NUTRITIONAL STATUS, HAEMATOLOGICAL AND IMMUNOLOGICAL CHANGES AND HEAVY METAL EXPOSURE IN VICTIMS POST MASSIVE FLOOD IN TUMPAT, KELANTAN

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by

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"You nurtured and protected me and taught me with great care. And every time I've needed you, you were always there"

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LIST OF SYMBOLS

<	Less than
>	More than
Δ	Delta
°C	Celsius
µ	Micro
fL	Femtoliter
G	Gram
Km	Kilometre
mL	Mililitre
N	Nano
P	Rho
Pg	Picogram
A	Alpha
B	Beta
Γ	Gamma
Z	Zeta
Σ	Standard deviation

LIST OF ABBREVIATIONS

AA	Atomic absorption
AKSB	Air Kelantan Sdn. Bhd
APCs	Antigen-presenting cells
As	Arsenic
BCRs	B cell receptors
BQL	Below quantitation limit
Cd	Cadmium
CD	Cluster of differentiation
CFCS	Community & family case studies
CMIA	Chemiluminescent Microparticle Immunoassay
CO	Cutoff rate
Cr	Chromium
DCs	Dendritic cells
DOE	Department of Environment
DTH	Delayed-type hypersensitivity
EDTA	Ethylenediaminetetraacetic Acid
FBC	Full blood count
GDP	Gross domestic product
GFAAS	Graphite furnace atomic absorption spectrophotometry
H_2O_2	Hydrogen peroxide
H_2SO_4	Sulphuric acid
Hb	Haemoglobin
HCI	Hydrochloric acid

Hg	Mercury
HNO_3	Nitric acid
HPA	Hypothalamic–pituitary–adrenal
HUSM	Hospital Universiti Sains Malaysia
IDA	Iron deficiency anaemia
IFN-γ	Interferon-gamma
Ig	Immunoglobulin
IL	Interleukin
LOD	Limit of detection
LOQ	Limit of quantitation
MCH	Mean corpuscular haemoglobin
MCV	Mean corpuscular volume
MHC	Major histocompatibility complex
$NaBH_4$	Sodium borohydride
NaOH	Sodium hydroxide
NCDs	Non-communicable diseases
NGOs	Non-government organizations
NK	Natural killer
NKCC	Natural killer cell cytotoxicity
Pb	Plumbum
Plt	Platelet
PTFE	Polytetrafluoroethylene
PTSD	Post-traumatic stress disorder
RBC	Red blood cell
RM	Ringgit Malaysia

SLE	Systemic lupus erythematosus
$SnCI_2.2H_2O$	Tin (II) chloride dihydrate
SS	Suspended Solid
TDS	Total dissolved solid
Th	T helper
TRBC	Total red blood cells
TRGS	Transdisciplinary Research Grant Scheme
TSS	Total suspended solid
TWBC	Total white blood cells
Zn	Zinc

PERUBAHAN KE ATAS STATUS PEMAKANAN, HEMATOLOGI DAN IMUNOLOGI DAN PENDEDAHAN TERHADAP LOGAM BERAT DALAM KALANGAN MANGSA BAH SELEPAS BANJIR BESAR DI TUMPAT, KELANTAN

ABSTRAK

Banjir besar yang dikenali sebagai "Bah Kuning" yang melanda Kelantan pada Disember 2014 adalah yang paling teruk dalam sejarah dan telah menjejaskan status kesihatan dan sosioekonomi mangsa. Akibat banjir, terdapat kesan segera atau lambat daripada aspek hematologi dan imunologi. Kajian mengenai perubahan fisiologi selepas banjir adalah terhad. Kajian ini bertujuan untuk menilai faktor sosiodemografi, status pemakanan, pendedahan terhadap logam berat, dan parameter hematologi & imunologi mangsa banjir yang mencerminkan kesan banjir besar 2014. Satu kajian rentas dalam kalangan mangsa banjir telah dijalankan di daerah Tumpat, Kelantan dari Mei hingga Ogos 2015 yang melibatkan 297 peserta. Kajian ini dilakukan 4 bulan selepas banjir. Para peserta telah direkrut dari lawatan rumah untuk menjawab soal selidik berkaitan sosiodemografi dan tahap ketidakjaminan dapatan makanan isi rumah. Sampel darah diambil dari dua orang dewasa (wanita dan lelaki) dalam satu isi rumah. Sampel darah kemudian diuji untuk analisis subset penuh, feritin, analisis subset limfosit, serum imunoglobulin (IgG, IgA dan IgM), folat sel darah merah dan analisis logam berat (kadmium, arsenik,plumbum dan raksa). Sebagai sebahagian daripada penyelidikan ini, kajian perbandingan keratan rentas turut dijalankan untuk membandingkan profil makmal dalam kalangan mangsa banjir dan bukan banjir. Penilaian terhadap tahap ketidakjaminan dapatan makanan isi rumah menunjukkan 71.6% isi rumah diklasifikasikan sebagai golongan ketidakjaminan

