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ORIGINAL ARTICLE

A Conceptual Framework for Analyzing Occupational Safety and Health Program Investment: Hierarchy of Controls-Based Approach

Adithya Sudiarno[1,2], Nadira Putri Maharani[3]

[1,3]Department of Industrial and Systems Engineering, Faculty of Industrial Technology and Systems Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia
[2]Occupational Safety and Health Council of East Java Province, Indonesia (DK3P Jawa Timur)

ABSTRACT

Introduction: The Frequency Rate (FR) of workplace accidents in 2019 was recorded at 3.4, meaning that for every million work hours, there were 3.4 cases of workplace accidents. In 2020, the FR increased to 3.6, and in 2021, it further rose to 3.8. Therefore, companies need to make improvements to reduce the number of work accidents by investing some resources in the Occupational Safety and Health (OSH) investment program. This study aims to develop a conceptual framework for analyzing the OSH investment program by considering its benefits and costs. **Methods:** Hierarchy of controls was used in this study to classify and identify OSH programs, OSH investment items, and OSH implementation options. The in-depth interview was also conducted by involving several experts to formulate and justify the items in the conceptual framework. **Result:** This study resulted in 2 main aspects, namely carefully chosen OSH experts to ensure reliable and relevant information collected and involving a detailed analysis of different data levels (3, 2, and 1) along with a breakdown of costs for each level 1 data. **Conclusion:** The finding of this study is a conceptual framework to help and direct companies in order to analyze the selection of OSH programs, OSH investment items, and OSH implementation options by prioritizing the hierarchy of controls.

Keywords: benefit cost ratio, benefit and cost, hierarchy of controls, OSH program investment

Corresponding Author:
Adithya Sudiarno
Email: adithya_sudiarno@ie.its.ac.id
Telephone: +628123012388

INTRODUCTION

Data on work accidents and work-related diseases during 2019-2021 are summarized in the form of Frequency Rate (FR) or violence rate, which is the number of accident cases that cause a number of workers not to work for every one million hours worked by (Direktorat Jenderal Pembinaan Pengawasan Ketenagakerjaan Dan Keselamatan Dan Kesehatan Kerja Kementerian Ketenagakerjaan, 2022). Data from 2019 - 2021 is more complete and more accessible by the public. This data is considered more relevant and reflects the current conditions so that the analysis will be more in accordance with the situation being faced. The average number of FR in 2019 was 3.4. then, in 2020 it increased to 3.6 and in 2021 it increased again to 3.8 cases of work accidents per million working hours of people. Hence, it can be concluded that the level of work accidents in Indonesia increases every year.

The application of Occupational Safety & Health (OSH) standards or programs in the company can be a way to reduce work accidents as well as function as system development and improvement (Purwanto *et al*., 2020). OSH standards commonly applied by companies in Indonesia are the Occupational Health and Safety Management System (Indonesian terminology: Sistem Manajemen K3) and ISO 45001:2018. A study states that the application of ISO 45001:2018 contributes to the improvement of the organizational internal system, the culture of communication in the company, and employee productivity. However, (Direktorat Jenderal Pembinaan Pengawasan Ketenagakerjaan Dan Keselamatan Dan Kesehatan Kerja Kementerian Ketenagakerjaan, 2022) shows that around 63.4% of companies in Indonesia have not implemented overall OSH standards. Therefore, it can be

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concluded that OSH conditions in the industry in Indonesia still need improvement (Sudiarno, *et al*., 2021). The most common work accidents are falling from the height (falling from stairs or other high surfaces) accidents, body injuries resulting from contact with objects or equipment (hit by falling objects, exposure to toxic chemicals, explosions or fires, poisoning, etc.), traffic accidents, accidents related to machinery and equipment (machine operation errors, equipment failure, etc.) (Aljbour, 2022 ; (Sudiarno-b, Amanullah, & Akbar, 2022).

