



Vision Zero for industrial workplace safety innovative model development for metal manufacturing industry

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ABSTRACT

This study target is to investigate Vision Zero strategy & develop a model that contributes to the reduction of injuries, accidents, and fatalities. In turn, this model aims to enhance the well-being, safety, and productivity of the manufacturing sector. The study has conducted comprehensive theoretical reviews from reputable journals that are relevant to Vision Zero, manufacturing industries in general, and specifically the metal manufacturing industries. The study also underwent a validation of the Vision Zero strategy model by discussing with a selected professional team in this field from the industry. The results of this study shows that research related to the Vision Zero strategy has not been widely disseminated or popularized. It further reveals that manufacturing industries predominantly operate based on traditional work environmental principles, rather than actively embracing the concepts and principles of Vision Zero. The study has also uncovered that previous research on Vision Zero primarily focused on road accidents, injuries, and fatalities. In contrast, studies conducted in the manufacturing sector primarily examined aspects related to safety, health, and worker well-being. However, these studies often failed to sufficiently align their objectives with the overarching priority of enhancing productivity, especially within the context of the industrial revolution. Due to the limited studies related to Vision Zero and a new area for the research database, setting comparative goals and developing a stringent strategy may not be the final outcome here with the developed model. The results of this research could provide valuable insights to policymakers & lawmakers in order to enhance workplace health and safety regulations which support industries' productivity. This study represents a pioneering effort in developing a new Vision Zero strategy model that aligns with productivity goals and emphasizes knowledge-based approaches for reducing or eliminating injuries, accidents, and fatalities.

1. Introduction

Vision Zero (VZ) strategies are a very important concept those have value in reducing or eliminating workplace injury, accidents, disease, or loss of productivity. Vision Zero has been discussed in a few studies related to road safety and industrial occupational safety. Road safety research linked to VZ found it is the philosophy initiating no one ought to be died (severely injured) while using public roads [1]. Choosing to implement VZ signifies a dedication to a road transportation system that places a high priority on preventing fatalities and serious injuries, aiming for a system where no individual is killed or seriously harmed. This idea reflects symmetrically

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that VZ accident, disease, injury, and death in road transport also works for manufacturing industries in the reduction or elimination of these injuries as well as increasing the wellbeing and productivity of the manufacturing industry in the meantime.

The risk of work-associated afflictions, injuries, accidents, and fatalities is, without a doubt, the most prevalent and main fitness question that influences the well-being and output of staff members. On account of work activities, deaths and fatalities have been reported in studies (e.g. Ref. [2]). According to the ILO estimate, 2.34 and 2.79 million fatalities were recorded in 2013 and 2019, respectively. ISO 45001:2018 [3] mandates employee participation in safety and health management and obligates organizations to ensure that their employees possess the necessary skills to carry out tasks safely [2].

Frequent engagement in the same work activities and continuous and excessive use of force might impose stress, resulting in work-musculoskeletal disorders (WMSDs), which are enhancing the hazard of emerging WMSDs in employees [4]. Occupational diseases due to Physical influences account for the highest prevalence of occupational diseases [5,6]. Placing people and their work at the center of economic, social, and business practice (having a human-centric organizational policy) is crucial for addressing global challenges [2].

A study showed that in Ethiopian manufacturing, there is a large population of employees relative to other industrial sectors, though occupational safety and health (OSH) issues were given less priority [7]. This study supports the fact that the Vision Zero accidents and injuries are not practiced by industries to save numerous employees in manufacturing industries. Due to the mismatch between workers and other workplace components like equipment, materials, procedures, environments, societies, and technology, workplace accidents, MSDs, and work errors frequently happen at various phases of the production process in the manufacturing industries. There are many reasons why accidents, injuries, hazards, and unhealthy work environments occur in industries. For instance, according to the study conducted by Isabel [8], accidents and injuries occur because ergonomics is not used to its full potential; and its value is not fully understood. Therefore, it is essential to reposition from a primary health, ergonomics, and safety strategy to a more business-oriented approach to address the present dynamic workplace issues that threaten the manufacturing industry's competency, welfare, and productivity. Berlin and Adams [9] have described that the everyday form of human workers may have an impact on how well the manufacturing industry's production system performs overall. But in order to maximize the effectiveness of human resources, workplace safety and wellbeing are essential [10]. If workplace safety and health are crucial for productivity and employee efficiency and effectiveness maximization, they need more attention in their workplace.

According to estimates shown in Fig. 1, illustrates distribution of occupational deaths and illness problems are unequally spread over the world. As it is seen from Fig. 1, worldwide work-related deaths are estimated to occur more than other continents in Africa and Asia [2].

According to the Ethiopian Ministry of Labor and Social Affairs (MoLSA), 25,812 workers in 14,914 establishments suffered death, temporary disability or permanent damage [11]. The same study has shown that the industrial sector accounted for 56.05 %, which is the biggest proportion of recorded accident cases. It has been discovered that the "Vision Zero" strategy has not yet been implemented in emerging nations' manufacturing and service sectors. The philosophy of Vision Zero is crucial to curbing the trend of the manufacturing industry from accelerated injuries to decelerated trend.

According to the research done by Kifle et al. [12], Ethiopia's steel and iron manufacturing business had an injury prevalence rate of 33.3 % annually, which was brought on by a lack of workplace safety and a health management system. According to Birhan [7] study, it shows that workers in the large & medium metal industry of Addis Ababa are likely to suffer injuries or injury due to the nature of their work and the application of personal protective equipment (PPE) without tools and poor PPE use culture. Based on the research finding by Alamneh et al. [13] by the systematic review study conducted in Ethiopia, when considering the probability of job-related injuries & factors associated with combined prevalence was found to be 44.66 % per year and was brought on by working more than 8 h, not supervising labourers, not having PPE, and not receiving adequate training in OSH.

