings. Hispanics, older people and those with tornado experience were also at higher risk if they heard an alert from an EWS they distrusted or did not understand. Population growth in these groups and technology changes have helped cause the recent fatality rise and, unless changes are made to the EWS, the continued increase in size of these groups will lead to more people becoming at risk from, or perishing in, tornadoes. Recommendations to prevent this include federal regulation and improved education materials for sirens, alerts translated into Spanish, discontinuing NOAA radio and developing an official forecast and alerting app.

1. Introduction

This paper initially examines the tornado threat compared to other American environmental hazards, historic fatality data and the methods developed to reduce risk and cut deaths. This self-funded research, which conforms to the British Psychological Society Code of Human Research Ethics [11] identifies the strengths and shortcomings of previous tornado mortality mitigation studies and demonstrates where this paper can increase knowledge and assist in lowering fatalities. It outlines why Ford County, Kansas, was chosen as a case study to gather data on tornado hazard alert and EWS perceptions, what the interviews with officials and survey of residents aim to provide, and describes the benefits and limitations of using online data collection and Facebook marketing to attract respondents. The results detail the quantitative and qualitative data as to whether people use, understand or trust alerts or the EWS they come from, any variation between how officials think residents perceive their warnings and how they actually receive them and, finally, if an individual's background or experience alters how they interact with warnings to encourage, delay or stop them from sheltering when a tornado approaches.

The discussion explores what causes each EWS to be perceived and trusted differently by people depending on their socio-demographic background. It assesses why certain groups are more at

Abbreviations and glossary of terms: Apps, Specific computer programmes designed to run on portable devices such as smartphones and tablet computers; *ARC*, American Red Cross.; *Doppler radar*, A specialised radar system that can track weather systems. Three iterations have been used in America. The first generation was Weather Surveillance Radar 1957 (WSR-57), the second was Weather Surveillance Radar 1974 (WSR-74). The current version is Weather Surveillance Radar 1988 (WSR-88) and replaced the existing systems; *DRR*, Disaster Risk Reduction; *EWS*, Early Warning Systems; *FEMA*, Federal Emergency Management Agency; *GPS*, The Global Positioning System is a satellite based navigation and location system; *Kernel Density*, A GIS method of examining and analysing data; *IPAWS*, The Integrated Public Alert Warning System is a federally designed system that enables alerts to be sent to local TV and radio stations and mobile phones via GPS co-ordinates; Outdoor siren alert system, Audible air raid wailing siren developed in the 1950s to warn of impending catastrophic disaster; *NOAA*, National Oceanic and Atmospheric Administration; *NOAA radio*, Nationwide network of radio stations developed between 1950 and 70s broadcasting local weather warnings via a standalone device; *NWS*, National Weather Service; Reverse 9-1-1, An emergency broadcast system allowing officials to call any phone in an area with information about the threat and what to do; *SMS*, Short Message Service; *SPC*, Storm Prediction Center; *Survey Monkey*, A free online survey and questionnaire web tool; *WEA*, Wireless Emergency Alert system. Smartphone and mobile alerting system developed in response to Hurricane Katrina that delivers 90 character warnings to those in a designated area

E-mail address: richstokoe@hotmail.com
[1] Present address: 97A Windsor Road, Forest Gate, London, United Kingdom, E7 0RA.

http://dx.doi.org/10.1016/j.ijdrr.2016.04.004
2212-4209/

risk from tornadoes regardless of which warning system an alert is heard from and why other groups are more vulnerable only when they are alerted by a specific EWS. It shows how the perception gap between the officials who do the alerting and the residents who receive the warning is preventing the development of methods that can reduce tornado vulnerability. It asserts that unless EWS and their perception amongst residents is improved and new alerting techniques developed, then population increases amongst the most vulnerable groups will lead to a continued rise in tornado deaths. The conclusion suggests areas where further research would be beneficial, proposes seven recommendations that reduce tornado risk and explains how the methods used, and observations made, in this paper could cut unnecessary fatalities in other fields of global environmental DRR.

The United States experiences around 1200 tornadoes each year, more than any other country on earth [2], p. 1214). Since 1950, when accurate record keeping began and meteorologists were first allowed to issue tornado forecasts to the public [54], over 7500 individuals have died - double the number who perished in the same period across America from earthquakes and hurricanes combined [50].

To reduce fatalities, a tornado warning process was created to identify and develop increasingly sophisticated methods of ensuring people shelter before a storm strikes (p. 567). This DRR procedure progresses through four chronological and sequential steps. Initially, long-range eight-day forecasts identify conditions favourable for supercell storms so as to ensure that the Storm Prediction Center (SPC) can issue a'tornado watch' to threatened areas; if a funnel is identified by storm spotters or the emergency services it triggers the authorities or meteorologists to issue a 'tornado warning' to those in its path; this alert is then disseminated through a multitude of EWS to affected people which, once received, should ensure they have sufficient time to evacuate to a nearby shelter as quickly as possible (Fig. 1).

