Social Capital´s Role for Disaster Resilience in Hurricane Harvey

Bachelor Thesis

Justus Baumann
s1867636

Date: 28.08.2018
Supervisors: Dr. Gül Özerol
Prof. Dr. René Torenvlied

Abstract

In August 2017 Hurricane Harvey, a category four hurricane, hit Texas and caused vast devastation and 70 fatalities in total. Surprisingly, most of the fatalities did not occur in the areas marked as most flood-vulnerable by the Federal Emergency Management Agency (FEMA), but rather outside of those areas. Recent studies found that social capital has been a key determinant of variance in disaster fatalities of different communities (see for instance Aldrich & Sawada 2015). This thesis examines whether differences in social capital might provide an explanation for this variance in the case of Hurricane Harvey. Bonding social capital has not only been discussed as a determinant of fatalities, but also as factor with influence on mental health and recovery. The association between bonding social capital and the status of mental health, intake of psychotropic drugs, increase in alcohol consumption and recovery rates, from disruption experienced, is investigated. These factors are included as they appear to be good indicators of the psychological resilience of individuals. The data of the Post-Harvey Survey of the Episcopal Health Foundation and the Kaiser Family Foundation has been used to investigate those factors. The dataset contains the answers of 1635 participants living in areas highly affected by the Hurricane.

No evidence could be found that a variance in social capital could be an explanation for the variance in fatality rates. Instead, share of persons aged 65 and older correlates strongly with the fatality rates. A strong correlation has been found between bonding social capital and mental health. Intake of new psychotropic drugs after Hurricane Harvey as well correlates strongly with bonding social capital. Bonding social capital also correlates strongly with the recovery rate three months after the hurricane. The results suggest that bonding social capital plays a key role in the resilience and recovery of disaster-affected individuals.

Contents

Overview of tables and figures

1. Introduction

In times, in which the world is facing frequent natural disasters and is anticipating a growth of these disasters in the face of climate change (Mendelsohn et al. 2012), one of the pressing questions is how to prepare cities for threats like severe disasters. In this context, resilience, the ability to cope with a disruption and adapt to changes (Intergovernmental Panel on Climate Change (IPCC) 2014), is a concept of growing importance.

The United States of America (USA) are subject to a variety of natural hazards regularly (National Hurricane Center 2018), often with devastating consequences including fatalities (Ashley & Ashley 2008) and posing risks towards social communities. These sudden disruptions often hit communities hard and can lead to a long-lasting recovery process. Hence, various scholars and policy- makers have shifted part of their attention towards the question of how to prepare beforehand to make human-ecological systems able to deal with disasters. Resilience has been found as an effective property of systems to cope with unpredictable risks and the change that follows from the disruptions (Folke et al. 2002).

A range of factors that influence the building/establishment of resilience have been discussed in the academic sphere. Most guidelines and frameworks focus on physical infrastructure and formal institutions (see for instance IPCC 2014, and Tyler & Moench 2012).

These elements are without doubt central in building resilience. However, it appears that another factor has not been given sufficient attention in approaches of building resilience: the role of social capital for the resilience of disaster affected communities and individuals. Recent research suggests that social capital plays a vital and underestimated role in disaster resilience and recovery (see for instance Aldrich & Sawada 2015, Aldrich 2015, Gordeev & Egan 2015, Paton & Johnston 2017). This makes social capital in the rising field of resilience research an extremely interesting factor to research. Social capital is still a relatively unexplored explanation for the variance in resilience of different human communities (Aldrich 2015) and individuals in in (post-)disaster environments. More investigation is needed to evaluate if social capital has a high potential of enhancing the capacity of communities and individuals to withstand natural disasters.

1.1. The Case: Hurricane Harvey

Hurricane Harvey has been taken as the single case for this study. It was a highly destructive hurricane that put severe pressure on the population affected by it (FEMA 2018). The storm was labelled a category four storm with extremely high wind. The measured peak on land being 233 km/h (126 kt) (FEMA 2018). Hurricane Harvey made landfall in San Jose, Texas the 26th of August 2017 and went offshore again the 8th of August 2017 (FEMA 2018). At this point the hurricane had already decreased to a tropical storm (FEMA 2018). The hurricane has been the second-costliest cyclone in U.S. history, with overall costs of 125 billion dollar (National Hurricane Center 2018) and had a death toll of 70 fatalities in the state of Texas (Jonkman et al. 2018). This makes Harvey the deadliest hurricane since Hurricane Sandy (FEMA 2018). It strongly affected the Houston metropolitan area, the fourth most-populated urban area of the USA (United States Census Bureau 2017).

Texas, situated in the south-central part of the USA, is the second largest state in terms of area and population (United States Census Bureau 2017). It has a population of 28,3 million inhabitants (United States Census Bureau 2017) and experienced a population growth of 12,6

percent between 2010 and 2017 (United States Census Bureau 2018). The most populated city in Texas is Houston, which is also the fourth largest in the USA (United States Census Bureau 2017). The Houston metropolitan area is also the fifth largest metropolitan area in the USA (United States Census Bureau 2017).

Texas is characterized by a deep distrust of government (Collier et al. 2013). An influential article in the New York times pointed out that this deep distrust and reluctance to the institutions of the federal government, including FEMA, poses a great barrier towards the recovery of Texas while at the same time local community networks play an important role in civic life (New York Times 2017).

Texas frequently experiences natural disasters, with thunderstorms being the most frequent type of disruption with annual average of 139 thunderstorms (National Centers for Environmental Information 2017). In the last decade, Texas was hit by two major hurricanes, Hurricane Rita and Hurricane Ike (National Hurricane Center 2018).

The recent date, the severity and its effect on a major urban area make Hurricane Harvey the best case for this research.

This bachelor thesis was furthermore created in the context of the Annual Program on Urban Resilience, a cooperation between the University of Twente, Twente, The Netherlands and the Stevens Institute of Technology, New Jersey, The United States of America – which made a disaster that took place in the US or The Netherlands a case of especially high interest.

1.2. Problem definition

One particular fact makes Hurricane Harvey furthermore an especially well-suited case to investigate a less-established factor for fatalities: The majority of the 70 fatalities occurred outside the designated 100- and 500-year flood hazard areas (Jonkman et al. 2018). These areas, which are mapped by the Federal Emergency Management Agency (FEMA 2017), are the primary indicator for flood risks in the USA (Jonkman et al. 2018). The 100/500-year flood hazard areas are identified due to flood-prone topography, the flood water levels, possible storm induced erosion, land use and overland wave modelling (FEMA 2017). Flood water levels are derived from the use of historic flood data and computer modelling (FEMA 2017). In case heavy rainfall and/or high waves occur, these areas are expected to have the highest flood levels. As flood levels have been a major determinant for fatalities in past disaster (see for instance Jonkman et al. 2009), it is reasonable to assume that the majority of fatalities can be found in these high-risk areas. Nevertheless, this was not the case for Hurricane Harvey. The Harris county, which includes Houston, had the highest number of deaths during Hurricane Harvey (36 fatalities). Only 22% of those fatalities occurred in a designated flood-hazard area (Jonkman et al. 2018).

To develop a hypothesis how the unexpected occurrence of most fatalities of Hurricane Harvey outside the most flood-prone areas can be explained literature on the determinants of fatalities during disasters was reviewed. This literature will be discussed in greater depth in a subsequent part of the thesis. Especially, it was enquired in what disasters a puzzle similar to the one of Hurricane Harvey has occurred and what explanation has been found in those cases.

A natural disaster, where a high number of fatalities appeared in areas that were less severely affected was the tsunami in 2011 that hit Japan after a severe earthquake (Aldrich & Sawada 2015). The earthquake was with a magnitude of 9.0 the strongest one ever recorded in Japan and 24.000 persons were reported dead or missing after the catastrophe (Mimura et al. 2011). Aldrich & Sawada (2015) found that the percentage of people that were dead or missing however varied greatly in communities that were hit by an equally high tsunami wave (figure 1).

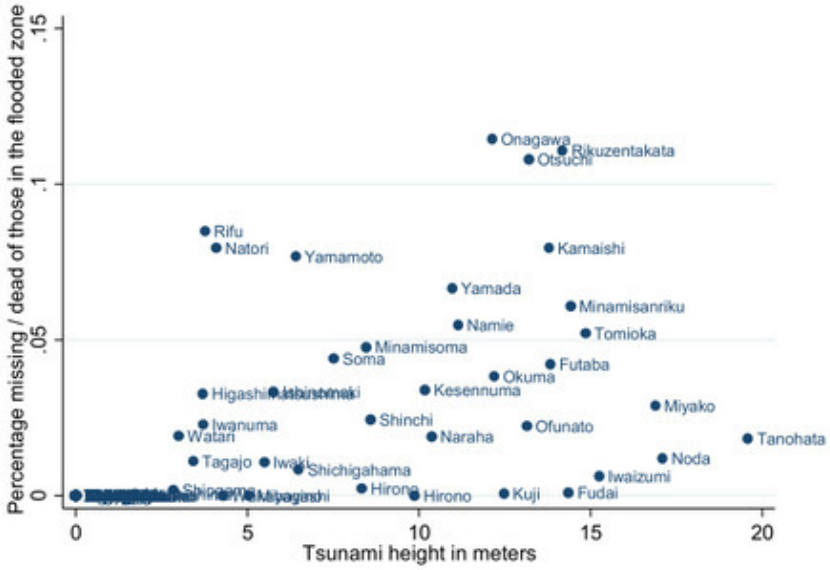

Figure 1: Correlation between tsunami height and percentage of population found dead or went missing

Source: Aldrich, D. P., & Sawada, Y. (2015). The physical and social determinants of mortality in the 3.11 tsunami. *Social Science & Medicine*, *124*, 66-75.

Investigating this variance of fatalities Aldrich & Sawada (2015) found no significant correlation between the existence/height of sea walls and the number of fatalities relative to population size and height of the tsunami wave. To detect the key determinants of the variance in fatality rates 16 possible determinants were tested. These had been derived from literature and interviews with experts on the region (for the full list of factors see Aldrich & Sawada 2015, p. 70). Social Capital was found to be the strongest determinant for the share of fatalities in equally affected communities (Aldrich & Sawada 2015).

The authors explain this correlation with a lacking ability to self-organize and provide mutual help in communities with low social capital. Weaker social networks, lower trust and weaker social norms lead to this inability to self-organize. Based on interviews that were conducted with survivors they found that in communities with high social capital neighbours and friends came to the homes of vulnerable inhabitants to ensure their safety and would often motivate them to evacuate (Aldrich & Sawada 2015).

Social capital is factor for fatalities, that, more intensively discussed, came into debate only recently. It might add a valuable dimension in addition to established determinants of mortality such as magnitude of the disaster and demographics. These well-known factors will be discussed in more detail in subsequent parts of this thesis. Aldrich & Sawada (2015) acknowledge the role of the magnitude of a natural disaster as the main determinant of the

fatality rate. However, their research reveals the significant role of social capital in moderating this effect for the case of the 2011 tsunami.

Literature on the role of social capital in disaster contexts and on social capital and resilience has been reviewed in a subsequent step. It has been found that social capital is possibly an important factor for another mark disasters leave: the mental health of those affected. A large share of a disaster-affected population in catastrophes worldwide suffers from mental health problems after a disaster (Norris et al. 2002). At the same time, it is often not feasible to provide appropriate mental health care for all in need due to the skyrocketed demand (Weisler et al. 2006). Deteriorated mental health can have a lasting impact on the general well-being of an individual and can lead to severe consequences such as the loss of one´s job or even suicide (Layard & Clark 2014). A resilient community would therefore be one where individuals can mentally cope with the disruptions of a disaster. In their guideline "Road to Resilience" the American Psychological Association (2018) names the embeddedness in a social support network as the most important factor for resilience.

Some evidence was also found that social capital is a central factor in aiding the recovery process (see for instance Aldrich 2011a, Islam & Walkerden 2014). Even with the most robust infrastructure major natural disasters will cause destruction and a disruption of the life of those affected. Hence, also a fast recovery after a disaster is an important dimension of resilience. A simple definition of full recovery is to define it as the state, in which a community (or individual) has managed to restore itself to the pre-disaster condition (Albala-Bertrand 1993). Adger (2003) shows in two case studies that high social capital in a community enhances climate adaption and resilience. Other authors stress the importance of social capital, especially bonding social capital especially in the short-term recovery (see Islam & Walkerden 2014, Hawkins & Maurer 2009, Nakagawa & Shaw 2004).

1.3. Scientific and Societal Relevance

Social capital is an understudied factor for disaster fatalities (Aldrich 2015). The studies that have found this relationship were in most cases investigating disaster fatalities in Southeast-Asian countries and evidence for the USA is missing.
In disaster recovery research there is a lack of empirical evidence on the role of economic capital, damage levels and social capital in post-disaster communities (Lin 2008). All three factors are investigated in the recovery part of this study. The role of all three factors is furthermore investigated regarding their effect on mental health. If evidence for the importance of social capital turns out to be strong and consistent in this and subsequent studies a stronger focus on building social capital as a mean to enhance resilience would be recommendable. The evidence so far (see for example Aldrich & Sawada 2015, Frankenberg et al. 2011, Islam & Walkerden 2014) indicates that social capital is an important factor in mitigating the consequences of disasters. This research adds new, valuable evidence to this by investigating the case of Hurricane Harvey.

Understanding the state and importance of social capital is also important to inform the public debates on shrinking social capital. Putnam (2000) gave rise to this debate with "Bowling alone" arguing that the social capital of the USA is shrinking. McPherson et al. (2006) showed for the USA that the number of close friends each American has is declining. This is a development worth considering not only when it comes to resilience, but also due to the central role of human connection for human well-being in general (Helliwell et al. 2014). Previous research has suggested that social capital could be a factor that enhances community resilience (see for instance Gordeev & Egan 2015, Poortinga 2012). This relationship though

is still understudied (Gordeev & Egan 2015). Especially on the role of social capital for mental health after natural disasters little research has been conducted so far. This thesis therefore will also investigate the influence of social ties on individual resilience after a natural disaster.

A better understanding of the role of social capital for building resilience can also aid resilience policy measures. Building social capital, defined as networks of acquaintance and recognition, through simple measures such as neighbourhood fests and local currencies might be furthermore an especially cost-effective way to strengthen the resilience of urban areas (Aldrich 2017).

1.4. Research Questions

Based on the reviewed literature on the role of social capital on resilience sensitive factors the main research question and five sub-questions have been developed. When referred to persons, always persons who lived during Hurricane Harvey in an area affected by the hurricane are meant. Strong social capital is defined as having a lot of persons nearby that one can rely on. Weak social capital is defined as having few or no persons nearby that one can rely on. These This definition is made due to the fact that data was only available on the quantity of relationships. The quantity of one´s relationship is one important dimension of one´s social capital (Bourdieu 1986) and is a factor that has been found associated with among other dimensions mental health (Wang et al. 2017). Unfortunately, no data was available on the differences in the quality of the relationships which is another factor discussed as important for one´s resilience, e.g. the individual reslilience in terms of mental health (Wang et al. 2017). The research questions have been formulated on the most precise social entity data was available on – as this allows for the most accurate association between social capital and the resilience factors. For fatalities the most accurate level for social capital data is the county level. For the four other factors data is available on the level of the individual. The first sub-question is therefore formulated on the community/county level. The four subsequent sub-questions are formulated on the individual level.

The main research question this thesis aims to answer is:
To what extent is higher social capital associated with better resilience outcomes in case of Hurricane Harvey, in terms of fatalities, mental health, psychotropic drug intake, alcohol use and recovery?

Five sub-questions have been formulated to answer this main research question:

1. Does high social capital in a county correlate with a lower share of the population found dead in the same county?

2. Do persons with stronger social capital on average have better mental health after Hurricane Harvey than persons with low social capital?

3. Have persons with a low social capital started taking new psychotropic drugs more often after Hurricane Harvey than those with a strong social capital?

4. Have persons with a low social capital increased their alcohol use due to the experiences of Hurricane Harvey more often than those with strong social capital?

5. Did persons with strong social capital report more often to have recovered in the medium-term after Hurricane Harvey than those with low social capital?

2. Literature Review

In the subsequent paragraphs first, a review of the literature on resilience will be presented and by that clarified what resilience comprises. A specific model for disaster resilience will be explicated and the concept of individual resilience will be introduced. Next, the concept of social capital will be discussed and it will be clarified what is meant by social capital when discussed in this thesis. In the next part factors influenced and/or associated with disasters and the potentially mitigating role of social capital will be outlined based on the relevant literature. First, literature on the relationship between fatalities and social capital is discussed. In the following sections four dimensions that can furthermore serve as indicators for resilience after a disaster are discussed. These dimensions have been derived from identifying which of the dimensions collected data on in the Post-Harvey Survey might be indicators of resilience and influenced by the level of social capital. Four dimensions have been identified: mental health, psychotropic drug intake, alcohol use and recovery level. It is briefly reasoned why an increase/deterioration in these dimensions is problematic and why thus stability would be a sign of resilience. Each section discusses the evidence from the literature if/what role social capital plays in moderating increase/deterioration of each dimension.

2.1. Resilience

In the subsequent part a review of the literature on resilience on the two levels of this study is presented. First literature on system resilience and community resilience, the resilience level of the fatalities data, is discussed. In 2.1.2. the concept of individual resilience as a characteristic of an individual person is discussed. Mental health, increase in alcohol consumption and psychotropic drug intake and the ability to recover fast from disruptions are taken as indicators of individual resilience. The concept is thus central for answering the four last subquestions.