Typically, several manufacturing sectors simply use a reactive strategy to manage the risks' effects. Many industries hold off on taking action until the situation has gotten out of hand. The human workforce was exposed to numerous MSDs and other incidents consequently these trends in OSH management systems, which also negatively impacted both individual employee productivity and

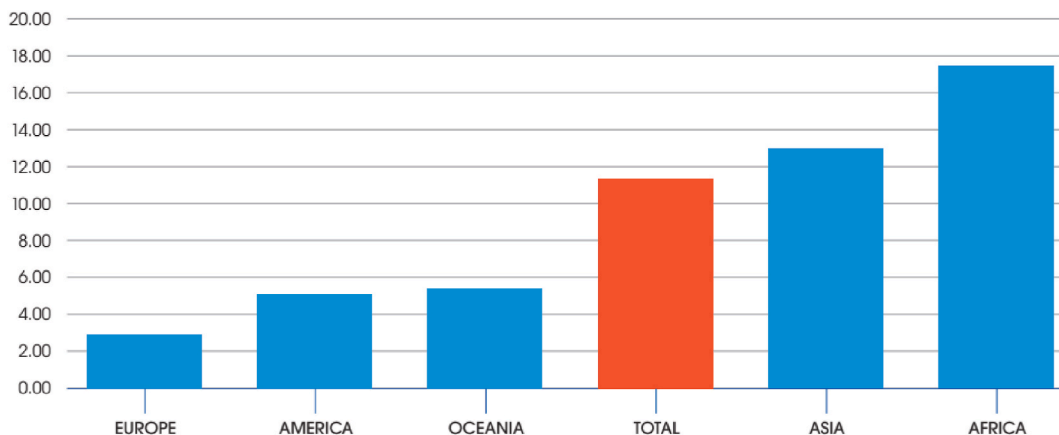


Fig. 1. Continental fatal rates distribution per 100,000 people in the Workforce [2].

industry productivity as a whole. Therefore, proactive strategies to minimize the root causes of accidents, injuries, MSDs, and disease that result from workplace errors are required to create a user-friendly working environment. According to ISO 45001:2018 [3], focusing on an organizational safety and health management system that is proactively enables the reduction of occupational diseases, injuries, and illnesses. Furthermore, it helps in the advocacy and protection of both physical and mental well-being. This ISO requirement emphasizes that an efficient organizational and safety management system should actively involve employees and other pertinent stakeholders or interested parties. This ISO statement must be in line with the Vision Zero accidents, injuries, and productivity enhancing measures.

From a business perspective, it is understandable that many firms prioritize productivity and quality performance as their primary goals, instead of solely concentrating on the safety and health of their employees [14]. Issues related to safety and health receive little attention and is ranked low on the list of national priorities [11]. The industrial sector often experiences a discrepancy between the capacity of workers and the demands placed on them by the system. This mismatch can be attributed to the inadequate correlation between productivity, quality, and the overall health and well-being of workers [15]. As workers who are afflicted by an illness or diseases have fewer capacity to accomplish their work, this imbalance remains the root cause of the loss of human resources inside the business. At the individual, organizational, and societal levels, this loss is the key reason why the majority of systems are currently unsustainable [15].

Many studies focusing on safety and health in manufacturing industries have found that many of them perceive safety as a static or unchanging aspect. The industries consider the productivity and profit of their organizations prior to human capital and health. The study conducted by Birhan [7] and Lehto & Cook [16] showed that management effort plays a noteworthy role in establishing a safe work atmosphere within any industry. However, Birhan [7] has shown that one of the reasons that metal industry accidents are due to lack of top management commitment, which is not strategically supported. The top management's commitment failure is due to a lack of a Vision Zero strategy for their organizations.

Hence, the ongoing study aims to develop an innovative strategy model for achieving Vision Zero accidents, injuries and death prevention. This model is specifically designed to assist the metal manufacturing industry in reducing or eliminating workplace injuries, accidents, diseases, and fatalities. By doing so, it will encourage the overall well-being, safety, and productivity improvement of the industry. The subsequent sections include supportive theoretical literature, the methodology of the study, results and discussion, Vision Zero innovative strategic model development, and concluding remarks.

2. Theoretical data review

The theoretical data analysis is discussed in this section to inculcate the current state of the Vision Zero accident and injury in the time of state-of- the art. A theoretical sources review has been made to show gaps in the studies related to the VZ manufacturing industries. Different models and strategies have been discussed in this study to develop the VZ method. Industrial safety has been given less consideration than the employees' safety and health. Historically, industrial safety has received less attention in comparison to the safety and health of employees. Any steel industry, in particular, is renowned for its hazardous working conditions [7,17], thereby increasing the probability of work related injuries in such sectors. The significance of incorporating leading indicators of OSH alongside lagging indicators is gaining recognition as a crucial aspect of fostering a prevention culture within organizations [18]. The studies under this review have shown how Vision Zero models are developed and implemented in reality. The review has discussed concept of VZ, models for VZ strategies, and implementation.

2.1. Concepts of Vision Zero

Vision Zero is an ongoing journey that urges companies, labor organizations, unions, stakeholders, and government entities to cultivate a mindset where every work-related injury and illness is preventable and emphasizes the belief that achieving zero harm is not only attainable but also essential. It was launched in 2015 [19]. As per the research undertaken by Kristianssen et al. [20] in Sweden, the concept of VZ has expanded beyond road traffic accidents and safety and has been adapted to other safety related domains like patient safety, fire safety, worksite safety, and suicide prevention. These study findings demonstrated that the VZ policies implemented in various areas beyond road traffic accidents and safety encompass more than just shared terminology. However, it was also observed that the concepts and principles associated with VZ were not consistently integrated and applied within each specific policy area as initially anticipated.

Vision Zero in the workplace is an innovative approach that combines health, safety and well-being to proactively inhibit workplace accidents and injuries [18,19]. VZ is recognized as a strategy based on commitment [21,22], which means ongoing improvement process is propelled through the dedication and commitment of both top managements and lower level labors. When implementing VZ, key aspects for reducing workplace hazards include commitment, communication, culture, and learning [22]. A commitment strategy has the potential to commence in every performance level of SHW and can initiate continuous process of development. It suggests VZ is applicable to a wide range of industries including all well-established leaders in the field and also smaller organizations.

VZ ideology in a workplace is founded by the fundamental belief that every harm, coincidences, injuries and work-related ill health can be prevented [23]. Vision Zero is a comprehensive ambition and commitment intended in creating and sustaining a safe and healthy work atmosphere and it encompasses the prevention of these injuries, accidents, harm, and work related illnesses, while simultaneously advocating for excellence in SHW practices. Vision Zero must be perceived as an ongoing journey and a systematic process towards the ultimate goal of achieving zero accidents. Furthermore, it is founded on a set of values that stress the importance of work not having adverse effects on workers' SHW, and work should support workers in maintaining or enhancing their SHW, while

fostering their self-confidence, competence, and employability. The three issues included by Vision Zero as SHW consider all aspects of the employees'; it is related to disease and workplace injuries [14,24]. The focus of this studies is more on the three elements, which are SHW disregarding the other elements for the achievement of VZ. In addition to this, the VZ accidents should include the impact of the implementation of VZ philosophy in turn. How the implementation of VZ affects the organization's development and employee's success must be shown in bold.

