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Antecedents of Safety and Health in the Workplace: Sustainable Approaches to Welding Operations

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Abstract: Assessing the occupational health and safety (OHS) factors in the welding process is necessary to determine the workers' perception of what contributes to their safety and health in the workplace. This would provide insight for stakeholders to aid them in their occupational safety and health programs. The non-probability sample technique utilized in this study is purposive sampling using an online survey. Welders in Singapore are the intended participants. The self-administered online survey was conducted using Google Forms. The hypothesis test's beta coefficient and R^2 results were used to evaluate the model using partial least squares structural equation modeling (PLS-SEM). The study's results revealed that safety culture has the highest association with top management attitudes toward safety and health in the workplace. Similarly, safety training was also found to have a strong association with employees' attitudes towards safety. Finally, factors such as compliance with safe working conditions, safety programs, and the absence of and lack of exposure to harmful agents were also proven to have a significant association with safety and health in the workplace. This study benefits not only those businesses conducting the welding process but also employees to better understand the factors contributing to their overall safety at work.

Keywords: OHS factors; PLS-SEM; welding process

Citation: Belmoro, B.J.B.; Gumasing, M.J. Antecedents of Safety and Health in the Workplace: Sustainable Approaches to Welding Operations. *Sustainability* **2023**, *15*, 14641. https://doi.org/10.3390/su151914641

Academic Editor: Paulo Santos

Received: 15 August 2023
Revised: 14 September 2023
Accepted: 25 September 2023
Published: 9 October 2023

1. Introduction

Ensuring that employees have a safe and healthy workplace is tantamount to ensuring a profitable business for employers. Regardless of the size of a company, be it a big multinational corporation or a small medium enterprise, the human resource is a business's most important asset [1]. Thus, implementing programs to look after the employees' welfare at work should be part of the top management's priorities. In addition to enterprises' efforts towards a healthy workplace for its people, several countries have laws that aim to provide a better workplace for everyone [2].

In the report released in 2022 by the Ministry of Manpower in Singapore, manufacturing has the greatest number of occupational major injuries among the industries in the country [3]. The manufacturing sector is composed of different businesses which conduct a variety of jobs such as machining, packing, painting, and welding. Although a number of previous studies have been conducted on the safety factors in the manufacturing industry, there is a research gap on specific processes such as welding.

Welding, according to the American Welding Society [4], is a fabrication process used to join materials, typically metals or thermoplastics, by melting their edges and fusing them together. This process is widely used in various industries, including manufacturing, construction, automotive, aerospace, and more. While welding is essential for creating strong and durable structures, it also presents several safety risks to workers [5].

The demands for fabricated products that involve these processes will continue to grow; therefore, this increases the risk of workplace injuries in the future, which makes it

imperative to conduct a study highlighting the different factors that are deemed relevant in ensuring the safety and health of workers in the welding process. To aid in building a solid foundation for this study, a review of the related literature was conducted by the authors.

A paper published by Quintino et al. [6] also delves into the occupational safety and health issues specific to the welding environment. It emphasizes the importance of risk assessment, hazard control measures, and the role of safety management systems in preventing accidents. Key findings highlight the need for effective hazard communication and monitoring of exposure levels to protect workers [6]. The American Conference of Governmental Industrial Hygienists (ACGIH) [7] also discusses the health effects of welding processes and provides exposure limits for various welding fumes and gases. Key findings include the recognition of respiratory hazards associated with welding, such as exposure to metal fumes and gases like manganese and hexavalent chromium, which can lead to lung diseases [7].

Another publication from the International Institute of Welding (IIW) [8] emphasizes the importance of occupational health and safety in welding. It covers topics such as risk assessment, protective measures, and health surveillance for welders. Key findings include recommendations for the use of local exhaust ventilation systems and the importance of regular health check-ups for welders to monitor their lung function [8].

Occupational Safety and Health Administration (OSHA) [9] also provides safety guidelines for welding, cutting, and brazing operations. Key findings stress the necessity of proper training, hazard identification, and the use of appropriate protective equipment to prevent injuries related to welding and cutting activities.

Through the review of the literature, there is a potential area to be explored which hasn't been touched by the previous studies. While numerous studies have focused on the physical health risks associated with welding, less attention has been given to the psychological and social aspects that can impact the well-being of welders. The welding profession can be physically demanding and is often conducted in challenging work environments. Welders may face various workplace factors that can affect their overall safety and health. Understanding and addressing these factors is crucial for creating comprehensive safety and health interventions for welders. Addressing these aspects of welding work can contribute to a more holistic understanding of the factors influencing the overall safety and health of welders. Such research can lead to the development of targeted interventions, policies, and workplace improvements that enhance both the physical and mental well-being of welders in their challenging profession.

This study is seen to be useful not only to those businesses conducting welding processes but also for employees to better understand the factors that contribute to their overall safety at work. With this information, employees will be more committed to doing their part in the programs set by the top management.

2. Conceptual Framework

The conceptual framework of this study shows the different variables which were part of the data gathering as shown in Figure 1.

Exposure to harmful substances can have a direct impact on workplace safety and health. Workers in industries that involve exposure to harmful substances, such as welding, are at risk of developing health problems ranging from respiratory issues to cancer and other chronic illnesses [10]. Welding involves heating and melting metals, which can release harmful substances into the air, such as metal fumes, gases, and dust [11]. Several studies have shown that the presence of harmful agents in the welding process such as welding fumes and dust have short-term and long-term effects on the health and safety of workers directly involved in this process [12]. According to the National Institute for Occupational Safety and Health [10], exposure to harmful substances can have significant effects on workplace safety and health. Furthermore, exposure to harmful substances can also increase the risk of workplace accidents and injuries. Thus, the effects of exposure

to harmful substances are critical for maintaining worker safety and health. With these findings, the following was hypothesized:

H1: *The absence and lack of exposure to harmful agents has a significant and direct effect on workplace safety and health.*

