Bridging the Competency Gap: Implementing a Hybrid-Collaborative Training Model for CPO Factory Pressure Vessel and Storage Tank Technicians in North Sumatera Province

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Abstract. This article examines the implementation of Indonesia's Law No. 1 of 1970 on Occupational Safety, highlighting its impact on worker safety and health. Enacted to replace older regulations, this law aims to create a safe working environment and enhance national productivity. It covers workplaces meeting specific criteria, focusing on worker safety, visitor protection, and resource efficiency. The law philosophically supports workforce welfare and legally ensures workplace safety. The article notes a rise in workplace accidents, especially in the palm oil industry, stressing the need for stringent OSH standards. It investigates compliance with international standards like ASME and API 650 in pressure vessels and storage tanks, revealing deficiencies in the current training model for technicians. To address these, the study proposes a Hybrid-Collaborative (HYLAB) OSH training model, developed using the ADDIE and ISD-Dick & Carey models. Early trials indicate improved technician competence, emphasizing the importance of industry and regulatory collaboration for effective training programs.

Keywords: Occupational Safety and Health (OSH), HYLAB Model, Pressure Vessel and Storage Tanks Technician Competencies.

1 Introduction

Law No. 1 of 1970 concerning Work Safety which was passed by the President of the Republic of Indonesia with the approval of the House of Representatives of the Republic of Indonesia on January 12, 1970 stated that *Veleigheidsregemene* (Work Safety Regulation) of 1910 *Staat blaad* (State Gazette) No. 406 was repealed and Law No. 1 of 1970 mentioned above was enacted.

After the above Work Safety Law is passed, the implementing regulations are followed in the form of, namely: (1) Government Regulations, (2) (Presidential Decree, (3) Minister of Manpower Regulation, and (4) Minister of Manpower Decree. In the description of article 1 paragraph (1) of Law Number 1 of 1970 it is stated that the scope of Law Number 1 of 1970

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applies to workplaces within the jurisdiction of the Republic of Indonesia. Include a workplace if there are three elements, namely: (1) the place where the work is done for the business, (2) there are workers working there, and (3) there are occupational hazards in that place.

Law No. 1 of 1970 and its implementing regulations are intended to: (1) so that workers are always safe and healthy in carrying out their work, (2) so that their safety is guaranteed for others who enter the workplace, (3) so that production resources can be used and used safely and efficiently, and (4) in the framework of national productivity. Article 3 paragraph (1) states, among others, that implementing regulations regulate work safety requirements to prevent work accidents, fires, and explosions [1, 2, 3].

Occupational Safety and Health (OSH) is philosophically considered as a combination of efforts and ideas aimed at safeguarding the physical and mental well-being of human beings, especially workers, and the results of their labor, with the aim of advancing towards a just, prosperous, and thriving society [4, 5, 6]. From a scientific point of view, OSH involves the application of knowledge, both technical and technological, to prevent occupational accidents and occupational diseases in all types of work. By law, OSH is an initiative to ensure that all workers and others entering the work environment remain in healthy and safe conditions, and to ensure that the resources used in the production process are managed in a safe, efficient, and productive manner [7, 8]. In addition, workplace accidents are identified as untoward and often unexpected incidents that can lead to loss of time, damage to assets or resources, and potentially loss of life, occurring during industrial activities or in processes related thereto [9, 10] .

The Social Security Manpower Organizing Agency recorded that in 2017, there were 123,041 cases of work accidents, which increased to 173,105 cases in 2018, with Work Accident Insurance claims of Rp 1.2 trillion. In 2019, the number rose to 114,000 cases, followed by a 55.2% increase to 177,000 cases in 2020. Furthermore, from January to September 2021, there were 82,000 reported incidents of work accidents and 179 cases of occupational diseases.

Indonesia has managed to become the world's largest palm oil producer since 2006. In 2017, national crude palm oil (CPO) production reached 37.9 million tons and this number increased to total production of 42.8 million tons in 2018, 47.5 million tons in 2019, 48.2 million tons in 2020, and 49.7 million tons in 2021. Meanwhile, the value of CPO exports in the last five years is presented in Table 1 below [11].

Table 1. Value of CPO exports from Indonesia

Year	Export Value (in Million USD)
2017	22.97
2018	23.00
2019	20.22
2020	22.90
2021	35.00

The success shown by the export value mentioned above certainly needs to be maintained, among others by applying applicable OSH norms and standards, so that production resources in the workplace at the CPO factory can always be utilized and used safely and efficiently and productivity is maintained in accordance with the mandate of Law No. 1 of 1970.

Based on Law No. 7 of 1981 concerning Mandatory Manpower Report, CPO factories in North Sumatra totaled 81 (eighty-one) units, and 16 (sixteen) units of which were CPO factories owned by PTPN-IV. The CPO factory in the PTPN-IV environment in the North Sumatra region is in the Regency area. Langkat, Serdang Bedagai Regency, Simalungun Regency, Asahan Regency, Labuhan Batu Regency, North Padang Lawas Regency and Mandailing Natal Regency [12].

According to data available at the Manpower Inspection Division of the North Sumatra Provincial Manpower Office, workplace incidents over the past five years caused by Storage tanks have occurred at one of the CPO factories in Labuhan Batu resulting in 4 (people) deaths, while pressure vessels that exploded in North Sumatra have also occurred in one of the companies in Binjai resulting in 3 (three) death victims.

According to the implementing regulations of Law No. 1970, namely the Regulation of the Minister of Manpower No. 37 of 2016 states that a Pressure Vessel is a vessel other than a steam aircraft in which there is pressure and is used to contain gas, air, gas campran, or air mixture either pressed into liquid in soluble or frozen state. A Storage tank is a vessel other than a pressure vessel that stores or Storages hazardous liquids or other liquids, in which there is a compressive force generated by the weight of the liquid stored or Storaged with a certain volume.

According to ASME Boiler and Pressure Vessel Standard Part VIII, a pressure vessel is described as a metal container designed to handle different types of loads, or vessels in which pressure comes either from an indirect source or through the direct or indirect application of heat. In contrast, API Standard 650 defines a storage tank as a structure engineered for the containment of liquid substances [13, 14, 15]. Mostly used in the oil industry (for gas tanks), these tanks are also used in other sectors, such as the food industry (for storing oil) and in the manufacture of fertilizers [16]. Storage containers are specifically intended to hold liquids, compressed gases, or mediums for short- or long-term storage at various temperatures. The fabrication and construction of these storage tanks comply with global standards [17, 18, 19]. Typically, the contents of these tanks include petroleum products or industrial chemicals. The most commonly adopted standards for building storage tanks in industry are API 650 and API 620, as defined by the American Petroleum Institute [20, 21].

In the initial study of this study, the results of observations conducted in November 2022 at 4 (four) CPO factories within PTPN-IV in North Sumatra Province showed that the types of pressure vessels used were: (1) several compressed air receiving tank compressors with a pressure between 8-10 bar, and (2) several pressure vessels containing combustible gas with a pressure between 10-12 bar. Meanwhile, the storage tanks used consist of: (1) tanks to store diesel fuel with a capacity of around 5000 liters, (2) several boiling temperature CPO heating/clarifying tanks with a capacity of 5000-8000 liters, (3) several CPO storage tanks each

unit has a capacity between 800-1000 tons of CPO, and (4) one unit of Feed Water Boiler Tank with a capacity of 12 to 20 tons of boiling temperature water [22, 23, 24].

