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Developing an integrated conceptual framework for monitoring and controlling risks related to occupational health and safety

Nazli Gulum Mutlu* and Serkan Altuntas**

** Department of Occupational Health and Safety, Bingol University, Bingol, 12000, Turkey*
*** Yildiz Technical University, Department of Industrial Engineering, , Istanbul, 34349, Turkey*
** Corresponding Author : ngmutlu@bingol.edu.tr*

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ABSTRACT

There is a strong relationship between monitoring and controlling risks from several perspectives and developing effective measures to ensure continuous improvement by creating value in occupational health and safety. Business systems that transform into complex and sociotechnical systems have a dynamic structure and contain various serious risks that threaten employee health and safety based on the technological development. Even if the risk impact is reduced with the classical attempts of occupational safety experts to prevent losses, new risks may arise owing to missed risks. Therefore, risks must be continuously monitored and controlled with functionally complementary tools. In addition, these tools must interact with each other. Achieving effective results from their effort in coping with risks is another key factor for businesses. In this paper, an integrated conceptual framework for monitoring and controlling risks in occupational health and safety is proposed. The proposed framework consists of four parts. The hypothesis proposed in the first part focuses on learning from accidents, and that proposed in the second part is related to the proactive analysis and evaluation of risks. The hypothesis proposed in the third part deals with the correct ranking of risks, and that proposed in the fourth part focuses on the development of an early-warning system based on safety technologies. The hypotheses should interact and support each other in the integrated conceptual framework. Finally, the safety performance can be enhanced, and continuous improvement can be achieved by preventing the waste of time and resources.

Keywords: Conceptual framework; Continuous improvement; Monitoring and controlling risks; Occupational health and safety; Safety performance.

INTRODUCTION

There is a strong relationship between monitoring and controlling risks from several perspectives and developing effective measures to ensure continuous improvement by creating value in occupational health and safety. Business systems that transform into complex systems have a dynamic structure and contain various serious risks that threaten employee health and safety based on the technological development. Even if the risk impact is reduced with the classical attempts of occupational safety experts to prevent losses, new risks may arise owing to missed risks. Therefore, risks must be continuously monitored and controlled with functionally complementary tools. In addition, these tools must interact with each other. Achieving effective results from their effort in coping with risks is another key factor for businesses. In this paper, an integrated conceptual framework for monitoring and controlling risks in occupational health and safety is proposed. The proposed framework consists of four parts. The hypothesis proposed in the first part focuses on learning from accidents, and that proposed in the second part is related to the proactive analysis and evaluation of risks. The hypothesis proposed in the third part deals with the correct ranking of risks, and that proposed in the fourth part focuses on the development of an early-warning system based on safety technologies. The hypotheses should interact and support each other in the integrated conceptual framework. The safety performance can be enhanced and continuous improvement can be achieved by preventing the waste of time and resources.

Production systems have turned into complex systems with serious risks threatening employee health and safety. In the face of this transformation, theoretical and practical regulations on occupational health and safety have not shown flexibility (Badri et al., 2018). Consequently, serious costs have been paid by experiencing work accidents, occupational diseases, and even major industrial accidents. Recognized as a milestone for the historical development of occupational health and safety, the first law is the law of factories, which is also known as the apprenticeship law published in 1802 in the United Kingdom (Singpurwalla and Wilson, 2008). Legal regulations on occupational health and safety have been established in the United States since the 1900s (Goetsch, 2015, p. 25). In 1919, the International Labor Organization (ILO) was established in 187 countries, thereby bringing together employers under a single roof, setting standards, and regulating working life. The ILO develops policies and sets standards for working life. The importance of occupational health and safety has been emphasized worldwide after the establishment of the International Organization for Standardization (ISO), which started its operations in 1947 and has published more than 22,810 standards, and the Occupational Safety and Health Administration (OSHA) in 1970 to develop healthy and safe working conditions for employees. In addition to the developments in legal regulations, accepted work accident theorems have been published. Khanzode *et al.* (2012) classified the accident theories as follows: (1) first generation: accident proneness theory, (2) second generation: domino theory, (3) third generation: injury epidemiology theory, (4) fourth generation: system theories, sociotechnical system theory, and macro ergonomic theory. Similar to the change in accident theories, work accident analysis approaches have changed over time. In addition, statistical inferences have been made with accident analyses (e.g., Erdugan & Türkan, 2017, Turkkan & Pala, 2016, Ceylan, 2012 & Swaen et al., 2003) and many data mining-based approaches have been published (Sarkar et al., 2019; Altunkaynak, 2018, Shin et al., 2018 & Sarkar et al., 2016b). As can be seen from previous studies, authors used accident records for the analysis of risks related to occupational health and safety. In addition, the analysis of risks related to occupational health and safety based on accident records can help to prevent the recurrence of similar accidents and to strengthen preventative measures (Jung et al., 2020). In this study, a conceptual framework consisting of four hypotheses is proposed to reduce losses due to accidents and injuries in industries that suffer from monitoring and controlling risks. The first hypothesis of the conceptual framework proposed in this paper suggests that researchers should analyze the accident records with data mining-based approaches to determine the most important risk factors for accidents, to take into account the accident rules consisting of important accident factors, and to develop security measures.