2.2. Vision Zero implementation practice

In a few nations around the world, VZ has been put into practice. This VZ's application is more heavily weighted toward improving traffic safety and preventing road accidents. The study revealed that the VZ strategy, which expands on road safety policies, strives to eliminate mortalities and severe injuries resulting from road traffic accidents [25]. Nevertheless, the study emphasizes that the VZ philosophy places greater responsibility on industries and system designers, shifting the focus beyond road safety alone. A study has proved that the principle of VZ has been accepted by several cities in the USA [26]. The other countries that implemented VZ were European and Australasian countries. The European country that used VZ in the 1990s was Sweden, which is focused on reducing road speed to save lives [26]. Australia and New Zealand, along with other countries in Australasia, have adopted a safe system technique in 2003 and this approach includes the successful elements of VZ and Sustainable Safety Policy in Dutch where it identified high risks and locations of its occurrences [25]. These countries practiced VZ with reference to road traffic safety regardless of manufacturing industries. Vision Zero implementation in China is also working on the numerous road accidents, fatalities, and severe injuries [27]. That is learnt most of the implementation and application of VZ principles is more focused on road traffic and accidents.

The central focus of this study is to carry out the implementation of VZ in industrial sectors, taking into consideration that the development of industrialization is a global concern and workplace hazards and injuries are emerging in parallel. In such contexts, the implementation of VZ concepts becomes a crucial element for industrial sectors.

2.3. Manufacturing industry safety and health

Every manufacturing process carries its own distinct set of hazards. There are several major hazards that are commonly found across various industries which include trips, falls, and slips inadequate machine guarding; risks associated with electrical hazards; powered industrial vehicles; proper lockout and tag-out procedures for equipment; as well as potential environmental hazards [28]. It is crucial to assess manufacturing processes for potential hazards, including sharp edges, pinch points, confined spaces, bump hazards and any other distinctive risks specific to the process [23,29]. Upon identifying hazards, it is of utmost importance to promptly take necessary measures to minimize or eliminate them with the aim of ensuring the safety of employees.

The analysis of numerous accidents revealed that a primary cause of injuries was deficiencies in organizational practices and inadequate worker training in which personnel who had insufficient qualifications, contributing to the occurrence of accidents [24, 30].

The study conducted by Zwetsloot et al. [18] and ISSA [23] focused on strategies for integrating safety, health, and well-being. These studies lack the integration of productivity and financial failure. Therefore, the gap that is linked to Vision Zero is also preventing productivity loss and waste management. In a study conducted by Fatini Hanim Binti Mohamed Taufek et al. [31] that the study investigated that there is strong relationship between health practice & safety and injury administration among workforces in the manufacturing sectors. The findings of this research indicated a positive and strong relationship between injury management and various factors, including training, safe workplace procedures and supervision, reporting safety, management commitment and consultation.

2.4. Relationship between SHW and productivity

The study conducted by Voordt and Jensen [32] found that a healthy workplace has an impact on the well-being and productivity of organizations, which in turn reduces their costs. This study has shown that a healthy workplace adds value to the employee's satisfaction by improving their workplace performance. Workplace health and productivity have a direct relationship, as numbers of studies have proven (e.g. Refs. [24,33,34]). The study conducted by Felicity, Claire, and Martin [34] stated that workplace proper ergonomic design, preventing all causes of workplace accidents and injuries, and reducing serious incidents result in well-being improvement, which in turn increases productivity and performance.

Safety, health (physical work environment), and wellbeing are the reasons for organizational productivity. According to the analysis mentioned in ISSA [23], the three aspects of SHW are interconnected and mutually influencing each other in pursuit of organizational success. This interrelation creates opportunities for synergy, emphasizing the relevance of proactive leading indicators across all three aspects.

2.5. Comparative study and gap analysis

Vision Zero strategic elements and models for comparative analysis in research has been assessed. There has not been much work presented related to the Vision Zero models, implementation and policy issues. The models presented have been inconsistent, and the presentation has not shown how industrial productivity improves in line with the wellbeing of industry workers. Previous studies have primarily concentrated on VZ in the context of road safety. Studies have defined VZ as a transformative approach to prevention that

encompasses the integration of SHW across all levels of work [29]. However, the VZ definition in itself ignores the productivity wings in the organizations as a fourth pillar. Hence, this study has attempted to fill the noticed gaps in the VZ application processes.

3. Methodology

3.1. Data sources

This study has used a mixed research approach for developing a conceptual Vision Zero model and implementation process. The methods used for research preparation came from both secondary and primary data sources. The other source of data was input from industry, a qualitative data source related to metal industries using evaluation through feedback from top management interviews.

3.2. Qualitative data

3.2.1. Review of the literature

Literatures reviewed to ascertain the existing research priorities and areas of deficiency concerning the principle, philosophy, and implementation of VZ. The data were collected from literature reviews, including sources like Elsevier journals, world sciences, Safety Science, MDPI, International Journal of Occupational Safety and Ergonomics, MJ Journals, Emerald journals, Taylor and Francis publishers, reports, strategic plans, and the International Labor Organization (ILO) database. The research obtained data from relevant areas related to Vision Zero, manufacturing industry safety, safety and health, productivity, occupational safety improvement strategies, industrial accidents, injuries, disease, wellbeing, and healthy issues. Keywords were also utilized. The study has considered 147 publications and finally screened out 49 relevant publications for this study's discussion. The 49 relevant references used passed through screening processes and became qualified for this study (Table 1).

3.2.2. Interview of top management

Data and information was gathered from the top management of the industry through interviews. Interview questions were prepared specifically for the industry's top management to assess their knowledge of VZ concepts and implementation. The interviews were conducted with the top management of 12 manufacturing industries, including human resource directors and general managers. In total, there were 18 respondents during the interview sessions. However, 6 of the intended interviewees were unable to attend due to unavailability on certain days during the program.

3.3. Overall research design and flow process

As shown in Fig. 2, this study identified the problems and the current importance of the research to the industries. Based on its importance, the methodology used set of objectives and problem formulations. After formulating the problems and objectives, the methodology included the identification of data sources and the data categorization methodology employed in order to gather all necessary data. Data gathering mainly focused on the exhaustive literature review and gap identification from the given reputable journal sources. The data was also collected from experts' experience opinion in the area and interviews with industry professionals. Analysis, synthesis, and discussions have been carried out based on the collected data. The data discussed related to Vision Zero resulted in the development of a VZ conceptual framework. The VZ success strategy and conceptual model have been checked for reliability and acceptability. After the reliability and acceptability of the conceptual framework by experts, it has been subjected to implementation procedure development so that the model users easily understand it (refer to Fig. 2).