In the initial study of this research, the results of interviews with OSH (Safety Office) Experts and Technical Assistants for the maintenance section and several Pressure Vessel and Storage Tank Technicians at PTPN-IV CPO factories in November 2022 at several CPO factories in the PTPN-IV area of North Sumatra Province, showed that based on Law No.1 of 1970, Law No.13 of 2003, Minister of Manpower Regulation No, Per.04/Men/1987 and Manpower Regulation No.Per.02/Men1992, employees who work as Pressure Vessel and Storage Tank Technicians are trained by General OSH Experts (safety officers) assisted by Technical Assistants for the maintenance of PTPN-IV CPO factory equipment themselves without involving other parties outside the company, and are carried out for 5 working days. The training above was carried out at the CPO factory where he worked, where the implementation team and evaluation team were carried out by General OSH Experts assisted by Technical Assistants without involving personnel from PTPN-IV.

From the description above, it can be concluded that the training of employees who serve as pressure vessel technicians and Storage tanks in CPO factories within PTPN-IV in North Sumatra is carried out without involving other parties outside the PTPN-IV company (*non-collaborative*), and is carried out in their respective workplaces (*On the Job Training*) [25, 26].

The subjects delivered in the training mentioned above are still limited; (1) work safely according to Law No.1 of 1970 article 12, (2) Maintain pressure vessels and Storage tanks in accordance with the Technical Guidelines / SOPs set by the leadership of PTPN-IV, and 3) set pressure vessels in the workplace correctly according to Minister of Manpower Law No.Per.01 / Men / 1982 concerning Pressure Vessels, so that it is less effective where the Pressure Vessel and Storage Tank Technicians at the CPO plant mentioned above have not been able to carry out their duties, its authority and responsibility in terms of installation, repair/modification, tuning safety devices, checking and evaluating the feasibility of coincidence of Pressure Vessels and Storage Tanks in its workplace as stipulated in the Minister of Manpower Regulation No.37 of 2016 concerning Pressure Vessels and Storage Tanks.

Indeed, the training that has been carried out independently by PTPN-IV above has had a positive impact where in 16 (sixteen) CPO factories within PTPN-IV there has never been an exploding Pressure Vessel, a broken Storage Tank or a work accident due to the Pressure Vessel and Storage Tank in the CPO factories mentioned above, but anticipation continues to need to be done in accordance with the development of OSH laws and regulations and *safety* standards. The applicable Pressure Vessels and Storage Tanks are ASME-BPVC and API 650 Standard, as well as the technical provisions contained in the Minister of Manpower Regulation No.37 of 2016 concerning Pressure Vessels and Storage Tanks.

Researchers have conducted pretests in the form of multiple choices, where it can then be concluded that the knowledge of employees who serve as Pressure Vessel and Storage Tank Technicians at CPO factories in the PTPN-IV Environment in North Sumatra Province is very poor, namely from all employees who took the written test, all of them obtained scores in the "very poor" category with an average score of 28.0 points each.

Researchers have also made observations about skills using checklists, where it can then be concluded that the skills of employees who serve as Pressure Vessel and Storage Tank Technicians at CPO factories in the PTPN-IV Environment in North Sumatra Province are very poor, namely from all employees who took the skill test, all of them obtained scores in the "very poor" category with an average score of 33.3 points each.

Based on the results of interviews with a OSH Expert/safety officer, with 4 (four) Technical Assistants for CPO plant equipment and 12 (twelve) Pressure Vessel and Storage Tank Technicians in 4 (four) CPO factories within PTPN-IV in Sumatra Province, it can be concluded that training for Pressure Vessel and Storage Tank Technicians and has been carried out in every CPO factory in the PTPN-IV area in North Sumatra Province which so far can be described in line as follows: (1) Training is carried out based on the applicable OSH laws and regulations, namely Law No. of 1970, Law No. 13 of 2013, Regulation of the Minister of Manpower No.Per.04/Men/1987, and Regulation of the Minister of Manpower No.Per.02/Men/1992, but has not been guided by the Regulation of the Minister of Manpower Number 37 of 2016 concerning Pressure Vessels and Stockpiling Tanks, (2) The implementation team, training team and evaluation team consist of PTPN-IV personnel themselves.

Based on the above conditions, it is necessary to carry out OSH training with a more appropriate training model for all Pressure Vessel and Storage Tank Technicians in CPO factories in the PTPN-IV area of North Sumatra Province, with the hope that training participants (targets) are able to carry out their responsibilities in terms of installation, maintenance, repair/modification, adjusting safety devices, checking and evaluating the feasibility of the condition of pressure vessels and lush tanks used in the CPO factory where its work, guided by ; (1) Law No.1 of 1970, (2) Regulation of the Minister of Manpower No.Per.02/Men/1982, (3) Regulation of the Minister of Manpower No.37 of 2016, (4) ASME-BPVC, and (5) API Standard 650.

Based on initial research conducted by researchers on the complexity of problems found in pressure vessel technicians and storage tanks in CPO factories, as well as the results of previous research on the effectiveness of On the Job Training, Off the Job Training and Collaborative training, researchers were then interested in combining the On the Job Training method with the Job Instructional Training Off the Job Training and Collaborative models between CPO factories companies that use Pressure Vessels and Storage Tanks with LLKS-OSH and related agencies in the local Central and Provincial Governments which are then implemented into training models.

Therefore, researchers intend to conduct a more in-depth study through the development of a Hybrid-Collaborative-based OSH (HYLAB) training model to improve the competence of Pressure Vessel and Storage Tank technicians for CPO (Crude Palm Oil) factories within PTPN-IV North Sumatra Province.

By implementing OSH training for Pressure Vessel and Storage Tank Technicians using the HYLAB (Hybrid-Collaborative) model, it is expected; (1) able to produce *output* in the form of producing competent graduates, namely able to carry out their responsibilities as stipulated in the Regulation of the Minister of Manpower Number 37 of 2016 concerning Pressure Vessels and Storage Tanks including; installation, maintenance, repair/modification, tuning of the equipment, checking and evaluating the feasibility of the condition of the Pressure Vessel and Storage Tank [27, 28].

The expected result is that in the future all Pressure Vessels and Storage Tanks used in each CPO factory in the PTPN-IV area of North Sumatra Province will always meet applicable *safety standards*, and in the process of installation, maintenance, repair / modification, and feasibility inspection of the condition of Pressure Vessels and Storage Tanks there will be no accidents [29, 30, 31] .

Furthermore, it is expected that *the future outcome* is that the condition of the Pressure Vessel and Storage Tank in the workplace can always be used safely and efficiently [32, 33]. In this way, the expected impact is that there will never be work accidents related to the existence of Pressure Vessels and Storage Tanks in every CPO factory within PTPN-IV North Sumatra region [34, 35].

2 Method

2.1 Research Approach and Research Method

The type of research in developing a Hybrid-Collaborative (HYLAB) training-based approach to enhance the competency of pressure tank and storage tank technicians is research and development, using the ADDIE (Analysis, Design, Development, Implementation and evaluation) model and training system funds. ISD-Dick & Carey model. The ADDIE model training system was chosen because it has the advantage of offering assessments at every phase to reduce the likelihood of mistakes or product flaws in the model's final stage. The ADDIE model encompasses five stages, which are; (1) analysis, (2) planning, (3) development, (4) implementation and (5) evaluation which are interrelated and structured systematically [36], [37]. The ISD-Dick & Carey model training system consists of ten steps, namely; (1) needs analysis, (2) training analysis, (3) analysis of training participants and their environment. (4) formulation of specific objectives, (5) development of instruments, (6) development of learning strategies, (7) development of training materials, (8) design and development of formative evaluation, (9) revision of training, and (10) design and develop a summative evaluation [38], [39].