Despite the pleasing developments in occupational health and safety, occupational accidents continue to occur. Another integral part of occupational health and safety management is risk analyses and evaluation practices (Vranješ & Todić, 2019). Marhavilas and Koulouriotis (2012, p.51) defined risk assessment as an essential and systematic process for assessing the impact, occurrence, and consequences of human activities for systems with hazardous characteristics. In addition, Moraru (2012) pointed out that risk analyses can identify weaknesses, consider and correct these weaknesses, and continuously improve the safety performance of systems. Risk analyses and management have been conducted for 30–40 years and remain a developing field (Aven, 2016). Therefore, many risk analysis and assessment methods have been developed to ensure safety in industrial plants (Tixier et al., 2002 & Gul, 2018). However, according to literature, the methods do still not meet the requirements in practice, and further research is necessary (Kjellén & Sklet, 1995, Hauke et al., 2011, & Marhavilas et al., 2011). Furthermore, Khanzode & Maiti (2012) pointed out that the risk analysis methods and accident analyses are independent of each other and should be intersected. Kjellen & Sklet (1995) criticized the inconsistency between the criteria used in risk analyses and assessment methods and the causes of accidents. Consequently, the second hypothesis of the conceptual framework proposed in this paper suggests that researchers should consider these accidents and include them in a proactive risk analysis and evaluation process.

Another criterion to be met through a risk analysis and evaluation is the degree of risk. The degree of risk is expressed as a combination of the probability and severity of risks (Ristić, 2013). It also indicates the relative importance of risks to each other. The degree or sequence of risks helps managers to determine preventive measures (Ouédraogo et al., 2011), and reliable risk ranking improves the safety performance (Alyami et al., 2019). Literature provides many risk prioritization or rating methods (e.g., Dabbagh & Yousefi, 2019, Oz et al., 2019, Podgórski, 2015; Gul et al., 2017, Balaraju et al., 2019 & Zhang et al., 2019a). The common objective of risk prioritization/rating methods is to ensure that the corrective actions eliminate or reduce the risks by starting with the highest-priority risk (Dabbagh & Yousefi, 2019 & Balaraju et al., 2019). However, different risk assessment methods for the same failure types can lead to inconsistent risk sequencing (e.g., Song et al., 2013, Kutlu & Ekmekçioğlu, 2012, Sachdeva et al., 2009 & Braglia, 2000). This inconsistency is a major challenge for decision-makers. Therefore, the third hypothesis of the conceptual framework proposes the use of data fusion approaches such as the technique of precise order preference (TPOP), which can easily integrate the risk rankings obtained by multiple risk analysis and evaluation methods in practice.

The fourth hypothesis proposed within the conceptual framework concerns safety technologies in the field of occupational health and safety. According to literature, the effects of technological developments in the occupational health and safety field can be expressed in two dimensions. These dimensions are the diversification of risk types, which have increased concurrently with the industrial development (Tixier et al., 2002); occupational health and safety practices and employees are inflexible in these situations, and employees are exposed to accidents (Song & Suh, 2019, Badri et al., 2018 & Fernández et al., 2015). The use of technological tools for improving occupational health and safety has become extremely important in today's increasingly complex businesses (Dündar, 2018). Many studies of the effectiveness of safety technologies regarding employees have been conducted (e.g., Antwi-Afari, 2019, Gao et al., 2019, Holte et al., 2018, Awolusi et al., 2018, Badri et al., 2018 & Yavuz, 2018), and the development of safety technologies has been investigated (e.g., Dehghani Madvar et al., 2019, Tatić & Tešić, 2017, Niu et al., 2019, Wu & Liz, 2019, Zhou et al., 2018 & Podgorski et al., 2017). The monitoring and forecasting technologies developed to ensure occupational health and safety in production and service systems will be an inspiration for the required technologies in this field. This can open the opportunity to make its legal arrangements compatible with the technological developments and changes. For this purpose, the focus is monitoring safety technologies, obtaining information that support the required investment decisions, and providing opportunities for updating legal regulations. Therefore, an approach based on a patent data analysis is suggested in the last hypothesis of the conceptual framework.