2.1.1. System/Community Resilience

Resilience is a concept that is used in different realms. Originally a concept in engineering, it has been transferred to the human-ecological system sphere and is a now the focus of a growing body of research. Increased attention is given to the concept in face of climate change to make societies better able to cope with its consequences (Folke et al. 2002).

The Intergovernmental Panel on Climate Change (IPCC) defines resilience as follows: “The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformations.” (IPCC 2014, p. 127).

Klein et al. (2004) use the term resilience only in a restricted sense for the “(i) amount of disturbance a system can absorb and still remain within the same state or domain of attraction and (ii) the degree to which the system is capable of self-organisation.” (Klein et al. 2004, p. 1). The capability of self-organization is important in a severe disaster when government agencies and established relief groups alone cannot provide the help needed. Self-organization

is also assumed to be important for fast and effective recovery. High social capital facilitates self-organization (Adger 2003).

Mileti (1999) established a concept of local resilience as the ability to withstand a natural disaster without high numbers of fatalities, damage, reduced productivity, or quality of life. This definition focusses more on the scope of the consequences that a disruption poses on the system and the subjectively experienced consequences.

Other authors have stressed that resilience does not only involve a mitigation of the consequences of a disaster, but also the development a system is going through afterwards. Berkes (2007), for example, stresses that resilient societies create resilience by institutional and individual learning via the creation of platforms to engage in dialogues and come up with innovative approaches after a crisis. This ability to learn and to adapt to changes, and in the ideal case improve over the pre-disaster level, is, according to Berkes (2007), a key dimension of a resilient human-ecological system.

Based on the reviewed literature on resilience the definitions discussed can be brought together for social communities as follows: Resilience comprises properties of a social system that make it able to withstand disruptions without losses in essential parts of its system, such as the loss of life and major deterioration of the quality of life. In case losses occur, a resilient social system is able to reorganize itself within a short time frame and to adapt to and learn from changes.

2.1.1.1. Disaster Resilience

The following model by the Department for International Development (DFIP 2011) of the UK government captures disaster resilience as a process. The model was developed as an attempt to provide a definition of disaster resilience that is valid for different kinds of disasters. It has been chosen to illustrate the process of disaster resilience as it comprises all the important dimensions before, during and after a disaster of resilience and visualizes them as a process:

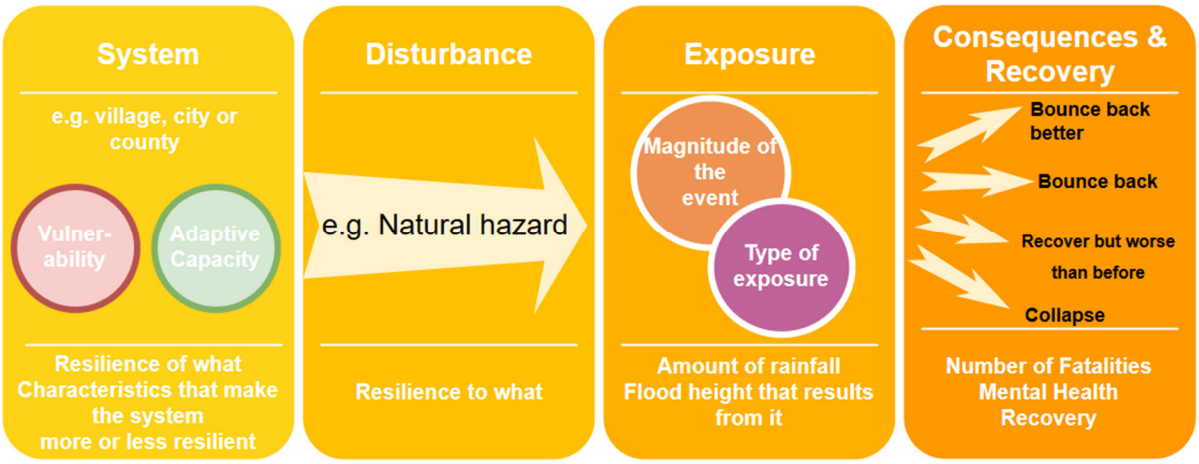

Figure 2: Modified Disaster Resilience Model of the DFIP (2011)

System

What exactly resilience is, is always highly dependent on the system context. The system´s resilience can greatly differ depending on its adaptive capacity and its vulnerability. Vulnerability might result from the proximity to a river or lake, being located in an

earthquake-prone region or having a high share of old, non-quakeproof building stock. Adaptive capacity examples include the amount of a high volume of water an urban system can absorb or the existence of a high amount of well-equipped flood-shelters. In the context of human community systems, the adaptive capacity includes, as has been argued before in the problem definition, the social capital of the community.

Disturbance

Disturbance can come in various forms and a system´s preparedness and appropriate measures to enhance resilience differ depending on the type of event. Therefore, it is central to assess what type of disturbance a system is especially prone to experience (Prasad et al. 2008).

Exposure

If a system can deal with a disturbance without major destruction is also greatly dependent on the magnitude of the disturbance. A system is not resilient against e.g. floods, but rather able to withstand a flood up to a certain level without major destruction or a system might be resilient against overflow of the nearby river due to the existence of flood walls but is not resilient against floods resulting from heavy rainfall.

Consequence and Recovery

The consequences cover all destruction and suffering that results from the disturbance. Exemplifying the two aspects of disaster consequences that are subject matter of this research – fatalities and mental health problems – are listed in the figure. Recovery as a next step the recovery process can have various paths. If systems have and use their high adaptive and learning capacity they can grow stronger from disruptive events and "bounce back better". Other less resilient systems may return to their status before the disturbance within a reasonable period of time.
Systems that are greatly vulnerable and ill prepared may deteriorate in terms of their infrastructure or their quality of life, as a consequence not just in the short term but also in the long term.

The possibilities of collapse or a deterioration of the system show how resilience is not only of great importance in the immediate aftermath but also for the long-term thriving of a system.

2.1.2. Individual Resilience

Resilience though can not only be defined for systems but also on the level of the individuum. Individual resilience can be defined as the capacity of an individual to maintain the psychological and/or physical well-being when facing stress (Yi-Frazier et al. 2015). Individual resilience can also be defined as a "dynamic process encompassing positive adaptation within the context of significant adversity" (Luthar, Cichetti & Becker 2000, p. 543). A resilient individual, according to Tugade & Frederikson (2004), is able to "bounce back" from a stressful experience. This is the same metaphor that the DFIP (2011) uses to characterize disaster resilience of a system. Connor & Davidson (2003) suggest to see individual resilience as a stress-coping ability.

All these definitions of resilience include in one way or another two major components. A severe disruption or adversity and an adaption towards the disruptions without major deterioration of functioning.

Part of emotional resilience is the ability to deal with hardship without major experiences of psychological distress. Central element of this is the ability to control and moderate one's emotions (American Psychological Association 2018). Hence, more resilient individuals will to a lower extent have problems to control their temper.

A lot of authors have focussed on detecting personality traits of individuals perceived as resilient. Connor & Davidson (2003) emphasize that resilience varies depending on personal traits such as optimism, sense of purpose and high-self-esteem. Coleman & Ganong (2002) argue that the popular conceptualizations of resilience factors based on personality traits insufficiently take into account the importance of social embeddedness as a factor for resilience. Also, Connor & Davidson (2003) stress that the existence of close and secure relationships is central to individual resilience. This importance has been found in a study of 92 families, in which a child had been diagnosed with a congenital heart disease. Perceived social support was an important determinant for the ability to cope with the situation (Tak & McCubbin 2002). Rew & Horner (2003) found that resilience is associated with better health outcomes among adolescents as it decreases the likelihood of participating in high-health-risk behaviours.

2.2. Social Capital

Social Capital has become one of the most well-established concepts in social sciences (Lin 2017). It has been associated with all kinds of benefits, among them economic performance (Knack & Keefer 1997) and Human Wellbeing (Delhey & Dragolov 2011). As discussed in the problem definition there is also some evidence that social capital is correlated with the rates of fatalities.

In its classical definition by Bourdieu (1986) social capital is defined as the aggregate of a durable network of mutual acquaintance and recognition. The volume of social capital possessed is dependent on the size of the network of connections he or she can effectively mobilize. Bourdieu states that this social capital will also result in material benefits, which are dependent on the economic and cultural capital of the social network. Such networks can be informal or can be institutionalized e.g. by family name, an organization like a school and are often maintained by material and symbolic exchanges. These advantages of the membership in the group are basis of the solidarity that makes the group possible. The existence and strength of the network cannot be seen as given, but is highly reliant on constant recreation via exchanges, rituals, conversations etc.

Putnam (2001) defines social capital as social networks with norms of reciprocity associated to them, which have some value that involves public as well as private returns. According to him, social capital has several dimensions that differ not only in their nature, but also in the purposes that they can be beneficial for. One scale on which different forms of social capital can differ is the degree of formality and organization ranging from highly formalized institutions such as labour unions to informal weekly meetings of friends. Another scale is the frequency of interaction which can range from rarely (possibly only once a year) to very frequent (working/living together).

Woolcock & Narayan (2000) in their work define social capital as norms and networks that enable people to act collectively. In accordance with this basic definition is also the work of Szreter & Woolcock (2004), which distinguish three forms of social capital; bonding,

bridging and linking social capital. Bonding social capital is characterised by the authors as trusting, cooperative relations between the members of a network with a perceived similarity in social identity. Bridging social capital at its core are relationships based on respect and mutuality between persons that see each other as not alike based on some socio-demographic characteristics (such as age, faith or occupation). Linking social capital as the newest of the three dimensions. Bridging social capital accounts for relationships of persons with similar societal position and power. Linking social capital accounts for vertical relationships that often allow access to private or public services that one can only make use of by some interaction with a person providing these services. Typical examples of linking social capital are contacts to politicians or administrators, health care providers and lawyers.

This thesis will use the conception of social capital developed by Woolcock & Narayan (2000). In the part on fatalities the effect of social capital as the sum of bonding, bridging and linking social capital is investigated. All three dimensions might have influenced the fatality rates. In the subsequent parts on mental health, psychotropic drug intake, alcohol use and recovery, also due to data availability, a conception of social capital understood as only bonding social capital is used. This choice was made as for mental health alcohol consumption and psychotropic drug intake because close social bonds have been found in previous studies to be an important factor for all this categories (see for instance Kawachi & Berkman (2001), Helliwell et al. (2012) for mental health, Lassalle et al. (2015), Lavigne & Bourbonnais (2010) for pyschotropic drug intake, Bonnin et al. (2005) for alcohol consumption). Also for recovery bonding social capital has been found to be an important factor (Nakagawa & Shaw (2004), Islam & Walkerden (2014)). Though bridging and linking social capital have been found to be also important factors (Hawkins & Maurer (2009)). Due to the unavailability of data this factors could not been taken into account. Social capital in these parts comprises the amount of cooperative, trusting relationship one has to friends and relatives and on which one can rely for help and support.

2.3. Disaster consequences

In this part literature on five different factors which can be consequences of disasters is discussed. These five factors have been selected due to their association with social capital found in earlier studies. These studies will additionally be discussed for each factor.

2.3.1. Fatalities

In a study on the fatalities of Hurricane Katrina Jonkman et al. (2009) found that water depth was the major explanatory factor for fatalities. For the case of Hurricane Katrina a clear empirical relationship has been derived (figure 3). Given the fact that the great majority of the deaths during Hurricane Harvey was due to drowning (Jonkman et al. 2018), it seems to be a reasonable factor that had a great influence on fatality rates and is therefore superior to other measurements such as rainfall or windspeed. It is also what comes closest to the research design of Aldrich & Sawada (2015) who measured the severity of affectedness by the height of the tsunami. They found that tsunami height had been the key determinant of fatality rates.

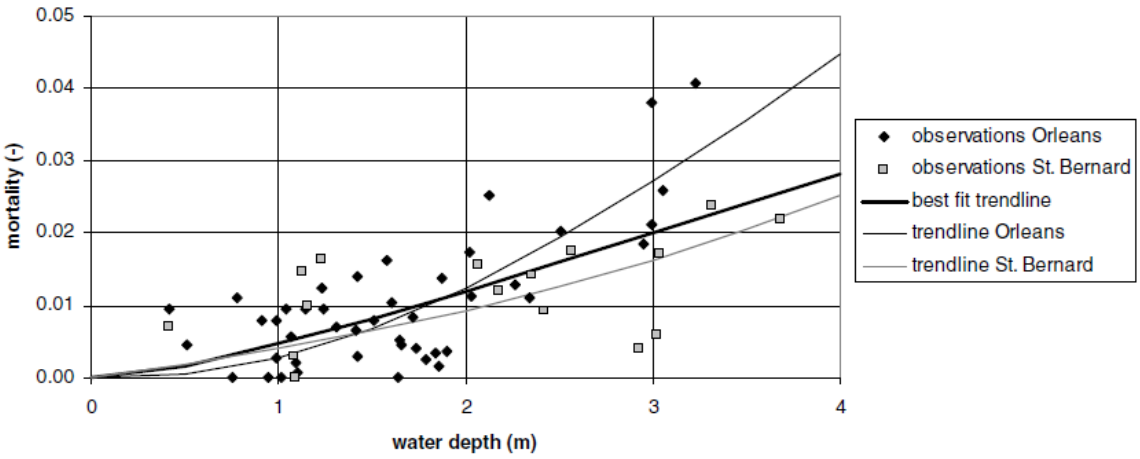

Figure 3: Correlation loss of life with water depth (m)

Source: Jonkman et al. (2009)

As the graph above shows there is uncertainty, which has been quantified as a uncertainty of 50%, in the model presented by Jonkman et al. (2009). It suggests that other factors are also important determinants of fatality rates. In Hurricane Katrina nearly 60% of all victims have been older than 65 years (Jonkman et al. 2009). After water depth, age was the most important determinant for the loss of life. However, the two factors combined can still explain the fatality distribution only partly.

The study of Aldrich and Sawada (2015) has already been discussed in the problem definition of this thesis. The study provides grounds that apart from the magnitude of the event and age also social capital might be an important determinant for fatality rates in different communities. This choice was made due to the unexpected distribution of fatalities as it is also the case for Hurricane Harvey and the rather unexplored explanation of social capital. This gives a chance to potentially better understanding the fatalities during Hurricane Harvey and to contribute to the research body on possible determinants of disaster fatalities.

Frankenberg et al. (2011) have found that for the 2004 Indian Ocean tsunami that physical strength was an important determinant of fatality rates and especially older people were more likely to become a victim of the tsunami. This effect was however mitigated by social capital. Stronger members of the community reached out to weaker members of the community and helped them. Especially the family composition was an influential factor. The physically stronger members of the family, mostly men, would help their partner and children and by that decrease the likelihood of becoming a tsunami victim.

Yamamura (2010) found in long-term study of earthquakes between 1988 and 2001 that communities with higher social capital, defined as social norms and social networks, have a lower number of victims. However, it is important to note that “victims”, as defined by Yamamura. include not only fatalities, but all persons directly negatively affected by the disaster.

However, the association between social capital and fatalities remains understudied (Aldrich & Sawada 2015). Recent data that is investigating this relationship for the case of the USA is

absent. This research aims at filling this gap and test if the relationship found for different collectivist Asian societies also holds true for the more individualistic culture in the USA.

2.3.2. Mental Health

Mental health has a major effect on well-being, being over the life course a stronger predictor of life satisfaction and other quality of life measures than external factors as for example income (Clark et al. 2018). Mental health problems in the USA cause more misery than any other area of life, including physical health, poverty and unemployment (Layard & Clark 2014). The most common mental health problems are various forms of depression and generalized anxiety disorders, such as frequent panic attacks (Layard & Clark 2014). Predispositions to mental health problems often get triggered by disruptive events (Layard & Clark 2014) such as natural disasters. The mental health of the overall population before as well as after a disruption is hence a plausible part of a conceptualization of resilience that comprises the quality of life.

After a natural disaster the need for mental health care dramatically increases in most cases far beyond the available capacities (FEMA 2008). Norris et al. (2002) estimate based on the responses of 60,000 natural disaster victims that after a natural disaster between five and ten percent of the affected face mental health problems in the long-term. A significantly higher number will face immediate short term and middle term mental health problems (FEMA 2008). For Hurricane Katrina 50% of the participants in a representative survey, conducted seven weeks after the hurricane, indicated needing mental health assistance (Weisler et al. 2006). Due to this very high demand sufficient mental health care is in most cases not available (Weisler et al. 2006). In the aftermath of a disaster largely persons close to each other are providing emotional support (Islam & Walkerden 2014). Due to this supporting role social support networks greatly mitigate the effects of an urgent crisis (Walsh 2007).

According to Kawachi & Berkman (2001) there is a general agreement that social ties are beneficial for the well-being of individuals. Also, Helliwell et al. (2012) investigated what factors negatively associated with mental distress. Using the data from the Gallup World Poll they found a clear and significant positive relationship between the level of social support and the general mental health for humans worldwide.

On the community level, Greene et al. (2015) found a strong negative correlation between the level of social bonds, trust in neighbours as well as reciprocity and mental health problems. Poortinga (2012) found by analysing correlation between different items of the 2007 and 2009 Citizenship Survey which was collected in England, that bridging and bonding social capital, trust and participation were significantly associated with better outcomes in well-being and community resilience. Another study by Gordeev & Egan (2015) supports this finding that stronger neighbourhood networks are strongly connected with better mental health.

2.3.3. Psychotropic Drug Intake

The use of psychotropic drugs in the USA has steadily increased between 1999 and 2014 (Pratt et al. 2017). The most common group of psychotropic drugs are antidepressants (National Center for Health Statistics 2016). In 2011-2014 12,7% of persons of age 12 or older have reported to have taken antidepressants in the past month (Pratt et al. 2017).