2.2 Research Location, Sample, and Technique of Data Collection

This study was conducted from April to December 2023 at the PTPN-IV Office Building in Pabatu, Kab. Serdang Bedagai, North Sumatra. Limited trials will be carried out in June 2023, and broad trials will be carried out in July 2023.

The number of employees who have duties as pressure vessel and storage tank technicians in 16 CPO factories in the PTPN-IV environment in the North Sumatra region is 6 people each, 4 of whom have been trained in OSH to carry out The duties of the Pressure Vessel and Storage Tank Technician are internal to PTPN-IV and 2 other untrained employees whose daily duties are to help carry out the duties of the Pressure Vessel and Storage Tank Technician. The level of education is similar to vocational/high school majoring in science, having an average of over three years of work experience. While the subject for the broad trials consisted of 2 technicians from two CPO factories including 28 technicians from 14 CPO factories in the PTPN-IV environment in the North Sumatra region. The total number of the subject in broad trials were 30 technicians.

To gather field data and perform initial tests for the assessment model, questionnaires served as the key instrument. Unlike the initial trial questionnaires, which contained 54 questions, those used for field data collection had only 5 questions. The assessment scores for each item were determined using a five-point Likert scale, comprising score-5 (strongly agree), score-4 (agree), score-3 (neutral), score-2 (disagree), and score-1 (strongly disagree).

2.3 Data Analysis

The pressure vessel and storage tank technician's attainment of OSH competences can be ascertained using the outcomes of the data analysis produced by the preliminary trials. Utilizing percentage descriptive computations, quantitative descriptive methods were applied to analyze the data from the preliminary trial outcomes [40], [41], [42]. The results of descriptive percentage computations were used to assess the quality of this management model design. The formula for figuring out descriptive percentages is as follows.

$$Suitability\ Score = \frac{gained\ score}{expected\ score} x\ 100\% \quad (1)$$

The percentage values generated by the above formula were classified using a five-level scale. According to this scale, a quality percentage above 81% falls into the excellent category, and 61 to 80% is considered good, indicating that there's no need for modifications to the evaluation model design. On the other hand, a quality percentage ranging from 41 to 60% is deemed moderate, 21 to 40% is categorized as below average, and 0 to 20% is rated as poor. These lower categorizations suggest that revisions are needed in the management model design.

3 Result and Discussion

3.1 Analysis

The analysis phase is the first stage in developing a Hybrid-Collaborative-based OSH training model to improve the competence of pressure vessel and storage tank technicians at a CPO factory in North Sumatra. The analysis phase includes needs evaluation, self-assessment by technicians, and analyzing their skills, knowledge, and assessment results, as shown in Figure 1.

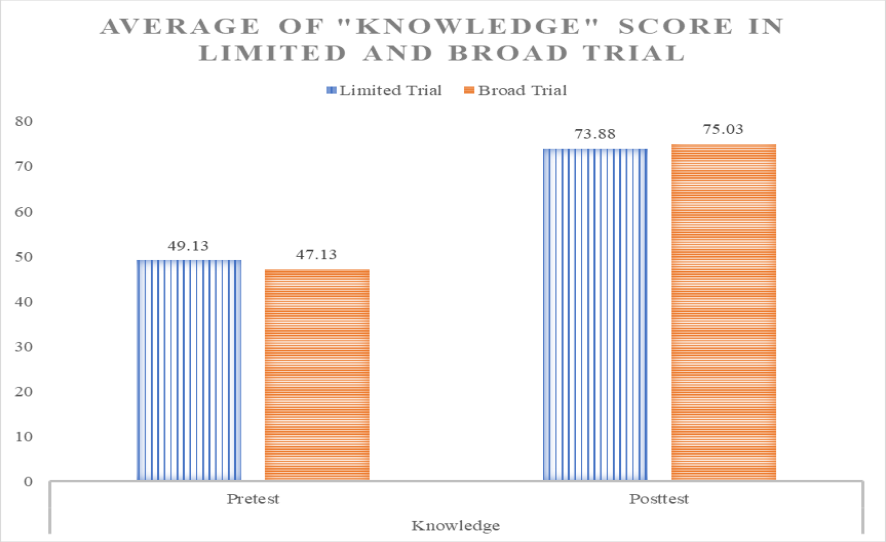

Fig. 1. Average score of the technicians' knowledge

Figure 1 shows the condition of technician competence in terms of knowledge. There are five OSH competency indicators for Pressure Vessel and Storage Tank Technicians evaluated through written tests at this stage, namely; (1) Mastery of basic knowledge of Pressure Vessels and Storage Tanks, types of filling fluids of Pressure Vessels and Storage Tanks, knowledge of materials, corrosion and heat transfer. (2) Mastery of welding knowledge material and Non-Destructive Test, (3) Mastery of safety equipment / material for Pressure Vessels and Storage Tanks (3) Mastery of materials for the calculation of the assessment of the strength of Pressure Vessel and Storage Tank construction. (5) Mastery of material on inspection and testing techniques of Pressure Vessels and Storage Tanks. The results on the knowledge pretest in the limited trial were in the very low category with an average score of 49.13 while in the limited trial postes showed a significant increase in score to 73.88 or the high category. Similarly, in broad trials, the average pretest score of all 47.13 increased sharply to 75.03.

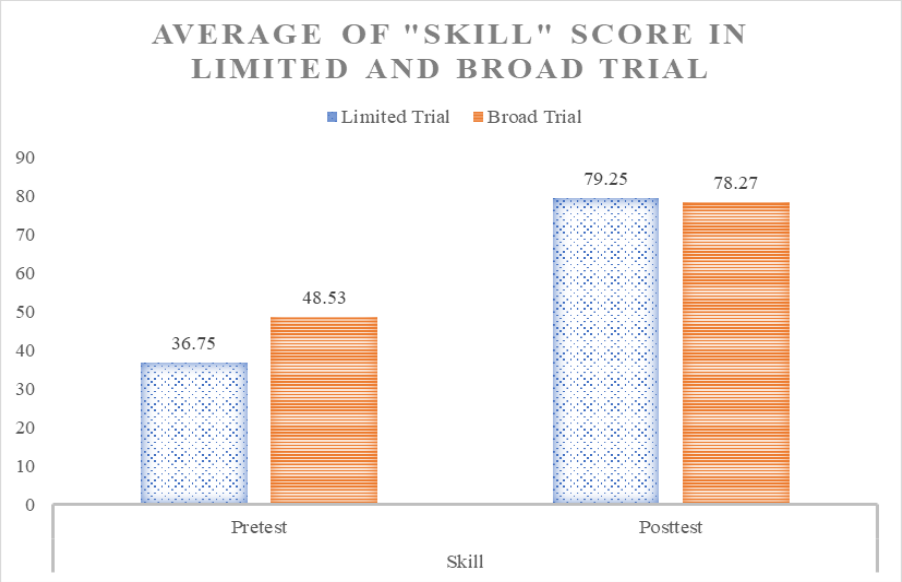

Fig. 2. Average score of technicians' skills

Figure 2 illustrates the condition of competence of OSH technicians in terms of skills. Five skill indicators of Pressure Vessel and Storage Tank Technicians are evaluated through observation at this stage, namely mastery of: (1) Skills in monitoring and evaluating the implementation of Law No. 1 of 1970 and technical provisions / OSH standards concerning the installation of Pressure Vessels and Storage Tanks carried out by third parties; (2) Skills in implementing Law No.1 of 1970, OSH technical provisions/standards, and Technical Guidelines that have been established by the leadership of PTPN-IV concerning the maintenance of Pressure Vessels and Storage Tanks; (3) Skills in monitoring and evaluating the implementation of Law No.1 of 1970 and OSH technical provisions/standards for the repair of Pressure Vessels and Storage Tanks carried out by third parties; (4) Skill to install Safety Valve on Air Receiving Tank, based on MAWP (Maximum Allowable Working Pressure); and (5) Skills in checking the suitability and evaluating the condition of the Pressure Vessel and Storage Tank including evaluating the NDT process carried out by a third party (NDT Expert) from CHD3, it turned out that the average skill score at the pretest stage of the limited trial was 36.75 and increased to 79.25 at the time of post-test. While in the broad trial, the average pretest score of 48.52 increased to 78.27 at the time of the post-test.