The proposed integrated conceptual framework for monitoring and controlling risks can be considered a mechanism that provides information and data flow and feeds itself for the continuous development of organization.

Improving the safety performance is crucial for the sustainability of enterprises (Bastan et al., 2018 & Zhang et al., 2019b). The proposed conceptual framework is expected to enable the reliable monitoring and control of risks and a proactive identification of the required measures; in addition, it should ensure continuous improvement.

LITERATURE REVIEW AND DEVELOPMENT OF HYPOTHESES

Several researchers have proposed conceptual frameworks in the field of occupational health and safety. For instance, Kruse et al. (2019) proposed a single integrated lean management system based on the Environmental Management System (ISO 14001), Occupational Health and Safety Assessment Series (OHSAS 18001), Eco-Management and Audit Scheme, American National Standards Institute (ANSI Z10), California Injury and Illness Prevention Program (CA-IIPP), and Occupational Safety and Health Administration's Voluntary Protection Program (OSHA VPP). Moreover, Fitriani and Latief (2019) introduced a conceptual framework based on a construction project management theory, regulations in Indonesia, the project scope, duration, and location, a hazard analysis, and safety programs to determine the cost of safety in accordance with the present conditions of infrastructure projects in Indonesia. Kamardeen (2019) proposed a conceptual framework for a web-based Occupational Health and Safety (OHS) management system for builders, and Mendis and Nandasena (2016) examined the impact of non-used personal protective equipment on occupational health and safety problems and developed a conceptual framework. Furthermore, Andersson & Menckel (1995) compared conceptual frameworks related to the prevention of accidents and injuries. Different from the study reports in literature, the proposed integrated conceptual framework is based on four hypotheses, which are explained in detail in the following sections.

Work Accident Analysis and Research Hypothesis

Work accidents and injuries are important occupational health and safety problems (Jafari et al., 2019). Analyzing past-accident information (Tixier et al., 2002) and developing preventive actions considering accident risks are crucial. An accident model must establish a shared understanding within the organization of how and why accidents happen (Kjellen & Sklet, 1995). According to Khanzode et al. (2012), the accident analysis based on past-accident data is considered a biased reactive approach. Andersson & Menckel (1995) examined 11 conceptual framework models related to measuring accidents and injuries: "primary, secondary, and tertiary prevention", "proactive and reactive primary prevention", "exposure and disposition prevention", "democratic and technocratic prevention", "prevention through intervention", "the Haddon matrix", "Haddon's ten strategies", "active and passive prevention", "prevention as a causal process", "absolute and relative prevention", and "absolute and relative prevention". Among the studies of accident analyses, studies of analyzing accidents in terms of organization, employee, and accident factors by statistical methods (Tatsaki et al., 2019, Erdugan & Türkan, 2017; Turkkan & Pala, 2016, Salguero-Caparros et al., 2015, Sanmiquel et al., 2014, Isara & Ofili, 2012 & Cheng et al., 2010) and the application of data mining-based approaches to accident analyses (Combertiet et al., 2018, Altunkaynak, 2018, Sanmiquel et al., 2018, Shirali et al., 2018, Gerassis et al., 2016 & Mutlu & Altuntas, 2019a) have been conducted. Salguero-Caparros et al. (2019) examined the methods used to analyze occupational accidents and listed 35 different methods. By analyzing occupational accidents, the safety performance can be improved by focusing on the factors causing the accidents (Stemn, 2019, Smirnyakov et al., 2019 & Vranješ & Todić, 2019). The increasing number of accidents recorded in digital media has increased the interest in data mining approaches with the development of new technology (Mutlu & Altuntas, 2019a). In addition, it is recommended that stakeholders such as government, regulators, company, management, staff, and work can be considered while performing accident investigation in complex systems. (Rasmussen, 1997). Therefore, identifying the important factors affecting accidents, considering these factors, determining accident rules in terms of accident outcome variables and effective preventive action plans are proposed to learn from work accidents within the conceptual framework proposed in this paper. Mutlu & Altuntas (2019a)'s study functions as an example for achieving these benefits. Mutlu & Altuntas (2019a) used accident data including information related to company, work, staff, etc. for the assessment of occupational risks. The first hypothesis supporting the integrated conceptual framework in this study is as follows:

Hypothesis 1: Developed safety actions affect positively occupational health and safety in-depth analyses of occupational accident records with data mining approaches.