1.1. The four stage tornado forecast to shelter process

The combination of permitting public tornado warnings; training storm spotters; the roll out of the first two generations of advanced weather forecasting Doppler radar systems WSR-57 and WSR-74; the introduction of tornado EWS; the proliferation of television and radio into rural communities and subsequent use as warning channels; improved education and awareness; stronger building construction and better shelter design helped fatalities drop from an average of 178 a year in the 1940s to 52 a year in 1980s (Fig. 2) [16,17,2,29].

The single biggest improvement in tornado DRR equipment came between 1992 and 97 with the introduction of the third generation Doppler radar, WSR-88. This forecasting technology increased warning times from three minutes in 1978 [29], p. 110) to an average of 13 min by 2010 [65], p.117), cut the number of unwarned fatal tornadoes from 15 in the five years before its introduction to just three between 2010 and 2014 (Fig. 3) and led to a 35–50% reduction in fatalities [65], p.135).

Yet, despite the introduction of ever more advanced DRR measures reducing fatalities over the four decades after 1950, and there being no evidence of more, or stronger, tornadoes occurring due to climate change [65], p. 18, [9], p.137, the average number, and proportion, of people perishing flatlined before rising again in the 1990s (Fig. 4). This increase has been so great that more people have been killed by tornadoes in the last decade than in the previous twenty years combined. Even if the high 2011 death toll is discounted as an anomaly and removed from the statistics, the trend and proportion of people dying since the 1990s still increases.

Despite this rising trend in tornado fatalities, studies have dismissed this issue as a statistical abnormality and have failed to examine what could be causing it [65], p. 5). This can be explained by the three specific methods used in previous tornado DRR papers which prevent the identification, analysis and explanation of this recent phenomenon.

The first group of papers explore tornado DRR by examining America-wide historical information and statistics dating from the mid-19th century to the end of the 20th century [2,17,8,64,65,7,80]. However, whilst valuable in describing previous successes and issues, the lack of analysis of 21st century data

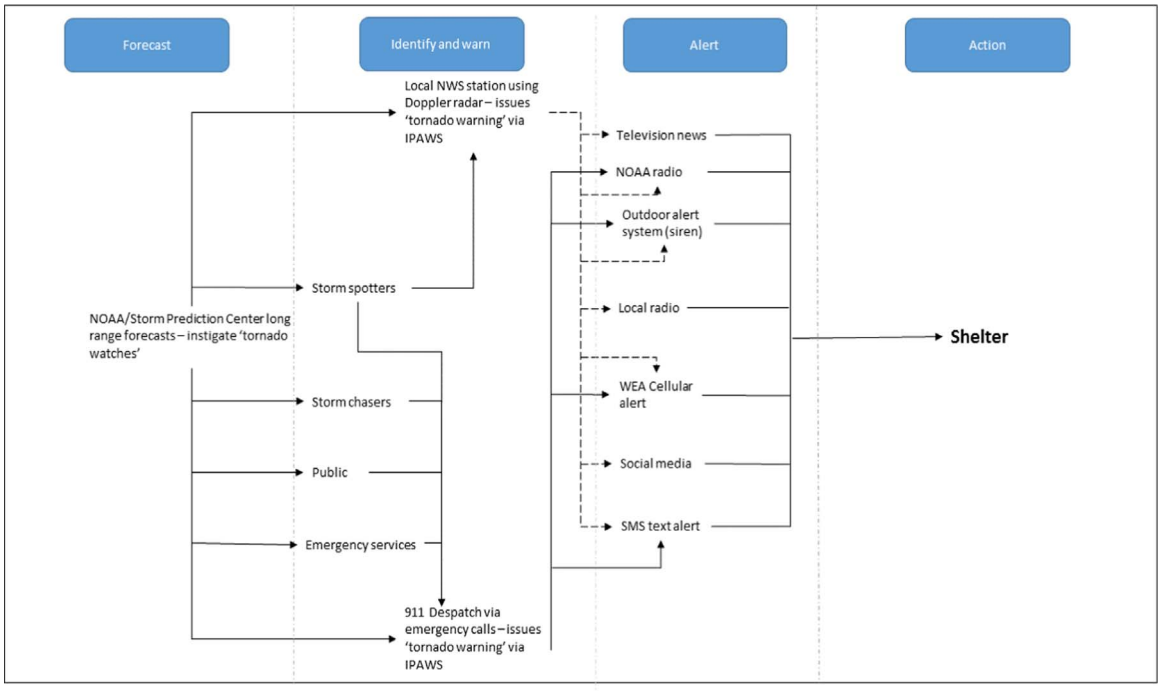

Fig. 1. The four stage forecast, identify, alert and action model for tornado warning dissemination across America [46–48]25].