The prescription of psychotropic drugs in the USA is often made inappropriately. Smith (2012) found that often psychoactive drugs are prescribed to persons that have not been

evaluated by a mental health professional and most patients are unaware of other evidence-based approaches to improve mental health such as cognitive behavioural therapy.

In recent years antidepressants as the most common group of psychotropic drugs have been increasingly classified as an ineffective approach for treating depression. This debate was mainly initiated by the so-called Kirsch-study, a meta-analysis that found that for mild and medium depression the intake of antidepressants results in about the same outcome as the intake of placebos, with better results for antidepressants than for placebos in cases of severe depression (Kirsch et al. (2008), see also the meta-analysis by Fournier et al. (2010)). Given the massive side-effects that a lot of antidepressants have (including suicidality (see the meta-analysis by Sharma et al. (2016)) and the dependence on them that can result from a regular intake makes the high and inappropriate prescription of those kind of drugs a serious health issue in the United States.

For the association between social capital and psychotropic drug intake the evidence is not consistent. Moisan et al. (1999) found in a 2-day study of white-collar workers that stress by job strain was significantly related to higher psychotropic drug intake. The study found no modifying effect of social support for this relationship. A more recent study of Lassalle et al. (2015) investigated the psychotropic drug use of 7542 workers over 4 years. The study found that apart from psychological demands, low social support and hiding emotions have been the key determinants of psychotropic drug use. A study by Lavigne & Bourbonnais (2010) among 1288 correctional officers in Canada researched the association between job strain, extrinsic efforts–rewards ratio, social support from colleagues and supervisors, intimidation and psychological harassment while controlling for age and gender. Low social support was shown to have the strongest association with higher psychotropic drug intake.

2.3.4. Alcohol use

Profuse alcohol consumption is one of the most severe health problems the United States are facing. It is third leading cause of preventable death and causes annual economic burden of 249 billion dollars (state 2010 (National Institute on Alcohol Abuse and Alcoholism 2017). Alcohol problems are also an immense toll for the young generation. In the USA around 7,1 million children, which are around 10% of all children, live with a parent with an alcohol consumption problem (Center for Behavioural Health Statistics and Quality 2012). This puts these kids at greater risk for depression, anxiety disorders and problems with mental and verbal skills (Center for Behavioral Health Statistics and Quality 2012).

After disasters not only health disorders are more likely to occur but also health risk behaviours such as increased alcohol consumption are more likely to be increased after an disaster (Ursano et al. 2017). Especially alcohol and nicotine consumption are reported to increase (Weisler et al. 2006). While alcohol consumption may be increased for the sake of pleasure it is safe to assume that a sudden increase in the alcohol consumption is rather a sign of difficulties to cope with the situation and missing support than a sudden increase in drinking for pleasure. Also, Foa & McFarlane (2006) found that persons that suffer from a trauma and posttraumatic stress disorder are more likely to start drinking as a result. Based on this evidence it is assumed that the stress posed by a disaster has an effect on alcohol consumption behaviour. The study of Foa & McFarlane (2006) suggests that the deterioration of mental health precedes the increase in alcohol consumption. In a study of two community-cohorts of young adults Bonin et al. (2000) found that both depression and loneliness were significantly related to the frequency of alcohol intoxication. Apart from the disruption itself

these factors may be important in moderating the effect. The study of Bonnin et al. (2005) supports the assumption that the absence of social capital is connected to increased alcohol use. It is furthermore conceivable that social capital has an indirect effect via mental health on alcohol use.

2.3.5. Recovery

The post-disaster discovery process can vary greatly from fast revitalization to slow rebuilding with major parts of the population leaving the area. As introduced earlier full recovery might be defined simplified as a state in which a city or community has managed to restore itself to the pre-disaster condition (Albala-Bertrand 1993). This is equivalent to the "bounce back" in the disaster resilience model of the DFIP (2011). Nevertheless, it is unlikely that a community restores itself to the exact same condition. Rather return to pre-disaster condition means a return to the same level of infrastructure, productivity and quality of life. The same holds true for individuals. Individual recovery may be defined as a state were life has returned to the pre-disaster level without being disrupted by consequences of the disaster.

For the recovery process of the Kobe earthquake 1995 in Japan, Aldrich (2011a) found that it was the social capital of the communities and a tradition of community activities that lead to a successful and speedy recovery. Social capital in this case was a stronger determinant of recovery than damage, or economic conditions (Aldrich 2011a). Higher social capital facilitated the self-organization of new civil society organizations that would organize and coordinate recovery efforts and enable long-term planning (Aldrich 2011a).

Nakagawa & Shaw (2004) studied the influence of social capital in four communities in Gujarat, India. They found that the level of social capital was the most effective element for a speedy recovery after the earthquake in the region.

A study by Aldrich (2011b) found ambivalent results for the effect of social capital on recovery studying the recovery of villages in southeast India after a tsunami. Social capital helped to reduce the barriers to collective action which greatly sped up the recovery. However, the recovery was not equally distributed among the population. Women, migrants and Muslims were facing obstacles to recovery due to the high organization of more advantaged groups that managed to draw resources to their members.

Islam & Walkerden (2014) found that both bonding social capital and bridging social capital play a key role in the community response to a natural disaster. Investigating two villages in Bangladesh after the Cyclone Sidir, their results showed a heavy reliance on both bonding and bridging relationships. With time bridging relationships become less important while bonding social capital still plays an important role in the recovery process. For long-term recovery however, the authors found, that NGOs, local governments and community-based organizations became a central element in the recovery process. Hawkins & Maurer (2009) found that while bonding social capital provides immediate relief in the long-term bridging and linking social capital become more important for recovery.

Following the definition of Klein et al. (2004) the capability to self-organize is an important part of resilience. This capability is also greatly dependent on the connections in the community (Adger 2003). Therefore, it is assumed that social capital is a central factor for post-disaster recovery.

3. Hypotheses

Based on the review of the literature and the case study background five hypotheses on the kind (positive/negative) and the direction between social capital and the five disaster dimensions fatalities, mental health, psychotropic drug intake, alcohol use and recovery are developed:

Fatalities:
The higher the social capital in a disaster affected county, the lower the share of fatalities in the population of this county, if the known contributing factors to fatalities (magnitude of disaster, demographics) are held constant.

Mental Health:
The stronger the social support network of an individual the lower the likelihood to have poor mental health. (Likelihood is measured by share of individuals with mental health problem in the group with a certain strength of the social support network.)

The stronger the social support network of an individual, the weaker the deterioration of the individual's mental health after a disaster.

Psychotropic Drug Intake:
Persons with strong the social support network (a lot of supportive relationships) are less likely to start taking a new psychotropic drug than those who have a weak social network (few or no supportive relationships).

Alcohol Use:
Persons with strong the social support network (a lot of supportive relationships) are less likely to increase their alcohol use than those who have a weak social network (few or no supportive relationships).

Recovery:
Persons with strong the social support network (a lot of supportive relationships) recover on average faster from a natural disaster than those who have a weak social network (few or no supportive relationships).

4. Theoretical Framework

In the following paragraphs it will be briefly outlined what mechanisms are assumed between social capital and the different dependent variables. These relationships are theorized based on the reviewed literature discussed beforehand. For this study social capital, due to the rather recent emphasis on this aspect as potentially central for disaster resilience, is the variable of interest. Also the influence of other factors will be taken into account such as household income or damage levels. These are well-established factors for the analyzed dimensions. Recovery for example takes longer if the damage level has been very severe in comparison to when damage has been only minor. This is done to test wether a correlation between social capital and one of the dependent variables is present only under specific circumstances or if this relationship is present under all circumstances.

4.1. Relationship between social capital and fatalities

Based on the research presented in part 4.3.1 on social capital and fatalities a significant role of social capital in mitigating the number of fatalities for the case of Hurricane Harvey is assumed. This effect may have come into action by neighbours warning neighbours/friends etc. about the coming disaster. In areas with higher social capital it is assumed that to a higher extent help with evacuation was provided by fellow citizens to vulnerable members of the community. In areas with higher social capital, checking on fellow citizens that they are in safety is assumed to have been more common.

Social capital was measured by Aldrich & Sawada (2015) via the crime rate per 100.000 inhabitants. This choice has been made by the researchers as social connections make individuals more likely to comply with social norms and take long-term consequences of their behaviour into account (Deller & Deller 2010). In “Bowling alone” Putnam (2000. p. 308) argues that “higher levels of social capital, all else being equal, translate into lower levels of crime … This inverse relationship is astonishingly strong – as close to perfect as one might find between any two social phenomena.” Given the sociological evidence and to assure that a non-existence of correlation between social capital and fatalities is not simply to a different form of measurement the relationship will be investigated with the rate of violent crime. To increase validity and to take other factors into account that might not be reflected in the crime rate the relationship will also be researched by using the Social Capital Index as measure for social capital that will be discussed in more detail in the data section of this thesis.

4.2. Relationship between water depth and fatalities

The effect of social capital is expected to be a mitigating effect of an exposure of a natural disaster as the cause of the fatalities. The stronger the magnitude of a disaster the higher is the number of fatalities, given all other factors are equal. Of all fatalities of Hurricane Harvey 81% can be accounted to drowning (Jonkman et al. 2018). In a study of Hurricane Katrina Jonkman et al. (2009) found a clear relationship between water depth and mortality. Therefore, water depth is included a potential explanatory factor of the fatalities during Hurricane Harvey. It is assumed that the greater the water depth the higher was the risk of drowning. Thus, it is expected that more fatalities occurred at places with a comparably high water depth than in places with a comparably low water depth.

4.3. Relationships between share of elderly and fatalities

As a control variable the percentage of people of above 65 is included. During Hurricane Harvey the majority of victims was older than 50 years old and especially persons over the age of 65 have a high share in the fatalities (Jonkman et al. 2018). A similar age distribution has also been found in other disasters. Guha-Sapir et al. (2006) found for the Indian Ocean tsunami 2004 that elderly had a distinctly increased mortality risk. One example for a similar age distribution as in Hurricane Harvey is Hurricane Katrina with a high share of the victims being aged 65 or older. Persons of a higher age often are, mainly due to reduced physical strength, more likely to become victims of a natural disaster. Therefore, it can be expected that more fatalities occur in communities with a higher percentage of elderly people if all other factors were constant.

Three factors are theorized to be the key determinants of the fatalities of Hurricane Harvey: social capital, water depth and share of elderly. Figure 4 on the next page summarizes their assumed relationship with the fatalities.

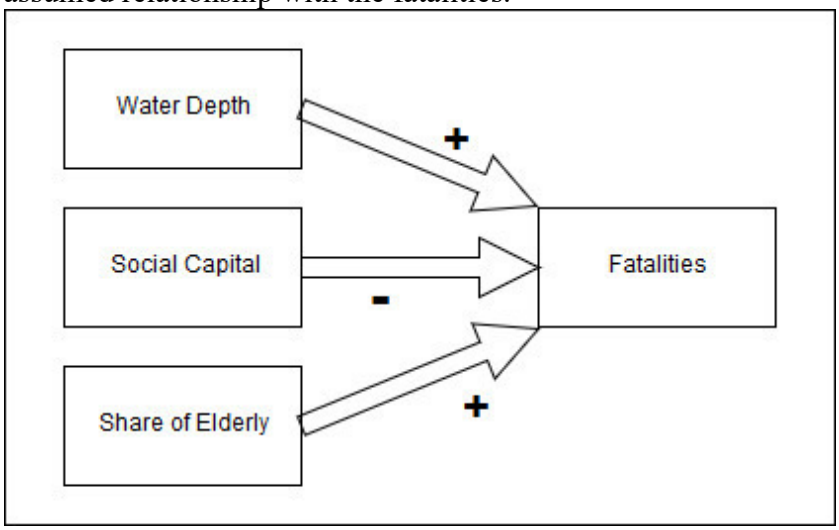

Figure 4: Relationship between water depth, social capital, share of elderly and fatalities

4.4. Relationship between social capital and mental health

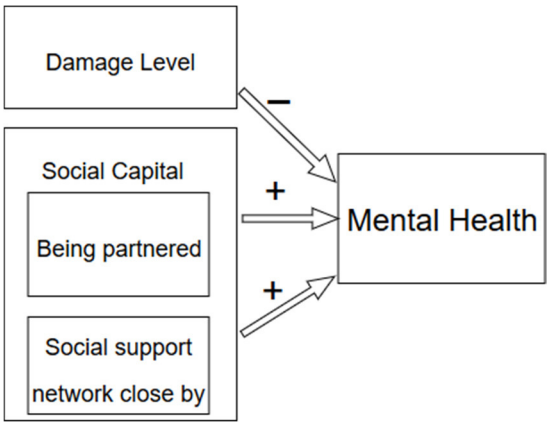

Figure 5: Relationship between Social Capital and Mental Health

When it comes to emotional resilience it is assumed to be influenced by two types of bonding social capital, being partnered and having friends, relatives and supportive neighbours close to one´s home. In a time of disruption partner and friends help provide emotional support by listening, encouragement or simply by their presence, as shown in the discussion of the literature on social capital and mental health, this emotional support can help to avoid getting into the automatic negative loop of negative thoughts that is at the core of depression and generalized anxiety disorders (Layard & Clark 2014).

4.5. Relationship between social capital and psychotropic drug intake

It is assumed that persons started to take new psychotropic drugs after Hurricane Harvey to deal with challenges experienced due to Hurricane Harvey. The relationship between social capital and new psychotropic drug intake is theorized to be twofold: The stronger one´s social support network the better the mental health of a person (on average). The better the mental health of a person the lower the chance that this person will start taking a new psychotropic drug. A disaster poses a situation one needs to cope with that poses challenges even for those who are in good mental health. The stronger the social support network of a person, with about the same level of mental health, the higher the chance that this person has someone near that is actually reachable that helps to cope with the challenges experienced and the less likely it is that this person will start to take a psychotropic drug.

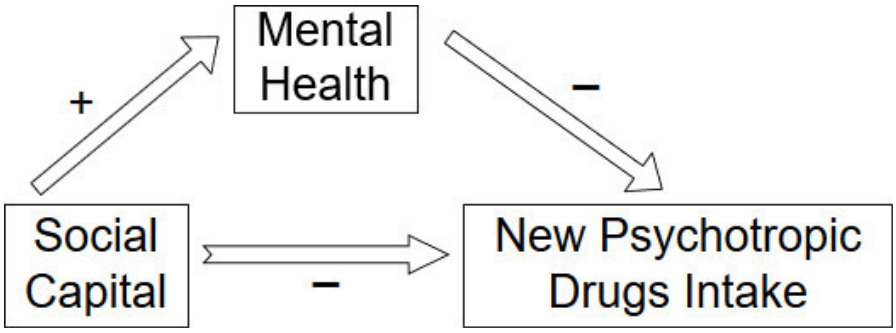

Figure 6: Relationship between Social Capital and New Psychotropic

4.6. Relationship between social capital and alcohol use

The relationship between social capital and alcohol use is theorized to be direct and indirect via mental health. The stronger the social support network of a person the better the mental health of a person on average. Persons with poor mental health experience more often extreme emotions, including negative emotions such as despair and sadness and have greater struggle to deal with them (Layard & Clark 2014). The better the mental health of a person the more likely it is that this person can cope with the disruption of a natural disaster and the less likely it is that this person will start to increase her/his consumption of alcohol due to the experiences with the natural disaster. For persons with roughly the same level of mental health, those who have more supportive relationships close to them will with a lower likelihood start to use alcohol to cope with the challenges posed by the disaster.

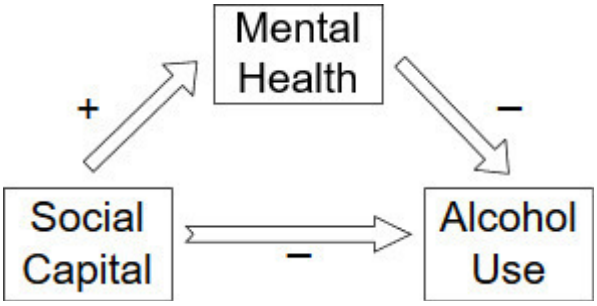

Figure 7: Relationship between Social Capital and Alcohol Use

4.7. Relationship between social capital and recovery

In the immediate aftermath and in the weeks afterwards not only state institutions help to repair damaged houses and flats and provide victims with needed resources. It is assumed that also neighbours, friends, church communities, relatives etc. help each other to restore houses and do what is needed to allow a life that is at the same level as before the disaster as fast as possible. However, a greater experienced damage will result in greater work necessary to recover and thus reduces the pace of recovery. Persons with higher economic status may recover faster than persons with lower economic status as they have greater assets to use in the recovery process and most likely a higher percentage of those with higher economic status is flood insured. This might also result in a lower dependence on their personal social support network. Damage level and household income are included to investigate if the correlation between social capital is a general one or if it is only present under certain circumstances.

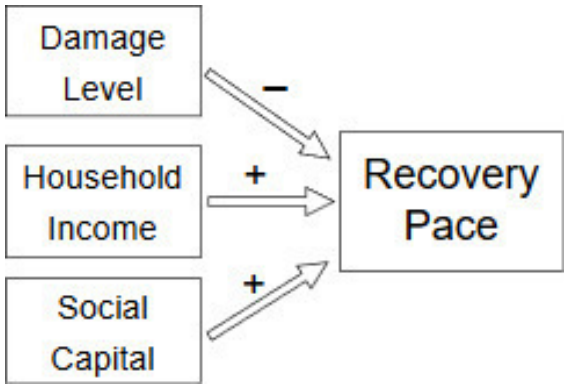

Figure 8: Relationship between Social Capital and Recovery Pace

5. Methodology

For the analysis of fatalities correlation and regression analyses are conducted. When continuous data is available and causal relationships are tested, multiple regression/correlation analysis is a common and powerful method (Cohen et al. 2014).
In a first step partial correlation between each independent variable (social capital, water depth, share of elderly) and the dependent variable, per mille of population found dead will be performed while including the two other independent variables as controls.