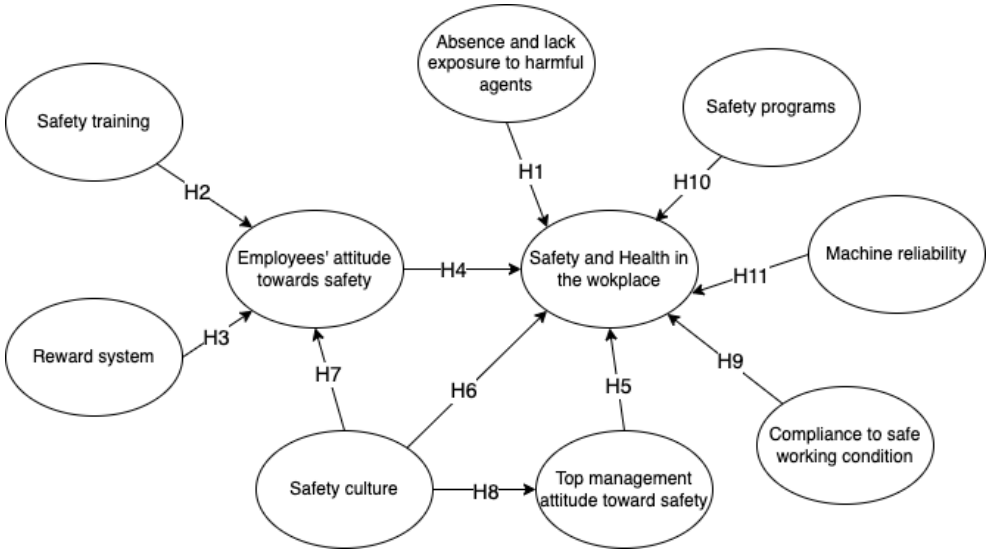

Figure 1. Theoretical framework of the study.

Employee attitude towards safety refers to the beliefs, feelings, and behaviors of employees in relation to their own safety and the safety of others in the workplace [13]. It includes their overall commitment and diligence to safety and health management in the workplace [14]. According to Vinodkumar and Bhasi [15], an employee's attitude towards safety is influenced by factors such as the implementation of safety training and presence of a rewards system. In a study by Aziz and Ozman [16], which assessed the effectiveness of safety training in the implementation of occupational safety and health in Malaysia, it was concluded that mandatory safety training indeed affects the attitude of Malaysian employees towards occupational safety and health. In addition, employee rewards and additional compensation benefits encourage responsible behavior and positive attitudes towards the different programs of the company including OHS [17]. A study by Liao et al. [18] states that reward systems can play an important role in shaping employee attitudes towards safety. In addition, Clarke [19] proved that well-designed reward systems can reinforce safe behaviors and encourage employees to take an active role in maintaining a safe work environment. With this information, the following was hypothesized:

H2: *Safety training has a significant and direct effect on the employee's attitude towards safety.*

H3: *Rewards systems have a significant and direct effect on the employee's attitude towards safety.*

A positive employee attitude towards safety is essential for maintaining a safe work environment. Employees with a positive attitude towards safety are more likely to follow safety protocols, identify potential hazards, and take proactive steps to prevent accidents and injuries [20]. Employee attitude towards safety is an important aspect of safety management in the workplace [21]. A review of related literature reveals several factors that influence employee attitudes towards safety, including safety climate, safety leadership, safety communication, safety training, and organizational culture [13,22]. In addition, according to Singh and Misra [23], employees construct a positive attitude towards safety in their workplace through compliance with safety standards and procedures. In the study conducted by the Institute for Labour and Family Research in Slovakia, it was revealed

that the employees aspire to a safe and healthy workplace; thus, they have a positive attitude toward programs with regards to safety [24]. With this information, the following was hypothesized:

H4: *Employee's attitudes towards safety have a significant and direct effect on workplace safety and health.*

The attitude of top management towards safety is also critical in creating a culture of safety within an organization [25]. According to [26], management commitment and support for safety were significant predictors of safety behavior and safety climate in the workplace. In a study by Neal et al. [13], it was found that employee perceptions of top management commitment to safety were associated with safety compliance and safety participation behaviors. A study by Glendon and Stanton [27] also emphasized the importance of senior managers as role models for safety behavior and the need for a proactive approach to safety management. With this information, the following was hypothesized:

H5: *Top management's attitude towards safety has a significant and direct effect on workplace safety and health.*

Safety culture is defined as the organization's regard towards safety [28], and how a company commits to ensuring a safe and healthy workplace for its stakeholders has an effect on an employee's mindset towards safety. According to Zwetsloot et al. [29], the established safety culture of a company has a connection with the company's performance with regards to its safe management system as well as how seriously they comply with the government-mandated policies on safety. A study by Zou [30] states that a strong safety culture is essential for creating a safe working environment and improving the compliance of a company with safety regulations. In addition, Saleem et al. [26] mentioned that safety culture helps employees understand the importance of safety and its impact on their work and personal lives. This awareness makes them more likely to comply with safety regulations. With this information, the following was hypothesized:

H6: *Company's safety culture has a significant and direct effect on the safety and health of the company.*

Safety culture refers to the shared values, attitudes, beliefs, and behaviors of employees related to safety within an organization. According to Haddad and Pardo-del-Val [31], the impact of safety culture on employees' attitudes towards safety is significant. A strong safety culture can lead to a more positive attitude towards safety among employees, which can result in increased compliance with safety policies and procedures and a lower incidence of accidents and injuries. According to [32], when employees feel that their organization values safety and prioritizes it as an integral part of their work, they are more likely to embrace safety as a core value and take personal responsibility for their own safety and the safety of others. With this information, the following was hypothesized:

H7: *Company's safety culture has a significant and direct effect on an employee's attitudes towards safety procedures.*

The impact of safety culture extends beyond the employees and can also have a significant impact on the top management of a company [33]. A positive safety culture can lead to improved safety performance, increased employee satisfaction, and reduced costs associated with accidents and injuries, which can ultimately benefit the company's top management [34]. In a study by Kaila [35] on the relationship between top management's support towards safety and its safety culture, it was found that 80% of the subjects across different Indian locations showed a lack of will from the top management which caused

poor safety culture as well as business instability. With this information, the following was hypothesized:

