European International University, EIU-Paris

Doctoral Thesis

Geographical Impacts and Regulatory Frameworks: A Critical Analysis of Challenges and Advancements in Kuwait's Industrial Hygiene Practices in the Petrochemical Sectors

Submitted by:

Mr. AHMAD FIRDAUS BIN MOHAMAD

Student ID: **EIU63006441**

In Partial fulfillment of the Requirements for the Degree of Doctor of Business Administration (DBA) in Occupational Safety Health Awareness (OSHA)

Supervisor:

Prof. (Dr.) S. Edmund Christopher

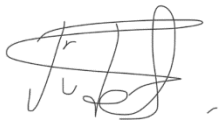
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I hereby declare that the work in this thesis entitled, "Geographical Impacts and Regulatory Frameworks: A Critical Analysis of Challenges and Advancements in Kuwait's Industrial Hygiene Practices in the Petrochemical Sectors" has been undertaken and completed by me for the award of the Degree of **Doctor of Business Administration (DBA) in Occupational Safety Health Awareness (OSHA)** with European International University, under the guidance of Prof. (Dr.) S. Edmund Christopher.

I also declare that this thesis is an original work and has not been submitted for any degree or diploma in any other university or institution. Further, I declare that the texts, figures, tables, and any other material taken from other sources has been acknowledge, referred and cited in the best of my knowledge and understanding.



Signature of Research Scholar,

AHMAD FIRDAUS BIN MOHAMAD

European International University

Date: February 2026

Place: UAE

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The thesis represents an original work undertaken in accordance with the academic regulations of the European International University. The content of this thesis reflects the independent research efforts of the candidate. This thesis has not been submitted for the award of any degree, diploma, or other qualification at any other university.



Signature of Supervisor
Prof. (Dr.) S. Edmund Christopher
Date: February 2026
Place: UAE

UNIVERSITY APPROVAL

This dissertation titled, "Geographical Impacts and Regulatory Frameworks: A Critical Analysis of Challenges and Advancements in Kuwait's Industrial Hygiene Practices in the Petrochemical Sectors" has been examined and approved by the European International University (EIU-Paris) for the award of the **Doctor of Business Administration (DBA) in Occupational Safety Health Awareness (OSHA)**

Signature: 

Name: Ky. Col. Prof. Dr. Edward Roy Krishnan
Position: Founder & Director General
European International University, Paris, France

Date:
University Seal:

Abstract

This study investigates the influence of organizational factors on hazard communication effectiveness and safety behaviours in high-risk industrial settings, with a specific focus on the petrochemical industry. The research examines how managerial governance, communication clarity, and training accessibility impact employees' comprehension of hazards, and explores the mediating roles of worker risk perception and training accessibility in shaping safety behaviours. A cross-sectional quantitative survey design was employed, collecting data from operators, maintenance personnel, and safety officers across multiple facilities. Reliability and validity of the measurement instruments were confirmed using Cronbach's alpha and factor analysis. Regression and mediation analyses revealed that managerial governance, communication clarity, and training accessibility significantly predict hazard communication effectiveness, which in turn directly influences safety behavior. Worker risk perception and training accessibility were identified as key mediators, facilitating the translation of organizational strategies into observable safety behaviors. The findings provide theoretical contributions to the Health Belief Model and Theory of Planned Behavior by integrating structural, cognitive, and training mechanisms into a comprehensive framework. Practical recommendations for industrial organizations include enhancing governance structures, improving communication clarity, and ensuring accessible and contextually relevant training programs to foster a culture of safety. This research advances understanding of how organizational and cognitive factors interact to promote effective hazard communication and consistent safety behavior, offering both theoretical insights and actionable strategies for improving workplace safety in high-risk environments.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

The issue of industrial hygiene has been emerging at the forefront of contemporary occupational health and safety management, especially in the high-risk industry like petrochemical, and the petrochemical industry. Industrial hygiene pays attention to the foresight, identification, assessment and administration of dangers that can possibly cause injury, sickness or lasting health impacts on employees at the workplace (Aiman Muhamad Bauzir and Tri Siwi Agustina, 2024). Industrial hygiene practices are necessary in industries where dangerous chemicals, toxic materials, and complicated industrial operations are involved to ensure that the workers are not exposed to occupational hazards, and that the working environments of the industries remain sustainable and healthy (Ali et al., 2025).

The petrochemical industry is universally noted to be one of the most dangerous industries in the world thanks to the complexity of its operations and the large amounts of dangerous chemicals, inflammable substances, and industrial machinery that it uses. These settings usually expose workers to various physical, chemical and other environmental risks which may cause serious health risks unless properly addressed (Batool, Awan and Chughtai, 2022). The most frequent challenges in the oil refineries and petrochemical plants are chemical exposure, toxic gases, high temperature and the dangerous operations of the processes. Therefore, there is need of efficient systems of industrial hygiene management that will identify the potential risks and allow monitoring of the occupational exposures, and enact preventive measures that protect health and safety of employees (Burke et al., 2006).

Exposure of the occupants to dangerous chemicals is one of the greatest risks associated with petrochemical and oil refining processes. Examples of harmful substances that workers may come across include hydrogen sulfide, benzene and volatile organic compounds among other toxic substances in different production and processing phases (Chapagain, Ghimire and Boro, 2024). The occupation diseases that may arise on these exposures are respiratory illnesses, skin diseases, neurological injuries, and chronic illnesses. The lack of proper industrial hygiene measures can lead to both chronic and acute health effects of workers, which have a profound effect on their health and performance (D, 2020).

In addition to the immediate health hazards of the chemical exposure, the safety at the workplace in the petrochemical industry is also affected by the efficiency of the hazard communication systems and organizational governance systems. Hazard communication is an important aspect of the occupational safety management, which ensures that employees are aware of the risks that may occur due to the types of chemicals and processes that they are exposed to in their work processes. Implementing effective ways of communication would help employees identify the hazards, decipher the safety warnings, and implement proper protective measures in order to reduce risk (D, 2020).

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) has become a generally accepted system used on an international level to provide a standardized method of communicating hazards of chemicals in various industries as well as nations. GHS system offers standard hazard pictograms, safety labels and safety data sheets (SDS) which assist workers in recognizing the hazards of chemicals very fast and learn what they need to do to take the necessary precaution (D. Miroonova, 2018). Hazard communication systems in industries where workers deal with various hazardous materials on a daily basis may have a high impact on risk perception and safety behavior of the workers.

Organizational governance and safety leadership are also significant in determining the outcomes in terms of workplace safety besides the technical safety measures. The level of effectiveness of the implementation of industrial hygiene programs can be directly affected by the reputation of the management to safety policies, compliance to regulations, and employee training in the industrial facilities. It is observed that organizations with high emphasis on good governance structures and safety culture will have a higher compliance with occupational safety standard and safety performance among workers (Gopalan, 2016).

In the environment of the petrochemical industry of Kuwait and petrochemical, industrial hygiene management is a specific issue because of the size of the system of activities, the nature of the environment, and the multifaceted nature of industrial processes. Kuwait is a major oil producing nation in the world and the economy depends more on petroleum production and refining activities. Consequently, thousands of workers are involved in working in areas where they are exposed to the hazardous chemicals and industrial risks (I. Chittumuri et al., 2025). In spite of enactment of

international safety standards and regulatory frameworks, there is still concern on effectiveness of hazard communications, safety awareness to workers and governance structures charged with enforcement of occupational safety practices. The interaction between industrial hygienic management regime, hazard communications, and the safety habits of workers in the petrochemical industry of Kuwait is thus vital in enhancing safety performance in the work environment as well as fortifying occupational health security (IPCC, 2023).

The research aims to analyze how the governance, the hazard communication, and the perception of risks of the workers can affect the safety behavior in the oil, gas, and petrochemical industry of Kuwait. In investigating the connection between organizational safety systems and the safety practices by the workers, the research will be beneficial in improving an effective industrial hygiene management system that safeguards workers and improves the overall workplace safety performance.

1.2 Background of the Study

The growth of the global energy demand as a result of industrialization and expansion of various operations in the field of petrochemicals have led to a significant rise in the scale and complexity of activities in the area. The industries are very important in economic growth and energy security in the global world. Nevertheless, the severe industrial operations of petroleum mining, refining, and the production of petrochemicals bring numerous occupational risks that should be managed and regulated successfully (Izadi, 2018). The industrial hygiene has consequently come to play as a core element of the occupational health and safety programs in these industries.

Industrial hygiene is a scientific field that involves the determination, assessment, and management of the environmental conditions within the workplace which can have negative health and wellbeing impacts to the workers. Industrial hygiene practices are especially relevant in high-risks industries like petrochemical, since employees have to deal regularly with dangerous chemicals, high-pressure machinery, poisonous gases, and potentially harmful industrial processes (Jamil et al., 2025). The objectives of effective industrial hygiene programs are to reduce the exposure of workers to toxic substances and make sure that the relevant preventive actions are taken to minimize work-related health risks.

The petrochemical sector has been defined by the application of intricate chemical operations where production, transportation, and storage of hazardous products are involved. Hydrogen sulfide, benzene, toluene, xylene, and other volatile organic compounds are some of the chemicals that may be exposed to the workers in such environments (Li et al., 2022). The effects of exposure to these substances may be severe and have health effects like respiratory, neurological, skin, and chronic illnesses like cancer. This has led to the fact that management of industrial hygiene in the petrochemical facility requires control of chemical exposure and proper hazard communication.

Kuwait is a major petrochemical-producing nation in the Middle East and it is a frontrunner in the international energy market. The economy of the country is also largely reliant on petroleum production and petrochemicals that bring big returns to the nation in terms of national revenue and employment (Masudin et al., 2024). Big state owned companies like Kuwait Petroleum Corporation (KPC) and its affiliates control extensive network of petrochemical refineries, petrochemical plants and industrial processing plants in the country.

These plants use a huge number of workers which are engineers, technicians, operators, maintenance and other workers in the industry who are constantly exposed to the working conditions which may be hazardous. It is thus important that regulation bodies in the government and the industry management ensure the safety and health of this workforce (MOHAMADI, KARIMI and KARIMI, 2022). In spite of the availability of the international occupational safety standards and regulatory frameworks in the occupational health and safety practices, there still exist a number of challenges on the effective application of the industrial hygiene programs in the region. Such issues can be the lack of communication of hazards, an uneven worker training program, low knowledge of chemical hazards, and different safety culture within organizations.

Hazard communication is important in preparing the workers in the capacity of identifying and responding effectively to hazards at the workplace. The knowledge of hazardous chemicals, ability of workers to identify warning signs, and interpret safety signs directly determine the ability of workers to safeguard themselves and their peers against possible harm. Clear and standardized communication of chemical hazards is needed in an industrial environment where several dangerous substances are involved (Ni Nyoman Ayu Cahyani and Yunita, 2025).

The United Nations invented the Globally Harmonized System of Classification and Labeling of

Chemicals (GHS) to harmonize the common hazard communication practices in industries and nations. GHS system presents standardized hazard pictograms, chemical labels as well as safety data sheets which are presented in clear and consistent form of information on the properties and risks of chemical substances (Omidi et al., 2023). Using the GHS system, the organizations will be able to enhance the level of awareness of the workers concerning the hazards of chemicals and decrease the risk of injuries in case of misinterpreting the information about the safety issues.

The usefulness of hazard communication systems however, does not only rely on the accessibility of safety information but also on the capability of the workers to interpret and put this information to practical use. Employees should also be sufficiently trained to understand the labels on hazards, potential dangers of chemicals and the right safety measures (Omidi et al., 2023). In the absence of efficient training and communication strategies, even the availability of hazard labels and safety documentation might not be effective in maintaining safe behavior at work place.

Besides hazard communication, organizational governance and safety leadership are also important aspects that determine the success of industrial hygiene programs. The governance structures dictate the manner in which the safety policies are adopted, tracked as well as implemented into industrial organizations. The management's dedication to safety, the allocation of funds towards the safety training, and compliance with regulatory provisions may play a great role in influencing the overall safety culture in an organization (Oughton, 2013).

In the petrochemical industry of Kuwait, the industrial hygiene management should be reinforced and the hazard communication system enhanced so as to reduce the effects of occupational health risks and facilitate safer work accidents. This study aims at making research contributions that may assist in ameliorating the coordination of more effective safety management practices within the industry by investigating the interplay between the governance structures, the hazard communication practices, and worker safety behavior.

1.3 Industrial Hygiene in the Petrochemical Industry

Industrial hygiene is a key factor in ensuring safe and healthy working conditions in petrochemical industry. The industry has extremely complicated industrial processes which entail the utilization of harmful chemicals, pressure systems, and sophisticated machinery. Such working situations

subject employees to a great variety of work hazards, which they must address with well-organized safety and health measures (Oughton, 2013).

Determining the possible sources of hazards at the workplace and assessing the associated risks is one of the key tasks of the industrial hygiene programs in the petrochemical industry. Such hazards can be chemical exposures, physical hazards like noise and vibration, biological hazards and environmental factors like extreme temperatures. The scientific methods and monitoring techniques that the industrial hygienists employ in evaluating the workplace exposures are aimed at determining whether the exposures are within acceptable safety limits (PALAČIĆ, 2019).

One of the most critical occupational health issues that can be observed in the petrochemical industry concerns chemical exposure. Workers might be exposed to harmful substances that are toxic during the process of drilling, refining and petrochemical production, which may cause severe health hazards. The exposure, even low, may result in irritation of respiratory system and eyes, whereas the exposure of high concentrations may result in severe poisoning or death (Priolo, Vignoli and Nielsen, 2025).

Benzene or a volatile organic substance, which is commonly known to be a carcinogenic compound, is also another dangerous chemical found in petrochemical plants. Benzene causes blood disorders and leukemia which have been observed after long-term exposure. Employees engaged in such activities as refinery, chemical processing and fuel handling are at risk of high exposure to benzene in case proper control measures are not taken.

Besides chemical hazards, there are other occupational hazards that petrochemical workers can be exposed to including a high noise level produced by industrial machines, high temperatures, and physical work which involves manual labor. Long-term effects of such conditions may include occupational diseases like hearing impairment, heat pressure, musculoskeletal conditions, and body fatigue related injuries.

The goal of industrial hygiene programs is to reduce these risks using a combination of engineering controls, administrative controls and personal protective equipment (PPE). Engineering controls thus entail the adjustment of working conditions in order to limit exposure to hazards which includes the provision of ventilation devices to eliminate toxic gases or isolate dangerous processes

by keeping them out of reach of the workers (Schulte et al., 2022). The administrative control measures involve the application of safety measures, working schedules and training programs which aim at minimizing the exposure of workers to hazardous conditions.

The last line of defense against occupational hazard whereby the other control measures are unable to eliminate the risks completely is personal protective equipment. The exposure of workers to dangerous substances in petrochemical facilities is a common issue that may be prevented by using respirators, protective dressing, gloves, helmets, and eye protection.