For the parts on mental health, psychotropic drug intake, alcohol use and recovery contingency tables are created and analysed. The method was chosen as all data for these categories is nominal and ordinal classification data. For such data contingency table analysis can provide rich insights of patterns that might be present in that data (Wickens 2014). In a first step a frequency table is created and the sum of cases for each category is calculated. In a second step, the proportion of each sub-category of the total population is calculated. In cases, where it aids the better comprehension of the data, the contingency tables will be visualized as graphs.

5.1. Data

In the following paragraphs an overview of the data sources for each variable is provided. The Social Capital Index, water depth data, census data on the percentage of and the dataset of Hurricane Harvey´s fatalities of the TU Delft are used to investigate the determinants of the fatalities. The Post-Harvey survey of the Episcopal Health Foundation and the Kaiser Family Foundation provide the data on the social capital, mental health, psychotropic drug intake, alcohol use and recovery.

5.1.1. Fatalities

Public records for the location of the fatalities are available for all counties with fatalities in Texas. Jonkman et al. (2018) have created a database of the fatalities in Texas that can be directly related to Hurricane Harvey. For this the researchers used fatality records from the authorities of the different counties of Texas and media coverage on fatalities. Fatalities were only included if they occurred during the hurricane and could be undoubtedly related to the hurricane.

5.1.2. Social Capital

The Social Capital Index aggregates public available data on four subdimensions, family unity, community health, institutional health and collective efficacy, to a Social Capital Index on both state and county level. The index was published in 2017, most data used is from datasets in 2015 and 2016. The index is the most accurate measure of social capital on the county level that has been found after an intensive review of data sources on social capital. Family unity is measured by percentage of birth to unmarried women, percentage of women married between the age of 35 and 44 and the percentage of children that live in a single-parent household. The community health is measured by political participation in the county, percentage that worked with neighbours to fix something and the membership in religious and non-religious congregations. Institutional health is measured by voting rates, mail-back

response to census and confidence in public institutions and media. Collective efficacy is constructed as a single-item sub-index measured by the rate of violent crimes per 100.000 inhabitants. A table giving the full overview of the sub-components of the Social Capital Index and its sources can be found in the appendix of this thesis.

5.1.3. Water Depth

For the water depths a publicly available dataset that combines the data on the maximal average flood depth in the census track, measured by height in feet above the ground by FEMA and the Costal Emergency Risk Assessment (CERA) group of the university of North Carolina has been used to, as accurately as possible, determine the maximum water depth of the flood by census tract.

5.1.4. Demographics

To determine the share of persons above 65 years old publicly available data of the United States Census Bureau on the share of persons above the age of 65 has been used. The data was derived on the county level.

Table 1: Overview data for fatality analysis

Variable	**Datasource**
Fatalities	Fatality dataset of Jonkman et al. 2018/TU Delft
Social Capital	County Level Index of the Social Capital Index
Water depth	Combined dataset of water depth data of FEMA and CERA
Share of elderly	County Facts of the United States Census

5.2. The Post-Harvey Survey

The Episcopal Health Foundation and the Kaiser Family Foundation have conducted an in-depth study of the effects of Hurricane Harvey. In total 1635 participants have been interviewed about their situation after Hurricane Harvey. The survey was conducted between the 17th of October and the 20th of November of a random representative sample of adults of the age of 18 or older who live in counties in Texas along the Gulf Coast. The selection of counties was based on the FEMA mapping analysis of property damages. The counties with the severe impact of Hurricane Harvey have been chosen for the study. These counties have been aggregated to four county groups: the Harris county (including Houston), counties surrounding Harris, the "Golden Triangle" (Jefferson, Hardin and Orange counties, east from the Harris counties) and the coastal counties. The interviews were conducted by random selection through telephone, both landline and cellular and have been conducted in English and Spanish. The sampling method was designed to slightly oversample especially vulnerable parts of the population, namely: to include a higher share of persons that experience property damage than the share in the overall population, to focus in sampling on including also those living close to or under the poverty line and to increase the number of low-income Hispanics and low-income Black respondents. The numbers called were chosen by a random digital dial procedure and all respondents have been screened to verify that they are actually from on of the 24 counties of the study.

The data of this survey is self-reported data. Self-reported data in comparison to other established measurements of mental health depression scales assessed by a psychiatrist is inferior in its validity (Fleishman & Zuvekas 2007). Multiple-item, multiple days questionaires, as used in the diagnosis of depression, though often are not feasible to conduct for greater populations (Tannenbaum et al. 2009). This is especially the case when the interest of the study is not only mental health but a lot of health dimensions as it was the case in the Post Harvey-Survey. Tannenbaum et al. (2009) therefore conclude that self-reported mental health is the best feasible method for mental health surveillance in greater populations. To address the challenges regarding the validity of self-reported data the authors propose to use multiple dimensions to assess a populations mental health, among them the intake of psychotropic drugs. This study follows this approach by including three dimensions of mental health: mental health status, deterioration of mental health and emotional mastery (harder time to control one´s temper). Additionally intake of psychotropic drugs is included as a separate dimension.

Table 2: Questions from the Post-Harvey Survey by data category

Personal Support Network	"Thinking about your personal support network – that is relatives and friends living nearby who you can rely on for help or support – do you have a lot of people you can rely on, a fair amount, just a few, or no people living nearby who you can rely on for help and support?"
Mental Health	"In general, would you say your mental health is excellent, very good, good, fair, or poor?" "Do you feel your mental health has gotten worse as a result of Hurricane Harvey, or not?" "Have you had a harder time controlling your temper, or felt you had a "shorter fuse" since Hurricane Harvey, or not?"
Psychotropic Drug Intake	"Since Hurricane Harvey, have you started taking a new prescription medicine for problems with your emotions, nerves, or mental health, or not?"
Alcohol Use	Have your experiences with Hurricane Harvey and its aftermath caused you to increase your alcohol use, or not?
Recovery Rate	"Which of the following best describes your personal situation in terms of recovering from Hurricane Harvey? Would you say that your day-to-day life is largely back to normal, almost back to normal, still somewhat disrupted, or still very disrupted?"

In the survey participants were explicitly asked about increased drinking that was caused by the experiences of Hurricane Harvey (Exact question: "Have your experiences with Hurricane Harvey and its aftermath caused you to increase your alcohol use, or not?")

Note on Recovery Rate Category:
To retain a number of cases per sub-category high enough for comparing them differentiated by both household income and personal support network largely, "Back to normal" and "Almost back to normal" have been aggregated to the category "Back to normal" and "Still somewhat disrupted" and "Still very disrupted" have been aggregated to "Still disrupted". The same was done by the EFF in their presentation of the results of the survey.

5.2.1. Control variables

Two control variables are included. Household income is included as a control variable in the recovery analysis to control for the role economic capital might have played in speeding up the recovery process. The damage experienced is included to account for differences in mental health and recovery due to severity of the disaster experienced by an indiviudal.

Table 3: Questions of Post-Harvey Survey used to determine household income and damage experienced

Household Income	How many dependent children do you have, if any? Besides yourself, how many people are in your family, meaning your spouse and any dependent children? Does anyone else, such as a parent, claim you as a dependent on their tax return? Is the parent or person who claims you as a dependent married, or not? Besides yourself, how many other dependent children (do/does) your (parents/parent) have? To help us describe the people who took part in our study, it would be helpful to know which category best describes your (personal/family) income last year before taxes.
Damage experienced	Was your home or the place you were living damaged as a result of Hurricane Harvey, or not? Was that minor damage that could be repaired within a month, major damage requiring more than a month to repair, or was your home destroyed?

6. Analysis

The analysis is divided in two main parts. The first part uses the data from the social capital index, the fatality database and the data on water depth and the share of persons aged 65 and above to analyse the share of fatalities per county. The second part uses the data from the Post-Harvey-Survey to analyse the correlation between the reported social support network and mental health, psychotropic drug intake, alcohol use and recovery.

6.1. Fatalities

The three possible explanatory factors, water depth, share of elderly and social capital are correlated with the per mille of fatalities per county. In total there have been 39 counties which have been heavily affected according to FEMA damage data (FEMA 2018).

6.1.1. Social Capital and Fatalities

In the correlation between social capital and fatality rate, measured by per mille of the population that has been found dead, no statistically significant relationship could be found. Three cases are especially influential (see figure 9). As can be seen in the scatterplot these cases show a relatively great difference in the fatality rate while they do not greatly differ in the level of social capital. Also, when following Sawada & Aldrich (2015) by operationalizing social capital as the collective efficacy of a community measured by the level of crime no statistically significant correlation is found. In comparison there is also no major difference in the level of social capital between those counties with and without fatalities (table 6).

Table 4: Correlation fatality rate and social capital index

Correlations

		Fatalities relative number	County-Level Index
Fatalities relative number	Pearson Correlation	1	-,133
	Sig. (2-tailed)		,420
	N	39	39
County-Level Index	Pearson Correlation	-,133	1
	Sig. (2-tailed)	,420	
	N	39	39

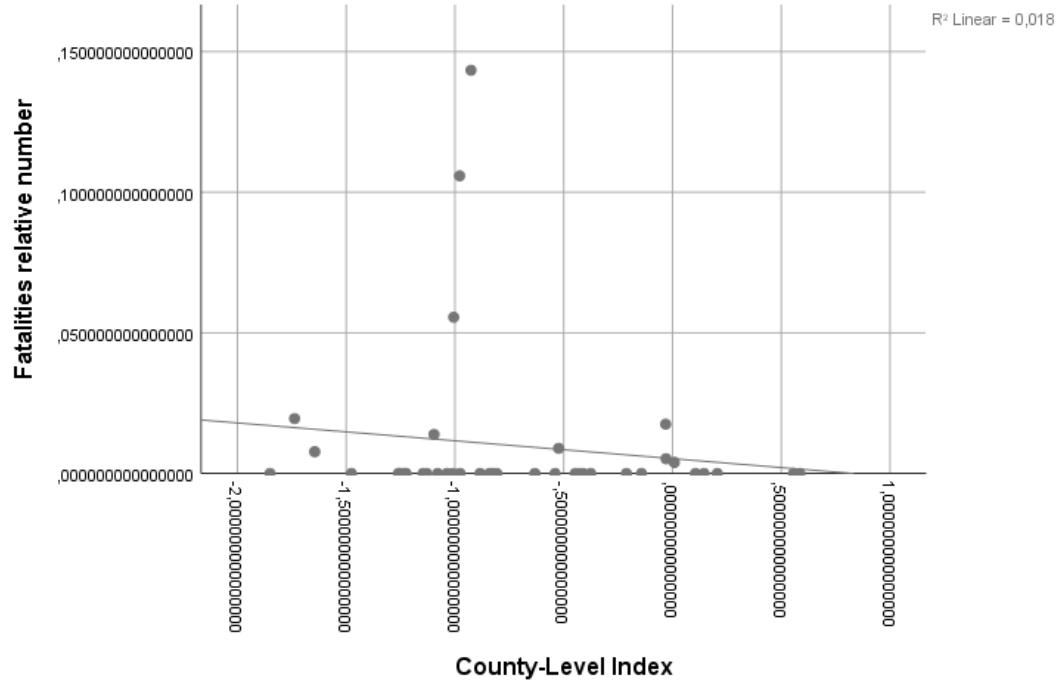

Figure 9: Scatterplot correlation fatality rate and social capital index

Table 5: Correlation between fatality rate and collective efficacy

Correlations

		Fatalities relative number	Collective Efficacy
Fatalities relative number	Pearson Correlation	1	,164
	Sig. (2-tailed)		,318
	N	39	39
Collective Efficacy	Pearson Correlation	,164	1
	Sig. (2-tailed)	,318	
	N	39	39

Table 6: Average social capital index in counties with and without fatalities

	Counties with Fatalities	Counties without fatalities	Total number of cases
Number of counties	10	29	39
Average social capital index	-0,72	-0,68	

6.1.2. Water Depth and Fatalities

As has been discussed before from previous research it is suggested that water depth is the key determinant for the fatality rate. Therefore, the most accurate available data on flood fatalities is compared against the per mille share of the population that was found dead. Figure 10 shows the correlation. For the same water depth the share of persons that were found dead

differs. There is no linear correlation between the water depth and the share of the population found dead as the adjusted r-square is 0,614 and the correlation thus statistically insignificant.

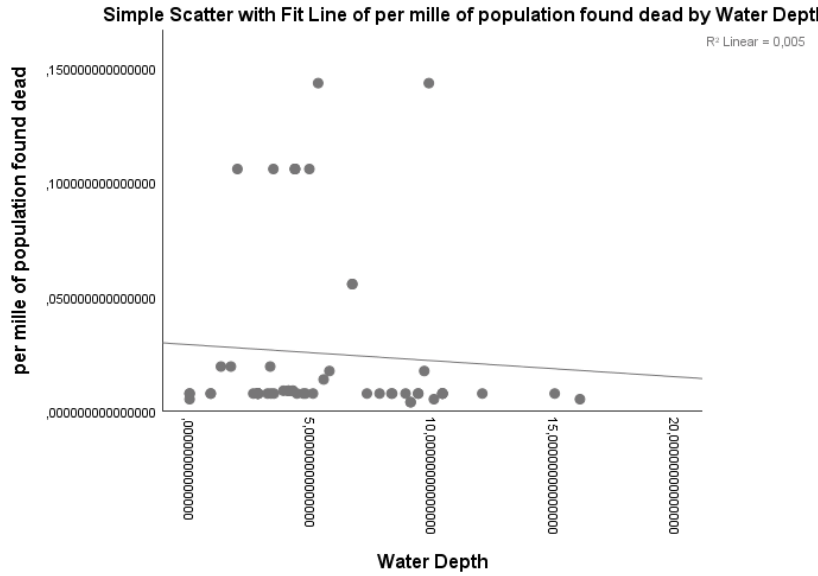

Figure 10: Correlation between water depth and share of fatalities

Table 7: Correlation between water depth and per mille of population found dead

Correlations

		Water Depth	per mille of population found dead
Water Depth	Pearson Correlation	1	-,068
	Sig. (2-tailed)		,614
	N	58	58
per mille of population found dead	Pearson Correlation	-,068	1
	Sig. (2-tailed)	,614	
	N	58	58

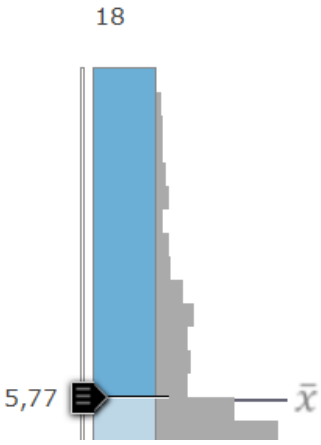

Figure 11: Frequency of water depth levels

A bit more than one third of the fatalities (22, N=58) has occurred in places with a maximum over the average level of flooding. Maximum also indicates that there is a high likelihood that the actual water depth at the time of death might have been even lower. The map above shows that also the high flood areas have by no means only been in the rural areas, but also in highly urbanized areas as Houston (white dot in the map). More than one third (21, N=57) of the fatalities is located in census track areas with a maximum water depth of less than 4 feet (121,92 centimetres). This suggests that rather than the average maximal water depth, the current or single high-hazard areas (as underpasses) have been causes for drowning.

