WORK SAFETY BEHAVIOUR MODEL FOR IMPROVING SAFETY IN CONSTRUCTION INDUSTRY USING BAYESIAN NETWORK

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For my beloved mother and father

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ABSTRACT

The construction industry involves one of the most hazardous occupations for workers due to complex management processes, environmental issues, work pressure and heavy equipment involved in modern construction projects. Despite the advancement of technology and the new approaches which have been developed and adopted to tackles the accidents in construction industry in Malaysia, an escalating number of fatal accidents are still occurring because of mainly the human errors and the unsafe behaviours. In the same vein, improving the safety behaviour became the main attention of the researchers recently in construction industry to reduce the accidents at workplace. Therefore, this study determined the key factors and the relationship between all safety behaviour factors (organizational factors, safety climate factors and individual factors) in order to build a safety behaviour model for improving safety and minizing the fatal accidents in the construction industry. In this research, all critical safety behaviour factors were defined from literature review in order to develop a comprehensive conceptual framework. After performing the pilot study, defining the proportionate stratified sampling, the data was collected accordingly from different construction projects. The key factors, then, were finalised by using explanatory factor analysis using SPSS. With the assistant of the experts in the safety field and by applying Dempster and Shafer theory, the structure of Bayesian network was built accordingly. Furthermore, Netica software embraced the latest shape of developed safety behaviour model. The developed Bayesian network model elaborated generally that the individual factors have registred the highest proportion of influence on safety behaviour while there was a mediocre influence by the safety climate factors. On the other hand, the safety behaviour received a low influence by the Organizational factors. Besides, Join Strategy assisted to deduce the best safety behaviour strategy to upgrade the safety at the workplace in the construction industry.The results revealed also that learning, safety compliance and safety knowledge have an enormous influence on safety behaviour and they should be well-taken care by the safety management to ameliorate the safety at workplace. All in all, safety behaviour can record a high performance among the workers by promoting these factors. Hence, the leaders and decision-makers are advised to enhance the organizations' learning, safety

knowledge and safety compliance to upgrade the safety behaviour of the employees in the construction site, and therefore this will improve the safety performance and minimise the fatal accidents in the construction industry.

ABSTRAK

Industri pembinaan melibatkan salah satu pekerjaan yang paling berbahaya bagi pekerja kerana proses pengurusan yang kompleks, masalah persekitaran, tekanan kerja dan peralatan berat yang terlibat dalam projek pembinaan moden. Meskipun kemajuan teknologi dan pendekatan baru telah dikembangkan dan digunapakai untuk mengatasi kemalangan dalam industri pembinaan di Malaysia, jumlah kemalangan maut terus meningkat disebabkan kesilapan manusia dan tingkah laku yang tidak selamat. Dalam keadaan yang sama, meningkatkan tingkah laku selamat telah menjadi perhatian para penyelidik dalam industri pembinaan untuk mengurangkan kemalangan di tempat kerja. Oleh itu, kajian ini bertujuan untuk menentukan faktor-faktor utama dan hubungan antara semua faktor tingkah laku selamat (faktor organisasi, faktor iklim keselamatan dan faktor individu) untuk membina model tingkah laku selamat yang berkesan bagi meningkatkan keselamatan dalam industri pembinaan. Dalam penyelidikan ini, semua faktor kritikal bagi tingkah laku yang selamat ditakrifkan dari tinjauan literatur untuk membangunkan kerangka konsep yang komprehensif. Setelah melakukan kajian rintis, data dikumpulkan melalui reponden yang terlibat dalam projek pembinaan yang berbeza dengan penentuan persampelan berstrata proporsional. Seterusnya, analisis faktor eksploratori dengan menggunakan SPSS dilakukan bagi mendapatkan faktor utama. Dengan bantuan pakar yang terlibat dalam bidang keselamatan serta menerapkan teori Dempster dan Shafer, struktur rangkaian Bayesian dibangunkan. Perisian Netica digunakan bagi membentuk model tingkah laku keselamatan yang dikembangkan. Model rangkaian Bayesian yang dikembangkan secara umum menjelaskan bahawa faktor-faktor individu telah mencatatkan pengaruh paling tinggi terhadap tingkah laku selamat sementara itu pengaruh yang biasa adalah faktor iklim selamat. Sebaliknya, tingkah laku selamat mendapat pengaruh yang rendah melalui faktor organisasi. Selain itu, gabungan strategi dapat membantu strategi tingkah laku selamat bagi meningkatkan keselamatan di tempat kerja dalam industri pembinaan. Hasil kajian juga menunjukkan bahawa pembelajaran, kepatuhan keselamatan dan pengetahuan keselamatan mempunyai pengaruh besar terhadap tingkah laku selamat bagi meningkatkan keselamatan di tempat kerja. Secara keseluruhan, tingkah laku selamat dapat memberikan prestasi

tinggi di kalangan pekerja dengan mempromosikan faktor-faktor terebut. Oleh itu, para pemimpin dan pembuat keputusan dinasihatkan untuk meningkatkan pembelajaran organisasi, pengetahuan dan kepatuhan keselamatan bagi meningkatkan tingkah laku selamat di tapak pembinaan. Dengan itu ianya dapat meningkatkan prestasi keselamatan dan meminimumkan kemalangan maut dalam industri pembinaan.