3.2 Design and Development

The design and development phase involves creating and refining OSH training using the Hybrid-Collaborative model. In addition, this stage is focused on building a competency-based training management system by utilizing the ADDIE model, which includes:

- Instruments for research, assessment tools, and module templates are part of the design phase.

- The pre-development phase involves creating training modules, training model frameworks, questionnaires, gaining expert validation, and revising the model design.

Table 2. Results of expert validation on training topics

Aspects	Average Percentage	Interpretation
Content suitability	98	Superior
Presentation suitability	99	Superior
Language compatibility	98	Superior
Contextual assessment	98	Superior

Table 2 informs that the overall evaluation of theme experts falls into the excellent category. This suggests that, depending on the expert opinion on the appropriateness of the topic, it is possible to implement an OSH training management model based on Hybrid-Collaborative to improve the competence of pressure vessel and storage tank technicians in CPO factories in North Sumatra Province.

Table 3. Results of expert validation on modules

Aspects	Average Percentage	Interpretation
Module size	92	Superior
Cover design	96	Superior
Content design	98	Superior
Content appeal	94	Superior

Table 3 clearly shows that all elements of module design and development are classified as excellent. This validation confirms that, according to expert evaluation of module suitability, a Hybrid-Collaborative-based OSH training management model to improve the competence of pressure vessel and storage tank technicians in CPO factories in North Sumatra Province can be applied.

3.3 Implementation

The purpose of the implementation phase is to test the Hybrid-Collaborative model. During the limited initial trial phase, 16 technicians participated, while subsequent broader trials included 30 technicians. In all, 46 technicians participated in the implementation phase as participants.

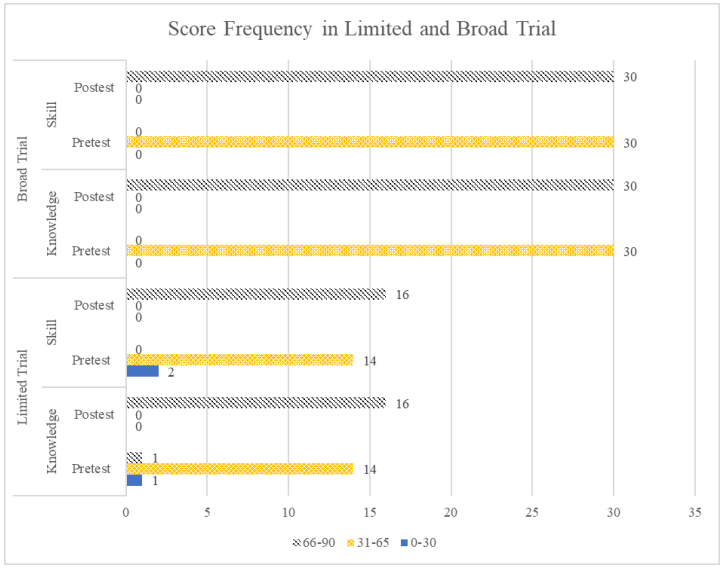

Fig. 3. Frequency of scores on limited and broad trials

To assess how well the Hybrid-Collaborative training management model improves the competence of pressure vessel and storage tank technicians in CPO factories in North Sumatra Province, one of the tools used is a written test and a skill test in the form of observation. Figure 3 illustrates the achievement of knowledge and skills scores on broad trials and limited trials. From Figure 3 it can be concluded that all technicians experienced an increase in knowledge and skills in broad trials, while in limited trials, the scores they obtained were below the passing grade of 65.

3.4 Evaluation

The final stage of OSH training for pressure vessel and storage tank technicians, based on the Hybrid-Collaborative approach, involves evaluation. This evaluation was conducted by the researcher through analysis of research data, focusing on the N-Gain score, as depicted in Figure 4.

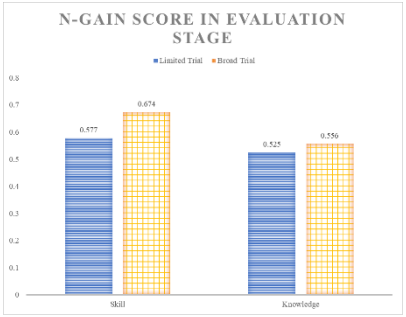

Fig. 4. N-Gain score in evaluation phase

Figure 4 presents the N-Gain score results of technicians' achievements in knowledge and skills in their responsibilities in terms of pressure vessels and storage tanks. The illustration clearly shows a rise in the average N-Gain. Given that the average score achieved was above 50 points in both limited and extensive trials, this is classified as a good level. In summary, the Hybrid-Collaborative training management model is effectively demonstrated to improve the competence of pressure vessel and storage tank technicians in the PTPN-IV area in North Sumatra Province.

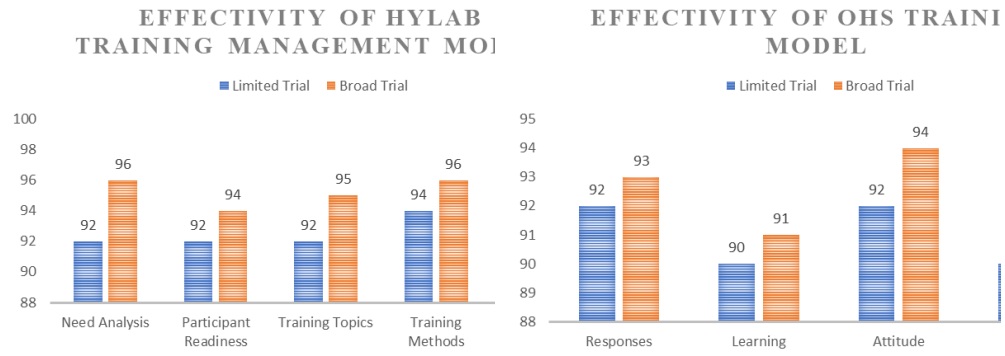

Fig. 5. Effectiveness of the HYLAB Model

Figure 5 illustrates the results regarding the effectiveness of the Hybrid-Collaborative management model and OSH training as part of the training. It can be observed that aspects of needs analysis, participant readiness, training topics, training methods, and training evaluation go up slightly for the Hybrid-Collaborative management model. Comparable steady improvements were also seen in responses, learning, attitudes, and outputs from OSH training. Overall, small but noticeable improvements are evident from the limited extensive trials in assessing the effectiveness of the Hybrid-Collaborative management model to improve the competence of pressure vessel and storage tank technicians in CPO factories in North Sumatra Province.

