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Syndromic surveillance for governance in health emergencies and disaster risk management in the Philippines

Inauguraldissertation
zur Erlangung des Doctor scientiarum humanarum (Dr. sc. hum.)
an der
Medizinischen Fakultät Heidelberg

der
Ruprecht-Karls-Universität

vorgelegt von
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Quezon City, Philippines
2019

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Abbreviations

ARI – Acute respiratory infection

APSED – Asia Pacific Strategy for Emerging Diseases

APSED III – Asia Pacific Strategy for Emerging Diseases and Public Health Emergencies

ADMU – Ateneo De Manila University

CRED – Centre for Research on the Epidemiology of Disasters

DOH – Department of Health (Republic of the Philippines)

DOST – Department of Science and Technology (Republic of the Philippines)

DRM – Disaster risk management

eHATID LGU - eHealth Tablet for Informed Decision Making of Local Government Units

EMR – Electronic medical record

ESSENCE – Electronic Surveillance System for the Early Notification of Community-based Epidemics

EB – Epidemiology Bureau

EBS – Event-based surveillance

EM-DAT - International Disaster Database of CRED

ESR – Event-based Surveillance and Response

EWARS – Early warning alert and response system

FHSIS – Field Health Service Information System

FOS – Fever with other symptoms

GP – General practitioner

GOARN – Global Outbreak and Response Network

H-EDRM – Health emergency and disaster risk management

HEMB – Health Emergency Management Bureau

ILI – Influenza-like-illness

IDSR – Integrated Disease Surveillance and Response

ICD-9 – International Classification of Diseases, Ninth Revision

ICD-10 – International Classification of Diseases, Tenth Revision

IHR – International Health Regulations

INGO – International non-governmental organization

LGU – Local government unit

MHO – Municipal Health Officer

NHS – National Health Service

NGO – Non-governmental organization

PAGASA – Philippine Atmospheric, Geophysical and Astronomical Services Administration

PCHRD – Philippine Council for Health Research and Development

PIDSR – Philippine Integrated Disease Surveillance and Response

RHIS – routine health information systems

SPEED – Surveillance in Post Extreme Emergencies and Disasters

TARG – Technical Advisory Reference Group

UTI – Urinary tract infection

US – Unites States of America

UK – United Kingdom

UHC – Universal Health Care

WHO – World Health Organization

WPRO – WHO Regional Office for the Western Pacific

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Overview of the Thesis

The thesis describes the use of syndromic surveillance in the Philippines to analyze health impacts inflicted by climatological, hydrological, meteorological hazards, and complex emergencies for the enhancement of hazard risk reduction. The thesis looks at two systems, an established syndromic surveillance for disasters, Surveillance in Post Extreme Emergencies and Disasters or SPEED, and a routine health information system, eHealth Tablet for Informed Decision Making of Local Government Units or eHATID LGU. First, the thesis describes the trends observed in SPEED in terms of syndromes and diseases in health facilities, age groups, and time periods seen in the aftermath of disasters in 2013. Second, the thesis looks at eHATID LGU trends in diseases seen across 2016 in a municipality in the Philippines and their relation to weather variables. This is a pilot demonstration of the use of routine health information systems to monitor and analyze climate-sensitive diseases. Lastly, the thesis discusses the governance implications of the use of health information systems for decision-making in research areas such as health emergency and disaster risk management (H-EDRM) and climate resilient health systems.

The **first section** (*Introduction*) gives an overview of the different frameworks used in disease surveillance, H-EDRM, and climate resilient health systems. This section introduces syndromic surveillance and different examples of its use in different countries. It also gives the specific objectives of the thesis. The **second section** (M*ethods*) gives the different analytical methods and indicators used to describe the two databases, SPEED and eHATID LGU. The **third section** (*Results*) describes the output of the statistical analysis of the databases. It is divided into four subsections: (1) SPEED in three natural hazards in 2013, (2) SPEED in typhoon Haiyan, (3) SPEED in the Zamboanga armed conflict, and (4) eHATID in San Jose de Buenavista, Antique. The **fourth section** (*Discussion*) describes the implications of the results of the study to common diseases in disasters, deaths in disasters, trends across time, health facilities used, health systems resilience, correlation with weather data, limitations, health information system use, research, and policy.

1. Introduction

1.1 Syndromic surveillance

Syndromic surveillance is a method of investigation where public health practitioners and officials monitor trends of diseases in real-time or near real-time with the assistance of automated data management and analysis to detect possible outbreaks and assist decision-making in disease or outbreak control and response (Buehler et al. 2004; Henning 2004). Syndromic surveillance can also be defined as the collection of data for the benefit of public health before laboratory or clinical confirmation of the condition (Berger et al. 2006). The United States of America (US) is one of the early adapters in the use of syndromic surveillance. In 1999, ESSENCE (Electronic Surveillance System for the Early Notification of Community-based Epidemics) was created by the Walter Reed Army Institute of Research. The system monitored outpatient International Classification of Diseases, Ninth Revision (ICD-9) codes in addition to other sources such as military and civilian outpatient or ambulatory care visits, chief complaint records of civilian emergency departments, pharmaceutical sales, requests for influenza diagnostics, and veterinary health records. Another expansive syndromic surveillance is BioSense which is part of the Public Health Information Network of the US Centers of Disease Control and Prevention. It monitors 11 syndrome categories and has reports coming from 49 federal states (Chen et al. 2010b; Chen et al. 2010a). One of the main reasons for the development of syndromic surveillance in the US was the emergence of bio-terrorism after the September 11, 2001 terrorist attack (Elliot 2009).

Around the same time as the developments in the US, syndromic surveillance systems in Europe had been gaining interest and funding. The United Kingdom (UK) had implemented a number of programs under the National Health Service (NHS), using telephone helpline, outpatient visits, absenteeism and pharmaceutical sales (Ziemann et al. 2015). Syndromic surveillance had also been used to monitor health trends during emergencies due to natural hazards, mass gatherings, identifying seasonal trends of communicable diseases, and early identification of possible outbreaks (Todkill et al. 2016). More and more countries in Europe are using syndromic surveillance to address needs in early identification of infectious disease outbreaks. There are currently syndromic surveillance systems in Europe that are national and local in scale (Ziemann et al. 2016). The use of national syndromic surveillance systems was demonstrated in the July 2013 heatwave in the UK where the four systems were monitored: a telephone helpline (NHS Direct), general practitioner (GP) office consults, GP out-of-hours consults, and emergency department consults. The syndromic surveillance assisted heatwave response and planning efforts by public health offices (Elliot et al. 2014). Syndromic surveillance was also used in a local setting during the 2012 London Olympics. Emergency department, GP out-of-hours consults, and NHS Direct were monitored. The exercise gave the management team the opportunity to refine its process in alert thresholds. The system was also able to detect common conditions prior to the event which prompted further investigation (Elliot et al. 2013). Syndromic surveillance systems in Europe have improved the capacity of countries in compliance to the International Health Regulations (IHR) provision of a timely all-hazards approach to surveillance (Ziemann et al. 2015; Ziemann et al. 2016).

Syndromic surveillance across the US, Canada, Australia, and Europe have included influenza-like-illness (ILI) as one of the syndromes usually monitored (Coory et al. 2009; Elliot 2009; Ziemann et al. 2016). Influenza has a yearly occurrence during winter in the Northern and Southern Hemispheres with a significant burden on the affected populations. Influenza has a long history of causing widespread morbidity and mortality with significant number of deaths occurring in three global pandemics in the following time periods: 1918-19, 1957-58, and 1968-69 (Viboud et al. 2004). With the increase in global travel and the unpredictability of a new pandemic, the need for accurate and timely surveillance is important to the expected evidenced-guided decision-making by public health officials (Elliot 2009; Viboud et al. 2004). ILI is used as a syndrome to monitor the rates of influenza cases and acting as an early warning to possible epidemics. Its use is common to the integrated influenza surveillance of the UK and US (Hiller et al. 2013; Tay et al. 2013). In the UK specifically, ILI monitoring is done in the general practitioner level using a sentinel surveillance model (Green et al. 2015).

1.2 Public health surveillance

In contrast to syndromic surveillance, public health surveillance is the continuous and systematic method of data gathering, analysis and interpretation as well as dissemination to improve the health of populations, specifically morbidity and mortality (Buehler et al. 2004). The main purpose of public health surveillance is to identify patterns of disease occurrence in populations so as to improve investigation, control, and prevention of diseases (Centers for Disease Control and Prevention (U.S.) 2017) (see Figure 1). One main critique of public health surveillance is that there is still vulnerability among different populations for infectious diseases of pandemic potential. This is the case for countries which are developing or low- to middle-income and needing improvements in health systems strengthening. On the global scale there is still fragmentation of efforts in identifying and alerting of possible outbreaks (Morse 2012).

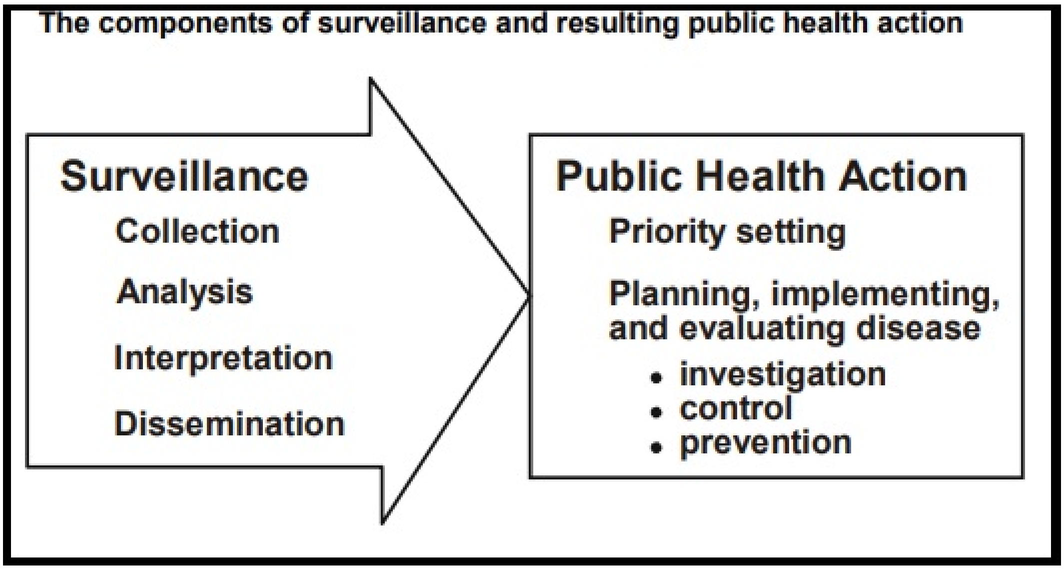

Figure 1 ***Public health surveillance (****Source: Centers for Disease Control and Prevention (U.S.) 2017)*

To address the shortcomings of international public health surveillance, the World Health Organization (WHO) with its convening capacity, drafted the revision of the International Health Regulations (IHR) of 2005. The IHR of 2005 was agreed upon by 196 countries with the purpose of global cooperation and transparency for better health security (Morse 2012; World Health Organization 2019). Its revision from the 1969 Regulations stems from the need "to prevent, protect against, control, and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade" (World Health Organization 2008b).

The Asia Pacific region, comprising the WHO Regional Offices of the Western Pacific and South East Asia, has created a shared framework to address potential public health threats outlined in the International Health Regulations of 2005, the Asia Pacific Strategy for Emerging Diseases and Public Health Emergencies or APSED III. Its first iteration was the Asia Pacific Strategy for Emerging Diseases (APSED) released in 2005. One of the core focus areas of APSED III is surveillance, risk assessment, and response (see Figure 2). APSED III continues to guide member states in strengthening core capacities of the IHR. The main goal of

APSED III is “to strengthen public health emergency preparedness and response capacity by improving core public health systems, increasing regional connectivity and coordination, and investing in ongoing performance improvement” (WHO Regional Office for the Western Pacific 2017).

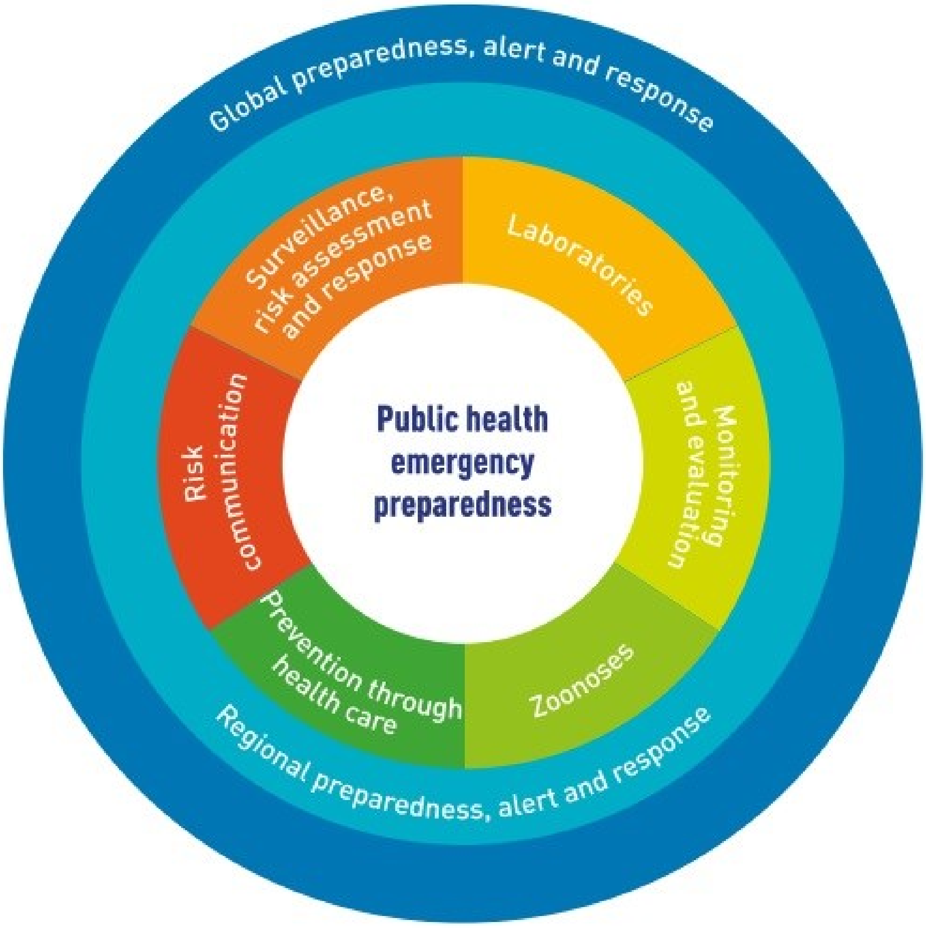

Figure 2 ***Core focus areas of APSED III (****Source: WHO Regional Office for the Western Pacific 2017)*

The IHR and APSED III are not limited to the traditional infectious diseases but may cover all diseases or events which have potential to cause harm to people irrespective of source and origin. It also obligates states to develop core capacities in surveillance and public health capacities. Furthermore, it has a component on appropriate and timely notification of incidents and events by affected countries to WHO and other nation-states. IHR provides the capacity of the director-general of the WHO to declare a “public health emergency of international concern” (World Health Organization 2008b). With this agreement in place, countries party to it need to improve their capacity for integrated real-time surveillance systems. Moreover, emphasis on a combination of surveillance systems is advised including event-based, syndromic, and digital surveillance (Morse 2012). The WHO recommends using the Integrated Disease Surveillance and Response system which was first introduced in 1998. The core functions include case detection, registration, confirmation, notification, data management and analysis, outbreak preparedness, detection, response and feedback. The support functions include supervision, training, laboratory function, resources, and coordination (Phalkey et al. 2015).

Event-based surveillance is one component of the Integrated Disease Surveillance and Response strategy (National Epidemiology Center 2014). Event-based surveillance (EBS) and its Philippine counterpart, Event-based Surveillance and Response (ESR) is defined as the systematic means of rapidly gathering information on events, which may pose a threat to the health of a particular population. These threats may pertain to disease entities or possible environmental exposures such as food, water, agriculture, chemical, and nuclear. The key activity to event-based surveillance is the rapid processing of information to assess if there is a public health threat leading to rapid response. The system is designed to detect rare and new events of outbreak potential or events in populations without formal channels of reporting through health facilities (WHO Regional Office for the Western Pacific 2008). EBS has moved forward to the digital age where events flagged through the internet and social media are further scrutinized. Systems have been created to screen through digital material across the world and use a combination of human analysis and automation (Keller et al. 2009). In its bare format, EBS is easily adaptable to conditions in developing countries (Dagina et al. 2013). As part of compliance to the IHR (2005), EBS has been implemented by the majority of member states (Li 2013).

1.3 Philippine public health surveillance

The Philippine Integrated Disease Surveillance and Response (PIDSR) system under the Epidemiology Bureau (EB) of the Department of Health (DOH) was a response to IHR (2005) and was able to unify four surveillance systems, which were separate at that time: Notifiable Disease Reporting System, National Epidemic Surveillance System, Vaccine Preventable Diseases Surveillance, and HIV-AIDS Registry. The public health surveillance framework of PIDSR revolves around the use of surveillance to inform public health action by focusing on the core activities of surveillance: detection, registration, reporting, confirmation, analysis, and feedback. These may lead to two possible responses, either acute (epidemic-type) or planned (management type) (see Figure 3). PIDSR uses case-based, laboratory-based, and event-based surveillance to catch possible epidemics at the earliest possible time. It also delves into health system strengthening through capacity-building at the local level to include community-based surveillance activities and governance from the local government unit (LGU). Reporting in PIDSR system entails communication between the local levels of government, which includes municipal, city, provincial, and the national levels of government, namely, the DOH (National Epidemiology Center 2014).

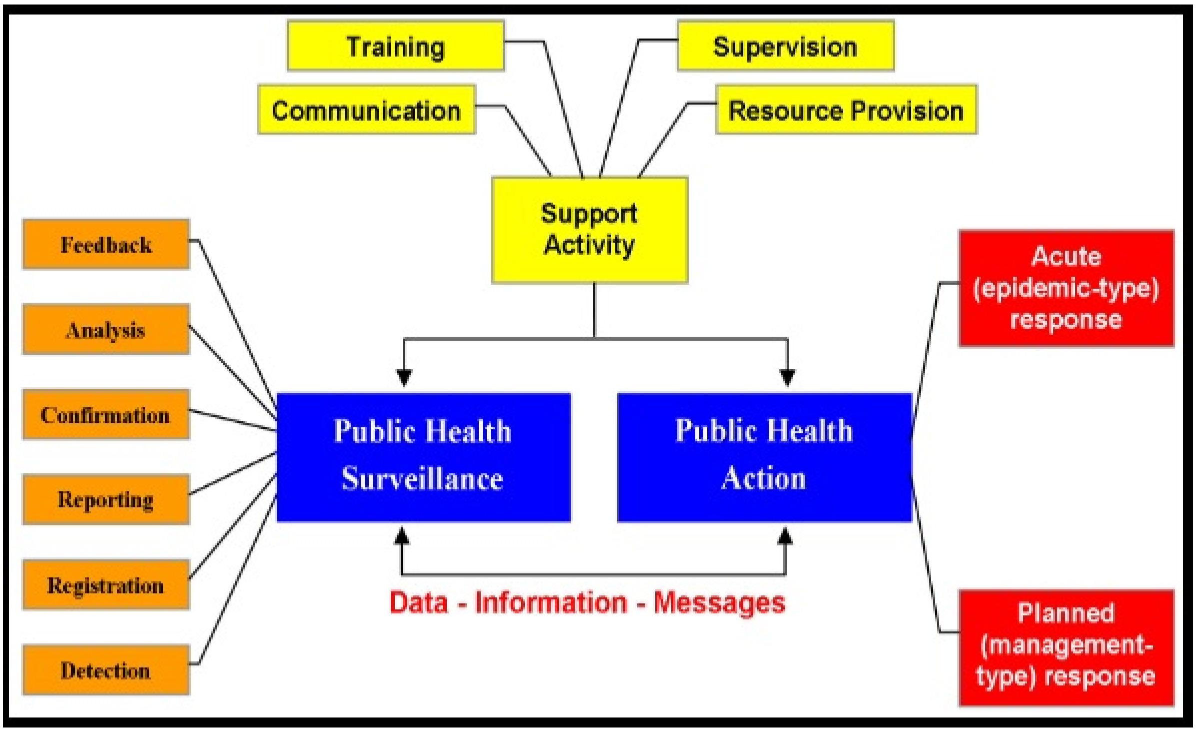

Figure 3 ***Framework of public health surveillance in the Philippines*** *(Source: National Epidemiology Center 2014)*

Syndromic surveillance as a separate surveillance system from ESR and routine health information systems is not mentioned in the manual of procedures of PIDSR (National Epidemiology Center 2014). A version of syndromic surveillance was introduced by the Department of Health through the Health Emergency Management Bureau (HEMB), Surveillance in Post Extreme Emergencies and Disasters (SPEED). SPEED is a syndromic surveillance specifically for disasters and emergencies which was influenced by typhoons and storms repeatedly hitting the country and by the recommendations of the Global Outbreak and Response Network (GOARN). SPEED has 21 predefined syndromes. However, syndromes can be added depending on the needs of the emergency or disaster (Health Emergency Management Bureau 2011).

On the other hand, there are a multitude of routine health information systems (RHIS) which are currently in use in the Philippines. As of 2016, there were six accredited providers of electronic medical record systems for primary care under the national health insurance corporation, PhilHealth. These were iClinicSys of the Department of Health, the Community Health Information and Tracking System or CHITS of the University of the Philippines, Seg-RHIS of Segworks Technologies, eHealth Tablet for Informed Decision Making of Local Government Units or eHATID LGU of the Ateneo De Manila University (ADMU), SHINE OS+ of Smart Communications and ADMU, and WAH-EHR of the Wireless Access for Health (Ateneo de Manila University et al. 2016; Ongkeko et al. 2016; Philippine Health Insurance Corporation 2016). These RHIS which use ICD codes can be used for monitoring of diseases during emergencies and disasters during response and recovery phases while it may also be used for long term monitoring of climate-sensitive diseases (Department of Health Philippines and World Health Organization 2012; Hope et al. 2008; Horst and Coco 2010). Aside from RHIS, there are other health-related information systems within the Department of Health system, such as the Tuberculosis Registry and the Philippine Malaria Information System. PhilHealth has the largest clinical database in the country taken from all its member registrations and medical claims (Romualdez Jr. et al. 2011).

1.4 Health emergency and disaster risk management and climate change resilient health systems

A disaster is defined as “civil emergency in which humanitarian needs are beyond local capacity to meet.” On the other hand, a hazard is a potential threat to the safety of the public as well as public health while emergency is an actual threat to both human health and safety (Health Emergency Management Bureau 2012). A disaster can also be defined based on set parameters: ten or more people killed, 100 or more people affected in a population, local authorities declaring a state of emergency, or a call for assistance to either national or international entities (CRED 2015). The management of disasters has become a critical task of government in the Philippines as the country is one of the most hazard-prone countries (Health Emergency Management Bureau 2012; Kirch et al. 2017). Health emergency and disaster risk management (H-EDRM) is the intersection of human health and disaster risk management and revolves around four components of the disaster risk management (DRM) cycle: prevention, preparedness, response, and recovery (Lo et al. 2017; WHO Regional Office for the Western Pacific 2015) (See Figure 4).