dapatan terhadap makanan. Parameter sosioekonomi dikaitkan dengan keselamatan makanan isi rumah, p=0.001. Lapan peserta adalah anemik dan semua peserta mempunyai folat RBC biasa manakala 27 orang mempunyai serum feritin yang tinggi. Tiada hubungan langsung antara parameter tahap ketidakjaminan dapatan makanan isirumah dan parameter makmal. Sebagai perbandingan dengan peserta kawalan (bukan mangsa banjir), hemoglobin jauh lebih rendah (p=0.02) dan jumlah sel darah putih jauh lebih tinggi (p=0.012) pada mangsa banjir lelaki. Monosit didapati lebih tinggi di kedua-dua mangsa lelaki dan perempuan masing- masing adalah, p=0.003 dan p=0.048. Peratusan dan kiraan mutlak CD4 lebih tinggi manakala peratusan CD8 menunjukkan penurunan yang signifikan pada mangsa banjir lelaki, p<0.05. Selain itu, nisbah CD4:CD8 juga signifikan antara lelaki, p=0.012 manakala semua serum imunoglobulin lebih tinggi pada mangsa banjir wanita, p<0.05. Logam berat dikesan dalam sampel darah peserta dan dalam satu sampel air telaga tetapi di bawah paras berbahaya. Sebagai kesimpulan, banjir mungkin menyumbang kepada beberapa risiko kesihatan subklinikal terutama dari segi perubahan imunologi yang dilihat di kalangan mangsa. Walaupun penemuan kajian ini tidak dapat disahkan secara langsung berkaitan dengan kesan banjir, hasilnya boleh digunakan untuk meramalkan kemungkinan komplikasi kesihatan yang mungkin berlaku jika masalah sosioekonomi dan tahap ketidakjaminan dapatan makanan/air isirumah tidak ditangani dengan baik selepas banjir.

NUTRITIONAL STATUS, HAEMATOLOGICAL AND IMMUNOLOGICAL CHANGES AND HEAVY METAL EXPOSURE IN VICTIMS POST MASSIVE FLOOD IN TUMPAT, KELANTAN

ABSTRACT

Massive flood known as "Bah Kuning" that hit Kelantan in December 2014 was the worst in the history of the state affecting health and socioeconomic status of the victims. There were immediate and delayed effects of the flood from the haematological and immunological aspects. There are limited studies pertaining to the physiological changes post disaster. This study aimed to assess the sociodemographic factors, nutritional status, heavy metal exposure, haematological & immunological parameters of the victims reflecting the impact of the 2014 massive flood. A cross-sectional study among flood victims was conducted in Tumpat district of Kelantan from May until August 2015 involving 297 participants. The study was done 4 months post-event. Participants were recruited from house visits to answer questionnaires regarding sociodemographic and food security related questions. Blood samples were taken from two adults (female and male) in a household. The blood samples were then tested for full blood count (FBC), ferritin, lymphocyte subset analysis, serum immunoglobulin levels (IgG, IgA and IgM), red blood cell folate (RBC folate) and heavy metals analyses (cadmium, arsenic, plumbum and mercury). As a part of this study, a cross-sectional comparative study was done to compare the laboratory profiles among the flood and non-flood victims. The finding from the food security assessment showed that 71.6% were classified as food insecure category. Socioeconomic parameters were significantly associated with household food security, p=0.001. Eight participants were found anaemic and all participants had normal RBC folate while 27

had high serum ferritin. There was no direct association between food security and laboratory parameters. In comparison with control participants (non-flood victims), haemoglobin was significantly lower (p=0.02) and total white blood cell (TWBC) was significantly higher (p=0.012) in male flood victims. Monocytes counts were found higher in both male and female victims, p=0.003 and p=0.048 respectively. The percentages and absolute counts of CD4 were higher while the percentages of CD8 showed significantly lower in male flood victims, $p<0.05$. Besides that, CD4:CD8 ratio was also significantly different in males, p=0.012 while serum immunoglobulins were all significantly higher in female flood victims, $p<0.05$. Heavy metals were detected in participants' blood samples and in one well water sample but below the harmful cut off levels. In conclusion, the flood might have contributed to some subclinical health risk especially from the immunological changes seen among the victims. Although the findings could not be confirmed directly related to the flood effect, the result could be used to predict possible health complications that could occur if the socioeconomic problems and food-water securities were not handled appropriately post-event.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Flood catastrophe is among the world's most frequent and damaging type of disaster. In the East Coast of Peninsular Malaysia, flood is an annual incidence. However, in the year of 2014, there was a massive flood that occurred during the Northeast monsoon in December. In this event, Kelantan was the most affected state among other states as it is located at the East Coast of Peninsular Malaysia. The flood occurred from 15th December 2014 to 3rd January 2015. In Southeast Asia, this annual monsoon season also hits a few countries such as West Malaysia, Southern Thailand, Indonesia and Sri Lanka.

The flood in 2014 mentioned above was recorded as the largest and most significant in the history of Kelantan state displacing almost 202,000 victims from eight out of ten affected districts of the state (Baharuddin *et al.*, 2015). The massive flood had left a trail of destruction to the community including affecting their health and socioeconomic status. Those who were affected by the massive flood event included the breadwinners of the family. They worked in the fields and most of them were self-employed. Poor socioeconomic status and improper oral consumption might lead to nutritional and immunological changes post-flood event. Impact of flood may vary due to poverty status, socio-structural inequality and other related factors.

