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ROLE OF FORENSIC INVESTIGATIONS IN DISASTER RISK REDUCTION

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The field of forensics is growing rapidly and significantly. It has made significant impacts in the advancement of science and technology particularly in disaster risk reduction. This is also due by current shift in emphasis where science and technology is used in preventing disasters or minimizing the threats or risks, rather than in responding to disasters that have already occurred. Medical forensic investigation has gone beyond determining cause of death to provide insight to the nature of injury and harm caused that is relevant for onsite response during disaster and can be used to help reduce risks relating to response in similar disaster events. The Forensic Investigations of Disasters (FORIN), under the umbrella of the Integrated Research on Disaster Risk (IRDR) programme proposes an approach that aims to uncover the root causes of disasters through in-depth investigations going beyond the reporting and case studies conducted in post-disaster events. This paper briefly highlights areas of potential contribution of medical forensic investigations in disaster risk reduction in line with the directions of Hyogo Framework of Action and Sendai Framework for Disaster Risk Reduction.

Keywords: Medical Forensic Investigations, Disaster Risk Reduction and Disaster.

INTRODUCTION

Disasters destroy lives and livelihoods around the world. Between 2000 and 2012, 1.2 million people died in disasters and an estimated US$ 1.7 trillion of damage was sustained (UNISDR 2000-2012). Disaster risk reduction (DRR) activities aim to reduce the human, economic and environmental costs of such disasters. Science can play an essential role in these efforts, uncovering new ways to prevent, prepare and respond to disasters and determining which technologies are most effective in reducing disaster risk. As a result of scientific research, there are now ways to forecast floods, detect tsunami waves, prevent infectious disease outbreaks with vaccination and effectively communicate disaster risk to enhance community resilience. Having said that, science is already helping to save lives and livelihoods in some instances.

EVOLUTION OF DISASTERS STUDY AND RISK

The notion of disaster has undergone an evolution and dramatic transformation of meaning over time (Quarantelli & Perry 2005). In the early development of humankind and civilisations, many, if not most of the cultures around the world viewed disasters as acts of God or attributed them to some false casual attentions such as “bad luck”, “Des Astro” or “evil star” and “blind faith”. In the social science perspective, the focus on disaster and risk came about through various initiatives and events after the Second World War. Gilbert (1995) indicates that the social science perspective approached the study of disaster from three different paradigms, that of content research, chronological development and, lastly, cleavages. In the first instance, disaster was viewed as a duplication of war; an external agent can be identified which requires communities to react globally against the “aggression”. The second (chronological development) views disaster as an expression of social vulnerability; disaster is therefore the result of underlying community logic or social processes. Thirdly, disaster is an entrance to a state of uncertainty; disaster is the impossibility of identifying and defining (real or perceived) dangers. Cardona (2003) is of the opinion that the above early paradigms within social science emphasised the reaction and perceptions of communities during and after emergencies and did not explicitly focus on issues of risk, or mitigating the risk of physical harm and social disruption before an event occurred.

A focus on the development of DRR and management would therefore be incomplete without a discussion of the roots of disaster studies and research both within the social as well as the natural sciences. The natural and physical science approach to disaster emphasised the hazard component in terms of hydrometeorological, geodynamic and technological or anthropogenic phenomena such as earthquakes, floods, mudslides, cyclones, industrial accidents and nuclear fallout (USAID 2011). The natural sciences therefore aimed to understand the dynamics of hazards (Smith 2002) and from this standpoint tried to quantitatively determine and simulate their possible occurrence and impact on humans and the environment.The focus of disaster is always on the emergency response and recovery that requires coordination and early action with particular attention to environmental health including water and sanitation, food aid and nutrition, evacuation and shelters as well as health care services to the injured and survivals. Development in science gradually started to question these perceptions and truths of disasters. The modern-day study of disaster risk relates closely to the first understanding and investigation of disaster, both within a social and natural or physical science perspective, as explained above. Increasingly, theorizing about disaster risk has given attention to difference, including how gender, race, class, age and other social power relationships bear on disaster risk (USAID 2011).In the 1990s, the United Nations strategized on reduction of natural disaster through the implementation of the Yokohama Strategy and Plan of Action for a Safer World (1994) during the World Conference on Natural Disaster Reduction in Japan. The strategy affirmed that there are four elements which are closely inter-related and urged the nations to incorporate them in their development plans and ensure efficient follow-up measures at all levels from the community, national, sub-regional to international level. These four elements are prevention, mitigation, preparedness and relief which contribute to and gain from the implementation of sustainable policies. Disaster response is not recommended and yielded a temporary result at a very high cost. This Yokohama Strategy emphasize on the natural disasters reduction. In November 1999, Kofi Annan, the seventh Secretary General of the United Nations, once said, "…*we must shift from a culture of reaction to a culture of prevention…it is more humane…also much cheaper*…".