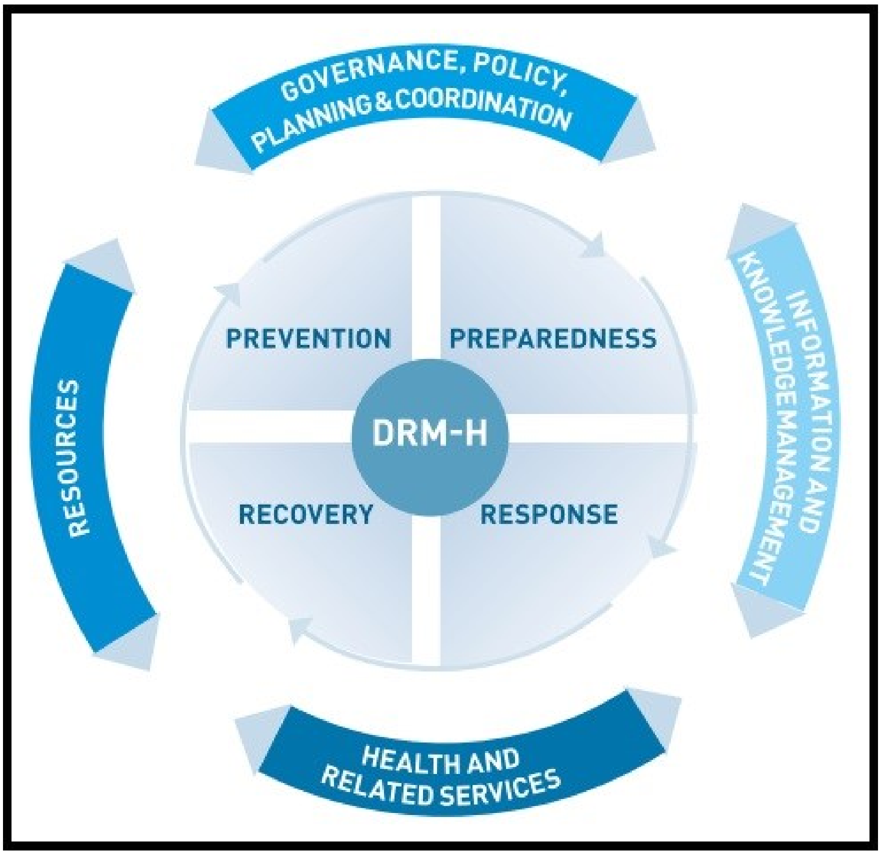

Figure 4 ***Components of the disaster risk management (DRM) cycle*** *(Source: WHO Regional Office for the Western Pacific 2015)*

The Western Pacific Regional Framework for Action for Disaster Risk Management for Health of the WHO Regional Office for the Western Pacific or WPRO puts a premium on addressing multiple hazards, on multiple levels (local, national, and international), and involving all sectors and disciplines. It discusses the components of the DRM cycle. Prevention is characterized as reducing human susceptibility to disasters. Preparedness is described as the capacitation of affected populations to anticipate and respond to all types of hazards which includes monitoring, early-warning systems, planning for emergency operations, training, drills, stockpiling, and logistics management. Response in H-EDRM includes public health services and emergency services during and immediately after the disaster. The aim of response is to provide for the basic needs of the population affected. Recovery, on the other hand, is the restoration and improvement of living conditions, basic services, and means of income generation of the affected population (WHO Regional Office for the Western Pacific 2015).

The WPRO framework for DRM is based on the Sendai Framework for Disaster Risk Reduction 2015 – 2030. The Sendai framework includes explicit health outcomes (WHO Regional Office for the Western Pacific 2015). Health resilience is a consistent theme under the Sendai framework where the integration of health measures with political, educational, environmental, structural, legal, social, economic, cultural and technological initiatives are proposed to reduce hazard vulnerability specifically in human health for the whole cycle of DRM. The priorities for action in the Sendai framework are understanding disaster risk, strengthening governance in DRM, investing in disaster resilience, and enhancing preparedness for improved response and recovery (UNISDR 2015). These four priorities for action are applicable to H-EDRM. Research on health impacts of disasters and emergencies will further inform decisions for preparedness and response planning of the health sector and other stakeholders. Management and operational researches can help improve governance measures for H-EDRM. Investing on initiatives informed by H-EDRM researches can further improve activities that highlight the shared responsibility of government and other stakeholders, multi-stakeholder engagement, coordination amongst partners, and the use of the all-hazards approach (Lo et al. 2017).

The WPRO framework for DRM is also patterned on the health systems building blocks. The key components of the framework include: (1) governance, policy, planning, and coordination, (2) information and knowledge management, (3) health services, and (4) resources, including human, supplies, and finances. What differs between the two is that the health systems building blocks of WHO consider human resources for health, technologies and medicines, and financing as separate (WHO Regional Office for the Western Pacific 2015; World Health Organization 2007). On the other hand, the components of the WHO Operational Framework for Climate Resilient Health Systems, a related framework to H-EDRM, have expanded into ten components from the original six health system building blocks (see Table 1). For the Climate Resilient Health Systems framework, health information systems and service delivery were divided into three components each. Health information systems component was divided into vulnerability, capacity, and adaptation assessment, integrated risk monitoring and early warning, and health and climate research. Service delivery was divided into emergency preparedness and management, climate-informed health programs, and management of environmental determinants of health (Dorotan et al. 2018; World Health Organization 2015a).

Table 1 ***WHO health system building blocks and the WHO operational framework of climate-resilient health systems*** *(Source: Dorotan et al. 2018)*

Health system building blocks	Functions of climate-resilient health systems
Leadership and governance	Leadership and governance
Health workforce	Health workforce
Health information systems	Vulnerability, capacity and adaptation assessments
	Integrated risk monitoring and early warning
	Health and climate research
Essential medical products and technologies	Climate resilient and sustainable technologies and infrastructure
Service delivery	Management of environmental determinants of health
	Climate-informed health programs
	Emergency preparedness and management
Financing	Climate and health financing

Health system strengthening is a common strategy to address the health effects of climate change and disasters alike. The use of the health systems approach to assess preparedness and response in extreme weather events have been done in areas such as in India affected by floods in 2008 (Phalkey et al. 2012). Health facility resilience as a part of continuity of service delivery in the face of extreme weather events has been highlighted as one of the areas for adaptation for climate change and preparedness in disaster risk management. More than improving the capacity of the health facility to withstand the environmental impacts of extreme weather events, climate-smart facilities also reduce their carbon footprint through the use of engineering controls (Banwell et al. 2018; Pan American Health Organization 2017; Sanchez et al. 2018). The health workforce has also been highlighted as an important building block for DRM and climate changed adaptation. Currently, there is limited knowledge among health care workers on climate-related events and the health effects of climate change that reduces their ability to advise their patients on reducing vulnerability to these diseases and conditions (Sanchez et al. 2018; World Health Organization 2015a). However, more than health systems strengthening, climate change adaptation, which includes DRM, needs to translate to health resilience of communities and improve health outcomes (Sanchez et al. 2018; Watts et al. 2017).

1.5 Health impacts of disasters and climate change

Climate change has been described as an amplifier of natural hazards. Of the five types of natural hazards, namely, biological (infections, infestations), geophysical (earthquakes, dry mass movements), hydrological (floods, storm surges, wet mass movements), meteorological (tropical cyclones, storms), and climatological (extreme temperatures, droughts, heat and cold waves), only geophysical natural hazards have not been related to climate change in recent research (Sauerborn and Ebi 2012). Extreme weather events, specifically floods and storms, are expected to increase in intensity and frequency based on climate change projections. On the opposite spectrum, wildfires and droughts are expected to increase as well. Not only do these hazards expose populations to injuries and infectious diseases, they may also lead to malnutrition due to loss of agricultural production (Patz et al. 2014).

Hyrdrometeorological hazards such as storms, floods, and storm surges have direct impacts on health such as mortality from drowning and physical injuries. Morbidity from these events include diarrheal diseases associated with eating and drinking spoiled food and unclean water, respiratory diseases from exposure to mold and allergens, and skin infections from the lack of sanitation and exposure to sewage (Centers for Disease Control and Prevention (U.S.) 2013; Lane et al. 2013). Flooding and storms can also expose affected populations to vector-borne diseases, mental health disturbance and exacerbation, and lack of food supplies (Van Minh et al. 2014). There is also the possibility of disease outbreaks due to population displacement or constraints in evacuation center or camp management (Kouadio et al. 2012).

Geophysical hazards, namely earthquakes and landslides, have deaths attributable to injuries from infrastructure collapse. However, the number of these deaths depends on the severity of the earthquake and the vulnerability of the affected population. Vulnerability can be in the form of socioeconomic status, location and time of the event, building type, and infrastructure quality (de Bruycker et al. 1983; Doocy et al. 2016; Shoaf and Rottman 2000). A study done comparing the health impact of the Haiti earthquake and Pakistani floods in 2010 showed that the earthquake had more injuries and mortalities compared to the flood even if the damage to households and economic losses were similar (Weiss et al. 2014). The most common injuries in the Haiti earthquake of 2010 were lacerations and fractures (Doocy et al. 2013). The Great East Japan Earthquake in 2011 was a magnitude 9.0 in the Richter scale. Studies of this disaster showed a variety of conditions depending on the time frame after the onset of the disaster. During the first 24 hours, injuries were observed. Within 10 days, coronary syndromes, cerebrovascular diseases, hypothermia, burns, and mental health conditions were more common. Within 30 days of the disaster impact, respiratory infections, gastritis, and allergies to debris were seen. After 30 days of the disaster the common conditions were allergy in children, musculoskeletal diseases, and deep vein thrombosis. However, all throughout the disaster response, non-communicable diseases such as hypertension and diabetes were common consults (Ochi et al. 2013).

Complex emergencies are described as disruptions to livelihood and threats to life due to war, civil disturbances, widespread migration or population displacement in which response is done under difficult political and security situations (Wisner and Adams 2002). Communicable diseases coupled with malnutrition are major contributors of mortality in conflict and complex emergencies. Response to complex emergencies are vital to avert possible outbreaks of communicable diseases such as respiratory infections, diarrhea, measles, malaria, meningitis, tuberculosis and viral hemorrhagic fevers. The lack of clean water, sanitation, food security, shelter, vaccination, and vector control exacerbate already vulnerable populations (Connolly et al. 2004).

Greenhouse gas emissions contributing to climate change have direct consequences such as extreme weather events, exposure to particulate matter, and ocean acidification which in part have health effects: disruption of health systems for extreme weather events, cardiovascular diseases and respiratory diseases for air quality issues, and under-nutrition for ocean acidification (Dorotan et al. 2018; Watts et al. 2016) (see Figure 5). According to the IPCC in 2014, the main health-related sectors affected by climate change are the following: (1) under-nutrition, (2) vector-borne diseases, (3) occupational health, (4) mental health and violence, (5) diseases related to extreme weather events, (6) air quality, (7) food- and water-borne infections, and (8) heat. Occupational conditions associated to climate change are mainly heat-related conditions, namely, heat stroke, heat exhaustion, and work capacity loss (Smith et al. 2014). Health consequences of climate change can be considered as direct, for example, when populations are affected by extreme weather events increasing the disease burden on the health system. Mediating process or indirect pathways include changes to physical systems (freshwater systems or air pollution), biological processes (mosquito numbers, agricultural production), and ecosystem structure (fish production, nutrient cycles, forest productivity), which can in turn give their corresponding health impact (McMichael and Woodruff 2008).

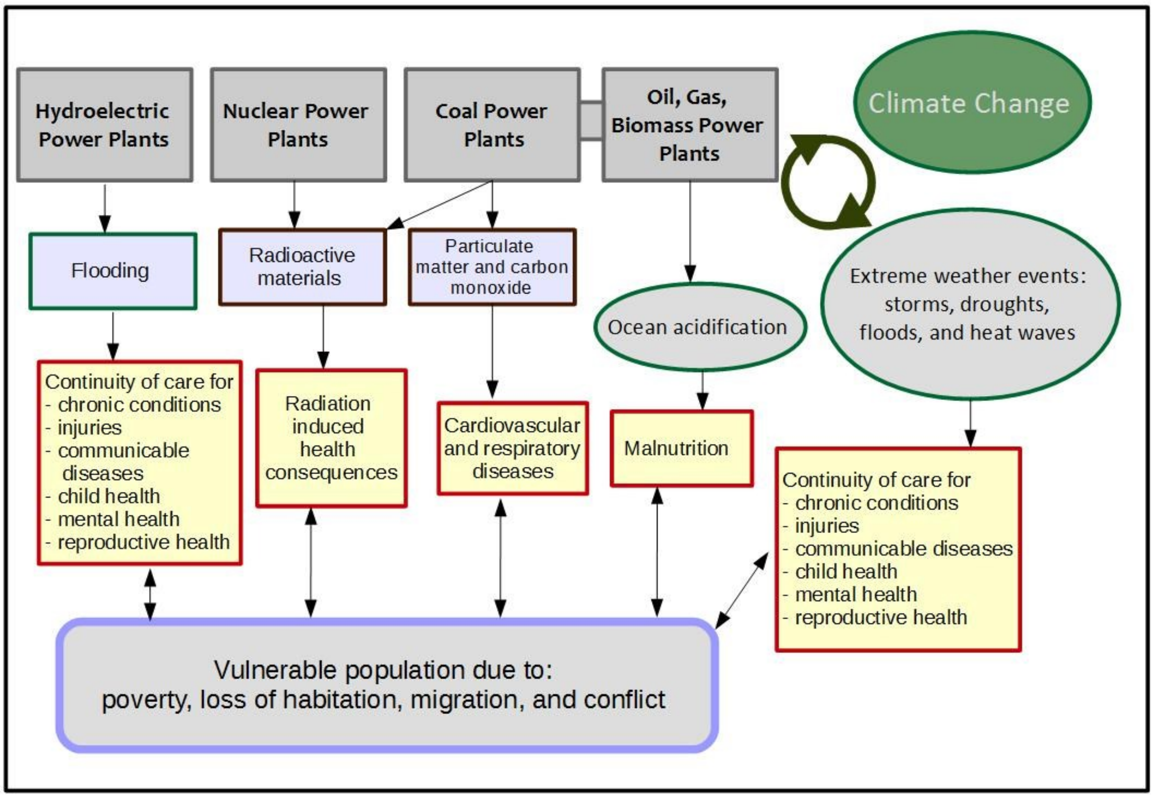

Figure 5 ***Links between greenhouse gas emissions, climate change and health*** *(Source: Dorotan et al. 2018)*

1.6 Philippine susceptibility to climate change, natural hazards, and complex emergencies

The Philippines is located in the Pacific Rim of Fire, comprised of oceanic, volcanic and continental plates forming faults and fractures all across the country thus the predisposition to earthquakes and landslides. Furthermore, approximately 20 tropical cyclones enter the Philippines every year, eight of which making landfall (Yumul et al. 2011). From the years 2000 to 2014, the Philippines had 245 disasters secondary to natural hazards recorded in the International Disaster Database or EM-DAT of CRED, the Centre for Research on the Epidemiology of Disasters (Salazar et al. 2016).

In 2013, the Department of Health was faced with four major disasters, one earthquake, a super typhoon, a flood, and a complex emergency secondary to conflict. In 2013 alone, there were eight storms, five floods, and one earthquake which were recorded in EM-DAT (Guha-Sapir et al. 2019; Salazar et al. 2016; Salazar et al. 2018). It was also in 2013 that typhoon Haiyan, made six landfalls in the Philippines and severely debilitated local health systems across the affected provinces. Typhoon Haiyan affected 16 million people across the Philippines and the storm surge killed more than six thousand. The category 5 typhoon damaged 42 hospitals, 95 community centers, and 427 village health centers (Law 2016; Salazar et al. 2017). The Bohol earthquake had 7.2 magnitude and affected 3.2 million people. The Luzon flood affected 2.5 million people across five regions in the northern Philippine island (Salazar et al. 2016). During the same year, Zamboanga City had a conflict between the Moro National Liberation Front and the Philippine government lasting 19 days affecting around 120 thousand people in the city (Salazar et al. 2018).

In 2009, the Philippines was flooded by three typhoons, namely, Ondong, Pepeng, and Santi, which increased the need for the nation, the DOH, and the HEMB to be cognizant of the consequences of disasters and the resilience needed (Health Emergency Management Bureau 2011). Resilience is defined as the “capacity to cope with or recover from the consequences of disasters” (Keim 2008). Resilience has been an important rallying point of the Philippines due to increasing severity of extreme weather events affecting the country. To support in health resilience efforts, the early warning system, SPEED, was developed due to the experiences of the Philippines in 2009 (Health Emergency Management Bureau 2011).

The Philippine National Unified Health Research Agenda (NUHRA) 2017-2022 is consistent with the country’s goal to be resilient to ever-changing needs from natural hazards, complex situations, and climate change. The NUHRA is the Philippines’ summary for health research and development. It guides researchers, funders, and end-users on the direction of the country in advancing health through the strengthening of research and translating research to better health. One of the six research themes of the NUHRA is health resiliency, which includes climate change and disaster risk reduction and health emergencies. The other topics under this theme are: accidents and injuries, emerging and re-emerging diseases, environmental threats to health, and occupational health and migration (Philippine National Health Research System 2017) (see Figure 6). Integrated risk monitoring and early warning systems are considered building blocks of health systems resilience (Sanchez et al. 2018). As early warning systems are part of climate change adaptation and H-EDRM, documenting their use in the Philippine setting and exploring possible applications of existing health information systems are key research activities to support the theme of health resilience under the NUHRA 2017-2022.

Health resiliency

To improve the ability of the country's health system to be resilient with respect to emerging global and domestic threats

Accidents and injuries | Research to provide public health solutions for road safety and injury prevention

Climate change | Research to understand, assess and intervene on the health impacts of climate change, and to design sustainable health infrastructure

Disaster risk reduction and health emergencies | Researches on assessment, management and evaluation of emergency health interventions across the disaster cycle (preparedness, response, recovery, mitigation) with emphasis on mental health and psychosocial services, food security and nutrition, risk communications, infrastructure and capacity; this area includes studies to improve health of internally displaced persons because of emergencies

Emerging and re-emerging diseases | Research on diseases which have the capacity to spread through outbreaks and pandemics, including but not limited to Zika, SARS, Malaria, MERSCoV, etc.; to include the evaluation of the effectiveness of interventions

Environmental threats to health | Research on the health impact of coal, mining, chemical pesticides and other pollutants and toxins, with the inclusion of research on interventions to address these health risks

Occupational health and migration | Research on compliance to occupational safety and standards, and interventions; health consequences surrounding documented and undocumented migrant workers and their families; and research on the health impacts of urbanization, industrialization and globalization

Figure 6 ***Health resilience theme of the NUHRA 2017-2022*** *(Source: Philippine National Health Research System 2017)*

SPEED was used in the four disasters mentioned previously: typhoon Haiyan, the Bohol earthquake, the Luzon flood, and the Zamboanga armed conflict (Salazar et al. 2016; Salazar et al. 2018). During the response to typhoon Haiyan, on record the strongest typhoon to make landfall in the western North Pacific Ocean, SPEED was the syndromic surveillance used by all actors: the government, international organizations, and foreign and local emergency medical teams (McPherson et al. 2015; Tante et al. 2015). It is only activated during disasters and allows early detection of possible outbreaks and can be used for monitoring disease trends (Salazar et al. 2016).

eHATID LGU, on the other hand, is a health information system used by health offices of municipalities or provinces thus utilized within a primary care context. eHATID uses ICD-10 (International Classification of Diseases, Tenth Revision) codes. As the consults are done in a community health center, the majority of the diagnoses were not laboratory confirmed. eHATID has electronic medical record and data analytics capabilities which make real-time decision-making possible (Salazar 2017). eHATID was deployed in 450 locations in the Philippines; 426 of these were deployed in municipalities, 23 in provinces, and one in the Bangsamoro Region of Muslim Mindanao. The key government officials involved in the implementation of the system are the local chief executive and the chief medical officer.

1.7 Aims and objectives of the study

The aim of the study is to compare the use of syndromic surveillance in the Philippines from an early warning and alert system, SPEED, and a routine health information system, eHATID, in describing the health impacts inflicted by climatological, hydrological, meteorological hazards, and complex emergencies for the enhancement of hazard preparedness and management. Furthermore, the study also aims to describe trends of diseases in different health facilities, age groups, and time periods seen in the aftermath of a disaster. The study also looks at trends in diseases seen in a routine health information system across time and the relation to weather variables as a pilot demonstration of the use of routine health information systems to monitor and analyze climate-sensitive diseases. Lastly, the study discusses the health systems and governance implications of the use of health information systems for decision-making in research areas such as H-EDRM and climate change and health.

The following objectives are formulated to achieve the above mentioned aims:

1. Describe syndrome rates for disasters affecting the Philippines in 2013 in which SPEED was activated.
2. Compare different syndromes, syndrome groups (communicable diseases, non-communicable diseases, injuries), age groups, health facility types, and time periods post-disaster.
3. Describe reporting frequency of health facilities for SPEED

4. Describe different ICD-10 diagnoses seen in 2016 by the municipal health team of San Jose de Buenavista in Antique.
5. Compare ICD-10 diagnoses and categories for different age groups and distribution across time.
6. Compare ICD-10 diagnoses across time with weather variables from the Philippines, namely, temperature and rainfall.
7. Demonstrate the potential use of analyzing existing syndromic surveillance and routine health information system databases to be used for decision-making of public health officials for topics such as H-EDRM and climate change and health.
8. Discuss governance implications for successful use of syndromic surveillance as a tool for health system strengthening for resilience in response to disasters and climate change.

2 Methods

This is a descriptive analysis of the SPEED database which was used in 2013 in four events deemed as disasters by HEMB: typhoon Haiyan, the Bohol earthquake, the Luzon flood, and the Zamboanga armed conflict. This study also describes the conditions seen in the municipality of San Jose de Buenavista in the province of Antique in the year 2016 using the eHATID LGU database. This thesis is based on four sub-studies which are documented in three publications and one technical report. The three publications describe the health trends observed in the SPEED database for 2013. The first publication is on the health trends seen in three natural hazards: Luzon flood, Bohol earthquake, and typhoon Haiyan. The findings for this publication are presented in the first sub-section of the results. The second sub-section is based on a publication specifically looking at the use of SPEED in typhoon Haiyan while the third sub-section is based on an analysis of SPEED in the armed conflict in Zamboanga. The last sub-section of the results section is based on a technical report written on the use of eHATID LGU in San Jose de Buenavista in Antique in 2016. The sub-section on eHATID used data for the whole year of 2016 compared to the technical report which only had data from January to July, 2016.

2.1 SPEED database

The Luzon flood was the first hazard considered as a disaster to affect the Philippines in 2013. It had its starting point in August. The Zamboanga armed conflict which affected Zamboanga City in Mindanao happened in September. The Bohol earthquake which affected the Visayas, or the central portion of the Philippines happened in October while typhoon Haiyan also affecting the Visayas made landfall in the Philippines in November. SPEED was activated in all four disasters by the HEMB (Salazar 2015; Salazar et al. 2018). SPEED was observed for 150 days post-disaster for the Bohol earthquake, typhoon Haiyan, and the Luzon flood (Salazar et al. 2016). As a protracted emergency, the Zamboanga armed conflict was observed 196 days post-disaster (Salazar et al. 2018).

SPEED data for the Luzon flood was composed of reports coming from three regions affected by the flood from tropical strom Trami: Central Luzon, the National Capital Region and CALABARZON. Data from the Bohol earthquake came from the provinces of Bohol and Cebu from the Central Visayas (Salazar et al. 2016). For typhoon Haiyan, SPEED data came from the Eastern Visayas Region. Data for the Zamboanga armed conflict were from Zamboanga

City the epicenter of the battle (Salazar et al. 2018). An illustration of the affected areas with SPEED reports for all four disasters are found in Figure 7.