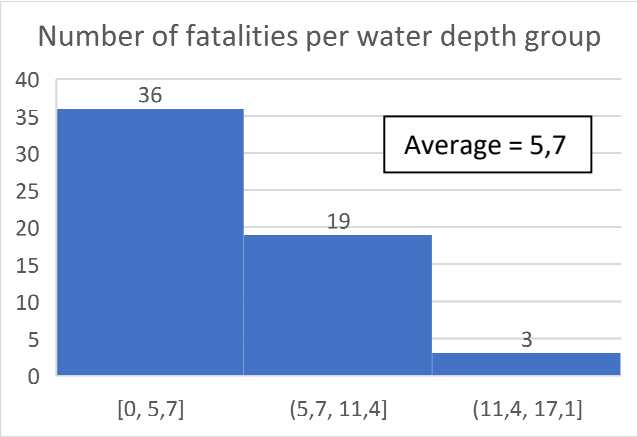

Figure 12: Number fatalities per water depth group

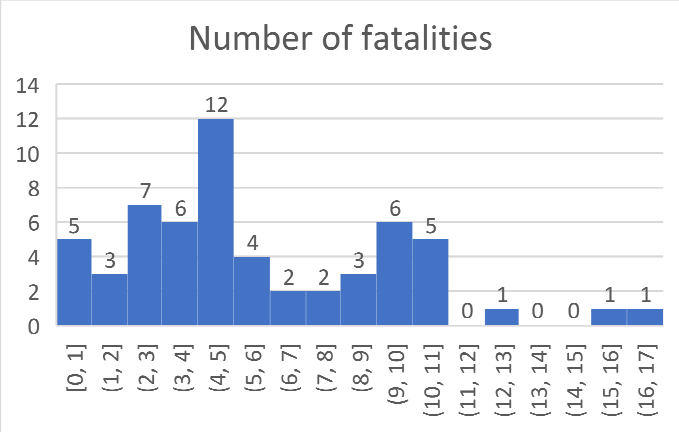

Figure 13: Number fatalities per feet water depth

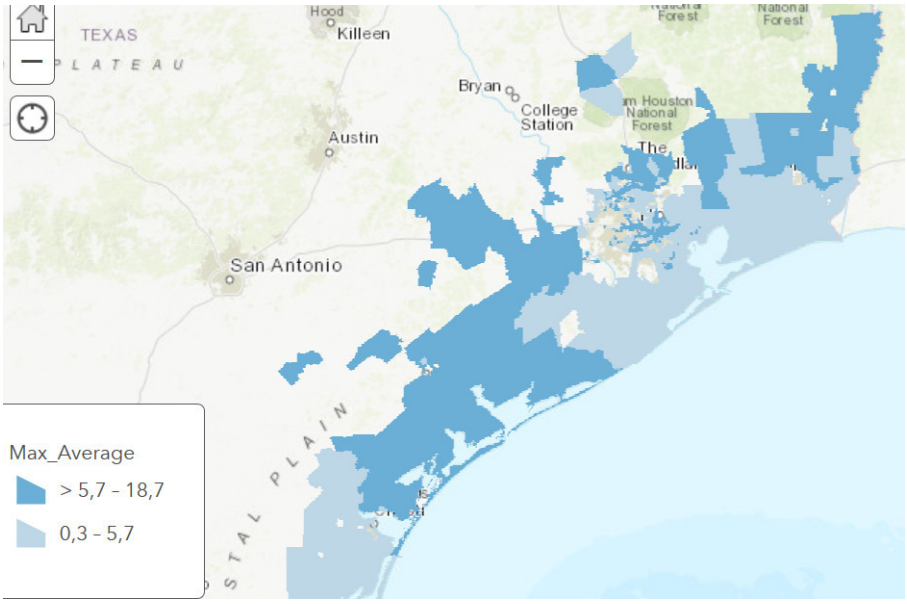

Figure 14: Geographical distribution of water depth levels above and below average water depth level

Source: Argis public dataset on water depth levels measured by FEMA and CERA
Retrieved from: https://www.arcgis.com/home/item.html?id=e24cf489530b41dc9a7a73ed93cd6834

6.1.3. Share of Elderly and Fatalities

The correlation between the share of persons and the fatality rate is statistically insignificant and very weak (adjusted r-square of 0,619). Also, the average percentage of elderly in the counties with poverty was not higher, as expected, but even slightly lower that in the counties with no fatalities (table 8).

Table 8: Correlation per mille of population found dead and share of elderly

Correlations

		Per mille of population found dead	Percentage persons aged 65 and older
Per mille of population found dead	Pearson Correlation	1	,082
	Sig. (2-tailed)		,619
	N	39	39
Percentage persons aged 65 and older	Pearson Correlation	,082	1
	Sig. (2-tailed)	,619	
	N	39	39

Table 9: Average percentage of persons aged 65 or older

	Counties with fatalities	Counties without fatalities
N	10	29
Average percentage of persons aged 65 and older	14,55	17,09

6.2. Personal Support Network

To give an overview of the general percental distribution of the different levels of social support networks is provided in table 10. The table shows the percentage of persons who gave one of the four possible responses to the question 67 in the Post-Harvey Survey: “Thinking about your personal support network – that is relatives and friends living nearby who you can rely on for help or support – do you have a lot of people you can rely on, a fair amount, just a few, or no people living nearby who you can rely on for help and support?” One percent of the participant refused or answered that they do not know the level of their social support network. Due to this low number of not provided answers it can be assumed that the missing answers of those participants do not significantly distort the outcome of the study. The by far largest group is the category of persons to have “just a few” people nearby. In total 14% of the participants reported to have no people nearby that they could rely on for help and support. This group is assumed to be the most vulnerable. While the group with just a few people living nearby might still be able to rely heavily on this few relatives and friends, those with no people living nearby may be left without emotional support or help to recover.

Table 10: Personal Support Network of participants living in Harvey-affected counties

Level of Social Support Networks	% per category of total answers
A lot	24
Fair amount	19
Just a few	43
No people living nearby	14
Don´t know/Refused	1
Sum A lot/A fair amount	43
Sum Just a few/No people living nearby	57

6.3. Mental Health

For the mental health status two dimensions of mental health have been analysed: the status of mental health and the change in mental health.

Figure 15 shows the mental health status in comparison to the personal support network. Noticeable is the significantly higher share of those with excellent mental health in the group with a lot of supportive relationships in comparison to all three other categories. The lower share in the very good and good mental health category for those with a lot of supportive relationships can therefore be explained with the high share in the excellent category. The trendline for the "A lot"-category shows the strong correlation. For fair and poor mental health the graph shows that the weaker your social support network, the higher the share of individuals with fair or poor mental health.

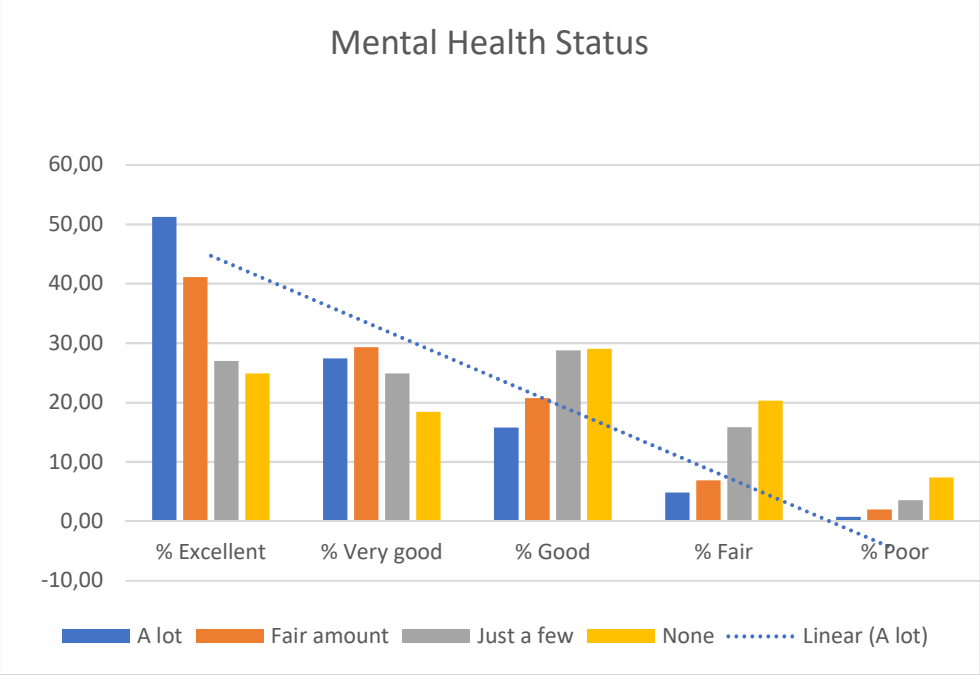

Figure 15: Bar graph of association between Mental Health and Personal Support Networks

What is especially noteworthy, when looking on the exact percentages in the table 11 is that among those with a very strong social support network very few reported to have poor mental health (0,73%). Also, in comparison this number is low as individuals with no personal

support network have a ten times higher share of persons with poor mental health as the group with a lot of supportive relationships.

Table 11: Total number and percental share of persons per Mental Health/Personal Support Network-category

Personal Support Network	Excellent	Very good	Good	Fair	Poor	N
A lot	211 (51,21%)	113 (27,43%)	65 (15,78%)	20 (4,85%)	3 (0,73%)	412
Fair amount	125 (41,12%)	89 (29,28%)	63 (20,72%)	21 (6,91%)	6 (1,97%)	304
Just a few	182 (26,96%)	168 (24,89%)	194 (28,74%)	107 (15,85)	24 (3,56%)	675
No people living nearby	54 (24,88%)	40 (18,43%)	63 (29,03%)	44 (20,28%)	16 (7,37%)	217

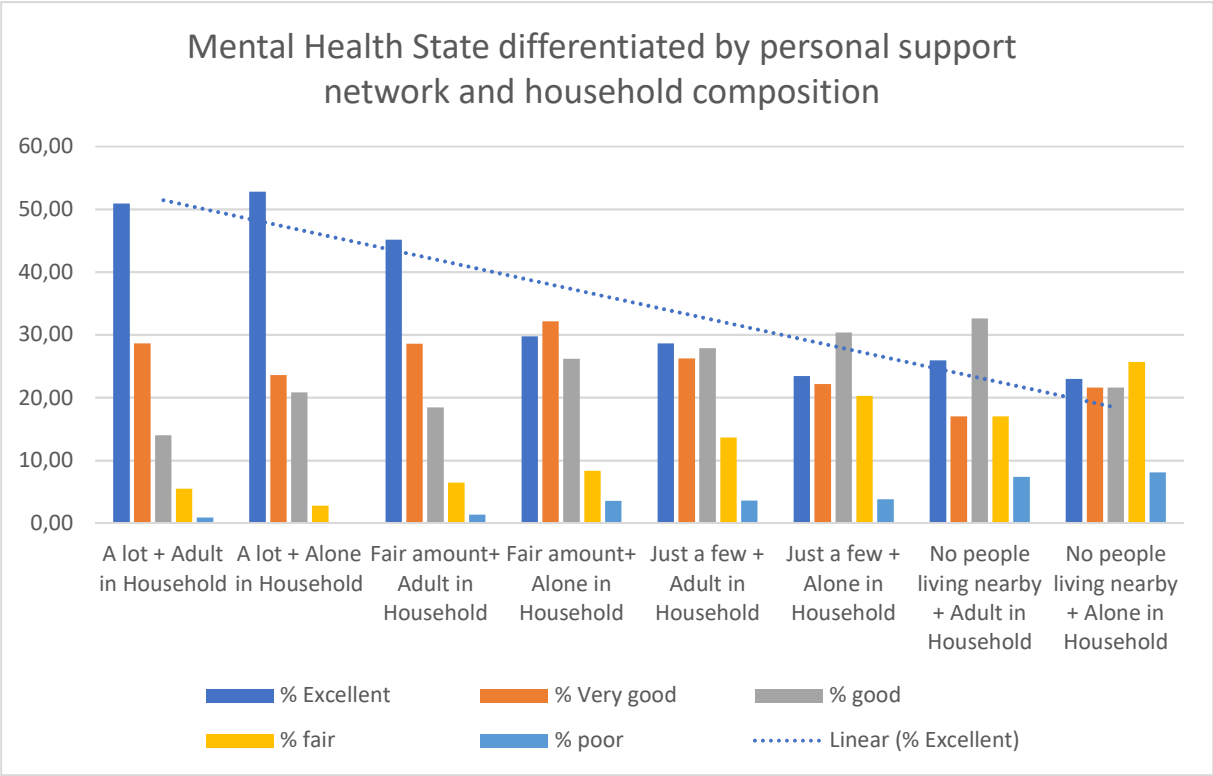

Figure 16: Mental health differentiated by personal support network and household composition

Next, the mental health state is analysed differentiated by the personal support network and whether another adult lives in the household. It can be assumed that in a lot of cases the adult living with someone in the household is a partner. Living with someone else in the household provides a contact that is very present in one´s life and might therefore provide especially important emotional support. In the "A lot"-category nevertheless, the group without another adult in the household has a slightly higher percentage of persons with excellent mental health than those who live with another adult. In all three other groups the subgroup that lives with an adult is doing better than the group without one. The only personal support network

category in which living with another adult has a greatly higher number of persons with excellent mental health is the “Fair amount” category.

6.3.1. Change in mental health

Figure 17 shows the number of persons that reported to have the same mental health and those who said their mental health deteriorated. Three months after the hurricane the percentage of persons who report that their mental health has deteriorated is at 16% percent. However, as can be seen in the figure 18, depending on the social support network one is reporting the percentage with deteriorated mental health is varying between 10% for persons with a lot of persons that they can rely on to 29% for those who have one close by on which they say they can rely on. There is only a minimal difference between those with a lot (10%) and a fair amount (11%) of supportive relationships. Among those with just a few supportive relationships the percentage is considerably higher (17%) compared to the first two groups. Given the strong, repeatedly found evidence (see for instance Wilkinson & Marmot 2003, Kawachi & Berkman 2001, Helliwell et al. 2012) for the importance of social relationships on mental health it can be expected that these differences in mental health deterioration are actually due to the differences in the social support network.

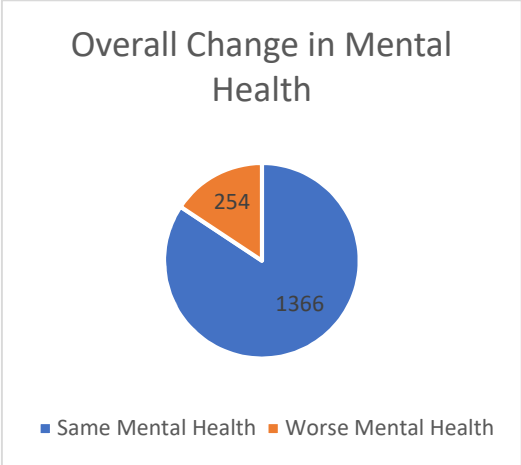

Figure 17: Change in mental health after Hurricane Harvey

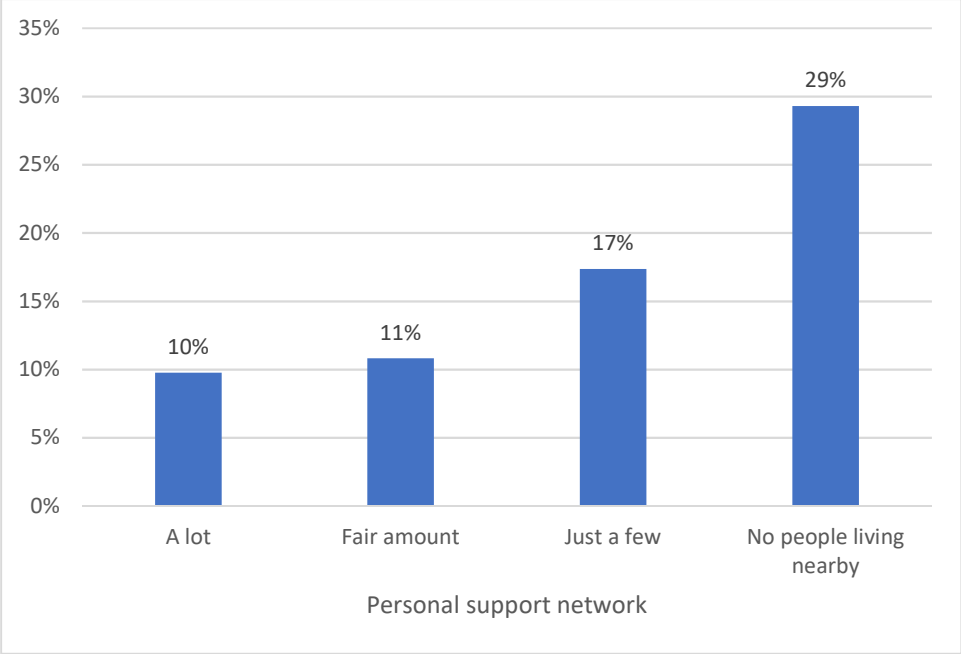

Figure 18: Deteriorated mental health differentiated by personal support network level

As clearly visible in the table 12 those who experienced major damage were about two and a half times as likely to say that their mental health is worse due to the experiences of Hurricane Harvey. This is a finding that was expected, as mental health is influenced by the magnitude of outside disruptions (Layard & Clark 2014).

Table 12: Change in mental health after Hurricane Harvey differentiated by damage level

Change in mental health	Major Damage	Minor Damage	No Damage	N	% Major Damage	% Minor Damage	% No Damage
Same Mental Health	247	334	765	1346	18,35	24,81	56,84
Deteriorated Mental Health	131	68	53	252	51,98	26,98	21,03

To investigate if deterioration is also associated with the personal support network if controlled for damage the tables 13-15 were created. For all three damage categories there is a great difference in the share of those who report deteriorated mental health depending on the personal support network. The share of individuals with deteriorated mental health in the sub-group with no supportive relationships and major damage experienced is twice as high as for those with major damage and a lot of supportive relationships.

Table 13: Change in mental health after Harvey among those who experienced major damage differentiated by personal support network

Personal Support Network	Same Mental Health	Worse Mental Health	N	% Deteriorated Mental Health
A lot	62	22	84	26,19
Fair amount	30	15	45	33,33
Just a few	126	62	188	32,98
No people living nearby	29	32	61	52,46

Among those who experienced minor damage 23,53% reported deteriorated health. This is a share almost twice as high as in the group with a lot of contacts in the same damage category. The biggest relative difference can be found in the sub-group that experienced no damage.

Table 14: Change in mental health after Harvey among those who experienced minor damage differentiated by personal support network

Personal Support Network	Same Mental Health	Worse Mental Health	N	% Deteriorated Mental Health
A lot	79	11	90	12,22
Fair amount	58	11	69	15,94
Just a few	145	30	175	17,14
No people living nearby	52	16	68	23,53

The share of those who say their mental health got deteriorated is 17,44% in the group with no supportive network and not damage experienced. It is a share almost six times as high as in the group with a strong personal support network and not damage experienced.

Table 15: Change in mental health after Harvey among those who experienced no damage differentiated by personal support network

Personal Support Network	Same Mental Health	Worse mental health	N	% Deteriorated Mental Health
A lot	228	7	235	2,98
Fair amount	183	7	190	3,68
Just a few	283	24	307	7,82
No people living nearby	71	15	86	17,44

For all three damage groups mental health was also less deteriorated for those with a lot of supportive relationships in comparison to those with a fair amount. A significant difference can also be found between those with just a few friends and relatives close by and those with no supportive relationships around.