The destructive effect of the flood also depends on the water level as measured by the dedicated river bank. The flood has brought the risk of contamination to food supply and water sources. Apart from communicable diseases, exposure to heavy metals such as arsenic (As), plumbum (Pb), mercury (Hg) and cadmium (Cd) may arise through various ways including diet, medications and environment. The Department of Environment (DOE) announced that the Kelantan River was classed as a polluted river based on the Suspended Solid (SS) Index with the sequence in order of severity of Pb > zinc (Zn) > Cd > chromium (Cr) > As > Hg. These were caused by the sand mining activities and logging activities in the upstream areas (Lojing Highlands) which lead to largest variation of total suspended solid (TSS), total dissolved solid (TDS), nitrogen nutrients displacement and turbidity (Ambak and Zakaria, 2010; Yen and Rohasliney, 2013). Fine silt and debris that were carried by the rainwater from the catchment area increased the amount of TSS throughout the monsoon season (Yen and Rohasliney, 2013). The overflow of Kelantan River during flooding season might also contaminate the housing area and well water supply.

Human projects for example heavy metal industries and mining may result in increased concentrations of heavy metals that would be found naturally. Intentional or unintentional ingestion of metal exposure, if unrecognized or inappropriately treated can result in significant morbidity and mortality leading to impairment of the health status of a population (Soghoian and Sinert, 2009). Limited access to clean water due to flood will urge the community to use the well water which may be contaminated with these inorganic substances. These metals tend to bio-accumulate in tissues and prolonged exposure at a higher concentration can lead to medical problems. As the consequences, it will increase the risk to ill health and chronic problems such as

neurological disorders, cancers and chronic anaemia. Hence, the severity of the flood increases the risk of obtaining certain diseases through lack of access to safe water, poor nutritional status and possible association with impaired immune responses (Watson *et al.*, 2007).

Flood also restricts food access. The wide ranges of health outcomes post-flood for adults are associated with food security (Ramsey *et al.*, 2012). Improper oral intake and acquiring contaminated food and water supplies may cause nutritional deficiencies and superimposed immune deficiency which may lead to higher risk of contracting infections or other non-communicable diseases (NCDs) such as chronic heavy metal poisoning and anaemia. Severe health problem including reduced protection to infectious diseases is one of the substantial effect due to mineral and vitamin scarcity (FOA, 2017). Vitamin A, iron and iodine are the most common micronutrient deficiencies. Iron deficiency is the most prevalent dietary deficiency that result in anaemia (Mirmiran *et al.*, 2012). Hence it is important to ensure food security of the community by improving nutritional status during and after flood events.

Nutritional deficiencies such as folate, iron and vitamin B_{12} lead to haematological abnormalities such as anaemia. One of the reasons of iron deficiency anaemia (IDA) is reduced dietary intake and can be detected by a few tests such as serum ferritin and red blood cell (RBC) parameters (Moll and Davis, 2017). Folate deficiency is the most common vitamin deficiency that causes anaemia (de Benoist, 2008). RBC folate was used to indicate long-term folate status (Organization, 2015). Besides, serum ferritin is also known as the most sensitive test for iron deficiency anaemia (Goddard *et al.*,

2011). Ferritin levels were expected to decrease in iron deficiency anaemia but may be normal or high if inflammation occurs concurrently (Punnonen *et al.*, 1997).

Kelantan state has been chosen for this study as it is one of the massively affected areas by the flood in 2014. In addition, Kelantan had the lowest mean monthly income (Ringgit Malaysia (RM) 3,168) among all the states of Malaysia as reported during 2012 (Department of Statistic, 2013). Kelantan was categorised as a less developed state and among the highest of poverty incidence (4.8%). The state also had the lowest gross domestic product (GDP) growth rate in peninsular Malaysia (Economic Planning Unit, 2010). District of Tumpat was chosen for this study as it was one of the massively affected districts by the flood in the year of 2014. It is located along the Kelantan River bank where flood disaster occurred. The participants were selected based on the engagement in the community & family case studies (CFCS) programme. Therefore, the purpose of this study was to investigate the impact of such catastrophe on nutritional, immunological and haematological changes and heavy metal exposure among the flood victims in the selected area of Tumpat.

1.2 Problem Statement

Changes in nutritional and immunological parameters among flood victims post-event may affect their health status on the long-term run. Following the flood disaster, physiological changes may directly or indirectly result in other medical problems such as the risk of contracting infections and other chronic NCDs. There is a possibility of heavy metal presence in the blood of the flood victims due to oral consumption from environmental contamination during the flood. This may affect the health status of the

community and probably impose some chronic health problems from immunological and haematological aspects.

1.3 Rationale of the Study

Flood is one of the natural disasters that happens all over the world and is a common event in East Coast of Malaysia. However, massive flood disaster is a rare event. The flood in 2014 was recorded as the largest and most significant since the one documented in 1967. Climate change is one of the reason caused the massive flood to occur and probably recur in future. Readiness to face such catastrophe is important. It leaves tremendous impact on people's lives and the environment.