Technical safety measures are not sufficient to the success of the industrial hygiene programs but rather the awareness and involvement of the workers (Shi, 2020). The employees need to be aware of the risks that may be involved in their working activities and adhere to laid down safety measures to help reduce risk. Hazard communication systems and training programs are thus very crucial in making sure that workers receiving the training programs have the required knowledge and skills to ensure that they protect themselves in hazardous environments.

1.4 Industrial and Environmental Context of Kuwait

The large oil reserves in Kuwait have been of great influence to the economic growth of the state since it is currently one of the top oil producers in the Middle East. The petrochemical industry forms the foundation of the Kuwait economy that provides a significant portion of the country income and jobs. Some of the key industrial activities in the country are oil exploration, crude oil production, petroleum refining and petrochemical production.

The magnitude of such activities necessitates the development of massive industrial plants, such as oil refineries, petrochemical plants, and storage plants. These plants have sophisticated processes of production which make use of a broad spectrum of chemicals and industrial machines. Consequently, employees working in the petrochemical industry of Kuwait are often subjected to possibly risky working conditions that need close control using occupational health and safety initiatives (Shi, 2020).

The occupational challenges that the industrial workers have to deal with in Kuwait are also contributed by the environmental conditions. The climatic conditions in the country are extreme and exhibit the warm weather, minimum humidity, and dust storms. In summer, the temperature

may reach 50 degrees Celsius, and this poses a challenging working environment to the employees who work in the industrial premises in the open air. The excessive heat may lead to strain of heat and dehydration in the employees, especially those involved in activities involving high levels of labor. Stress of heat might cause fatigue, lack of concentration and inability to make decisions that might put them at a higher risk of accidents at the workplace. Industrial organizations, therefore, need to put in place the right safety precautions that would safeguard the workers against environmental risks that are related to extreme weather conditions (Siegrist and Árvai, 2020).

Kuwait's petrochemical industry is based on a structure that is mostly controlled by the state-owned enterprises, under the control of the Kuwait Petroleum Corporation and the subsidiaries. These organizations handle large refining and petrochemical plants which are significant to the energy supply chain in the world (Walters, Ho and Hardesty, 2014). Because of the strategic nature of the petrochemical industry, the occupational safety and industrial hygiene standards should be maintained at a high level in order to make the operations in the sector sustainable and efficient.

Although, there are international standards of safety, and regulatory measures have been put in place, the nature of the industrial process and the environment can pose some difficulties in ensuring that there is consistency in the safety performance across plants. Employees should be alert on the identification of hazards, safety measures, and protective gear to reduce workplace hazards (Wang et al., 2023). It is thus necessary to know the environmental and industrial environment under which workers work to be able to produce effective strategies of industrial hygiene management. Through the discussion of the particular circumstances, that define the oil and petrochemical industry in Kuwait, this study aims to formulate factors that determine the behavior of workers in terms of their safety and awareness of hazards in this high-risk area.

1.5 Hazard Communication and GHS Systems

Hazard communication is a very important aspect in the management of health and safety of occupations in an organization, especially when it involves handling of harmful chemicals. Good hazard communication would mean that employees have been made aware of the dangers posed by chemical substances and can go on to undertake relevant measures to guard themselves against the exposure. The capacity of workers to comprehend and decipher safety information is vital in a complicated industrial setting like an petrochemical refinery or petrochemical plant in preventing

accidents and work-related diseases.

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) was created with the aim of offering a standard method or means of conveying the hazards of chemicals in all industries and nations(Wingate et al., 2023). Before the emergence of GH, various countries and organizations had distinct classification systems and labeling formats thus confusion and inconsistencies were common with hazard communication. The GHS system was developed to deal with the aforementioned problems with the introduction of a universally accepted system of chemical classification and sharing of hazards they present.

The use of standardized hazard pictograms that are used to visually depict the various chemical hazards is one of the critical characteristics of the GHS system. Pictograms enable workers to have instant visual information about the type of hazard that they can be involved in. As an illustration, there are certain symbols that display toxicity, flammability, corrosiveness, and environmental hazards. The GHS system enhances the capacity of workers to identify harmful substances within a short duration and take the necessary action by means of relatively universal symbols (Zohar, 2010).

Besides the hazard pictograms, GHS implies utilizing standardized chemical labels that also involve significant details regarding the substance, such as hazard statements, precautionary statements, the signal words reflecting the degree of the risk. The labels are normally placed on the chemical containers and give necessary safety data that is to be comprehended by the workers prior to processing the hazardous materials.

Another significant part of the hazard communication system is the Safety Data Sheets (SDS). SDS documents contain all necessary information regarding chemical materials such as their physical and chemical properties, health risks, safety of their handling, emergency response rules, and disposal. SDS documents enable workers and safety personnel to get detailed information on safety with respect to the chemicals involved in industrial processes (Zohar, 2010).

Nevertheless, hazard labels and safety documentation are not enough to facilitate the effective hazard communication. Proper training to the workers should be provided on ways of interpreting information on safety and apply it in real life circumstances in the workplace. The training

programs are thus required such that the employees are conversant with GHS symbols, chemical labels and safety procedures related to dangerous materials.

In a factory setting where more than one chemical is being performed at the same time then proper hazard communication can greatly mitigate the risk of accidents and exposure accidents. Organizations can reinforce their industrial hygiene programs, as well as increase the safety of their workplaces, by enhancing awareness of chemical hazards on the part of workers, and ensuring adherence to appropriate safe handling behaviors.

1.6 Problem Statement

Occupational health and safety management systems have made great strides in recent years, but the number of accidents and occupational health risks in the workplace is not negligible, especially in the sector where employees are exposed to hazardous chemicals. The petrochemical industry continues to be one of the most dangerous industrial fields due to the constant contact with toxic substances, physical dangers, and intricate procedures involved in operations. Safety management systems and other international standards, like the Globally Harmonized System (GHS), have been developed to enhance hazard identification and communication, but the success of these systems depends on workers being able to interpret and understand safety information and apply it correctly.

The petrochemical industry in Kuwait has implemented measures to reduce the risk of exposure and create a safer working environment for these workers. But, there are issues in effectiveness of hazard communication systems and worker knowledge about chemical hazards. Having available safety procedures, warning labels and regulations does not automatically ensure safety outcomes, unless workers have the necessary knowledge, are properly trained and supported by a robust safety governance framework. This means there is an implementation gap between the formal safety systems set up and their effective implementation at the workplace level.

There are a number of organizational and individual reasons that can lead to shortcomings in hazard communication effectiveness. This includes poor safety training, language issues in a multicultural work environment, lack of awareness of chemical hazard symbols/pictograms, inconsistent supervision and poor enforcement of safety procedures. Moreover, the organization's

governance and management commitment are also crucial factors in achieving effective communication, implementation and maintenance of safety policies. Poor management practices can be associated with low staff engagement, and greater risk of unsafe behaviours and poor risk assessment.

Past research has indicated that key factors in influencing performance of occupational safety include worker awareness, safety culture and communication. Very little research, however, has investigated the interaction between organizational governance, hazard communication effectiveness, training availability, and workers' risk perception on safety behaviour in the petrochemical industry in Kuwait. The existing research typically deals with isolated safety factors and/or regulatory compliance, without enough consideration of the interaction between organizational and cognitive factors that impact on workers' safety decisions.

Furthermore, the multinational composition of the Kuwaiti industrial labor force also poses further issues in respect to effective communication of chemical hazards. Some factors, such as language, education, and safety awareness, can affect the perception of risk and reaction to safety information among workers. Thus, it is important to know how organizational behaviour, hazard communication systems, risk perception, and safety behaviour are connected to be able to design better industrial hygiene measures.

Due to the critical role of the petrochemical industry in Kuwait's economy and the possible risks arising from industrial accidents at work and chemical poisoning, it is necessary to conduct an empirical investigation of the effectiveness of the current industrial hygiene management in the petrochemical industry. The present study aims, therefore, to explore the relationship between hazard communication effectiveness, training availability, worker risk perception and safety behaviour, with regard to the relationship between managerial governance and these factors among workers in the petrochemical industry in Kuwait. The results will help enhance the industrial hygiene practices within the industry, the safety management system, and the establishment of a safer workplace.

1.7 Research Objectives

The main purpose of this research will be to discuss the effectiveness of the industrial hygiene

management and hazard communication practices in the Kuwaiti petrochemicals industry sector, and specifically, how the organizational governance and perception of the workers towards risk affects safety behavior in hazardous industries.

In an attempt to realize this objective, the study aims to achieve the following specific objectives:

- To examine the impact of managerial governance on hazard communication and worker safety behavior.
- To assess how GHS comprehension and safety training influence risk perception and behavioral intention.
- To develop an evidence-based framework to enhance hazard communication and reduce workplace risks.

The study will seek to achieve a holistic explanation of the role played by governance, hazard communication, and worker awareness on the effectiveness of industrial hygiene in the Kuwait petrochemical industry through these objectives.

1.8 Research Questions

The study aims at answering several important research questions based on the research objectives and the research gaps identified in the research area, i.e. the gap in industrial hygiene management and hazard communication practices in the petrochemical industry in Kuwait.

The following is the main research question that will direct this research:

What role does governance structure and hazard communication system play in the worker perception of risk and safety behavior in the petrochemical industry in Kuwait?

To address this more general question, the research questions that will be examined in the study are:

RQ1: How does managerial governance quality influence the effectiveness of hazard communication systems in Kuwait petrochemical organisations?

RQ2: What is the level of worker comprehension of Globally Harmonised System pictograms, and

how does it affect safety behaviour?

RQ3: How do safety communication practices and training accessibility influence worker risk perception and behavioural intention?

RQ4: How can managerial decision-making be structured to improve hazard communication effectiveness and reduce exposure-related risks?

Answering these questions, the research will be able to determine aspects, that affect the safety of workers and lead to better industrial hygiene regulation in the petrochemical industry of Kuwait.

1.9 Research Hypotheses

Using the conceptual framework elaborated in the current study and the theoretical standpoints **H1:** *Managerial governance positively influences hazard communication effectiveness and worker safety behavior.*

IV: Managerial governance

DV: Hazard communication effectiveness, safety behavior

Theory: Safety Climate Theory – governance sets the organizational safety tone, influencing compliance and behavior.

H2: *Effective hazard communication (GHS labels, pictograms, SDS) increases worker risk perception, which enhances safety behavior.*

IV: Hazard communication

Mediator: Risk perception (HBM – perception of severity and susceptibility)

DV: Safety behavior

Mechanism: Workers who understand hazards perceive risk more accurately and act safely.

H3: *Workers' comprehension of GHS pictograms and access to safety training positively affect their risk perception and behavioral intention.*

IV: GHS comprehension, safety training

Mediator: Risk perception (HBM)

DV: Behavioral intention/safety behavior (TPB – intention predicts behavior)

Mechanism: Better knowledge and training improve awareness and motivate safe practices.

The hypotheses are the foundations of the empirical analysis performed in this paper that will contribute to exploring the relationships between organizational safety systems and the behavior of workers in the petrochemical industry in Kuwait.

1.10 Significance of the Study

The findings of this study are important for academic research, industry practice and occupational health and safety policy formulation, especially in terms of an understanding of the effectiveness of industrial hygiene management systems in hazardous working environments. This study explores the connection between the effectiveness of hazard communication, worker risk perception, safety behaviour, and organizational governance in the petrochemical industry in Kuwait, and offers insights into the factors that affect the outcomes of occupational safety.

Academic Significance

Academically, this study makes a contribution to the existing knowledge related to occupational health and safety management systems, industrial hygiene practices, hazard communication and employee safety behaviour in high risk industrial environments. In developed countries, there has been extensive research on the relationship between OSM practices and workers' safety attitudes, whereas in the Middle East, the interaction between OSM practices and worker safety attitude has received little attention, especially in the context of hazardous communication in the petrochemical industry in Kuwait (Ali et al., 2025).

Moreover, the work builds on previous theoretic work by incorporating organizational and individual factors that affect workplace safety outcomes. This study explores the connection between management commitment, communication effectiveness, risk perceptions, and safety behaviour, giving a more comprehensive understanding of the functioning of safety systems

beyond regulatory requirements. The results are relevant to the occupational safety literature by emphasizing the need for good communication processes and the perception of workers in order to improve the performance of industrial hygiene.

Industry Significance

For industries, this research offers practical guidance for improving safety management in the workplace and minimizing occupational health hazards in the context of the petrochemical sector. Effective industrial hygiene practices and safety communication systems are necessary to protect workers at all of the petrochemical facilities because of the complexity of the operations and the continuous exposure to hazardous chemicals encountered.

The knowledge of the comprehension of employees on the hazard information, the perception of the hazards and the response of employees toward the safety procedures can help the organisations to develop more effective safety training programmes and communication strategy (Batool et al., 2022). The results of this research can assist industrial entities to recognize the problem areas in the current hazard communication system, increase knowledge about the hazards of chemicals among employees, and enhance adherence to safety protocols.

Further, it offers recommendations for enhancing organisational safety governance, including the importance of management commitment, supervision, and the safety culture in fostering positive safety behaviours. Implementing these practices can help to prevent workplace accidents, reduce occupational health risks, and promote the overall well-being of workers in the petrochemical industry, while also boosting the efficiency of operations.

Policy and Regulatory Significance

The results of this study also bring some significant implications to the attention of the policy makers, regulatory bodies for workplace safety and the institutions involved in the establishment and implementation of the workplace safety standards in Kuwait. Government agencies and regulatory bodies have an important role in developing occupational health and safety standards, surveillance, and enforcement of the standards to ensure that the working conditions of organizations are safe (Burke et al., 2006).

This study offers evidence-based perspectives on problems that may exist with hazard communication practices, worker knowledge, and safety management implementation. The results could help guide policy makers in assessing current occupational safety laws and make recommendations for needed changes. It is particularly the study that could help in developing policies for strengthening the industrial hygiene standards, better training for workers on safety and better implementation of globally recognized hazard communication frameworks like Globally Harmonized System (GHS).

Overall, this study helps meet the overall aim to enhance the occupational health and safety performance of the Kuwait petrochemical sector by establishing the organizational and individual factors that impact on the safety behaviour and effectiveness of industrial hygiene management. The findings from this research could inform the design of organizations and policy makers on safer, more effective, and sustainable workplace safety systems.

1.11 Scope of the Study

This study is restricted to the analysis of industrial hygiene management, the practices of hazard communication, and worker safety behavior in the petrochemical industry in Kuwait. The study has narrowed down to employees working in petrochemicals plants, and similar industrial facilities where workers are usually exposed to dangerous chemicals and industrial operations (Batool, Awan and Chughtai, 2022).

The research mainly examines the impact of organizational governing, hazard communicative mechanism and perception of the workers in hazardous workplaces with regard to the development of safety behavior. The focus is made on the role of the Globally Harmonized System (GHS) of chemical classification and labelling in enhancing hazard communication in the industrial workplaces.

The study, in terms of geographic coverage, will be limited to industrial facilities located in the State of Kuwait. The Kuwait focus gives a country-specific analysis of the industrial hygiene management practices in a country whose economy is majorly dependent on the petroleum industry and petrochemical industry.

