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A Methodology to Develop Occupational Safety and Health Costs Model for the Urban Rail Infrastructure Projects

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Abstract
This article presents the methodology applied for the development of occupational safety and health costs model of the urban rail infrastructure projects in Malaysia. It consists of four phases; the identification of related issue and research problems, the establishment of the issues and importance of safety and health costs in the project phases, the determination of safety and health items considering cost significant including the cost weightage for those items, the development of safety and health costs model and the validation of the model by the expert who involved in the urban rail infrastructure projects in Malaysia. The works packages contractors (WPC) from viaduct (guideway) package of Mass Rapid Transit (MRT) and Light Rail Transit (LRT) were selected as the respondents for this research.
Keywords: Methodology, Safety and Health Cost, Urban Rail Infrastructure Project

Introduction

Urban rail transit system such as metro and light rail has significant impacts on the mitigation of traffic congestion and sustainable developments of urban traffic system. Kyriakidis et al., (2012) defined urban rail as metro railways are mainly related to urban passenger electric railways with a significant proportion of grade separated (underground or elevated) track and relatively close station spacing. The two commuter routes have longer station spacing and surface track than most metros.

The system has many benefits in terms of speed, land occupation, and low emission (Yang et al., 2014). Moreover, this type of trains could carry a considerable number of passengers with high speed compared with bus due to spatial isolation feature of the trail route. In addition, the passengers' travelling time can be guaranteed, more saved energy and less emission do favor to better environment and people's health and the accident rate of rail transport is very small, which could reduce accident mortality of city residents.

Malaysia continued to excel in the aspect of rail infrastructure with the completion of Mass Rapid Transit (MRT) from Sungai Buloh to Kajang line in July 2017. The other rail

infrastructure projects which are currently in construction progress such as MRT 2, from Serdang to Putrajaya line, Light Rail Transit (LRT) 3 and LRT Bandar Utama to Klang line signal that Malaysia is in line with other developed countries that have modern and complete public transportations.

The safety at a construction site is one of the most essential issues that cannot be taken lightly. According to Mahmoudi et al. (2014), a comprehensive tool is required to continuously assess and promote the health and safety performance in the construction industry as it is regarded as one of the most hazardous industries. The argument that the construction industry is high risk is further developed by Misnan and Mohammed (2007) who emphasizes the uniqueness of the construction industry as its activities are frequently outdoors where safety and health conditions are inadequate.

Through the rapid development of these urban rail infrastructure projects, the construction site has a very high place in the ranking of individual sectors regarding the accident rate. This type of project is recognized as high complexity project with numerous construction risks activities, large cost involvement, highly technical requirements and several of resources. When the accident has been reported, it become a big issue about the safety at workplace due to these projects are one of the biggest projects in Malaysia recently. Neither the worker's fatal or nonfatal injuries, all the incidents will cause significant economic burden to the stakeholders of the project especially to the contractor itself. They should bear unexpected costs and at the same time their reputation and image will affect from this injury.

Description of the Research Problem

The infrastructure construction projects differed from small and medium-sized construction projects in which routine practice can be applied. The major infrastructure construction projects often involved a multitude of different tasks with a range of features (Shiferaw, A.S., Klakegg, O.J. and Haavaldsen, 2012). Safety is one of the risk management elements that are common in large infrastructure projects due to the involvement of many workers, large and heavy plants, a lot of materials, complex construction operation, multi-interface and complex management activities and the accident rate is higher than the common construction projects (Guo, Li, & Li, 2013).

MRT and LRT project is one of the mega projects that involved various hazardous construction activities. The hazardous activities of MRT projects are such as tunnel excavation, construction work near uses public road, piling that cause the vibration near the residential transporting, big load of material and equipment to site and the uses of high voltage of electric at station for electrical works. Derived from the online newspapers and information from the client, sixty four (64) numbers of accident cases for SBK line were reported to the DOSH since the project was started. These accidents had cause death and injured to construction workers, where majority of the victims are foreign labour.

Moreover, the construction of urban rail infrastructure projects exposed to the public risk when the construction is near with the road traffic area. A few accidents occurred at MRT and LRT projects were involved public or third party injuries including their property damages. This issue had been concerned by the Institution of Engineers Malaysia (IEM) through it press statement on 1st July 2014. In view of these incidents, IEM considered the importance to highlight the need to observe strict safety procedures in construction work especially in on-going construction sites located adjacent to public access areas. Thus, safety management and accident prevention are vital to create safe construction workplace for the workers and public.