This followed by a global consensus by 168 governments to reduce the impact of disaster and adopted an action plan known as the Hyogo Framework for Action 2005-2015 in January 2005 as a blueprint to ensure DRR. The United Nations International Strategy for Disaster Reduction (UNISDR) is mandated to coordinate DRR and the implementation of the blueprint mentioned. There is a major shift from the traditional emphasis on disaster response to disaster reduction, and in effect seeks to promote a "culture of prevention". DRR is a systematic approach to identifying, assessing and reducing the risks of disaster, aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them. UNISDR defines DRR as a conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation or preparedness) the adverse impacts of hazards, within the broad context of sustainable development.The recent Sendai Framework for DRR 2015-2030 in March 2015 has reinforced the international political agreements and promote cooperation towards DRR. This Framework is a continuity of the Hyogo Framework for Action to further understand disaster risks in all its dimensions of exposure, vulnerability and hazard characteristics. In this framework, the scope of DRR has been broaden significantly to focus on both natural and man-made hazards and related environment, technological, biological hazards and risks with the implementation of the post-2015 Framework which emphasises on the effective disaster risk management. In pursuance of the expected outcome and goal in the Sendai Framework, there is a need for focused action within and across sectors by states at local, national, regional and global levels in the following four priority areas; (a) understanding disaster risk, (b) strengthening disaster risk governance to manage disaster risk, (c) investing in disaster risk reduction for resilience and (d) enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction (WCRD 2015).

ADVANCEMENT OF SCIENCE & TECHNOLOGY

Science is defined as the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment (Oxford 1986). In short, science is a knowledge obtained through study or practice. For DRR, scientific capacities must be interpreted broadly to include all relevant matters of a scientific and technical nature, where science is considered in its widest sense to include, natural, environmental, social, economic, health and engineering sciences. Science can be applied to mitigate risk and vulnerability throughout the whole of the risk reduction cycle; through prevention, whenever possible, prediction and early detection to resilient systems for response and recovery (UNISDR 2013). Scientists and researchers have progressively developed an array of risk assessment models and tools to assist the disaster risk management community in making evidence-based decisions. However, it has been observed that there is a disconnection between the needs of disaster decision makers and the studies, models, and tools produced by scientists and researchers. This gap is explained by the lack of interaction and communication between tool developers and users, which leads to inadequate understanding of users about such tools and models (ASEAN 2013).Our knowledge of the causes of disasters and how to effectively manage disaster risks has grown considerably in recent years, but to evaluate by results it remains seriously inadequate. Moreover, the considerable amounts of information that are available are not being adequately deployed, nor effectively communicated, used and implemented. A more demanding and penetrating approach to understanding the actual various causes of a disaster would potentially go a long way in supporting future evidence-based decision-making, as well as increasing accountability for responsible policy-making in DRR.The field of forensics is growing rapidly and significantly. It has made significant impacts in the advancement of science and technology particularly in DRR. Integrating science and policy processes can make major contributions to reducing disaster risk. For example, early warning systems using meteorological knowledge and technology combined with emergency management plans help save lives before a disaster occur. Flood forecasting and early warning underscore the interplay among the fields of meteorology, hydrology, agriculture, natural resource management, engineering, land-use planning, public administration, and policy making (ASEAN 2013). According to the UNISDR Scientific and Technical Advisory Group Report (2013), greater effort is needed to achieve a more effective interplay of science, technology and policy in support of DRR. In order to achieve this, the study recommends establishing; (a) better mechanisms for integrating science &technology into policy and processes, (b) greater interaction and collaboration among the scientific and technical disciplines at the international level; and (c) more systematic efforts to build relevant scientific and technical capacities.Social science research has also contributed to the understanding of people's attitude to and perception of risk and behaviour during an emergency. Satellite-based information and remote sensing systems are also being used to conduct rapid risk assessment for response planning. Seismology and engineering sciences have progressively developed building design codes and standards to improve earthquake resistance of buildings and infrastructures. Risk assessments, coupled with public awareness and education programmes, increase the level of disaster preparedness of people and communities.