H8: *Company's safety culture has a significant and direct effect on the top management's attitude towards safety.*

Compliance with safe working procedures is an important aspect of ensuring workplace safety and health [36]. According to Santos et al. [37], compliance with safe working procedures helps to prevent accidents, injuries, and illnesses and ensures that work is performed in a safe and effective manner. A study by Colligan and Cohen [38] states that compliance with safe working procedures is critical to ensuring workplace safety and health. The United States Department of Labor has recommended workplace practices to achieve a company's objective of having a safe and healthy workplace for its workers. Moreover, these practices also aid organizations in preventing injuries, enhancing productivity, minimizing costs due to accidents, and improving compliance with mandated policies [10]. Thus, by identifying and mitigating potential hazards, protecting workers' health, and complying with regulations, compliance with safe working procedures can have a direct and positive impact on the safety, health, and productivity of workers [13]. With this information, the following was hypothesized:

H9: *Compliance with safe working procedures has a significant and direct effect on workplace safety and health.*

The role of safety programs being implemented in a company is not only to ensure that workers are safe but also to prevent financial suffering to employers caused by workplace accidents and injuries. This shows that having a relevant safety program is necessary to achieve the overall objective of the business, be it quality or safety. According to Kaminski [39], safety programs have a significant impact on workplace safety. When implemented effectively, safety programs can help to reduce the number of accidents and injuries in the workplace, improve employee morale and productivity, and minimize the costs associated with workplace accidents and injuries. With this information, the following was hypothesized:

H10: *Safety programs being implemented by a company have a significant and direct effect on workplace safety and health.*

Machine reliability is essential for ensuring safety in the workplace [40]. Machines that are not reliable can break down unexpectedly, malfunction, or cause accidents, leading to injuries, fatalities, and damage to equipment and property [41]. A study by Zhang et al. [42] examined the impact of machine reliability on safety in the mining industry and found that machine reliability was positively associated with safety performance and that improving machine reliability can lead to a reduction in workplace accidents [41]. Li and Liang [43] also found a significant relationship between machinery reliability and safety performance. The authors suggest that investing in machinery reliability and safety can lead to improved manufacturing performance. In addition, a study by Liu et al. [44] highlighted the importance of reliable equipment in preventing workplace accidents and injuries and suggested that equipment maintenance and inspection should be a key component of safety programs. In an article discussing the relationship between equipment reliability and workplace safety, it was mentioned that an occupational safety and health program that is centered on protecting the company's assets, which are people and machinery, ensures that both safety objectives and productivity objectives are achieved [45]. With this information, the following was hypothesized:

H11: *Reliability of equipment and machines has a significant and direct effect on workplace safety and health.*

3. Methodology

3.1. Participants

The study utilized purposive sampling in selecting the participants who took part in the survey which was conducted on 18 April to 28 May 2023. The authors employed a systematic approach to recruit participants in the welding division and distribute questionnaires. These target respondents were project engineers, production managers, welding inspectors or supervisors, and welders, among others. The authors initiated the participant recruitment process by leveraging multiple strategies to ensure a diverse and representative sample of workers in the welding operations. The researchers have reached out to several key sources, including welding schools, welding industry associations, and local welding companies. This multi-pronged approach was aimed at encompassing welders from various backgrounds, skill levels, and work settings. Based on standard procedures, the questionnaires were sent via e-mail with a link to the Google Form to the selected participants, accompanied by an introductory letter explaining the purpose of the study, assuring confidentiality, and providing instructions on completing the questionnaire. The survey questionnaires were distributed to 400 respondents who were based in Singapore and who were directly involved in the welding process in their respective companies. However, only 309 participants responded to the study, resulting in a response rate of 77%. Additionally, a pilot test was conducted to ensure that the questionnaire was well-understood by participants. This pilot testing involved a small group of welders who provided feedback on the clarity, relevance, and comprehensibility of the questionnaire items.

3.2. Instruments

There were 45 questions in the survey. In the first component of the questionnaire, five item questions covering the respondent's age, gender, civil status, employment status, and length of employment were used to ascertain their demographics. The information about the distribution of the chosen respondents was revealed by the data gathered from this part.

The indicators based on the proposed framework comprised the second section of the questionnaire. This measured workers' assessment of workplace safety and health. The survey item questions and responses ranged from "strongly disagree" to "strongly agree" on a five-point Likert scale. Nine (9) latent variables were used in the survey which included the (1) presence and exposure to harmful substances, (2) safety training, (3) reward system, (4) employee attitude, (5) top management attitude, (6) safety culture, (7) safety program, (8) reliability of equipment and machines, and (9) compliance with safe working conditions. The summary of measures and constructs is shown in Table 1. The items for the constructs were adopted from existing studies.

Table 1. Summary of items and constructs.

Variable	Items	Measure	Supporting Reference
Lack of exposure and absence of harmful substance	EX1	I am not exposed to metal fumes.	[46–48]
	EX2	I am not exposed to harmful gases	
	EX3	I am not exposed to unsafe hot work processes.	
	EX4	I am not exposed to harmful dust.	
	EX5	I am not exposed to ultraviolet (UV) radiation.	