Various authors highlighted the importance of economic losses generated by accidents at the construction work site (Helander, 1980); (Davies & Teasedale, 1994); (Everett and Frank, 1996); (Rubio et al., 2005); (Waehrer et al., 2007) (Jallon et al, 2011); (Goestsch, 2013); (Asan, n.d.); (Pellicer, Carvajal, Rubio, & Catalá, 2014); (Feng et al., 2015a) and (Feng et al., 2015b). Feng et al. (2015) in his discussion indicated that other cost losses to victims and their families, employers and society might be involved. Many researchers revealed that these losses may affect the implication of costs to productivity, property, equipment, morale and impaired company image on a construction company's profit and loss statement.

However, if employers had a tool that allowed them to calculate aprioristically the occupation safety and health costs from the pre-construction phase (design phase) to the construction phase of a construction project, they could reduce these costs later at the construction site by improving procedures and increasing the quantity and quality of accident prevention measures.

Therefore, a developed safety and health costs model is necessary in identifying and calculating the specific costs for the whole construction project. The most logical amount of safety and health costs can be allocated in the future project, as it will also create and spreads awareness to the client and contractors.

Methodology of Research

Research methodology refers to the principles and procedures of logical thought processes applied to a scientific investigation. Methods concern the techniques which are available for data collection and analysis (Fellows & Liu, 2008). The research methodology for this study consists of the following phases.

- Desk study – the identification of safety and health research trend from the literature review.
- Preliminary survey – the establishment of safety and health costs estimation method issues and the evaluation of the relevant questionnaire.
- Design of the questionnaire, pilot test & main study – the determination of prevention costs and the accident costs, the effect of safety prevention costs and accident occurrence and originate a mathematical formulation for the calculation of cost of each safety and health costs item for urban rail infrastructure projects.
- Data analysis, development and validation of model – the analysis of data, the development and validation of Safety & Health Costs Model for urban rail infrastructure projects.

The propose methodology for the development of occupational safety and health costs model is shown in Figure 1.

The Identification of Safety and Health Research Trend

Desk Study

The vital part in collecting data for research are searching and reviewing the literature. According to Boote & Beile (2005), a literature review is an evaluative report of studies found in the literature relating to the selected area. The review should describe, summarize, evaluate and

clarify the literature to provide a theoretical basis for the research and help determine the nature of one's own research. (Shuttleworth, 2009) described the literature review as a critical and in-depth evaluation of previous research. A good literature review expands upon the reasons behind selecting a research question. In addition, the literature review goes beyond the search for information and includes the identification and articulation of relationships between the literature and one's own field of research (Creswell, 2012; Shuttleworth, 2009).

During the literature research for this study, the review involved a wide range of secondary data comprising leading journals, books, seminar papers, reports, legal regulations and unpublished doctoral and master theses from local and international universities. Fifteen (15) numbers of the current research articles were reviewed to determine the relevant issues related to safety and health in construction industry. Most of the researchers highlighted about the safety and health estimation method.

Based on that issue, a few economic safety cost models from different countries, which are Singapore, United Kingdom and Australia were selected. These countries were selected due to the establishment of cost estimation models developed so many years ago compared to other countries. While in Malaysia, Occupational Safety and Health Costs Calculator (OSH Calculator) was developed by the Department of Safety and Health (DOSH) team in 2013.

The critical review synthesized that the existing models highlight on the financial losses of the accidents, which are incurred to the employer, employee and society. In addition, Singapore, United Kingdom and Australia provided the percentage of estimated total cost of occupational injuries from the gross domestic product (GDP) in every year have also emerged. The study gives significant impact in estimating the negative losses bared to their countries.

However, the safety items costs required during the pre-construction stage were not covered in those studies. Moreover, the other limitation of those economic models was, they did not include the costs incurred by employers for compliance with work health and safety regulations and prevention activities. If employers had a suitable tool that allowed them to calculate aprioristically the occupational health and safety costs during the design phase of a construction project, they could try to reduce these costs later at the construction site by improving procedures and increasing the quantity and quality of accident prevention measures.

Therefore, the input gathered from the existing accident cost models across the globe described to strengthen the research gap. It then helps to formulate the research questions, objectives and the significance of conducting this research. The proposed development of occupational safety and health costs model comprises of all of the safety and health costs involved, from the pre-construction to the construction stage. All of the costs incurred will be taken into consideration to enable the relevant stakeholders to identify and prioritize potential levers to reduce the cost of poor health and safety practices by using a more strategic approach.