In fact, work accidents need to be handled because of their significant impact on workers and companies (Mustard and Yanar, 2023). Handling work accidents can prevent occupational diseases caused by work, provide a safe and comfortable work environment, improve employee performance, and finally improve the positive image of the company in the eyes of employees, business partners, and even the public (Aminian *et al*., 2023). One method that can be used is the Hierarchy of Controls, which is a method that identifies and regulates risk control steps based on the level of preferences, starting from the most effective action to the lowest (National Institute for Occupational Safety and Health, 2023). Existing control steps at a lower level in the hierarchy (PPE and Administrative Control) tend to have lower effectiveness in reducing risk. Nevertheless, it still needs to be done in the existing process to control residual risk (Hopkin, 2017), which arises because not all hazards can be fully eliminated or substituted (Purohit *et al*., 2018). Thus, the use of lower control steps in the hierarchy is still important in some situations to complete the higher control steps (Ewertowski and Butlewski, 2021). Companies need to make considerations in choosing which Hierarchy of Controls steps to implement to reduce the risk of work accidents. The considerations include availability and affordability, suitability for working conditions, worker involvement, as well as evaluation and review to ensure whether the selected control measures are effective in reducing hazards that frequently occur in the work environment.

Issues that are often faced by companies when controlling the risk of work accidents are the ones related to limited resources (costs) (Roze *et al*., 2021; (Sudiarno-c, Dewi, Widyaningrum, Ma'arij, & Supriatna, 2024). These issues can affect the company's ability to provide adequate training, personal protective equipment, health monitoring, and necessary supervision. Hence, when applying the Hierarchy of Controls, the concept of As Low as Reasonably Practicable (ALARP) is used, which is a guide that considers the balance between reducing the risk and cost or effort needed to achieve it (Turnham *et al*., 2023). Because if the company cannot manage resources and uncertainty of costs well, the company will make the wrong investment and will suffer losses. Cost uncertainty, including production costs, input costs, and capital costs, can affect risk assessment, resource allocation, long-term investment strategies, corporate investment levels, and investment decision making (Zeira, 1990). Thus, it needs a tool that helps companies to choose the most optimal OSH program investment, by considering the needs and costs of the company.

In real conditions in the company, urgency related to the application of OSH is only felt by field workers. Top management in national companies tends to be more selective in resources that must be spent for OSH investment. Top management needs to be convinced (especially quantitatively) related to the appropriate OSH investment feasibility. The output of this study can be a support system to help investment decision making based on financial analysis so that the top management will be more confident related to the feasibility of selected OSH investment items by considering the company's resources. Thus, the framework of Benefit Cost Ratio (BCR) is used. Benefit Cost Ratio (BCR) is a metric used to evaluate the feasibility of an investment by comparing the expected benefits with the costs incurred for the investment (Riaño-Casallas and Tompa, 2018). BCR is a comparison between the total benefits of an investment and the total costs incurred for that investment (Trisna, Mahessya and Elva, 2022).

This study aims to develop a conceptual framework for analyzing OSH programs investment using BCR perspective.

METHODS

In the research process, two main considerations form the identification of OSH investment items and options for the OSH implementation program. The selection of OSH Investment Items and OSH implementation options to be identified will be limited by the availability of relevant data and information. In addition, the OSH program, type of OSH investment item, and OSH implementation options identified in this tool are mandatory and general OSH programs.

The field study phase focuses on exploring what has been done by practitioners in leading industries to justify the amount of OSH investment. To analyze all qualitative information, the data triangulation method is carried out by conducting an in-depth interview and asking each expert related to the answers of other experts for data validation and crosschecking if there is a different opinion. Expert judgement has been used in different fields to solve problems that can vary from very simple to very complicated and provide an important input for decision- making (Hanea *et al*., 2021)

The selected experts must meet specific criteria, such as having a minimum OSH work experience for 5 years, serving/having a minimum work experience at the Middle Management (Supervisor) level, currently serving/having work experience in the company with a minimum of 500 employees, once joining certification / OSH-related training that is relevant and can be considered as an indication of expertise, and having the experience in the preparation of OSH guidelines, regulations or policies, and the application of OSH standards. The in depth interviews with selected respondents will discuss the existing OSH conditions, the general description of the needs of the OSH program in the company, the obstacles experienced in proposing OSH programs, and the strategic and technical urgency in implementing OSH programs.

The data collection phase is carried out to extract related information regarding the OSH program and its implementation within the company obtained from experts as well as identification of benefits, direct saving, and soft saving of each OSH investment program. The information collected is then categorized into various levels of data. Data level 3 categorizes the OSH program based on the level of Hierarchy of Controls framework. Meanwhile, data level 2 defines investment items and level 1 data outlines OSH implementation options.