Table 1. *Cont.*

Variable	Items	Measure	Supporting Reference
Safety training	ST1	I am provided with safety training which contributes to ensuring I am safe and healthy.	[46–48]
	ST2	I am provided with safety training which shapes how I regard safety and health.	
	ST3	Safety training provided to me is adequate.	
	ST4	My commitment to safety and health is not compromised because of the safety training provided by the company.	
	ST5	Safety training provided to me is relevant in ensuring a safe and healthy workplace for me.	
Reward system	RS1	The reward given by the company for positive contribution to safety is adequate.	
	RS2	I am motivated to ensure that the workplace is safe and healthy because of the reward.	
	RS3	Commitment to safety and health has been instilled in me because of the reward system.	
	RS4	It is necessary for my company to compensate my performance with regards to safety.	
	RS5	I tend to remember the need to be safe at work more because of rewards and incentives.	
Employee attitude	EA1	I have a positive attitude towards safety.	
	EA2	I like to participate in programs related to safety and health.	
	EA3	I like to be informed by the management with updates regarding safety and health.	
	EA4	I am willing to volunteer my time and effort to ensure that our workplace is safe for everyone.	
	EA5	I am interested in anything about safety and health.	
Top management attitude	TM1	Our top management is committed to providing a safe and healthy workplace for their employees.	
	TM2	Our top management put high regard to safety more than anything else.	
	TM3	Our top management prioritizes its employees' overall safety through its program.	
	TM4	Our top management influences everyone in the workplace to have a positive attitude towards safety.	
	TM5	Our top management encourages us to work safely.	
Safety culture	SC1	The shared beliefs of the company regarding safety have positively affected our attitude towards safety and health in workplace.	
	SC2	The shared beliefs of the company regarding safety have positively affected the attitude of the top management towards safety and health in workplace.	
	SC3	I am confident that my safety is the top priority of the company because of its shared beliefs regarding safety.	
	SC4	Safety culture in the company aids in avoiding accidents and near misses in our workplace.	
	SC5	Our company's safety performance is the result of our company's safety culture.	

Table 1. *Cont.*

Variable	Items	Measure	Supporting Reference
Safety program	SP1	There are safety programs being implemented in the company.	[46–48]
	SP2	The safety programs in our company ensure the general safety and health of everyone in the workplace.	
	SP3	Without safety programs in our company, it will be difficult to achieve our goal of having a safe and healthy workplace.	
	SP4	The safety programs in the company provide information on risky situations, therefore decreasing the likelihood of accidents.	
	SP5	The presence of safety programs in the company is relevant and effective.	
Reliable equipment and machines	RE1	Machines and equipment that we are using in the company are reliable and safe.	
	RE2	Machines that are faulty are tagged properly to avoid any accidents.	
	RE3	Proper machine guards are installed to ensure the safety of operators.	
	RE4	Ensuring that machines and equipment in the company are working properly contributes to the overall safety and health of workplace.	
	RE5	The importance of maintaining a reliable machine is part of our company's safety program.	
Compliance with safe working conditions	CS1	Our company sees to it that safe working conditions are provided to its employees.	
	CS2	My company complies with safe working conditions stipulated by authorities.	
	CS3	My company doesn't have any problem following the prescribed safe working conditions with its employees.	
	CS4	My company hasn't infringed on any recommended safe working conditions.	
	CS5	Our safety policy adheres to strict compliance with safe working conditions.	
Safety and health in the workplace	SH1	I am working in a safe and healthy workplace.	
	SH2	I am working in a workplace where safety is the top priority.	
	SH3	Since joining, there are no major accidents and/or fatalities in the workplace that I am part of.	
	SH4	Our company hasn't been penalized by authorities due to safety violations.	
	SH5	Our company has received recognition because of our safety performance.	

3.3. Structural Equation Modeling

Multivariate analysis was used to examine the survey data. The present study used a variance-based partial least squares structural equation model (PLS-SEM) with maximum likelihood estimation. PLS-SEM is a technique for researching how abstract concepts are related to one another [49]. It works well for prediction and is helpful in our research since it deals with complex constructs at higher levels of abstraction and yields greater construct reliability and validity. For instance, in a study by Ofori et al. [50] where the safety practices and performance in the oil and gas industry in Ghana were studied, the authors

utilized PLS-SEM to achieve the study's objective of recording the connection between safety training, safety knowledge, and safety compliance, as well as how these factors affect safety culture. Moreover, in another study where the objective was to assess safety at work by defining the employees' capability to follow safety regulations, the authors were aided by PLS-SEM combined with neuro-fuzzy inference system (ANFIS) method to analyze the data which were collected through survey questionnaires. PLS-SEM aims to account for variance in the dependent constructs.

4. Results

4.1. Profile of the Respondents

Among the 309 respondents who answered the survey, 64.08% were male, while 35.92% were female. As for the age bracket, the majority of the participants were 35 to 39 years old, which accounted for 42.72% of the respondents, followed by 30 to 34 years old at 36.89%, 40 to 44 years old at 11.65%, 25 to 29 years old at 4.85%, and 45 years old and above at 3.88%. Furthermore, 64.08% of the participants were married, while participants with a single status were 35.92%. Most of the respondents were welders, at 38.83%, followed by project engineers at 24.27%, project managers at 13.59%, welding supervisors at 7.77%, design engineers at 3.88%, production engineers and safety officers both at 2.91%, welding inspectors at 1.94%, and other job titles such as production manager, quality assurance manager, director, and proposal engineer at 3.88%. Lastly, 63.92% of the respondents worked for an average of more than 8 h but less than 12 h a day, 35.92% worked for an average of 8 h a day, and 0.97% worked for an average of less than 8 h a day.

4.2. Validity of the Results

Figure 2 shows the framework used in the study with the initial result of the SEM. This model illustrates the 10 constructs and the relationship of the different factors to the safety and health of the workplace in the welding process of workers in Singapore. A total of 11 hypotheses are shown in the model which were reflected in the questionnaire used in data gathering. Table 2, on the other hand, shows the results of the model's reliability, factor loading, and validity using Cronbach's alpha (α), composite reliability (CR), and average variance extracted (AVE). Some items, namely ST1, RS3, TM5, SC1, CS2, SP1, RE2, and SH2, have a factor loading value of less than 0.7 and were removed from the final model. As for the validity tests, constructs with a Cronbach's alpha value of more than 0.7, a composite value of more than 0.7, and an average variance extracted value of more than 0.5 are considered acceptable. With this, the initial results of the model as shown in Table 2 are valid and reliable.

Table 2. Reliability and convergent validity results.