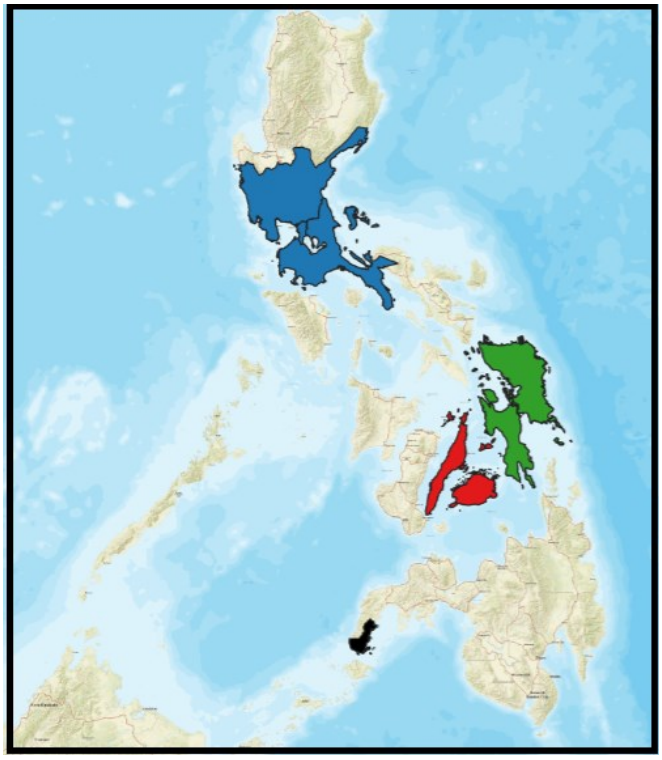

Figure 7 ***Areas with SPEED reports in 2013.*** Blue – Luzon flood, red – Bohol earthquake, green – typhoon Haiyan, black – Zamboanga armed conflict

SPEED reports are composed of consultations for particular diseases or syndromes which are set by the health managers of HEMB. The number of these consultations are recorded per day in each reporting health facility. SPEED reports include consultations regardless of attribution to the particular disaster. The SPEED syndromes, 21 in all, were grouped into three disease groups: communicable, non-communicable diseases (NCDs), and injuries. The total number of consultations per day per facility were also observed. Acute bloody diarrhea, acute flaccid paralysis, acute hemorrhagic fever, acute jaundice syndrome, acute respiratory infection (ARI), acute watery diarrhea, animal bites, conjunctivitis, fever, fever with other symptoms (FOS), skin disease, suspected leptospirosis, suspected measles, suspected meningitis, and tetanus were included in the communicable disease group. Fractures and wounds were put under injuries. The NCD group were comprised of acute asthmatic attack, acute malnutrition, high blood pressure, and known diabetes mellitus (Salazar et al. 2017; Salazar et al. 2018). Case definitions for these syndromes and diseases are seen in Table 2 (Salazar et al. 2016).

Syndromes were presented as rates per 10,000 people as the unit of population prepared for by health planners for emergency health kits (Salazar et al. 2017).

Table 2 ***Case definitions and syndrome groups for SPEED syndromes and diseases*** *(Source: Salazar et al. 2016)*

#	Syndrome	Initial Diagnosis	Syndrome Group
1	Difficulty of breathing and wheezing	Acute Asthmatic Attack	NCD
2	Loose stools with visible blood	Acute Bloody Diarrhea	Communicable
3	Floppy paralysis of the limbs which occurred recently in a child < 15 years who was previously normal	Acute Flaccid Paralysis	Communicable
4	Fever with spontaneous bleeding	Acute Hemorrhagic Fever	Communicable
5	Yellow eyes or skin with or without fever	Acute Jaundice Syndrome	Communicable
6	Visible wasting, with or without bipedal pitting edema	Acute Malnutrition	NCD
7	Cough, colds or sore throat with or without fever	Acute Respiratory Infection	Communicable
8	Loose stools, 3 or more in the past 24 hours with or without dehydration	Acute Watery Diarrhea	Communicable
9	Animal Bites	Animal Bites	Communicable
10	Eye itchiness, redness with or without discharge	Conjunctivitis	Communicable
11	Fever	Fever	Communicable
12	Fever with other symptoms not listed above	Fever with Other Symptoms not specified above	Communicable
13	Fractures	Fractures	Injury
14	High blood pressure (≥ 140/90)	High Blood Pressure	NCD
15	Known diabetes	Known Diabetes Mellitus	NCD
16	Open wounds and bruises/ burns	Open Wounds & Bruises/Burns	Injury
17	Skin Disease	Skin Disease	Communicable
18	Fever with headache, muscle pains and any of the following: eye irritation, jaundice, skin rash, scanty urination	Suspected Leptospirosis	Communicable
19	Fever with rash	Suspected Measles	Communicable
20	Fever with severe headache and stiff neck in children 12 months and older/ Fever and bulging fontanels or refusal to suckle in children <12 months	Suspected Meningitis	Communicable
21	Spasms of neck and jaw (lock jaw)	Tetanus	Communicable

For the SPEED database, there were two age groups compared (≥5 years of age and <5 years of age). These were the available age disaggregation available in the SPEED database (Salazar et al. 2017). Time periods were also examined comparing syndromes, disease groups, and total consultations for the time period within two months of the disaster and after two months. These were analyzed for the four disasters in 2013. The difference between rates of the two time periods were first discussed by Salazar in 2015 where the two-month mark demarcated response and recovery periods.

Disease rates for health facility types were calculated by dividing the number of consultations per facility by the catchment area of each facility. The catchment area was determined by the type of the facility. Community health centers service the whole municipality thus its denominator was the population of the municipality affected. This was also done for the hospitals. In the typhoon Haiyan, foreign medial hospitals which made up 0.4% of the total SPEED reports, was combined with SPEED reports for hospitals. Village health centers and evacuation centers, both serving the village population, were given village catchment populations. In typhoon Haiyan, mobile clinics and foreign medical clinics which contributed 1% and 2% of SPEED reports were merged with village health centers (Salazar et al. 2017; Salazar et al. 2018). Municipality and village populations were taken from the 2010 Philippine Census data of the Philippine Statistics Authority (Philippine Statistics Authority 2012).

Other variables available in the SPEED database were province, municipality, village, health facility code, health facility name, and date of consultation. The variable, days post-disaster, used the onset of the particular disaster as the start date. The onset of the disaster was based on the records of HEMB and reports from international organizations.

2.2 Statistical analysis for SPEED

For the analysis of the SPEED database, mean syndrome rates and mean disease group rates with 95% confidence intervals were presented and analyzed using Stata 13 (Bonita and Beaglehole 2006; Kirkwood and Sterne 2003). Splines were used to illustrate total consultations over time for the three disasters due to natural hazards. Comparisons among time periods for syndrome groups for all three natural hazards used Poisson regression. Time series for specific syndrome rates were compared for typhoon Haiyan using splines and scatter plots (Salazar et al. 2016; Salazar et al. 2017). For typhoon Haiyan and the Zamboanga armed conflict, the comparison of time periods for syndromes and health facility types used Poisson regression. The comparison between age groups were presented as mean differences with 95%

confidence intervals. Multivariable fractional polynomial with Poisson distribution was used to model consultation rates for health facilities. For the Zamboanga armed conflict, actual number of consults were described and visualized with scatter plots to look at diseases with outbreak potential (Salazar et al. 2018).

2.3 eHATID database

eHATID is an existing electronic medical record system in the Philippines deployed mainly in government health centers in local government units or LGUs. eHATID data from San Jose de Buenavista in the province of Antique for 2016 was described in this study. San Jose de Buenavista was selected due to the relatively high use of the system by the local health team. Thus this was the pilot site selected for the use of eHATID data for surveillance of conditions occurring in a specific municipality. ICD-10 codes from consultations done on a daily basis were aggregated. Since the diagnoses from consultations done in the primary health center were assumed to have no laboratory confirmation, eHATID in this context can be considered a syndromic surveillance (Salazar 2017).

2.4 Statistical analysis for eHATID

For eHATID, scatter plots were used to illustrate distribution of ICD-10 conditions across time for actual number of consultations. Daily rates were presented with 95% confidence intervals. The total number of consults per day were also presented as rates using the population of the municipality from the 2016 Philippine Census as the denominator (Philippine Statistics Authority 2017). The rates produced were presented per 10,000 population so the data could be compared to that of SPEED. Other variables available in the eHATID database were the ages of the people seeking consult. The ICD-10 categories were derived from the ICD-10 diagnoses recorded in the database.

Data from eHATID were also compared to the metereological data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) of the Department of Science and Technology (DOST). Meteorological data were requested from PAGASA and were given as analyzed and tabulated data. Temperature and rainfall values were presented as mean monthly rainfall, maximum temperature, and minimum temperature. Comparisons between the 2016 data and five-year means were also presented. PAGASA has no weather station in Antique thus meteorological information from a weather station in the adjacent province of Iloilo was used.

2.5 Data requisition

As part of the technical assistance of WHO to the DOH in 2014, I was assigned as a technical assistant for information management to the health cluster looking at the recovery efforts for typhoon Haiyan. Through this assignment I provided technical assistance for information management not only for typhoon Haiyan but all the other disasters that occurred in 2012 and 2013 in the Philippines. These included the disasters in this study. I was also assigned to assist in the management of the operations center of HEMB which handles SPEED. I requested the SPEED database from HEMB and cleaned and organized it to fit the time-series analysis requirements of this study. Data variables such as syndrome group, age group, health facility type, location, and catchment population were developed to increase the points of analysis which were not investigated by HEMB in their operational reports post-disaster.

In 2016, I was invited to be part of the Technical Advisory Reference Group (TARG) of eHATID LGU, Institute of Philippine Culture, Ateneo de Manila University. As part of the assessment of the technology adoption and utilization of the eHATID LGU system, I was commissioned to create a technical report that looked at frequency and completeness of use of eHATID and trends of diseases seen. This technical report was done as an operational research project under the eHATID LGU Project Evaluation of Short –Term Outcomes: Technology Adoption and Utilization of the eHATID LGU System funded by the Philippine Council for Health Research and Development (PCHRD). This was the basis of the eHATID portion of this study. Data variables such as age groups, ICD-10 groupings, and dates were developed, organized and cleaned for the analysis in the technical report and further refined in the analysis of this study.

Data from SPEED and eHATID were requested from their respective offices in charge. For SPEED, data was requested from the Director of the Health Emergency Management Bureau. The eHATID database for 2016 was initially requested from the eHATID LGU team of the Institute of Philippine Culture of the Ateneo de Manila University. Once a municipality was recommended by the eHATID LGU team, permission was requested from the Municipality of San Jose de Buenavista. The approval of the request for data was decided upon by the chief health officer, the Municipal Health Officer or MHO. To add to the eHATID technical report findings, the results from eHATID LGU were overlapped with meteorological data from PAGASA. Meteorological data were requested from the Climatology and Agrometeorology Division of DOST-PAGASA.

2.6 Ethics

This study describes syndrome rates and counts for ICD-10 conditions for two existing databases. Data from SPEED and eHATID were received as aggregated health facility data with no individual patient records. Since data for both databases were in aggregated format when received by the study team, patient information was kept anonymous. Both SPEED and eHATID data were handled by individuals involved in this study as confidential.

3 Results

3.1 SPEED in three disasters due to natural hazards (Salazar et al. 2016)

During the observation period of 150 days post-disaster, 4,645 SPEED reports were made for all 3 disasters combined. There were 3,425 SPEED reports for typhoon Haiyan. There were 609 and 611 respectively for the Bohol earthquake and the Luzon flood respectively. The typhoon, earthquake, and flood had the following total consultation rates respectively: 59.2 per 10,000 population (CI95: 50.6-67.8), 68.2 (CI95:46.1-90.2), and 20.7 (CI95:15.9-25.4). Figure 8 illustrates that for typhoon Haiyan, the peak of the number of daily consultations was at the 25th day post-disaster with a decrease in the number of consultations and variability after the 50th day. The Bohol earthquake had a more dispersed period of increased variability which started from the first day to the 46th day post-disaster. The flood, on the other hand, had low variability relative to the two other disasters throughout the whole observation period.

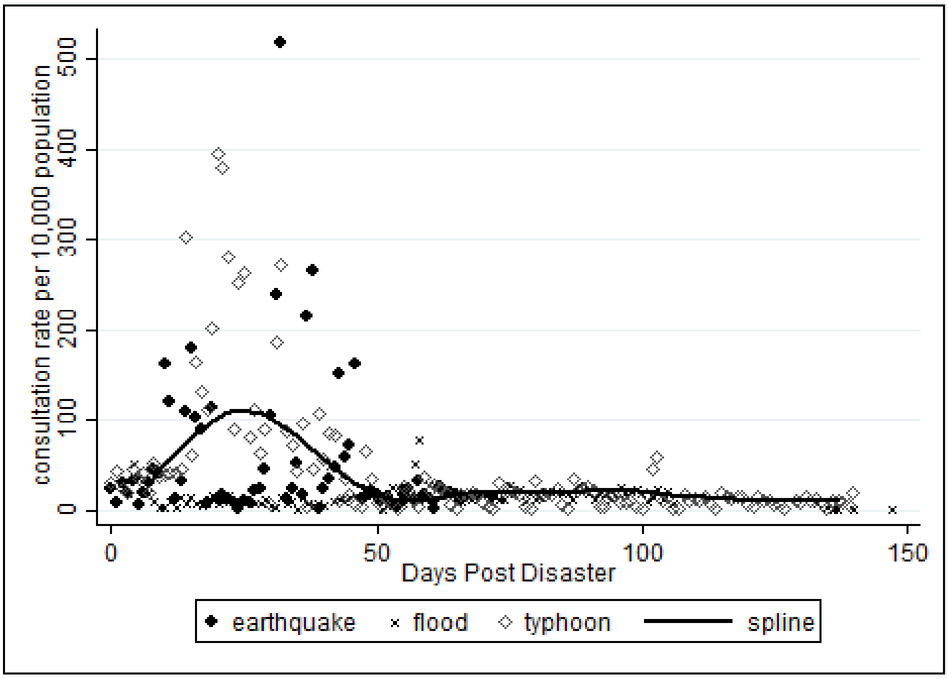

Figure 8 ***Total daily consultations rates per 10,000 population for natural hazards in 2013*** *(Source: Salazar et al. 2016)*

When rates were combined for the Luzon flood, the Bohol earthquake, and typhoon Haiyan, the top syndromes for each syndrome group were ARI (communicable diseases), wounds (injuries), and high blood pressure (NCDs). The tops six syndromes were ARIs [32.9 (CI95:

28.2-37.6)], open wounds, bruises and burns [5.2 (CI95: 4.3-6.2)], high blood pressure [4.6 (CI95: 3.8-5.3)], skin disease [4.1 (CI95: 3.4-4.8)], fever [3.0 (CI95: 2.4-3.5)], and acute watery diarrhea [2.2 (CI95: 1.9-2.5)]. When comparing before and after two months, the difference was in favor for the time period, within two months. The differences of the top six syndromes are the following: ARIs (37.4, $p<0.01$), open wounds, bruises, and burns (6.5, $p<0.01$), high blood pressure (4.8, $p<0.01$), skin disease (5.1, $p<0.01$), fever (3.9, $p<0.01$), and acute watery diarrhea (2.6, $p<0.01$).

Within two months, typhoon Haiyan had the highest consultation rates among the three disasters for all syndrome groups with the following breakdown: communicable diseases [84.5 (CI95: 69.5-99.4)], injuries [10.9 (CI95: 8.3-13.5)], and NCDs [10.3 (CI95: 8.4-12.2)]. Communicable diseases had the highest rates among the three for the first two months. The Luzon flood had more injuries than NCDs. The earthquake, on the other hand, had more NCDs than injuries. Typhoon Haiyan had similar rates for injuries and NCDs (see Table 3).

There were differences among the total consultation rates for the three disasters within two months with the following decreasing order: typhoon Haiyan (105.7), Bohol earthquake (70.6), and the Luzon flood (21.2). But after two months post-disaster, they had already similar rates among each other for the three syndrome groups. Communicable diseases had values within the range of 14.2 to 14.7 consultations per 10,000 population while injuries and NCDs had values below 2.3 per 10,000 population. For the difference between time periods, typhoon Haiyan, Bohol earthquake, and the Luzon flood had differences among time periods with p-values below 0.01 for each syndrome group (see Table 3).

Table 3 ***Consultation rates per 10,000 population with 95% confidence intervals disaggregated by syndrome group comparing ≤ 2 months and > 2 months post-disaster*** *(Source: Salazar et al. 2016)*

Disaster	Communicable diseases	Injuries	Non-communicable diseases
≤ 2 months post-disaster			
Flood (n=551)	18.8 (14.2-23.5)	1.7 (0.9-2.5)	0.7 (0.5-1.0)
Earthquake (n=582)	54.9 (36.5-73.2)	6.5 (4.3-8.6)	9.2 (5.2-13.1)
Typhoon (n=1,614)	84.5 (69.5-99.4)	10.9 (8.3-13.5)	10.3 (8.4-12.2)
> 2 months post-disaster			
Flood (n=60)	14.5 (12.4-16.7)	0.4 (0.1-0.6)	0.2 (0.1-0.2)
Earthquake (n=27)	14.7 (11.3-18.2)	1.2 (0.6-1.7)	1.5 (0.7-2.3)

Typhoon (n=1,811)	14.2 (12.5-15.8)	1.4 (1.1-1.7)	2.3 (1.9-2.6)
Difference between ≤ 2 months and >2 months post-disaster			
Flood	4.3 (p<0.01)	1.3 (p<0.01)	0.5 (p<0.01)
Earthquake	40.2 (p<0.01)	5.3 (p<0.01)	7.7 (p<0.01)
Typhoon	70.3 (p<0.01)	9.5 (p<0.01)	8.0 (p<0.01)

3.2 SPEED and its use in typhoon Haiyan (Salazar et al. 2017)

This section specifically discusses the intricacies of the conditions seen in typhoon Haiyan. The SPEED database for this disaster only covered the Eastern Visayas region of the Philippines which includes four provinces: Biliran, Eastern Samar, Leyte, and Western Samar. When looking at the whole 150-day period, communicable diseases (47.3) had the highest rate followed by NCDs (6.0) and injuries (5.9). Moreover, the representative diseases for the syndrome groups are acute respiratory infections for communicable diseases, wounds for injuries, and hypertension for NCDs as they have the highest rates for their respective groups (see Table 4).

Table 4 ***Syndrome rates per 10,000 individuals separated by time post-disaster and by age*** *(Source: Salazar et al. 2017)*

Syndrome	**total**	**≤ 2 months (n=1614)**	**> 2 months (n=1811)**	**Difference between ≤ 2 months and > 2 months (p-value)**	**< 5 years of age**	**≥ 5 years of age**	**Difference between < 5 years and ≥ 5 years (95% confidence interval)**
Communicable diseases							
Acute respiratory infection	36.0	64.0	11.1	52.9 (p<0.01)	112.4	25.6	86.9 (73.9-99.8)
Skin disease	4.5	8.2	1.2	7.0 (p<0.01)	13.8	3.2	10.5 (8.3-12.8)
Acute watery diarrhea	2.5	4.6	0.6	4.0 (p<0.01)	11.4	1.3	10.0 (8.0-12.1)
Fever	2.3	4.1	0.7	3.4 (p<0.01)	8.4	1.4	6.9 (5.4-8.5)
Fever with other symptoms	0.8	1.3	0.3	1.0 (p<0.01)	1.4	0.7	0.7 (0.0-1.5)
Animal bites	0.5	0.8	0.2	0.6 (p<0.01)	1.1	0.4	0.8 (-0.2-1.7)
Conjunctivitis	0.3	0.5	0.1	0.4 (p<0.01)	0.5	0.3	0.2 (-0.1-0.6)
Suspected leptospirosis	0.1	0.3	<0.1	0.3 (p<0.01)	0.2	0.1	0.1 (-0.2-0.3)
Acute bloody diarrhea	0.1	0.2	<0.1	0.2 (p<0.01)	0.3	0.1	0.3 (0.1-0.4)
Suspected meningitis	0.1	0.2	<0.1	0.2 (p=0.01)	0.1	0.1	<0.1 (-0.1-0.2)

Suspected measles	0.1	0.1	0.1	<0.1 (p<0.01)	0.5	<0.1	0.4 (0.0-0.9)
Acute hemorrhagic fever	<0.1	<0.1	<0.1	<0.1 (p=0.01)	0.1	<0.1	<0.1 (0.0-0.1)
Acute jaundice syndrome	<0.1	<0.1	<0.1	<0.1 (p<0.01)	<0.1	<0.1	<0.1 (0.0-0.0)
Tetanus	<0.1	<0.1	<0.1	<0.1 (p=0.13)	<0.1	<0.1	<0.1 (0.0-0.0)
Acute flaccid paralysis	<0.1	<0.1	<0.1	<0.1 (p<0.01)	<0.1	<0.1	<0.1 (0.0-0.0)
Communicable disease total	**47.3**	**84.5**	**14.2**	**70.3 (p<0.01)**	**150.2**	**33.3**	**116.9 (100.0-133.9)**
Injuries							
Open wounds & bruises/burns	5.8	10.7	1.4	9.3 (p<0.01)	6.2	5.7	0.4 (-0.2-3.0)
Fractures	0.1	0.2	<0.1	0.2 (p<0.01)	0.3	0.1	0.2 (-0.1-0.4)
Injury total	**5.9**	**10.9**	**1.4**	**9.5 (p<0.01)**	**6.4**	**5.8**	**0.6 (-0.2-3.2)**
Non-communicable diseases							
High blood pressure	4.7	8.0	1.8	6.2 (p<0.01)	0.1	5.4	5.3 (4.4-6.2)
Acute asthmatic attack	0.9	1.6	0.3	1.3 (p<0.01)	2	0.8	1.2 (0.8-1.7)
Known diabetes mellitus	0.4	0.7	0.1	0.6 (p<0.01)	<0.1	0.4	0.4 (0.3-0.5)
Acute malnutrition	<0.1	0.1	<0.1	0.1 (p<0.01)	0.2	<0.1	0.2 (-0.1-0.4)
NCD total	**6.0**	**10.3**	**2.3**	**8.1 (p<0.01)**	**2.2**	**6.6**	**4.3 (3.3-5.3)**

The consultation rates across time were visualized with a splines and scatter plots for the representative diseases for each syndrome group in Figure 9. There were peaks in consultations around the 20th to 25th day post-disaster for all three diseases: ARI, wounds, and hypertension. The rates decreased and so did the variability after the 50th day. The peak of consultations was more prominent for the communicable disease, ARI, than the other two syndromes.