3.5 Discussion

In the initial condition, the training was carried out for 5 days by the PTPN-IV Internal team. The legal basis for its implementation is: (a). Law No.1 of 1970 (b). Minister of Manpower and Transmigration Regulation No.per.04/men/1987; (c). Regulation of the Minister of Manpower and Transmigration No.per.02/men/1992. While the subject matter includes: (a) Law No.1 of 1970; and (b). Maintenance of pressure vessels and storage tanks [43, 44, 45]. The implementation is carried out by PTPN-IV's internal team with a team of safety officer instructors and PTPN-IV technical assistants [46, 47, 48]. The homogeneous participants used on the job training and instructional job training. Limited training budget for copying modules and the results of training using this model are participants: (a). Understand and implement Law No.1 of 1970 article 12; (b). Maintain pressure vessels and storage tanks in accordance with the technical sheet specified by PTPN-IV [49, 50, 51]. However, the technicians did not understand

and were unable to apply the standards of ASME-BPVC, API 650 and technical provisions in Ministry of Manpower Regulation No.37 of 2016 [52, 53, 54].

Meanwhile, in the Hybrid-Collaborative (HYLAB) model, training is carried out for 9 days (90 hours) according to the curriculum set by the Director General of Manpower &; OSH No.04 of 2017 with the following legal basis for implementation: (a). Law No.1 of 1970; (b). Minister of Manpower Regulation No.per.04/men/1987; (c). Minister of Manpower Regulation No.per.02/men/1992; (d). Minister of Manpower Regulation No.per.04/men/1995; (e). Minister of Manpower Regulation No. 37 of 2016, and (f). Government Regulation No.6 of 2021 [55, 56, 57, 58]. Updated training topics include: (1) OSH Fundamentals and OSH Legislation; (2) Basic knowledge and parts of Pressure Vessels and Storage Tanks; (3) Liquid filling Pressure Vessel and Storage Tank; (4) Knowledge of materials, heat transfer and corrosion; (5) Welding knowledge; (6) Knowledge Non-Destructive Test (NDT); (7) Safety equipment; (8) Construction strength review calculation, and (9) inspection/test standards [59, 60, 61, 62]. The implementation of the training was carried out collaboratively by involving a joint team of two PTPN-IV personnel and two OSH Company workers (PT. EMCOTAMA). The instructors consisted of a joint team consisting of two OSH pressure vessel and storage tank experts, one NDT expert, two academicians commissioned by PT. Emcotama, one OSH safety officer from PTPN-IV; two labor supervision department officers &; one OSH expert [63, 64, 65, 66]. The participants are homogeneous and the method is carried out in a hybrid manner through off the job training-job instructional training. The budget is allocated for module photocopying, transportation, accommodation, meals for the implementation team and the instructor team as well as participants, remuneration for the implementation team and instructor team is provided by PTPN-IV [67, 68, 69, 70]. Training equipment such as pressure vessels and storage tanks for practicum are also provided by PTPN-IV. Pressure vessels and storage tank testing equipment are provided by PT. Emcotama [71, 72, 73, 74]. This training proved effective where participants were able to apply [75, 76]: (a) Law No.1 of 1970 article 12; (b). Maintenance of pressure vessels and storage tanks in accordance with technical guidelines. In addition, in the final stage, participants are also able to: (a). Understand Manpower Regulation No. 37 of 2016; (b). Understand the ASME-BPV Part VIII standard and the API 65O standard [77, 78, 79]; (c) carry out their responsibilities in terms of installation, maintenance, repair, adjustment, feasibility checks and evaluation of the condition of pressure vessels and storage tanks in the CPO factories where they work [80, 81, 82, 83]. The results of this management model result in the prevention of possible explosions/fires/work accidents during installation, maintenance, repair, adjustment and inspection activities of pressure vessels and storage tanks. Then, all pressure vessels and storage tanks used in PTPN-IV always meet the requirements of OSH/applicable OSH standards, so that they are safe to use.

4 Conclusion

In conclusion, the study aimed to enhance the competencies of pressure-vessel and storage tank technicians in CPO factories in North Sumatera through the development and implementation of an OSH training model based on Hybrid-Collaborative. The analysis stage revealed significant deficiencies in both knowledge and skills among technicians, indicating a critical need for improvement. The subsequent design and development phase successfully created a comprehensive training model, as evidenced by expert validation results. The implementation

phase, involving limited and broad trials, demonstrated the effectiveness of the Hybrid-Collaborative model in improving technicians' competencies. The evaluation stage further affirmed the positive impact of the training, with N-Gain scores indicating a good level of improvement in knowledge and skills.

The theoretical implications of this study lie in the successful development and validation of the Hybrid-Collaborative model for OSH training. The model, grounded in competency-based training management and utilizing the ADDIE model, provides a structured and effective approach to enhance the competencies of technicians in the specific context of pressure-vessel and storage tank operations. The research adds to the wider body of literature on OSH training by demonstrating the applicability and effectiveness of a hybrid collaborative approach.

Despite the positive outcomes, this study has some limitations. First, the research focused specifically on pressure-vessel and storage tank technicians in CPO factories in North Sumatera, limiting the applicability of the results to different settings or industries. Additionally, the sample size for the implementation phase was fairly limited, which could impact the external validity of the results. Furthermore, the evaluation mainly relied on N-Gain scores, and a more comprehensive assessment of long-term retention and transfer of knowledge and skills could provide a more nuanced understanding of the model's effectiveness. Finally, the study did not explore potential contextual factors that may influence the implementation and sustainability of the Hybrid-Collaborative model in different organizational settings.

To sum up, while the Hybrid-Collaborative model shows promise in improving the competencies of pressure-vessel and storage tank technicians, future research should consider addressing these limitations to enhance the robustness and applicability of the proposed training approach.

References

[1] P. Manu et al., “Design for occupational safety and health: key attributes for organisational capability,” Engineering, Construction and Architectural Management, vol. 26, no. 11, pp. 2614–2636, Nov. 2019, doi: 10.1108/ECAM-09-2018-0389.

[2] J. Johansson et al., “Occupational safety in the construction industry,” Work, vol. 64, no. 1, pp. 21–32, Sep. 2019, doi: 10.3233/WOR-192976.

[3] M. Zhang, R. Shi, and Z. Yang, “A critical review of vision-based occupational health and safety monitoring of construction site workers,” Saf Sci, vol. 126, p. 104658, Jun. 2020, doi: 10.1016/j.ssci.2020.104658.

[4] K. Jilcha Sileyew, “Systematic industrial OSH advancement factors identification for manufacturing industries: A case of Ethiopia,” Saf Sci, vol. 132, p. 104989, Dec. 2020, doi: 10.1016/j.ssci.2020.104989.

[5] I. S. Sánchez-Herrera and M. J. Donate, “Occupational safety and health (OSH) and business strategy: The role of the OSH professional in Spain,” Saf Sci, vol. 120, pp. 206–225, Dec. 2019, doi: 10.1016/j.ssci.2019.06.037.