Construct	Items	Mean	S.D.	FL (≥0.7)	α (≥0.7)	CR (≥0.7)	AVE (≥0.5)
Presence and exposure to harmful fumes (EX)	EX1	3.08	1.14	0.946	0.943	0.952	0.800
	EX2	3.48	0.93	0.915			
	EX3	3.62	0.93	0.826			
	EX4	3.20	0.96	0.861			
	EX5	3.26	1.10	0.920			
Safety training (ST)	ST1	4.25	0.46	-	0.771	0.806	0.689
	ST2	4.23	0.47	0.831			
	ST3	4.07	0.55	0.704			
	ST4	4.15	0.51	0.896			
	ST5	4.18	0.48	0.877			
Reward system (RS)	RS1	3.37	0.63	0.844	0.859	0.867	0.702
	RS2	3.32	0.70	0.846			
	RS3	3.20	0.78	-			
	RS4	3.35	0.79	0.817			
	RS5	3.27	0.76	0.844			

Table 2. *Cont.*

Construct	Items	Mean	S.D.	FL (≥0.7)	α (≥0.7)	CR (≥0.7)	AVE (≥0.5)
Employee attitude (EA)	EA1	4.20	0.50	0.702	0.845	0.855	0.618
	EA2	4.39	0.55	0.759			
	EA3	4.39	0.53	0.802			
	EA4	4.20	0.60	0.796			
	EA5	4.23	0.53	0.862			
Top management attitude (TM)	TM1	4.14	0.42	0.855	0.727	0.808	0.678
	TM2	3.83	0.69	0.858			
	TM3	3.93	0.49	0.835			
	TM4	4.09	0.42	0.790			
	TM5	4.17	0.40	-			
Safety culture (SC)	SC1	4.10	0.30	-	0.781	0.789	0.695
	SC2	4.07	0.43	0.858			
	SC3	4.04	0.42	0.845			
	SC4	4.18	0.44	0.813			
	SC5	4.08	0.36	0.828			
Compliance with safety (CS)	CS1	4.22	0.44	0.737	0.830	0.841	0.663
	CS2	4.17	0.44	-			
	CS3	4.15	0.41	0.883			
	CS4	4.16	0.44	0.786			
	CS5	4.10	0.36	0.843			
Safety programs (SP)	SP1	4.21	0.41	-	0.842	0.848	0.678
	SP2	4.16	0.36	0.797			
	SP3	4.16	0.41	0.800			
	SP4	4.17	0.42	0.879			
	SP5	4.18	0.41	0.815			
Machine reliability (RE)	RE1	4.09	0.35	0.822	0.784	0.832	0.606
	RE2	4.02	0.52	-			
	RE3	3.96	0.46	0.713			
	RE4	4.13	0.39	0.860			
	RE5	4.14	0.37	0.815			
Safety and health in the workplace (SH)	SH1	4.42	0.50	0.873	0.882	0.886	0.895
	SH2	4.09	0.70	-			
	SH3	4.35	0.52	0.941			
	SH4	4.31	0.49	0.951			
	SH5	3.32	0.74	0.879			

The discriminant validity of the constructs was tested using the Fornell–Larcker criterion and Heterotrait–Monotrait ratio, as shown in Tables 3 and 4. The need to assess the discriminant validity in a study that involves latent variables is necessary to ensure that the constructs used in the model are unique from one another [51]. In the Fornell–Larcker criterion, to be deemed valid, the square root of the average variance extracted (AVE) must be higher than the correlations between constructs [52]. With this, the results shown in Table 3 are acceptable. As for the use of the Heterotrait–Monotrait ratio, Molina-Castillo et al. [53] suggested the threshold to be below 0.85 for the results to be considered not lacking discriminant validity. As such, the values shown in Table 4 confirmed the validity of the constructs.

Table 3. Discriminant validity: Fornell–Larcker criterion.

	CS	EA	RE	EX	RS	SC	SH	SP	ST	TM
CS	0.814									
EA	0.650	0.786								
RE	0.626	0.650	0.778							
EA	0.622	0.626	0.681	0.948						
RS	0.592	0.622	0.690	0.770	0.838					
SC	0.663	0.592	0.707	0.560	0.768	0.834				
SH	0.581	0.663	0.729	0.648	0.638	0.766	0.946			
SP	0.745	0.581	0.648	0.674	0.594	0.675	0.766	0.823		
ST	0.631	0.627	0.562	0.713	0.560	0.623	0.675	0.827	0.830	
TM	0.543	0.562	0.626	0.677	0.634	0.712	0.623	0.604	0.821	0.823

Table 4. Discriminant validity: Heterotrait–Monotrait ratio.

	CS	EA	RE	EX	RS	SC	SH	SP	ST	TM
CS										
EA	0.677									
RE	0.481	0.425								
EA	0.624	0.377	0.230							
RS	0.541	0.648	0.434	0.349						
SC	0.449	0.379	0.306	0.286	0.704					
SH	0.303	0.537	0.348	0.695	0.345	0.304				
SP	0.681	0.387	0.670	0.308	0.443	0.354	0.480			
ST	0.680	0.122	0.432	0.650	0.427	0.443	0.559	0.324		
TM	0.580	0.135	0.433	0.390	0.626	0.327	0.691	0.397	0.207	

4.3. Hypothesis Test

Table 5 shows the results of the test performed to check the proposed hypotheses using Smart PLS v.3.4. Results show that top management's attitude towards safety ($\beta = 0.654$, $p < 0.001$), and safety and health in the workplace ($\beta = 0.606$, $p < 0.001$) were significantly influenced by safety culture. Other constructs that significantly influenced safety and health in the workplace were the presence and exposure to harmful agents ($\beta = 0.214$, $p = 0.002$), employees' attitude towards safety ($\beta = 0.311$, $p < 0.001$), top management's attitude towards safety ($\beta = 0.414$, $p < 0.001$), compliance with safe working conditions ($\beta = 0.286$, $p = 0.031$), and safety programs ($\beta = 0.314$, $p < 0.001$). Furthermore, the result also showed that employees' attitude towards safety was significantly influenced by safety training ($\beta = 0.437$, $p < 0.001$). Conversely, some of the hypotheses were rejected as they were found to have no significant relationship, such as a reward system ($\beta = 0.133$, $p = 0.199$) and safety culture ($\beta = 0.075$, $p < 0.527$), on employees' attitude towards safety and health in the workplace ($\beta = 0.117$, $p = 0.084$).