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LIST OFABBREVIATION

SB	Safety Behaviour
L	Learning
C	Communication
LD	Leadership
RS	Reward System
RA	Resource Allocation
SA	Safety Attitude
MC	Management Commitment
SMS	Safety Management System
EI	Employees' Involvement
SE	Safety Experience
SK	Safety Knowledge
SC	Safety Compliance
SM	Safety Motivation
JS	Job satisfaction
GDP	Gross Domestic Product
DOSH	Department of Occupational Safety and Health
CIDB	Construction Industry Development Board
DOSM	Department of Statistics Malaysia
BN	Bayesian Network
HSE	Health, Safety and Environment
HSEUG	Safety Executive of the UK government
CIRC	Construction Industry Review Committee
PsyCap	Psychological Capital

Good	G
Poor	P
Average	A
UTHM	Universiti Tun Hussein Onn Malaysia
SEM	Structural Equation Modelling
SBB	Safety Based Bahaviour

CHAPTER 1

INTRODUCTION

This chapter clarifies the whole research purpose and this is significant to establish overall research flow. It starts with a clear explanation of the gap of this research through the background and the problem statement. Followed by the research questions, aim and the objectives, and then the significance of research are clarified. This chapter concludes by reviewing the methodology and the structure of this research.

1.1 Research Background

The Malaysian construction industry is considered as a key component and important contributor to the Malaysian economy. The value of construction work is increasing year per year, where the first and second quarter of 2017 recorded RM 35.1 billion and RM 33.8 billion respectively which saw a huge growth of 11.2% compared to the previous years (Department of Statistic Malaysia, 2017a). All sub-sectors are leading the expansion in value of construction work such: civil engineering (19.3%), special trades' activities (11.6%), non-residential buildings (9.7%) and residential buildings (3.8%) sub-sector. In terms of contribution, the performance of value of construction work done is still dominated by the civil engineering sub-sector with 35.5%, followed by non-residential buildings (31.2%), residential buildings (28.5%) and special trades activities (4.8%). the construction activity is predominated by the private sector with 64% share (RM21.6 billion) as compared to the public sector only with a 36% share (RM 12.2 billion) (DOSM, 2017a). It can be clearly seen that construction is one of the main contributors to the Malaysian economy.

On the other hand, many authors, researchers and experts have classified the construction as one of the riskiest industries across the world (Dong *et al.*, 1995; Sacks *et al.*, 2009; Oswald *et al.*, 2015; Hoła *et al*, 2017). Malaysia construction industry has experienced 453 cases of death investigated by the Department of Occupational Safety and Health (DOSH) in the last 6 years as shown in Figure 1.1, where it accounts for more than 40% of the total number of fatal deaths across all industries in Malaysia (DOSH, 2017a). Moreover, the numbers of construction incidents are increasing and moving towards a larger scale with more complexity in the design of construction (Hamid *et al.*, 2008; Kraus *et al.*, 2017), recently the frequency of fatal accidents in the Malaysian construction industry is accelerating compared to other industries where the highest deaths recorded for the year 2016 is 106 deaths (DOSH, 2017a). This tends to support the crucial need for better safety measures and standards in construction projects and also a need to have a more accurate understanding about the causes of the accidents and also to develop new risk analysis methods to ease the management of construction safety (Hinze *et al.*, 1998; Lee *et al.*, 2016)