The Establishment of Safety and Health Estimation Method Issues

Preliminary Survey

The purpose of the preliminary survey is to obtain the expert's view on the safety and health costs estimation method issues, to identify the critical phases for safety and health costs in the construction industry and the potential respondent for the main data collection of this research.

The preliminary survey involved qualitative approach, where the semi-structured interviews with seven (7) construction stakeholders who involved in urban rail infrastructure

project. The inputs were needed to establish the importance of this research. The transcription and interpretation from the interview findings were completed by using Atlas.ti© qualitative software. To ease the semi-structured interview process, the questions were prepared in an interview form. The initial process of the semi-structured interview was short-listing the potential participants based on the stipulated respondents' criteria.

Screening forms were distributed earlier via email and telephone to the potential participants. The process was intended to acquire their demographic details that included their designation, academic backgrounds, years of working experiences and current responsibilities/duties. The interview form consists of a cover page and four sections; the demographic background of the interviewee(s); the critical phases for safety and health costs in the construction industry, the safety & health costs estimation method issues and the potential respondent for the main study data collection.

The sampling survey was directed to the experts in the construction of urban rail infrastructure project in Malaysia. They involved in the construction of MRT and LRT projects, representing various position such as project director, safety manager, safety officer, quantity surveyor and traffic safety. The diverse background positions of the experts generated variety of perspectives.

The Determination of Prevention and the Accident Costs, Effect of Safety Prevention Costs and Accident Occurrence & Provide a Mathematical Formulation for the S&H Costs Item for Urban Rail Infrastructure Projects

Design of the Questionnaire

Questionnaires are traditional method of obtaining data, and are often used to discover regularities among groups of people, by comparison of the answers for the same set of questions. Analysis of the survey is able to provide more precise numerical data, from which tables, graphs, etc. can be produced and presented.

As explained by Creswell (1994), a questionnaire survey was undertaken as it was considered as the most appropriate method to acquire a lot of data inexpensively and openly from many people. In this case, questionnaires were distributed to the respondents based on purposive random sampling. The respondents are from Work Packages Contractors (WPC) of the construction of Mass Rapid Rail (MRT) and Light Rail Transit (LRT) projects. Multiple data collection techniques were used in this study. Data Collection Personal interviews by using questionnaires were used to collect data for this study. The respondents were also referred to the archival records in completing the required data in the questionnaires.

A survey was conducted to identify the safety and health items in the Bills of Quantities (BQ) or also known as prevention items and accident costs which considering cost significant to explore the effect of prevention costs to the accident occurrence, to provide a mathematical formulation for the calculation of cost weightage of each safety & health item and to develop and validate the occupational safety & health costs model for urban rail infrastructure projects.

The questionnaire was divided into six (6) separate sections, namely, Section A (Organization Background), Section B (Respondent Particulars), Section C (Prevention Costs), Section D (Direct Accident Costs), Section E (Indirect Accident Costs) and Section F (Extraordinary Costs).

The types of questions consist of multiple choice questions as well as Likert scale type questions. These multiple-choice questions consist of a nominal scale, interval scale and ordinal scale of data. Utilizing the 5-point Likert scale, the respondents were requested to answer for the identification of prevention costs and accident costs considered as cost significant. The respondents were also requested to estimate the costs incurred for those items at the open-ended questions in order to determine the costs weightage for those items.

Pilot Test

The questionnaires were piloted in order to verify the appropriateness and clarity of the questions. An attempt was made to word the questionnaires as clearly as possible. The aim of the pilot study was also to test the wording of the questionnaire, identify confusing questions, test the intended technique for data collection and measure the effectiveness of the potential response.

Face validity was used to evaluate the relevance of the questionnaire. It was being done by showing researcher the measurement to expert to get their feedback of whether these measures were relevant in measuring what researcher intended to measure. According to (Hardesty & Bearden, 2004), face validity was the degree that respondents or users judged that the instrument items of an assessment were appropriate to the targeted construct and assessment objectives.

The pilot study acted as a trial run that assisted the researcher to smoothen out the survey instrument to ensure the participants in the main survey experienced no difficulties in completing it. A total of 20 numbers of questionnaires were distributed to representatives from the following groups:

1. Doctorates of similar specialization
2. Doctorates of different specialization
3. Doctorates in Statistics
4. PhD candidates
5. Client for MRT and LRT Project
6. Private Delivery Partnership (PDP) for MRT and LRT Projects
7. Contractors of MRT and LRT Project
8. Occupational Safety Health (OSH) Calculator Team
9. Department of Occupational, Safety & Health (DOSH)
10. Construction Industry Development Board (CIDB)

Based on these responses, a minor modification was made to the instruments items to improve clarity and comprehension. The members of the pilot study assessed the contents such as types of variables that will be measured, the style, the format and the clarity of the questions and provide feedback as to their relevance and to offer any suggestions for improvement. After adjustment and corrections, the final questionnaire was derived.