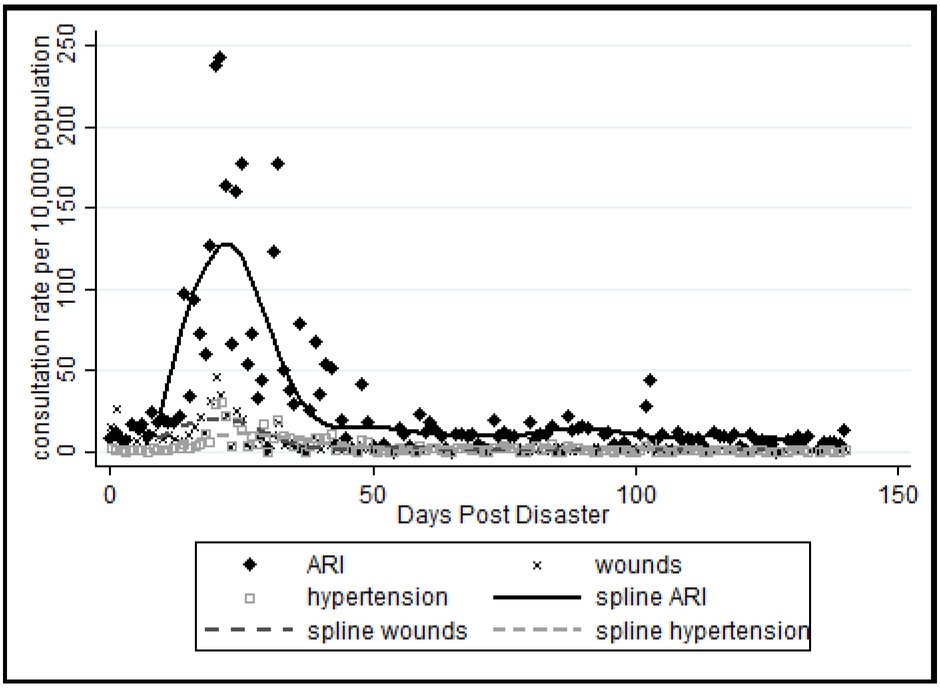

Figure 9 ***Consultation rates per 10,000 individuals for acute respiratory infections, wounds, and hypertension*** *(Source: Salazar et al. 2017)*

There was a similar number of reports for response (≤ 2 months) and recovery (>2 months) periods. Within two months there were 1,614 reports while after two months there were 1,811 SPEED reports. The representative syndromes for each syndrome group had the following decreasing rates: ARI with 64.0 per 10,000 population, wounds with 10.7 per 10,000 population, and hypertension with 8.0 per 10,000 population. After two months post-disaster, there was a significant decrease in the rates for the said syndromes with ARI with 11.1, wounds with 1.4, and hypertension with 1.8 (see Table 4).

When looking at the whole 150-day period, the top six syndromes with decreasing order are the following: ARI (36.0), wounds (5.8), hypertension (4.7), skin disease (4.5), acute watery diarrhea (2.5), and fever (2.3). These were all of the syndromes with values above one. However, within two months, there were eight syndromes with rates above one per 10,000 population. The two additional syndromes were acute asthmatic attack and FOS. But after two months, only four syndromes had rates above one consultation per 10,000 population: ARI, wounds, hypertension, and skin disease (see Table 4).

There were consistently higher rates for all syndromes for the time period, within 2 months. There was only one syndrome which had a p-value greater than 0.05, tetanus. ARI, wounds, hypertension, skin disease, watery diarrhea, fever, asthma, and FOS were the eight syndromes which had rate differences greater than one per 10,000 population and p-values less than 0.01 (see Table 4).

The syndromes with rates greater than one per 10,000 population for children less than five years of age were ARI, skin disease, watery diarrhea, fever, wounds, asthma, FOS, and animal bites. The most common syndromes in adults with rates greater than one were ARI, wounds, hypertension, skin disease, acute watery diarrhea, and fever. For communicable diseases, only four syndromes had differences among age groups greater than one, all favoring those less than five years old: ARI, skin disease, acute watery diarrhea, and fever. For injuries, wounds had rates greater than one for children less than five (6.2) and those five and older (5.7) thus the difference among age groups had a 95% confidence interval crossing zero. In the NCD group, hypertension and diabetes were more common in those five and older while asthma was more common in children (see Table 4).

Most SPEED reports came from community health centers (54%) and hospitals (30%). Village health centers had the highest rates among the health facility types but also had the highest variability. For all health facility types the difference between response and recovery time periods had p-values below 0.01. Hospitals and community health centers had the narrowest confidence intervals among the four health facilities (see Table 5).

Table 5 ***Total consultation rates per 10,000 population for health facility types and time periods for typhoon Haiyan***

Health Facility Type	Mean number of consultations per day (95% confidence intervals) (n)	≤2 months (response) (n)	>2 months (recovery) (n)	Difference between ≤2 months and >2 months (p-value)
Community health center	25.0 (20.3-29.7) (n=1850)	38.2 (n=776)	15.4 (n=1074)	22.8 (<0.01)
Evacuation Center	19.5 (0-43.9) (n=39)	19.5 (n=39)	0.0 (n=0)	19.5 (<0.01)
Hospital	7.0 (6.5-7.6) (n=1039)	8.6 (n=417)	5.9 (n=622)	2.7 (<0.01)
Village health center	299 (247.1-350.9) (n=497)	357.5 (n=382)	104.7 (n=115)	252.8 (<0.01)
Regardless of health facility type	59.2 (50.6-67.8) (n=3425)	105.7 (n=1614)	17.8 (n=1811)	87.9 (<0.01)

Modeled rates using multivariable fractional polynomial regressions showed exponential decreasing rates for community health centers with a less distinct decrease for the hospitals.

Community health centers maintained higher rates for the recovery period compared to the three other health facility types. For village health centers and evacuation centers there were increases around the 20th day post-disaster with a decreased rate thereafter. The rates maintained by the community health centers were seen in the backdrop of having the most SPEED reports and the narrowest 95% confidence intervals (see Figure 10).

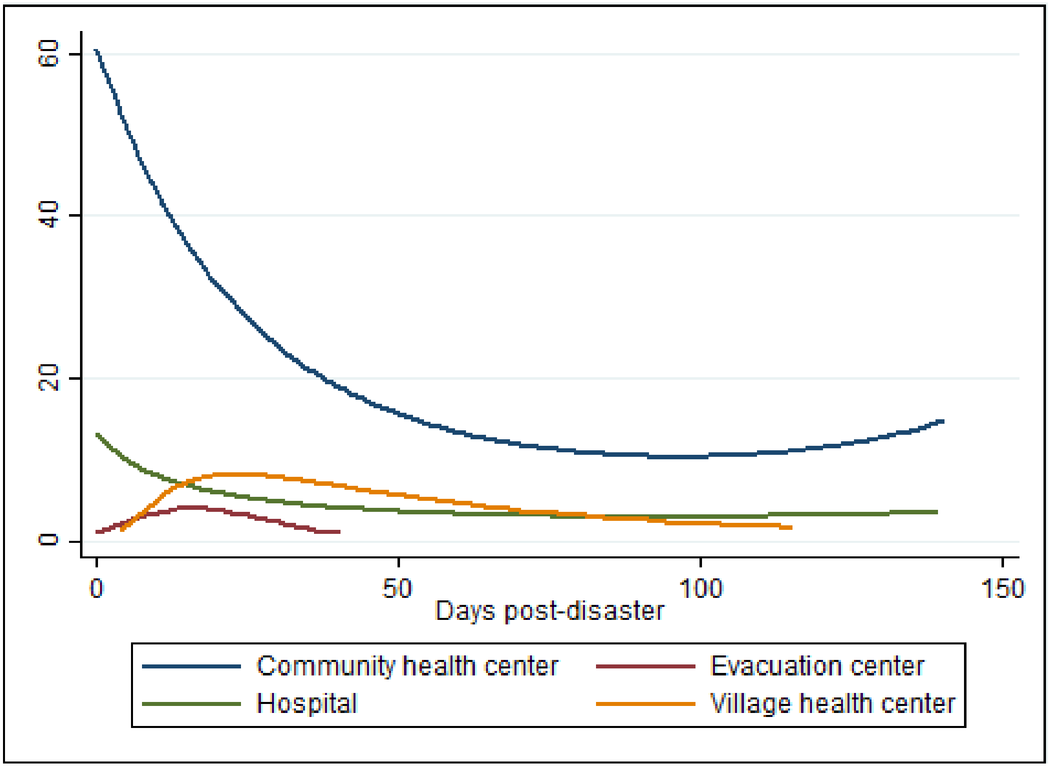

Figure 10 ***Multivariable factorial polynomial regressions for daily total consultations per 10,000 population across time for different health facility types for typhoon Haiyan.***

3.3 SPEED and its use in the Zamboanga armed conflict (Salazar et al. 2018)

During the Zamboanga armed conflict there were 1,065 SPEED reports which spanned 196 days post-disaster. The first SPEED report was recorded on day two of the complex emergency. There was a steady decrease in the number of reports starting the first day of reporting but the decline stabilized around the 60th to 80th day post-disaster (Figure 11).

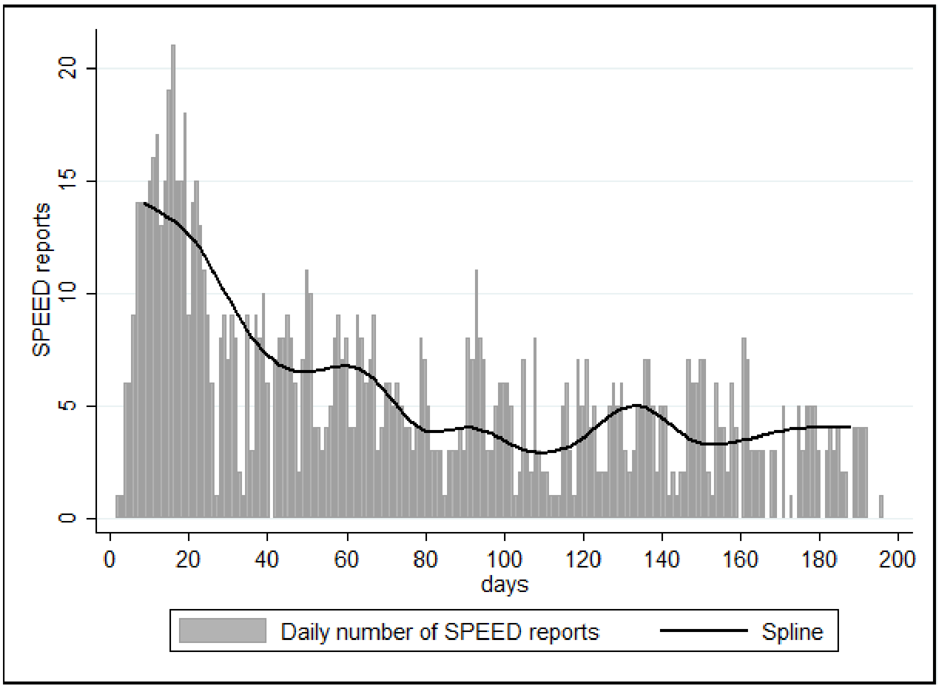

Figure 11 ***Bar graph of daily number of SPEED reports with spline for the Zamboanga armed conflict.*** *(Source: Salazar et al. 2018)*

There were 49 health facilities sending SPEED reports to the HEMB. Of these, 21 were evacuation centers, 15 were village health centers, nine were hospitals, and only four were community health centers. All of these were located within Zamboanga City. The number of SPEED reports for each health facility type followed the number of reporting facilities with evacuation centers with 448, village health centers with 297, hospitals with 266, and community health centers with 54. The daily total rates of consultations for health facility types had similar results as SPEED reports and reporting facilities. They had the following decreasing order: evacuation centers (32.3 per 10,000 population), village health centers (28.5 per 10,000 population), hospitals (0.3 per 10,000 population), and community health centers (0.2 per 10,000 population). Total consultation rates per time period per health facility showed consistently higher rates for response then recovery (see Table 6).

Table 6 ***Total consultation rates per 10,000 population for health facility types and time periods for the Zamboanga armed conflict.*** *(Source: Salazar et al. 2018)*

Health facility type	Mean number of consultations per day (95% confidence intervals) (n)	≤ 2 months (n) [response]	> 2 months (n) [recovery]	Difference between ≤ 2 months and > 2 months (p-value)
Evacuation center	32.3 (27.9-36.7) (n=448)	34.3 (n=373)	22.4 (n=75)	11.93 (<0.01)
Village health center	28.5 (24.5-32.5) (n=297)	65.5 (n=70)	17.1 (n=227)	48.4 (<0.01)
Hospital	0.3 (0.2-0.3) (n=266)	0.5 (n=68)	0.2 (n=198)	0.3 (<0.01)
Community health center	0.2 (0.1-0.2) (n=54)	0.4 (n=13)	0.1 (n=41)	0.3 (0.03)
Regardless of facility type	21.6 (19.3-23.9) (n=1065)	33.2 (n=524)	10.3 (n=541)	22.9 (<0.01)

There were similar number of SPEED reports for response (524) and recovery (541) periods. Comparing health facility types, evacuation centers had more SPEED reports for the response period. On the other hand, village health centers, hospitals, and community health centers had more SPEED reports for the recovery period. With all health facility types combined, total consultation rates for response were higher than the recovery period. Among the four, village health centers had the highest difference in total rates between time periods where each health facility type had more consultations during the response period than recovery (see Table 6).

When total consultation rates were modeled for health facility types, village health centers had the highest rates initially from first day of observation then had an exponential decrease from response to recovery periods. Evacuation center daily rates increased from day two post-disaster until the tenth day then had decreased rates thereafter. For hospitals and community health centers, there were consistently low rates (see Figure 12).

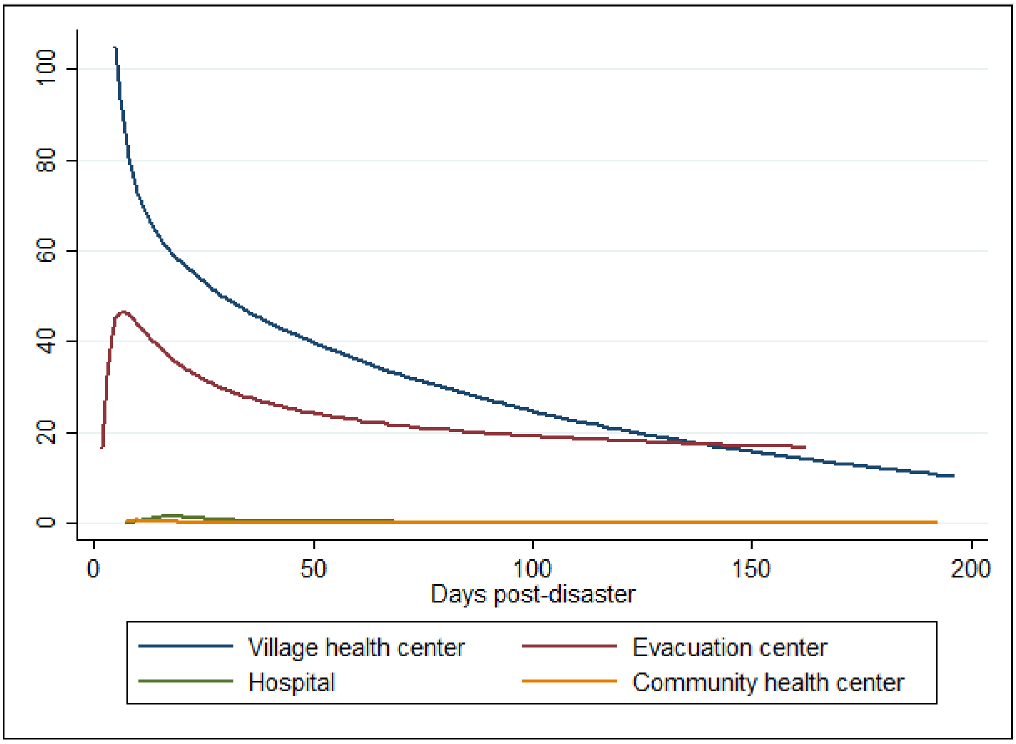

Figure 12 ***Multivariable factorial polynomial regressions for daily total consultations per 10,000 population across time for different health facility types for the Zamboanga armed conflict.*** *(Source: Salazar et al. 2018)*

For syndrome rates, the most common communicable diseases were ARI (11.3 per 10,000 population), fever (3.5), acute watery diarrhea (2.3) and skin disease (1.7). Hypertension was the only syndrome not part of the communicable disease group which had a rate greater than one per 10,000 population (see Table 7). Looking at injuries, wounds and fractures both had syndrome rates below one per 10,000 population; however, when comparing absolute values, there were more consultations for wounds (1,982) than fractures (154).

For syndrome rate for response and recovery periods, most syndromes had higher rates for the response period. Among the 21 syndromes, there were 13 with p-values less than 0.05 split between higher rates in response and higher rates in recovery. When looking at communicable diseases alone, ARI, fever, acute watery diarrhea, skin disease, acute bloody diarrhea, and animal bites had higher rates for response. However, FOS, conjunctivitis, and suspected measles had higher syndrome rates for recovery. The remaining syndromes from the above mentioned 13, namely, wounds (injury), hypertension (NCD), asthma (NCD), and diabetes (NCD), had higher syndrome rates in the response period (selected syndromes are seen in Table 7). There were no consultations for acute flaccid paralysis for the whole 196 days of observation.

Table 7 ***Top syndrome rates per 10,000 population comparing time period and age for the Zamboanga armed conflict.*** *(Source: Salazar et al. 2018)*

Syndrome	Total n=1065	≤ 2 months n=524 [response]	> 2 months n=541 [recovery]	Difference between ≤ 2 months and > 2 months (p-value)	< 5 years of age	≥ 5 years of age	Difference between < 5 years and ≥ 5 years (95% confidence interval)
Communicable diseases							
Acute respiratory infection (ARI)	11.3	18.0	4.8	13.2 (<0.01)	41.8	7.2	34.7 (30.7 – 38.6)
Fever	3.5	4.9	2.2	2.7 (<0.01)	14.0	2.1	11.8 (10.1 – 13.6)
Acute watery diarrhea	2.3	3.8	0.9	2.9 (<0.01)	8.5	1.5	7.0 (5.9-8.1)
Skin disease	1.7	2.4	1	1.4 (<0.01)	5.7	1.2	4.5 (3.7 – 5.3)
Fever with other symptoms (FOS)	0.3	<0.1	0.1	0.5 (<0.01)	0.3	0.3	<0.1 (-0.1 – 0.2)
Communicable disease total	**19.4**	**29.9**	**9.3**	**20.6 (<0.01)**	**71.1**	**12.5**	**58.6 (52.0 – 65.2)**
Injuries							
Open wounds & bruises/burns	0.7	0.9	0.4	0.4 (<0.01)	0.9	0.6	0.3 (0.1 – 0.5)
Injury total	**0.7**	**0.9**	**0.4**	**0.4 (<0.01)**	**0.9**	**0.6**	**0.3 (0.1 – 0.5)**
Non-communicable diseases							
High blood pressure	1.0	1.8	0.3	1.4 (<0.01)	<0.1	1.2	1.2 (1.0 – 1.4)
Acute asthmatic attack	0.4	0.6	0.2	0.4 (<0.01)	1.1	0.3	0.8 (0.6 – 1.0)
NCD total	**1.5**	**2.4**	**0.6**	**1.8 (<0.01)**	**1.4**	**1.5**	**0.1 (-0.3 – 0.5)**

Looking at age groups, all of the communicable diseases except for FOS, tetanus, and suspected meningitis had higher rates for those under five years of age. Hypertension (NCD), diabetes (NCD), and fractures (injury) were the other syndromes with higher rates for those five years and older. Furthermore, FOS, tetanus, and suspected meningitis had 95% confidence intervals crossing zero.

Diseases of epidemic potential that are being monitored by the DOH have either been classified as immediately or weekly notifiable (Department of Health Philippines 2008). From the SPEED syndromes, acute flaccid paralysis, tetanus, animal bites (which can be a proxy for rabies), and suspected measles are immediately notifiable diseases. Weekly notifiable diseases in SPEED are acute bloody diarrhea, suspected meningitis, acute watery diarrhea (which can be a proxy for cholera), suspected leptospirosis, and FOS (which may indicate typhoid or malaria) (Department of Health Philippines 2008; Health Emergency Management Bureau

2013). For the 196 days of observation, the following are notifiable syndromes with increasing order: acute flaccid paralysis (0), suspected meningitis (4), tetanus (12), suspected leptospirosis (31), acute bloody diarrhea (60), suspected measles (60), animal bites (235), FOS (794), and acute watery diarrhea (4781).

Figure 13 illustrates the most common immediate and weekly notifiable diseases showing differing characteristics. The weekly notifiable diseases, acute watery diarrhea and FOS, had higher absolute number of cases per day than the immediately notifiable diseases, animal bites and suspected measles. Suspected measles had consistently low rates and low variability while animal bites had a peak in the 50th day post-disaster. Acute watery diarrhea and FOS both had peaks during disaster response around the 20th day post-disaster.

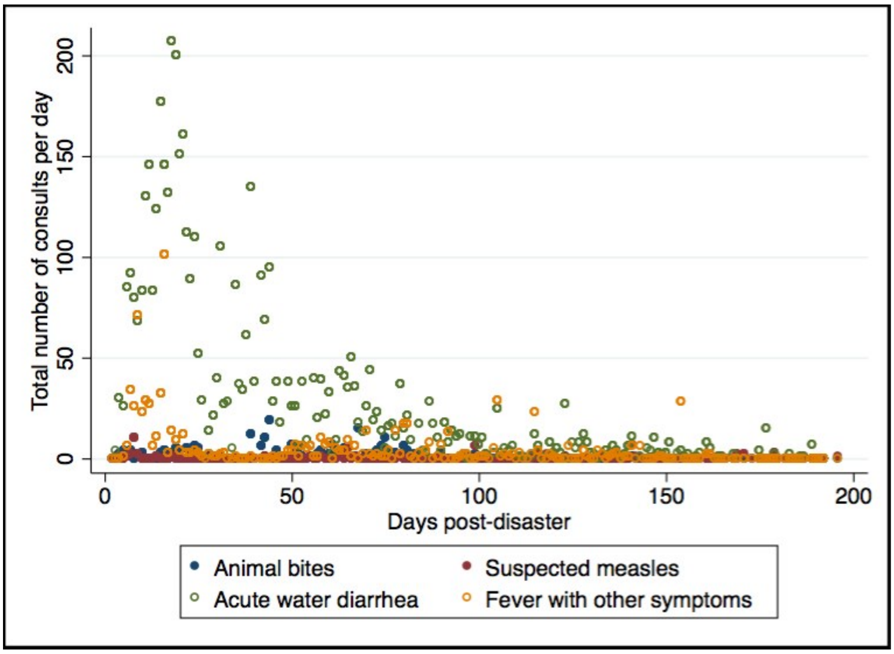

Figure 13 ***Total daily consultations of the most common immediately notifiable syndromes (animal bites and suspected measles) and the most common weekly notifiable syndromes (acute watery diarrhea and FOS) across days post-disaster.*** *(Source: Salazar et al. 2018)*

3.4 eHATID and its use for decision-making in San Jose de Buenavista, Antique (Salazar 2017)

There was a total of 3,376 consultations in the community health center in San Jose de Buenavista where eHATID was used to electronically document patient interactions. Since the DOH health information system, Integrated Clinic Information System, otherwise known as iClinicSys was specifically made for the use of government community health centers and village health centers (Department of Health and Department of Science and Technology Philippines 2013), this was the preferred system used by the municipality for PhilHealth members. The municipal health officer decided to use the eHATID system only for non-PhilHealth members so as not to have double reporting in terms of the census of the patients. In total eHATID was used 101 days within the year 2016. For six months within the year, the system was used more than 10 days per month with the month of April having the most days with 18. The other months were January, March, May, June, and December. For the months of February, July, August and November the range of days used were between two and five working days. For the months of September and October there were no days in which the system was used (see Figure 14).