FORENSIC INVESTIGATIONS OF DISASTERS (FORIN)

Recently, more emphasis is given to the potential of science in preventing disasters to occur, rather than in responding to disasters that have already occurred. There is a need for conducting forensic investigations which are not only concentrating on surface symptoms of observations and events rather than critical causes and various processes of disaster risk management. Since 2011, FORIN, under the umbrella of the Integrated Research on Disaster Risk (IRDR) programme proposes an approach that aims to uncover the root causes of disasters through in-depth investigations that go beyond the typical reports and case studies conducted in post-disaster events. IRDR is an interdisciplinary research programme sponsored by International Council for Science (ICSU) in partnership with the International Social Science Council (ISSC) and the United Nations International Strategy for Disaster Reduction (UNISDR). IRDR is a global initiative to address the challenges brought by natural hazard events, mitigate their impacts and improve related policy-making mechanisms (IRDR 2011).

FORIN is designed to address several ideas concerning disaster risk and subsequently four hypotheses have been formulated, which are; the risk reduction hypothesis, the integration hypothesis, the responsibility hypothesis and the communication hypothesis. There are four basic approaches used in FORIN research methodology, namely; critical cause analysis, meta-analysis, longitudinal analysis and case studies of disasters. It is hoped that FORIN investigations will move from a discipline-based inquiry into a more systemic approach to penetrate deeply into the fundamental causes of disasters in a broad, multidisciplinary and comprehensive manner, engaging specialists from various fields (Burton 2010). Forensic investigations represent an attempt in future to anticipate risks, improve management and governance in the case of 'natural' hazards or of 'technological' hazards. The FORIN research is undertaken to produce transformational changes and in paradigm shift required. These studies will contribute in important and insightful ways to the advancement of DRR and management.

MEDICAL FORENSIC INVESTIGATION

Medical forensic investigation of disasters can be observedfrom the field of ForensicMedicine and Pathology. Ithas contributed in the development of various techniques and particularly in the field of forensic management of mass disaster. Victim identification has been the primary role for forensic pathologist since the 19th century. Disaster Victim Identification (DVI) is a method used to identify victims of mass casualty incidents (INTERPOL 2014). DVI is not a new discovery where identification procedures has been evolved and developed (Schuliar& Knudsen 2012). DVI enables the expansion of the forensic medicineservices with the birth of Forensic Odontology in 4th May 1897, Forensic Radiography in 1949 (Brough et al. 2015) and Forensic Genotyping in 1993(Graham2006). As a matter of fact, Anthropology has been involved in DVI activities for more than a century (Blau & Briggs 2011; Mundorff 2012).Each disaster is in some way unique where the management of dead in mass disasters is a multidisciplinary and multi-stage task. The role of medical forensic investigation starts at the very beginning which is parallel with the role of the first responders at the scene. First responders, be they law enforcement officers, armed forces, fire fighters, urban search and rescue team or volunteers, collectively structured the three inter-related tiers in search and rescue of victims and survivals, physical management of dead as well as information management of the dead and supporting bereaved families. Most of the first responders are non-forensic personnel and thus necessary interventions from the medical forensic team are critical in facilitating the first responders especially in disasters, where these personnel will be exposed to unsafe structures, unexploded explosives, biological and chemical hazards as well as radiological and electrical risks on site.