Study on the well-being of the flood victims after the massive flood is lacking especially in Malaysia. It is known that natural disaster will affect the food security, environment and vulnerability towards diseases including changes in haematological & immunological parameters. There are limited studies in Malaysia and South-East Asia as a whole on the health and environmental effects of flood to the local population. Studies are needed to explore these possible changes that may harm the community, for example, the extended timeframe of the impacts of the flood on people, their homes and health consequences. The whole community are at greater risk from the implications of secondary stressors from the damages affecting their welfare, physical and psychosocial wellbeings.

Food insecurity is known to contribute to the health status of post-disaster victims. Thus, together it is important to assess factors contributing to food insecurity such as the household income, income per capita, poverty line and extend of damage after the

flood among the victims. These informations may help to assess the holistic effects of the massive flood to the local community. Besides that, the health of the post-flood victims can be assessed through laboratory profiling of the affected area. For these reasons, hopefully, will enable further interventional studies to be carried out in future and protect the wellbeing of the flood victims.

This study was carried out four months after the massive flood event and the findings are still considered reliable. This is based on the expected delayed impact of the massive flood which may continually affect the community health and environment. Physiological changes from haematological and immunological parameters are expected to take time to be manifested after the flood event from various reasons including psychological stress factor.

1.4 Hypotheses

1. There is an association between sociodemographic and household food security statuses.
2. There are relationships between household food security and anaemia (haematological findings) & immunological parameters.
3. There are differences in haematological and immunological parameters among post-flood victims and non-flood victims based on laboratory profiling.
4. There is presence of heavy metals in the blood of flood victims and water contamination from the flood event.

1.5 Research Questions

1. Are biosocial parameters such as socioeconomic status contributed to the non-communicable morbidities from the immunological and haematological perspectives (laboratory parameters) among post-flood victims?
2. What are the haematological and immunological changes among post-flood victims following the massive event in Kelantan?
3. Whether the water supply and blood samples of post-flood victims showed contamination with heavy metals during flood event?

1.6 Objectives of the Study

General objective:

To study the sociodemographic factors, nutritional status, haematological & immunological parameters, and environmental changes reflecting the impact after 4 months of a massive flood event in 2014 in Tumpat, Kelantan.

Specific objectives:

1. To describe sociodemographic and household food insecurity among the flood victims post-event in Tumpat, Kelantan.
2. To describe the haematological and immunological parameters based on laboratory profiles post-flood victims in Tumpat, Kelantan.
3. To determine the association between sociodemographic and household food insecurity.
4. To determine the association between household food security and anaemia (haematological parameters) & immunological parameters.
5. To compare the haematological and immunological parameters among the flood victims post-event and non-flood victims based on laboratory profiles.
6. To investigate the presence of heavy metals in the blood and water samples of the flood victims as part of possible environmental changes at the affected area.

1.7 Significance of the Study

It is important to assess and estimate the effects of the 2014 massive flood on the community's socioeconomic livelihoods and their health statuses. There are people in village community in Kelantan state still depending on well water. Hence, water sanitation is a serious problem in flood-affected areas. Flood and waterlogging in the near area also influenced the water and sanitation practices of the community as these factors may contaminate the local water supply. Floods may bring a lot of debris and waste to the common water sources, for example, dead animals and human waste products.

Flood event indirectly reduces economic and agricultural production thus decreasing social-economic welfare. Household incomes also can be affected and hence the purchasing power of the community. These factors will alter food consumption pattern and nutritional intake of the flood victims, particularly post massive catastrophic event. Changes in consumption patterns can have negative impacts on the health and could be one of the reasons for high malnutrition and consequently anaemia and other medical consequences. The outcomes of this study are expected to give insights and improvement to the future health planning of flood victims. In addition, the findings may lead to association of possible physiological changes post-event as detected by some laboratory parameters conducted in this study.

Based on study findings, higher authorities can ensure food security in the flood-prone area, providing welfare and reducing poverty-related malnutrition from the recurring disaster. Besides, it will be helpful for other researchers who are interested in doing advanced works on the same topic. They may adopt the basis of these findings in

predicting flood-related health outcomes, as well as long-term monitoring of potential delayed health effects after a few months of flood. This includes acknowledgement of the specific aspects of water and food supplies, gender and other vulnerable groups in the community. This study is expected to benefit future communities living in flood-prone areas, policymakers, researchers, disaster managers and funding agencies.

1.8 Conceptual Framework

A conceptual framework of the contributing factors leading to impairment of post-flood victims health status is shown in Figure 1.1. The conceptual framework illustrates the various levels of causes consisting of biological, host & environmental causes and underlying causes that propose potential pathways that may impair the health of the flood victims.