Hazard and Risk Assessment and Research Hypothesis

A hazard is defined as an accident and potential situation causing undesirable consequences. (Ericson, 2005, p.15). Hazards are specific to business systems, and the professional experience plays a crucial role in the reliable identification of hazards in the system (Khanzode et al., 2012). Ericsson (2005) likened risks to radio signals and stated that they sometimes appear clear, invisible, or pale. Kahnzado et al. (2012) emphasized the importance of identifying hazards in a reliable way to identify and overcome the risk of injury; they classified the hazard identification methods into three groups: biased reactive, biased proactive, and unbiased proactive approaches. The biased reactive approach relates to the analysis of an accident event after its occurrence. The biased proactive approach is a hazard analysis based on the information on possible hazards and the recorded historical error/danger associated with the system. The unbiased proactive approach is a hazard analysis that is conducted without incident/accident and restrictive assumptions. Details on these approaches can be found in Khanzode et al. (2012). The occurrence probability and severity of the hazard are the most important factors that constitute the risk, and the risk is defined by an uncertainty function of these two factors (Pham, 2011, p.369).

Regarding the studies related to risk analyses and assessments, Tixier et al. (2002) classified the methods into six classes based on the combination of four usual criteria (qualitative, quantitative, deterministic, and probabilistic). Moreover, Marhavilas et al. (2011) classified the classic risk analysis and evaluation methods into three classes: qualitative, quantitative, and hybrid approaches. According to literature, the classical methods do not meet the requirements and must be enhanced to analyze the risks of work environments, which have become more complex (Can & Toktas, 2018, Goerlandt et al., 2017, Mohsen & Feresteh, 2017 & Mutlu & Altuntas, 2019b). Some researchers have suggested that classical risk analysis and evaluation methods should be developed by hybridizing the methods with fuzzy logic, multi-criteria decision-making methods (Dabbagh & Yousefi, 2019, Mete et al., 2019, Tepe & Kaya, 2019, Gul, 2019, Gul et al., 2018, Akyildiz & Mentes, 2017 & Gürcanlı & Müngen, 2009). In 2018, Gul listed 40 methods that integrate risk analysis and assessment methods, multi-criteria decision making, and fuzzy logic approaches and stated that most of the developed methods are based on the FMEA method. However, researchers have criticized that hazard and risk analysis practices are not integrated and that the criteria used in both analysis processes do not overlap (Khanzode & Maiti, 2012, Raouf, 2004 & Kjellen & Sklet, 1995).

The basis for the proposed the conceptual framework is based on articles 8 and 12 of the Occupational Health and Safety Risk Assessment Regulation indicating that it is appropriate to with accident analysis (OHS Risk Assessment Regulation, 2012). In the 8th article of the mentioned regulation, the information that must be collected within the scope of the identification of hazards includes “past accident records” and “near-miss incident” information. In article 12 of the same regulation, it was reported that the risk assessment should be performed again in the event of “occupational accident, occupational disease or incident before the incident”. Another important issue is the statement “The risk assessment is carried out by a team created by the employer”, as stated in Article 6 of the Occupational Health and Safety Risk Assessment Regulation. In other words, it was stated that the team consisting of the employer or his representative, occupational safety expert, employee representative, support staff, and employees who are knowledgeable about the risks in the workplace should carry out the risk assessment with a participatory perspective. Therefore, the second hypothesis of the conceptual framework proposed in this paper recommends that factors learned from accidents should be considered in risk analyses and evaluations. For example, Mutlu & Altuntas (2019b) presented an unbiased proactive risk analysis and evaluation approach based on FMEA, which is based on biased proactive features; it can be used in risk analysis and evaluation processes to improve occupational health and safety in production and service systems. Researchers are recommended to integrate Mutlu & Altuntas (2019b)’ results into their analysis and evaluation processes. The reasons for recommending the study of Mutlu & Altuntas (2019b) to researchers are listed below:

a) The proposed method is based on FMEA method, which meets the need for strong risk assessment method in complex systems (Flaus, 2013, p. 179).