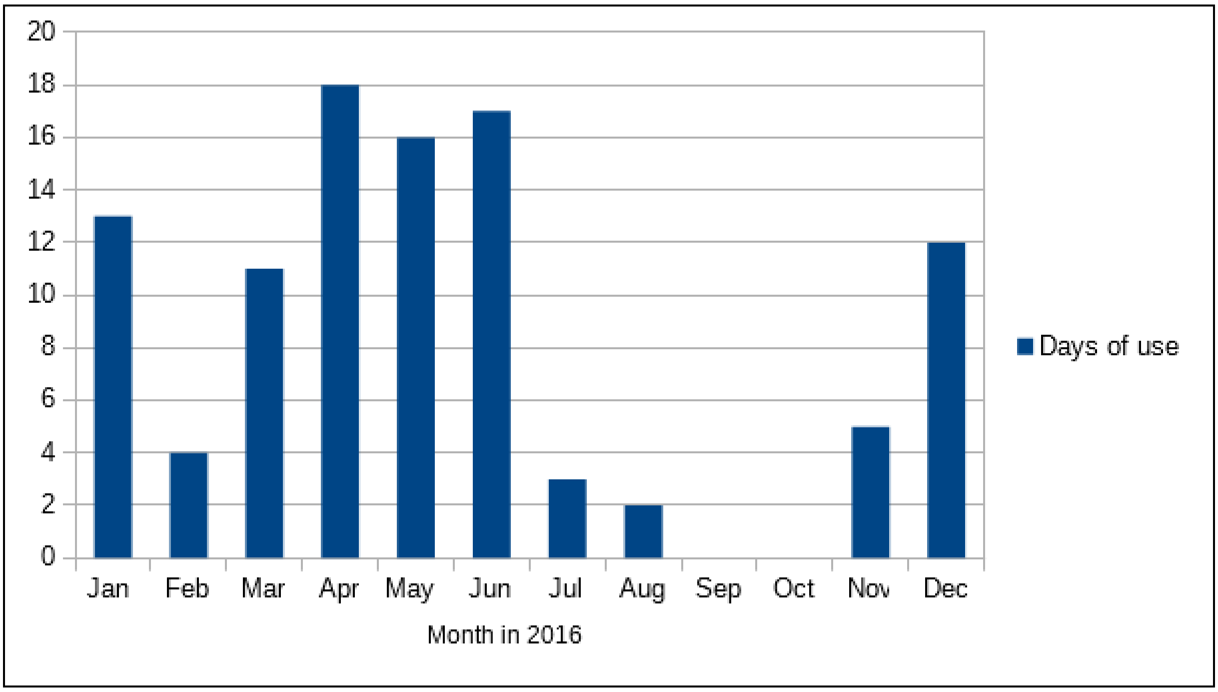

Figure 14 ***Number of days in a month in which eHATID was used.***

Different age groups within the population accessed health services in the community health center with varying frequency. The most number of consults came from the 60- to 70-year-olds, followed by the 50- to 60-year-old then the 20- to 30-year-old groups. However, when adjusted to the population of these age groups within that of San Jose de Buenavista, those over 80 had the highest rates followed by 70 to 80 and 60 to 70 age groups. When compared to the under-five age group, collectively those over five had a lower total rate of consultation per day. When taking into account all those consulting the San Jose de Buenavista community health center regardless of age group, the rates are similar to those over five years (see Table 8).

Table 8 ***Total consultations during 2016 using eHATID with daily total consultation rates per 10,000 population with 95% confidence intervals disaggregated by age groups.***

Age group	**Total consultations**	**Total rate (95% confidence interval)**
<5	395	8.4 (7.9-9.0)
≥5 & <10	256	9.0 (7.3-8.7)
≥10 & <15	149	5.5 (4.9-6.1)
≥15 & <20	182	9.4 (8.3-10.5)
≥20 & <30	437	6.5 (6.2-6.9)
≥30 & <40	241	5.4 (4.9-5.8)
≥40 & <50	374	9.3 (8.6-10.0)
≥50 & <60	448	14.5 (13.6-15.4)
≥60 & <70	534	28.6 (27.0-30.1)
≥70 & <80	281	42.0 (39.1-44.9)
≥80	79	82.0 (64.0-100.1)
Over 5	2981	7.3 (7.2-7.5)
Regardless of age	3376	7.3 (7.2-7.4)

The age groups studied had different profiles in terms of their most common ICD-10 diagnoses. Those under five years old had predominantly respiratory conditions encompassing both infectious and non-infectious. For those in the groups ranging from the age of five to 20 years old, respiratory diseases were now mixed with urinary tract infections, pulpitis (otherwise known as toothaches), and other viral infections. The age group 20 to 30 years showed the presence of tuberculosis and the sexually transmitted disease, gonococcal cervicitis. Tuberculosis was also in the top five ICD-10 diagnoses of the 40 to 50, 50 to 60, 70 to 80, and over 80 age groups. From age 30 onward, essential primary hypertension was more common. And from age of 40 onward, there were more consults for diabetes without complications. Acute upper respiratory infections were in the top five in all age groups except those 40 to 50 and 50 to 60 while pneumonia was present in all age groups except the 20 to 30 and over 80 age groups. Hip osteoarthritis was only in the top five of the over 80 age group (see Table 9).

Table 9 ***Most common ICD-10 diagnoses per age group with total consultations for 2016.***

ICD-10	Description	Consultations	ICD-10	Description	Consultations
<5			Over 5		
J18.9	Pneumonia, unspecified organism	122	I10	Essential (primary) hypertension	510
J06.9	Acute upper respiratory infection, unspecified	81	N39.0	Urinary tract infection, site not specified	323
J30.9	Allergic rhinitis, unspecified	22	J06.9	Acute upper respiratory infection, unspecified	241
J40	Bronchitis, not specified as acute or chronic	12	E11.9	Type 2 diabetes mellitus without complications	215
J47.1	Bronchiectasis with (acute) exacerbation	12	J18.9	Pneumonia, unspecified organism	177
≥5 & <10			≥40 & <50		
J06.9	Acute upper respiratory infection, unspecified	38	I10	Essential (primary) hypertension	94
J40	Bronchitis, not specified as acute or chronic	23	E11.9	Type 2 diabetes mellitus without complications	42
N39.0	Urinary tract infection, site not specified	18	N39.0	Urinary tract infection, site not specified	37
J18.9	Pneumonia, unspecified organism	17	J18.9	Pneumonia, unspecified organism	30
J30.9	Allergic rhinitis, unspecified	17	A15.0	Tuberculosis of lung	23
≥10 & <15			≥50 & <60		
J06.9	Acute upper respiratory infection, unspecified	40	I10	Essential (primary) hypertension	115
J40	Bronchitis, not specified as acute or chronic	15	E11.9	Type 2 diabetes mellitus without complications	61
J18.9	Pneumonia, unspecified organism	11	N39.0	Urinary tract infection, site not specified	45
K04.0	Pulpitis	9	A15.0	Tuberculosis of lung	38
B34.9	Viral infection, unspecified	7	J18.9	Pneumonia, unspecified organism	30
J30.9	Allergic rhinitis, unspecified	7			
≥15 & <20			≥60 & <70		
N39.0	Urinary tract infection, site not specified	23	I10	Essential (primary) hypertension	161
J18.9	Pneumonia, unspecified organism	12	E11.9	Type 2 diabetes mellitus without complications	66
J40	Bronchitis, not specified as acute or chronic	11	N39.0	Urinary tract infection, site not specified	50

K04.0	Pulpitis	11	J18.9	Pneumonia, unspecified organism	33
J06.9	Acute upper respiratory infection, unspecified	9	J06.9	Acute upper respiratory infection, unspecified	32
≥20 & <30			≥70 & <80		
N39.0	Urinary tract infection, site not specified	93	I10	Essential (primary) hypertension	83
J06.9	Acute upper respiratory infection, unspecified	25	E11.9	Type 2 diabetes mellitus without complications	24
A54.03	Gonococcal cervicitis, unspecified	24	A15.0	Tuberculosis of lung	19
A15.0	Tuberculosis of lung	22	J06.9	Acute upper respiratory infection, unspecified	18
J40	Bronchitis, not specified as acute or chronic	19	J18.9	Pneumonia, unspecified organism	16
≥30 & <40			≥80		
N39.0	Urinary tract infection, site not specified	35	I10	Essential (primary) hypertension	21
I10	Essential (primary) hypertension	23	M16.9	Osteoarthritis of hip	14
J06.9	Acute upper respiratory infection, unspecified	17	J06.9	Acute upper respiratory infection, unspecified	12
J18.9	Pneumonia, unspecified organism	12	N39.0	Urinary tract infection, site not specified	8
J40	Bronchitis, not specified as acute or chronic	10	E11.9	Type 2 diabetes mellitus without complications	5

The top consultations for eHATID regardless of age group had rates per 10,000 population below one. The three diseases with the highest rates are essential hypertension (0.8 per 10,000 population), urinary tract infection (0.5 per 10,000 population), and acute upper respiratory infection (0.5 per 10,000 population). Four out of the ten, were under the diseases of the respiratory system category (J00-J99): acute upper respiratory infection, pneumonia, non-specific bronchitis, and allergic rhinitis. There are two other respiratory-related diseases but not in the J00-J99 category: tuberculosis and cough. Diseases of the respiratory system had the highest rates among the different categories (see Table 10).

Table 10 ***Daily consultation rates per 10,000 population for 2016 for the top ICD-10 diagnoses and respective categories for eHATID in San Jose de Buenavista.***

Rank	ICD-10	ICD-10 description	Total Rate (95% Confidence Interval)	ICD-10 category	Category total rate (95% confidence interval)
1	I10	Essential (primary) hypertension	0.8 (0.7-0.9)	Diseases of the circulatory System	0.9 (0.7-1.0)
2	N39.0	Urinary tract infection, site not specified	0.5 (0.4-0.6)	Diseases of the genitourinary system	0.6 (0.4-0.7)
3	J06.9	Acute upper respiratory infection, unspecified	0.5 (0.4-0.6)	Diseases of the respiratory system	1.7 (1.5-1.9)
4	J18.9	Pneumonia, unspecified organism	0.5 (0.4-0.5)	Diseases of the respiratory system	1.7 (1.5-1.9)
5	E11.9	Type 2 diabetes mellitus without complications	0.3 (0.3-0.4)	Endocrine, nutritional and metabolic diseases	0.4 (0.3-0.5)
6	A15.0	Tuberculosis of lung	0.3 (0.2-0.3)	Certain infectious and parasitic diseases	0.3 (0.3-0.4)
7	J40	Bronchitis, not specified as acute or chronic	0.3 (0.2-0.3)	Diseases of the respiratory system	1.7 (1.5-1.9)
8	J30.9	Allergic rhinitis, unspecified	0.1 (0.1-0.2)	Diseases of the respiratory system	1.7 (1.5-1.9)
9	R05	Cough	0.1 (0.1-0.1)	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	0.2 (0.1-0.2)
10	M16.9	Osteoarthritis of hip, unspecified	0.1 (0.1-0.1)	Diseases of the musculoskeletal system and connective tissue	0.2 (0.1-0.2)

Prior to the months of September and October when the system was not used, the daily total consultation rates varied. Between the months of January to June, majority of daily total rates were in the range of four and eight consultations per 10,000 population. The peak in the number of consultations was in the month of April which also has the most days in which eHATID was used. There were also a low number of consultations in February, July, August, and November which coincides with the months were eHATID was used five days or less. The number of the consultation increased again in December but these were still low compared to the months from March to June (see Figure 15).

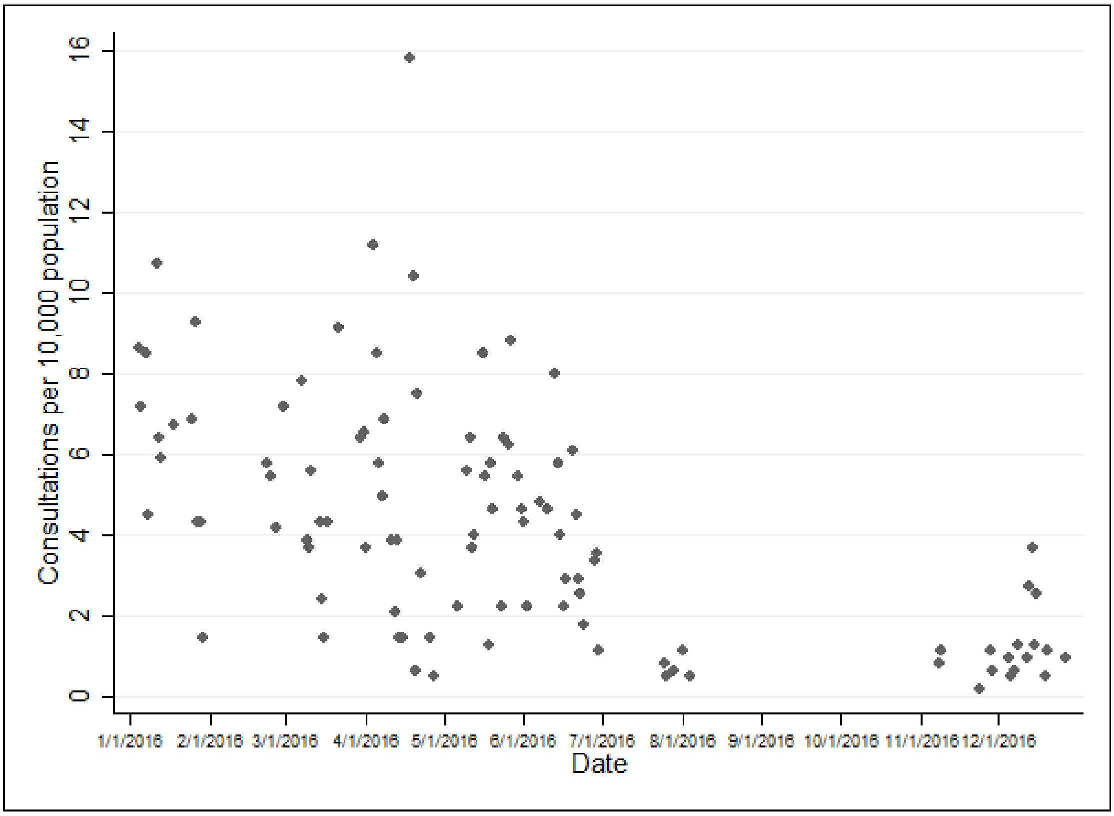

Figure 15 ***eHATID total daily consultations per 10,000 population in 2016.***

When comparing the most common ICD-10 diagnoses across time, essential hypertension had two peaks between the months of January and August. The peaks were in the months of January and April. Within the months of January and August, the consultations for essential hypertension were variable. Urinary tract infections, on the other hand, had a single peak in April surrounded by the highest number of consults within the months of April to June. Acute upper respiratory infections had a decreasing trend across time with highest number of consultations occurring in January. Acute upper respiratory infection and essential hypertension both did not exceed the three consultations per 10,000 population mark while urinary tract infection surpassed this level only once during its peak (see Figure 16).

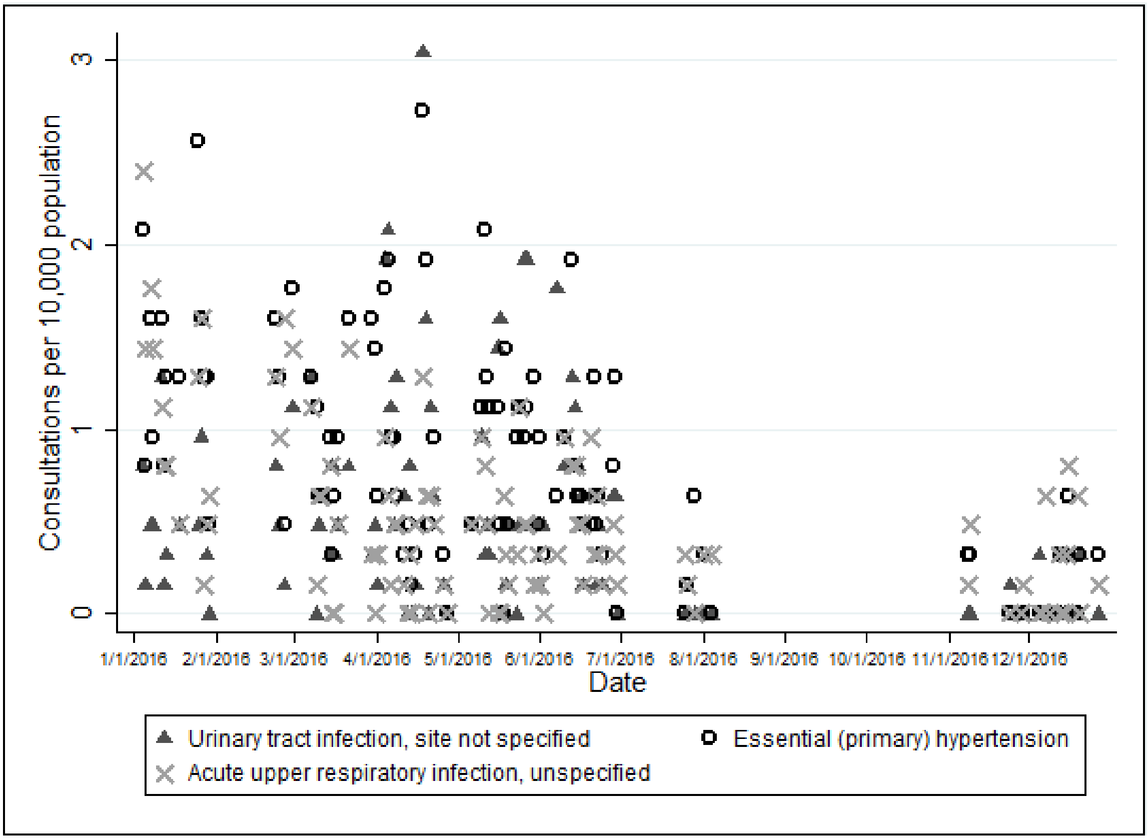

Figure 16 ***Daily consultations rates per 10,000 population for the top three ICD-10 diagnoses for eHATID in 2016.***

Upon comparing ICD-10 categories, both diseases of the respiratory system and diseases of the genitourinary system had peaks in the month of April with differing rates. The diseases of the respiratory system had higher rates among the three categories. Compared to the individual rates from acute upper respiratory infection where the highest point was below three consultations per 10,000 population, the respiratory disease category had a peak just above five consultations per 10,000 population. The other ICD-10 diseases in the respiratory disease category contributed to its higher distribution of daily consultation rates. The diseases of the circulatory system and diseases of the genitourinary system had similar distribution of daily consultation rates to essential hypertension and urinary tract infections respectively (see Figure 17).

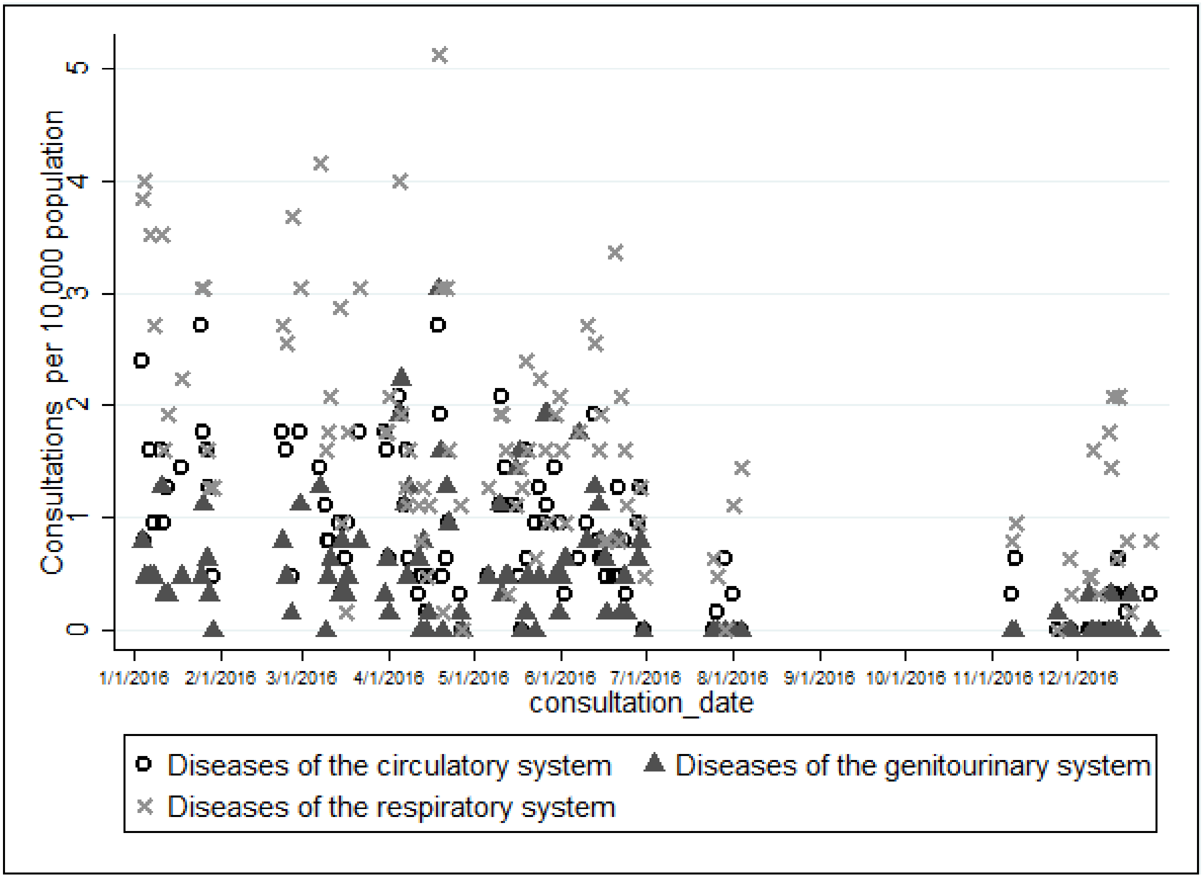

Figure 17 ***Daily consultations rates per 10,000 population for the top three ICD-10 categories for eHATID in 2016.***

The available weather variables from PAGASA were from the Dumangas weather station in Iloilo, an adjacent province to Antique. The hottest months from 2016 were May and July with April coming in third. The highest amount of rainfall occurred in August and September. The lowest maximum temperature was seen in the months of November and December with 30.3 and 30.5 degree Celsius respectively. The lowest minimum temperature readings were seen in the months of January and February with 23.1 and 23.2 respectively. The months from January to July where both hotter in terms of the monthly maximum temperature and colder for monthly minimum temperature compared to the five-year mean. Rainfall for the months of January, March, April, June, July, and October where lower compared to the five-year mean (See Table 11 and Figure 18).