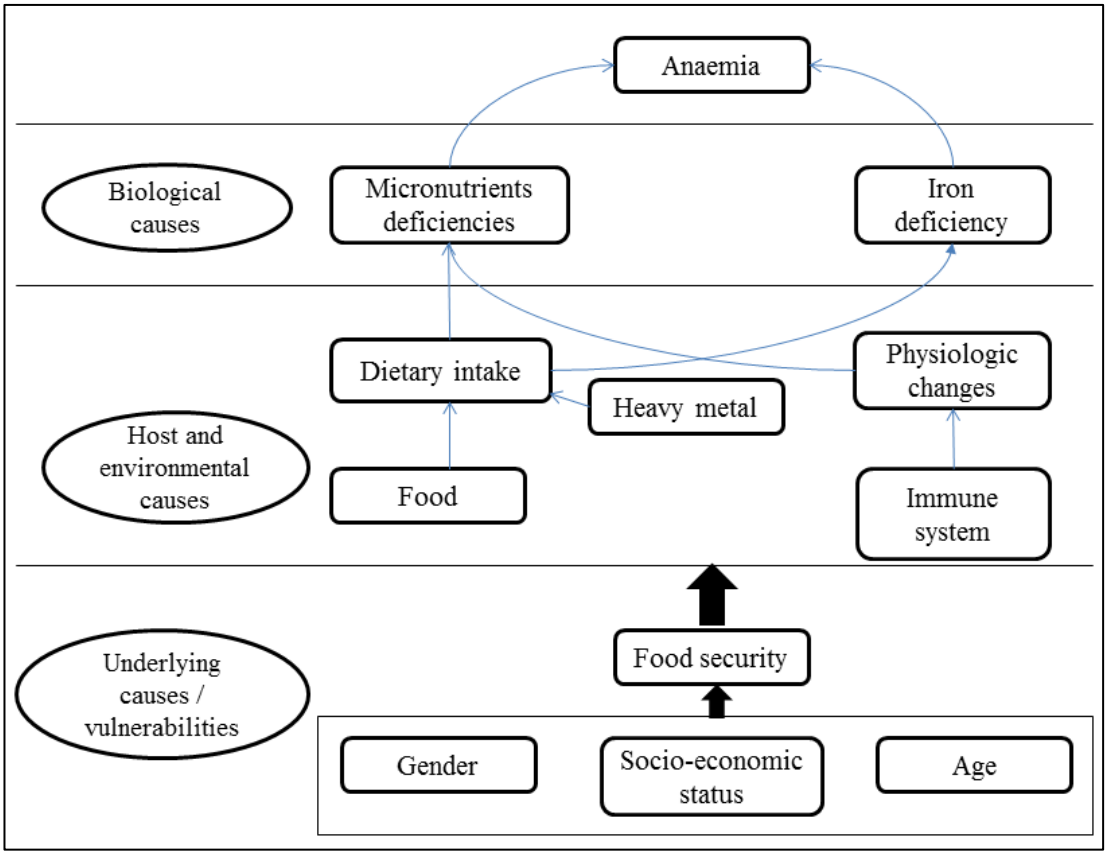

Figure 1.1: Conceptual framework adapted with modification from Nguyen *et al.* (2015).

1.9 Operational Definitions

Flood: Flood is an overflow of large amount of water covering of land beyond its normal limits.

Flood damage: Damage to receptors (buildings, infrastructure, goods), production and intangibles (life, cultural and ecological assets) by a flood.

Flood disaster: A flood event that has the potential to cause harm with resulting great damage or loss of life.

Household: A person or group of people who occupy the same primary residence regarded as a unit.

Income: Amount of incoming money from various sources at the end of each month especially on regular basis.

Vulnerability: The conditions determined by physical, social, economic and environmental factors, which increase the susceptibility of a community to the impact of hazards (e.g. Flood).

Food security: A state when all people at all times, have physical and economic access to sufficient quantity, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Food insecurity: A state in which consistent access to adequate food is limited by a lack of money and other resources at times during a year.

Income per capita: Income per capita is a calculated amount of money earned per person in a certain area and is used as a method in evaluating the living conditions.

Poverty line: A level of personal or family income classified as poor according to governmental standards to secure the necessities of life.

Household income: Household income is the combined gross income of all the members sharing a particular household includes every form of income.

1.10 Outlines / Thesis Overview

This thesis is separated into chapters.

Chapter 1 gives a concise background on the study.

Chapter 2 narrate the report of related study on flood, heavy metal, food security and immune system.

Chapter 3 presents the methodology in assessing food security, determination of heavy metal, immune response and haematological parameters of the flood victims.

Chapter 4 provides the results and analyses of the study.

Chapter 5 discusses the results and lastly

Chapter 6 gives conclusions, limitations and suggestions for future study.

Appendix A provides consent form

Appendix B provides ethical approval

Appendix C provides questionnaire for the study

List of publication and abstracts in conferences

CHAPTER 2

LITERATURE REVIEW

2.1 Flood Disaster

Natural disaster is generally known to be disaster caused by nature or natural processes of the earth. Flooding is one of the most common natural disasters that occur all around the world. The scenario happens with the contribution of heavy rains, the edge of the river will rupture cause overflow water out onto the floodplain (Pradhan, 2010). In China (1959) and Bangladesh (1974) flood has cause devastating impact. This disaster can develop endangered society because of the elevated chronic health effects of flooding, for example, injury and post-traumatic stress disorder (PTSD) (Ramin and Svoboda, 2009).

In Malaysia, fortunately, this country does not face natural disasters that commonly happened elsewhere such as the earthquakes, volcanoes eruption, typhoons and others. However, the flood has been classified as the most serious natural catastrophe encountered in the country. For example, Northeast Monsoon is the monsoon flood that happens during November to March upon substantial rainfalls to the East Coast States of the Peninsula, Southern part of Sarawak and Northern part of Sabah and also flash floods in urban areas (Hassan *et al.*, 2006). This natural disaster has multiple environmental consequences that can also affect the public health (Euripidou and Murray, 2004).