b) The proposed method complies with the consideration of Rasmussen (1997) principles, which are related to the participation of stakeholders in the risk management process within the scope of "inclusiveness", which is one of the accident principles of multiple actors and levels, external pressure.
c) The proposed method also complies with the ISO 31000 (2018, p.3) which highlights taking into account the information, opinions and perceptions by ensuring the participation of stakeholders in the risk management process within the scope of "inclusiveness", which is one of the risk management principles.

Therefore, the second hypothesis supporting the integrated conceptual framework in this study is as follows:

Hypothesis 2: Factors affecting accidents have a positive impact on occupational health and safety when included in a proactive risk assessment approach.

Risk Prioritization, Rating, and Research Hypothesis

Risk is a combination of the likelihood of a harm and the severity of that harm (ISO 12100, 2010, p.3). Risk assessment helps to identify, analyze, and evaluate possible riks (Brauer, 2016, p.650). Hazards are identified by risk identification. The purpose of risk identification is to reduce uncertainty in factors that have the potential to cause accidents, injuries, diseases and death. (Brauer, 2016, p.646). Risk analysis has qualitative and quantitative techniques, which are applied to potential hazards, and frequency and severity of risks are generally taken into account (Brauer, 2016, p.647). According to ISO (12100, 2010, p.3), risk analysis is the determination of the framework to be analyzed, the definition of hazards and the prediction of risks. Residual risk means remaining risk after preventive measures are applied. (ISO 12100, 2010, p.3). Risk estimation involves identifying the severity of the possible harm and the probability of occurrence (ISO 12100, 2010, p.3). In addition, Risk evaluation assesses risk aversion and risk acceptance in practice (Brauer, 2016, p.650). According to ISO (12100, 2010, p.3), risk assessment is the stage to decide whether risk reduction targets are achieved based on risk analysis. Risk hierarchy / priority order obtained during the risk analysis phase is used as information that facilitates decision making (Silvestri et al., 2012a). For instance, risk priority is used for various purposes such as increasing organizational benefits (Dodsworth et al., 2007), improving safety by rating fire hazards (Lo, 1999), rating critical equipment for maintenance planning (Mahmoudi et al., 2019), rating health risks according to priority, and improving safety in general (Chang et al., 2012).

In the literature, the use of Multiattribute utility theory (MAUT) and Event Tree Analysis (Garcez & Almedia, 2013; Brito & Almedia, 2009), the use of fuzzy logic based FMEA (Yazdi, 2019, Alyami et al., 2019 & Pillay & Wang, 2003) and the use of multi criteria decision making based FMEA (AL Mashaqbeh et al., 2019 & Hu et al., 2019) have been conducted to decrease uncertainty and to enhance the current risk ranking technique. However, different risk priorities for the same hazards can be obtained, which causes failures in case of the use of multiple risk analysis approaches (Gul & Ak, 2018, Liu et al., 2019, Liu et al., 2017a). This leads to a confusing problem for decision makers. This paper proposes a single risk sequencing order based on the integration of the risk grades to overcome the problem and obtain a more reliable risk priority ranking in the developed conceptual framework. One of the methods that can be used to solve this risk degree problem is TPOP, which was proposed by Bairagi et al. (2015). When the method is applied to a risk analysis and evaluation process, the working principle is based on the use of multiple risk analysis and evaluation methods. By integrating the advantages of different methods, a single risk sequence can be obtained. For example, Mutlu & Altuntas (2019b) proposed a risk analysis and evaluation method based on the FMEA, FTA, and BIFPET algorithms and compared the results obtained from the FMEA-FTA, FMEA-FTA, and PERT distributions to assess the performance. Single risk ranking can be achieved with the TPOP approach by using the final risk priority rankings obtained by these three different methods. The method is expected to provide great convenience to decision makers and contribute to the improvement of occupational health and safety. Therefore, the third hypothesis supporting the integrated conceptual framework in this study is as follows:

Hypothesis 3: Reliable risk ranking affects occupational health and safety positively.