4. Results and discussions

4.1. Interview data analysis

Data on the VZ concept, its comprehension, and its implementation process were gathered from the interviews conducted with top management and organizational observations. Table 2 lists the inputs received from the top management of 18 manufacturing industries. To be completely honest, the survey revealed that 72 % of senior management respondents indicated that they currently had no awareness or understanding of the VZ concept. Only 28 % of the management had some knowledge of the concept from literature

Table 1
Literature review Screening Methods followed.

S/n	Focused areas	Numbers of papers considered (n)
1	Potential papers retrieved from the sources	147
2	<ul style="list-style-type: none"> • Duplicate included 	11
3	<ul style="list-style-type: none"> • Papers excluded after screening by Title, keywords and abstract 	70
4	After the introduction and result discussion assessment	60
5	After full text papers assessment for eligibility test	55
6	Total papers included in this review	49

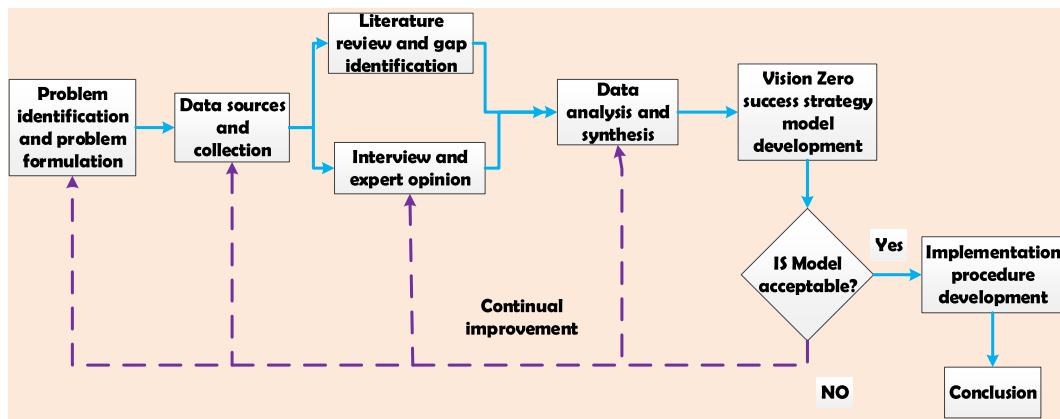


Fig. 2. Methodology framework (Author).

Table 2
Top management interview questions and response.

s/n	Interview questions	Responses obtained	Respondent Numbers	Percentage
1	Understanding of Vision Zero concept	Have the idea but not sure about its implementation Have no idea of Vision Zero and it is new concept	5 13	28 % 72 %
2	Knowledge of Vision Zero policies availability Training for employees affects company productivity positively	Any of the respondents do not hear about VZ policies Not only Training but also resources availability Training with rules and guidelines Training with PPE	18 7 8 3	100 % 39 % 44 % 17 %
3	providing effective employee training during employees' first couple of weeks on the job	Effective safety training and induction for employees available Induction training related to safety is not practiced except the overall company operation	15 3	83 % 17 %
4	A time you had to manage an unproductive employee	Reducing absenteeism through keeping safety and health of workplace is available There is no clear sources of unproductive employees in the company	13 5	72 % 28 %
5	Workplace ergonomically designed	Workplaces design, layout like sitting chair, table, etc. are not well designed Good workplace design available	16 2	89 % 11 %
6	Availability of personal protective equipment and top management commitment	PPE is available but employees are not comfortable with it to use it All employees are given and use it properly	14 4	78 % 22 %
7	Occurrence of accidents and injuries in their company	Major accidents registered Minor accidents registered Both major and minor accident registered Death registered	11 12 12 0	61 % 67 % 67 % 0 %
8	Communication flow in the company related to the workplace safety and health	There is smooth communication and information sharing related safety There is no clear information flow related to accident occurrence, signal and reduction	8 11	44 % 61 %

but had not been involved in implementing the VZ principles.

All the respondents reacted by saying that they do not know the availability of VZ policies in the manufacturing sector. Every employee agrees that Training is a good industrial employee self-development parameter for the improvement of the productivity of the company. But training alone is not the way to improve the worker's productivity. The response of 39 % of the top management agrees that both the availability of training and the necessary resources are important constraints to productivity improvement. In addition to training availability, 44 % of the respondents believe that procedures, rules, and guidelines are important to improve employee's productivity. The remaining respondents agree that the availability of training and Personal protective equipment (PPE) is important requirements for improving organizational productivity.

During the discussions with top management, the topic of effective employee training during the initial weeks of employment was addressed. The responses from the interviewees revealed that 83 % of them indicated the availability of effective safety training and induction programs for employees. However, 17 % of the respondents stated that safety-related induction training was not practiced, except for general operations within the company.

An interview was conducted with top management related to the question of how workplace ergonomic design affects employee

productivity. According to the interview responses, 89 % of the interviewees stated that proper workplace design and layout, including factors such as suitable seating, tables, lighting, sound, and vibration, are lacking or inadequate in their companies. Conversely, 11 % of the respondents agreed that their company has a good workplace design in place.

The question raised with the top management focused on two aspects: the availability of personal protective equipment (PPE) and

Table 3

Variables used in this study for Vision Zero strategy models development.