Table 11 ***Temperature and rainfall monthly averages for 2016 with anomaly values relative to 5-year median.***

Month	**Absolute Values**			**Anomaly Values (Taken relative to the 5-year mean)**		
	Tmax (Deg C)	**Tmin (Deg C)**	**Rainfall (mm)**	**Tmax (Deg C)**	**Tmin (Deg C)**	**Rainfall (mm)**
Jan	32.3	23.1	14.6	2.8	-0.5	-87.6
Feb	32.2	23.2	64.6	2.3	-0.1	14.4
Mar	33.8	23.5	2.2	2.5	-0.3	-57.8
Apr	35.2	25.1	0	2.6	-0.1	-32.1
May	35.5	25.4	155.6	1.7	-0.4	57.4
Jun	34.5	24.6	120.8	1.6	-0.6	-71.9
Jul	35.5	24.3	134.8	3.7	-0.6	-133.8
Aug	33	26.3	336.2	1.3	1.1	53.1
Sep	33.2	26.1	418.8	1.7	1.1	135.2
Oct	31.4	26.3	214.3	-0.4	1.1	-6.9
Nov	30.3	25.8	244.2	-1.1	0.2	87.5
Dec	30.5	25.6	182	0.2	0.6	23

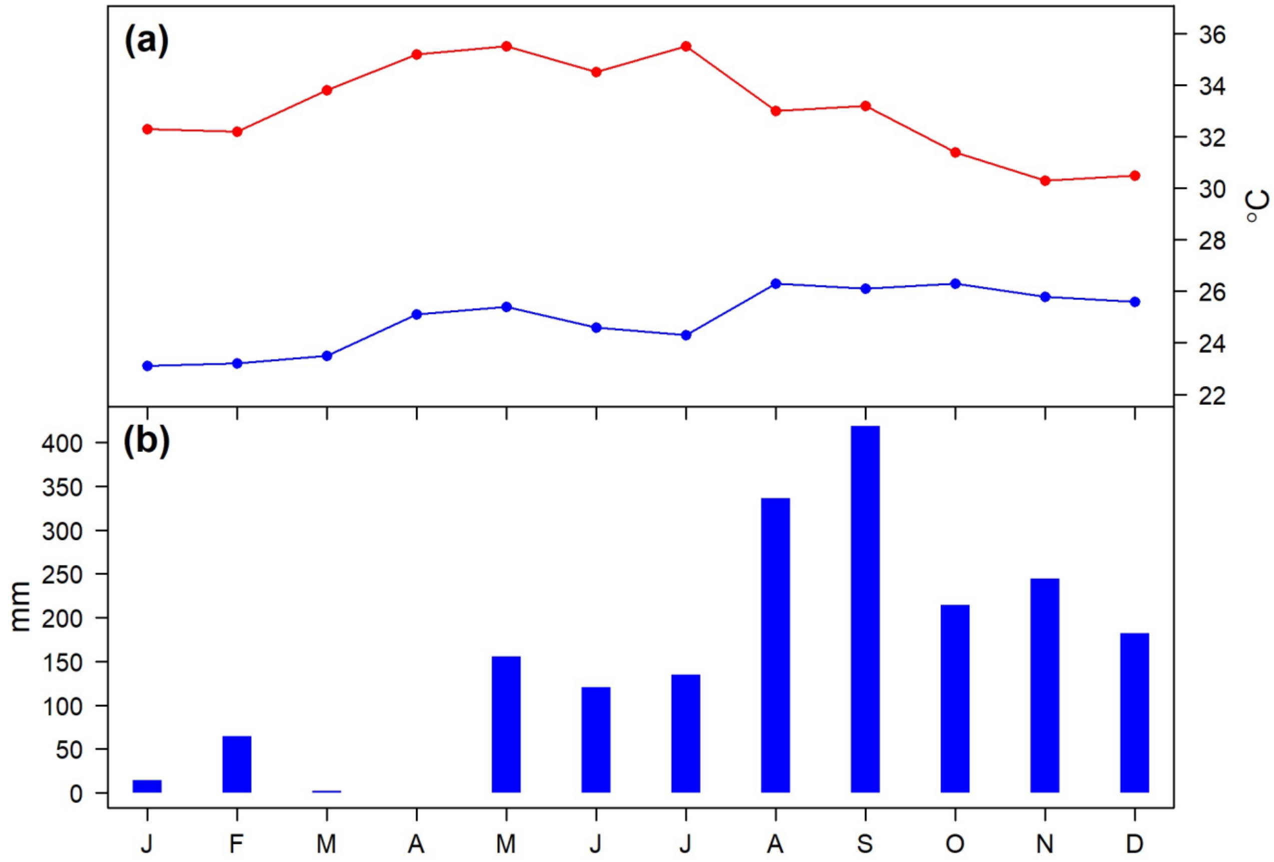

Figure 18 ***Monthly averages for temperature (in degrees Celsius) and rainfall (in millimeters) for 2016 for the Dumangas weather station in Iloilo.***

4 Discussion

4.1 Common syndromes and diseases

The natural hazards in this study, the flood, earthquake, and typhoon, had medical consultations appropriate for a primary care setting. Putting these natural disasters together, the most common condition in SPEED, ARI, reflected the country's morbidity profile in 2013 in which respiratory conditions dominated. Fever (which could represent influenza), acute watery diarrhea and hypertension were also in the top causes of morbidity in the country which also featured urinary tract infections, tuberculosis, and dengue (Epidemiology Bureau 2014). The Zamboanga armed conflict, a complex emergency, had similar findings in which ARI dominated the syndromes seen. Respiratory infections and diarrhea are two of the most common conditions seen in complex emergencies and natural disasters alike (Connolly et al. 2004; Polonsky et al. 2013). Acute respiratory infections can be attributable to over-crowding in evacuation centers and lack of shelter for the displaced populations. Diarrheal diseases, on the other hand, can be attributed to the lack of clean and potable water, sanitation facilities, and soap (Connolly et al. 2004).

Compared to natural hazards wounds did not increase the burden on the health situation of those affected by the Zamboanga armed conflict. This could be explained by the timing and number of reports from village-level health facilities, namely evacuation centers and village health centers. People seeking consult in evacuation centers and village health centers would more likely come for environmentally-related conditions due to deficits in water, sanitation, and shelter (Connolly et al. 2004). Trauma from gunfire is more often fatal or is treated in military settings. These injuries and deaths may have been missed by SPEED reports coming from mainly primary care settings. These facilities would have been set-up far from the gun battle. Moreover, non-continuous and sporadic reporting which had a delayed peak from the onset of the conflict could also have contributed to the low numbers of trauma-related injuries (Salazar et al. 2018). In contrast, wounds in typhoon Haiyan were more prominent than that for the earthquake due to the exposure to more debris, obstructions, and flooding leading to more minor injuries. Moreover, the delay in the initial response for both typhoon Haiyan and the Bohol earthquake may have skewed the injuries from fracture and major trauma to minor injuries such as wounds, bruises, and burns (Salazar et al. 2016).

Hypertension was a consistent condition seen in the disasters of 2013 in the Philippines regardless of hazard type. Non-communicable diseases are a growing concern for public health officials as they are becoming more common in high income, middle income, and low income countries (Magnusson 2007). NCDs are dependent on social and environmental factors affecting particular populations such as inequities in income, access to basic services, and proper nutrition (WHO Regional Office for Europe 2006). As populations affected by disasters are vulnerable with added psychological stress, increases in blood pressure have been shown to occur after the aftermath of the disasters such as the Great East Japan Earthquake in 2011. There were also disruptions in the medication supply of those with diagnosed hypertension thus further exacerbating their condition (Murakami et al. 2017). After Hurricane Katrina in the US in 2005, preexisting conditions prompted consults for maintenance medications while chronic diseases such as hypertension, asthma, and diabetes made up a high proportion of the total number of consults for mobile clinics (Arrieta et al. 2009; Krol et al. 2007; Millin et al. 2006).

Typhoon Haiyan and the Zamboanga armed conflict showed that the under-five age group was vulnerable to communicable diseases secondary to environmental exposures such as the lack or inadequate appropriation of shelter, water, sanitation, and nutrition. The particular diseases which affect the under-five age group in both disasters were ARI, acute watery diarrhea, skin disease, and fever. In a review of internally displaced populations in Africa, children also had higher rates of fever, respiratory problems, and diarrhea (Owoaje et al. 2016). Non-communicable diseases may also be attributable to particular environmental conditions post-disaster and may adversely affect children more. One such disease is asthma which was seen more in the under-five population in both the typhoon and complex emergency in the Philippines in 2013. In Hurricane Katrina, children with a pre-existing asthma diagnosis had more respiratory complaints than before the onset of the disaster (Rath et al. 2007). Moreover, in the Great East Japan Earthquake, children had worsening of their allergic conditions after 30 days from the onset of the disaster (Ochi et al. 2013).

eHATID data showed that during business as usual or non-disaster periods older age groups starting from age 50 had more consultations than those below 50 when adjusted for the population size. In the aftermath of a disaster such as in SPEED, the elderly face different challenges that may impede treatment or exacerbate certain health outcomes. Elderly populations may have difficulty in evacuation or mobility during disaster response thus making the journey to access health services more challenging. Having limited financial capacity further puts the elderly at risk (Wisner and Adams 2002). They are also one of the most susceptible groups to diarrheal diseases during floods because of unsanitary conditions (Davies et al. 2014). During heatwaves, heat-related mortality increases after the age of 50. Both physiology and social factors affect heat-related disease susceptibility with the latter being linked to social isolation of the elderly (Kovats and Hajat 2008). Thus preparedness and response measures should include the monitoring of diseases attributable to vulnerable patients such as the elderly (Paterson et al. 2014).

Environmental determinants of health post-disaster have consequences regardless of type of diseases observed and age groups affected. Environmental health measures such as water and food safety, sanitation, waste management, hygiene, and vector control help reduce the burden of disease of affected populations during disasters and the recovery thereafter (Lee and Riley 2006). Populations may also be more vulnerable to disasters due to the pre-disaster characteristics of their locality. Financial capacity, networks (social, political, and economic), available infrastructure, community cohesion, and stability affect the vulnerability of communities and municipalities to disasters from natural hazards and conflict (Briggs et al. 2009). Response measures from health professionals and health organizations may have a limited effect on reducing morbidity and mortality if there is continued political and societal instability as seen in complex emergencies (Burkle and Greenough 2006).

From post-disaster periods in affected locations to time periods where no disasters were recorded, the conditions observed in SPEED and eHATID were similar. Respiratory infections dominated both in SPEED and eHATID with hypertension contributing to the disease burden seen in health facilities. These were the most common diseases seen in the Philippines in 2013 and 2015 based on the Philippine Health Statistics reports of the Epidemiology Bureau of the DOH (Epidemiology Bureau 2014; Epidemiology Bureau 2016). However, urinary tract infection was in the top three conditions seen in eHATID and was in the top ten diseases in the country in the said reports from DOH for 2013 and 2015. This was not clearly reflected though in SPEED. In the SPEED operations manual, FOS can have the following possible causes: malaria, urinary tract infection, and typhoid fever (Health Emergency Management Bureau 2011). Even though it is somewhat represented in SPEED through its inclusion as a possible consideration for FOS, more importance could be given to urinary tract infections similar to hypertension, asthma, and diabetes. As urinary tract infections have a significant disease burden in real-time consultations in a sample municipality and in the national health statistics, it could be considered as a possible new standard syndrome to be added in SPEED for future use.

4.2 Mortality

In typhoon Haiyan, there were a total of 166 deaths recorded in SPEED for the 150-day observation period. There were 79 deaths for the five years and older age group and 87 from the under-five age group. The most common deaths were for ARI with 32 in total followed by wounds, bruises, and burns with 51 and hypertension with 23 in total. Health facilities had the following breakdown: hospitals with 121, community health centers with 27, village health centers with 11, and evacuation centers with seven. Deaths recorded in SPEED for typhoon Haiyan reflected the morbidity profile seen in SPEED. These were coming from deaths in health facilities and did not reflect the reasons of the total number of deaths recorded for the disaster.

The total deaths reported for typhoon Haiyan was 6,300 (National Disaster Risk Reduction and Management Council 2013b). A case control study done after typhoon Haiyan comparing cases of deaths due to Haiyan to a surviving family member living in the same affected area, specifically Tacloban, reported that the deaths they studied were all due to drowning (Ching et al. 2015). The high death toll from Haiyan was compounded by the delay in the response due to the magnitude of the disaster and the difficulty of medical teams reaching the affected area. These circumstances shifted the profile of both morbidity and mortality seen in health facilities towards primary care conditions and the complications of these conditions (Salazar et al. 2017).

In the Zamoboanga armed conflict there were 13 deaths recorded in SPEED with five deaths recorded for response and eight deaths for the recovery period. For health facilities, hospitals had 11 deaths while village health centers and community health centers had one each. Fever was the most common cause of death with six deaths followed by leptospirosis with four, hypertension with two, and wounds with one. Similar to typhoon Haiyan, the deaths recorded in SPEED in Zamboanga did not match the total number of deaths tallied by response and recovery officials.

In the Zamboanga armed conflict, there were 268 deaths recorded by the DOH. These were mainly secondary to gunshot wounds (Health Emergency Management Bureau 2014). Similar to typhoon Haiyan, the deaths recorded by the DOH were direct consequences of the conflict and gun-fire. The deaths recorded may not have been treated in the peripheral health facilities providing care to the general population, thus were not captured in SPEED. However, the reporting of deaths could further be investigated in future studies on conflict. Further studies using time series analysis of the registration of deaths, with indirect and direct causes, in localities affected by complex emergencies or natural hazards are suggested. These studies would give more complete assessments of the impact of disasters on mortality (Salazar et al. 2018).

4.3 Trends across time

Regardless of natural hazard, cumulative syndrome group rates for response (≤ 2 months) were greater than recovery (> 2 months). This was similar to the results from the Zamboanga armed conflict. Before this study there was no definite mark between the end of disaster response and the beginning of disaster recovery. In a study by Runkle et al. in 2012, the acute response phase is defined to be in the first four days where the immediate medical needs of the population affected are addressed. The succeeding phase is the secondary surge phase where medical logistics concerns are addressed such as prescription refills and need for medical equipment for chronic conditions. This phase has no defined end. The needs in the secondary surge phase are compounded by the incapacity of the health facilities post-disaster where bed capacity may be reduced.

In a study by Gocotano et al. in 2015 on typhoon Haiyan, the end of the response phase was pegged at three months post-disaster as this was also the time when the Inter Agency Standing Committee or IASC deactivated the level 3 response. This was also the time international medical teams were leaving the country. Preliminary results from SPEED for that particular disaster showed a decrease in consultations during the three-month mark. However, the national government declared the start of the recovery period only eight months post-disaster.

In our study, the response and recovery periods were demarcated at two months post-disaster. The same trend for post-disaster total consultations were shared by all four disasters in 2013 regardless of hazard type. Even when separated by syndrome group, the trend showed that the number of response consultations were higher than that of the recovery period. The disasters response rates regardless of syndrome group had the following decreasing order for natural hazards: typhoon Haiyan, Bohol earthquake, and Luzon flood. The differences among disasters was attributable to the disaster's severity (Salazar et al. 2016). Typhoon Haiyan had the greatest health system disruption among disasters 2013 with 53 community health centers, 22 hospitals, and 113 village health centers damaged in the Eastern Visayas region alone (Department of Health Philippines 2014). It was so devastating that within one month of the disaster a total of 108 of the total of 151 foreign medical teams were deployed in addition to the national response of the DOH. These teams provided out-patient services while some were capable of providing in-patient care with the ability to do major and minor surgeries (Brolin et al. 2015).

The rates presented in the study could be used as a guide for both national and foreign medical teams to estimate the number of expected patients that may arrive in their facility post-disaster. The expected number of additional consultations per person per year in the aftermath of a disaster or emergency is between two and four according to Sphere standards. When translated to the rates presented in this study, per 10,000 population, this range would be 55 to 110 consultations per day per catchment area of 10,000 people (The Sphere Project 2011). The Sphere rates only match those for disaster response. But in the recovery period less consultations are expected.

The demarcation using the two-month post-disaster point can be used for planning of the composition of medical teams in terms of human resources as well as the logistics required. In the initial days of the disaster, DOH and international organizations such as the WHO, International Federation of the Red Cross, and Doctors Without Borders have to allocate more staff and equipment for the expected consultations in disaster response. As the disaster reaches the two-month mark, the number of teams and staff can be reduced to focus on the rebuilding and recovery efforts where the remaining consultations are mostly communicable in nature and can be addressed in a primary care setting.

4.4 Health facility type

The health facility type which was utilized more in a particular disaster describes the intricacies of that said disaster. The two disasters where health facility type was analyzed were typhoon

Haiyan and the Zamboanga armed conflict. Typhoon Haiyan affected nine regions, 44 provinces, 591 municipalities, and 57 cities across the Philippines. The Visayas is composed of three administrative regions. All of which were affected by typhoon Haiyan. Haiyan also disrupted three administrative regions in the islands of Luzon and Mindanao each. Eastern Visayas otherwise known as Region VIII had 5,902 reported deaths, 1,005 missing, and 26,186 injuries (National Disaster Risk Reduction and Management Council 2013b). The scope of this study is the Eastern Visayas region which was the hardest hit among all regions. Community health centers were utilized more in typhoon Haiyan than any other health facility. On the other hand, the Zamboanga armed conflict was isolated to Zamboanga City. SPEED reports for Zamboanga mostly came from evacuation centers.

Comparing the health facility types which were utilized more in typhoon Haiyan and the Zamboanga armed conflict, community health centers were more prominent in Haiyan while evacuation centers had more reports and higher rates in Zamboanga. This difference can be attributed to the scale of the disaster of Haiyan compared to the complex emergency. Haiyan spanned multiple regions and more than 500 municipalities. The scope of the disaster put more emphasis on the central health facility in municipalities, the community health center. As the response was massive with local, national, and international health teams, coordination and management of health services were centered in the municipality level. During non-disaster times, community health centers provide both public health services and primary health care to a municipality. Community health centers are the main link of government health services to Philippine citizens across the country (Department of Health Philippines 2014).

In the Zamboanga armed conflict, on the other hand, evacuation centers were the central point of care observed. The conflict was centered on four villages in Zamboanga City. More than 118,000 people were displaced and evacuated the area due to the gun fire. More than 70% of these people were initially placed in evacuation centers (National Disaster Risk Reduction and Management Council 2013a). Since the conflict was localized and most of the people affected were settled in evacuation centers, most of the SPEED reports came from these facilities. And as a consequence most of the consults came from these facilities as well. The hazard type, scope, and impact of disasters affect the way in which health facilities are utilized. With a more localized response, village-based facilities such as evacuation centers receive more consults. With disasters affecting multiple provinces, municipality-based facilities such as community health centers are central to disaster response and recovery.

In the Philippine setting, the health facilities that were supported by various medical teams were fixed facilities. Only a small number of the reporting facilities were coming from mobile facilities. Aside from evacuation centers, all other health facilities were static facilities which are used in normal times, namely, hospitals, community health centers, and village health centers. As such these facilities should be prioritized to be resilient to disasters. This was such the sentiment during the recovery efforts in typhoon Haiyan where the “build back better” strategy was used (McPherson et al. 2015). One such past initiative is the Safe Hospitals in Emergencies and Disasters: Philippine Indicators which was developed by the DOH in the Philippines in 2009. The safe hospital indicators are based on the structural and building codes of the Philippines as well as expert advice from structural engineers (Health Emergency Management Bureau and WHO Western Pacific Regional Office 2009).

The safe hospitals initiative has been further enhanced to include climate resilience in the Smart Hospitals Toolkit of WHO. A smart hospital is defined as a health facility which is “safe and green”. It has the following characteristics: protects lives of people within the facility, has damage reduction qualities, can continually function even during a disaster or emergency, uses resources efficiently, and has processes for improvement in climate and hazard resilience (Pan American Health Organization 2017). Safe hospital assessments have already been done in the Philippines prior to 2013. In light of the health facility needs seen in this study, these initiatives can be upgraded to assessments for smart hospitals. As the country is expected to face more hyrdrometeorological hazards in the future, it would be prudent for the Philippines to invest in climate resilient health facilities.

4.5 Health systems strengthening for resilience through information management

Resilience pertains to the ability of a community, region, or country to resist or recover from disruptions or changes to maintain function or stability (Gaillard 2007). In the same way, health systems have to be able to withstand external disruptions during the onset of hazards and the response and recovery to these. This study showed the effect of the magnitude of disasters to the number of consultations observed in health facilities. As the magnitude of the disaster increases, the health system disruption increases as well. To better maintain health system resilience during disasters and emergencies, material resources such as medicines, medical supplies as well as human resources have to match the projected requirements.

Health program specialists handling service delivery have to understand their catchment population. They have to understand the projected disruption that the hazard may produce so that they can prepare for human resource capacities and logistics. This would prepare them to accommodate the expected number of daily consultations in their particular health facility. Post-incident evaluations of health information systems such as this study assists decision-makers, health managers, and medical team leaders to prepare for succeeding disasters. In the context of the Philippines, as typhoon Haiyan was one of the most devastating disasters affecting the country, the findings from this typhoon can be the basis for the worst-case scenario which planners should prepare for.

Aside from post-incident analysis use, syndromic surveillance systems are early warning systems which are essential components of H-EDRM and climate resilient health systems. SPEED was developed under the early warning alert and response systems (EWARS) umbrella. EWARS are designed to detect outbreaks or the occurrence of epidemic-prone conditions in humanitarian emergencies regardless of hazard. As the system is facility-based, it only approximates the community occurrences and gives a partial picture of the diseases it monitors (World Health Organization 2012).

In typhoon Haiyan, PIDSR and ESR, both systems under the Epidemiology Bureau, had been suspended in the hardest hit city, Tacloban, for seven weeks post-disaster. On the other hand, SPEED, a system under the Health Emergency Management Bureau, was activated within one week post-disaster. In other areas there were minimal disruptions in PIDSR and ESR reporting. Majority of users noted that the three systems worked complimentary to each other; however, there were perceived problems specifically from SPEED where users were not familiar with its use and there were instances where electricity was down and reporting had to be done via manual pen and paper method (Tante et al. 2015). The routine monitoring systems of the Epidemiology Bureau, PIDSR and ESR, were unable to respond during disaster response in the hardest hit areas in the aftermath of typhoon Haiyan. SPEED’s multiple reporting methods, namely pen and paper, short message system via mobile phone, or internet-based reporting (Salazar 2015), provided flexible options for medical teams the ability to report consultations seen even with the failure of electricity and loss of cellular phone coverage. These extreme circumstances are where SPEED thrives. Its capability to get down to basics such as courier-delivered reports give emergency medical teams the ability to continue to report daily.

Foreign medical teams (FMTs) were able to use SPEED in response and recovery efforts after Typhoon Haiyan. The Japanese FMTs specifically used the opportunity to study the system and modify it into J-SPEED. The system was used in 2016 in the response to an earthquake in Japan. J-SPEED used standardized information collection and quantitative analysis to help local health officials to make evidence-informed decisions. Such system is suggested in countries and localities where there is only basic data collection capacity (Kubo et al. 2017). From early warning alert and response systems using aggregated data, the international community has moved to an individualized form where chief complaints, diagnoses, and outcomes are collected aside from basic demographic data. Its development is under the WHO minimum data set (MDS) working group, specifically for use by emergency medical teams (Jafar et al. 2018). As countries continue to fine-tune the collection of relevant health information post-disaster, the analysis of these data sets are valuable to the improvement of health systems resilience in the long run.

Under the Operational Framework for Building Climate Resilient Health Systems of the WHO, health information systems are broken down into three components: vulnerability, capacity & adaptation assessment, integrated risk monitoring & early warning, and health & climate research (World Health Organization 2015a) (see Figure 19). As there is an overlap between consequences of climate change and disasters, the framework encompasses the needs of both climate change adaptation and disaster risk management. The framework includes the spectrum in which health information systems can be utilized for resilience and understanding risks. For example, health information systems can be used for capacity and adaptation assessment. This study shows the ways in which syndromic surveillance and routine health information systems can be used to assess health system capabilities from human resource, medicines, to service delivery requirements of health facilities. Health information systems are also used for early warning in which EWARS was first designed for. Lastly, research in both climate change and disaster resilience is advanced through the examination and analysis of existing databases which are operational in nature. These databases give researchers a look into the real-world experiences of health professionals in short-term response and recovery in disasters and long-term monitoring of climate and health indicators.