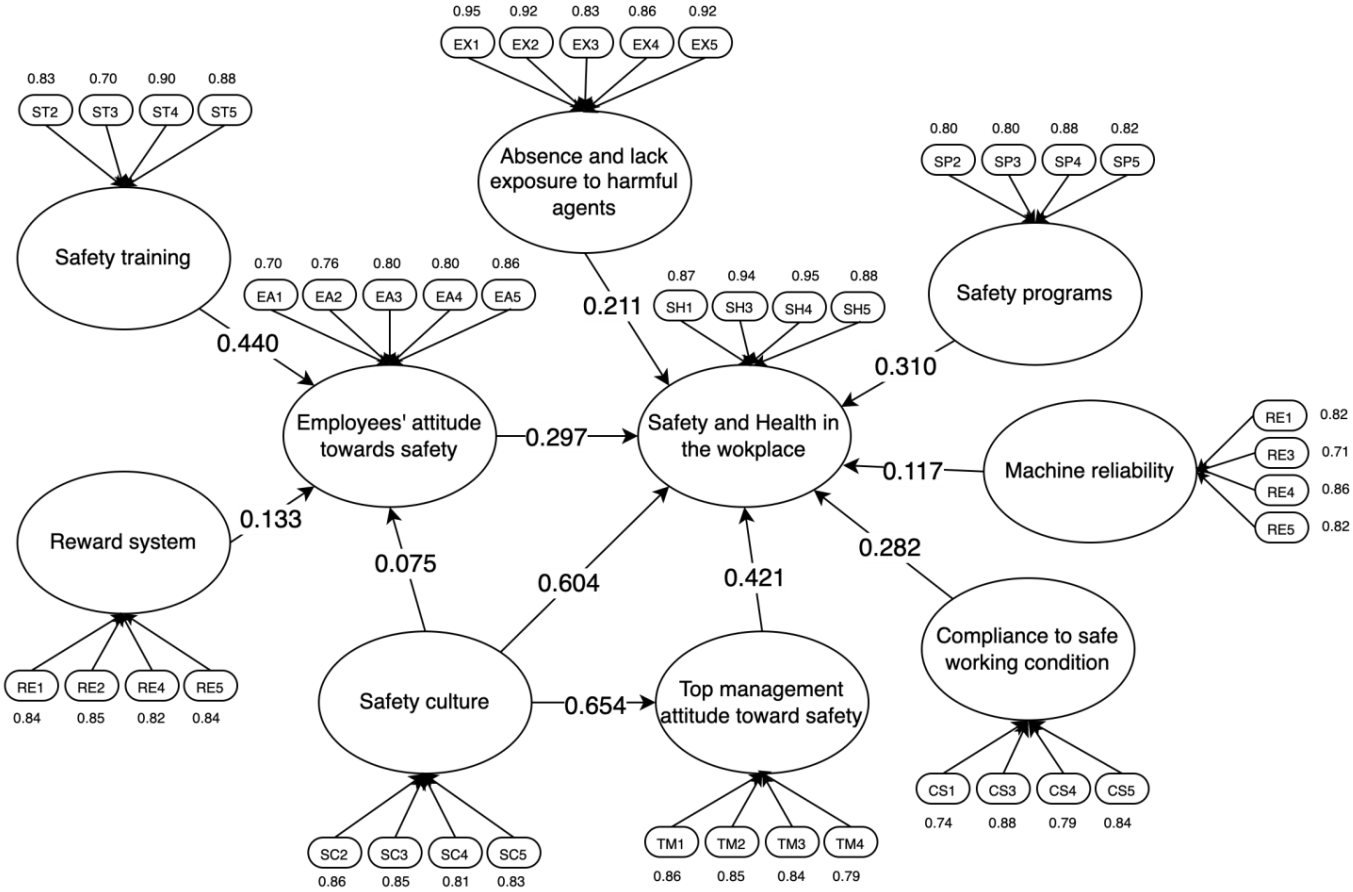

Figure 2. Initial SEM Model.

Table 5. Hypothesis test.

No	Relationship	Beta Coefficient	*p*-Value	Result	Significance	Hypothesis
1	EX→SH	0.214	0.002	Positive	Significant	Accept
2	ST→EA	0.437	<0.001	Positive	Significant	Accept
3	RS→EA	0.133	0.199	Positive	Not Significant	Reject
4	EA→SH	0.311	<0.001	Positive	Significant	Accept
5	TM→SH	0.414	<0.001	Positive	Significant	Accept
6	SC→SH	0.606	<0.001	Positive	Significant	Accept
7	SC→EA	0.075	0.527	Positive	Not Significant	Reject
8	SC→TM	0.654	<0.001	Positive	Significant	Accept
9	CS→SH	0.286	0.031	Positive	Significant	Accept
10	SP→SH	0.314	<0.001	Positive	Significant	Accept
11	RE→SH	0.117	0.084	Positive	Not significant	Reject

Figure 3 presents the final SEM model which includes the values of beta coefficient and R^2. The model assigns 54.6% to employees' attitude towards safety, 72.8% to safety and health in the workplace, and 34.4% to top management's attitude towards safety. As suggested by Hair et al., the acceptable value of R^2 depends on the context of the study [54]. Hence, for this study, an R^2 value of above 20% is acceptable.