Technological Developments in Occupational Health and Safety And Research Hypothesis

Risks related to occupational health and safety have increased in industries that have become more complex with the technological development (Huang & Ren, 2010, Myers, 2007). In addition, technological tools have been increasingly used, and new safety technologies have been developed; however, they are not sufficient for improving occupational health and safety (Antwi-Afari, 2019, Holte et al., 2018, Gao et al., 2019, Tang et al., 2019, Awolusi et al., 2018 & Tatić & Tešić, 2017). The past and present technologies must be accurately analyzed, and information that sheds light on the future must be obtained to use business resources efficiently and assist in investment decisions.

One of the ISO 31000 (2018, p.3) risk management principles is *Dynamic* which implies that the risks can be estimated, identified, accepted or accepted taking into account that new risks may arise and risks may disappear or turn into another form due to changes in an organization's internal and external environment. Hence, it is thought that the rapid development of safety technologies should be taken into consideration in the process of monitoring and controlling the risks, which contributes to the dynamic nature of the risks.

One of the most important indicators of technological developments is the use of patent documents (e.g., Yakişik & Çetin, 2014, Tunç, 2008 & Narin & Olivastro, 1988). Based on the studies of Song & Suh (2019) and Jeon & Suh (2019), use of patent documents in the field of safety technologies is suggested to follow the technological developments in the field of occupational health and safety within the integrated conceptual framework. For example, Durmusoglu (2018)'s results can be used to create a technology forecasting model with patent documents and to identify significant changes. Durmusoglu (2018) used Individual Moving Range control charts based on patent documents to monitor the changes in technology. These researchers have not used the approach in the monitoring process of the changing safety technologies in the field of occupational health and safety and in the development of the forecasting model. The years leading to the significant changes in security technologies can be determined based on the control charts. This way, the factors responsible for the changes can be investigated, and the technologies to be investigated can be determined. The occupational health and safety field is expected to be improved by encouraging the use of safety technologies in practice. Therefore, the fourth hypothesis supporting the integrated conceptual framework in this study is as follows:

Hypothesis 4: Monitoring changes in safety technologies affects the improvement of occupational health and safety positively and promotes the construction of proactive occupational health and safety management systems in practice.

THE PROPOSED CONCEPTUAL FRAMEWORK

Figure 1 illustrates the proposed conceptual framework for improving occupational health and safety and monitoring and controlling risks. The information and data flow between the approaches of the proposed conceptual framework are presented in Figure 2. The first part in Figure 1 presents the first hypothesis of the proposed conceptual framework, which deals with learning from accidents by analyzing past-accident information (biased reactive hazard analysis). The second part in Figure 1 presents the analysis and assessment of risks and the consideration of the information learned in the previous part (the first part) during the unbiased proactive risk analysis and evaluation process.

The third part in Figure 1 demonstrates how to simplify the decision-making process of security managers or experts with the correct ranking of risks for a single ranking with multiple risk analysis approaches. The proposed conceptual framework encourages technology investors to monitor and control risks and draws attention to the development and changes of safety technologies to improve occupational health and safety in the last part of Figure 1.

The proposed approaches for monitoring and controlling risks and the information flow of the conceptual framework are summarized in Figure 2. A robust occupational health and safety system can be constructed in an organization using the proposed conceptual framework.