RESULT

Expert Selection and In-Depth Interview

The in-depth interview method was used in this study to organize and structure an interview aiming to generate insights on this research topic with limited information (Margaret R. Roller, 2019; Beiderbeck *et al*., 2023). A total of 4 prospective experts were selected. Then, the in-depth interview was carried out to the 2 experts that meet the 5 categories listed. The in-depth interview discussed the existing OSH conditions in the company (to find out the gap between the ideal conditions and the real conditions in the company), the general description of the OSH improvement needs in the company, the constraints experienced in submitting the OSH program, as well as strategic and technical urgency in implementing the OSH program.

Level 3, Level 2, and Level 1 Classification

Level 3, level 2, and level 1 are classified based on the results of the in-depth interview

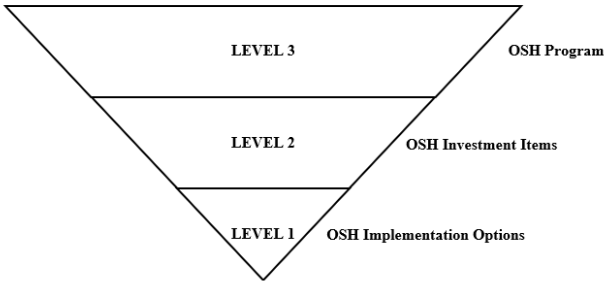

Figure 1. Data Level Visualization

Table 1. Data Level Differences

	Definition	Scope	Example
Level 3	The big picture of OSH Program	Identified based on stages in the hierarchy of controls framework	Substitution Engineering Controls Administrative Controls PPE
Level 2	The specific items invested by the company to conduct the OSH program	Identified for each OSH program in the Level 3	System/process improvement Equipment design Ergonomics program Employee health program
Level 1	The range of reasonable alternative options that can be implemented for each investment item	Identified for each investment item (level 2) in each OSH program (level 3)	Reduction of Hazardous & Toxic Material doses Providing Protective Guarding and Shielding Conducting training on ergonomic topics

by considering hierarchy of controls framework and fulfillment of regulations in Indonesia. In the conceptual framework, the mapping for level 3, level 2, and level 1 formed inverted triangle graphics as shown on Figure 1.

Each level has different definition, scope, and examples. Table 1 will explain the difference between all data levels.

The following Figure 2 is an example of level 2 and level 1 breakdown in an OSH program investment that focuses on the "Substitution" efforts of level 3.

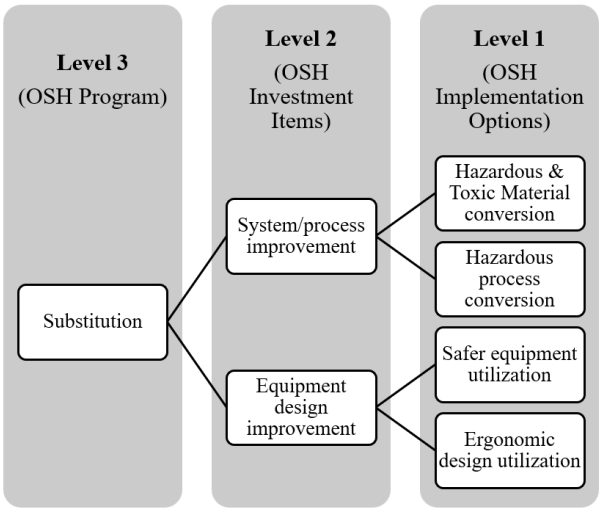

Figure 2. Data Mapping for "Substitution' OSH Program

Benefit and Cost Classification Process for Each Level

Level 1 corresponds to the benefits and the costs of implementing OSH options. Benefit is a profit or saving that the company will get if the company choose certain OSH implementation options. On the other hand, cost is the amount of expenses paid by the company if it wants to implement an OSH program. Figure 3 visualizes the relationship among level 3, level 2, and level 1 with the benefits and costs.

In this study, there are 2 benefits that will be considered, namely direct saving and soft saving. Direct saving is the benefit that the company will get directly if the company choose the OSH implementation option. Meanwhile, soft saving is the benefit that the company will get indirectly in a certain condition if some requirements are met. Figure 4 (a) visualizes the possible direct saving and soft saving associated with the "Substitution" OSH Program.