Undersigned prompt development and unrestricted construction of buildings are examples of human actions that can influence towards the pattern of hazards (Khan *et al.*, 2014). Heat waves, floods and drought are the examples of extreme climate that possess direct consequences on fatality as well as longer-term issues. Intensity of a catastrophe is evaluated by mortality, economic loss such as property loss and the preparedness of the affected community to reconstruct after the disaster.

Natural disasters tend to be catastrophic and may contribute to a direct or indirect impact towards the public health and community wellbeing (Kousky, 2014; Watson *et al.*, 2007). Other than that, rapid population growth and environmental degradation also contribute to disaster severity especially among the poor countries (Lemonick, 2011). Population that experienced frequent flooding may experience constant increment in common mental derangement (Ahern *et al.*, 2005). These factors intensify the rationale for studying flood-related health consequences on affected individuals and communities.

2.1.1 Flood Disaster in Kelantan

Kelantan River (Sungai Kelantan) is the biggest river in the Kelantan state, with a catchment area approximately 11900 km^2 (Ahmad *et al.*, 2009). Local people benefited from the river for domestic uses, transportation, agriculture, small-scale fishing industries, plantation irrigation and sand mining project. There are about 128 sand mining activities along the waterway from Kuala Krai to Tumpat (Ambak and Zakaria, 2010). Presence of heavy metals in the river endangers freshwater species and results in impairment of human health if consumed (Hashim *et al.*, 2014). Annual disaster

from the monsoon are usually not massive with minimal damages to the properties and a small outbreak of infectious diseases.

However, in December 2014, overflow of Kelantan River had caused severe flooding as shown in Figure 2.1. The flood inundation showed severe area affected due to the flood (*Disaster Declaration*, 2014; *Flood Inundation*, 2014). The flood was recorded as the largest and most significant event in the history of Kelantan state displacing almost 202 000 victims (Baharuddin *et al.*, 2015). The flood is called 'yellow-coloured flood' because the colour of the water was yellowish-brown with the very high mud contents (Nor and Ahmad, 2015).

Pollution carried by massive flood water can be divided into two major groups: the first group includes primarily inorganic substances that contain heavy metals and nutrients, which are retained by physical or chemical absorption during the process of migration into the soil profile and finally enriched the flooded soil. The other group consists of the organic compounds present in the form of the pre-decomposed remains of plants and animal tissues. Excessive nitrate component may come from anthropogenic sources, for example, agricultural run-off, domestic sewage and other waste discharge involve nitrogenous compounds (Prasanna and Ranjan, 2010).