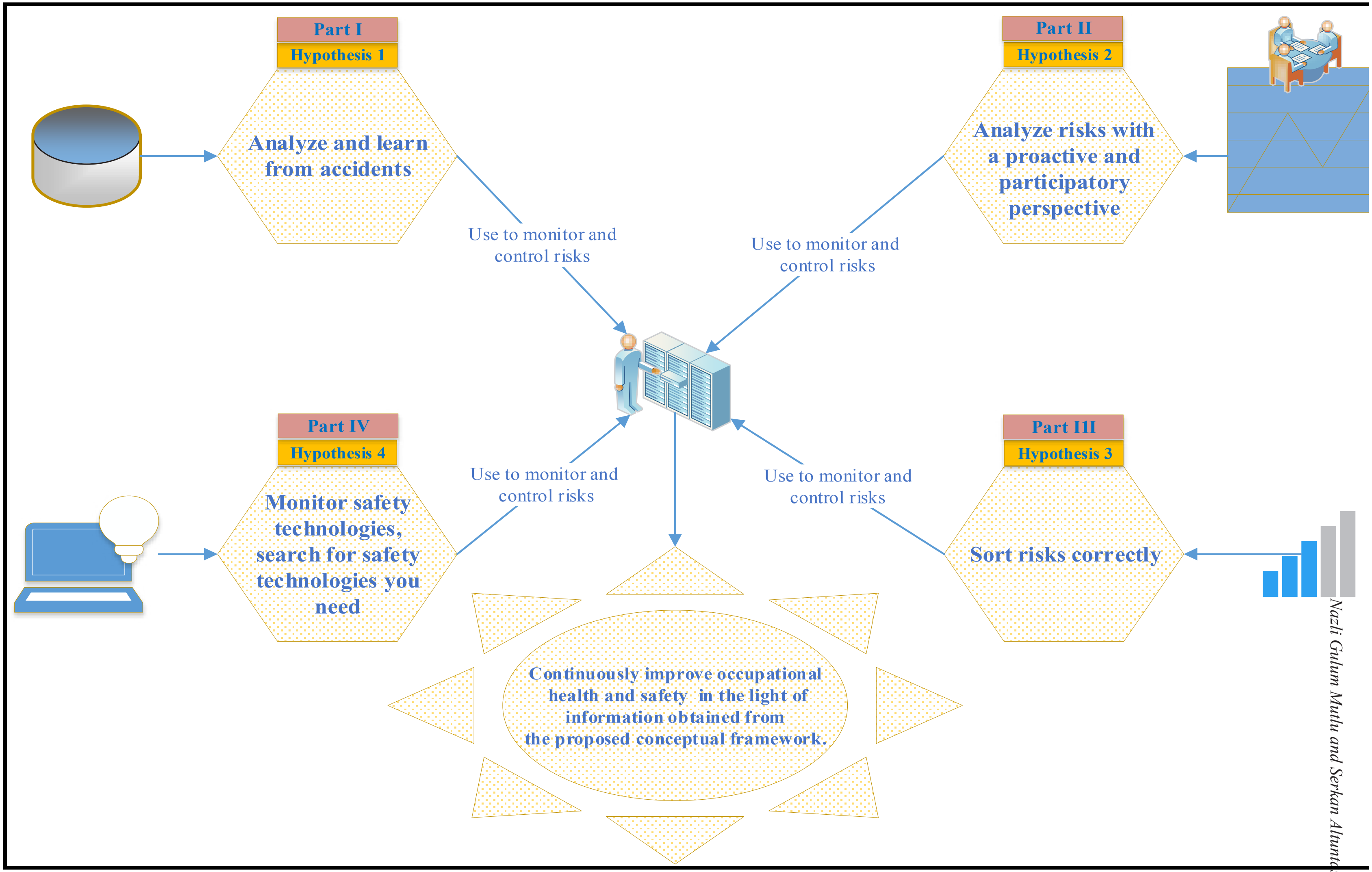

Figure 1. Summary of objectives and desired results in the proposed conceptual framework.