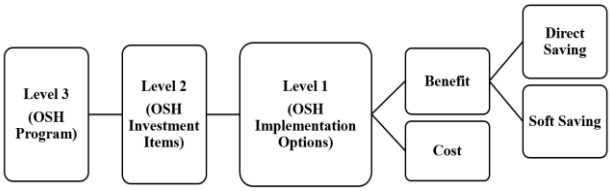

Figure 3. Visualization of Relationship Between Each Level, Benefit, and Cost

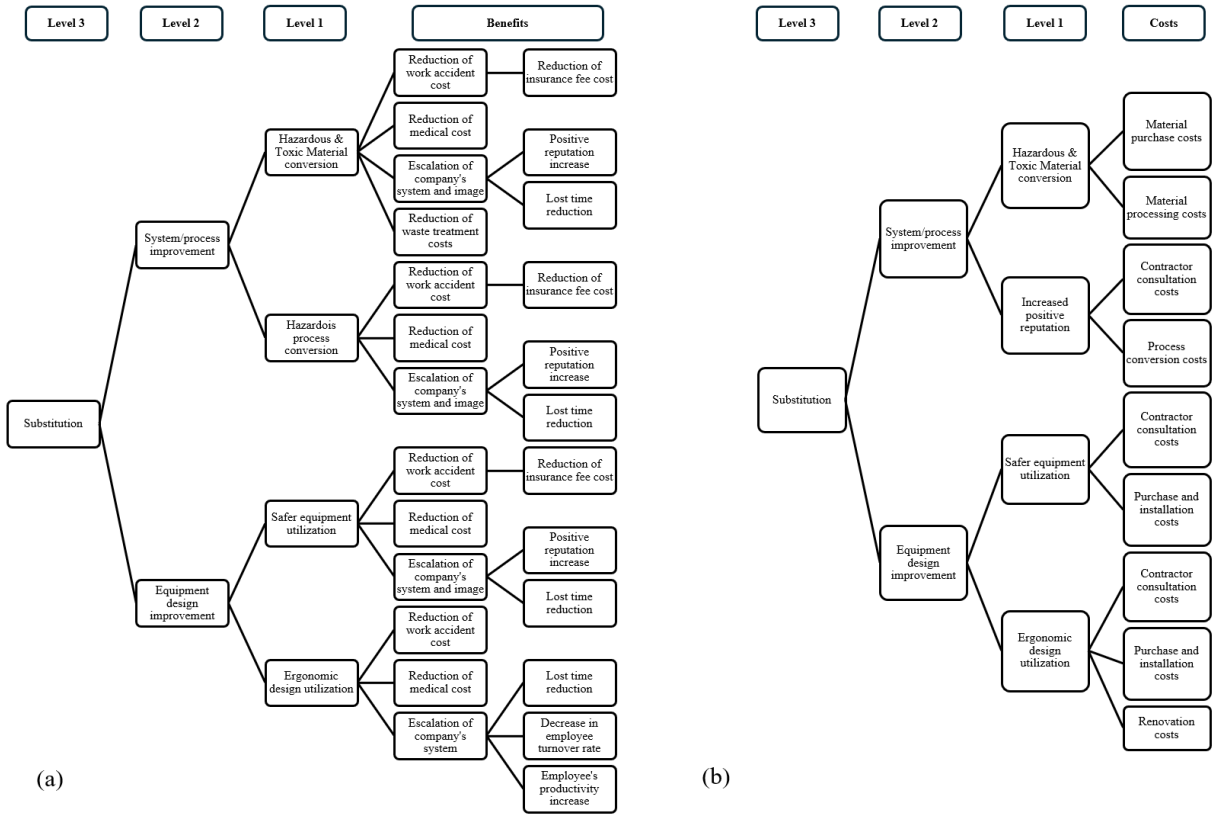

Figure 4. (a) Benefit of "Substitution" OSH Program (b). Cost of "Substitution" OSH Program

By contributing to the provision of investment funds for the OSH program, this means that the company pays attention to the social sustainability of its employees. Figure 4 (b) visualizes a breakdown of the various costs that may be incurred in implementing "Substitution" OSH Program.

DISCUSSION

The study focused on two main aspects: Firstly, it carefully chose OSH experts to ensure reliable and relevant information collection. Secondly, expert judgments were obtained by doing in-depth interview to develop conceptual framework for analyzing OSH programs investment (Margaret R. Roller, 2019; Beiderbeck *et al*., 2023).

The expert selection was thorough, guaranteeing the expertise needed in OSH (Simola, Mengolini and Bolado-Lavin, 2005). This ensured the credibility of the information gathered (Emoghene and Nonyelum, 2017). The analysis created a clear structure among data levels, linking OSH programs with OSH investment items and OSH implementation options. This organized approach helped in understanding how various OSH programs relate one another, covering different control aspects like Substitution and Personal Protective Equipment.