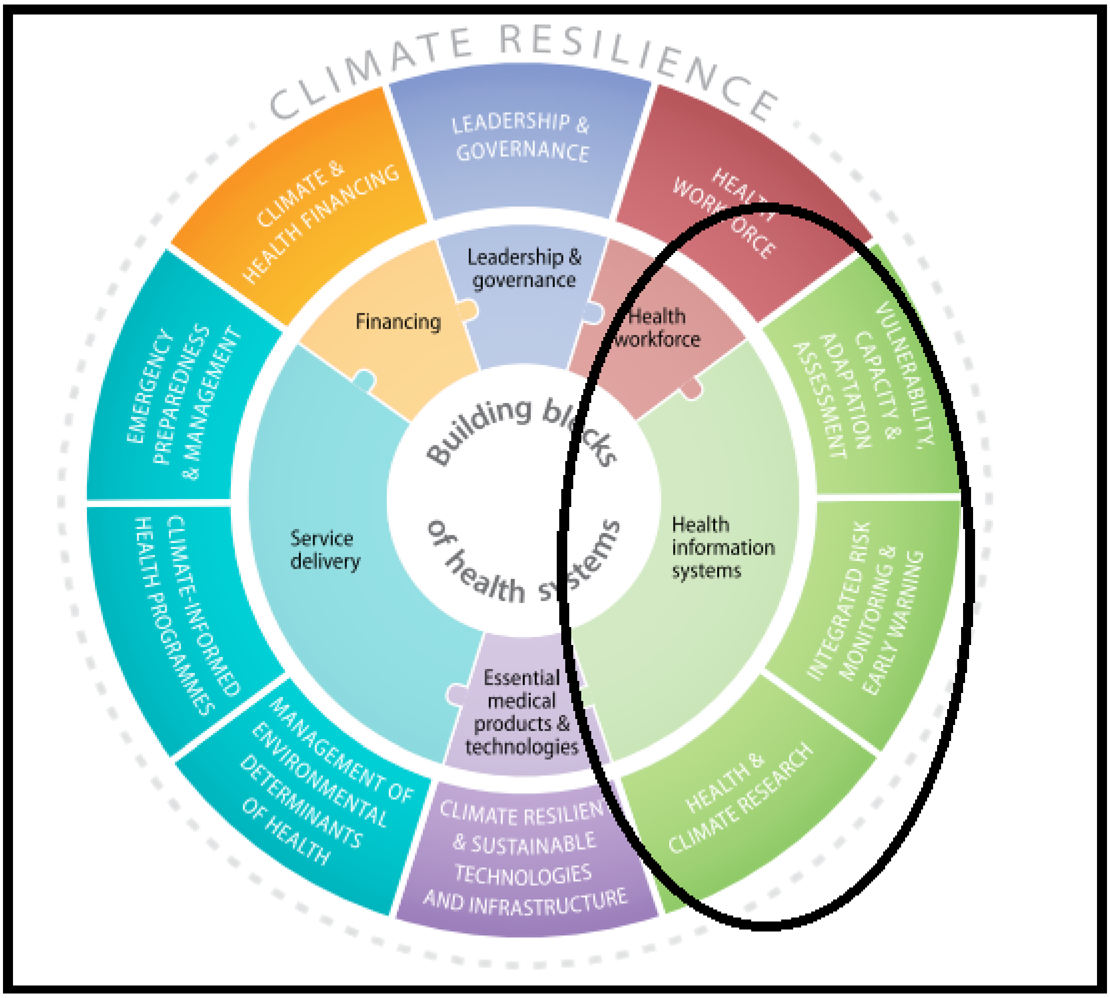

Figure 19 ***Climate resilient health systems and corresponding health system building blocks*** *(Source: World Health Organization 2015)*

Routine health information systems are usually health facility-based and are ideally used as standard business process regardless of a disaster. RHIS are the basic source of evidence for policy-making, health systems management, and monitoring and evaluation (Shiferaw et al. 2017). The use of RHIS in a syndromic manner has been done using emergency department data in the US (Rosenkötter et al. 2014). Syndromic surveillance in emergency departments usually monitor discharge diagnosis and chief complaints. However, other data sources may be used such as telephone inquiries, ambulance dispatch calls, and total number of emergency room consults (Hiller et al. 2013).

In the UK, syndromic surveillance is centered on general practitioner sentinel surveillance looking at in-office hours and out-of-office consults. This is augmented by data from Public Health England emergency department syndromic surveillance system and the National Health Service non-emergency medical helpline. Data are combined into syndromic indicators and analyzed by teams composed of scientists from Public Health England and the academe (Elliot et al. 2017). It has been used to monitor influenza trends across the UK, the 2012 London Olympics, and extreme cold events (Elliot 2009; Elliot et al. 2013; Hughes et al. 2014). Climate-related events like heatwaves have been monitored in the UK using the said syndromic surveillance system. The system showed moderate morbidity levels of associated syndromic indicators. This observation was in line with expected seasonal fluctuations. These, in turn, informed public health messaging of concerned health agencies (Elliot et al. 2014).

Developments in sydromic surveillance have also benefited from innovations in informatics. Electronic medical records or EMRs in high income countries such as the United States have been collected and analyzed to evaluate and monitor groups of health facilities and physicians. Artificial intelligence algorithms were developed and validated to analyze data for case-finding. The system showed high sensitivity and positive predictive value for identifying outbreaks of infectious diseases. The development of electronic laboratory reporting, on the other hand, decreases the time for validation of laboratory confirmed diagnoses. The combination of the two can decrease the workload required in the identification and validation of notifiable diseases (McNabb et al. 2017). The evolution of public health informatics using machine learning enhance syndromic surveillance specifically for those which analyze large amounts of data coming from diverse systems. Without automation, case finding for potential outbreaks will require increased human resource requirements leading to additional costs and delays in reporting.

Syndromic surveillance, including modified RHIS, are potential monitoring tools for climate-related hazards such as droughts, floods, storms, and extreme heat events (Hess et al. 2012). However, RHIS as syndromic surveillance comes with limitations as seen in typhoon Haiyan; extreme emergencies may produce difficulties in the continued use of RHIS in disaster response and recovery in areas where lifelines such as electricity, landlines, and cellular phone connectivity are lost. EWARS are still useful tools to maintain real-time reporting in situations where RHIS operations are hampered. Thus a combination of EWARS and RHIS are optimal to monitor both climate change and disaster health effects regardless of the magnitude of the hazard.

Aside from monitoring areas where health system disruptions are still manageable and lifelines still available, routine health information systems could be used as the baseline for EWARS consultation rates. In this study, eHATID could be used as the baseline for the disasters documented in SPEED. Comparatively, the total consultation rates from eHATID were less than 50% of the total rates from all three natural disasters for their respective recovery periods: typhoon haiyan (40%), Bohol earthquake (42%), Luzon flood (48%). eHATID total consultation rates were 71% of the recovery period total consultation rates for the Zamboanga armed conflict. For the four disasters in this study, recovery rates are still higher compared to daily averages for non-disaster periods seen in eHATID thus showing the need of continued health services augmentation during recovery efforts. Although eHATID was not used in the same province as any of the disasters in the study and had many limitations which will discussed in a later sub-section, there is promise in its use as a baseline for comparison to syndromic surveillance for climate- or natural hazard-related events.

Health information systems, specifically syndromic surveillance in the forms of EWARS and RHIS, are tools for adaptive management to improve capacities in climate resilience including disaster risk management. Adaptive management is an iterative process that looks into complex systems, involves different stakeholders, and promotes continuous improvement. The steps for adaptive management are assess, plan, implement, monitor, evaluate, and adjust. Adaptive management has been advocated as means to analyze climate-sensitive health threats (Hess et al. 2012). Syndromic surveillance, both EWARS and RHIS-based, are promising monitoring and evaluation tools advocated for in adaptive management. These systems also fulfill the roles of HIS in the Climate Resilient Health Systems Framework where they are used for assessment, early warning, and research. By understanding risks through better analysis of information, health systems build capacity towards resilience for both disasters and climate change. Continued improvement and learning in public health informatics, specifically syndromic surveillance, leads to increased resilience of health systems and more evidence-based decision-making.

4.6 Correlation of weather data

Climate change and health research in the Philippines is still in its infancy with little research done spear-headed by local institutions. A study done by Chua et al. in 2019 looked at studies done in the Philippines from 1980 to 2017. Only 34 quantitative studies were retrieved from published sources and gray literature on climate factors and health in the Philippines. Most of the studies used time-series analysis using meteorological parameters looking at surveillance data. Some of which were hospital admissions data. Limitations mentioned from the studies were in the areas of data quality, options for long-term daily time-series health data sets, and spatial data. Improvements in health data and meteorological data were recommended to increase research output on the topic in the Philippines.

Modeling of health data require information that measures health outcomes of environmental exposures. Health data reflecting climate-sensitive diseases have to be adequate in quality and quantity to measure health outcomes across time (McIver et al. 2016). Access to long-term data is required to study complex interactions such as that in climate change and health (Ebi and Rocklö v 2014). Studies on national capacities and vulnerabilities to climate change of developing countries are limited by the availability of national and local health data key to establishing relationships between meteorological data to health outcomes (Berry et al. 2018). For climate change and health research in Philippines to flourish, aside from meteorological data which is available from PAGASA, the available health databases from which health indicators can be derived from should be strengthened and improved.

As climate change impacts are not only manifested as increased vulnerability to infectious diseases, other health outcomes like cardiovascular diseases and allergies increase with increased temperatures and worsening air quality (World Health Organization 2018). Disease surveillance systems such as PIDSR monitor infectious diseases with outbreak potential and are notifiable in nature (National Epidemiology Center 2014). Thus climate and health studies looking at non-infectious diseases have to rely on data from the Field Health Service Information System or FHSIS. FHSIS data are composed of reports from the front line health care workers in municipalities and cities across the country. As manual reporting means manual aggregation of data, timely reporting is difficult to accomplish with these dated methods (Ongkeko et al. 2016). eHATID and other electronic medical records in the Philippines such as CHITS, iCinicSys, and WAH-EHR are built to automate and improve reporting of municipalities, cities, and provinces thus improving data aggregation and better evidence-based policy-making (Coronel et al. 2016; Department of Health and Department of Science and Technology Philippines 2013; Ongkeko et al. 2016). With continued use of these EMRs, non-communicable diseases as well as communicable diseases and injuries can be better monitored across long periods of time to be included in modeling studies on climate change and health.

Burden of disease studies attributable to environmental hazards are also based on health indicators that are routinely collected. In a burden of disease study looking at outdoor air pollution, daily all-cause, cardio-pulmonary, lung cancer, and respiratory mortality rates were collected from the Thailand Ministry of Health and attributable deaths to air pollution were computed (Ostro et al. 2004). To do a similar study in the Philippines, mortality statistics are available from the Philippine Statistics Authority (Epidemiology Bureau 2016). However, to have a better understanding of health outcomes influenced by weather and climate, aside from the analysis of mortality, information on daily health consultations or morbidity data for these conditions would improve the specificity of the time of exposure of the environmental hazard and the resulting health condition. Yearly or monthly averages are currently the data available due to the limitations in data aggregation which is centrally done (Ongkeko et al. 2016). With specific consultations already being recorded through RHIS, these data points are a wealth of information that can be monitored to look at relationships with weather and climate. Moreover, environmental hazards could be better monitored based on their health consequences through the analysis of daily information.

eHATID LGU is such a RHIS which can provide daily consultations in the form of ICD-10 diagnoses. An example of a diagnosis which can be observed across time and related to weather and climate variables is urinary tract infection or UTI. UTI was shown to have a peak during the month of April in San Jose de Buenavista, Antique. This coincided with high temperatures and low rainfall. In studies done in Canada and the US, UTI cases in both a single-hospital and multi-hospital settings have shown to be influenced by weather patterns; specifically, incidence goes up with hotter weather. Some of the biological hypotheses given for increased bacterial infections in the urinary tract were relative dehydration, increased concentration of urine, and increased moisture in the perineum during hotter weather (Anderson 1983; Simmering et al. 2018). Even if there were gaps in the reporting for eHATID, the findings for this pilot analysis can prompt further investigation into possible climate or seasonal fluctuations in consultations for UTI, hypertension, and acute respiratory tract infections, the three most common diagnoses. Increasing the number of municipalities and provinces studied to include those surrounding the weather station in Iliolo could improve the disease picture described in this analysis of eHATID in the area.

eHATID data and other routine health information systems can pinpoint probable diseases to study in relation to climate change and disasters. As SPEED and eHATID validate regular reporting from FSHIS and PIDSR seen in the Philippine Health Statistics (Epidemiology Bureau 2014; Epidemiology Bureau 2016), syndromic surveillance data can be used to study consultations seen in health facilities on a daily basis. At the present, these activities require centrally aggregated initiatives done by the DOH. However, the existing HIS infrastructure of DOH may not be able to do this real-time. eHATID has shown promise in real-time processing and scope as it has more than 400 deployment sites which can be aggregated instantly as part of the system being cloud-based. However, information governance measures have to be established to aggregate all these data, as the owners of the health data are the local government units themselves. Currently, to access the data, permission has to be requested per LGU whether municipality or province.

Improvements in the access and coverage of meteorological data are also suggested. Currently access to data is requested from PAGASA, the government agency tasked to monitor meteorological indicators across the country. Better collaboration between health research groups and national agencies such as PAGASA are needed so that more climate and health researches can be accomplished. A scoping review looking at climate change and health research in the Philippines in 2018 suggested that research gaps include the need for researches looking at the spatio-temporal relationship of diseases and climate indicators using the meteorological data of PAGASA and health data from PhilHealth or the DOH. Furthermore, in the stakeholder workshop organized after the scoping review, participants noted the lack of institutional cooperation among different disciplines in the academe and professional practice that is needed in creating joint researches on climate and health (Dorotan et al. 2018). This felt need is now reflected by the efforts of DOST and PCHRD in funding workshops where professionals and researchers from different fields such as health, engineering, meteorology, urban planning, and public policy meet to discuss efforts for increasing disaster risk reduction and climate change and health researches (Philippine Council for Health Research and Development 2018).

Aside from rainfall and temperature, PAGASA also has more data sets such as the heat index. The heat index takes into account dry-bulb temperature and relative humidity (PAGASA 2019). Heat waves and increased temperatures are issues that concern tropical countries like the Philippines as workers' health and productivity are affected, especially those who are working outdoors. Construction and agricultural workers across the country are at risk of heat stroke and heat exhaustion (Smith et al. 2014). In the long run, these impediments to sustained working hours may affect economic and social development of low and middle countries like the Philippines if adaptive measures are not integrated (Kjellstrom et al. 2009). Further studies on the effect of heat in the health of the Philippine workforce need to be backed up with proper health data which syndromic surveillance can provide. The use of eHATID and PAGASA data in this study demonstrates the potential of RHIS data using ICD-10 counts from community health centers overlapped with meteorological data from PAGASA to describe the relationship of heat and health outcomes. Further collaboration of public health researchers and PAGASA are essential to increase the research base on this specific topic.

4.7 Limitations

SPEED and eHATID are secondary data sources where data quality needs further assessment. The SPEED database is made up of aggregated consultations for different syndromes. It is based on SPEED reports accomplished by health teams treating patients in affected areas. As an aggregated data source, severity of the conditions assessed are not specified. Furthermore, the population used as the denominator to formulate disease rates only roughly estimate the catchment population affected. For the rates computed in the SPEED portion of the study, out-migration was not taken into account. As displaced populations move into their new municipalities and provinces, increases in medical consultations in these localities were not accounted for. Furthermore, due to out-migration, the true catchment population in the affected municipalities would be less than reported statistics from the 2010 Philippine census (Salazar et al. 2016).

SPEED has limitations in making generalizations from the results of this study. SPEED used health facility data for particular cities and regions in the Philippines with diverse population characteristics. Thus, care should be exercised in adapting results of this study to other populations within and outside of the country. As secondary data sources with no laboratory disease confirmation, syndromic surveillance research is limited to descriptive studies. As syndromes used in SPEED are not definitive diagnoses and health facilities did not report on a daily basis, findings should be considered rough estimates. The experience of disaster managers still plays a role in integrating the findings of this study with their experience in logistics and human resource management (Salazar et al. 2017).

Reporting of health facilities are dependent on health worker capacities. Aside from organic health facility staff, the use of SPEED is also dependent on designated teams sent to manage SPEED operations in debilitating disasters such as typhoon Haiyan, the Bohol earthquake, and the Zamboanga armed conflict. These teams could come from the DOH, local non-governmental organizations (NGOs), or international non-governmental organizations (INGOs). The limitation of needing external support to augment overworked health teams for the continuity of SPEED operations could have led to the inconsistent reporting experienced in the disasters in this study (Salazar et al. 2018).

Similar to SPEED, eHATID consultations can be assumed as having no laboratory confirmation because the source of the data is a community center (Salazar 2017). But unlike SPEED, the diagnoses in eHATID are presented in ICD-10 format making them more specific. Nevertheless, these cannot be conclusive without necessary measures for confirmation.

There are further limitations in the use of eHATID data. One of which is the consistency of its use. There was lack of data for the month of February and between the months of July and November. Even if rainfall and temperature data was available from PAGASA, correlations could not be established due to the lack of data. The use of eHATID as a syndromic surveillance is still to be established. This study provides preliminary data as a base of evidence for further investigation. As a possible basis for infectious disease sentinel surveillance in the future, assessments of eHATID's capacities as an outbreak surveillance are warranted.

APSED III and Integrated Disease Surveillance and Response (IDSR), both internationally recognized frameworks, advocate for the integration of surveillance systems such as indicator-based surveillance and event-based surveillance. These efforts of integration help to improve preparedness and response efforts to global threats to public health (WHO Regional Office for the Western Pacific 2017; World Health Organization 2015b). Strengthening integrated disease surveillance and response is both a priority in disaster risk management and climate resilient health systems. In the Philippine setting, it is suggested that syndromic surveillance be combined with other existing surveillance systems. Isolating syndromic surveillance will limit its impact in the bigger context of health system strengthening for resilience.

4.8 Health information system use

Syndromic surveillance systems can be assessed based on quality of surveillance and system performance. The indicators for quality of surveillance are timeliness, completeness, data validity, and representativeness. For system performance, the indicators include usefulness, flexibility, simplicity, acceptability, stability, and cost (Sheel et al. 2019). This study, however, does not assess SPEED and eHATID on these parameters. On the other hand, this study shows the different outputs and potential uses of the two systems on health systems strengthening in the face of disasters and climate change. This initial study pinpoints the need for further assessments of SPEED and eHATID using the indicators introduced by Sheel et al. looking at their actual impact in terms of front-line health care workers, epidemiologists, and public health managers.

One indicator not included in the study by Sheel et al. but is of interest in this study is long-term sustainability. Will a syndromic surveillance system like SPEED be used continuously and consistently through the years by the Department of Health? This question is part of the considerations of the Health Metrics Network in health information system development. The Framework and Standards for Country Health Information Systems takes into account the principles of empowerment, leadership, and ownership. One of the strategies in the document is building upon existing systems and enterprises and not recreating the wheel for novelty (World Health Organization 2008a). The guiding principle of ownership is one particular aspect that needs further development. Ownership may play a very important role in the continued use of SPEED by the DOH and the adoption of RHIS by local government units in the future.

In the case of SPEED, was it actually used by the different actors in disaster response, specifically the epidemiologists and those doing disease surveillance? SPEED was an initiative initially of the World Health Organization and the Health Emergency Management Bureau of the Department of Health. Although disease surveillance is under the purview of the Epidemiology Bureau, SPEED’s use and governance is not under the said bureau but under HEMB. As the national system for disease surveillance, PIDSR did not integrate or include syndromic surveillance as one of the surveillance modalities specified in its operations manual thus in effect excluding SPEED in its improvement and innovation measures. This may have hampered the continued use of SPEED in other emergencies and disasters. As described by

Tante et al. in typhoon Haiyan, there were different surveillance systems functioning at the same time during that particular disaster. Did the increased workload from having multiple systems running at the same time decrease the acceptability of SPEED to its users? These are questions needing further investigation through qualitative studies and stakeholder meetings for system users.

SPEED has shown promise in its ability to describe front-line experiences in health facilities during disaster response to decision-makers real-time. It gives feedback to public health officials regarding the logistic and human resource needs of the health teams across the areas affected. However, SPEED has its limitations in its sustained use. Aside from the four extreme emergencies and disasters that affected the Philippines in 2013, SPEED was only activated again and used consistently by the regional and national government in 2017 during the siege of Marawi, a town in the province of Lanao del Sur in the Bangsamoro Region of Muslim Mindanao. SPEED's use has not been reviewed for that particular complex emergency. The particular circumstances surrounding SPEED's use or non-use in Marawi would be interesting to investigate to see if SPEED still fulfills its role during disaster response and recovery.

Satellite internet services are options in today's disaster response and recovery efforts (Sakurai et al. 2014). With these new technologies now available, the use of a courier- or SMS-based system such as SPEED may already be outdated. Although SPEED has an internet function, its capacity for basic transmission such as SMS is what sets it apart from other systems. Further developments in internet capability for disaster response and recovery have to be monitored as these may affect the usefulness of SPEED and the required functionality to keep it relevant to the times.

SPEED's autonomy from the Epidemiology Bureau and PIDSR may be a hindrance for its use by disease surveillance personnel. Stakeholder engagement activities bringing together health professionals from EB and HEMB discussing the use of syndromic surveillance for disasters and emergencies is suggested as a means to re-envision SPEED and its integration in mainstream surveillance activities of the DOH. These activities and their documentation would be steps in building ownership for syndromic surveillance in the DOH, specifically both EB and HEMB, thus ensuring sustainability in the long-term.

Furthermore, this study demonstrated how gaps in the eHATID system usage is still evident in its early stages. Being in operation since 2013 (Coronel et al. 2016), consistency of its use has to be evaluated in other sites across the country. Similar to questions on SPEED implementation, investigations on the problems encountered by eHATID users hindering daily reporting are suggested Furthermore, as eHATID is only part a number of existing RHIS in the country, there are questions on the strategy of the Philippine DOH in using all these systems to its advantage in disease surveillance.

4.9 Research recommendations

Research recommendations can be directed towards specific topics such as expanding the methodology used in this study. Topics could range from the use of SPEED for other disasters after 2013 or monitoring the use of eHATID in other municipalities and provinces. These researches will reinforce the potential use of analyzing existing syndromic surveillance and RHIS to be used for public health decision-making in H-EDRM and climate resilient health systems. One such example for SPEED is comparing the use of SPEED in the Marawi siege. The study of this complex emergency in 2017 will demonstrate if the use of SPEED was similar to that of the cases seen in 2013. This future research will either show the progression, maturity, or waning interest in syndromic surveillance in disasters. Similar to this, further studies using the eHATID database will show if there are still inconsistencies in reporting in San Jose de Buenavista or if these inconsistencies are mirrored in other municipalities where it was also deployed.

Other research recommendations may be directed towards operational use of both systems. After years of using these systems, there are still hurdles for users which need improvement. Assessments for both SPEED and eHATID can be based on the methodology used by Sheel et al. with surveillance quality and system performance indicators. These baseline assessments are needed for further discussions from HEMB and EB of the Philippine DOH on governance directions for disease surveillance. This should be further supported by stakeholder meetings bringing together key stakeholders in the DOH on disease surveillance. The discussions and consensus established are key elements for ownership of the desired system to be used. Ownership is one of the factors discussed in this study for the sustainability of both eHATID and SPEED. These efforts are in the hopes that all these emerging health technologies in information management can be fully mainstreamed into PIDSR.