[6] C. Barbosa, R. Azevedo, and M. A. Rodrigues, “Occupational safety and health performance indicators in SMEs: A literature review,” Work, vol. 64, no. 2, pp. 217–227, Oct. 2019, doi: 10.3233/WOR-192988.
[7] Y. Sun, M. Arning, F. Bochmann, J. Börger, and T. Heitmann, “Development and Validation of a Practical Instrument for Injury Prevention: The Occupational Safety and Health Monitoring and Assessment Tool (OSH-MAT),” Saf Health Work, vol. 9, no. 2, pp. 140–143, Jun. 2018, doi: 10.1016/j.shaw.2017.07.006.
[8] Y. Suh, “Sectoral patterns of accident process for occupational safety using narrative texts of OSHA database,” Saf Sci, vol. 142, p. 105363, Oct. 2021, doi: 10.1016/j.ssci.2021.105363.
[9] D. Masi, E. Cagno, S. Farne’, and P. Hasle, “Design of OSH interventions: A model to improve their actual implementation,” Saf Sci, vol. 115, pp. 51–65, Jun. 2019, doi: 10.1016/j.ssci.2019.01.009.
[10] S. L. C. da Silva and F. G. Amaral, “Critical factors of success and barriers to the implementation of occupational health and safety management systems: A systematic review of literature,” Saf Sci, vol. 117, pp. 123–132, Aug. 2019, doi: 10.1016/j.ssci.2019.03.026.
[11] E. Erniaty and H. Harun, “Understanding the impacts of NPM and proposed solutions to the healthcare system reforms in Indonesia: the case of BPJS,” Health Policy Plan, vol. 35, no. 3, pp. 346–353, Apr. 2020, doi: 10.1093/heapol/czz165.
[12] A. I. Itamary, “ANALISIS DAYA SAING EKSPOR CRUDE PALM OIL (CPO) INDONESIA DI PASAR INDIA,” Jurnal Ekonomi Pembangunan STIE Muhammadiyah Palopo, vol. 8, no. 2, p. 208, Dec. 2022, doi: 10.35906/jep.v8i2.1184.
[13] H. S. Tuhul, A. El-Hamouz, A. R. Hasan, and H. A. Jafar, “Development of a Conceptual Framework for Occupational Safety and Health in Palestinian Manufacturing Industries,” Int J Environ Res Public Health, vol. 18, no. 3, p. 1338, Feb. 2021, doi: 10.3390/ijerph18031338.
[14] T. Acheampong and A. G. Kemp, “Health, safety and environmental (HSE) regulation and outcomes in the offshore oil and gas industry: Performance review of trends in the United Kingdom Continental Shelf,” Saf Sci, vol. 148, p. 105634, Apr. 2022, doi: 10.1016/j.ssci.2021.105634.
[15] T. R. Cunningham, P. J. Tinc, R. J. Guerin, and P. A. Schulte, “Translation research in occupational health and safety settings: Common ground and future directions,” J Safety Res, vol. 74, pp. 161–167, Sep. 2020, doi: 10.1016/j.jsr.2020.06.015.
[16] J. Xu, W. Lu, L. Wu, J. Lou, and X. Li, “Balancing privacy and occupational safety and health in construction: A blockchain-enabled P-OSH deployment framework,” Saf Sci, vol. 154, p. 105860, Oct. 2022, doi: 10.1016/j.ssci.2022.105860.
[17] M. Westhoven and L. Adolph, “Concept for Supporting Occupational Safety Risk Analysis with a Machine Learning Tool,” 2022, pp. 468–473. doi: 10.1007/978-3-031-06417-3_63.
[18] R. B. Kantcheva and E. Bickle, “Inclusive learning development practices: the consequences of flexibility and choice in the hybrid era,” Journal of Learning Development in Higher Education, no. 26, Feb. 2023, doi: 10.47408/jldhe.vi26.886.
[19] G. Claxton, P. Hosie, and P. Sharma, “Toward an effective occupational health and safety culture: A multiple stakeholder perspective,” J Safety Res, vol. 82, pp. 57–67, Sep. 2022, doi: 10.1016/j.jsr.2022.04.006.
[20] M. N. Maliha, Y. I. Abu Aisheh, B. A. Tayeh, and A. Almalki, “Safety Barriers Identification, Classification, and Ways to Improve Safety Performance in the Architecture, Engineering, and Construction (AEC) Industry: Review Study,” Sustainability, vol. 13, no. 6, p. 3316, Mar. 2021, doi: 10.3390/su13063316.
[21] D. J. Provan and P. Pryor, “The emergence of the occupational health and safety profession in Australia,” Saf Sci, vol. 117, pp. 428–436, Aug. 2019, doi: 10.1016/j.ssci.2019.04.036.

[22] L. Peng and A. H. S. Chan, “A meta-analysis of the relationship between ageing and occupational safety and health,” Saf Sci, vol. 112, pp. 162–172, Feb. 2019, doi: 10.1016/j.ssci.2018.10.030.
[23] M. Rudakov, E. Gridina, and J. Kretschmann, “Risk-Based Thinking as a Basis for Efficient Occupational Safety Management in the Mining Industry,” Sustainability, vol. 13, no. 2, p. 470, Jan. 2021, doi: 10.3390/su13020470.
[24] N. Myzabella, L. Fritschi, N. Merdith, S. El-Zaemey, H. Chih, and A. Reid, “Occupational Health and Safety in the Palm Oil Industry: A Systematic Review,” Int J Occup Environ Med, vol. 10, no. 4, pp. 159–173, Oct. 2019, doi: 10.15171/ijoem.2019.1576.
[25] R. Yadav, M. Yadav, and N. S. Vihari, “High-performance work system and learning orientation in offline, online, and hybrid workplaces: the mediating role of affective commitment,” The Learning Organization, Oct. 2023, doi: 10.1108/TLO-10-2022-0118.
[26] S. D. Eberth, I. Provident, and C. Chase, “Hybrid Learning to Develop Safe Patient Handling Judgement in Occupational Therapy Students,” Journal of Occupational Therapy Education, vol. 3, no. 3, Jan. 2019, doi: 10.26681/jote.2019.030306.
[27] P. Marhavilas, D. Koulouriotis, I. Nikolaou, and S. Tsotoulidou, “International Occupational Health and Safety Management-Systems Standards as a Frame for the Sustainability: Mapping the Territory,” Sustainability, vol. 10, no. 10, p. 3663, Oct. 2018, doi: 10.3390/su10103663.
[28] D. Hudson and J. D. Ramsay, “A roadmap to professionalism: Advancing occupational safety and health practice as a profession in the United States,” Saf Sci, vol. 118, pp. 168–180, Oct. 2019, doi: 10.1016/j.ssci.2019.04.018.
[29] V. Chellappa, V. Srivastava, and U. R. Salve, “A systematic review of construction workers’ health and safety research in India,” Journal of Engineering, Design and Technology, vol. 19, no. 6, pp. 1488–1504, Nov. 2021, doi: 10.1108/JEDT-08-2020-0345.
[30] P. Swuste, C. van Gulijk, J. Groeneweg, F. Guldenmund, W. Zwaard, and S. Lemkowitz, “Occupational safety and safety management between 1988 and 2010,” Saf Sci, vol. 121, pp. 303–318, Jan. 2020, doi: 10.1016/j.ssci.2019.08.032.
[31] N. H. Abas, N. Yusuf, N. A. Suhaini, N. Kariya, H. Mohammad, and M. F. Hasmori, “Factors Affecting Safety Performance of Construction Projects: A Literature Review,” IOP Conf Ser Mater Sci Eng, vol. 713, no. 1, p. 012036, Jan. 2020, doi: 10.1088/1757-899X/713/1/012036.
[32] M. H. Jaafar, K. Arifin, K. Aiyub, M. R. Razman, M. I. S. Ishak, and M. S. Samsurijan, “Occupational safety and health management in the construction industry: a review,” International Journal of Occupational Safety and Ergonomics, vol. 24, no. 4, pp. 493–506, Oct. 2018, doi: 10.1080/10803548.2017.1366129.
[33] B. Calle, E. Sigcha, R. Guaman, and L. Siguenza-Guzman, “Occupational Health and Safety for Decision-Making in the Framework of Corporate Social Responsibility: Models, Guidelines, and Indicators,” 2021, pp. 157–169. doi: 10.1007/978-3-030-59194-6_14.
[34] F. Ncube and A. Kanda, “Current Status and the Future of Occupational Safety and Health Legislation in Low- and Middle-Income Countries,” Saf Health Work, vol. 9, no. 4, pp. 365–371, Dec. 2018, doi: 10.1016/j.shaw.2018.01.007.
[35] T. Shabani, S. Jerie, and T. Shabani, “The impact of occupational safety and health programs on employee productivity and organisational performance in Zimbabwe,” Safety in Extreme Environments, vol. 5, no. 4, pp. 293–304, Dec. 2023, doi: 10.1007/s42797-023-00083-7.
[36] J. Zhou and Y. Zhou, “Research on Innovation and Entrepreneurship Talent Training Model for Application-Oriented University under Perspective of Collaborative Innovation,” International Journal