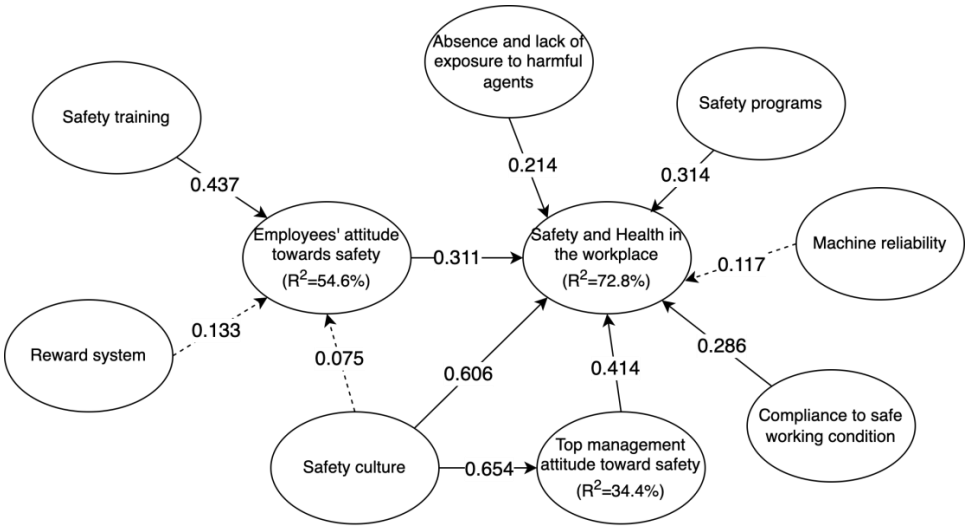

Figure 3. Final SEM model.

To validate the final model, model fit analysis was done as shown in Table 6. Adopting the tests used for goodness of fit from previous research, this study also utilized SRMR (<0.08), chi-square (<5.0), and NFI (>0.90) [55]. Table 6 shows that the value exceeded the minimum cut-off of each test, thus accepting the model as valid.

Table 6. Model fit.

Model Fit for SEM	Parameter Estimates	Minimum Cut-Off	Recommended by
SRMR	0.077	<0.08	[49]
(Adjusted) Chi-square/dF	3.93	<5.0	[49]
Normal Fit Index (NFI)	0.918	>0.90	[49]

5. Discussion

The continuous growth in demand for welded products from the manufacturing industry in Singapore requires all stakeholders to ensure that the safety and health of workers in the welding process are not being taken for granted. While there are previous studies assessing the different safety and health factors in the manufacturing industry, one that focuses on welding processes has not been explored. Thus, this study closed the gap by utilizing the methods discussed in the previous section.

Based on the results, safety culture (SC) has a direct influence on top management's attitude towards safety (TM) and on safety and health in the workplace (SH). This implies that the safety culture, which is based on the shared beliefs and behaviors of an organization and its employees, represents the overall approach and commitment to maintaining a safe working environment [56]. This finding is supported by prior safety studies that proved that leaders and top management who prioritize safety foster a sense of responsibility and accountability for safety and health across all levels of the organization [20]. According to a study [57], safety culture in the welding industry and other sectors significantly influences top management's attitude toward safety and has a direct impact on safety and health in the workplace. Acceptance of this hypothesis may have suggested that creating a safety culture is the sole responsibility of the top management, but it will require everyone's effort in the organization to establish a safety culture.

The study also proved that the presence and exposure to harmful agents (EX) is a significant factor and has a direct influence on safety and health in the workplace (SH). In the context of welding processes, the agents that pose a risk to a worker's well-being are metal fumes, hot works, gas, and UV radiation, among others. Previous studies have confirmed that being exposed to the welding process's common pollutants has a direct

effect on a welder's health and on a workplace's overall safety [58]. As it is deemed impossible to avoid these agents altogether in the welding process, one study suggested that the proper use of safety gear and personal protective equipment will somehow lessen the risk of being affected by these welding pollutants, health-wise [59]. Prior studies also recommend conducting thorough risk assessments and implementing appropriate control measures to minimize the exposure of employees to harmful substances [60]. Also, it is recommended to establish clear protocols for handling and storing toxic substances safely and monitor workplace conditions regularly to identify potential exposure risks [61]. With this, employers may foster a safer working environment by proactively monitoring and minimizing exposure risks.

Employees' attitude towards safety (EA) was also proven to directly influence safety and health in the workplace (SH). This means positive attitudes among employees can contribute to a safer and healthier work environment. According to Gebrezgiabher et al. [62], when employees have a positive attitude toward safety, they are more likely to adhere to safety protocols and guidelines. They are conscious of their responsibility for their own safety and the safety of their colleagues, leading to better compliance with safety procedures. This was also confirmed in a study by Choudhry et al. [20], wherein it was found that employee attitudes help to shape an organization's safety culture collectively. Thus, organizations can enhance their workplaces to be safer, more effective, and sustainable for their employees by fostering a positive attitude toward health and safety.

Compliance with safe working conditions is also a critical factor that proved to have a direct influence on the safety and health of employees within the welding industry. This implies that compliance with safe working conditions significantly reduces the risk of workplace injuries for welding operators. According to Azeez and Akinlabi [51], following safety protocols, wearing appropriate personal protective equipment (PPE), and adhering to safe work practices help prevent accidents and injuries in a welding operation. Zhou et al. [56] also mentioned that when employees and employers adhere to safety regulations, standards, and best practices, it leads to several positive effects on workplace health and safety.

The implementation of safety programs was also proven to have a direct and positive influence on the safety and health of welding operators in the workplace. It implies that safety programs that are designed to create a structured and proactive approach to workplace safety directly affect the well-being of welding operators. According to Alexander et al. [52], safety programs raise awareness among welding operators about the potential hazards they may encounter during their work. McSween [53] also stated that safety programs establish consistent safety procedures that welding operators are expected to follow. Compliance with these procedures directly contributes to a safer work environment. Given this, it is suggested that all employees should be involved in the creation and implementation of the safety program. Additionally, all employees should receive thorough safety training and ongoing education.