The research is also focused on the workers who are directly engaged in either operational and

technical functions of an industrial facility such as technicians, operators, maintenance workers and safety workers. Such employees have more chances to deal with dangerous substances and manufacturing operations, and their attitudes and actions have a significant impact on the safety results at the workplace.

Though the study focuses on the governance structures and safety management practices of industrial organizations, it is not a study that tries to analyze all the nature of the occupational health and safety systems in the country. Rather, the researcher is narrowing down to the correlation between hazard communication, perception of risk among workers, and safety behavior as some of the contributing factors to industrial hygiene effectiveness (Burke et al., 2006).

This study focuses on the analysis of industrial hygiene management in Kuwait's petrochemical industry, specifically examining the effects of managerial governance, hazard communication, and workers' risk perception on safety behavior. The unit of analysis is the individual worker, including operators, technicians, and maintenance staff who are directly exposed to chemical hazards. The study does not cover engineering controls, financial performance, or organizational-level operational processes. Methodologically, the research is survey-based, geographically limited to Kuwait, and restricted to petrochemical facilities, providing a targeted understanding of how governance, communication, and risk perception influence safety practices in high-risk industrial environments.

The study aims at providing the insights that may help in the improvement of the hazard communication strategies, training of workers on safety and the industrial hygiene management practices in the petrochemical industry of Kuwait by focusing on these particular variables and industry environments.

1.12 Structure of the Thesis

This thesis is divided into six chapters, which deal with a particular aspect of the research process and all of which are related to the investigation of the essential topic of industrial hygiene management and safety-related behavior of workers in the petrochemical industry of Kuwait.

In chapter 1, the author introduces the research topic and provides an overview of the study. It provides the history of industrial hygiene in the hazardous industry, the significance of the hazard

communication system, and the situation concerning the petrochemical industry of Kuwait. The chapter further puts forth the research problem, objectives, research questions, hypotheses and the importance and the scope of the research.

Chapter 2 will provide a high level of review of the available literature associated with industrial hygiene, occupational hazards in the petrochemical sector, hazard communication systems, and safety behavior among workers. The chapter also has a discussion of the relevant theoretical frameworks and research gaps that in the present study would warrant the research need (Chapagain, Ghimire and Boro, 2024).

Chapter 3 outlines the research method used in the study. It describes the research philosophy, research design, sampling strategy, data collection methods, and statistical methods to be applied to analyze the data. The chapter also addresses reliability, validity, and ethical issues.

Chapter 4 shows the findings of the empirical research. Data obtained through the research are processed with the help of statistical methods to study the association between governance and hazard communication, risk perception, and worker safety behavior.

Chapter 5 addresses the research results and their relation to objectives, hypotheses, and available literature of the research. The chapter also interprets the findings and provides their implications to the industrial hygiene management and workplace safety practice.

Chapter 6 is the final chapter of the study because it summarizes the key results of the research, explains the limitations of the study process, and gives recommendations on how the research and policies could be improved in future studies.

1.13 Chapter Summary

Chapter 1 introduced the topic of industrial hygiene management and worker safety in Kuwait's petrochemical industry, highlighting the high-risk nature of chemical and operational hazards in this sector. The chapter outlined the research problem, emphasizing gaps in hazard communication, governance effectiveness, and the role of worker risk perception in shaping safety behavior. The study's objectives were refined to focus on the impact of managerial governance on hazard communication and safety behavior, the influence of GHS comprehension and training on

risk perception and behavioral intention, and the development of an evidence-based framework to enhance workplace safety. Corresponding hypotheses were formulated to test clear cause–effect relationships, integrating the Health Belief Model, Theory of Planned Behavior, and Safety Climate Theory. The scope of the study was defined as survey-based, focused on individual workers in Kuwait's petrochemical facilities, and excluding factors such as engineering controls or financial performance. Overall, this chapter established the foundation for the study, justifying its importance for academic knowledge, industry practice, and policy-making, and setting the stage for the conceptual framework and empirical investigation in the subsequent chapters.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter is a literature review on the sources of information that pertain to the management of industrial hygiene, occupational health risks, hazard communication, and occupational safety in the hazardous industries, specifically in the petrochemical industries. The literature review will be conducted to determine the theoretical and empirical basis of the current study and outline the most important themes, debates, and gaps that will underpin the study (D, 2020).

Industrial hygiene has been known to be one of the key aspects in the management of health and safety of workers in industries where people are exposed to chemical, physical and environmental dangers. Industrial hygiene is especially important in industries like petrochemical where the industrial process is highly complicated and the hazardous substances are routinely handled. The literature has consistently noted that efficient industrial hygiene practices do not focus on technical monitoring and compliance strategies, but note that they are a wider framework of hazard prediction, risk assessment, exposure management, employee education, and commitment to safety (D. Miroonova, 2018).

The initial theme that was discussed in this chapter relates to the conceptual underpinnings of industrial hygiene, such as occupational exposure assessment, monitoring at the workplace, and industrial hygiene program structure. This part offers the theoretical background behind the manner in which industrial hygiene is a preventive field as well as a management framework of industrial organizations.

The second theme is on occupational health hazards in the petrochemical industry. Since petroleum extraction, refining, and petrochemical processing are quite hazardous, a wide variety of risks linked to toxic exposure, work with chemicals, fire and explosion risks, and accidents is emphasized in the literature. The significance of these risks to the health of the workers, the continuity of operations and compliance with regulations is significant (Gopalan, 2016).

Collectively, these themes can be used to advance the main idea of this study, which is that, to be effective, industrial hygiene requires that risks are identified, communicated, monitored, and

controlled within organizational systems rather than merely being present. The conceptual framework underlying the studies in this chapter, thus, offers the rationale of studying the connections between governance, hazard communication, risk perception, and worker safety behavior in the petrochemical industry of Kuwait.

This chapter is structured into categories, where it shifts the general conceptual discussion to a more industry-based discussion as it goes through. This way, it sets the academic background that is required in the formulation of the conceptual framework of the study and the location of the current research relative to the current body of literature on occupational health and industrial safety.

2.2 Industrial Hygiene Concepts and Practices

Industrial hygiene is a professional discipline in occupational health and safety involved with the prediction, identification, assessment, and management of the occupational hazards that could impact the health and wellbeing of workers. Its essence is preventive: to find harmful conditions before they can lead to any harm or illness and to establish the means of control that will limit the exposure of workers to an acceptable extent. Industrial hygiene is not an incidental safety aspect in risky industries like petrochemical processing, but forms a vital part of the daily running of the company (I. Chittumuri et al., 2025).

The theoretical basis of industrial hygiene lies in the fact that the work place has various types of hazards which can work either singly or as a combination. Such hazards normally involve chemical, physical, biological, ergonomic, and environmental hazards. Even though each of these categories could be also applicable in industrial practice, the phenomenon of chemical exposure stands out as one of the most conspicuous in workplaces in petrochemical. The exposure of workers can be by inhalation, skin absorption, ingestion, or accidental contact, depending upon the nature of the substance, and the conditions in which it is dealt with. Consequently, the industrial hygiene lays a massive weight on establishing the routes of exposure and evaluating the degree to which workers can be put in jeopardy.

One of the most often mentioned concepts of industrial hygiene literature is that of occupational exposure. Exposure takes place when a worker gets in contact with a risky agent to a level and

time span that possibly may generate undesirable health effects. As a matter of fact, exposure assessment includes the determination of the cause of the hazard, the manner in which the worker is in contact with it, and the frequency, intensity, and duration of the contact. This is the key to the industrial hygiene since without understanding the nature and scale of the hazard, it is impossible to manage it appropriately (IPCC, 2023). Exposure assessment also enables organizations to rank the control measures in relation to the level of seriousness of the risk and the number of workers that will be affected.

One of the major principles in the industrial hygiene practice is that exposure should be controlled in a hierarchical manner. The best actions are those which completely remove the danger or replace the danger with a less threatening one. Where removal cannot be done, engineering controls, namely local exhaust ventilation, process enclosure, isolation systems, and automated handling, are the best solution since they minimize exposures at their source. The probability or the length of exposure can be minimized through administrative measures such as work procedures, job rotation, maintenance schedules, warning systems, and training programs. The personal protective equipment (PPE) although important is normally viewed as the last defense with regard to defense since it requires proper and consistent workers to be put into practice (Izadi, 2018).

Another pillar of the industrial hygiene practice is workplace monitoring. Monitoring can be defined as a systematic set of measurement and observation of the working conditions to be in a position to identify the presence of hazards and the effectiveness of the current control measures. Monitoring in the workplace can be done through air sampling of chemical pollutants, noise, heat stress, surface contamination and monitoring of work practices in industrial environments. Periodic surveillance helps the organisations to identify any alterations in the conditions at the workplace, concealed hazards, and to ensure that the occupational exposure level and safety measures are met.

Environmental monitoring is often differentiated in the literature with biological monitoring. Environmental monitoring aims at quantifying the presence of hazardous agents in the workplace which could be airborne concentrations of gases, vapors, dust or fumes. Biological monitoring, in its turn, measures the uptake of hazardous substances into the body of the worker using biological parameters as blood, urine, or breath sampling. These measures combined give a more detailed

picture of the exposures at work and can assist organizations in determining whether the safety measures are working well under actual working conditions (Jamil et al., 2025).

The industrial hygiene programs are more comprehensive than the single monitoring activities; the programs are a systematic and continuous program of handling the occupational health hazards. A good industrial hygiene plan usually involves identification of hazards, risk evaluation, monitoring of exposure, control measures, documentation, review of incidents, training of workers as well as periodic review of system performance. According to the literature, organizational commitment is critical in the strength of such programs. As the management assigns resources, facilitates monitoring of the activities, enforces safety measures, and encourages the involvement of the workers, the industrial hygiene measure is more likely to be effective and sustainable.

Another common element in the literature on the industrial hygiene practices is worker training. Technical controls can never work with their intended effect unless workers are aware of the risks they are exposed to and the precautionary measures that should be taken. Training is both educational and behavioral in nature (Jamil et al., 2025). It enhances the awareness of the hazards by the workers, improves the adherence to the procedures and helps to form the culture of safety conscious organization. Chemical handling, personal protection equipment, emergency response, labeling systems, and exposure reporting procedures are some of the most common personal protection, emergency response, labeling, and exposure reporting training taught in high-risk environments.

The other point, which is significant in the literature, is that industrial hygiene cannot be regarded as a single technical field. More often, researchers and practitioners are employing it as a component of an integrated system of safety management through the interlinkage of engineering, operations, human behavior, regulatory compliance, and organizational governance. The integrated approach is specifically important in the case of petrochemical industries where the impact of exposure is not only on the health of individuals alone but also on the disruption of operations, damage to the environment, and large-scale industrial catastrophes (Li et al., 2022).

In this context, the industrial hygiene is seen as a scientific activity as well as an administrative task. Its success lies in proper exposure measurement, ongoing monitoring at the work place, control measures and availability of organizational systems to aid in safety measures. In the current

research, the literature is of particular significance as it provides the conceptual framework of investigating industrial hygiene as both a technical role, as well as a practice that is associated with governance, risk consciousness, and employee actions.

Table 1: Core Components of Industrial Hygiene Practice

Component	**Description**	**Relevance to Petrochemical Workplaces**
Hazard anticipation	Identifying potential sources of harm before exposure occurs	Helps prevent incidents during chemical handling and processing
Hazard recognition	Detecting existing chemical, physical, or environmental hazards	Essential in refineries and plants with multiple hazard sources
Exposure assessment	Evaluating intensity, frequency, and duration of worker exposure	Supports risk-based decision-making
Workplace monitoring	Measuring contaminants, heat, noise, and other risk factors	Tracks real exposure conditions
Control measures	Applying elimination, engineering, administrative, and PPE controls	Reduces risk at source and during operations
Training and awareness	Educating workers on hazards and safe practices	Improves compliance and behavioral safety

You can insert this table near the middle of the section after introducing the major concepts.

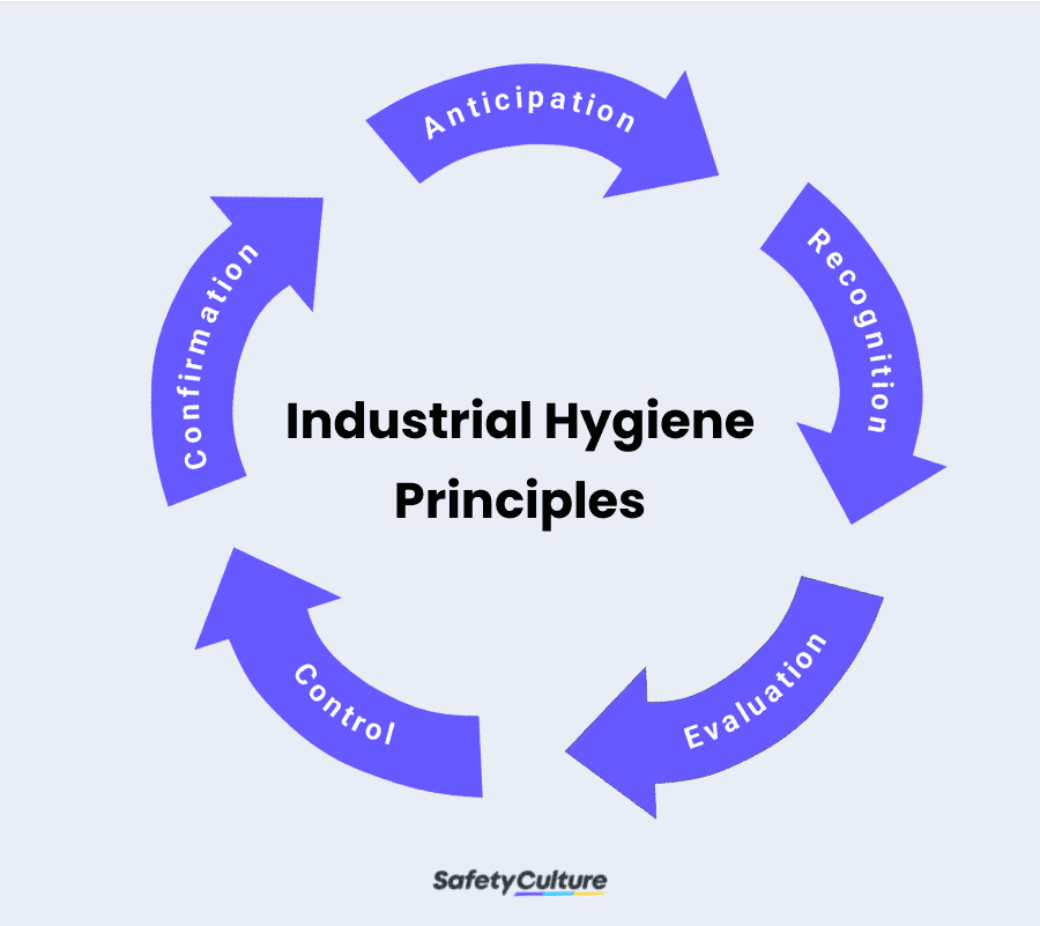


Figure 1: Industrial Hygiene Cycle

2.3 Occupational Health Risks in the Petrochemical Industry

Petrochemical industry has been considered as one of the most dangerous industrial sectors because of the nature of its operations, the materials it deals into, and the environments of work is being conducted. Drilling, extraction, refining, transportation, storage, and petrochemical processing are some of the activities that expose workers to a wide range of occupational health and safety hazards. Chemical hazards, toxic exposures, fire and explosion risks and workplace accidents have always been regarded in the literature as some of the key issues in this industry. The complexity of production systems, the magnitude of the operations and the potentially serious implication of even small breakdowns in safety management enhance these risks (Li et al., 2022).