of Information and Education Technology, vol. 9, no. 8, pp. 575–579, 2019, doi: 10.18178/ijiet.2019.9.8.1269.
[37] L. Melis, C. Song, E. De Cristofaro, and V. Shmatikov, “Exploiting Unintended Feature Leakage in Collaborative Learning,” in 2019 IEEE Symposium on Security and Privacy (SP), IEEE, May 2019, pp. 691–706. doi: 10.1109/SP.2019.00029.
[38] S. Sumaryanto, S. Arif, O. Sinaga, Z. Zainuddin, and K. Kisno, “IMPLEMENTATION OF OCCUPATIONAL SAFETY TRAINING FOR DOCTORS AT OHS TRAINING CENTER MEDAN,” JURNAL EDUCATION AND DEVELOPMENT, vol. 11, no. 2, pp. 101–105, Apr. 2023, doi: 10.37081/ed.v11i2.4622.
[39] I. Siregar and T. H. Nasution, “Identification of Intervention Program Effectiveness at Work Accident revention,” IOP Conf Ser Mater Sci Eng, vol. 505, no. 1, p. 012107, May 2019, doi: 10.1088/1757-899X/505/1/012107.
[40] A. Waring, “The five pillars of occupational safety & health in a context of authoritarian socio-political climates,” Saf Sci, vol. 117, pp. 152–163, Aug. 2019, doi: 10.1016/j.ssci.2019.04.008.
[41] D. Fan, C. J. Zhu, A. R. Timming, Y. Su, X. Huang, and Y. Lu, “Using the past to map out the future of occupational health and safety research: where do we go from here?,” The International Journal of Human Resource Management, vol. 31, no. 1, pp. 90–127, Jan. 2020, doi: 10.1080/09585192.2019.1657167.
[42] E. Adaku, N. A. Ankrah, and I. E. Ndekugri, “Design for occupational safety and health: A theoretical framework for organisational capability,” Saf Sci, vol. 133, p. 105005, Jan. 2021, doi: 10.1016/j.ssci.2020.105005.
[43] M. Jamil, F. Maulina, Fachurrazi, M. Hasan, and Muslimsyah, “The influence of occupational safety and health program on the manpower performance of construction company in Banda Aceh city,” IOP Conf Ser Mater Sci Eng, vol. 933, no. 1, p. 012005, Sep. 2020, doi: 10.1088/1757-899X/933/1/012005.
[44] Z. Haryati, V. Subramaniam, Z. Z. Noor, Z. Hashim, S. K. Loh, and A. A. Aziz, “Social life cycle assessment of crude palm oil production in Malaysia,” Sustain Prod Consum, vol. 29, pp. 90–99, Jan. 2022, doi: 10.1016/j.spc.2021.10.002.
[45] P. Kekkonen, A. Reiman, S. Väyrynen, and H.-K. Rajala, “Occupational safety and health in shared workplaces according to workplace inspection reports,” International Journal of Occupational Safety and Ergonomics, vol. 27, no. 2, pp. 504–516, Apr. 2021, doi: 10.1080/10803548.2019.1600314.
[46] E. Svertoka et al., “Wearables for Industrial Work Safety: A Survey,” Sensors, vol. 21, no. 11, p. 3844, Jun. 2021, doi: 10.3390/s21113844.
[47] F. Caffaro, M. Micheletti Cremasco, G. Bagagiolo, L. Vigoroso, and E. Cavallo, “Effectiveness of occupational safety and health training for migrant farmworkers: a scoping review,” Public Health, vol. 160, pp. 10–17, Jul. 2018, doi: 10.1016/j.puhe.2018.03.018.
[48] A. Hale, “From national to European frameworks for understanding the role of occupational health and safety (OHS) specialists,” Saf Sci, vol. 115, pp. 435–445, Jun. 2019, doi: 10.1016/j.ssci.2019.01.011.
[49] M. F. Antwi-Afari et al., “Sensing and warning-based technology applications to improve occupational health and safety in the construction industry,” Engineering, Construction and Architectural Management, vol. 26, no. 8, pp. 1534–1552, Sep. 2019, doi: 10.1108/ECAM-05-2018-0188.
[50] J. W. Cherrie, W. Fransman, G. A. H. Heussen, D. Koppisch, and K. A. Jensen, “Exposure Models for REACH and Occupational Safety and Health Regulations,” Int J Environ Res Public Health, vol. 17, no. 2, p. 383, Jan. 2020, doi: 10.3390/ijerph17020383.

[51] F. Blanc and M. M. Escobar Pereira, “Risks, Circumstances and Regulation – Historical development, diversity of structures and practices in Occupational Safety and Health inspections,” Saf Sci, vol. 130, p. 104850, Oct. 2020, doi: 10.1016/j.ssci.2020.104850.
[52] J. Min, Y. Kim, S. Lee, T.-W. Jang, I. Kim, and J. Song, “The Fourth Industrial Revolution and Its Impact on Occupational Health and Safety, Worker’s Compensation and Labor Conditions,” Saf Health Work, vol. 10, no. 4, pp. 400–408, Dec. 2019, doi: 10.1016/j.shaw.2019.09.005.
[53] R. J. Guerin and D. A. Sleet, “Using Behavioral Theory to Enhance Occupational Safety and Health: Applications to Health Care Workers,” Am J Lifestyle Med, vol. 15, no. 3, pp. 269–278, May 2021, doi: 10.1177/1559827619896979.
[54] A. Poghosyan, P. Manu, L. Mahdjoubi, A. G. F. Gibb, M. Behm, and A.-M. Mahamadu, “Design for safety implementation factors: a literature review,” Journal of Engineering, Design and Technology, vol. 16, no. 5, pp. 783–797, Oct. 2018, doi: 10.1108/JEDT-09-2017-0088.
[55] C. Sinyai and S. Choi, “Fifteen years of American construction occupational safety and health research,” Saf Sci, vol. 131, p. 104915, Nov. 2020, doi: 10.1016/j.ssci.2020.104915.
[56] R. J. Nayani, K. Nielsen, K. Daniels, E. J. Donaldson-Feilder, and R. C. Lewis, “Out of sight and out of mind? A literature review of occupational safety and health leadership and management of distributed workers,” Work Stress, vol. 32, no. 2, pp. 124–146, Apr. 2018, doi: 10.1080/02678373.2017.1390797.
[57] T. N. Hanvold et al., “Occupational Safety and Health Among Young Workers in the Nordic Countries: A Systematic Literature Review,” Saf Health Work, vol. 10, no. 1, pp. 3–20, Mar. 2019, doi: 10.1016/j.shaw.2018.12.003.
[58] Adriaensen, Decré, and Pintelon, “Can Complexity-Thinking Methods Contribute to Improving Occupational Safety in Industry 4.0? A Review of Safety Analysis Methods and Their Concepts,” Safety, vol. 5, no. 4, p. 65, Oct. 2019, doi: 10.3390/safety5040065.
[59] M. A. Ahamad et al., “Systematic Literature Review on Variables Impacting Organization’s Zero Accident Vision in Occupational Safety and Health Perspectives,” Sustainability, vol. 14, no. 13, p. 7523, Jun. 2022, doi: 10.3390/su14137523.
[60] H. O. Kalteh, S. B. Mortazavi, E. Mohammadi, and M. Salesi, “The relationship between safety culture and safety climate and safety performance: a systematic review,” International Journal of Occupational Safety and Ergonomics, vol. 27, no. 1, pp. 206–216, Jan. 2021, doi: 10.1080/10803548.2018.1556976.
[61] S. Felknor, J. Streit, L. Chosewood, M. McDaniel, P. Schulte, and G. Delclos, “How Will the Future of Work Shape the OSH Professional of the Future? A Workshop Summary,” Int J Environ Res Public Health, vol. 17, no. 19, p. 7154, Sep. 2020, doi: 10.3390/ijerph17197154.
[62] M. D. Cooper, “The efficacy of industrial safety science constructs for addressing serious injuries & fatalities (SIFs),” Saf Sci, vol. 120, pp. 164–178, Dec. 2019, doi: 10.1016/j.ssci.2019.06.038.
[63] I. P. Adamopoulos, A. N. Bardavouras, and N. F. Syrou, “Occupational safety, policy, and management in public health organizations and services,” Eur J Environ Public Health, vol. 7, no. 1, p. em0122, Jan. 2023, doi: 10.29333/ejeph/12445.
[64] S. Park, M. D. Johnson, and O. Hong, “Analysis of Occupational Safety and Health Administration (OSHA) noise standard violations over 50 years: 1972 to 2019,” Am J Ind Med, vol. 63, no. 7, pp. 616–623, Jul. 2020, doi: 10.1002/ajim.23116.
[65] S. L. Tamers et al., “Envisioning the future of work to safeguard the safety, health, and well-being of the workforce: A perspective from the CDC’s National Institute for Occupational Safety and Health,” Am J Ind Med, vol. 63, no. 12, pp. 1065–1084, Dec. 2020, doi: 10.1002/ajim.23183.