In-depth interview is a qualitative data collection method that involves intimate interviews between the interviewer and the interviewee (Tavory, 2020 ; Rutakumwa *et al*., 2020). One of the main advantages of this method is the possibility of establishing relative closeness between the interviewer and the interviewee. The relative closeness of the interviewer–interviewee relationship potentially increases the credibility of the data by reducing response biases (Margaret R. Roller, 2019). Next, the main conclusion of experts' feedback was identified. This conclusion is considered an interpretation of in-depth interview in which many assumptions and expert judgments are made (Hanea *et al*., 2021).

This study involved an analysis of different levels (3, 2, and 1), along with the breakdown of benefits and costs for each level 1 data. OSH programs are classified based on the hierarchy of controls concept which consists of "Substitution", "Engineering Controls", "Administrative Controls", and "Personal Protective Equipment (PPE)" (Hierarchy of Controls | NIOSH | CDC, Centers for Disease Control and Prevention, 2023). The example can be observed in the framework in appendix 1 which shows that the OSH programs "Engineering Controls" (level 3) can be conducted by investing in system / process improvement (level 2). Thus, the implementation options (level 1) can reduce the doses of hazardous materials or the use of protectors in production machines (Guarding, Shielding, and LOTO).

The "Elimination" choice in hierarchy of controls was not used in this study. Elimination focuses on removing or eliminating hazards from the workplace, or in other words, completely eliminating hazards or potential sources of hazards from the work environment without using any substitute alternatives (Reese, 2008). Thus, there is no risk associated with the hazard and ultimately no risk control is carried out because the hazard has been completely eliminated (Ramaganesh *et al*., 2021). As a result, there is no additional control needed. Therefore, due to the limitation in this study, elimination was not identified as an OSH program.

In this study, the classification of the benefits and costs is meticulously outlined, namely direct and soft saving benefits, plus costs linked to each OSH implementation option (Yılmaz and Kanıt, 2018). The focus of this study is making a framework, so the benefits and costs classification process is made to help practitioners to estimate what benefits and costs that the company might get if it implements an OSH program, OSH Investment Items, and OSH Implementation Options. Thus, the discussion in this paper does not determine the amount of benefits and cost, but only provides a framework based on Hierarchy of Controls approach. The breakdown of the benefits and costs framework is shown on Appendix 1 dan Appendix 2. Appendix 1 visualizes the benefits of the "Engineering Controls" OSH Program. Several benefits of this control would be reduction of work accident cost, reduction of medical cost, reduction of insurance cost, etc. Meanwhile, Appendix 2 visualizes the possible cost breakdown of the "Engineering Controls" OSH Program, namely material purchase cost, material processing cost, consultation cost, etc.

As shown in Appendix 3, if a company follows certification and applies international standards related to OSH, namely ISO 45001:2015 (Matias *et al*., 2022), then the company will gain direct saving in the form of increasing the company's positive reputation. Thus, the investment costs for direct promotion or product marketing can be reduced (soft saving) due to this positive reputation. This means that the costs incurred by the company for

marketing activities can be reduced. Apart from that, the company will get an increase in orders from customers (direct saving) because in some conditions, customers prefer to place orders from companies that already have standards (Darabont *et al*., 2018 ; Malinda *et al*., 2022). This means that the costs obtained by the company if there are additional orders from customers will increase. This breakdown enabled a thorough assessment of potential benefits against initial costs, offering a clearer financial overview for companies (Horhota *et al.*, 2020 ; Akcay *et al*., 2018)

Appendix 4 explains the costs that must be paid if a company wants to obtain ISO 45001:2015 certification, namely certification costs (the costs required to employ an independent certification body that will audit and provide an ISO certificate), consultation costs (the costs for hiring a consultant to plan the compliance of ISO 45001 requirements, which usually include training, document preparation, and preparation for audits), employee training costs (the costs incurred to train employees on the ISO 45001 standard and the way to implement it, which include instructor fees, materials, and employee time spent on training), internal audit costs (the costs of training internal auditors and time spent for conducting audits), and surveillance costs (the costs for responding to audit findings, completing follow-up actions, and updating procedures) (Lee *et al*., 2020).

Ultimately, this study contributes to the advancement of science and technology by providing a structured methodology and a tangible framework for enhancing occupational health and safety practices within organizations, benefiting the broader community. The limitation of this study does not involve direct calculations in the case of OSH program investment and does not consider all items in the hierarchy of control.