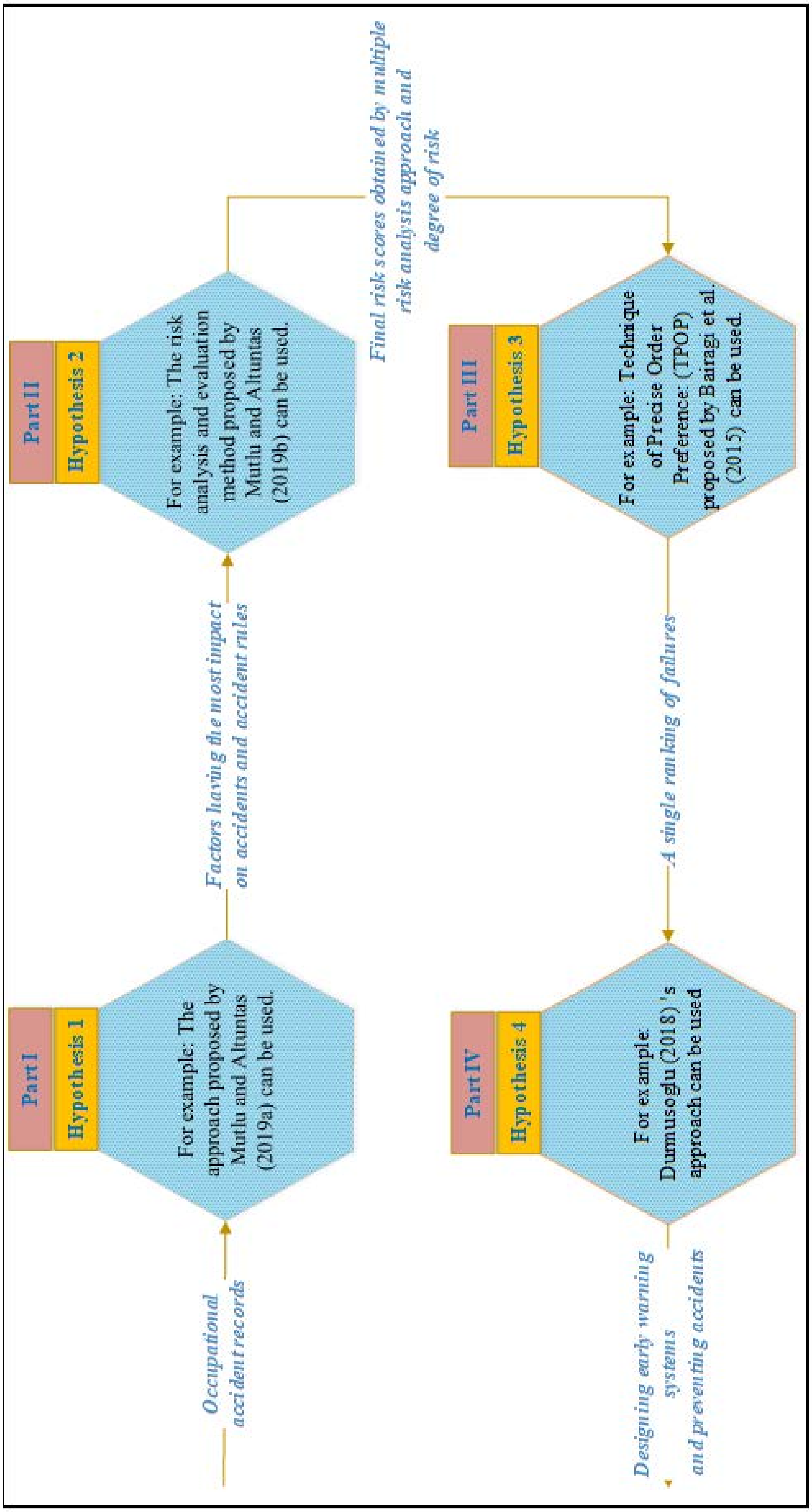

Figure 2. Proposed approaches for monitoring and controlling risks and information flow within conceptual framework

CONCLUSION

The development of occupational health and safety can be determined by predicting possible hazards and critical factors, monitoring critical factors, and using safe monitoring tools to ensure that they are not exposed to accidents and losses (Pęciłło, 2016). In addition, the systems gain flexibility against risks; thus, the risks and ranking are known, systems that provide continuous risk monitoring are used, and the risk effects can be eliminated without being exposed to losses (Hollnagel et al., 2006). Therefore, understanding the accident structure is crucial for predicting future accidents and developing effective measures by analyzing past-accident data.

In this paper, a conceptual framework for monitoring and controlling risks in occupational health and safety in practice is proposed. It is based on four hypotheses, which focus on important points regarding occupational health and safety in practice. The data and information flow within the proposed conceptual framework support each part to achieve robust occupational health and safety practice in an organization.

The combined use of the proposed solution approaches is expected to integrate the advantages of independently used tools to improve holistic occupational health and safety. This way, decision making can be conducted with minimal cost and maximal efficiency to improve occupational health and safety in practice.

DISCUSSION

Occupational safety professionals and safety engineers are expected to eliminate the risks of accidents, control safety measures, and develop necessary measures when they know the critical factors and their importance in terms of accident types based on the use of the proposed conceptual framework.

In addition, three important factors should be considered: (1) the risk factors learned from accidents, (2) proactive perspective, and (3) information from all relevant stakeholders to achieve a successful outcome based on the analysis and assessment of risks. Another important step for improving occupational health and safety is starting with the top-priority risk when controlling and developing safety measures to reduce or eliminate risks. Furthermore, the risk priority ranking is of great importance for planning the precautionary costs of company resources. Risks should be assessed correctly. Otherwise, more important risks may be overlooked, and serious losses may occur. Analyzing past-accident information for safety, analyzing and evaluating risks, and correctly ranking risks are as important as monitoring safety technologies and introducing the required technologies to the enterprise.

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