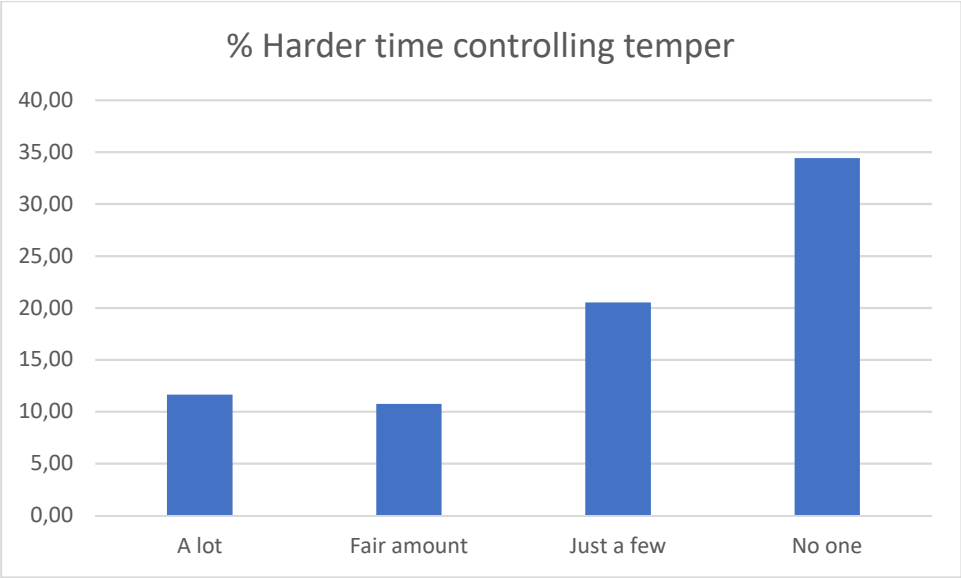

Figure 19: Percentage of participants with deteriorated emotional moderation differentiated by the level of their personal support network

As figure 19 shows there are major differences between different levels of social connectedness. More than one third of the socially disconnected individuals said they had a harder time controlling their temper. In comparison, only 11,65% of those who have a lot and 10,75% of those who a fair amount of supportive relationships reported problems with controlling their temper.

6.4. Psychotropic Drugs

Table 16 shows that those with no supportive relationships were more than two and a half times as likely to start taking new psychotropic drugs after Hurricane Harvey. However, as was shown before, among those with a weak personal support system a higher share suffers from mental health problems and is thus more likely to take new psychotropic drugs after Hurricane Harvey. To control for that in a second comparison only those with excellent to good mental health have been included. Also, among those with good to excellent mental health the share of those who have started to take a new psychotropic drug despite not suffering from mental health problems is about 2.5 times as high in the group with no personal support network in comparison to those with a strong network. This is almost exactly the same relative difference between those two categories as for the whole population, including those with mental health problems. This suggests that the strength of the relationship is not greatly influenced by poor or fair mental health but clearly correlates with the personal support network. The share of new psychotropic drug consumption is almost the same between those with a lot and a fair amount of relationships. The share is significantly higher compared to the first two groups. For those with just a few supportive contacts and for those with no supportive contacts the new intake rate is again higher than for the latter category.

Table 16: Starting to take new psychotropic drugs after Harvey all mental health categories

Personal support network	**Yes**	**No**	**N**	**% Yes**
A lot	14	399	413	3,39
Fair amount	9	298	307	2,93
Just a few	43	634	677	6,35
No people living nearby	20	199	219	9,13
Total	86	1530	1616	5,32

Table 17: Starting to take new psychotropic drugs after Harvey among those with excellent to good mental health

Personal Support Network	**Yes**	**No**	**N**	**% Yes**
A lot	8	381	389	2,06
Fair amount	6	271	277	2,17
Just a few	20	524	544	3,68
No people living nearby	8	149	157	5,10
Total	42			

6.5. Alcohol Use

Those who reported to have no personal support network close to them were most likely to increase their alcohol use (7,76%). However, persons with a fair amount of supportive relationships around were less likely to increase alcohol use than those with a lot of supportive relationships. This is contrary to the relationship that was expected and while this difference might be mostly to either higher rates of social drinking after the hurricane among those with a lot of supportive relationships, the dataset used provides no further information on the motivations to increase alcohol use. Therefore, it can be concluded that the personal support network is no direct central determinant for an increase in alcohol use.

Table 18: Share of persons that started increasing alcohol consumption due to the experiences with Harvey differentiated by personal support network

Social Support Network	**Increased Alchohol Consumption**	**No In-crease**	**Don´t drink**	**N**	**Percentage Increased drinking**	**N (excluding non-drinker)**	**Percentage Increased drinking2**
A lot	18	384	11	413	4,36	402	4,48
Fair amount	8	291	8	307	2,61	299	2,68
Just a few	30	620	28	678	4,42	650	4,62
No people living nearby	17	191	11	219	7,76	208	8,17

The share of persons who started to increase their alcohol use due to the experiences of Hurricane Harvey is a lot higher among those with poor mental health. Also, among those with fair mental health the share is comparably high, however considerably lower (5,16%) than for those with poor mental health. The differences between those who reported to have excellent, very good or good mental health is only marginal. If mental health was good or better this difference in mental health is associated with a difference in alcohol consumption.

Table 19: Share of persons that started increasing alcohol consumption due to the experiences with Harvey differentiated by mental health group

Increase in Alcohol Consumption	Excellent mental health	Very good mental health	Good mental health	Fair mental health	Poor mental health
Yes	19	11	11	23	8
No	544	385	359	165	38
N	563	396	370	188	46
Percentage that increased drinking	3,37	2,78	2,97	12,23	17,39

6.6. Recovery

As the table 20 shows there is a great difference in the recovery rate between those who have no personal support network (48,36%) and those who have a lot of supportive relationships (72,89%). Additionally, those who report to have only a few supportive relationships have a significantly lower recovery rate (57,7%). No significant difference is found between having a lot or a fair amount of supportive relationships close by.

Table 20: Recovery of individuals in comparison to personal support network

Social Support Network	Back to normal	Still disrupted
A lot	72,89	27,11
Fair amount	74,92	25,08
A few	57,70	42,30
No people living nearby	48,36	51,64

However, as shown a higher share of individuals who have no social support network are more likely to experience mental health problems. It might be the case that those who are facing mental health problems are in general more pessimistic about their state of recovery and therefore distort the data on recovery. To control for this the recovery rate of those who reported to have excellent to fair mental health has been compared to the social support network.

Table 21: Recovery of individuals with excellent to fair mental health in comparison to personal support network

Personal Support Network	N	Back to normal	Still disrupted	% Back to normal	% Still disrupted
A lot	378	279	99	73,81	26,19
Fair amount	270	207	63	76,67	23,33
Just a few	528	320	208	60,61	39,39
No people living nearby	153	82	71	53,59	46,41

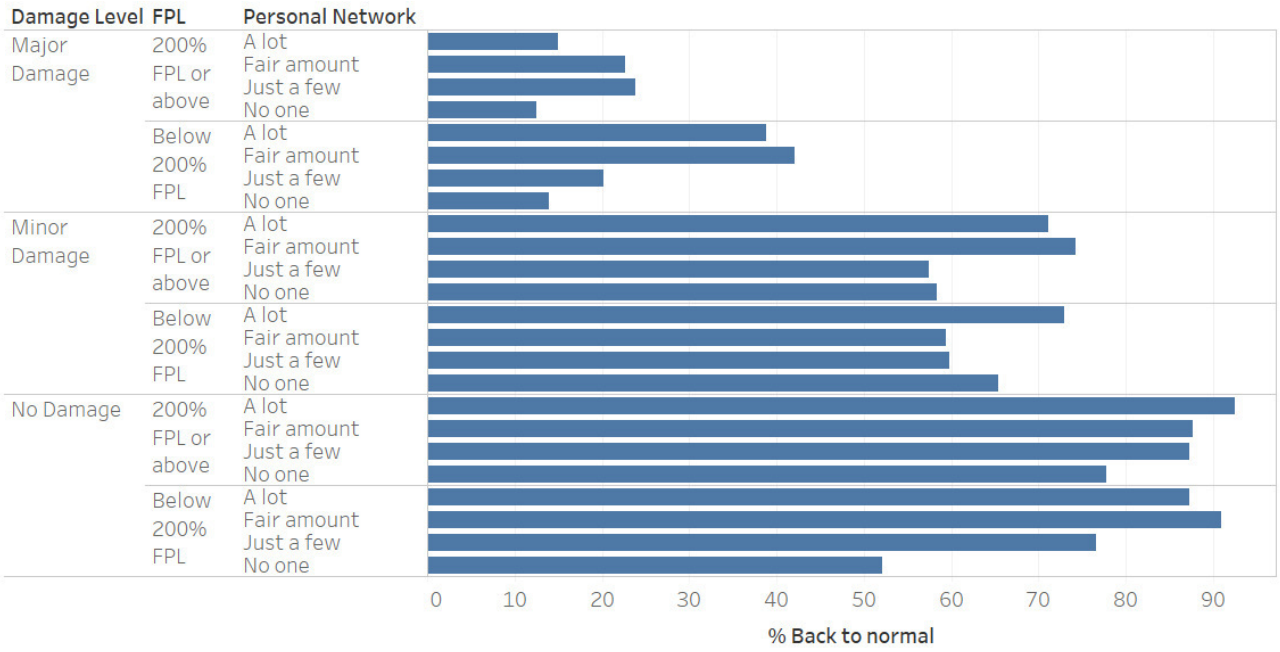

Figure 20: Percentage of persons that reported that life has returned back to normal differentiated by damage level, household income and personal support network

For those who experienced major damage and have a household income of 200% or above the personal support network seems to be insignificant. Interestingly those with a lot of supportive relationships report a lower recovery rate than those who have a fair amount of these relationships. What is surprising is that for those who are below the 200% FPL but have a lot of supportive relationships the recovery rate is about three times as high as for those in the same category with a household income of 200% of the FPL or above. It remains unclear what the factor is that accounts for this difference. It may be the case that the group below the 200% FPL was more successful in activating their social capital.
In the group below 200% of the FPL it can be seen that it made no great difference if one has a lot or a fair amount of supportive personal relationships. Individuals with just a few or no supportive personal relationships however have a significantly lower recovery rate.

For minor damage those with household income of 200% or above the FPL who have a strong personal support network have higher recovery rate than those with a weak or not existing network. For the group below 200% of the FPL the results are less clear. Indeed, is the recovery rate higher in the "a lot" category, however it is significantly lower in the "fair amount"-category, a pattern that cannot be found in the other categories. Quite unforeseen is the fact that the recovery rate in the "no people living nearby"-category is higher than the recovery rate for both those with a few and those with a fair amount of supportive relationships. This leaves a puzzle worth investigating.

The importance of social capital for the recovery rate is clearly visible for those who experience no damage. The greater differences between the personal support network categories and thus a greater importance is found for the group below 200% of the FPL. While around 87% of those with a lot of supportive relationships say their life has returned (largely) back to normal, only 50% of those with a lacking support network think their life has returned back to normal. For those with no support network and no damage, income makes the greatest difference in terms of recovery state.

7. Discussion

In this chapter, the results derived from the analysis are discussed in the context of the case of Hurricane Harvey and the reviewed literature.

7.1. Fatalities

Hurricane Harvey had a historically low death toll for a category four hurricane. Natural disasters of similar strength usually come with a death toll of around 1% of the population (Jonkman et al. 2009). The same was true for Hurricane Katrina with more than 2000 fatalities (Jonkman et al. 2009). The total fatality number of Hurricane Harvey was 70 fatalities (Jonkman et al. 2018). This conforms only a small fraction of what would be typically expected of an event of such magnitude. Hurricane Rita that hit Texas in 2005 resulted in 111 fatalities in total (Zachria & Patel 2006). This is a considerably higher death toll than Hurricane Harvey (27% higher). However, Hurricane Rita was a category 3 storm when making landfall (Dietrich et al. 2010) - a lot weaker than Hurricane Harvey (Zachria & Patel 2006).

In case of the 2011 tsunami in Japan social capital seems to have been important mitigating factor for fatalities. Social capital led to higher rates of timely evacuation (Aldrich & Sawada 2015). For the case of Hurricane Harvey the role of social capital might have been different. When it comes to explaining the fatalities it was found that the counties with fatalities did not have a on average higher social capital than those with no fatalities. It might be the case that the level of social capital of the persons found dead was significantly lower than the overall level of social capital of the county. Correlation might not have been found due to the low number of cases. The first hypothesis could thus not be verified.

Nevertheless, it was not possible to assess the social capital of the victims individually or on a more precise level. Likewise, water depth as another factor found to be strong determinant of fatality rates in another study was not correlated in the case of Hurricane Harvey. On the contrary, most fatalities occurred in areas with a water depth under 1,5 meters suggesting that it was rather the current than the actual water depth that was leading to the death of the victims.

Water yet has been a central factor for the occurrence of fatalities. The vast majority of the fatalities can be accounted to drowning (Figure 21). No other factor of the three other categories is clearly the second key cause of death during Hurricane Harvey.

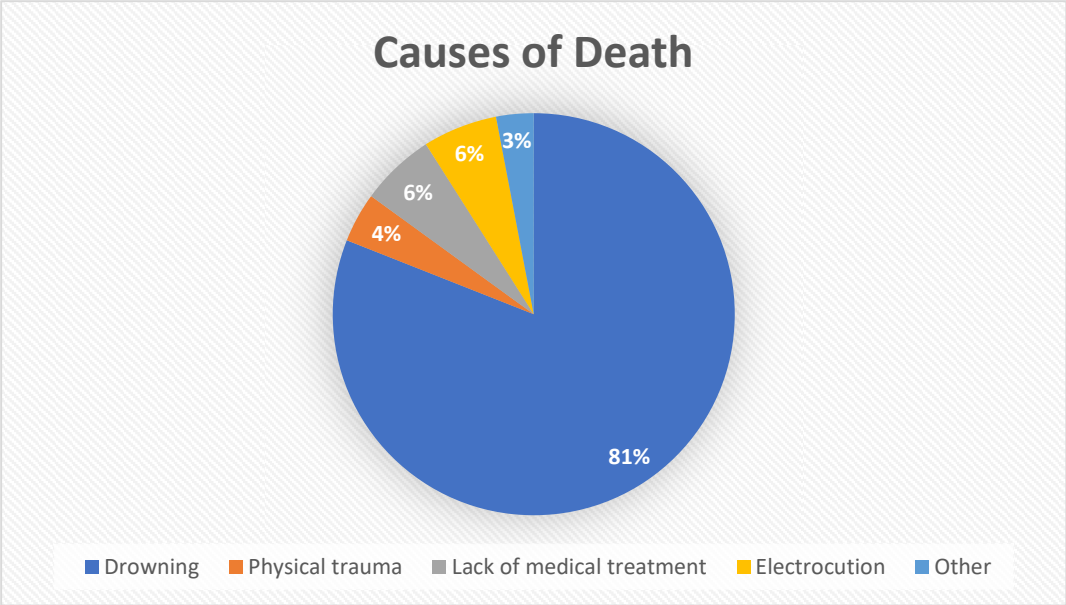

Figure 21: Causes of Death of Hurricane Harvey fatalities

Source: Jonkman et al. 2018

A closer look on the circumstances of drowning shows that the highest share of deaths occurred in and around vehicles ("In a vehicle", "Swept away while exiting vehicle") with 36% in total. Research on disaster fatalities in Texas shows that this is however a rather low share compared to other floods in the USA. Drobot et al. (2007) found in an analysis of flood fatalities in the USA that vehicle related deaths account for more than the half of all flood fatalities in the USA.

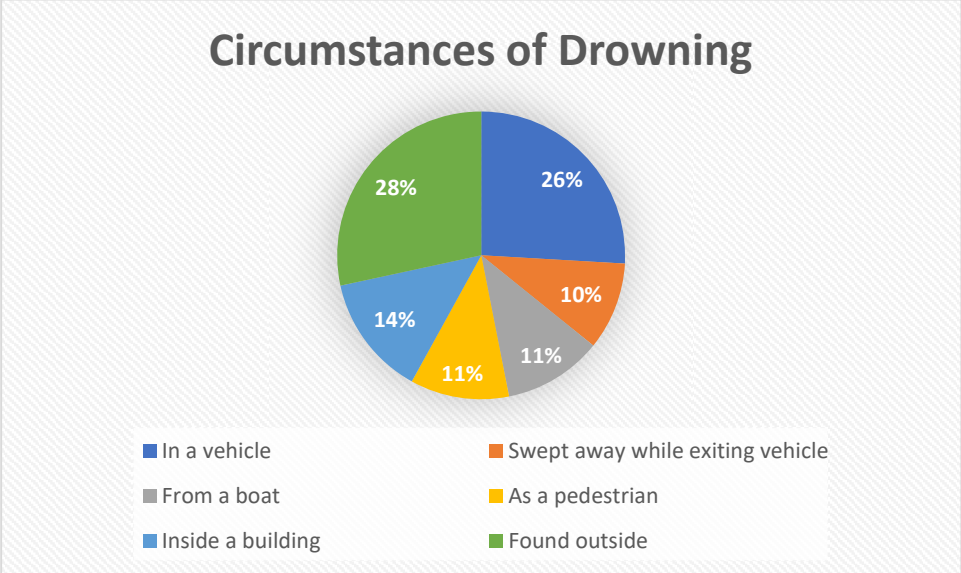

Figure 22: Circumstances of Drowning

Source: Jonkman et al. 2018

An analysis of Sharif et al. (2014) finds that 93% of all flood fatalities can be accounted to driving or walking into water. A study specifically on the county of Austin Texas suggests that some citizens do not take warning signs seriously and drive into flooded roads and are unaware of the dangers of driving and walking into flood waters (Drobot et al. 2007). The study found that those who were unaware of the dangers of walking or driving into flood

waters where more likely to do so. Furthermore, lacking knowledge of living in a flood-prone area contributes to a higher chance to drive or walk into flooded water. This also supports the suggestion of Jonkman et al. (2018) that small, unmarked high-hazard areas such as crossings beneath bridges can be accounted as a major contributor to the fatality rate.