s/n	Important VZ variable	Variable description	Authors
1	Proactive Leading indicators	These variables or approaches are contemporary cultured based variables which are used to prevent accidents and injuries prior to occurrences. For example, training on how to prevent workplace accidents and near miss in the industrial workplace especial to metal manufacturing industries where there are huge accident accidences. For instance, activities like induction training, procurement training, pre-work briefings, as well as efficient planning and organization of work play a vital role in maintaining a strong emphasis on continuous improvement in terms of SHW.	ISSA [23], Zwetsloot et al. [36]
2	Commitment of the organization's leaders & their Competency	The top management commitment is an extra mile to make VZ successful in the organization and control occurrence of hazards. The top management decision in putting organizational policies and knowledge to the industry community is irreplaceable. Leaders, through their visible commitment, exhibit their dedication to SHW and enthusiastically encourage the enhancement of its practices. The presence of dedicated and inherently motivated SHW management is instrumental in propelling the developmental practices of VZ.	Kassu [37]; Berhan [38]; ISSA [23]; Obwan et al. [39]
3	Risk management Evaluation and learning from unplanned events	The effectiveness of SHW risk administration assessment highlights the significant commitment and focus of leadership to enhancing SHW within an organization. Additionally, it facilitates organizational learning and promotes continuous development. Through the analysis and learning from unplanned events, organizations can effectively prevent the recurrence of similar incidents and enhance their overall SHW performance.	ISSA [23]; Zwetsloot et al. [18]
4	Workplace job induction and targeted programs evaluation	Interconnecting SHW into induction programs processes, organizations ensure that SHW becomes an intrinsic component of every job and business process. Conducting evaluations of specific SHW programs, such as temporary campaigns, assists in ensuring their implementation according to the intended plan and the achievement of improvement goals. This evaluation process verifies the effectiveness of the programs and facilitates ongoing improvement in SHW performance.	ISSA [23], Kassu [37]; Hawseand Wood [40]; José [41]
5	Pre-work briefing and Planning organization work	The integration of SHW in to prior work briefings introduces and permits for the sorting out context specific harms, hazards, risks, and places mechanism to preventive measures before starting jobs. Additionally, effective preparation and coordination of duties are crucial components for any organization to thrive while protecting employee SHW.	ISSA [23]; Zwetsloot et al. [18]
6	Innovation, change and procurement	Frequent changes, whether personal, technological, or organizational, are a common occurrence in organizations. It is important to take a proactive approach in considering these factors right from the beginning, during the design phase, to enhance SHW effectively. Procurement decisions can have long-term implications for SHW risks within an organization. These indicators serve as triggers to ensure that SHW considerations are integrated into procurement practices.	ISSA [23], Kassu, Daniel, Birhanu [42]
7	Initial and refreshment training	Initial training plays a pivotal role in establishing a strong foundation for promoting SHW and ensuring that leaders and workers are adequately qualified before commencing their roles. Refresher training, on the other hand, is essential for maintaining leaders and workers' knowledge and skills in SHW, ensuring that they stay updated with the latest practices and regulations.	ISSA [23]
8	Suggestions and reward for enhancement	Creating an environment where ideas are welcomed and treated seriously for SHW improvements to stimulate active commitment among employees and contributes to the enhancement of it within the organization. The appreciation and reward also improve the behaviors of the employees to implement VZ properly	ISSA [23]; ISSA [29]
9	commitment strategy for safety	To foster commitment and engagement among employees, it is essential to empower them by minimizing administrative or hierarchical controls.	Zwetsloot et al. [18]; Zwetsloot et al. [36]; ISSA [29]
10	Engineering protection	The workplace design needs to be properly designed based on engineering principles such as layout design, use of appropriate equipment control system, etc.	Kassu and Daniel [11]; Canberra [43]
11	Design for Safety	Integrating risk assessment methods and identification of hazard to the early product or process design eliminates or minimizes the risks of accidents occurrence during the life cycle of product or process being designed. This includes systems, equipment, facilities, products, processes, tools, material, control systems, energy, layout, software, hardware and configuration of overall requirements.	Nicolas & Dimitris [44] Canberra [43], Nicolas & Dimitris [44]

their commitment to improving workplace safety. Among the 18-manufacturing industry's top management, 78 % of the respondents answered that PPE is available but employees are not comfortable using it during working hours. In these companies, 22 % of respondents agreed that all employees who are given PPE are using it appropriately. It is seen that some of the employees are using PPE properly, and some of them are uncomfortable using PPE.

Another interview question raised important concerns about the occurrence of accidents and injuries within their company. The response obtained from 61 % indicated that there are major accidents recorded in the companies; 67 % of them accepted that there is a minor accident registered, and 67 % of the respondents agreed on the existence of both major and minor accidents in their company. The good news obtained from the top management response is that there are no severe injuries or deaths recorded.

An interview was also conducted on communication flow in the organization related to workplace safety and health. The top management's major responses related to communication flow regarding workplace safety, health, and well-being indicated that 44 % of the respondents agreed that there is smooth communication and information sharing related to workplace safety. The remaining answer agrees that there is no clear information flow related to accident occurrence, signaling, or reduction mechanisms in the industries.

In general, the preliminary primary data suggests that the concept of VZ is not well integrated or widely adopted by research and the industry's top management. There is a problem with mainstreaming workplace safety, health, and well-being to the employee's productivity improvement platform. Therefore, it requires the development of a generic VZ model and an implementation procedure as indicated in the subsequent sections. The next subsection works on the justification and development of this model.

4.2. Vision Zero strategy and productivity

This study has covered crucial indicators and the construction of a knowledge-based workplace safety model in order to satisfy the Vision Zero objective. Without a conceptual foundation, the Vision Zero will not be realized. There should be response to the basic questions like what signs point to Vision Zero? How will the Vision Zero Principle be applied to the manufacturing industry Safe System?

The VZ concentrates on leading indicators, which are frequently process-oriented and act as proxies for actions thought to increase and improve SHW including productivity (P), among other things. Many leading indicators are associated with activities that are widely recognized as best practices in the field, such as incorporating productivity as fourth pillar of SHW, in order to make SHWP model, leadership functions and obligations, the onboarding and training procedures, meetings, and procurement activities are considered as good practices [23]. Proactive leading indicators capture the dynamic and continuing developments, accomplishments, and performances that surpass mere existence and are characterized by action, continuity, and present relevance. Leading indicators that are proactive focus on identifying, developing, utilizing, and evaluating opportunities for continuous improvement rather than just controlling current risks and maintaining the status quo. In contrast to VZ, the traditional strategy relies on lagging indicators, which are frequently outcome-focused and assemble historical data over a considerable amount of time [18,23]. The VZ approach discourages the lagging indicator approach to accident control because it adopts a reactive strategy in response to incidents that result in employee and organizational accidents and injuries. A proactive strategy known as a leading approach involves preventing any illness, accident, or death before it occurs [24,35]. Important variable in VZ are indicated in Table 3.