The literature of occupational health in petrochemical occupations is dominated by chemical hazards. Employees in this industry often deal with flammable, corrosive, toxic, or cancer causing substances. These chemicals can be discharged in the course of normal operations, during maintenance, leakage, transfers of materials or unintentional failure of processes. The exposure may be in closed spaces, open processing zones, storage facilities and transport services (Jamil et al., 2025). There are numerous instances where employees can be exposed to multiple hazardous substances at the same time, thereby forming cumulative and interactive health effects, which are harder to control.

Of special concern is toxic exposure since the effects can either be instantaneous, delayed, acute, or chronic. Intermediate-term exposure to some substances can be characterized by irritation of the skin, eyes, or respiratory system, whereas with high-content exposure, they can poison, become unconscious, or die (Jamil et al., 2025). Prolonged or chronic exposure can be a risk factor in chronic respiratory disease, neurological, organ damage, reproductive, or cancer. It is stressed in the literature again and again that this is one of the problems of toxic exposure in industrial settings, since even some of the harmful substances cannot be easily noticed by human senses. There are those gases that are colorless, others that are accumulated in the air without our notice, and others that cause negative effects when exposed to in the long run. This renders systematic monitoring and hazard communication to be necessary.

In addition to direct toxicological impacts, the petrochemical industry is typified by the existence of process-related hazards that may cause severe accidents in the workplace. High-pressure systems, presence of inflammable materials, high temperatures, and ignition possibilities ensure constant fire, explosion and devastating releases possibilities. However, in spite of these being commonly categorized as process safety risks, they have significant occupational health implications as well since workers are the initial people subsequently to be impacted when these incidents take place. Burn injuries, inhalation of the products of combustion, the blast trauma, and the exposure to the toxic by-products of decomposition can all be the effects of the major industrial accidents.



Figure 2: Occupational Risk Model in Petrochemical Operations

The petrochemical industry does not exclude the possibility of workplace accidents that are not considered to be large scale disasters. Routine risks of an injury that are featured in the literature include: slips, trips, falls, equipment related injuries, confined-space accidents, manual handling accidents, and accidents during maintenance works. Such incidences might be due to poor work environments, human factor, lack of vigilance, exhaustion, lack of communication or effective observation of safety measures. Accidents are often caused by the combination of many failures, as opposed to the contribution of a single cause to accidents. Due to this reason, the current occupational safety studies are more likely to consider accidents as a system level consequences associated with organizational culture, training, risk perception and management system.

The other pattern that is repeated in the literature is that occupational risks in the petrochemical sector are influenced by the environment under which the work is done. Offshore platforms, desert facilities and high-temperature processing areas are other areas which pose extra challenge to the health and safety of the workers. Severe weather can increase fatigue, diminish focus, complicate the process of emergency response and make work more physically challenging. Hot weather conditions, heat stress, dehydration, and lack of situational awareness are of particular consideration in hot weather, where the environment, combined with chemical and operational

hazards, combine to compound the overall risk.

The significance of safety culture and hazard communication in mitigating the occupational health risks is also mentioned in the literature. The employees will always be more inclined to protect themselves when they know the type of hazards they are dealing with, when they know the warning signs, and when they are assured by the management that they care about their safety. On the other hand, a weak communication system, a deficient training system and inconsistent supervision can lead workers to underestimate risks or make unsafe practices as a norm. This is especially dangerous in the conditions when potentially dangerous substances are constantly present, since being exposed to danger over time will lead to an illusion of familiarity and decrease the perceived urgency.

Another problem that is present in the literature is invisibility and underreporting of occupational health effects. These injuries tend to be more evident and easier to record but occupational illnesses due to exposure to chemicals may take a long time to start appearing. This may make organizations concentrate more on short term accident prevention as compared to long term exposure management (Younes Mehrifar et al., 2023). Consequently, this means that chronic health risks will not be given much focus unless the industrial hygiene systems are robust and monitoring methodical. This point is of particular importance to petrochemical sectors, where some of the gravest health outcomes of workers are not due to the occurrence of dramatic incidents, but rather due to constant low or moderate exposure to dangerous chemicals or substances.

The literature thus clarifies that the occupational health hazards that are experienced in the petrochemical industry are multidimensional. These are direct chemical hazards, toxic exposure control, acute accident risks, long-term health consequences, and environmental stressors, which are known to affect physical security and behavioral performance. These risks cannot be effectively controlled using technical protection only. It also involves effective communication, governance, and continuous monitoring as well as organizational climate whereby the workers are helped to identify and act on the hazards (Younes Mehrifar et al., 2023).

In the current study, this literature will be of direct importance since it will place the behavior of worker safety within a wider risk context. Within the petrochemical industry in Kuwait, the environment that the workers work in is characterized by presence of chemical hazards and

environmental forces, and therefore it is necessary to know how risk communication, governance, and perception affect reality in terms of actual safety behavior.

Table 2: Major Occupational Health Risks in the Petrochemical Industry

Risk Category	**Examples**	**Potential Health/Safety Consequences**
Chemical hazards	Solvents, gases, vapors, corrosive agents	Poisoning, irritation, chronic disease
Toxic exposure	Inhalation, skin absorption, accidental contact	Respiratory illness, neurological effects, organ damage
Fire and explosion hazards	Flammable chemicals, pressure systems, ignition sources	Burns, fatalities, blast injuries
Physical hazards	Noise, heat, vibration, confined spaces	Hearing loss, heat stress, fatigue, injury
Workplace accidents	Falls, machinery incidents, maintenance errors	Fractures, trauma, lost-time injuries
Environmental stressors	Extreme heat, dust, remote-site work	Dehydration, reduced concentration, higher accident risk

2.4 Governance and Safety Management

The effective occupational health and industrial hygiene systems are incomplete without governance and safety management. In risky sectors like petrochemical processing a governance structure is used to influence the safety policy development, implementation and monitoring in the

organizations. Effective governance systems are in place to make sure that occupational safety is not a mere regulatory requirement but is one that forms part of the organizational strategy and organizational management (Younes Mehrifar et al., 2023).

Safety governance is the system of leadership, policies, responsibilities and accountability systems that govern safety practices in an organization. It formalizes the channels of communication, enforcement and assessment of safety standards. It is a common theme in the literature that safety governance structures in organizations are associated with higher safety performance, reduced accident rates, and enhanced worker health outcomes.

Safety leadership is one of the key aspects of governance in occupational safety. Safety leadership is the organizational dedication of the leaders and managers to foster safe working conditions and also proactively advocate the safety programs. Leaders impact safety results through effective expectation setting, provision of resources on safety interventions and evident dedication to safety behaviors. The studies in the field of management of occupational safety indicate that the employees tend to adhere to the safety procedures more, when the management takes care of safety as the priority and sets the right example (Achumie et al., 2022).

The role of leadership in the development of perceptions of risk and responsibility is also a key factor in risk among workers. By leaders conveying the value of safety and through incessant feedback on safety performance, employees would exhibit greater positive attitude towards safety and be more alert on the dangers at workplace. On the other hand, poor leadership and absence of managerial participation in safety programs might result in complacency, diminished adherence to safety protocols and naturalization of risky actions



Figure 3: Safety Governance

The provision of minimum safety standards and industrial practices that direct the work of the industry is another major facet of governance. Occupational health and safety regulations are set by governments and other regulatory bodies to ensure that workers are not exposed to hazardous conditions and that organizations ensure that they have the proper safety management systems in place. Such rules in most cases contain the provision of hazard identification, risk evaluation, monitoring of the exposure, reporting of incidence and training of the workers (Achumie et al., 2022).

Regulatory control is especially relevant in the case of petrochemical industries because the possible accident and environmental harm can be massive. The regulatory frameworks usually take into consideration the international standards and regulations like the ones that have been developed by the International Labour Organization (ILO), the Occupational Safety and Health Administration (OSHA) and other international safety organizations. These standards promote systematic safety management systems by organizations which combine industrial hygiene, hazard communication and worker protection.

Nevertheless, effective safety performance cannot be ensured by adherence to regulations only.

According to the literature, regulatory systems are supposed to be supported by powerful internal governance systems in organizations. These mechanisms encompass internal safety audits, performance monitoring systems, incident investigation systems and continuous improvement strategies. Companies that combine regulatory compliance and proactive safety management are in a better position to avoid accident and manage occupational risks.

The third significant issue of governance is the establishment of the safety culture in the organization. Safety culture is the collective beliefs, values, and attitudes that affect the perception and response of the employees on matters concerning safety in the work place. In companies that have effective safety cultures, there is awareness of the significance of safety by employees who are very involved in safety programs and they have the feeling of being accountable of ensuring that there is a safe working environment.

The factors that form the culture of safety are various and may include leadership practice, organizational policy, organizational communication and the participation of the workers in decision making processes. It is a matter of practice that effectiveness of safety is made a focus of training, communication, and set as an example to the leadership level and will incorporate itself in the daily routine of the employees. Employees will be more inclined to report issues, procedures and intervene when hazardous conditions occur.

Weak safety cultures, on the contrary, can result in hazards underreporting, negligence of safety protocols, and exposure to intolerant attitudes to unsafe conditions. This type of environment usually comes about when the production concerns take precedence over the safety concerns or when the workers feel that the management is not truly committed to the safety efforts (Achumie et al., 2022).

In the petrochemical Kuwaiti industry, the governance and safety management are very important in maintaining safe operations in an environment where the majority of industrial processes and materials are hazardous. Effective regulatory control, strong leadership, and positive safety culture will create a better industrial hygiene result and safer working environments to the workers.

It is therefore important to understand how the governance structures contribute to the development of safety behavior in order to determine the effectiveness of industrial hygiene

management systems. This paper considers the role of governance practices in shaping hazard communication, worker risk perception and the safety compliance within petrochemical workplaces.

Table 3: Key Elements of Safety Governance

Governance Component	Description	Impact on Workplace Safety
Safety leadership	Management commitment and leadership support for safety	Encourages compliance and accountability
Regulatory frameworks	National and international safety regulations	Establish minimum safety standards
Internal safety management	Organizational safety policies and procedures	Ensures consistent safety practices
Safety culture	Shared attitudes and values regarding safety	Promotes proactive safety behavior

2.5 Hazard Communication Systems

The role of hazard communication systems in the field of occupational health and industrial safety is central to the information of the workers on the risk related to dangerous substances and industrial procedures. In the setting where chemicals are constantly dealt with, moved, and processed, the communication of hazards should be done clearly and uniformly to avoid accidents and safeguard the health of workers (Achumie et al., 2022).

Hazard communication can be discussed as the process of informing employees who might encounter dangerous substances in the course of their work and may be exposed to different chemical hazards about them. Good hazard communication mechanisms would make sure that the

workers are aware of the type of hazard they are exposed to and they can put in place the right preventive measures to reduce such exposure.

Among the most universally well-known models of hazard communication is the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). The GHS is a system of chemical classification and hazard communication that was developed by the United Nations to harmonize the practices across the world. Before the implementation of GHS, various countries adopted various systems of labeling chemicals used, and this, in most cases, led to confusion and misunderstanding of the information on hazards (Astiaso Garcia et al., 2013).

The GHS system gives one a standardized system of categorizing chemicals according to their physical, health and environmental-related risks. It brings standard hazard pictograms and signal words, hazard statement and precautionary statements which convey nature and severity of chemical risks. GHS enhances the ease and transparency of hazard information by workers working in various industries and geographical locations by relying on standardized symbols and terminologies (Astiaso Garcia et al., 2013).

The GHS system has hazard pictograms as one of its main characteristics. These pictograms are symbolic and employ standardised symbols that are encircled by a red diamond-shaped border signifying particular types of hazards. As an example, some pictograms are used to show flammable materials, toxic elements, corrosive chemicals or environmental dangers. Such visual images allow the workers to identify possible hazards with a glance even when they are not in a position to read the detailed safety measures.

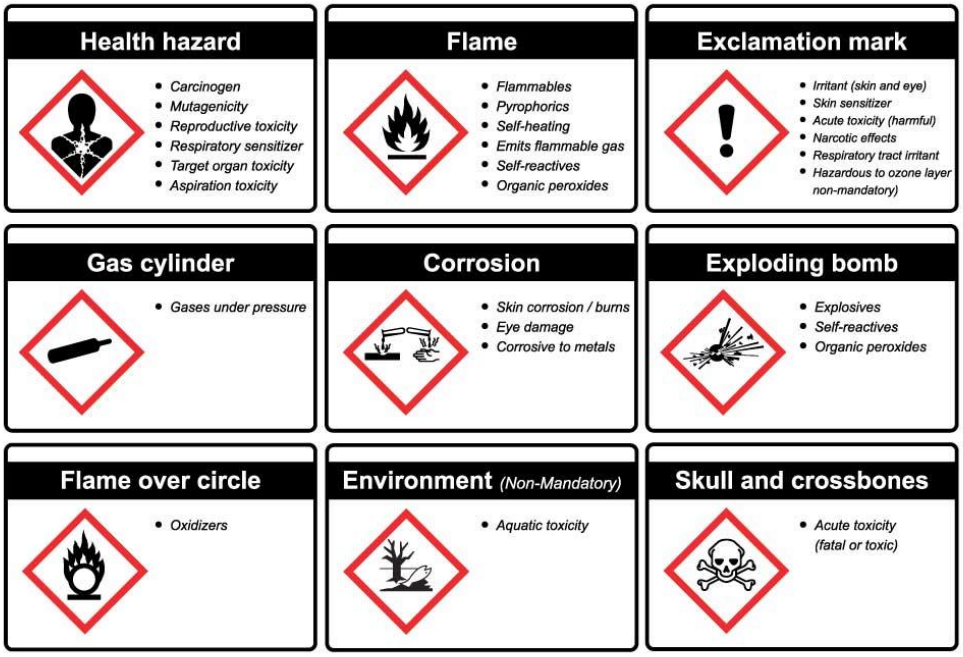


Figure 4: Understanding Global Harmonized System Pictograms

The other necessary part of hazard communication systems is chemical labeling. Chemical containers have labels on them which present very important information including name of the chemical, classification of its hazards, signal words showing the magnitude and precautions that should be followed when handling or storing it. Such labels are used as a quick guide that workers working with dangerous materials can use, as well as to facilitate the observance of the necessary procedures related to safety.