CONCLUSION

The finding of this study is a conceptual framework to help and direct companies in order to analyze the selection of OSH programs, OSH investment items, and OSH implementation options by prioritizing the hierarchy of controls. OSH Program (level 3) is the big picture of OSH plan. OSH Investment Items (level 2) are specific elements invested by the company. OSH Implementation Options (level 1) are some of the choices or alternatives available for companies to implement an investment option in the OSH program. The financial parameter used to make conceptual framework is Benefit Cost Ratio (BCR). Benefit breakdown consists of the summary of direct saving and soft saving, while cost breakdown consists of all incurred costs for the initial investment.

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CONFLICTS OF INTEREST

The authors declare that there are no significant competing financial, professional, or personal interests that could have influenced the performance or presentation of this study.

AUTHORS' CONTRIBUTION

AS was responsible for conceptualizing and designing the study, acquiring the funding, performing the analysis, supervising the entire study, as well as interpreting, reviewing, and editing the results of the analysis. Meanwhile, NPM was in charge of collecting the data, performing the analysis, writing the original draft, and editing the article.

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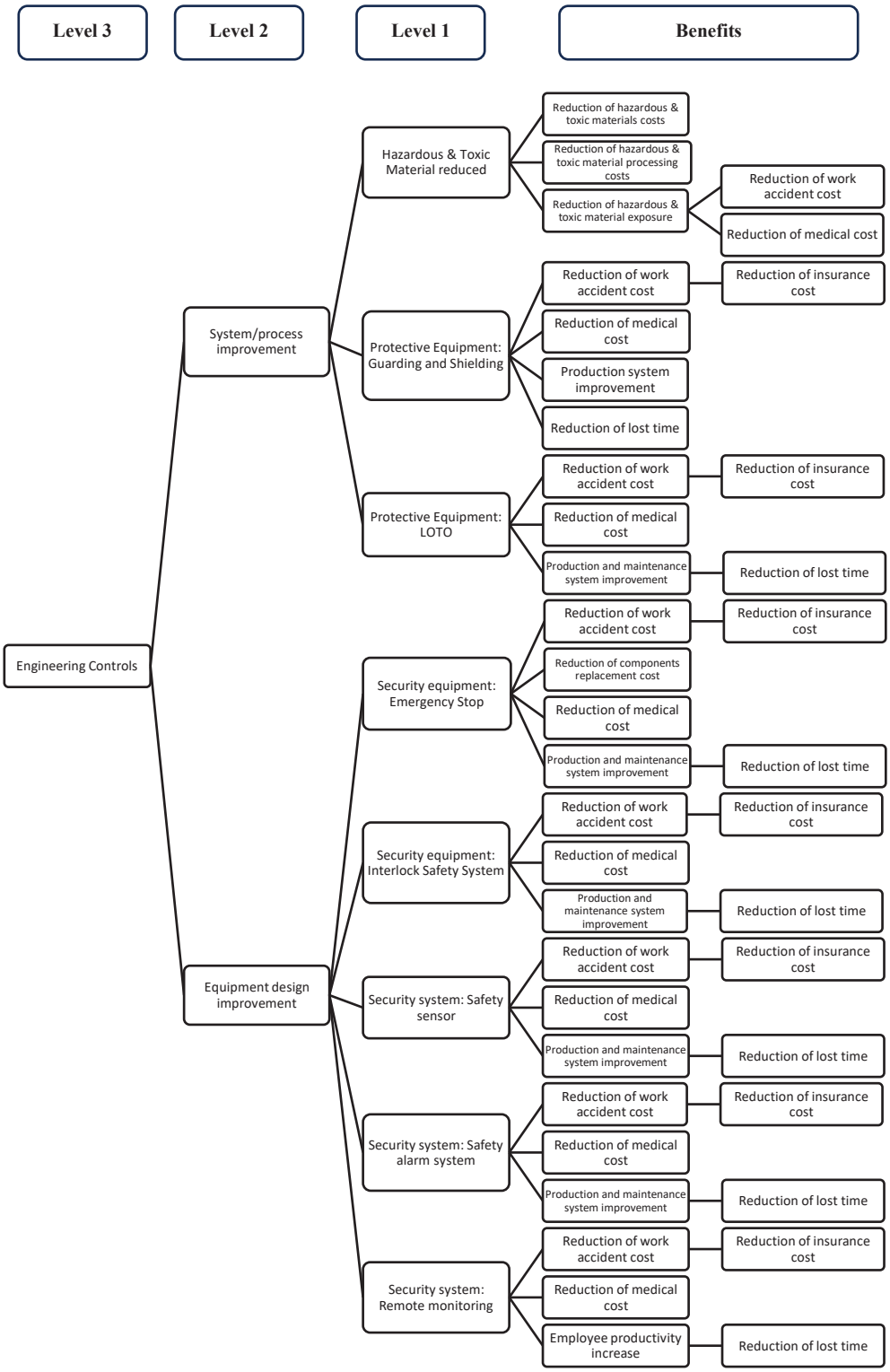
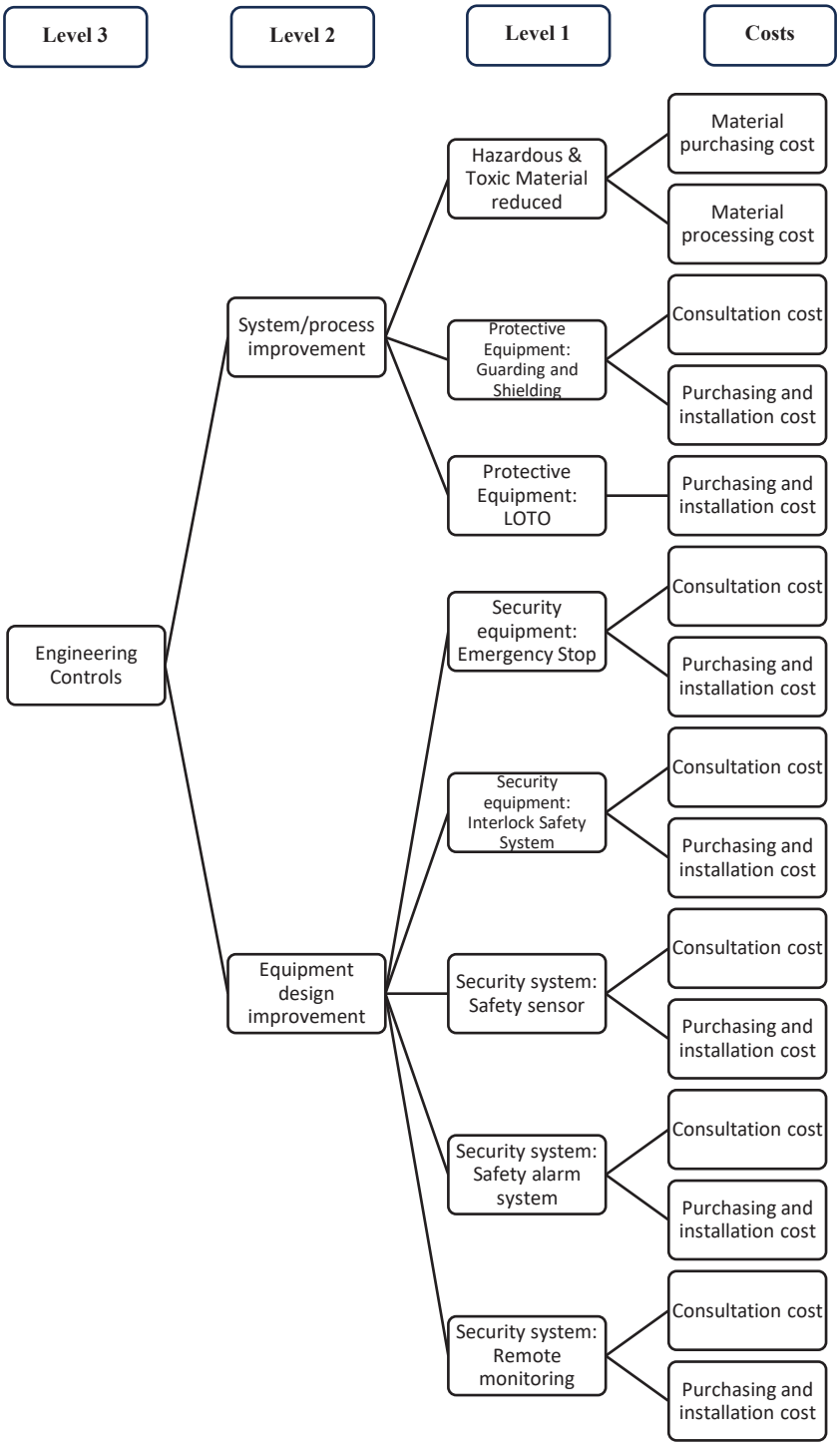
APPENDIX