[66] V. Patel, A. Chesmore, C. M. Legner, and S. Pandey, “Trends in Workplace Wearable Technologies and Connected-Worker Solutions for Next-Generation Occupational Safety, Health, and Productivity,” Advanced Intelligent Systems, vol. 4, no. 1, Jan. 2022, doi: 10.1002/aisy.202100099.
[67] L. Botti, R. Melloni, and M. Oliva, “Learn from the past and act for the future: A holistic and participative approach for improving occupational health and safety in industry,” Saf Sci, vol. 145, p. 105475, Jan. 2022, doi: 10.1016/j.ssci.2021.105475.
[68] S. N. Ismail, A. Ramli, and H. A. Aziz, “Influencing factors on safety culture in mining industry: A systematic literature review approach,” Resources Policy, vol. 74, p. 102250, Dec. 2021, doi: 10.1016/j.resourpol.2021.102250.
[69] F. Guennoc, C. Chauvin, and J.-C. Le Coze, “The activities of occupational health and safety specialists in a high-risk industry,” Saf Sci, vol. 112, pp. 71–80, Feb. 2019, doi: 10.1016/j.ssci.2018.10.004.
[70] M. Gul, “A review of occupational health and safety risk assessment approaches based on multi-criteria decision-making methods and their fuzzy versions,” Human and Ecological Risk Assessment: An International Journal, vol. 24, no. 7, pp. 1723–1760, Oct. 2018, doi: 10.1080/10807039.2018.1424531.
[71] D. B. Moyano, D. A. Paraiso, and R. A. González-Lezcano, “Possible Effects on Health of Ultrasound Exposure, Risk Factors in the Work Environment and Occupational Safety Review,” Healthcare, vol. 10, no. 3, p. 423, Feb. 2022, doi: 10.3390/healthcare10030423.
[72] R. Sharma and D. K. Mishra, “An analysis of thematic structure of research trends in occupational health and safety concerning safety culture and environmental management,” J Clean Prod, vol. 281, p. 125346, Jan. 2021, doi: 10.1016/j.jclepro.2020.125346.
[73] H. Chen, C. Hou, L. Zhang, and S. Li, “Comparative study on the strands of research on the governance model of international occupational safety and health issues,” Saf Sci, vol. 122, p. 104513, Feb. 2020, doi: 10.1016/j.ssci.2019.104513.
[74] R. Zorzenon, F. L. Lizarelli, and D. B. A. de A. Moura, “What is the potential impact of industry 4.0 on health and safety at work?,” Saf Sci, vol. 153, p. 105802, Sep. 2022, doi: 10.1016/j.ssci.2022.105802.
[75] P. K. Marhavilas and D. E. Koulouriotis, “Risk-Acceptance Criteria in Occupational Health and Safety Risk-Assessment—The State-of-the-Art through a Systematic Literature Review,” Safety, vol. 7, no. 4, p. 77, Nov. 2021, doi: 10.3390/safety7040077.
[76] A. Badri, B. Boudreau-Trudel, and A. S. Souissi, “Occupational health and safety in the industry 4.0 era: A cause for major concern?,” Saf Sci, vol. 109, pp. 403–411, Nov. 2018, doi: 10.1016/j.ssci.2018.06.012.
[77] F. Salguero-Caparrós, M. C. Pardo-Ferreira, M. Martínez-Rojas, and J. C. Rubio-Romero, “Management of legal compliance in occupational health and safety. A literature review,” Saf Sci, vol. 121, pp. 111–118, Jan. 2020, doi: 10.1016/j.ssci.2019.08.033.
[78] K. H. D. Tang, “A comparative overview of the primary Southeast Asian safety and health laws,” Int J Workplace Health Manag, vol. 13, no. 6, pp. 601–632, Jul. 2020, doi: 10.1108/IJWHM-10-2019-0132.
[79] M. Tejamaya, W. Puspoprodjo, H. Susetyo, and R. Modjo, “An analysis of pivotal factors in the implementation of occupational health and safety management systems in micro, small and medium enterprises (MSMEs): Literature review,” Gac Sanit, vol. 35, pp. S348–S359, 2021, doi: 10.1016/j.gaceta.2021.10.050.
[80] W. Simukonda, P. Manu, A.-M. Mahamadu, and K. Dziekonski, “Occupational safety and health management in developing countries: a study of construction companies in Malawi,” International

Journal of Occupational Safety and Ergonomics, vol. 26, no. 2, pp. 303–318, Apr. 2020, doi: 10.1080/10803548.2018.1482649.
[81] H. De Cieri and M. Lazarova, "'Your health and safety is of utmost importance to us': A review of research on the occupational health and safety of international employees," Human Resource Management Review, vol. 31, no. 4, p. 100790, Dec. 2021, doi: 10.1016/j.hrmr.2020.100790.
[82] A. Polak-Sopinska, Z. Wisniewski, A. Walaszczyk, A. Maczewska, and P. Sopinski, "Impact of Industry 4.0 on Occupational Health and Safety," 2020, pp. 40–52. doi: 10.1007/978-3-030-20494-5_4.
[83] O. Nicolaidou, C. Dimopoulos, C. Varianou-Mikellidou, G. Boustras, and N. Mikellides, "The use of weak signals in occupational safety and health: An investigation," Saf Sci, vol. 139, p. 105253, Jul. 2021, doi: 10.1016/j.ssci.2021.105253.