Safety Data Sheets (SDS) contain information on chemical substances used in industrial works in addition to labels and pictograms. SDS documents include rigorous information on safety, in terms of chemical composition, physical properties, health risks, exposure limits, handling procedures, emergency matters and disposal. The employees and the safety workers use SDS documents to learn about the dangers of certain chemicals and take adequate precautions.

The hazard communication systems can only be effective when the workers are aware of the information being communicated. The safety training is thus very vital in ensuring that the employees are able to understand hazard labels, pictograms, and SDS information correctly.

Training programs involve most commonly education on chemical Hazard recognition, safe handling practices, emergency response measures and use of personal protective gear.

Education level of workers, language barriers and culture in the workplace also determine the effectiveness of hazard communication. The language barrier, which can be manifested by differences in language knowledge and literacy levels, can influence the workers in their understanding of the safety information in the industries that have a multicultural workplace. This makes visual symbols and in particular GHS pictograms particularly significant since they offer hazard warnings that are recognized worldwide (Boman et al., 2024).

Occupational safety studies indicate that the better hazard communication mechanisms are established, the more hazard awareness employees and better risk perception and adherence to safety measures are exhibited. On the other hand, poor communication can contribute to the lack of hazard awareness, risky work with chemicals, and the higher possibility of occupational accidents.

In petrochemical industry within the state of Kuwait, the hazard communication systems are important in safeguarding employees against chemical exposures as well as the operational risk factors. To determine the effectiveness of industrial hygiene management practices in these workplace, it is therefore important to assess the level of understanding of GHS symbols and labels as well as safety information among the workers.

Suggested Visuals for Section 2.5

Table 4: Components of Hazard Communication Systems

Component	Description	Purpose
GHS classification	Standardized classification of chemical hazards	Ensures consistent hazard identification
Hazard	Visual symbols representing hazard	Quick hazard recognition

pictograms	types	
Chemical labels	Information attached to chemical containers	Provides handling and safety instructions
Safety Data Sheets	Detailed chemical safety documentation	Comprehensive risk information
Safety training	Worker education on hazard communication	Ensures correct interpretation and compliance

2.6 Worker Risk Perception and Safety Behaviour

Perception of risks and safety behavior by workers are key considerations that determine the success of occupational health and safety systems in industries under high risks. The final success of safety management even with the use of advanced safety technologies and monitoring systems in organizations is determined by the perception that workers have towards risks and how they react to them in their day to day undertakings (Astiaso Garcia et al., 2013).

Risk perception is defined as the manner in which people interpret and judge the possible dangers in the surrounding. In the workplace, risk perception by workers will be used to determine their level of compliance to safety protocols, the use of protective gears and the way workers will act upon warning signs. When employees feel that hazards are dangerous and relevant to them, they will tend to adopt protective activities that minimize the chances of accidents or injuries.

Risk perception concept is highly linked with behavioural safety theory, as it focuses on human behaviour, which helps to avoid accidents at workplace. The behavioural safety techniques concentrate on psychological and social variables that affect the activities of workers, including the levels of attitudes to safety, perception of risks, peer pressure, and safety culture in organisations.

Unsafe behaviour is a large aspect of the work place accidents according to the behavioural safety theory. These may be behaviors such as neglecting the safety procedures, neglecting wearing protective materials, circumventing safety controls, or performing shortcuts when undertaking duties. Such behaviors can be caused by different reasons such as a deficit of awareness, time pressure, complacency, or wrong estimation of the severity of risks.

Perception of risks is fundamental in influencing the behavior of workers to adopt safe or unsafe behaviors. Employees who do not consider the risks posed by some activities might think that safety measures are not as necessary as they are rather limiting. Conversely, employees with a clear knowledge of the probable effects of dangerous exposure will tend to act in accordance with safety protocols, and take proactive steps to prevent the risky behaviour.

The perception of risk among workers in the industrial setting is dependent on a number of factors. These are prior experience of accidents, safety training level, knowledge of workplace hazards, transmission of safety information, and confidence in the safety management systems in the organizations. Whenever workers are exposed to a regular safety training and effective hazard communication, they are likely to develop more realistic perceptions of the risks at the workplace.

Another concept that is significant in occupational safety research is safety compliance. The concept of safety compliance is the extent to which the workers adhere to the set safety rules, procedures and guidelines aimed at saving them against risks (Boman et al., 2024). The possible compliance behaviors that can be undertaken include using personal protective equipment, observing operation procedures, reporting hazards and attending safety training programs.

Nevertheless, compliance might not be the sole concept that defines the scope of safety behaviors portrayed by workers. Other researchers identify the difference between safety compliance and safety participation. Safety compliance is the observation of required safety measures, and safety participation can be considered as the voluntary behavior that leads to the improvement of workplace safety, i.e. reporting safety hazards, assisting coworkers and participating in safety enhancement programs.

Both types of safety behavior have to be present in high risk sectors like petrochemical processing. The employees should also follow safety practice and procedures in addition to being proactive in

recognizing possible hazards besides playing a role in ensuring the overall safety culture of the company (Fu et al., 2019).

According to the literature, the developed hazard communication systems can impact the perception of risks and safety behavior among workers at a significant level. Whenever the workers are fully aware of the hazard posed by the chemicals and industrial processes, it would be easier to identify the dangerous situations and react accordingly. Consequently, hazard communication is a significant process of converting technical safety data into more behavioral results.

In conducting this research, it is necessary to know the correlation of hazard communication, risk perception, and safety behavior in order to determine the efficiency of industrial hygiene management systems in the Kuwait petrochemical industry. The research is expected to identify aspects leading to safer industrial workspaces and better occupational health outcomes because the researchers will be concerned with how workers perceive hazards and react to them in actual situations.

Table 5: Factors Influencing Worker Risk Perception

Factor	**Description**	**Impact on Safety Behaviour**
Safety training	Knowledge of workplace hazards	Improves awareness and compliance
Hazard communication	Understanding of warning labels and symbols	Enhances risk recognition
Previous experience	Past exposure to accidents or hazards	Influences caution levels
Organizational safety culture	Management commitment to safety	Encourages safe behavior

2.7 Theoretical Framework

The theoretical framework of the proposed study gives the conceptual basis of the relationship between governance, hazard communication, and worker perceptions and how they interact to determine the level of safety behaviour in hazardous industrial settings (Ajzen, 1991). Within the framework of occupational safety studies, behavioural and organizational theories have been adopted to identify why employees either engage in safe or unsafe behaviour at the workplace. Some of the commonest frameworks used include the Health Belief Model (HBM), Theory of Planned Behaviour (TPB) and Safety Climate Theory. All these theories have a reason behind the development of workplace safety in relation to individual perceptions, organization and behavioural intention.

The theoretical foundation of this study integrates the Health Belief Model (HBM), Theory of Planned Behavior (TPB), and Safety Climate Theory to explain worker safety behavior in the petrochemical industry. According to HBM, workers' perception of risk—their awareness of chemical hazards and potential health consequences—influences their motivation to adopt protective behaviors. TPB complements this by linking behavioral intention to actual safety compliance, suggesting that workers who understand hazards and perceive risk are more likely to act safely. Safety Climate Theory emphasizes the role of managerial governance and organizational culture in shaping safety norms, demonstrating that strong leadership and effective hazard communication enhance workers' risk perception and adherence to safety protocols. Prior studies have shown that governance quality and clear hazard communication positively affect risk perception, which in turn mediates safety behavior, supporting the conceptual framework of this study (Astiaso Garcia et al., 2013; Boman et al., 2024; Achumie et al., 2022).

2.7.1 Health Belief Model (HBM)

One of the earliest psychological models that were developed to explain the health-related behaviours is called the Health Belief Model. The model was developed by social psychologists researching the behaviour of the populace in relation to health matters and suggests that people are more prone to take action to protect themselves where they feel there is a health threat and the action will decrease the risk. HBM is constructed on a number of main constructs, which include the perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to

action, and self-efficacy. Perceived susceptibility is a belief of a person about the possibility of being hurt or sick whereas perceived severity is the severity of the possible consequences. People tend to engage in risk-aversive behaviours when they suspect that they are susceptible to extreme damages (Gopalan, 2016).

The Health Belief Model in the industrial setting is useful in explaining the reaction of the workers to work hazards in an industrial setting like a petrochemical facility. Whenever workers are exposed to chemicals and feel that such exposure is potentially hazardous, and they are aware of the possible side effects on their health, they will tend to adhere to best safety practices, wear protective items, and adhere to control means of hazards (Ajzen, 1991). Hazard communication systems like chemical labels and safety warnings may act as indicators of action which will help to build awareness of the workers about the hazards at the workplace.

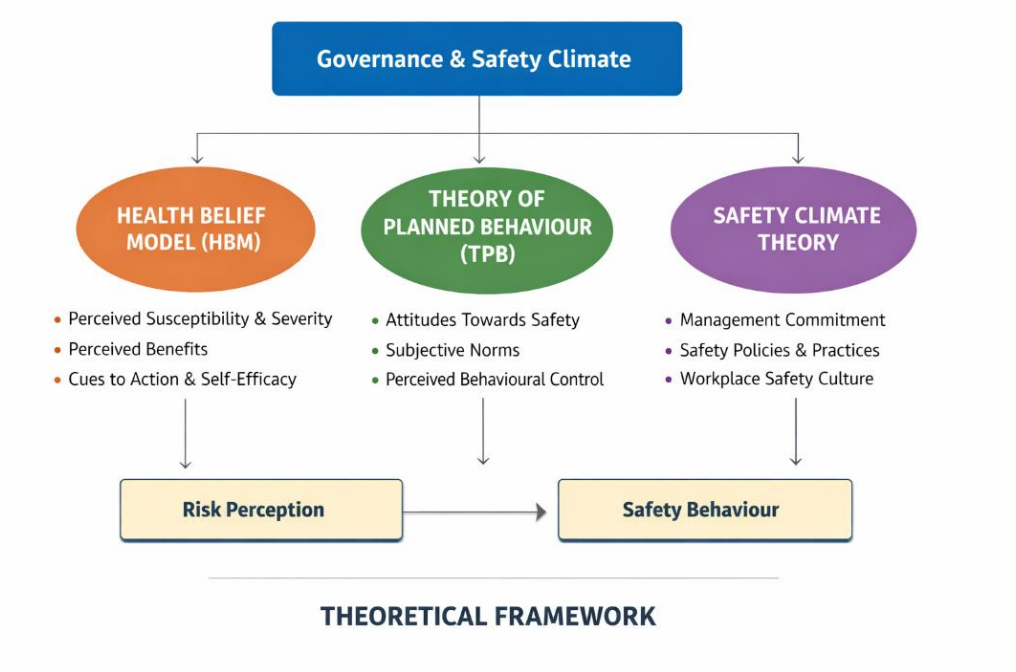


Figure 5: Theoretical Framework

2.7.2 Theory of Planned Behaviour (TPB)

Another theory that is extensively applied in explaining human behaviour at both the organisational and safety environment is the Theory of Planned Behaviour introduced by Ajzen (1991). Behaviour according to this theory is mostly determined by behavioural intention which

is influenced by three variables i.e. attitudes towards the behaviour, subjective norms and perceived behavioural control.

Attitudes are used to the consideration of a behaviour made by an individual, e.g. is adhering to safety practices deemed to be helpful or not. Subjective norms entail social pressure that people feel as a result of their workmates, superiors, and organizational culture. Perceived behavioural control is an indicator that shows how much individuals feel they possess the capability and means to carry out a given behaviour (Hymel et al., 2011).

The Theory of Planned Behaviour is useful in explaining the decision-making process of workers with regards to adherence to safety regulations and protocols in the workplace. Employees who hold the view of the significance of following safety measures, the social pressure to act safely, and the ability to adhere to safety measures are more likely to be motivated towards following safe practices.

In petrochemical workplaces, attitudes towards safety can be raised through the use of hazard communication and safety training which will improve the social expectation of workers in staying abreast with safety rules and enhance the level of confidence in the capabilities of the participants to adhere to safety rules. In turn, TPB offers a viable model of the role of organizational communication and governance in worker safety behaviour.

2.7.3 Safety Climate Theory

Whereas the Health Belief Model and the Theory of Planned Behaviour accentuate the perceptions and intentions of the behaviour, the Theory of Safety Climate accentuates the influence of the organizational setting on safety behaviour. Safety climate entails the collective beliefs of employees in the significance of safety in their company. It indicates the attitude that workers have towards the management in terms of management commitment to safety, implementation of the safety policies, and the priority they accord to safety in their daily activities (Hymel et al., 2011).

The available literature in occupational safety indicates that organizations that have a good safety climate record low accident rates as well as safety compliance levels. When it is clear to employees that the management cares about the safety, they tend to adhere to safety protocols, report incidents involving hazards, and engage in safety programs.

The governance structures, the leadership behaviour and communication systems in the organization have a strong impact on safety climate. The overall safety climate can be reinforced by management measures, including the delivery of safety training, implementation of safety policies, the provision of resources to manage hazards, and the quick response to safety issues (Nasution et al., 2022).

The Health Belief Model in this study describes the perception of occupational hazards by the workers and the ways in which risk perception produces an effect on safety behaviour. The Theory of Planned Behaviour offers an understanding of the influence of attitudes, the social factors and perceived control on safety compliance. The Safety Climate Theory emphasizes the organizational environment that affects the perceptions and behaviour of the workers.

Combined, these theoretical lenses give a comprehensive framework of the study of the effects of the governance and hazard communication systems on the worker risk perception and safety behaviour in the petrochemical industry in Kuwait.

2.8 Research Gap

Although there is extensive literature regarding the topic of occupational health and safety management in the hazardous industries, in the context of petrochemical industry in Kuwait, there are various gaps of significance in the literature regarding industrial hygiene, hazard communication, and worker safety behaviour (Shahverdieva et al., 2020).

To begin with, there is a prominent absence of empirical researches that specifically deal with the industrial hygiene management practices within the petrochemical industry of Kuwait. Although considerable studies on occupational safety have been carried out in the industrialized world, very little scholarly research has been done into the specifics of operation and environmental factors in the Gulf region. The petrochemical industry in Kuwait is functioning on a background with extreme environmental conditions, complicated industrial infrastructure, as well as the presence of a diverse workforce with a combination of workers of several cultural and linguistic backgrounds. These aspects present unique problems to the industrial hygiene management that are not fully addressed in the literature (Shaikh, 2020).

Second, there is little research on the effectiveness of hazard communication in petrochemical

workplaces especially in the knowledge of the workers about the Globally Harmonized System (GHS). Even though the GHS framework has gained considerable acceptance in most industrial sectors, the understanding of hazard pictograms, chemical labels, and safety data sheets in the workplace by industrial workers is not well explored. Under conditions where dangerous chemicals are processed on a regular basis, the efficacy of hazard communication systems is greatly defined by the capacity of workers to respond correctly to the safety information.