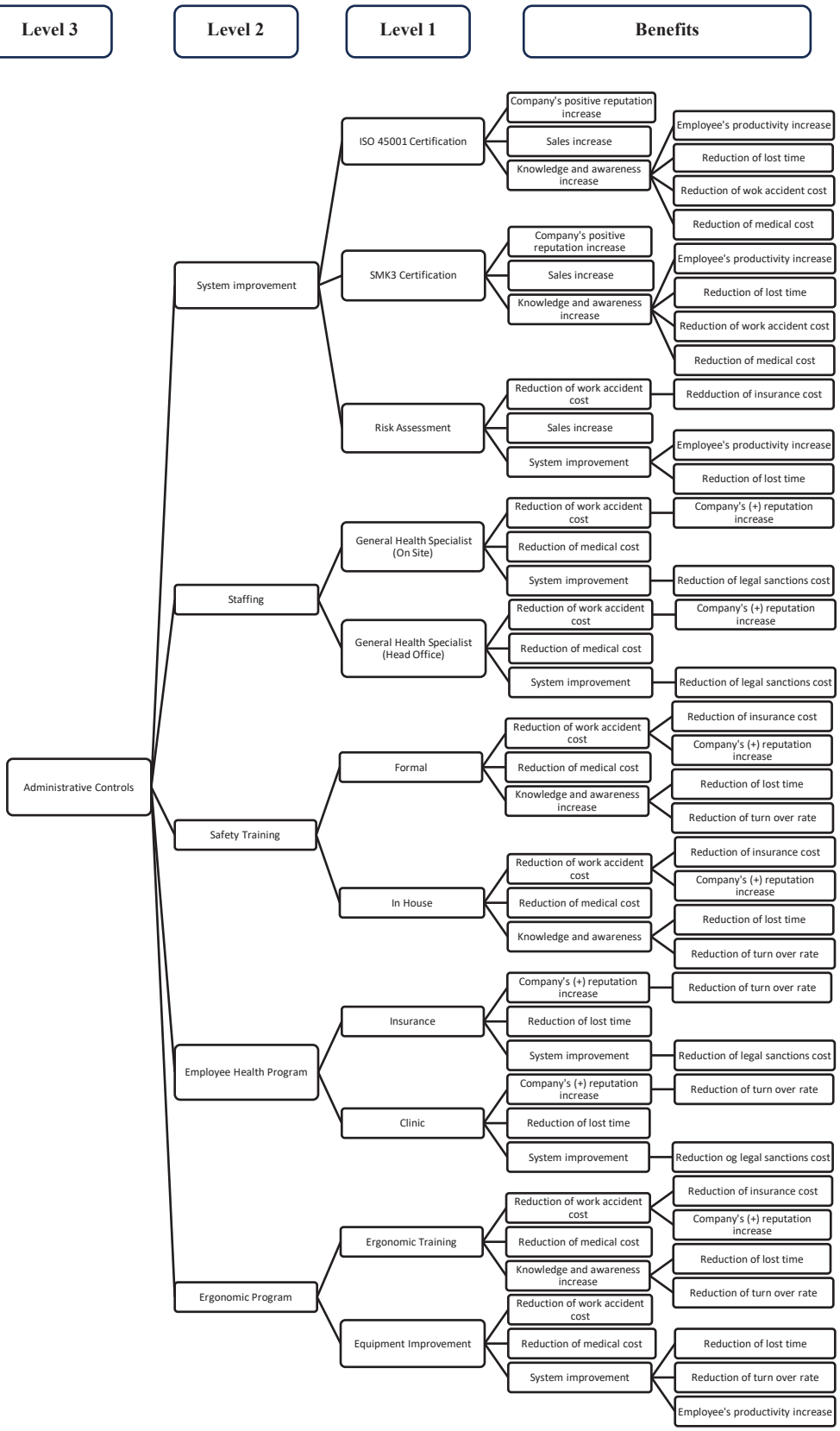
Appendix 1. Conceptual Framework of the Benefits of "Engineering Controls" OSH Program



Appendix 2. Conceptual Framework of the Costs of "Engineering Controls" OSH Program



Appendix 3. Conceptual Framework of the Benefits of "Administrative Controls" OSH Program



Appendix 4. Conceptual Framework of the Costs of "Administrative Controls" OSH Program