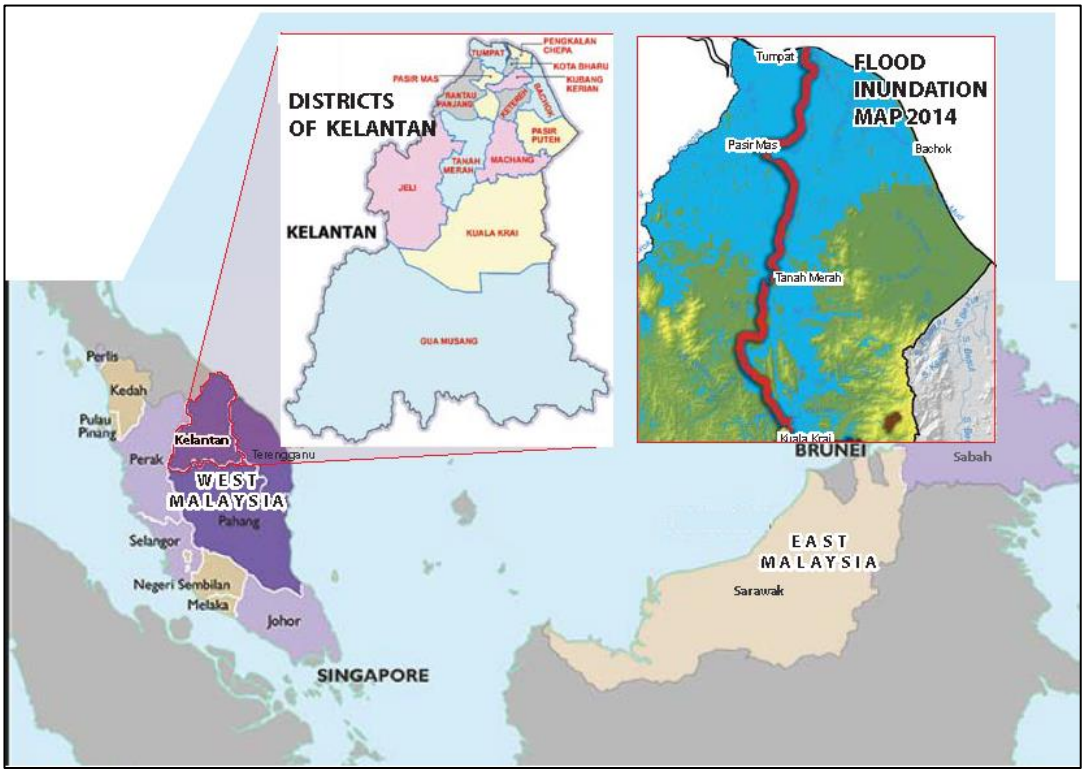

Figure 2.1: Flooding area involving Tumpat in Kelantan

A review study found that some runoff may have entered the water supply during heavy rainfall (Lowe *et al.*, 2013). In Kelantan, problems in water services are considered as a long-standing issue (Kamaludin *et al.*, 2013). Consumer complaints included dirty water, coloured water, unreliable of water services and frequent unscheduled water disturbances which disrupt their household activities (Malaysia, 2011). Air Kelantan Sdn. Bhd. (AKSB) is the only water provider in Kelantan (Zamri, 2009). Tumpat, Kota Bharu and Bachok receive their water source from groundwater while the rest of the district use surface water hence nominated AKSB as the largest groundwater operator in Malaysia. Surface water and groundwater are the main Kelantan water sources which constitute of 60% and 40% respectively (Kamaludin *et al.*, 2013). A study reported that status of the water source, for example, river water is related with the heavy metal contamination in drinking water (Bobaker *et al.*, 2014).

2.2 Impact of Flood on Health

Water damaged homes had significantly increased indoor humidity and visible mold growth as contrast with those in the undamaged properties. Even though the problem gradually decreased one week following flooding, the effects persevered for up to six months and escalated in properties with the increased flood levels (Azuma *et al.*, 2014).

Extreme events such as flooding give impact as secondary stressors to the long-term health of individuals. The consequences of flooding on health may be short term or long term and may varies (Ahern *et al.*, 2005; Alderman *et al.*, 2012). These ranges from instant results of physical injury to possibility of long-standing outcomes on the mental health.

2.2.1 Communicable Disease

Accessibility of clean water and uncontaminated facilities, the amount of crowding and the unrevealed health status of the community also influence the risk of communicable diseases in the affected population (Watson *et al.*, 2007). Enormous population displacement and increasing exposure for disease transference cause the communicable diseases transmission or epidemics to be observed days, weeks or even months following the disaster. Besides, increasing capacity and characteristics of the relocated population within the local disease ecology, lack of food, dietary status, poor private hygiene and low level of immunity to vaccine-preventable diseases may increase the disease transmission (Kouadio *et al.*, 2012).

In displaced community with lack of hygiene after flood, there are possibility of rises in disease epidemics, for example, Hepatitis E, gastrointestinal diseases and leptospirosis (Alderman *et al.*, 2012; Ligon, 2006). Following days post-flood disaster, soft tissue infections and injury are the probable consequences. While up to one-month post disaster, airborne, food-borne and water-borne diseases are expected (Lemonick, 2011).

In Malaysia, transition in temperature and difference weather basis following climate changes probably influence the dissemination and occurrence of food and water-borne diseases (Hassan *et al.*, 2014). Post-flood hence increase of cholera cases, typhoid (Biswas *et al.*, 2015), nonspecific diarrhea (Heller *et al.*, 2003) and paratyphoid (Vollaard *et al.*, 2004). Consuming contaminated water after flooding may cause diarrheal disease outbreaks. For example, occurrence of diarrhea outbreaks increases after floods in Mozambique in January-March 2000 (Kondo *et al.*, 2002).

Infections by vector-borne disease are complex. Floodwaters shatter breeding areas of mosquitoes which breed in or near to static, or slow-moving water and lower mosquito-borne transmission (Sidley, 2000). However, after some weeks' delay following disaster, this condition result in an upsurge of the vector population which facilitates disease transmission. These occurrences are influenced by the preferred habitat of the local mosquito vector species. The threat of vector-borne disease transmission is intensified due to the increased number of infected and susceptible hosts, inadequate public health facilities and delays of existing control programs.

Heavy rainfall and flooding also may increase disease transmitted infections by rodents such as leptospirosis (Vincent *et al.*, 2000). In Brazil, flooding of open sewers and streets throughout the rainy weather increased the risk component for leptospirosis (Sarkar *et al.*, 2002). In Mumbai, India, outbreaks of leptospirosis occurred after flooding in 2000 (Karande *et al.*, 2003).

2.2.2 Non-communicable Disease

Longstanding losses and stresses provoke by floods may lead to physical and social functioning deterioration (Heo *et al.*, 2008). A report found that, PTSD is the utmost frequent health disorder found in mankind affected by natural catastrophe (Mason *et al.*, 2010). There are a few factors that contribute to psychological disorders after natural disasters, for example, socioeconomic status, level of vulnerability, religion and community assistance (Neria *et al.*, 2008). In addition, a study noted that women, children and elderly were the most vulnerable groups in a disaster (Nishikiori *et al.*, 2006).

2.3 Food Security

Food security is identified through food adequacy, nutrient efficacy, cultural acceptability, safety, certainty and stability (Coates, 2013). Health is also associated with food security. Food security is achieved once every individual constantly have access to the sort of foods that empower them to live a dynamic and healthy life. Inadequate amount or poor standard in nutrition values contribute to malnourishment and weaken the general welfare.

The natural disaster caused by climate change may intensify poverty status and may cause malnutrition and bring about diseases (Sandhu and Singh, 2016). Poverty is one of the leading factor related to restricted access to clean water, hygiene, good nutrition, poor health and health care whether it is directly and indirectly (Kim *et al.*, 2013b). Besides that, groups with low income have limited allocation on food. Thus, the concern of increasing in food prices and food security among poverty-stricken group arises.