Third, the connection between hazard communication, worker risk perception and safety behaviour within the petrochemical industry has not been adequately studied. Most occupational safety research is done in terms of accident statistics, safety management systems, or regulatory compliance, whereas less research is done on the behavioural processes by which safety communication affects decision-making and behaviour of workers (Tabor and Moraru, 2022).

In addition to this, there is little evidence that has been conducted on the role of organizational governance and safety leadership in increasing the level of worker perceptions of hazards and safety compliance in the industrial sector of Kuwait. The form of governance is important in determining safety culture, safety communication systems and safety procedure enforcement but the connection of governance practices with safety behaviour of workers has not been significantly researched.

This study is valuable in that it will help in solving these research gaps to enhance the quality of the industrial hygiene and the result of occupational safety in the petrochemical industry of Kuwait. This research will address the relationship between governance, hazard communication systems, risk perception, and safety behaviour, which is the interaction between the process and its results, hence to offer new knowledge with relevance to the academics and practical safety management measures.

2.9 Conceptual Framework

This study conceptual framework demonstrates the associative nature of the key variables that are under consideration in the study. According to the literature review and theoretical framework mentioned in the earlier sections, the research hypothesis is that the governance structures and hazard communication systems impact the worker risk perception, which also impacts the worker

safety behaviour in petrochemical workplaces.

Governance is the forms and patterns of organization, leadership directed to safety in industrial organizations. Effective industrial hygiene programs such as hazard communication systems and safety training programs are likely to be implemented with the help of strong governance structures.

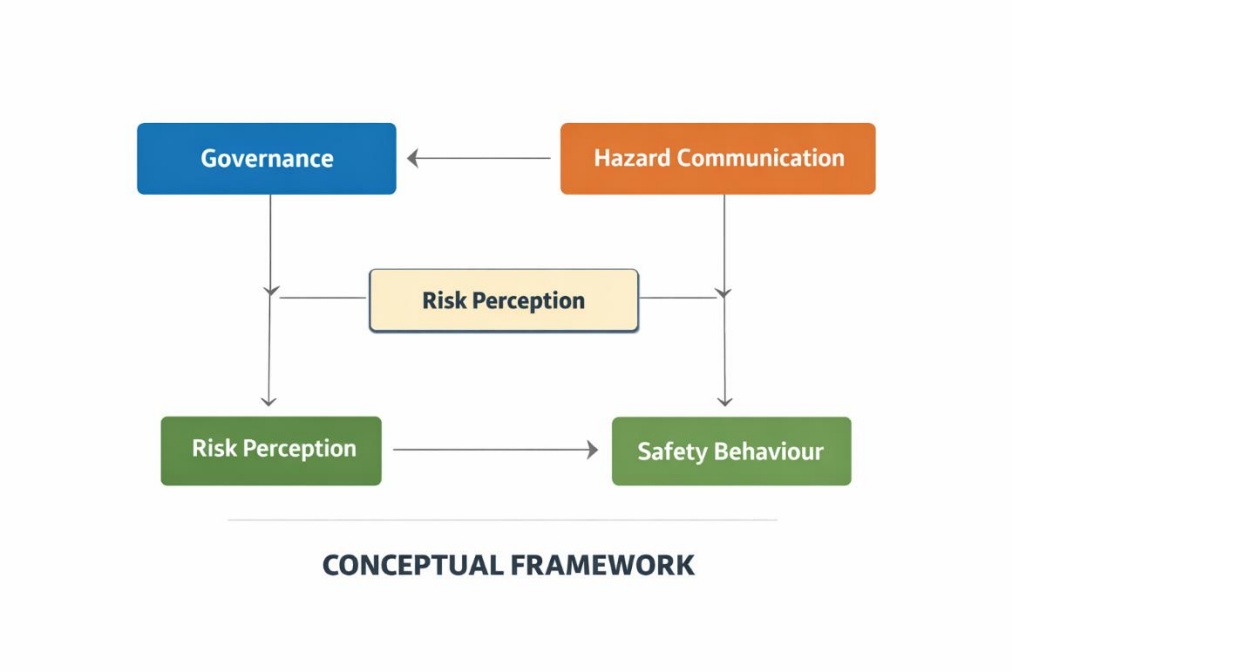


Figure 6: Conceptual framework on safety behaviour

The GHS labels, pictograms, and safety data sheets are some of the tools used to pass the information on the chemical hazards to the workers through the hazard communication systems. Communication on hazards will help to increase the knowledge of workers with potential hazards and the capacity to identify hazardous conditions.

Risk perception is the perception by workers of risks involved in exposure to chemicals and other risks at the workplace. When workers have a clear understanding of the level of risk and probability of dangers, they have more chances to adopt protective behaviour and adhere to the safety measures (Younes Mehrifar et al., 2023). Safety behaviour is defined as the measures adopted by the workers in order to ensure that they are safeguarded against the hazards at the work place and others. These behaviours are adherence to safety procedures, wearing personal protective

equipment, proper response to warning signs and hazard information. The conceptual framework thus offers the opinion that both governance and hazard communication directly and indirectly affect the safety behaviour via the perception of risk by workers. These relationships will be understood to be able to establish factors promoting a better industrial hygiene management and safer working conditions in the petrochemical industry of Kuwait.

2.10 Conclusion

The chapter has discussed available literature pertaining to the industrial hygiene management, occupational health hazards, and governance, hazard communication system, and worker safety behaviour in risky industrial environments with specific focus on petrochemical industry. The review offers the theoretical and conceptual background of the research on the impacts that organizational and behavioural factors have on the workplace safety outcomes.

The first topic of the chapter was about the principles and practices of industrial hygiene, the role of occupational exposure assessment, workplace monitoring, and organized industrial hygiene programs in the prevention of occupational hazards. Industrial hygiene management practices are quite necessary in the petrochemical processing industries where workers are frequently prone to chemical, physical, and environmental hazards to minimize health risks and ensure safe working environments.

The occupational health hazards related to the petrochemical industry were also addressed in the literature such as the chemical hazards, toxic exposures, and occupational accidents. Complexity of industrial processes and the hazardous substances involved in refining and petrochemical processes tend to increase these risks. Consequently, there is a need to have proper safety management systems and effective hazard communication practices that would help guarantee that workers understand the possible risks and are able to react to hazardous situations in an appropriate way.

Moreover, the chapter explained the significance of governance and safety management in determining the safety outcome in the workplace. The safety leadership, regulatory systems, and organizational safety culture all have an impact on the implementation of the safety policies, the way the workers recognize and react to the hazards. Hazard communication systems especially the

Globally Harmonized System (GHS) are very important in offering standardized information on dangerous chemicals and safe handling.

The theoretical construct of the research is an amalgamation of the Health Belief Model, the Theory of Planned Behaviour and the Safety Climate Theory to describe the effects of governance structures and hazard communication on the worker risk perception and safety behaviour. The theoretical and empirical background was used to come up with a conceptual framework of the study to demonstrate a relationship among governance, hazard communication, risk perception, and safety behaviour.

On the whole, the literature examined in the chapter reveals the significance of knowledge of both organisational and behavioural issues in the enhancement of the industrial hygiene management and work safety in the petrochemical industry of Kuwait. The next chapter shows the methodology of the research in order to explore these relationships empirically.

Chapter 3: Research Methodology

Chapter 3 provides the methodology used to explore the associations between the managerial governance, hazard communication effectiveness, training accessibility, worker risk perception, and safety behavior in the petrochemical industry in Kuwait. The main goal of this chapter is to explain in detail the research design, sampling strategy, data collection techniques, instrumentation of the variables, instrument validation, data analysis plan, and ethical considerations. The study results require reliability, validity and generalizability of the findings and provide empirical evidence for testing the proposed conceptual framework and hypotheses, therefore, there is a need for a rigorous and systematic methodology.

This chapter starts with a description of the research design, the rationale for choosing a cross sectional quantitative survey design. By using this design, it is possible to gather standardised data from several participants at a specific time, therefore offering a snapshot of the practices and behaviours of the organisation and of individuals involved in hazard communication and working safely. The chapter then outlines the target population and describes the sampling procedure used, which incorporates stratified random sampling to ensure a representative and balanced sampling of operators, maintenance staff and safety officers, based on varying exposure, duties and access to safety training.

The chapter then outlines the data collection techniques and tools (structured questionnaire and the GHS pictogram comprehension test). Operational definitions, item wording, and measurement scales have been carefully considered for every instrument, with organizational and individual level constructs being measured. Measurement of variables section provides information on the measurement of independent, dependent and mediating constructs in relation to the theory to ensure consistency and facilitate sound statistical analysis.

The chapter also covers instrument validation and pilot testing, which show how the initial testing of the survey and the pictogram assessment are done to ensure clarity, feasibility, reliability, and construct validation of the assessment. Internal consistency of scales is assessed by Cronbach's alpha, and exploratory factor analysis is conducted to test the factor structure of scales that are comprised of multiple items. In addition to this, methodological triangulation was used, by having both subjective and objective measurements, further enhancing the validity and credibility of the instruments.

The chapter also provides the data analysis plan that will be used to describe demographic and important study variables, test for direct links, and explore the working of the worker risk perception between the organizational factors and the behaviors of safety. The plan guarantees that the research hypotheses are well tested, and the results will be both meaningful and practical.
Finally the chapter covers ethical issues that include confidentiality, informed consent, compliance with regulatory requirements, and minimizing risk. Ethical protections are in place to safeguard participants' rights, ensure proper data management, and responsibly communicate results. Together, these methodological approaches offer a strong theoretical foundation for research on the organizational and behavioral factors that influence hazard communication and safety behaviors that lead to valid and reliable results and meaningful implications for academic research and industry application.

3.1 Research Design

The research uses a cross sectional quantitative survey design which is suitable for studying the relationship between managerial governance, the effectiveness of hazard communication, worker risk perception and safety behavior in the petrochemical industry in Kuwait. A cross sectional design can collect a multitude of workers' data at one time and give a snapshot of the organizational and behavioral factors affecting hazard communication effectiveness. This is a method that is especially appropriate for measurable constructs that can be measured along numerical scales and analysed statistically, such as governance quality, understanding of Globally Harmonised System (GHS) pictograms, training accessibility, perceived risk etc.

The methodology used for the quantitative survey is directly related to the research goals. It specifically intends to statistically assess the impact of managerial governance on hazard communication and safety acts, and to investigate the mediating effect of employees' risk perception. Structured questionnaires provide standardized, comparable data across participants and appropriate for multivariate analyses such as regression and mediation modeling. The approach aligns with previous research on industrial hygiene and behavioral safety, which have focused on organizational and individual factors that affect hazard communication results in high-risk chemical processing settings (Younes Mehrifar et al., 2023; Boman et al., 2024).

In addition, the survey design provides practical benefits with regard to feasibility and efficiency.

It allows the researcher to communicate with operators, maintenance staff and safety officers in various petrochemical plants without the need for complicated measurement of exposures, which can be resource-intensive and time consuming. The research can take organizational governance and behavioral measures into account instead of direct chemical exposure measures, allowing to provide actionable insights applicable to policy and managerial decisions.

Table 3.1 below illustrates an overview of the key constructs, their operationalization, and the approach to their measurement for the cross-sectional survey design, to better understand the research design's connection to the study objectives.

Table 6: Alignment of Research Design with Study Objectives

Objective	Key Constructs	Measurement Method	Justification
Examine the relationship between managerial governance and hazard communication effectiveness	Managerial governance quality, hazard communication effectiveness	Structured questionnaire, Likert scale, GHS pictogram comprehension test	Allows quantification of governance and communication outcomes for statistical analysis
Assess the impact of training and communication practices on worker risk perception	Training accessibility, communication clarity, perceived risk	Likert-scale items and standardized survey questions	Enables evaluation of how organizational practices influence worker perceptions
Evaluate the influence of risk perception on safety behavior	Risk perception, safety behavior	Survey items adapted from behavioral safety literature	Supports mediation analysis to test theoretical model
Develop evidence-based managerial framework	Integration of above variables	Quantitative analysis and modeling	Provides policy-relevant insights based on statistically tested relationships

In a nutshell, the cross section quantitative research design is a structured approach, it is replicable,

and it is statistically sound to accomplish the study goals. It helps organize data that will reflect both the organizational process and individual behaviour responses which can be used to develop an empirically-based manager's framework of hazard communication and safety in the petrochemical industry in Kuwait.

3.2 Population and Sampling

Operators, maintenance workers and safety officers working in petrochemical processing plants in Kuwait are the target population for this study. These groups were chosen as they are the main groups with exposure to chemical and biological hazards and because their daily work involves direct contact with potentially hazardous airborne compounds, e.g., volatile organic compounds, industrial gases and airborne particulates. The study targets these occupational groups to provide a representative sample of data that reflects practices and personal reactions to hazard communication systems in hazardous workplaces.

With the study's emphasis on organizational governance, training availability and worker safety behaviour, the population was determined as workers with at least six months of experience in their roles. This criterion provides that there is adequate exposure to the facility's safety management systems, training, and communication procedures for hazards, such as the Globally Harmonised System (GHS) of chemical classification. The sample is restricted to those who have a sufficient period of employment to reduce the variation due to lack of familiarity with work-safety and give more meaningful measurements of comprehension and behavioural adaption.

A stratified random sampling method will be used to get a representative sample. The employees will be segmented by job type and department based on differences in exposure risk, job function and exposure information. Operators, maintenance workers and safety officers are in different strata, due to their distinct interactions with hazardous materials, training received and their role in safety enforcement. Stratification also provides an equal sample size for each of the subgroups, so that more accurate comparisons can be made between the roles and the results are more generalizable to the larger petrochemical industry population.

The number of samples is expected to be 200-300. This size is deemed adequate to conduct intensive multivariate statistical analyses, such as regression analysis and mediation analysis,

which play a vital role in testing the proposed relationships in the conceptual framework. The sample size is also determined in relation to the feasibility, so the study could be conducted in multiple petrochemical facilities, and to the statistical power, because of the need to use structured questionnaires and pictogram comprehension test. In addition, the sample selected will contain sufficient variation to ensure a broader range of managerial governance, communication clarity, training access, and safety behaviors will be captured, which in turn will increase the reliability of the analysis.

Data collection will consist of coordination with facility management to identify eligible participants within each stratum. The lists of employees from the HR and safety departments will be retrieved to ensure that participants are included in the study and to ensure random sampling within each stratum. For those employees who refuse to participate or who don't meet the tenure requirement, a random selection of alternates from the same stratum will be chosen to maintain representativeness of the sample. This process helps to ensure that the data collected accurately represent the population's diversity in terms of both experiences and exposure, and this is essential to assess the impact of managerial decision making on hazard communication and safety behavior.

To sum up, the population and sampling have been planned to provide accurate, representative and reliable information from employees who are most impacted by hazard communication practices. The stratified random sampling method also increases external validity and gives the ability to analyze sub-group differences, such as risk perceptions and behavioral adherence of operators, maintenance and safety officers. The systematic sampling method and a careful definition of the population positions the study to generate statistically significant and practically relevant results that will aid in the process of enhancing the governance of industrial hygiene and outcomes in the petrochemical industry of Kuwait.