The fact that the great majority of the victims was male (Jonkman et al. 2018) might be explainable by the tendency of male persons for higher risk-taking behaviour. Byrnes et al. 81999) found in a meta-analysis of 150 studies that male are significantly more likely to participate in a variety of risk-taking behaviours. The same was found by Charness & Gneezy (2012) in a more recent meta-analysis of 15 experiments. The authors found strong evidence for risk-taking gender differences, finding that men were in general more likely to take risks.

7.2. Mental Health

As the study showed for the status of mental health as well as the change in mental health they are strongly associated with the level of the personal support network. For the deterioration of mental health personal support networks were strongly correlated with a smaller deterioration rate even among those who experienced major damage. In those cases, one might expect that the great impact of the disturbance makes the buffering effect of social relationships irrelevant. However, this was not the case. A distinct difference in deteriorated mental health between the mental health state groups has been found. This is very much in line with the findings of Szreter & Woolcock (2004) who found for settings without any (disaster-)disturbance that social support networks are a key determinant of mental health. It is also in line with the findings of Helliwell et al. (2012) for the World Happiness Report that found that those with good social relationships experience less mental distress. The study also found that commonly discussed factors such as income have no significant effect on mental distress experiences.

The social embeddedness in personal support networks was also strongly negatively associated with a harder time to control one´s temper. Or put the other way around: On average persons that are strongly socially embedded persons showed better emotional control.

These results confirm the second hypothesis, “The stronger the social support network of an individual the lower the likelihood to have poor mental health.”.

7.3. Psychotropic Drug Intake

An alarming result is the share of new psychotropic drug intake among those with excellent to good mental health but no supportive contacts nearby. The survey explicitly asked if the intake of a new prescription-only psychotropic drug has been started. Mental health experts advise to only take psychotropic drugs in cases of severe depression or anxiety disorders as well as in cases of serious self-harm and posttraumatic stress disorder (Layard & Clark 2014). Therefore, it was reasonable to expect that only very few with good to excellent mental health would take a new prescription-only psychotropic drug. The fact that these persons take medicine although reporting to be in general in good to excellent mental health suggest that they might take those drugs to deal with struggles of feeling low or overwhelmed from time to time and especially with a higher likelihood after a disruptive event as a natural disaster but are lacking the possibility to turn to friends or family to better deal with those emotions. The

difference is stunningly high: those who do not have the opportunity to turn to friends or family nearby have a high share (almost one fifth) of individuals who started to take psychotropic drugs after Hurricane Harvey. This results meet the expectations derived from the review of academic literature on this issue. The third hypothesis, “Persons with strong the social support network (a lot of supportive relationships) are less likely to start taking a new psychotropic drug than those who have a weak social network (few or no supportive relationships).” is approved by the results of this study.

7.4. Alcohol Use

No direct relationship was found between increased alcohol consumption and a weaker personal support network. The fourth hypothesis, “Persons with a strong social support network (a lot of supportive relationships) are less likely to increase their alcohol use than those who have a weak social network (few or no supportive relationships).” is thus rejected. The evidence suggests though that an increase in alcohol consumption is indirectly related to social capital. Those with a weaker personal support network were more likely to have fair or poor mental health and those with fair or poor mental health were more likely to start drinking due to the experiences of Hurricane Harvey.

7.5. Recovery

For recovery the results suggest that in general personal support networks play a vital role. In most categories the strength of the social network was clearly correlated with the recovery rate. For two groups, over 200% FPL with major damage and under 200% FPL with minor damage, no correlation was found. No clear correlation between income level and recovery could be found. This is a surprising result as other studies before suggested economic factors as at least to some extent important factor of recovery (Sawada & Shimizutani 2008).

The expectations formulated in the fifth hypothesis, “Persons with a strong social support network (a lot of supportive relationships) recover on average faster from a natural disaster than those who have a weak social network (few or no supportive relationships).”, has therfore been confirmed by the results of the analysis.

8. Conclusions

The low death toll for Hurricane Harvey, albeit its severity, indicates an overall good preparedness and resilience in the aspect of disaster fatalities in Texas. At least in case of Hurricane Harvey, the overall social capital of the county-community had no measurable mitigating effect on the fatality rate. The first sub-question can thus be answered that differences in the fatality rate of a country did not correlate with the social capital of a county.

As discussed before, two factors may have been especially predictive for the fatalities of Hurricane Harvey: First, unawareness of the dangers of driving or walking in flood water. Second a willingness for risk-taking that increased the likelihood of driving or walking into the floods. Both the specific literature on flood fatalities in Texas and the data on the circumstances of the fatalities in the case of Hurricane Harvey make this a plausible

explanation. These factors may also provide an explanation for the high occurrence of fatalities outside the 100-years flood hazard areas and the areas with the greatest water depth.

Both mental health state and the change in mental health have been found to be strongly correlated with the level of personal support networks. The correlation is astonishingly strong. In the group with a lot of supportive relationship very few persons (0,73%) reported to be in poor mental health while in the group with no personal support network the share of persons is ten times higher (7,37%). Regarding the second sub-question it can therefore be answered that persons with a stronger social capital did have on average better mental health than those with weaker social capital.

Those with strong bonding social capital were also distinctly less likely to struggle with emotional mastery (having a harder time to control one´s temper). The ability to deal with a disruption without experiencing a significant deterioration is core part of most definitions of individual resilience (see for instance Connor & Davidson 2003, American Psychological Association 2018). It can therefore be stated: Individuals with a stronger self-reported personal support network have been significantly more resilient in their reaction to Hurricane Harvey.

Intake of new psychotropic drugs was also found to be negatively correlated with the level of one´s personal support network. The answer to the third sub-question thus reads as follows: Persons with a stronger social support network were less likely to take new psychotropic drugs, also when controlling for mental health. Concerning the fourth sub-question, the analysis revealed only an indirect correlation between bonding social capital and increased alcohol use via the negative association of social capital with mental health and mental health with alcohol use. This relationship was though also expected, as stated in the theoretical framework.

Bonding social capital was found to be of great importance for recovery rates. The stronger one´s personal support network was, the faster, on average, an individual´s life returned back to normal. The main research question can thus be answered as follows: In terms of individual resilience social capital has been found to be associated to a high extent with better outcomes in terms of individual resilience.

This bachelor thesis showed the great importance of social capital, defined as a self-assessed high quantity of close, trustful relationships, for individual resilience and recovery in the case of Hurricane Harvey.

9. Limitations of the research

Due to the limitations of time and financial resources and the point of time the study relied fully on secondary data. This resulted in the unavailability of data in some dimensions which wil be critically discussed in this subsequent part.

Differences in social capital in this thesis are investigated based on the difference in the number of relationships to friends and relatives that one can rely on. A central limitation of the research is that no data was available of the strength of this relationships. It can be assumed that also a few very strong relationships have a similar effect compared to a high number of rather weak relationships.
The exact question which answers were taken as the indicator of a person´s social capital is:

“Thinking about your personal support network – that is relatives and friends living nearby who you can rely on for help or support – do you have a lot of people you can rely on, a fair amount, just a few, or no people living nearby who you can rely on for help and support?” A friend or relative that one “can rely on for help or support” indicates a strong and trustful relationship. A “to rely” in the English language is synonimous with a relationship full of trust and confidence (Oxford dictionary 2018) making it likely that a lot of participants actually thougth of their trustful relationships.

Data from the Post Harvey-Survey is self-reported data. No data was available on objective meauserements of e.g. the mental health of participants. Results might to some extent be distorted by the personal perspective of the particpants. Tannenbaum et al. (2009) conclude despite these limitations of validity that the best feasible measures for surveilance of the mental health of a population are self-reported mental health and intake of psychotropic drugs. To increase the validity of the mental health dimension having difficulties to control one´s temper has been taken into account. It can be assumed that the assessment of one specific element of one´s mental health is easier to assess correctly than the overall mental health.

In an optimal case data on mental health, psychopharmaka intake etc. from the exact same group before Hurricane Harvey would be available. Self-evaluated change, especailly in mental health, might be flawed to some extent by the inaccurate memory of the human. This data however was not available for the group.

It is likely that other factors such as the levels of trust and the sense of belonging are factors of social capital/embededness that play an important role for the persons affected by Hurricane Harvey. As the Post Harvey-Survey did not ask participants about this two dimensions it was not possible to research those aspects. As discussed before the relationships that has been asked for though are strong and most likely trustful relationships.

It is assumed that the organisation of citizens in formal and informal groups that formed after the disaster, as another form of social capital, have played an important role for both fatalities and recovery. Rescue and relief groups such as Crowdsourced Rescue might have helped with their online social capital to reduce the number of fatalities. It has been tried intensively to include an assessment of social capital measured via the data from social networks such as Twitter or Facebook. An analysis of trust indicating language has been conducted. This analysis however revealed high margins of error (roughly 40%), due to the extremely limited amount of text per individuals (usually one tweet of 140 characters, often including mainly hashtags and links) leaving serious concerns about the validity of the data in terms of the actual trust levels between individuals. This threat to validity might have been reduced by training an algorithm to identify trust indicating language specific to the case of Hurricane Harvey. This possibility was evaluated but sorted out due to its complexity and time demand that would have been way beyond the scope of this research. In favour of a strong validity an approach based on survey data has been chosen, also due to the availability of excellent survey data provided by the Episcopal Health Foundation.

10. Policy Recommendations

Given the high percentage of fatalities that occurred due to drowning in and around vehicles and as pedestrians, a greater awareness of the dangers of walking and driving into flood

waters may be the most effective policy measure to reduce flood-related fatalities. When it comes to identifying disaster-vulnerable areas apart from paying attention to the flood-proneness the share of older-aged persons should be taken into account.

Although organizing events like neighbourhood fests do not seem to be a direct measure to make a community more resilient it seems that whatever is found effective in building ties between citizens in communities could be a very effective way to enhance resilience. Of special importance in designing such measures would be to reach those who lack any personal support networks. This research provides further support for the hypothesis that the establishing of social relationships, especially for those who are lacking those ties, is of great importance. However, this research cannot provide any answers on how this might be done most effectively. It is suggested that policy-makers assess in how far their resilience agenda already includes the enhancement of this mean of resilience and if there is room to test out strategies for including it, if social connectedness should be lacking in resilience plans. Also, urban design has great potential to include the facilitation of social capital building in their activities.

11. Recommendations for further research

This study shows the importance of social capital in disaster resilience however it is recommendable to investigate more cases for the United States. Several severe hurricanes that hit the USA in the last few years are disasters that could be investigated as additional cases, if data is available. A meta-analysis that investigates if, for natural disasters with similar devastating impact, social capital has been a strong determinant of fatalities, mental health and recovery is strongly recommended. This research could also not investigate the exact mechanisms behind the correlation of, for example, personal support networks and recovery. Here it would be recommendable to complement this quantitative study with some qualitative research. Also a multi-level analysis focussing on the social capital of communities as villages and neighbourhoods in comparison to their resilience outcomes in terms of mental health, recovery etc. would be recommendable.

References

Adger, W. N. (2003). Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography*, *79*(4), 387-404.

Alabala-Bertrand, J. M. (1993). Political economy of large natural disasters; with special reference to developing countries. Oxford University Press.

Aldrich, D. P. (2011a). The power of people: social capital's role in recovery from the 1995 Kobe earthquake. *Natural hazards*, *56*(3), 595-611.

Aldrich, D. P. (2011b). The externalities of strong social capital: Post-tsunami recovery in Southeast India. *Journal of Civil Society*, *7*(1), 81-99.

Aldrich, D. (2015). The need for 'social capital'. *The Oriental Economist*, 83 (5). X

Aldrich, D. P., & Sawada, Y. (2015). The physical and social determinants of mortality in the 3.11 tsunami. *Social Science & Medicine*, *124*, 66-75.

Aldrich, D. P. (2017). In disaster recovery, social networks matter more than bottled water and batteries. https://www.citylab.com/solutions/2017/02/recovering-from-disasters-social-networks-matter-more-than-bottled-water-and-batteries/516726/. Last retrieved: 07.08.2017.

American Psychological Association (2018). The road to resilience. https://www.apa.org/helpcenter/road-resilience.aspx. Last retrieved: 14.07.2018.

Ashley, S. T., & Ashley, W. S. (2008). Flood fatalities in the United States. *Journal of Applied Meteorology and Climatology*, *47*(3), 805-818.

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural hazards*, *41*(2), 283-295.

Bonin, M. F., McCreary, D. R., & Sadava, S. W. (2000). Problem drinking behavior in two community-based samples of adults: Influence of gender, coping, loneliness, and depression. *Psychology of Addictive Behaviors*, *14*(2), 151.

Center for Behavioral Health Statistics and Quality (2012). More than 7 Million Children Live with a parent with Alcohol Problems. https://www.samhsa.gov/data/spotlight/Spot061ChildrenOfAlcoholics2012.pdf. Last retrieved: 07.08.2018.

Clark, A. E., Flèche, S., Layard, R., Powdthavee, N., & Ward, G. (2018). The origins of happiness: the science of well-being over the life course. Princeton University Press.

Cohen, P., West, S. G., & Aiken, L. S. (2014). Applied multiple regression/correlation analysis for the behavioral sciences. Psychology Press.

Collier, K., Galatas, S., & Harrelson-Stephens, J. (2013). Lone Star Politics: Tradition and Transformation in Texas. Sage.

Connor, K. M., & Davidson, J. R. (2003). Development of a new resilience scale: The Connor-Davidson resilience scale (CD-RISC). *Depression and anxiety*, *18*(2), 76-82.

Deller, S., Deller, M. (2010). Rural crime and social capital. Growth Change 41 (2), 221-275.

Dietrich, J. C., Bunya, S., Westerink, J. J., Ebersole, B. A., Smith, J. M., Atkinson, J. H., & Cardone, V. J. (2010). A high-resolution coupled riverine flow, tide, wind, wind wave, and storm surge model for southern Louisiana and Mississippi. Part II: Synoptic description and analysis of Hurricanes Katrina and Rita. *Monthly Weather Review*, *138*(2), 378-404.

Drobot, S. D., Benight, C., & Gruntfest, E. C. (2007). Risk factors for driving into flooded roads. *Environmental Hazards*, *7*(3), 227-234.

Federal Emergency Management Agency (FEMA) (2008). Hurricane Ike impact report – Social Environment.

Federal Emergency Management Agent (FEMA) (2017). Costal Flood Risk Mapping Process. https://www.fema.gov/coastal-flood-risk-mapping-process. Last retrieved at: 03.08.2018.

Federal Emergency Management Agency (FEMA) (2018). National Hurricane Center Tropical Cyclone Report, Hurricane Harvey (AL092017).

Foa, E. B., Stein, D. J., & McFarlane, A. C. (2006). Symptomatology and psychopathology of mental health problems after disaster. *J Clin Psychiatry*, *67*(Suppl 2), 15-25.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment*, *31*(5), 437-440.

Fournier, J. C., DeRubeis, R. J., Hollon, S. D., Dimidjian, S., Amsterdam, J. D., Shelton, R. C., & Fawcett, J. (2010). Antidepressant drug effects and depression severity: a patient-level meta-analysis. *Jama*, *303*(1), 47-53.

Fleishman, J. A., & Zuvekas, S. H. (2007). Global self-rated mental health: associations with other mental health measures and with role functioning. *Medical Care*, 602-609.

Frankenberg, E., Gillespie, T., Preston, S., Sikoki, B., & Thomas, D. (2011). Mortality, the family and the Indian Ocean tsunami. *The Economic Journal*, *121*(554), 162-182.

Gordeev, V. S., Egan M. (2015). Social cohesion, neighbourhood resilience, and health: evidence from New Deal for Communities programme. *The Lancet,* 386.

Greene, G., Paranjothy, S., & Palmer, S. R. (2015). Resilience and vulnerability to the psychological harm from flooding: The role of social cohesion. *American journal of public health*, *105*(9), 1792-1795.

Guha-Sapir, D., Parry, L. V., Degomme, O., Joshi, P. C., & Arnold, S. (2006). Risk factors for mortality and injury: post-tsunami epidemiological findings from Tamil Nadu.

Hawkins, R. L., & Maurer, K. (2009). Bonding, bridging and linking: how social capital operated in New Orleans following Hurricane Katrina. *British Journal of Social Work*, *40*(6), 1777-1793.

Helliwell, J. F., Layard, R. & Sachs, J. (eds.) (2012), World Happiness Report. New York: The Earth Institute, Columbia University.

Intergovernmental Panel on Climate Change (IPCC) (2014). *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change* (p. 151). IPCC. X

Islam, R., & Walkerden, G. (2014). How bonding and bridging networks contribute to disaster resilience and recovery on the Bangladeshi coast. *International journal of disaster risk reduction*, *10*, 281-291.

Jonkman, S. N., Godfroy, M., Sebastian, A., & Kolen, B. (2018). Brief communication: Loss of life due to Hurricane Harvey. *Natural Hazards and Earth System Sciences*, *18*(4), 1073-1078.

Jonkman, S. N., Maaskant, B., Boyd, E., & Levitan, M. L. (2009). Loss of life caused by the flooding of New Orleans after Hurricane Katrina: analysis of the relationship between flood characteristics and mortality. *Risk Analysis: An International Journal*, *29*(5), 676-698.