By demonstrating the limitations of systems working in silos, this study has highlighted the need for collaboration both in H-EDRM and climate resilient health systems. Without these collaborations, potential sources of health and meteorological data would be unnoticed, unused, and eventually forgotten. Moreover, key decision-makers will continually be under-informed of the realities being faced in real-time for climate-related extreme weather events, gradual changes in climate, and outbreaks of climate-sensitive diseases. Future partnerships in H-EDRM and climate and health research can be developed between disaster experts, academics, DOST, DOH, PhilHealth, regional and urban planners, engineers, architects, health researchers, meteorologists, geologists, local NGOs, INGOs, and development partners.

4.10 Policy recommendations

Quantitative descriptive studies on existing syndromic surveillance and RHIS databases combined with qualitative studies on systems performance and quality are needed for policy considerations in the future. To supervise and give directions to these studies, there is a need for a well-planned national syndromic surveillance initiative that is integrated with PIDSR. A specific office handling syndromic surveillance under the Epidemiology Bureau would be able to handle governance considerations for aggregation and consolidation of information from different RHIS and extreme event syndromic surveillance. This office would be able to further monitor and evaluate the eventuality of increasing number of innovations and developments in syndromic surveillance. However, with the wide range of uses of syndromic surveillance, close coordination between different offices within DOH and with external collaborative networks have to be maintained so that overlaps and redundancies are minimized.

One such framework that supports the possible use of diverse health information under the DOH is the Philippine eHealth Strategic Framework and Plan 2014-2020. Under the framework, PhilHealth electronic claims data and DOH electronic medical records such as iClinicSys and the Integrated Hospital Operations and Management Information System are provided as possible sources of information. These information sources are included in the Philippine Health Information Exchange (Department of Health and Department of Science and Technology 2014). A health information exchange is integral in the function of service delivery networks. It provides access and exchange of electronic health information between health facilities, service providers, information managers, and government health agencies

(Department of Health Philippines 2019). This framework leads to the identification of possible health data sources for research. However, the framework leaves out non-DOH electronic medical records such as eHATID. Thus it is expected that consolidation of data on the national scale using RHIS will prioritize DOH controlled data. These are the data sources which the national syndromic surveillance initiative can look into.

Looking at a long term strategy, the health information exchange should also involve non-government controlled health information systems. As these private HIS may contribute to outbreak detection, they hold a wealth of information for PIDSR and syndromic surveillance managers. There are also new initiatives in the Philippines that support the use of health information for better decision-making in health such as the Universal Health Care Act of 2019. The new law focuses on local service delivery networks which will depend on electronic health information from private and public providers alike for better health system efficiency. Thus the concepts of health information integration discussed in this study will need further revisions as the new initiatives in syndromic surveillance mature into established programs under the guidance of Universal Health Care (UHC). Moreover, as the governance mechanisms under UHC are still in flux, more operational studies on health information system governance using the new model of service delivery are suggested.

5 Summary

Syndromic surveillance can monitor disease trends in real-time, potential outbreaks, mass gathering events, and environmental hazards. Health information systems play a pivotal role in enabling evidence-informed decision-making especially in the Philippines, one of the most vulnerable countries to climate-related hazards. A syndromic surveillance for disasters, Surveillance in Post Extreme Emergencies and Disasters, and a routine health information system, eHealth Tablet for Informed Decision Making of Local Government Units or eHATID, were analyzed in this thesis. The thesis describes the health impacts inflicted by natural hazards and complex emergencies. For the disaster syndromic surveillance, the different syndromes, syndrome groups, age groups, health facility types, and time periods post-disaster were compared using data for four disasters in 2013: Luzon flood, Bohol earthquake, typhoon Haiyan, and Zamboanga armed conflict. For the routine system, the different diagnoses seen, the age groups affected, distribution across the year 2016, and possible correlation were described with weather variables in San Jose de Buenavista in Antique province.

The disaster syndromic surveillance has 21 syndromes divided into three groups: communicable, injuries, and non-communicable. Mean syndrome and disease group rates were presented with 95% confidence intervals while comparisons between time periods used Poisson regression. Multivariable fractional polynomial with Poisson distribution was used to model health facility consultation rates. Analysis of the routine system used International Classification of Diseases, Tenth Revision diagnoses. Scatter plots were used to illustrate distribution of diagnoses across time and daily rates were presented with 95% confidence intervals. Denominators used for the daily consultation rates were based on 2010 and 2016 Philippine census for the disaster syndromic surveillance and routine system respectively. Meteorological data from Philippine Atmospheric, Geophysical and Astronomical Services Administration were presented as mean monthly rainfall, maximum temperature, and minimum temperature.

The four disasters studied using the disaster syndromic surveillance had acute respiratory infections as the most common condition followed variably by diarrhea, skin disease, and fever. These reflected the country's morbidity profile. Infectious diseases are dependent on environmental health conditions such as water, sanitation, hygiene, and shelter. Wounds were not prominent in the Zamboanga armed conflict in contrast to natural hazards which had numerous minor injuries from exposure to debris. This was attributed to the village health centers and evacuation centers not receiving serious gun injuries attributable to conflict. Hypertension was a consistent condition seen in the disasters regardless of hazard type reflecting its growing morbidity globally.

Regardless of hazard, the disaster syndromic surveillance had higher cumulative syndrome group rates for the response phase than the recovery phase. Morbidity rates in the response phase, regardless of syndrome group, had the following decreasing order for natural hazards: typhoon Haiyan, Bohol earthquake, and Luzon flood, reflecting the disaster's severity. Thus response and recovery efforts need differing logistic requirements taking in consideration the disaster's severity. Post-incident evaluations of health information systems provide valuable information to senior health officials, health managers, and medical team leaders to prepare for succeeding disasters.

Routine health information systems and disaster syndromic surveillance fulfill roles identified in the climate resilient health systems framework of the World Health Organization, namely vulnerability assessment, integrated risk monitoring, and research. The use of routine systems post-disaster may not function in disaster response and recovery where electricity, landlines, and cellular phone connectivity are absent. Early warning alert and response systems are flexible real-time reporting tools thus its combination with routine systems are optimal to monitor both climate change and disaster health effects. The findings from the analysis of the routine system serves as a pilot analysis for future climate and health studies. With continued use of routine systems, non-communicable diseases, communicable diseases, and injuries can be better monitored across long periods of time to be included in modeling studies with environmental variables.

This study demonstrated how gaps in health information system usage are still evident. Assessments for both systems in this study using surveillance quality and system performance indicators are suggested. Individuals and institutions working in disaster risk management, climate resiliency, and information management need to collaborate to avoid situations where they work in silos. A national syndromic surveillance initiative integrated within the Philippine Integrated Disease Surveillance and Response system is thus suggested. Its establishment would entail further discussions on governance directions for disease surveillance from the Health Emergency Management Bureau and Epidemiology Bureau of the Philippine Department of Health.

6 Zusammenfassung

Mithilfe von Syndrom-Überwachungssystemen können Krankheitstrends in Echtzeit, potenzielle Ausbrüche, Ereignisse bei Massenansammlungen und Umweltrisiken überwacht werden. Insbesondere auf den Philippinen, einem der anfälligsten Länder für klimabedingte Gefahren, spielen Gesundheitsinformationssysteme eine entscheidende Rolle um evidenzbasierte Entscheidungsfindungen zu ermöglichen.

In dieser Arbeit wurden sowohl Daten des Syndrom-Überwachungssystems „Surveillance in Post Extreme Emergencies and Disasters" als auch Daten des Routine-Gesundheitsinformationssystems „eHealth Tablet for Informed Decision Making of Local Government Units" analysiert. Dabei wurden Auswirkungen von Naturgefahren und komplexen Notfällen auf die Gesundheit beobachtet. Mithilfe der Daten des Syndrom-Überwachungssystems wurden die verschiedenen Syndrome, Syndromgruppen, Altersgruppen, Krankenhaustypen und Zeiträume getrennt für folgende vier Katastrophen im Jahr 2013 beobachtet: die Überschwemmung in Luzon, das Erdbeben in Bohol, der Taifun Haiyan und der bewaffnete Konflikt in Zamboanga. Mit den Daten des Routine-Gesundheitsinformationssystems wurden die verschiedenen Diagnosen, die betroffenen Altersgruppen, die Verteilung über das Jahr 2016 und eine mögliche Korrelation mit Wettervariablen in San Jose de Buenavista in der Provinz Antique beschrieben.

Das Syndrom-Überwachungssystem umfasst 21 Syndrome, die in drei Gruppen unterteilt sind: übertragbar, Verletzungen und nicht übertragbar. Die mittleren Raten der Syndrom- und Erkrankungsgruppen wurden mit 95% Konfidenzintervallen berechnet. Für die Vergleiche zwischen den Zeiträumen wurde eine Poisson Regression verwendet. Die Konsultationsraten der Gesundheitseinrichtungen wurden mithilfe der sogenannten „multivariable fractional polynomials" und einer Poisson-Verteilung modelliert. Für die Analyse der Daten des Routine-Gesundheitsinformationssystems wurde die Internationale Klassifikation der Krankheiten in ihrer zehnten Revision genutzt. Scatter Plots wurden verwendet, um die Verteilung der Diagnosen über die Zeit zu veranschaulichen und täglichen Raten wurden mit 95% Konfidenzintervallen dargestellt. Die Nenner der tagesgenauen Konsultationsraten basierten auf den philippinischen Volkszählungen in 2010 (Analyse der Daten des Syndrom-Überwachungssystems) und in 2016 (Analyse der Daten des Routine-Gesundheitsinformationssystems). Die meteorologischen Daten der philippinischen Verwaltung für Atmosphäre, Geophysik und Astronomie wurden als mittlere monatliche Niederschlagsmenge, maximale und minimale Temperaturen angegeben.

Bei der Analyse der Syndrom-Überwachungssystemdaten zeigte sich, dass akute Atemwegserkrankungen die häufigsten Erkrankungen bei den vier beobachteten Katastrophen waren, gefolgt von Durchfall, Hautkrankheiten und Fieber. Diese Erkrankungen spiegeln das Morbiditätsprofil des Landes wider. Infektionskrankheiten sind von den Umweltbedingungen wie Wasser, sanitären Einrichtungen, Hygiene und Wohnsituation abhängig. Bei Naturgefahren waren Wunden von größerer Bedeutung als im bewaffneten Zamboanga Konflikt. Dies kann damit erklärt werden, dass Menschen mit schwerwiegenden Waffenverletzungen gar nicht erst in die Gesundheits- und Evakuierungszentren der Dörfer gegangen sind um sich dort behandeln zu lassen. Hypertonie wurde unabhängig von der Art der Katastrophengefährdung beobachtet, was auf die weltweit wachsende Morbidität zurückzuführen ist. Es zeigten sich höhere kumulative Raten der Syndromgruppen während der sogenannten Notfallbewältigungsphase als in der Wiederherstellungsphase, unabhängig von der Art der Gefährdung. Die Morbiditätsraten während der Notfallbewältigungsphase spiegelten den Schweregrad der Katastrophen wider: Während des Taifuns Haiyan waren die Raten am höchsten, gefolgt von dem Erdbeben in Bohol und der Überschwemmung in Luzon. Dies zeigt, dass die Bemühungen während der Notfallbewältigungs- und Wiederherstellungsphase unterschiedliche logistische Anforderungen haben und dabei der Schweregrad der Katastrophe berücksichtigt werden muss. Nach einer Katastrophe liefern die Bewertungen von Daten der Gesundheitsinformationssysteme wertvolle Informationen für Gesundheitsbeamte, Gesundheitsmanager und medizinische Teamleiter, um sich auf künftige Katastrophen vorzubereiten.

Routine-Gesundheitsinformationssysteme und Syndrom-Überwachungssysteme von Katastrophen erfüllen Aufgaben, die im Rahmen der Weltgesundheitsorganisation für klimaresistente Gesundheitssysteme festgelegt wurden: Gefahrenabschätzung, integrierte Risikoüberwachung und Forschung. Die Verwendung der genannten Systeme funktioniert möglicherweise nicht bei der Notfallbewältigung und Wiederherstellung, wenn Strom, Festnetzanschlüsse und Mobiltelefonverbindungen während der Katastrophe ausfallen. Da Frühwarn- und Notfallbewältigungssysteme flexible Instrumente zur Echtzeit-Berichterstattung sind, ist die Kombination mit Routinesystemen optimal, um sowohl den Klimawandel als auch die Auswirkungen der Katastrophen auf die Gesundheit zu überwachen. Die Erkenntnisse aus den vorliegenden Analysen dienen als Pilotanalyse für zukünftige Studien im Bereich Klima und Gesundheit. Durch die weitere Verwendung von Routinesystemen können nicht-übertragbareund übertragbare Krankheiten sowie Verletzungen über einen längeren Zeitraum hinweg besser überwacht und in Modellierungsstudien mit Umweltvariablen einbezogen werden.

Die vorliegende Studie hat gezeigt, dass Lücken in der Nutzung von Gesundheitsinformationssystemen bestehen. Daher wird empfohlen beide Informationssysteme die für diese Arbeit zu nutzen und unter Berücksichtigung der Indikatoren für Leistungsqualität und der Systemleistung zu bewerten. Einzelpersonen und Institutionen, die in den Bereichen Katastrophenschutz, Klimaresistenz und Informationsmanagement tätig sind, müssen zusammenarbeiten, um eingeschränkte Einsätze zu vermeiden. Daher wird eine nationale Initiative zur Überwachung von Syndromen vorgeschlagen, die in das philippinische „Integrated Disease Surveillance and Response System" integriert wird. Ihre Einrichtung würde weitere Diskussionen über die Richtlinien zur Überwachung von Krankheiten durch das „Health Emergency Management Bureau" und das „Epidemiology Bureau" des philippinischen Gesundheitsministeriums bedeuten.

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List of Publications

Published peer-reviewed articles which are part of the thesis

- **Salazar, M. A.**, Law, R. and Winkler, V. (2018). Health Consequences of an Armed Conflict in Zamboanga, Philippines Using a Syndromic Surveillance Database. Int J Environ Res Public Health 15, doi:10.3390/ijerph15122690.

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- **Salazar, M. A.** (2017). Introducing Morbidity Data Analytics in a Community Health Center in the Philippines: The Experience of San Jose de Buenavista, Antique., Institute of Philippine Culture, Ateneo de Manila University, Quezon City.

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Unpublished technical reports not part of the thesis

- Dorotan, M. M., **Salazar, M. A.**, Chua, P. L., Estanislao, R. D. and Sigua, J. A. (2018). A Review of Climate and Health Research in the Philippines: Mapping the Themes, Actors, and Gaps, Philippine Council for Health Research and Development, Quezon City.

- Water and Environment International (2018). Environmental Health in Disasters for Mekong Countries: A Guidance Document for WHO Environmental Health Officers, WHO Regional Office in the Western Pacific, Manila.

- Marcelo, P. F., Salisi, J. and **Salazar, M. A.** (2014). Assessment of Current Health Information System (HIS) and Building Capacity for HIS in Malita, Davao del Sur Final Report, WHO Regional Office for the Western Pacific, Manila.

Curriculum Vitae

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EDUCATION

Since February / 2017	Doctoral Student at Institute of Global Health at Heidelberg University Topic of Thesis: Syndromic surveillance for governance in health emergencies and disaster risk management in the Philippines
September / 2014 – September / 2015	Master of Science in International Health at Institute of Global Health at Heidelberg University Topic of Thesis: A descriptive analysis of the post-disaster health impact of a flood, an earthquake and a typhoon in the Philippines for 2013 using a syndromic surveillance database (SPEED)
June / 2004 – April / 2009	Doctor of Medicine at the University of the Philippines Manila
June / 2000 – April/ 2004	Bachelor of Science in Psychology at the University of the Philippines Diliman

Professional Experience

Since February / 2017	Consultant for Alliance for Improving Health Outcomes Inc. (AIHO), Quezon City, Philippines - Cluster Lead for Northern Luzon (2017), facilitated and headed regional consultations for the National Unified Health Research Agenda 2017-2022 of the Philippine National Health Research System in regions I, II, III and CAR. - Lead organizer and facilitator (2018) for the DAAD/PCHRD funded workshop, Strengthening Research in Global Health in Disaster Risk Reduction and Climate Change Adaptation in the ASEAN Region. - Senior research specialist (2018) for the PCHRD funded project, A Review of Climate and Health Research in the Philippines: Mapping the Themes, Actors, and Gaps. - Consultant (2017) for the DOH funded project, Development of a National Framework on Strengthening Hospital Regulation.
Since November / 2017	Associate for Water and Environment International, USA - I contributed to the development of the guidance document for WHO WPRO, “Environmental Health in Disasters for Mekong Countries: A Guidance Document for WHO Environmental Health Officers”. We consolidated different environmental health guidelines for disasters and emergencies tackling the following: (1) shelter and emergency settlements, (2) water supply, (3) sanitation, (4) food safety, (5) vector and pest control, (6) control of communicable diseases and prevention of epidemics, (7) special incidents: chemical and radiation emergencies and (8) mortuary services and handling of the dead.
October / 2016 – November / 2016	Consultant for the WHO European Centre for Environment and Health, Bonn, Germany - I content-proofed the draft publication “Protecting health from climate change in Europe: 2017 update”.

October / 2015 – December / 2015	Intern at the WHO European Centre for Environment and Health, Bonn, Germany - I contributed to the following meetings: (1) Environmentally sustainable health systems, (2) Health co-benefits of mitigation: evidence and methods for decision support, and (3) Flood Meeting (with representatives from member states of WHO EURO) - I contributed to the development of the guidance document, "Flooding: Managing Health Risks in WHO European Member States".
February / 2014 – June / 2014	Technical Assistant for Information Management of the Health Cluster at the World Health Organization Philippine Country Office - Provided technical assistance to the Health Emergency Management Bureau of the Department of Health for information management for rehabilitation and recovery efforts for Typhoon Haiyan, Zamboanga Armed Conflict, Typhoon Bopha and the Bohol Earthquake. - Provided technical assistance in the crafting of Philippine national guidelines for the management of the dead in disasters
November / 2013 – January / 2014	Research Associate at the National Telehealth Center, University of the Philippines Manila - As part of an APW with the WHO Country Office in the Philippines, I contributed to the development of the report, Assessment of Current Health Information System (HIS) and Building Capacity for HIS in Malita, Davao del Sur. I facilitated a workshop which shared the findings of the report to the stakeholders, mainly the health office of the Municipality of Malita.
December / 2012 – August / 2013	Project Officer at Health Futures Foundation Inc (HFI), Philippines - I headed the community health program, Alaga Ka, a technical assistance to the municipality of Balete, Batangas.

January / 2011 – November / 2012	Medical Officer (Orthopedic Resident) at the University of the Philippines – Philippine General Hospital, Department of Orthopedics -Clinical practice and training in orthopedics
August / 2009 – October / 2010	Associate Acupuncturist at the Traditional and Integrative Medicine Clinic, University of the Philippines – Philippine General Hospital -Clinical practice in medical acupuncture; lecturer for medical acupuncture

Teaching Experience

Since July 2017	Lecturer at Public Health Program of the Graduate School of Angeles University Foundation, Pampanga, Philippines - Classes: (1) risk communication, (2) health policy, (3) disease control and (4) public health informatics

Additional Skills

Coding skills

Stata	Good Knowledge

Language skills

English	Proficient
Filipino	Native language

Licences

Physician (Medical Doctor)	Professional Regulation Commission (Philippines) – since 2009 and valid until 2021
Certified Medical Acupuncturist	Philippine Institute of Traditional and Alternative Health Care – Department of Health (Philippines) since 2009 and valid until 2021

Acknowledgements

This thesis would not be possible first and foremost without my family: my wife Joyce and my son Miro. Without them, I would not have the motivation to complete the work. I would like to thank Joyce for allowing me the time spent away from her and my son.

I would also like to thank my family in Heidelberg, the staff and academics of the epidemiology and biostatistics unit of the Heidelberg Institute of Global Health. I would like to show my gratitude to Prof. Dr. Sabine Gabrysch, Dr. Andreas Deckert, and Elke Braun-van der Hoeven. They have made this doctoral journey achievable despite difficulties. I would like to give a special thank you to my thesis advisor Dr. Volker Winkler. He has been invaluable in writing this thesis and the publications that have been produced through our collaborative work. He has been such a supportive supervisor and mentor.

I would also like to acknowledge the people who have helped me learn more about public health, epidemiology, H-EDRM, and climate change in the real world of global health. I would like to thank Dr. Miguel Dorotan, Paul Chua, Deo Estanislao, Jem Sigua, Dr. Lester Geroy, Dr. Juan Leonardia, Teddy Dizon, Dr. James Salisi, Dr. Yves Aquino, Dr. Ronald Law, and Dr. Arturo Pesigan for their help in our projects and manuscripts on H-EDRM, public health, and climate change & health. I would specifically like to acknowledge the work that Paul Chua has contributed in creating Figure 7 in this thesis. I would also like to thank Dr. Vladimir Kendrovski, Dr. Gerardo Sanchez Martinez, and Terrence Thompson for giving me more opportunities to work on projects thus improving my knowledge and analysis for my thesis.

I would also like to thank our research partners. These include the Health Emergency Management Bureau under Dr. Gloria Balboa, the eHATID LGU team under Dr. Dennis Batangan, and Dr. Marcelino Villafuerte of the Climatology and Agrometeorology Division of DOST-PAGASA.

I would also like to thank the members of HIGH teaching unit, Dr. Olaf Horstick, Dr. Andreas Ruppel, and Dr. Pauline Grys. They have made staying in Heidelberg light and fun thus improving my mental health while writing my thesis.

Affidavit

Eidesstattliche Erklärung zum Antrag auf Zulassung zur Promotion gemäß PromO „Dr.sc.hum.“

1. Ich habe an keiner anderen Stelle einen Antrag auf Zulassung zur Promotion gestellt oder bereits einen Doktortitel auf der Grundlage des vorgelegten Studienabschlusses erworben und mich auch nicht einer Doktorprüfung erfolglos unterzogen (dies schließt äquivalente Verfahren bzw. Titel ausserhalb Deutschlands ein).

2. Die an der Medizinischen Fakultät der Universität Heidelberg zur Promotion eingereichte Arbeit mit dem Titel:

“Syndromic surveillance for governance in health emergencies and disaster risk management in the Philippines”

Am **Institut für Global Health**

unter Anleitung von Doktorvater PD Dr. sc. hum. Volker Winkler

Abhandlung aufgeführten Hilfsmittel benutzt.

3. Die Arbeit oder Teile davon habe ich bislang an keiner Hochschule des In- oder Auslands als Bestandteil einer Prüfungs- oder Qualifikationsleistung vorgelegt.

4. Die Dissertation wurde ohne Hinzuziehung einer kommerziellen Promotionsberatung erstellt.

5. Mit der Veröffentlichung meines Lebenslaufes im Rahmen des Promotionsverfahrens (Dissertation) bin ich einverstanden.

6. Ich komme der Veröffentlichungspflicht gemäß § 13 PromO nach und stimme der Veröffentlichung der Zusammenfassung meiner Dissertation im Internet unter Angabe meines Namens und des Studienabschlusses zu.

7. Die Bedeutung der eidesstattlichen Erklärung und die strafrechtlichen Folgen einer unrichtigen oder unvollständigen eidesstattlichen Erklärung sind mir bekannt.

Ich versichere an Eides statt, dass ich nach bestem Wissen die reine Wahrheit erklärt und nichts verschwiegenhabe.

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