3.3 Data Collection Methods

The data collection is an integral part of the study as it has a significant impact on the accuracy, reliability and validity of the results obtained. This study aims to analyse the relationships between managerial governance, effectiveness of hazard communication, worker risk perception and safety behaviour in the petrochemical industry of Kuwait. Since this research is quantitative, structured survey method was chosen as the main method of data collection. Surveys provide the means to

systematically gather standardized data from many participants and assure statistical rigor and comparability that is needed for the planned multivariate analyses and hypothesis testing.

The data collection process aims to capture both organizational and individual behavioral responses and details the impact of managerial decision-making, communication clarity and training accessibility on understanding and implementation of hazard communication systems, specifically the Globally Harmonised System (GHS) pictograms. The methods have been chosen to provide the opportunity for objective measurement of the constructs of interest within the time and resource limitations imposed on the study.

3.3.1 Structured Questionnaire Design

Structured questionnaire is the main data collection instrument, which has been developed based on previous studies in industrial hygiene, safety governance and behavioral safety (Younes Mehrifar et al., 2023; Tabor & Moraru, 2022; Gopalan, 2016). The questionnaire has several parts that address certain variables of the conceptual framework. The questionnaire has been designed to be clear, standardized and reliable, and the items have been structured using available scales and adjusted to the context of Kuwait's petrochemical industry.

There are the following sections of the questionnaire:

Demographic and Professional Information: This section gathers the general information about the respondents such as age, gender, level of education, job role (operator, maintenance or safety officer), department and experience years they have in the facility. These variables will be useful in examining intergroup differences and controlling for possible confounding variables in the regression analyses.

Managerial Governance: Items under this section assess the quality of managerial decision-making and governance including leadership commitment, policy implementation, resource allocation and supervisory oversight. The responses are graded on a 5-point Likert scale from “Strongly Disagree” (1) to “Strongly Agree” (5) so that the quality of governance can be quantified for statistical analysis.

Hazard Communication Effectiveness: Assesses clarity, access and effectiveness of hazard

communication in the facility. Staff are encouraged to feedback on the clarity, consistency and relevance of safety messages. The GHS pictogram comprehension test helps complement this section by objectively assessing workers' knowledge about chemical hazard pictograms.

Training Accessibility and Training Quality: This section evaluates the availability, frequency and perceived quality of safety training programs. Items assess if workers are appropriately trained in hazard communication, whether it is easy to access training materials, and how training promotes safe behaviors.

Worker Risk Perception: Participants are asked to assess their risk perception regarding threats in the workplace, the seriousness of the threat and their ability to manage the threat. They have been adapted from Health Belief Model (HBM) constructs and assessed with a Likert scale to measure the risk perception.

Safety Behavior: This section reflects self-reported compliance with safety procedures, proactive risk mitigation and hazard communication. Items are modified based on behavioral safety literature to fit with the empirical studies conducted in industrial settings.

However, since the majority of technical employees in the Kuwait petrochemical plant are fluent in English, the structured questionnaire has been prepared in English. A pilot test was carried out with 20 respondents to ensure the questions were understood by all respondents, irrespective of their language background and for this reason minor changes to the wording and clarity of the questions were made. Self-reported and objective measures are included on the final questionnaire to enhance data validity.

3.3.2 GHS Pictogram Comprehension Test

The study also provides a GHS pictogram comprehension test in addition to the questionnaire, which is a quantitative assessment of the effectiveness of hazard communication. This test will assess the knowledge of chemical hazards by having the participants match a set of a standard group of hazard symbols with their meaning. The pictogram test can also assess how effective the hazard communication process is directly in order to measure worker understanding of the hazard communication process quantitatively, which is essential to understanding the relationship between managerial governance and behavioral safety outcomes.

Ten pictograms are used in the GHS test, representing common chemical hazards found in petrochemical facilities, including flammables, corrosives and toxic agents. Each correct identification earns a point and target scores are combined by respondent for a total comprehension score. It is then standardized and included as a dependent variable in regression and mediation analyses. This objective measure provides triangulation to the self reported perception items in the questionnaire's hazard communication section, thereby enhancing the reliability of the results.

3.3.3 Administration of Data Collection

The data will be collected during the onsite field visit visits in selected petrochemical plants in Kuwait.Data will be collected during the field visits in the selected petrochemical plants within Kuwait. Coordination with facility management to make sure that workers in the target population, such as operators, maintenance personnel, and safety personnel are available and meet the inclusion criteria (6-month employment). Questionnaires and the pictogram tests will be given in allocated times, and the researcher will give clear directions and clarify any questions that might arise to ensure that the test is answered correctly.

Respondents are guaranteed anonymity and that their responses will only be used for research, so that they feel comfortable in answering and reporting what is happening truthfully, without fear of being judged by others. The instruments were administered after obtaining consent forms, stating the purpose of the study, voluntary participation and ethical considerations. Data is collected as soon as the questionnaires are completed, minimizing data loss and also improving response rates.

3.3.4 Measurement and Scoring of Variables

Each section of the questionnaire and pictogram test is designed to generate quantitative data suitable for statistical analysis. Table 3.2 summarizes the variables, measurement tools, and scoring methods.

Table 7: Summary of Data Collection Instruments and Measurement

Construct	Measurement Tool	Scale/Method	Scoring

Managerial Governance	Likert-scale items adapted from governance and safety studies	5-point scale	Higher scores indicate better governance practices
Hazard Communication Effectiveness	Questionnaire items + GHS pictogram test	Likert-scale + objective test	Average Likert score; pictogram test scored 0–10
Training Accessibility	Survey items assessing frequency, access, and quality	5-point Likert scale	Higher scores indicate better access and quality
Worker Risk Perception	Adapted from Health Belief Model	5-point Likert scale	Higher scores indicate higher perceived risk
Safety Behavior	Self-reported adherence to safety protocols	5-point Likert scale	Higher scores indicate safer behaviors

This table clarifies the operationalization of each variable, demonstrating how the survey and pictogram tests provide quantitative metrics for statistical modeling.

3.3.5 Pilot Testing and Instrument Validation

To test the clarity, reliability, and validity of the survey instrument, a pilot study was undertaken with 20 employees from similar petrochemical facilities. The ambiguous wording and the sequence of items was based on the feedback received from participants, which helped to improve the test of the pictogram test and ensure that it truly reflected workplace hazards.

The reliability of the questionnaire is measured by the Cronbach alpha, and the minimum

acceptable value is 0.7 for multi-item scales. Confirmatory factor analysis (CFA) is used to assess construct validity whereby the survey items reflect the constructs measured as intended, for example managerial governance, communication clarity and risk perception. The pilot test verifies that data obtained from the instruments are consistent, reliable and valid for the main study.

3.3.6 Advantages of the Selected Data Collection Methods

The chosen data collection techniques were a structured questionnaire complemented by an objective GHS pictogram comprehension test, which offers a comprehensive approach to collecting both organizational and individual factors affecting the effectiveness of hazard communication and safety behavior in the petrochemical industry in Kuwait. The main benefit of this combined measure is that it allows them to assess both the perceived and real understanding of hazard communication systems. The self-reported questionnaire measures the employees' perceptions, attitudes and self-reported compliance with the safety protocols, but the pictogram test measures the employees' actual understanding of the chemical hazard symbol. This dual method helps prevent potential self-reported bias, like over-reporting of compliance or social desirability bias, that can affect the data, and ensures it reflects workers' knowledge and implementation of safety procedures.

One benefit of standardized survey items is the use of the Likert scale, which enables key constructs like managerial governing behavior, communication clarity, the availability of training, risk perception, and safety behavior to be systematically quantified. Standardized items increase reliability and comparability of responses across the sampled population, and produce data that are appropriate for using in rigorous statistical analyses like multivariate regression, correlation and mediation modeling. This will allow for the assessment of complex relationships within the conceptual framework including indirect effect of managerial governance on safety behavior via hazard communication and risk perception. The survey results provide empirical data to test the proposed hypotheses, enhancing the scientific rigor of the research.

The ability to carry out the structured survey in several petrochemical plants is another benefit. The structured approach facilitates the researcher to gather data from a large sample size from a dispersed population (operators, maintenance staffs and safety officers). Stratified random sampling provides representation by job role, department and exposure level that allows

comparison between subgroups and increases the generalizability of findings to the wider petrochemical workforce. Also, it is possible to give the survey in a specified place, having instructions and the researcher's supervision, ensuring that the survey is completed without a lack of consistency and incompleteness.

Finally, the combination of pilot testing and instrument validation assures the reliability, quality of data gathered. Pilot testing not only helps the researcher to detect and eliminate ambiguous items, but also to clarify the wording of items and ensure the relevance of the pictogram test. Multi-item scales are tested for internal consistency and construct measurements are validated by reliability analysis (e.g., Cronbach's alpha) and exploratory factor analysis. The comprehensive validation process helps ensure the data's accuracy and reliability, offering a solid foundation for further analysis, testing of hypotheses, and model construction.

To conclude, the tools used, namely the structured questionnaire and the objective pictogram assessment, have several advantages. It provides a way to assess perceived and actual understanding, provides standardized analyzable data that can be subjected to statistical testing, enables efficient collection of data from a representative sample, and allows for the reliability to be established by pilot testing and validating the data. All these benefits render the chosen methods suitable for fulfilling the study goals and provide meaningful actionable lessons for managerial governance, hazard communication and behavioral safety in high-risk industrial settings.

To sum up, the data collection techniques are well planned and are appropriate to the research objectives and methodology. The structured questionnaire examines key organizational and behavioral parameters and the GHS pictogram test gives objective proof of the effectiveness of hazard communication. The instruments undergo pilot testing, reliability assessment and construct validation, which increase the scientific value of the instruments. The overall plan provides for quantitative, generalizable and statistically valid data, thus laying a firm foundation for subsequent analysis, hypothesis testing, and development of evidence-based managerial approach for improvement of hazard communication and safety behavior in the petrochemical industry in Kuwait.

3.4 Measurement of Variables

Measurement of variables is one of the most important aspects of any quantitative research study

since, it makes the constructs in a conceptual framework operational in a reliable and valid way. The main purpose of the present study is to examine the effect of three variables; the managerial governance, the availability of training resources, and the clarity of communication on the effectiveness of hazard communication, the perception of risk among workers, and the workers' safety behavior in the petrochemical industry in Kuwait. The measurement of these variables is essential in evaluating the statistical relationships among them as hypothesized in the research hypotheses, and in providing practical implications of the research findings for policy and management. The study examines variables on both the organizational and individual level, which are operationalized in structured survey instruments and objective assessments that cover the phenomena under study in a comprehensive manner.

3.4.1 Independent Variables

Hazard communication effectiveness and safety behavior are influenced by the independent variables in this study which are organizational determinants.

Managerial Governance is described as the goodness of leadership, policy implementation, allocation of resources and supervision over petrochemical organizations. This construct reflects the ways that management affects the culture of safety and that practices of hazard communication are implemented. Structured Likert-scale survey items are employed to measure managerial governance that are adapted from previous studies on the topic of industrial hygiene and safety governance (Younes Mehrifar et al., 2023; Boman et al., 2024). Items that are measured include leadership commitment to safety, transparency of policy, resources, and employee feedback. The items are all anchored on a 5 point Likert scale ranging from “Strongly Disagree” (1) to “Strongly Agree” (5). A composite managerial governance score is calculated for each respondent by aggregating the scores and higher scores indicate better governance practices.

The second independent variable is Training Accessibility, which includes both availability and frequency of safety training courses as well as the perceived quality of available safety training courses. In high-risk chemical environments proper training is crucial to ensure workers understand and follow the communication of hazards and the safety rules. The items on training accessibility seek participants' responses to the frequency of training, the availability of training materials, relevance of training to the day-to-day work and how well training has enabled participants to understand the pictograms and safety practices of GHS. These items are also measured on a 5-point Likert scale, with a higher score for the aggregate indicating more access

to training and higher perceived quality.

Communication Clarity is used as an extra independent variable. Transparency, understandability and uniformity of communications of safety information to staff, such as hazard symbols, written information and verbal briefings. Communication is a critical component to making managerial policies into safety behaviors. Survey questions elicit participants' ratings of the clarity, unambiguity, understandability across various language backgrounds, and actionability in daily operations of messages. The responses of the Likert scale are summed to create a score for clarity of communication that is then used in further statistical analyses.

Table 3.4 summarizes the independent variables, operational definitions and types of measurement.

Table 8: Independent Variables – Operational Definitions and Measurement

Variable	Operational Definition	Measurement Tool	Scale/Scoring
Managerial Governance	Quality of leadership, policy implementation, supervision, and resource allocation	Structured survey items adapted from governance literature	5-point Likert scale; higher scores = better governance
Training Accessibility	Availability, frequency, and quality of safety training programs	Survey items assessing frequency, relevance, and accessibility	5-point Likert scale; higher scores = better accessibility
Communication Clarity	Clarity and consistency of hazard communication messages	Survey items on comprehension, consistency, and actionability	5-point Likert scale; higher scores = clearer communication

3.4.2 Dependent Variables

The dependent variables used in this study reflect outcomes at the worker level that are affected by the governance and communication of the organization.

Safety Behavior is the main dependent measure, which is the degree of safety behaviors engaged in, proactive risk reducing behaviors, and compliance with organizational hazard communication

policies. This construct is assessed using survey items reported by the participants, drawn from the behavior safety literature (Tabor & Moraru, 2022). The questions address personal protective equipment (PPE) use, following GHS guidelines, reporting unsafe conditions and involvement in safety programs. The individual items are scored on a 5-point Likert scale ranging from not at all to very often, with higher scores representing more adherence and more safe practices.

Hazard Communication Effectiveness is a dependent variable and a mediating variable in this study. Evaluates how well workers comprehend and use hazard communication and GHS pictograms. There are two ways of measuring: subjective survey items and an objective pictogram comprehension test. Survey items measure employees perceptions of clarity, relevance and accessibility of the communications. The pictogram test is represented through 10 standard GHS symbols which are given to the participants and they are requested to associate them with their corresponding meaning. Each of the correct responses is awarded 1 point, and each incorrect response is awarded 0 points, for a total of 0 points to 10 points. Mixing subjective and objective measures provides a strong evaluation of the effectiveness of hazard communication.

3.4.3 Mediating Variable

The intervening variable between organizational factors (managerial governance, training, and clarity of communication) and safety behavior is conceptualized as Worker Risk Perception. The items adapted from the Health Belief Model (HBM) are used to measure risk perception. They assess how likely they are to be exposed to hazards in the workplace, the level of potential exposure to hazardous chemicals or microorganisms, and how effective they believe they are at reducing these risks by following the safety rules. Responses are summed up to determine the risk perception score using a Likert scale. Scores more positive suggest greater risk awareness and increased willingness to perform risk compensatory actions. This variable is used to examine mediation effects, determining if the mediation between managerial governance and hazard communication and safety behavior exists**.**

3.4.4 Operationalization of Variables

The operationalization of all variables is summarized in Table 3.5 to provide a clear overview of how each construct is defined, measured, and scored.