In accordance with identification process in CBRNE incident, types of aggressive agents used will determine the body burial procedure, means of personal protection to first responders, rescuers as well as emergency and mortuary personnel, health problems to personnel and public in general, dead body management, special autopsy procedures and equipment used and improvement in specialised training for CBRNE disasters. Information from forensic investigation is important in the recovery phase to plan for the scene evaluation and triage of bodies of the unfortunate victims (Schuliar & Knudsen 2012). The selection of bodyaccording to the degradation state for rapid and successful identification later on. The pathologist will estimate the duration of body recovery process and suggests to the first responders the correct methodology used to tag and bag contaminated bodies to ensure safety for both the personnel on site and at the mortuary. DVI is part of the medical forensic investigation in a mass fatality incident that provides information that will definitely benefit DRR by reducing disaster impacts, reducing casualties, reducing damages and at the same time increase safety at site for first responders, rescuers and body management team.

A recent chemical and explosives disaster at Tianjin Port, China, reported to have originated from a warehouse designed to store hazardous and flammable chemicals, including calcium carbide, sodium cyanide, ammonium nitrate andpotassium nitrate (Willan 2015).Before the explosions, several firefighters were already present at the scene to control a blaze using water. Water sprayed on some of the chemicals like calcium carbide, reacts with water to create ahighly explosive acetylene while sodium cyanide is soluble in water, releases a highly poisonous gas hydrogen cyanide. Chemical experts were in opinion that the acetylene could have detonated the other chemicals and thus created a much larger blast and killed at least 21 firefighters whom were present at the site earlier. As of 12 September 2015, 173 people died from the explosions and 797 others have been injured, mostly from burns and explosive blast injuries and several thousand people living near the port were evacuated. In fact 17,000 homes were damaged, more than 170 companies were affected and 3000 cars were destroyed completed and the initial total insurance losses were estimated up to $1.5 billion. More than 1000 firefighters were deployed to the scene to contain the fire.

In this incident, the types and location of the chemicals were not known to the firefighters and authorities. Mr. Paul Pang, Vice President of IHS Chemical said, "*The reality is that sometimes these regulations may not be strictly followed, and in some cases, the people working in this industry are not fully trained and qualified for handling hazardous materials. It is uncommon to have 700 tonnes of sodium cyanide stored in one location*". Various questions raised about whether firefighters were well trained and equipped, whether the materials they used to battle the flames were appropriate as well as whether the protocol used by the firefighters to spray water initially causing the further explosion was correct. Having said that, people are pointing fingers at which authority to be responsible in order to detect the large amount of chemical storage asthe company that owned the site had an expired license to handle dangerous chemicals.Industrial safety manuals state that calcium carbide fire should be put out using dry powder fire extinguishers and clean up by mixing sand into chemical while sodium cyanide is recommended to be neutralised with sodium hydroxide.In China, there are standard global safety regulations for producing, transporting and storing hazardous chemicals, where such materials must at least be properly secured 1 km away from public buildings and transport networks. However, there were three major residential communities located within 1 km radium of the warehouse causing a huge impact and disruption to the people, community, environment and economy (BBC 2015; CNN 2015).

DISCUSSION

Disasters are increasingly being understood as 'processes' and not discreet 'events'. Moreover, the causes of disasters are driven by complex engineering, socio-economic, socio-cultural, and various geophysical factors. Such interacting driving factors, occurring across a range of temporal and spatial scales, combine in numerous ways to configure disaster risks. It is well accepted that much of the knowledge used today in designing, constructing and operating engineered facilities has been obtained through learning from disasters. Most articles related to disasters obtained from professional journals focus on the technical or physical cause of the disaster. There is a need for more discussion of procedural issues. There is always a technical or physical explanation for a disaster, but the reasons disaster occurs are often procedural within organizations, institutions, laws, codes, etc. These investigations therefore are concentrating more deeply at the intermediate phase between the trigger event and the response. The medical forensic investigation of disasters can make a significant contribution to the process of learning from disasters by disseminating information to scientists, politicians, decision-makers and to the civil society.