Kawachi, I., & Berkman, L. F. (2001). Social ties and mental health. *Journal of Urban health*, *78*(3), 458-467.

Kirsch, I., Deacon, B. J., Huedo-Medina, T. B., Scoboria, A., Moore, T. J., & Johnson, B. T. (2008). Initial severity and antidepressant benefits: a meta-analysis of data submitted to the Food and Drug Administration. *PLoS medicine*, *5*(2).

Klein, R. J., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept?. *Global Environmental Change Part B: Environmental Hazards*, *5*(1), 35-45.

Knack, S., & Keefer P. (1997). "Does social capital have an economic payoff? A cross-country investigation." *The Quarterly journal of economics* 112(4): 1251-1288.

Lassalle, M., Chastang, J. F., & Niedhammer, I. (2015). Working conditions and psychotropic drug use: Cross-sectional and prospective results from the French national SIP study. *Journal of psychiatric research*, *63*, 50-57.

Layard, R., & Clark, D. M. (2014). Thrive: The power of evidence-based psychological therapies. Penguin UK. X

Lin N (2008). A network theory of social capital. In: Castiglione D, Van Deth JW, Wolleb G (eds). The handbook of social capital. Oxford University Press, New York, 50–69.

Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The Construct of Resilience: A Critical Evaluation and Guidelines for Future Work. *Child Development*, *71*(3), 543-562.

McPherson, M., Smith-Lovin, L., & Brashears, M. E. (2006). Social isolation in America: Changes in core discussion networks over two decades. *American sociological review*, *71*(3), 353-375.

Mendelsohn, R., Emanuel, K., Chonabayashi, S., & Bakkensen, L. (2012). The impact of climate change on global tropical cyclone damage. *Nature climate change*, *2*(3), 205.

Mileti, D., ed. (1999). Disasters by design: A reassessment of natural hazards in the United States. Joseph Henry Press. Washington, D.C.

Mimura, N., Yasuhara, K., Kawagoe, S., Yokoki, H., & Kazama, S. (2011). Damage from the Great East Japan Earthquake and Tsunami. A quick report. *Mitigation and adaptation strategies for global change*, *16*(7), 803-818.

Moisan, J., Bourbonnais, R., Brisson, C., Gaudet, M., Vezina, M., Vinet, A., & Regoire, J. P. (1999). Job strain and psychotropic drug use among white-collar workers. *Work & Stress*, *13*(4), 289-298.

National Centers for Environmental Information (2017). Annual Average Number of Tornados, 1953-2004. https://www.ncdc.noaa.gov/img/climate/research/tornado/small/. Last retrieved: 18.07.2018.

National Center for Health Statistics (2016). Health, United States, 2015: with special feature on racial and ethnic health disparities. https://www.ncbi.nlm.nih.gov/pubmed/27308685. Last retrieved: 05.08.2018.

National Institute on Alcohol Abuse and Alcoholism (2017). Alcohol Facts and Statistics. https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/alcohol-facts-and-statistics Last Retrieved: 22.07.2018.

National Hurricane Center (2018). Costliest U.S. tropical cyclones tables updated. https://www.nhc.noaa.gov/news/UpdatedCostliest.pdf. Last retrieved: 19.07.2018. X

Nektarios, N., Kourgialas, N. N., & Karatzas, G. P. (2011). Flood management and a GIS modelling method to assess flood-hazard areas—a case study. *Hydrological Sciences Journal–Journal des Sciences Hydrologiques*, *56*(2), 212-225.

New York Times (2017). In Texas, Distrust of Washington Collides With Need for Fedral Aid. https://www.nytimes.com/2017/09/04/us/texas-storm-federal-aid-abbott-cruz.html. Last retrieved: 22.07.2018.

Norris, F. H., Friedman, M. J., Watson, P. J., Byrne, C. M., Diaz, E., & Kaniasty, K. (2002). 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. *Psychiatry: Interpersonal and biological processes*, *65*(3), 207-239.

Oxford dictionary (2018). Definition rely. https://en.oxforddictionaries.com/definition/rely. Last retrieved: 26.08.2018.

Paton, D., & Johnston, D. (2017). Disaster resilience: an integrated approach. Charles C Thomas Publisher.

Prasad, N., Ranghieri, F., Shah, F., Trohanis, Z., Kessler, E., & Sinha, R. (2008). Climate resilient cities: A primer on reducing vulnerabilities to disasters. The World Bank.

Pratt, L. A., Brody, D. J., & Gu, Q. (2017). Antidepressant use among persons aged 12 and over: United States, 2011-2014. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.

Putnam, R. D. (2000). Bowling alone: America's declining social capital. In *Culture and politics* (pp. 223-234). Palgrave Macmillan, New York.

Putnam, R. (2001). Social capital: Measurement and consequences. *Canadian journal of policy research*, *2*(1), 41-51.

Rew, L., & Horner, S. D. (2003). Youth resilience framework for reducing health-risk behaviors in adolescents. *Journal of pediatric nursing*, *18*(6), 379-388.

Sawada, Y., & Shimizutani, S. (2008). How do people cope with natural disasters? Evidence from the great Hanshin-Awaji (Kobe) earthquake in 1995. *Journal of Money, Credit and Banking*, *40*(2-3), 463-488.

Sebastian, A. G., Lendering, K. T., Kothuis, B. L. M., Brand, A. D., Jonkman, S. N., van Gelder, P. H., van de Walle, B. A. (2017). Hurricane Harvey Report: A fact-finding effort in the direct aftermath of Hurricane Harvey in the Greater Houston Region.

Sharif, H. O., Jackson, T. L., Hossain, M. M., & Zane, D. (2014). Analysis of flood fatalities in Texas. *Natural Hazards Review*, *16*(1).

Sharma, T., Guski, L. S., Freund, N., & Gøtzsche, P. C. (2016). Suicidality and aggression during antidepressant treatment: systematic review and meta-analyses based on clinical study reports. The British Medical Journal, 352(65).

Smith, B. L. (2012). Inappropriate prescribing. *Monitor on Psychology*, *43*(6), 36.

Szreter, S., & Woolcock, M. (2004). Health by association? Social capital, social theory, and the political economy of public health. *International journal of epidemiology*, *33*(4), 650-667.

Tak, Y. R., & McCubbin, M. (2002). Family stress, perceived social support and coping following the diagnosis of a child's congenital heart disease. *Journal of advanced nursing*, *39*(2), 190-198.

Tannenbaum, C., Lexchin, J., Tamblyn, R., & Romans, S. (2009). Indicators for measuring mental health: towards better surveillance. *Healthcare Policy*, *5*(2).

Tugade, M. M., & Fredrickson, B. L. (2004). Resilient individuals use positive emotions to bounce back from negative emotional experiences. *Journal of personality and social psychology*, *86*(2), 320.

Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. *Climate and development*, *4*(4), 311-326.

United States Census Bureau (2017). Estimates of Resident Population Change and Rankings: July 1, 2016 to July 1, 2017 - United States - Metropolitan Statistical Area; and for Puerto Rico; 2017 Population Estimates. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. Last retrieved: 28.06.2018.

United States Census Bureau (2018). Quick Facts – state and county statistics. https://www.census.gov/quickfacts/fact/table/US/PST045217. Last Retrieved: 05.08.2018.

Ursano, R. J., Fullerton, C. S., Weisaeth, L., & Raphael, B. (Eds.). (2017). *Textbook of Disaster Psychiatry*. Cambridge university press.

Walsh, F. (2007). Traumatic loss and major disasters: Strengthening family and community resilience. *Family process*, *46*(2), 207-227.

Wang, J., Lloyd-Evans, B., Giacco, D., Forsyth, R., Nebo, C., Mann, F., & Johnson, S. (2017). Social isolation in mental health: a conceptual and methodological review. *Social psychiatry and psychiatric epidemiology*, *52*(12), 1451-1461.

Weilser, R. H., Barbee J. G., Townsend, M. H. (2006). Mental Health and Recovery in the Gulf Coast After Hurricanes Katrina and Rita. *Jama*, *296*(5), 585-588.

Wilkinson, R. G., & Marmot, M. (Eds.). (2003). *Social determinants of health: the solid facts*. World Health Organization.

Wickens, T. D. (2014). *Multiway contingency tables analysis for the social sciences*. Psychology Press.

Woolcock, M., & Narayan, D. (2000). Social capital: Implications for development theory, research, and policy. *The world bank research observer*, *15*(2), 225-249.

Yamamura, E. (2010). Effects of interactions among social capital, income and learning from experiences of natural disasters: A case study from Japan. *Regional Studies*, *44*(8), 1019-1032.

Yang, Z., Nguyen, L. H., Stuve, J., Cao, G., & Jin, F. (2017). Harvey flooding rescue in social media. In *Big Data (Big Data), 2017 IEEE International Conference on* (pp. 2177-2185). IEEE.

Yi-Frazier, J. P., Yaptangco, M., Semana, S., Buscaino, E., Thompson, V., Cochrane, K., ... & Rosenberg, A. R. (2015). The association of personal resilience with stress, coping, and diabetes outcomes in adolescents with type 1 diabetes: Variable-and person-focused approaches. *Journal of health psychology*, *20*(9), 1196-1206.

Zachria, A., & Patel, B. (2006). Deaths related to Hurricane Rita and mass evacuation. *Chest*, *130*(4).

Appendix

Table I: Detailed list of circumstances and causes of the Hurricane Harvey fatalities

Circumstances	**Cause/ Manner of Death**	**Subcategory of cause / note**
Found in workplace with 1.5 ft debris line	Drowning	Inside a building
Found floating in flood water near vehicle	Drowning	Swept away while exiting vehicle
Exited vehicle and fell into flood waters, transported to local hospital	Drowning	Swept away while exiting vehicle
Found floating in 4 ft of flood water in residence	Drowning	Inside a building
Found by HPD Dive Team submerged in 14 ft of water	Drowning	In a vehicle
Found floating in high waters on a residential street	Drowning	As a pedestrian
Found face down in parking lot after flood waters receded	Drowning	Found outside / details unknown
Found in a grassy area near the E Tx Freeway	Drowning	Found outside / details unknown
Found floating in flood water by HFD	Drowning	From a boat
Found floating in flood water by HFD	Drowning	From a boat
Found in van off the roadway in high water	Drowning	In a vehicle
Found in van off the roadway in high water	Drowning	In a vehicle
Found in van off the roadway in high water	Drowning	In a vehicle
Found in van off the roadway in high water	Drowning	In a vehicle
Found in van off the roadway in high water	Drowning	In a vehicle
Found in van off the roadway in high water	Drowning	In a vehicle
Witness to collapse in flood waters	Drowning	As a pedestrian
Found in Greens Bayou/Ship Channel	Drowning	Found outside / details unknown
Found floating during Coast Guard search and rescue operation	Drowning	Found outside / details unknown
Found floating in tree in flood waters	Drowning	Found outside / details unknown
Found in alleyway after flood waters receded	Drowning	Found outside / details unknown
Found in ditch after evacuating his residence	Drowning	Found outside / details unknown
Found floating in 4ft of water after leaving residence	Drowning	Found outside / details unknown
Found lying across fence after flood waters receded	Drowning	Found outside / details unknown
Found on the banks of Greens Bayou	Drowning	From a boat
Found on the banks of Greens Bayou	Drowning	From a boat
Found in a drainage ditch near Harris County Katy Park	Drowning	Found outside / details unknown
Found floating in Cypress Creek flood water	Drowning	From a boat
Found in Cypress Creek	Drowning	From a boat

Found in previously flooded wooded area	Drowning	Found outside / details unknown
Found in basement of the Omni Hotel after flood water receded	Drowning	Inside a building
Found in residence with flood damage	Drowning	Inside a building
Found in flooded residence	Drowning	Inside a building
Found floating in ship channel during flood	Drowning	Found outside / details unknown
Found floating half a mile from her car with toddler (who was rescued). The mother was getting out of her car when she stepped into a canal.	Drowning	Swept away while exiting vehicle
Found in a few inches of water in her residence	Drowning	Inside a building
Found floating, apparently being swept away in the strong current while trying to leave his vehicle	Drowning	Swept away while exiting vehicle
Drove his pickup into standing water	Drowning	In a vehicle
Died when walked into floodwaters, swept away by current	Drowning	As a pedestrian
The car she was driving was swept from road by flood water	Drowning	In a vehicle
Found in floodwater. Drowned after attempting to ride a four-wheeler through floodwaters to check on a neighbour.	Drowning	In a vehicle
Vehicle swept away by flood waters, got out of his car and drowned	Drowning	Swept away while exiting vehicle
Found in a vehicle	Drowning	In a vehicle
Found dead	Drowning	Inside a building
Found in a creek	Drowning	Found outside / details unknown
Driving their pickup truck into floodwaters	Drowning	In a vehicle
Driving their pickup truck into floodwaters	Drowning	In a vehicle
Drowned when her car was swept off the road	Drowning	In a vehicle
Witnessed to step on live electrical wire in flood waters	Electrocution	
Electrocution due to standing in flood water, in a shed behind their home	Electrocution	
Electrocution due to standing in flood water, in a shed behind their home	Electrocution	
Unable to access medical treatment in time, rescue was started but came too late	Lack of medical treatment	
Suffered an asthma attack, fell into a coma, died in hospital three days later	Lack of medical treatment	
House on fire	Other	Fire
Crushed by a tree that fell down on her mobile home	Physical trauma	Crushed by tree
A tree fell on their truck traveling down FM 777	Physical trauma	Car accident

A tree fell on their truck traveling down FM 777	Physical trauma	Car accident

Source: TU Delft – 4TU.Centre for Research Data (2017). Fatalities due to Hurricane Harvey. Retrieved from: https://data.4tu.nl/repository/uuid:95690fdd-b13f-4bf9-a28d-c9b924696a96.

Table II: Deterioration in mental health differentiated by personal support network

Social Support Network	**Same Mental Health**	**Deterioration**	**N**	**Percentage with detoriated mental health**
A lot	370	40	410	10%
Fair amount	272	33	305	11%
Just a few	557	117	674	17%
No people living nearby	152	63	215	29%

Table III: Mental Health Status in comparison to social support network.

Social Support Network	**Same Mental Health**	**Deterioration**	**N**	**Percentage with deteriorated mental health**
A lot	370	40	410	10%
Fair amount	272	33	305	11%
Just a few	557	117	674	17%
No people living nearby	152	63	215	29%

Table IV: Deterioration in mental health differentiated by personal support network

Personal Support Network	A lot	A lot	Fair amount	Fair amount	Just a few	Just a few	No people living nearby	No people living nearby
Other Adult/Alone in household	Adult in Household	Alone in Household	Adult in Household	Alone in Household	Adult in Household	Alone in Household	Adult in Household	Alone in Household
Mental Health								
Excellent	167	38	98	25	143	37	35	17
Very good	94	17	62	27	131	35	23	16
Good	46	15	40	22	139	48	44	16
Fair	18	2	14	7	68	32	23	19
Poor	3	0	3	3	18	6	10	6
N	328	72	217	84	499	158	135	74

% Excellent	50,91	52,78	45,16	29,76	28,66	23,42	25,93	22,97
% Very good	28,66	23,61	28,57	32,14	26,25	22,15	17,04	21,62
% good	14,02	20,83	18,43	26,19	27,86	30,38	32,59	21,62
% fair	5,49	2,78	6,45	8,33	13,63	20,25	17,04	25,68
% poor	0,91	0,00	1,38	3,57	3,61	3,80	7,41	8,11

Table V: Deteriorated emotional moderation differentiated by the level of their personal support network

Personal Support Network	Yes	No	N	% Harder time controlling temper
A lot	48	364	412	11,65
Fair amount	33	274	307	10,75
Just a few	139	538	677	20,53
No people living nearby	75	143	218	34,40

Table VI: Recovery rates differentiated by personal support network, household income and damage level, by case numbers per category and percentage per category

Major Damage		Back to Normal	Still disrupted	N	% Back to normal	% Still disrupted
A lot	200% FPL or above	6	34	40	15,00	85,00
	Below 200% FPL	14	22	36	38,89	61,11
Fair amount	200% FPL or above	5	17	22	22,73	77,27
	Below 200% FPL	8	11	19	42,11	57,89
Just a few	200% FPL or above	16	51	67	23,88	76,12
	Below 200% FPL	23	91	114	20,18	79,82
No people living nearby	200% FPL or above	2	14	16	12,50	87,50
	Below 200% FPL	5	31	36	13,89	86,11
Average Recovery Rate (%)					23,65	76,35
Minor Damage						
A lot	200% FPL or above	32	13	45	71,11	28,89
	Below 200% FPL	27	10	37	72,97	27,03
Fair amount	200% FPL or above	26	9	35	74,29	25,71

	Below 200% FPL	19	13	32	59,38	40,63
Just a few	200% FPL or above	27	20	47	57,45	42,55
	Below 200% FPL	67	45	112	59,82	40,18
No people living nearby	200% FPL or above	7	5	12	58,33	41,67
	Below 200% FPL	34	18	52	65,38	34,62
Average Recovery Rate (%)					64,84	35,16
No Damage						
A lot	200% FPL or above	112	9	121	92,56	7,44
	Below 200% FPL	69	10	79	87,34	12,66
Fair amount	200% FPL or above	78	11	89	87,64	12,36
	Below 200% FPL	60	6	66	90,91	9,09
Just a few	200% FPL or above	82	12	94	87,23	12,77
	Below 200% FPL	131	40	171	76,61	23,39
No people living nearby	200% FPL or above	21	6	27	77,78	22,22
	Below 200% FPL	24	22	46	52,17	47,83
Average Recovery Rate (%)					81,53	18,47