In studies, it has been seen that when employees are aware of their health, safety, wellbeing, and happiness in the work environment, they are motivated and energized to exercise their responsibility extraordinarily [18,23]. This workplace safety and health leads the employee to react to their assignments properly. As these studies ratified that happy and healthy employees are energetic and motivated to work, always smiling. The exclusive focus on the three pillars of safety, health, and employee well-being can cause hesitation among top management. This is because the top management perceives that leading safety activities in an imaginative and proactive manner can be costly to the organization, despite fulfilling the necessary proactive requirements. When we instead link these three pillars to productivity, the organization now understands how they affect productivity and increase it. This situation improves SHW practice while also increasing organizational productivity. Many studies discussed in the so far have missed the key ingredient for convincing top management, which is productivity integration with Vision Zero. Only focusing on the three pillars, which are safety, health, and wellbeing, may not give full meaning to the organization's leaders and, in the end, halt the successes of the Vision Zero implementation. Of course, the three pillars discussed in these studies help the employee be motivated and smile to work properly. But it doesn't boldly tell the organization's owner or managers how it links the situation to productivity, as the target of many organizations is to increase productivity within their organization. Therefore, it is necessary to link and talk about the SHW within the productivity enhancement so that the leader is guaranteed from it. In this case, the leaders of the organization are now ready to exercise more freedom over the employees' Vision Zero strategy implementation when the process aligns with how the productivity of the organization booms. Therefore, the Vision Zero strategy will come true when safety, health, wellbeing, and productivity (SHWP) are integrated.

4.3. Vision Zero innovative model

For all process and production industries, OSH are a high priority due to the variety of workplace characteristics. The most hazardous manufacturing industries are the metal manufacturing industries, which use huge resources on all continents. The concerns of these industries are very crucial to developing innovative and implementable models for them. It is a must to pay attention to a Vision Zero system during consideration of a work related fatalities in the manufacturing industries. At the workplace, employees being healthy means more than just their physical state; it also includes their well-being and mental health. There are key roles in making

Vision Zero concerns for all through mainstreaming strategies [23] as stated in the next paragraph.

One potential improvement could be enhancing collection of data on workplace incidents injuries, and workplace diseases, and conducting root cause analyses for every work related fatality or damage. In the second place, it is important to establish a multilateral working group on Vision Zero and develop focused information, operations, and tools to enhance awareness. The third strategy could be supporting the Senior Labour Inspectors Committee (SLIC) to strengthen consciousness on minimizing workplace fatalities in organization wise in order to share positive exercise, and increasing support for intensification of training for labor the inspectors. A proactive approach is one that eliminates the death of employees at the workplace.

This section has strived to develop a model that focuses on reducing workplace injuries and fatalities while enhancing the proactive efforts of implementers. The model specifically emphasizes the symmetry of input to impact process in achieving these goals, with Vision Zero as the guiding principle (Fig. 3). The model includes different factors to be considered in the implementation procedure of the conceptual developed model.

The input: The input is the Vision Zero driving forces, which include organization employees, who are the big and central keys concerned with the reduction of accidents and injuries. On the other hand, the industry’s top management serves as the responsible party, implementing and practicing mechanisms for accident and injury prevention. The top management needs to be concerned about the facilitation and enforcement of safety rules. As an input, the third role player is the government in building policy and enforcing intervention methods to control hazardous work environments in the manufacturing industries. The government is the body that has the capability of implementing systems of safety, health, and wellbeing improvement approaches.

The system: The process of transforming inputs to effectively reduce workplace accidents and injuries is a vital component of the Vision-Zero success method. It necessitates thorough attention and implementation within the industry’s processes. The process of controlling, detecting, and preventing accidents, injuries, diseases and deaths begins with the successful implementation of preventive interventions and controls. This section discusses methods of hazard identification. Hazard identification must be the target of the industry to consider near misses. Identifying the hazards and risks helps the industry to control the hazards. The other important process here is conducting research on the safety, health, wellbeing, and productivity of the organization. This research movement assists the industry in identifying the underlying problems, improvement mechanisms, and strategies required to create Vision Zero environments.

The transformation stage also shows us that the provision of protective equipment to employees and follow-up employees must be given proactive protective equipment before accidents, hazards, diseases, and injuries are detected at the workplace. The preparation of leading indicators and proactive measures through guidelines or manuals must also be developed at this stage. The available manuals and policy guidelines are very important for the protection of the employee’s safety and the organization’s equipment. The safety manual must be followed and controlled, whether it is properly implemented by the employees or not. Action plan preparation and reporting system development are the two activities that need to be developed here.

In general terms, the success of a VZ approach relies on several crucial factors. These factors include having sufficient financial resources, providing comprehensive OSH training and development, ensuring continuous involvement of stakeholders, empowering both leadership and workers, streamlining system and work procedures for ease of use, implementing effective planning processes, and maintaining compliance with rules and regulations. Additionally, linking protective OSH system processes, integration of OSH system, identification of risk and hazard analysis, workflow re-engineering, use of PPE, benchmarking performance of OSH, consultants usage, communicating OSH properly, OSH policies & standards, best practices of OSH and culture of safety, and user friendly in the choice of OSH system involvement are very important leading factors to transform the Vision Zero into reality.

The Output: The output of the process in this strategic conceptual model is designated as Vision Zero finding and result, which is the result of the previous process. The Vision Zero process result puts properly policy in the hands of the organization, which leads the process effectively. Provision of the training related to Vision Zero accidents and injuries is the output. One of the outputs is that employees’ awareness levels have increased regarding proactive and leading indicators of OSH. Committed top management toward Vision Zero is recorded as output. Workplace innovation and improvement are the result of the preceding occurrences and their implementation. If the processes fail to achieve what are planned, it takes the system back to continual improvement of the foregoing

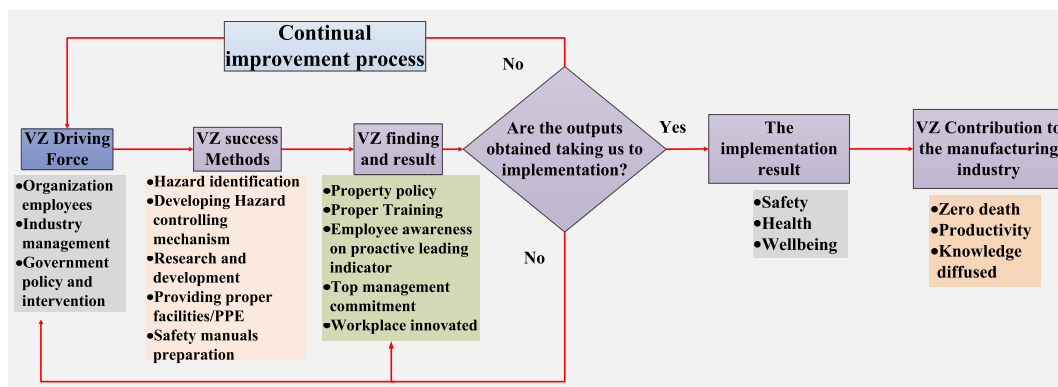


Fig. 3. Vision Zero success strategic conceptual models.

processes and activities of the manufacturing industries. Once the output process is correctly executed, as indicated in Fig. 3, the system directs the implementers to carry out the results to observe the status of safety, health, well-being, and productivity improvements. This implementation results in the creation of an impact on the industrial workplace through a zero-death record, high productivity, and proper knowledge diffusion to the whole system at the workplace.