Main Study (Sampling Frame)

According to Shamsuri (2004), sampling is the process of selecting a group of subjects for a study in such a way that the individuals represent the target population or larger group from which

they were selected. Hence, this representative portion of a population is called a sample. In order to obtain samples of respondents for the questionnaire survey, purposive random sampling was used. Purposive random sampling is conducted by identifying groups in the population.

Since the types of work for packages in construction of MRT and LRT are varied, the work packages contractors (WPC) from viaduct (guideway) package were selected as sample of study. Eight (8) numbers of WPC (viaduct/guideway) for MRT 1 (SBK Line) Project, ten (10) numbers of WPC (viaduct/guideway) for MRT 2 (SSP Line) Project, four (4) numbers of WPC for LRT 2 (Extension Line) Project and ten (10) numbers of WPC (viaduct/guideway) for LRT 3 (Bandar Utama to Klang Line) Project were the targeted number of respondents for this study.

The selected work packages were involved for the identification of prevention costs. Sixty-four (64) numbers of accident cases from Class 1 (Fatality), Class 2 (Permanent Disability), Class 3 (Temporary Disability) and Class 8 (Dangerous Occurrence) were selected to achieve the second objective, which is the identification of accident costs items (direct & indirect costs) incurred in the construction of urban rail infrastructure projects. Those classifications were the directly reported cases to the Department of Safety and Health (DOSH), Malaysia.

The Analysis of data, Development and Validation of Safety and Health Costs Model for urban rail infrastructure projects

Data Analysis

Data analysis is a means of reducing the data collected into a more manageable entity that can be interpreted. Data analysis establishes the respondents' insights into words. As described by Shamsuri (2004) the researcher needs to arrange the information in the correct form, which depends very much on the methodology of the research.

In the main survey, the results were presented and analyzed using descriptive analysis for the organization and respondent particulars. They included the presentation of tables, pie charts and bar charts pertaining to the frequency and percentage of each section in the questionnaire form. The results were demonstrated and described in sequence to provide ease of understanding concerning the flow of questions. The researcher's own analysis was included after each table and chart was depicted.

Factor analysis (FA) was used to test whether the key study variables were distinct from each other (Griffin & Hu, 2013). The safety & health costs items were extracted from the factor analysis. If the significance level of safety and health cost items was higher than 3.00 (in the five-point scale), then this item was regarded as more significant; otherwise it was less significant. At a significant level higher than 3.00, the category was said to be of some degree of significant (in accordance with the definition of the scale). This strategy was intended to achieve research objective one (1) and two (2).

Regression and correlation analysis procedures were applied to study the relationships between safety and health costs items. Regression was used to predict the value of one cost item based on the value of different items. Correlation is a measure of strength of relationship between those items (Tharenou et al., 2007). Both analyses were employed to achieve research objective three (3), which is to explore the effect of prevention costs to the accident occurrence and accident costs incurred for urban rail infrastructure projects. Specifically, a set of hypotheses was tested in order to estimate the predicted power of independent variables on a dependent variable.

The Development and Validation of Model

In developing the occupational safety and health costs model, the mathematical formulation for the calculation of cost weightage for each safety & health item was originated. The cost weightage for each prevention cost and accident cost was determined based on the mathematical formulation provided to achieve objective four (4).

Finally, the final objective was achieved by developing the occupational safety and health costs model. To ensure that the model is being evaluated in terms of content and meet the reasonable level of acceptance, the model need to be validated by the expert within the industry players. Panels of the validation were selected based on their proactive involvement and contribution to enhance safety at national level. However, the validation was limited to the following aspects;

- Appropriateness;
- The ease of use;
- The coverage in terms of its content, components and items;
- Solicit comments for future improvement.

Thus, the proposed model of occupational safety and health cost for the urban rail infrastructure projects, which are MRT and LRT projects were evaluated by panels presented from the MRT Corporation Sdn Bhd, Syarikat Prasarana Negara Berhad, DOSH, OSH Calculator Team from DOSH, Public Works Department (PWD), Master Builders Association Malaysia (MBAM), Construction Industry Development Board (CIDB) and academicians in a local university.

Conclusion

This article presents the research design in conducting the research. The definition of research methodology and the importance of research design based on literatures were highlighted. Both qualitative and quantitative methods have unique potential for assessment and the combination of both methods is beneficial towards a comprehensive understanding of safety and health costs for the construction of urban rail infrastructure projects.