Moreover, it was found that management attitudes influence workplace safety and health. This implies that management attitudes affect employee involvement in safety initiatives. When management values input from welding operators and other employees, it encourages active participation in safety committees, hazard reporting, and safety improvement efforts. This finding supports prior studies that prove that when the top management actively supports and participates in safety programs, employees are more likely to be involved. According to Ekenedo [54], management attitudes play a role in fostering a culture of continuous improvements to safety. Managers who seek ways to enhance safety performance and engage employees in safety-related discussions contribute to long-term safety and health improvements.

Lastly, safety training was also proven to have a direct and significant influence on welders' attitudes toward safety. Safety training provides welders with the knowledge and awareness of safety hazards, risks, and best practices in their work environment. According to Sabitu et al. [55], safety training often includes the development of specific safety skills

and techniques. As welders acquire these skills through training, they gain confidence in their ability to work safely. This confidence positively shapes their attitude toward safety. Furthermore, Dahl [63] found that through training, welders become familiar with safety regulations and guidelines. They understand their responsibilities in adhering to these rules. This sense of responsibility contributes to a positive safety attitude, as they recognize their role in maintaining a safe workplace.

On the other hand, the results showed that a reward system and machine reliability have an indirect impact on the health and safety of workers in the welding industry. This explains that reward systems, which typically involve monetary incentives or recognition, may encourage safe behavior, but they do not directly control an individual's actions. Workers in welding operation may still engage in unsafe practices despite the existence of a reward system, emphasizing the indirect nature of influence. In addition, while machine reliability is critical for preventing equipment-related accidents, it does not address the potential for human error, which is a significant factor in welding-related accidents. Even with reliable machines, accidents can still occur due to human factors, such as inattentiveness, fatigue, or lack of training. Thus, a comprehensive approach to workplace safety should consider multiple factors and address human behavior, training, hazard mitigation, and regulatory compliance in addition to reward systems and machine reliability.

To summarize, the findings support the aim of the study, which is to assess the safety and health factors in the welding process of workers in Singapore. It was established that exposure and presence of harmful agents, employees' attitude towards safety, top management's attitude towards safety, safety culture, compliance with safe working conditions, and safety programs have a direct and significant influence on safety and health in the workplace. All these findings contribute to the existing body of knowledge with regards to the study of safety and health in the workplace, especially in the welding process.

6. Conclusions

This study assessed the occupational safety and health factors in the welding process of workers in Singapore. The factors were identified through a review of the related literature, which was used in data gathering by means of a survey questionnaire distributed using purposive sampling to 309 workers based in Singapore. Using PLS-SEM, the factors included in the model were tested. Among the 11 hypotheses, eight were accepted while the other three were rejected. The results showed that based on the perception of workers in Singapore who were directly involved in the welding process, the following factors have a direct effect on workplace safety and health: presence and exposure to harmful agents, employees' attitude towards safety, top management attitude towards safety, safety culture, compliance with safe working conditions, and safety programs. Conversely, it was found that machine reliability doesn't have a direct effect on workplace safety and health. Looking at the profile of the respondents, only the welders were operating machines among all the other jobs of the respondents. This could explain why machine reliability wasn't deemed as important in determining the safety and health of a workplace. To validate this possibility, future studies may focus on other occupations that are directly dealing with machines and equipment.

6.1. Practical Implications and Managerial Insights

Through the results of this study, the manufacturing industry, with welding as part of its process, can be guided on how workers perceive the safety and health of their workplace. This can be used in improving the initiatives and programs of the industry in general, as well as the government bodies in charge of occupational safety and health with regards to promoting a safer and healthier workplace for all stakeholders. In addition, top management can use the findings to better understand the workers' perception of a safe and healthy workplace. This knowledge can aid them in connecting with the workers, which will make it easier for the top management to gain their support in advocating for a safe and healthy workplace for everyone. For instance, since a reward system wasn't

assessed by the respondents as a factor that affects the way employees shape their attitude towards safety and health, top management and even government bodies in charge of occupational safety and health could investigate other ways that might motivate employees to have a positive attitude towards safety.

Moreover, companies in the manufacturing industry who are underperforming in their workplace's safety and health may refer to the results presented in this study. The accepted hypotheses can serve as the foundation for creating effective safety programs for their employees.

6.2. Theoretical Implications

Establishing the different factors assessed by the workers as important in determining the safety and health of the workplace in the welding process is necessary, especially in Singapore, where they aim to be one of the countries that has the safest workplace in the world. Although there have already been numerous studies in the past with regards to occupational safety and health, this is the first one to focus on a specific process, which is welding. Furthermore, the framework that was formulated in the study can be a basis for future researchers who are looking into exploring other areas of occupational safety and health in workplaces regardless of the industry and process. With the continuous growth of the manufacturing sector in countries like Singapore, the presence of studies that tackle safety and health in the workplace is imperative now more than ever.

6.3. Limitations and Future Research

This study used purposive sampling in selecting its respondents. Although the study presented good results, one of the limitations of the study is that the respondents could be anyone from welders to engineers as long as they are directly involved in the welding process. This could result in bias in the way they perceived safety and health in the workplace since some of the occupations of the respondents are more exposed to different hazards than others. Future research on the subject may focus on one occupation to better understand the perception of safety and health in the workplace based on a specific job.

Furthermore, the authors of this study urge future researchers to challenge the rejected hypotheses and look into other aspects as to why reward systems and safety culture were not deemed as necessary in shaping employees' attitudes towards safety as well as why the relationship between machine reliability and safety and health in workplace was not established. Moreover, conducting studies on other processes in the manufacturing industry will be beneficial to all stakeholders since in doing so, a larger body of knowledge will be present to aid companies and government bodies in ensuring a safer and healthier workplace for everyone in the midst of continuous growth in the manufacturing industry.

Author Contributions: Conceptualization, B.J.B.B.; Methodology, B.J.B.B. and M.J.G.; Data Collection, B.J.B.B.; Software, M.J.G.; Analysis and Discussion, B.J.B.B. and M.J.G.; Writing—original draft, B.J.B.B.; Writing—review and editing, M.J.G.; Funding acquisition, M.J.G. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by Mapua University.

Institutional Review Board Statement: This study was approved by Mapua University Research Ethics Committee.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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