In general, the important Vision Zero implementation strategies indicated by the study of Bernard Mabika [45] are important elements of this model as additional tool.

The seven golden rules for Vision Zero by ISSA [29], ISSA [23] and ISSA [46] are important for the success of the conceptual model indicated under Fig. 3. These rules and principles include identifying hazards and controlling risks, demonstrating leadership commitment, setting targets to develop programs, establishing a well-organized and safe system, ascertaining health & safety of machines, workplaces & equipment, enhancing experiences to advance capability, and financing in people to encourage in work involvement. The VZ process shall follow the commitments mentioned so that to attain the objectives of the strategy.

4.4. Vision Zero implementation strategy

The strategy that is useful to implement the conceptual model developed in the last section (Fig. 3) is crucial for the implementers and actors in the prevention of workplace accidents and injuries. Prior to the accidents control, the hazard energy is converted to death or serious injury. Implementing a real strategy is a crucial element of achieving organizational accomplishment and can serve as a potential source of viable advantage, even though several studies lack an implementation framework for proactive hazard control [47]. The essential steps are indicated in Fig. 4 involving implementation of VZ model concept.

The first step for the implementers is to define industrial goals and how to eliminate accidents along the way. The second step is to conduct appropriate research on the causes and solutions to accidents and injuries. This step helps to investigate the root causes of accidents, injuries, sources, and consequences of the hazards after an analysis of the industrial employees and overall system. The third procedure of the implementation is to map out any risks that will occur or have occurred in the industrial system. The fourth procedure to be followed is to schedule all milestones involved in Vision Zero accident protection in the industrial sectors. The fifth step and procedure for implementing the model is to assign tasks to individuals and teams in order to give responsibility to the implementers. The last procedure of implementation is to allocate helpful resources to reduce accident occurrences in the industrial sectors. The implementation of the Vision Zero model can follow a gear system approach that encompasses three core areas. These core areas include complementary goals, strategic actions, and transformative alignment with the Vision Zero principle. These factors are crucial in successfully completing the implementation process. Transformative policies at the core level serve as the driving force behind the establishment of complementary goals. They reinforce the presence and significance of these goals, ensuring their existence and implementation. The existence of the goal drives the strategic action placement to control the hazards and accidents at the workplace. Ensuring safety in the manufacturing process is of utmost importance so as to minimize or eliminate the risks of illnesses, worksite injuries, and even fatalities. Employees' confidence and effectiveness improve where there is a safe processing workplace. Unsafe workplaces and working equipment led employees to receive risk energy that adds costs to running facilities, degrades morale and efficiency, and thereby hammers organization productivity. Creating an effective safe manufacturing process involves fostering 100% participation of employees and ensuring that each individual takes responsibility for maintaining a safe working environment [29]. Vision Zero requires the application of the following major steps:

- ✓ Priority of Equity: Equity is not merely a desired outcome of VZ; it is an essential aspect that permeates every facet of Vision Zero planning and implementation. To achieve this, it is crucial to adopt equitable strategies that prioritize safety and health improvements in historically underserved areas. Specifically, in the context of accidents and injuries within the metal manufacturing industry, robust engagement strategies should be developed to reach and support those who are most vulnerable.
- ✓ A robust Data Framework Building: V) is an approach driven by data, where the gathering, analysis, utilization, and sharing of various forms of information are fundamental to its success. This includes formal data on injuries, accidents, near misses, errors, PPE, as well as input from the industrial community to understand workplace safety priorities. Despite its promise as an approach developed within industry, the concept of Zero Accident Vision has received limited attention from the safety science research community, as indicated in a study [48].
- ✓ Create Multi-stakeholder a VZ Task Force that brings together representatives from various backgrounds, including public health experts, policymakers in the industrial sector, leaders from different industries, members of the community, and advocates. In today's interconnected world, the importance of establishing collaborative partnerships among multiple stakeholders to tackle complex challenges in the realm of SHW is increasing [49]. Collaborating effectively and addressing the complexities of SHW



Fig. 4. Procedures and steps to implement vision zero model.

necessitates establishing common ground among stakeholders and equipping them with the necessary principles and techniques to understand and control their areas of interest. This tells us that the Vision Zero VZ mission cannot be achieved by isolation and a single responsible body.

- ✓ **Set Measurable Goals with timeline:** To ensure effective implementation of employee safety prevention measures, it is essential to establish measurable goals with clear timelines. By setting specific short-term and mid-term objectives, and assigning ownership to relevant government agencies and industry leaders, a well-defined framework can be created. This framework not only facilitates evaluation and funding but also promotes buy-in, accountability, and transparency throughout the entire implementation process.
- ✓ **Shoulder Accountability:** VZ is based on the belief that both system designers and policymakers have a joint responsibility to create and maintain safe systems for industrial operations. It emphasizes the need for a clear and defined ownership of action plan strategies, which is crucial for attaining success and ensuring the long-term integration of VZ principles and outcomes [29].
- ✓ **Transparency Ensuring:** Transparency is a vital aspect of the Vision Zero process, encompassing the establishment of baseline data, formulation of the action plan, and evaluation of progress towards the zero incidents objective. It is essential to involve key stakeholders and the wider industrial community in this process, ensuring that they have access to information and insights about the steps being taken. This transparency fosters trust, facilitates collaboration, and encourages collective responsibility in achieving the shared objective of eliminating incidents and promoting a safer industrial environment.
- ✓ **Utilize impactful Education Strategies:** Education is a very important matter that every industry should practice on safety and health prevention rather than curing injuries. It should include educating industrial safety and health policymakers, decision makers, top managers, and there are several other influencers who may take the crucial responsibilities in emphasizing the significance of VZ and promoting effective strategies to bring about significant change. Developing a VZ training manual and sharing it with key stakeholders is an essential requirement [29]. Based on the VZ training manual, provide training to employees and the industrial community as a whole.

In general, to attain VZ implementation, the manufacturing industries must follow the implementation model. The VZ success process needs to develop implementation procedures. The steps followed to control the hazards prior to their occurrences should focus on the following key processes.