The methodology is systematically conducted based on four vital phases, which are from the initial research from the literature review, preliminary survey to establish of related issues and the pilot test in evaluating of the relevance questionnaire, the identification of safety and health costs items for the main study data collection and the analysis of data for the development of Safety and Health Costs Model for urban rail infrastructure projects. These appropriate phases are specifically designed to achieve the research objectives and to answer all of the research questions.

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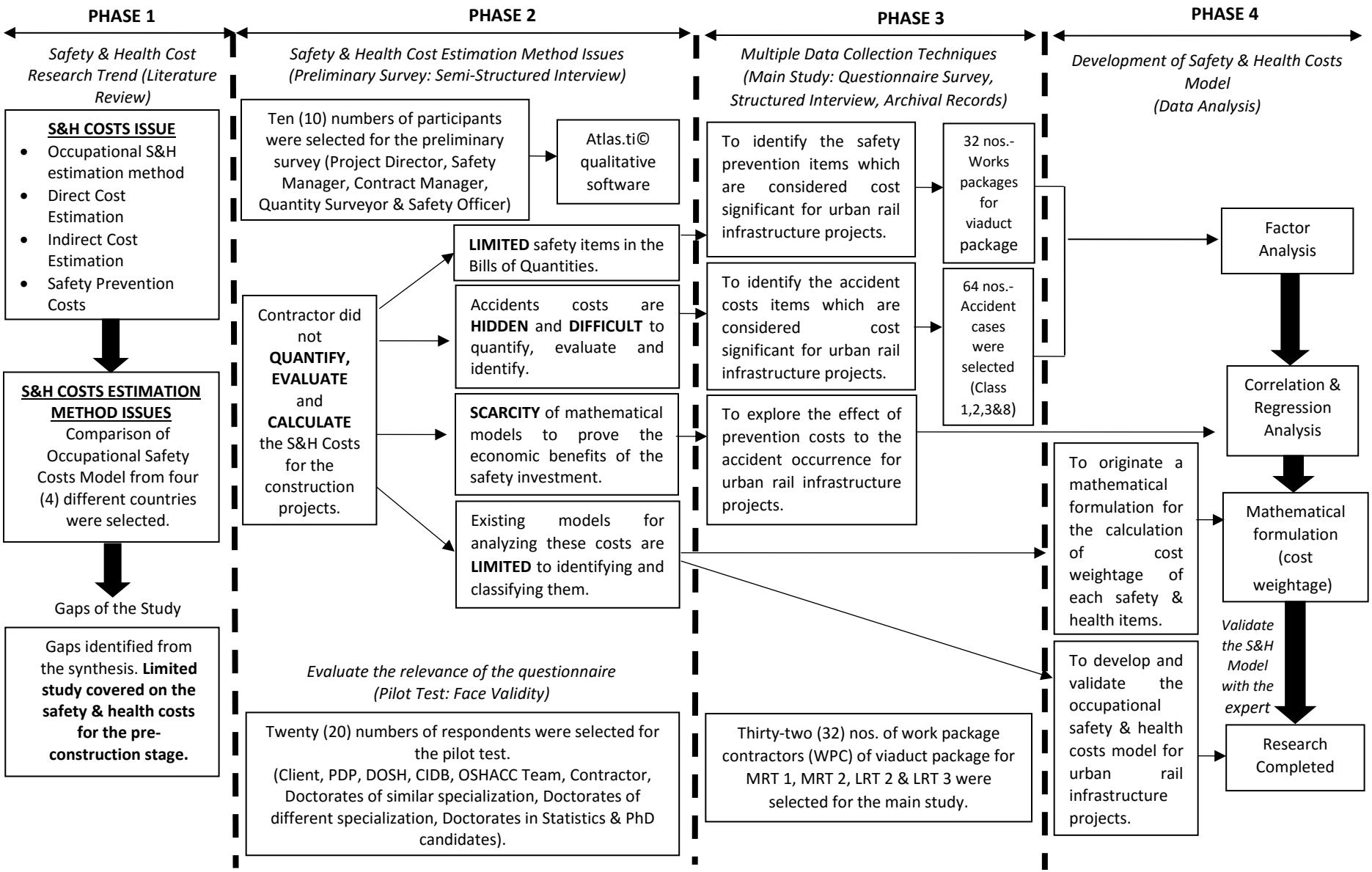

Figure 1: Proposed methodology for the development of occupational safety and health costs model

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