Food insecurity is a circumstance where inadequate food supply to the extent of consuming less foods or omit meals, provokes decreased nutrient intake that can result in nutrient deficiency including iron deficiency and iron deficiency anaemia (Bothwell *et al.*, 1996; Council, 2006; Eicher-Miller *et al.*, 2009). Deficiency in nutrition, food insecurity, poor physical and mental health have been proposed to be associated with the potential biological changes and stress mechanisms at the individual level.

On the other hand, unsatisfactory health status among food insecure population showed that inadequate nutrition resulted in a broad spectrum of health consequences (Vozoris and Tarasuk, 2003). In adults, a wide range of health outcomes is associated with limited/uncertain availability of nutritionally secure food (Ramsey *et al.*, 2012).

Nutritional status is strongly associated with the health status. Losing appetite, eating a poor diet and having a poor digestive system are traits of sick individuals. Hence, under nourished individual is further susceptible to infections due to declining immune system (Leathers and Foster, 2004).

2.3.1 Food Security Classification

The Radimer/Cornell Hunger and Food Insecurity Instrument was used for deciding the severity of food insecurity in a household based on 10-item questions (Radimer *et al.*, 1992). This questionnaire has been adapted in many studies on food security. In Malaysia, this instrument was translated into Malay language and was validated among low-income household in Kuala Lumpur (Sharif and Ang, 2001). This instrument was extensively employed in some studies conducted in Malaysia, for example, in a study of household food insecurity in rural district in Kelantan (Ihab *et al.*, 2013). This instrument highlighted that food insecurity is experienced differently at the household with sequenced level of severity and was found to be valid and reliable to be used in various populations (Kendall *et al.*, 1996; Kirkland *et al.*, 2013).

Food security status was obtained through qualitative interviews among women with children to assess the food security status. Food security status can be divided into four different categories which consist of "household food secure, household food insecure, individual food insecure and child hunger".

2.3.2 Factors Affecting Food Security

Basic factor that affects nutritional status is poverty. Poverty influences the ability to supply food, accessibility of food, sufficient care for mothers and children, suitable health environment maintenance and accessibility to health assistance. Nutrition is influenced by political status and accustomed socioeconomic of a province. Poverty-stricken households and human beings are incapacitated to reach food security due to

insufficient money for care and not able to employ resources for health on a sustainable basis (Smith and Haddad, 2000).

In children, food insecure causes limited intake of healthy food compared with food secure children. Consequently, they were unable to gain the essential iron needed for proper growth and development (Matheson *et al.*, 2002). A finding stated that participants in the food insecure household have unsatisfactory functional health level in contrast with those in foods secure households. The unfortunate consequences on the welfare of human beings in low-income communities reveal the relationship between food security and the element of life (Ihab et al., 2013).

In Malaysia, 58% of the household in the rural area encounter food insecurity (Haemamalar *et al.*, 2010). While in Kuala Lumpur, people who earn low wages reported that 65.7% of these household experienced food security issue (Baig-Ansari *et al.*, 2006). Socioeconomic outline, nutritional status and dietary intake of individuals and household have been evaluated as immediate measures of a person or household food insecurities (Baig-Ansari *et al.*, 2006).

Through reports, undernourished children were found to live in countryside society with high poverty index, for example, East coast and Northeast areas of Peninsular Malaysia, particularly in Kelantan (Zulkifli *et al.*, 1999). Owing to the poverty index with 12% below the poverty line for the household compared to 5% at national level, Kelantan claimed as second highest poverty index in the country (Economic Planning Unit, 2010). A few approaches to overcome food insecurity and food inequity were invented by nutritionists and health professionals. These include food support, small-

scale livestock set up & intervention and community awareness programs due to food insecurity levels in rural areas in Malaysia (particularly in Kelantan).

2.3.3 Nutrition and Infection

Micronutrient deficiencies such as vitamins A, C, E, mineral, iron and iodine cause weakened intellectual capacity, deficient growth, increased fatality and proneness to infection (Katona and Katona-Apte, 2008). In the establishment of immune system and configuration of antibody, micronutrients contribute a vital part. Nutritional deficit impairs immune response, particularly in cell-mediated immunity, phagocyte activity, cytokine production and antibody synthesis. Besides, undersupply of trace elements, vitamins and essentials fatty acids are contributing to deterioration of immunity in protein-energy malnutrition. (A Puertollano *et al.*, 2011).

Malnutrition in an individual caused him more vulnerable to infection and vice versa. Nutrition of a sick person's is more affected by malabsorption, diarrhea, loss of desire for food and diversion of nutrients for the immune response. These factors lead to nutrient deprivation and additional deterioration to defence mechanism hence result in reduced dietary intake (Müller *et al.*, 2003).

Nutrition determines the function of the body defense system hence it is related to the risk of illness. Malnutrition can cause a defect in the immune system, for example, humoural responses, cell-mediated responses, phagocytosis and the complement system (Cunningham-Rundles *et al.*, 2005). Undernutrition due to inadequate macronutrients and/or due to shortage of micronutrients can weaken the immune