- ✓ **Hazard Identification:** The initial step in addressing VZ is SHW, the elimination of fatalities, and productivity enhancement in the production or process is to identify the sources of harms. Industrial employees need to identify the causes of accidents, injuries, near misses, deaths, and loss of productivity in their industries.

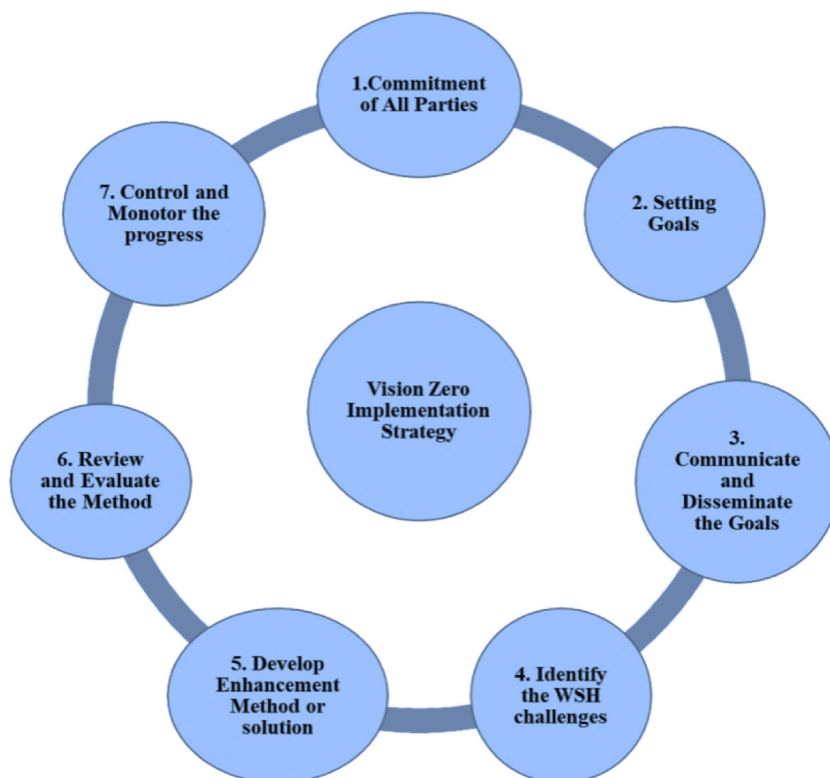


Fig. 5. Vision Zero implementation procedures.

- ✓ Hazard Controls: Once the sources of hazards and accidents are known, the mechanism of the hazard control is implemented. Many issues tend to be resolved at the training or audit level, but a more thorough and comprehensive analysis would often result in better resolutions for hazards. This could be one of the many methods to control injury, hazard, and death occurrences.
- ✓ Proper Guarding: Examples of equipment that need protection from hazard cause include chains and gears, turning rolls, conveyors, belts and pulleys, presses, and similar machinery. Ensuring the guard is securely installed and not easily removable is of utmost importance. This must be checked by the supervisors and controllers of safety issues.
- ✓ Environmentally caused Hazards: Access to the manufacturing industry process area should be granted while considering the presence of biological, chemical, and physical hazards. Environmental hazards, accidents, injuries, and death causes must be identified.
- ✓ Personal Protection Equipment (PPE): PE for a task may include various items such as hearing protection, eye protection, task-specific gloves, appropriate protective clothing, and respiratory protection, as needed. The selection and use of appropriate PPE depend on the specific hazards present in the workplace. Proper training, maintenance, and regular inspection of PPE are essential to ensure its effectiveness in providing adequate protection to workers.
- ✓ Safety Training: Industrial workplaces and manufacturing processes are prone to accidents and injuries. The workplace safety issue is very crucial to include in all manufacturing industry training. So far, Vision Zero has not been included in the workplace safety training.

The Vision Zero implementation model has seven implementation procedural and application elements. The first Vision Zero implementation contains the commitment of all parties to workplace safety control. A second implementation step follows to set a goal or objectives for zero visibility. The third implementation procedure is to communicate and disseminate the goal as an output. The fourth implementation of the workplace accident and injury policy is to identify Workplace Safety and Health (WSH) challenges and problems in addition to productivity. The fifth implementation method and procedure are to develop an improvement solution. The last step we may follow to bring Vision Zero to truth is to review and monitor the progress of the model. A conceptual model implementation strategy to be followed by the Vision Zero model is introduced in [Fig. 5](#).

5. Conclusion

In general, this research deals with to investigate the situation of industrial workplace health and safety focusing on its importance for manufacturing industries. The implementation of Vision Zero has not been exercised in many manufacturing industries other than road safety, which has been discussed more in studies and is gradually mainstreaming. However, the vision zero principle has not been given due consideration for industrial workplace safety improvement; it requires more prompting from top management and practitioners. Vision Zero is the principle that focuses on the minimizer, or making accidents, injuries, and deaths to zero. Based on its principles, this study has analyzed the current situation of Vision Zero in the manufacturing industry and tried to show a new insight. The study has developed a conceptual model that provokes vision zero in the manufacturing industry's workplaces. This conceptual model included a missed variable that undermined the implementation and practice of Vision Zero and resulted in less due consideration by manufacturing industry management. The prior study included three pillars, which are safety, health, and wellbeing (SHW), whereas this study included one variable as additional element, which is productivity to make the model complete (SHWP). The concept has been supported by the implementation procedures and steps so that implementers will have a clue on how to work with the conceptual framework, which is a guiding role player. The study recommends that the implementers of this Vision Zero framework in the industrial manufacturing workplace implement it through the creation of awareness and the involvement of all the employees of the industries.

Ethics declarations

Review and/or approval by an ethics committee were not necessary for this study as it does not involve any animal or human-related research. Therefore, obtaining informed consent from participants was not required for this study.

Financial support

This research was conducted without any financial support from external organizations.

Data availability statement

This study did not include the interview responses from industry top management, as those interviews were solely used to validate the managers' understanding of Vision Zero concepts. The primary objective of this study was to develop a new model related to Vision Zero depending on basic research concept. Since the interview data was not particularly relevant to public sharing, it has not been included in the publication. Generally speaking, data sharing and availability are more suitable when the purpose is to support software-based analysis and algorithm development. In this case, the qualitative interview responses served for an internal purpose for model development rather than public dissemination of the information gathered. Hence, data included in article/supplementary material/referenced in article.

Any additional information

Unfortunately, there is no further information accessible regarding this specific paper at this time. This means, no additional details or relevant data are currently available to provide.

CRedit authorship contribution statement

Kassu Jilcha: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The author declare that I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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