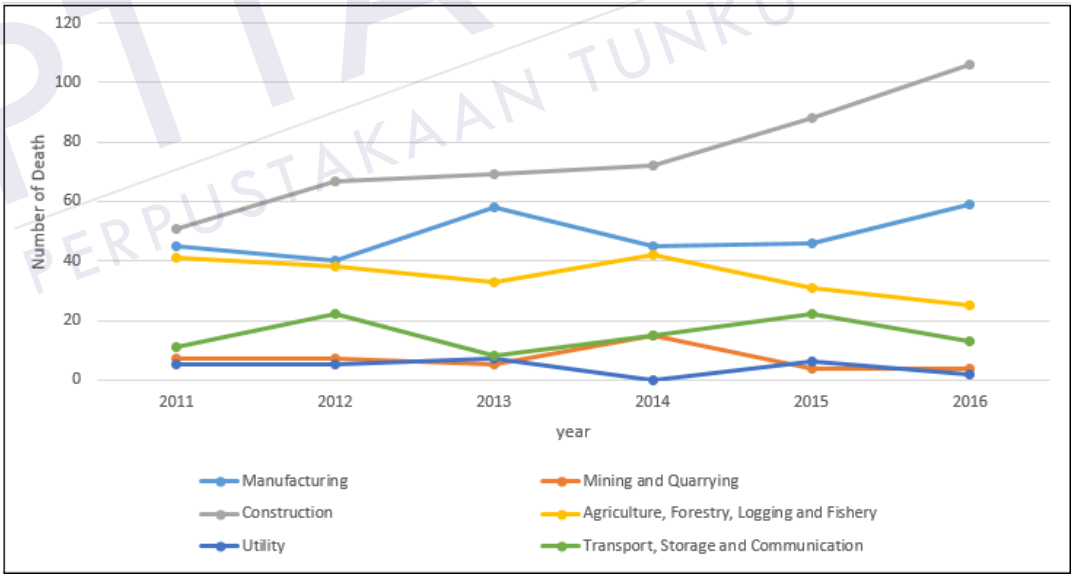

Figure 1.1**:** Death Statistics by Sector in Malaysia (2011-2016) (DOSH, 2017a)

To produce better safety standards, the unsafe conditions and behaviours must be detrimined to eliminate out all accidents in constructions. However, much attention tends to focus on site conditions, once an accident or near miss happens because the physical proof can be easily accumulated to represent the accident in order to apply prior precautions to avoid the same accidents in future (Gould and Joyce, 2009*).* Respectively, construction sites have become more secure in recent decades. However, unsafe behaviours have allocated some relatively little efforts to reduce or eliminate safety risks in the workplaces. Moderately, little efforts have been dedicated to lessening or remove dispensing risk factors (Choudhry, 2014). There is little improvement with regards to the safety of the physical workplace in construction, but further safety construction improvement is not really predicted (Donald and Young, 1996). Many authors addressed the severity of unsafe actions in construction. Unsafe acts are considered the main cause of 98% of accidents in construction industry (Blackmon and Gramopadhye, 1995). At the same vein, 80-90 % of accidents were occurred due to unsafety behaviour at workplace (Oswald *et al.,* 2015)

Taking into account that unsafe behaviours have contributed to 80-90% of accidents that have affected the construction projects, on the other hand only small number of accidents are caused by unsafe conditions (Oswald *et al.,* 2015) and that risks condition of workers are easier to identify than unsafe behaviours (Gould and Joyce, 2009), the management of construction projects must significantly reconsider the efforts made in the implementation of construction management safety measures to reduce the risks of dangerous behaviours. The workers' safety related behaviours need to be closely monitored and adjusted if necessary, to reduce or eliminate their unsafe behaviours (Mullanet *al.,* 2015). However, it is a big challenge to quantify the workers s' safety behaviours and attitudes, hence, the effect of safety implementation on workers s' behaviours shall be properly assessed (Guo *et al.,* 2016; Zaira and Hadikusumo, 2017).

Despite the potential of the behaviour-based approach for safety enhancement, there are many critical gaps in the implementation of such a behavioural approach in construction. Nevertheless, the number of fatalities in construction remains higher than the average of all other industries (Amiri *et al*, 2014; Kang *et al.,* 2017). A lack of understanding of how accidents occur in construction is a major reason for this continually

high number (Kraus *et al.,* 2017). Most efforts to understand the accident process, thus far, have not been successful due to their inadequate ability to consider the dynamic and interdependent nature of construction work (Vasconcelos and Junior, 2015), as well as the lack of understanding of human behaviour in this complex system (Krause *et al.,* 1999; Hoła *et al.,* 2017). Therefore, there's an urgent need to carry out the research on the prevention of fatal accidents in building construction activities

1.2 Problem Statement

Several studies revealed that the human errors are the main reasons of the fatal occupational accidents regardless of the risky workplace conditions (Lehtola *et al.,* 2008; Fugas *et al.,* 2012; Reyes *et al.,* 2015). Furthermore, the ramifications of construction accidents are growing with trends toward larger-scale and more complex construction projects (Hamid *et al.,* 2008; Kraus *et al.,* 2017). Lastly, traditional reporting requires the active participation of workers, necessitating workers to inform managers of their own risk behaviour or unsafe actions of others. It is not surprising that, construction workers tend to be reluctant to report as such, minor or negligible accidents were found to be unreported in the preliminary study, besides that most of accident reports ignore workers behaviours as causes of accidents and instead focus on the physical causes (Ling *et al.,* 2009; Yilmaz, 2014).

Many researches demonstrate that roughly 80% fatal accidents at work are created by near-miss behaviours whilst 15% resulted from hazardous workplace conditions and the rest of 5% is inescapable (Fugas *et al.,* 2012). The occupational accidents are affected substantially by risky behaviours, and many studies have addressed this issue (Zhou *et al.* 2008; Guo *et al,* 2017; Mohammadfam *et al*., 2017; Hadikusumo *et al.,* 2017). Furthermore, 80-90 of all accidents are attributed to the unsafe behaviours (Oswald *et al.,* 2015). Blackmon and Gramopadhye (1995) identified the risky acts as one of the reasons for 98% of incidents. Dekker (2013) posited that, the unsafe behaviour as one the primary causes of incidents which occurs at construction sites. Haslam *et al.* (2005) have stated that 70% of construction accidents are caused by human errors. This makes safety experts

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