Forensic approach is perhaps similar to solving a picture of a disaster puzzle. Methodically, the various pieces are sorted and patiently fitted together in a logical context taking into account all the parameters. Gradually, an overall picture of the disaster emerges. When a significant portion of the disaster puzzle has been solved, it then becomes easier to see where the remaining pieces fit. The objective of the medical forensic investigation is to dig more deeply into the causes of disasters in an integrated, comprehensive, transparent, and investigative style. Often, this analysis requires the simultaneous application of several scientific disciplines simultaneously. To establish a sound basis for analysis, medical forensic investigations of disasters rely upon the actual evidence found and applies accepted scientific methodologies and principles to interpret the disaster in all its process (Auld 2008). It seeks ways to disseminate information to the most appropriate individuals and organizations, in the most appropriate form, so that lessons learned from disasters can be most efficiently integrated into DRR practice. The concept of learning from disasters is fundamental to the practice of in all fields of DRR.After the Millennium Declaration in year 2000, the United Nations moved on to the Hyogo Framework for Action 2005 – 2015: Building the Resilience of Nations and Communities to Disasters (HFA) to promote a strategic and systematic approach to reducing vulnerabilities and risks to hazards. In HFA, there are five main areas identified which are governance, risk identification, knowledge management and education, reducing underlying risk factors and preparedness for effective response and recovery. The Sendai Framework for Disaster Risk Reduction is the successor instrument to the HFA that covers a duration of 15 years from 2015 – 2030. It is the continuity to the work done from the HFA and to further improve on the understanding of disaster risks in all its dimensions of exposure, vulnerability and hazard characteristics. In this framework, the scope of DRR has been broadened significantly to focus on both natural and man-made (anthropogenic) hazards and related environment, technological and biological hazards.In the Tianjin Port chemical and explosives disaster discussed earlier, the extent of damages, the numbers of the dead and injured as well as the amount of the monetary losses could have been reduced if the medical forensic investigations have had been initiated. The blast occurred at scene could have suggested a proper CBRNE protection gear for the firefighters knowingly that sodium cyanide releases highly poisonous gas when dissolved, potassium nitrate causes breathing problems and damages kidneys, while ammonium nitrate can be toxic when burned. The information obtained from dead bodies from the blast scene and examination of the clothing may turn out to be of importance, particularly areas of burns, tears and deposits of soot and explosive material, whose localisations on the bodies may be relevant for investigations (Schuliar& Knudsen 2012). The extent of the blast injuries found on the bodies and origin of the bodies will indicate the possibility of the structures collapse and portray a valuable sign to the first responders and the DVI team; to beware of the hazard during the search and rescue. The agent or types of chemicals involved will immediately inform the search and rescue personnel on the proper way to handle contaminated bodies and to transport them back to the temporary mortuary. The amount of hazardous materials illegal stored in a huge quantity has clearly established the lacking of the enforcement and the regulating agencies in this particular matter. The inappropriate location of the warehouse and the inadequate safety measures adhered by the personnelindicate the importance of the Occupation Safety and Health (OSH) regulation and standardsfor employer to provide a safe workplace.The proper investigation conducted at scene will definitely reduce the risk of the number of dead and injured by disasters triggered by natural hazards as well as man-made hazards through strategic broad-based global movement to achieve a sustainable development, strengthening livelihood security and to protect assets, in line with the HFA and Sendai Framework.

CONCLUSION

Medical forensic investigations of disasters will certainly enable conclusions to be drawn and recommendations to be established that will facilitate perceptive decision on measures to disaster risk reduction. Medical forensic investigation has gone beyond determining cause of death to provide insight to the nature of injury and harm caused that is relevant for onsite response during disaster and can be used to help reduce risks relating to response in similar disaster events. This investigation has proved its role in delivering the HFA and Sendai Framework and to achieve the substantial reduction disaster risk and losses in lives, livelihoods and health in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

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