Table 9: Operationalization of Variables

Variable	Type	Operational Definition	Measurement Tool	Scale/Scoring
Managerial Governance	Independent	Leadership, policy implementation, supervision, resource allocation	Structured survey items	5-point Likert scale; higher scores = better governance
Training Accessibility	Independent	Availability, frequency, and quality of training programs	Survey items	5-point Likert scale; higher scores = better accessibility
Communication Clarity	Independent	Clarity, consistency, and comprehensibility of messages	Survey items	5-point Likert scale; higher scores = clearer communication
Hazard Communication Effectiveness	Dependent / Mediator	Understanding and application of hazard messages and GHS pictograms	Survey + GHS pictogram test	Likert scale for perception; 0–10 for pictogram comprehension
Worker Risk Perception	Mediator	Employees' perceived susceptibility and severity of hazards	Survey items based on HBM	5-point Likert scale; higher scores = higher perceived risk
Safety Behavior	Dependent	Adherence to safety protocols and proactive hazard mitigation	Survey items adapted from behavioral safety literature	5-point Likert scale; higher scores = safer behaviors

3.4.5 Theoretical Justification for Measurement Approach

The measurement strategy is based on the theories of behavior and organization and is conceptually valid and measurable. Managerial governance is based on organizational theory with focus on leadership, policy enforcement and governance as factors influencing organizational effectiveness. The Health Belief Model (HBM) is used as a foundation for explaining the effectiveness of hazard communication and risk perception, and connects risk perception with behaviour. The application of Theory of Planned Behavior (TPB) also provides for measurement of attitudes, norms and perceived behavioral control as predictors of safety behavior. Combining these theoretical viewpoints allows for organizational determinants and individual responses to be measured.

The objective pictogram test is used to supplement the subjective survey items to establish criterion validity of the effectiveness of hazard communication. The study uses several measures which triangulate data and thus minimize measurement error and increase the strength of the results. All responses are coded on a Likert Scale, enabling all constructs to be measured and appropriately modeled using multivariate statistical analysis such as regression, correlation, and mediation analysis.

3.4.6 Reliability and Validity of Measurement Instruments

The reliability and validity of the measurement tools is an integral part of quantitative research. The validity and reliability of the instruments to measure each construct have a critical effect on the credibility of the results obtained in this study which examines the effects of managerial governance, effectiveness of hazard communication, workers' perception of risk and safety behavior in the Petrochemical Industry in Kuwait. Reliability is the consistency in which a measurement instrument gives the same result from one application to the next under similar conditions while validity is the extent to which an instrument measures the concept that it is intended to measure. Reliability and validity play an important role in the rigor and trustworthiness of quantitative data, as well as for meaningful and interpretable subsequent analyses such as regression, mediation, and structural modelling.

In this study, internal consistency of multi-item scales is the major source of reliability considered. Internal consistency: degree of correlation between the items of the scale and between the items and the construct measured. The assessment of managerial governance, for instance, is based on

several items of the survey, which focus on leadership commitment, policy clarity, resource allocation and supervisory oversight. The items should be measurability on governance quality consistently across items.

Cronbach's alpha is used as the main criterion for internal consistency. A statistical measure of the reliability of a set of items, with the possible values of 0 and 1. The higher the number, the more reliable it is. For multi-item constructs, a score of 0.7 is considered acceptable (Nunnally & Bernstein, 1994) and was used for this research. If the value is greater than 0.8, it means that the overall reliability of the instrument is good, and if the value is above 0.9, it means that the overall reliability is excellent. In the pilot test, Cronbach's alpha will be calculated for each multi-item scale of the questionnaire, which includes the managerial governance, training accessibility, communication clarity, risk perception and the safety behavior of the questionnaire. This process will help to ensure that the scales used in the final data collection are reliable, thereby minimizing measurement error and increasing the reliability of the results.

For constructs with fewer items, or objective tests, such as the GHS pictogram comprehension assessment, test-retest reliability is used to measure reliability. This includes giving the pictogram test to a small number of people twice, usually with a time interval of 1-2 weeks. The correlation of the two sets of scores suggests the stability of the instrument over time. The high correlation values indicate that the instrument has a good test–retest reliability, meaning that workers' knowledge of hazard symbols is not being influenced by transient variables such as mood or fatigue.

Also, the study examines the inter-item correlations in each scale to look for any items that do not meaningfully contribute to the scale. Very low correlations with other items or negative correlations could signify ambiguity or deviation from the construct and may need to be modified and/or eliminated before full-scale data collection. The iterative refinement of the survey items is to ensure that all the elements of each scale make a coherent and reliable measure of the construct.

Construct validity is the extent to which a measurement instrument is valid in its representation of the theoretical construct it is designed to measure. The importance of construct validity in this study is due to the fact that the variables being studied in this study are abstract variables that are not directly observed, which are organizational and psychological variables of management, effectiveness of hazard communication, and risk perception and safety behavior by workers. It is important that the instruments adequately measure these constructs if meaningful analysis is going

to be done.

In the study, exploratory factor analysis (EFA) is used as the main technique for the assessment of construct validity. EFA studies the structure of multi-item scales in order to determine whether items group together in the manner theorized by the scale's developers. For instance, the items designed to assess managerial governance should be loaded onto one factor (measuring governance quality) and those designed to assess the accessibility of training onto a different factor (measuring training accessibility). Loadings ≥ 0.4 are regarded as acceptable evidence that the item is related to the construct under investigation. Those items that are not well loaded (have low loading or multiple cross loadings) should be considered for removal or re-wording.

Content validity is also achieved by expert review and literature alignment, in addition to EFA. Items for the survey are developed from validated industrial hygiene, behavioral safety and organizational governance instruments that were previously used (Gopalan, 2016; Younes Mehrifar et al., 2023; Tabor & Moraru, 2022). The instruments are reviewed by subject-matter experts (SMEs) including industrial hygiene professionals and occupational safety managers to make sure that items are representative, comprehensive, and contextually relevant to the Kuwait petrochemical industry. This process ensures that the instruments represent all of the dimensions of each construct and that no important dimension is missing.

The GHS pictogram comprehension test is also included to address criterion-related validity. The pictogram test measures actual knowledge of hazard communication while self-reported survey items measure perceived knowledge. Convergent validity is supported by the relationship between the scores on the survey items and the comprehension of the pictograms. The self-reported level of understanding of the employees' work is correlated positively with their actual knowledge, lending support to the measurement approach.

The GHS pictogram test is a novel part of this study that is objective validation of the effectiveness of hazard communication. Reliability is determined by test re-test methodology outlined above and internal consistency is measured to ensure that all pictogram items are measuring the comprehension of hazard symbols. Validity of the pictogram test is demonstrated by a mapping of the items to the established GHS framework, as well as consultation with safety experts to verify that the selected pictograms adequately represent the chemical hazards found in the workplace. The study uses both objective and subject measures, which helps reduce potential biases and increases the overall robustness of the measure.

In order for the study to be more reliable and valid, methodological triangulation is used. The study combines several types of measurement, including self-reported survey items, objective pictogram comprehension tests, and expert review, to provide a comprehensive and accurate assessment of the effectiveness of hazard communication. Triangulation minimizes the chance of a single measure error influencing the results, enhances construct validity, and offers greater depth of understanding of the interaction between managerial governance, communication clarity, and worker safety behavior.

The reliability and the validity of the measurement instruments directly affects the data analysis. Variance in the data is minimized by relying on reliable scales, so that any variation that is seen is due to true differences in the respondents, and not due to measurement error. Valid instruments allow statistical tests, such as regression or mediation analyses, to examine meaningful relationships and not relationships created because of constructs that are not well defined. The pre-structured reliability and validity criteria increase the credibility of those conclusions and help to ensure that the policy recommendations and managerial frameworks that are derived from the analysis are based on sound empirical evidence.

Finally, the trustworthiness of measurement tools used in this study is guaranteed with multiple complementary strategies. To evaluate internal consistency, Cronbach's alpha is used, while test-retest reliability is used in the GHS pictogram test and inter-item correlations are analyzed to modify survey instruments. Exploratory factor analysis is used to assess construct validity, expert review for content validity and survey self-report compared against objective comprehension of pictograms for criterion-related validity. Triangulation between and within methods, and using subjective and objective data, guarantees reliable and consistent measurement of all constructs. These rigorous procedures serve as a basis for future statistical analysis and hypothesis testing, which ensures reliability, validity and usefulness of the study results to enhance hazard communication and safety behavior in the petrochemical industry in Kuwait.

To conclude, the measurement of variables in this study is aimed to capture the organizational factors and the outcomes at the worker level as comprehensively as possible. The independent variables (managerial governance, training accessibility, communication clarity) are assessed with structured Likert scale survey items, the dependent variables (hazard communication effectiveness, safety behavior) are assessed with survey items and objective pictogram assessments. The risk perception of workers is used as a mediating variable. Tables of variables,

operational definitions, instruments, and scoring are clear and transparent. The combination of validated scales, objective testing, pilot testing, and reliability testing assures high quality, quantifiable data for rigorous statistical analysis. This approach allows testing of the proposed hypotheses and the development of a framework for enhancing hazard communication and safety behavior that is grounded in the evidence.

3.5 Pilot Testing and Validation

In quantitative research, the development and refinement of research instruments involves a critical step, namely pilot testing, especially in high stakes industrial environment like petrochemical industry in Kuwait. The main objective of pilot testing is to validate and confirm both the feasibility and the reliability and validity of the data collection instruments before full scale administration. Pilot testing was done in this study to validate the structured questionnaire and the Globally Harmonised System (GHS) pictogram comprehension test, which measures managerial governance, training accessibility, communication clarity, hazard communication effectiveness, worker risk perception, and safety behavior. The pilot study helps to identify and address any potential issues with the instrument design, understanding, and administration, minimizing the risk of potential data errors and improving the overall quality of the research.

The pilot study was conducted with a small sample of twenty persons selected from the petrochemical industry sites that had the same operational conditions as the main study sites. The participants were chosen to reflect a range of operators, maintenance workers and safety officers to ensure that the pilot sample reflected a range of roles, exposures and responsibilities in the study population. The stratified approach enabled the researchers to evaluate the understandability and applicability of the survey items and pictogram test across the various job functions as well as evaluate meaningful variation in the perception of governance, communication and safety behavior. Participants were requested to fill in the survey and pictogram test in the same conditions as they would be asked to for the full-scale data collection.

In pilot testing, several important factors were assessed such as clarity of instructions, understanding of the language, length of the questionnaire, the relevance of the items, and administration procedures. The responses of participants identified the areas of ambiguity, confusion and redundancy in the survey items. For instance, some items measuring clarity of communication needed to be restated to make sure that every employee, regardless of their level of English, understands the message and doesn't misunderstand it. Likewise, the order of the items

presented in the survey was designed to reduce respondent fatigue and to improve the logic of the questionnaire, starting with the demographic and moving to the organizational constructs and behavioral items. The pilot testing process ensured that the instruments are contextually appropriate, culturally sensitive and operationally feasible for the Kuwait petrochemical workforce.

One of the main concerns in the pilot testing was reliability analysis. The multi-item scales were evaluated for internal consistency with the widely used measurement of reliability in quantitative research, Cronbach's alpha. Cronbach's alpha is used to determine the level of consistency of the items in a scale and a measure of the correlation among the items. For social science research, 0.7 is regarded as acceptable level of reliability and indicates that items are measuring one's intended construct. The Cronbach's alpha was used to analyze each of the multi-item scales during pilot testing: managerial governance, training accessibility, communication clarity, worker risk perception, and safety behavior. The results showed that the scales have values above 0.7, which indicates that they have high internal consistency. The items with lower correlations or negative correlations to the scale were selected for revision or elimination in order to have reliable measure items in the main study. The iterative process of fine-tuning of the items increased reliability, as well as the clarity and relevance of the constructs measured.

Construct validity was also tested by exploratory factor analysis (EFA) and reliability was tested. Construct validity is validated by the accuracy of the items of the survey in representing the theoretical constructs the survey is supposed to measure. EFA can be especially helpful in pilot testing, giving researchers an opportunity to explore the factor structure of multi-item scales and to determine if items belong to the intended factors. This study employed EFA with each multi item construct analyzed separately, with principal component analysis, varimax rotated for maximum interpretability. Factor loadings were analysed to check the representativeness of items for intended constructs. Items with factor loadings less than 0.4 were regarded as weak indicators, and were either rewritten or eliminated from the final survey instrument.

The EFA results were consistent with this as the items assessing aspects of managerial governance, training access and communication clarity were grouped cleanly into separate factors, indicating that these organizational constructs are conceptually and empirically distinct. In the same way, the items that loaded on the worker risk perception and safety behavior factors did so at the appropriate level, and were found to adequately capture the intended constructs at the individual level. The

GHS pictogram comprehension test was an objective test and was subject to preliminary validation through the examination of the difficulty and discrimination index of the items. If an item was too easy or too difficult for the pilot sample, this was flagged and the item was changed to be of an appropriate level of difficulty to differentiate levels of understanding among respondents in the main study.

Pilot testing also helped to assess the relationship between independent variables and inter-scale correlation as well as potential multicollinearity. The researchers looked at correlations between managerial governance, training availability and communication transparency to ensure the constructs were correlated, but not so correlated as to reduce the unique measurement. This step was crucial in preparing the instruments for the subsequent multivariate analysis such as regression analysis and mediation modelling. This preliminary descriptive analysis and normality of responses provided the research team with a basis for refining the instruments and the data collection procedure and identified any outliers or anomalies on the measurement scales.

The other important factor in pilot testing was to evaluate the practicality of data collection procedures. This research team monitored the time it takes to complete the questionnaire and pictogram test to ensure the instruments can be completed in a reasonable amount of time, without causing fatigue or disengagement among participants. The procedures for conducting the survey were standardized, such as using APA style to read each item for those who requested it, ensuring confidentiality, and emphasizing that responses were voluntary. The pilot study also showed that the survey as well as the pictogram test could be used effectively in the field, verifying the logistical feasibility of both data collection and the use of the questionnaire test for the large-scale data collection.

Pilot participants' feedback also helped with enhancing ethical protections and understanding by respondents. The participants were asked to give input regarding the clarity of consent forms, the anonymity of the answers and their level of comfort with participating. Changes were made to the consent process to ensure that participants were fully aware of the purpose of the study, their rights, and confidentiality of their responses. The attention to ethics both supports the validity of answers as well as conforms to best practices in occupational safety and organizational research.

The instruments were then pilot-tested and refined and finalised, which involved changes to the wording of the items, the sequence of the items, the response options and the pictograms used. The internal consistency, the factor structure and the contextual relevance of the final survey and GHS

test are high, reflective of Kuwait's petrochemical industry. Those validation procedures give confidence that the instruments are able to be used to measure the theoretical constructs that are of interest, thus laying a good foundation for the primary measurement of the instruments.

To conclude, the purpose of the pilot testing in this study was very multifaceted. It was also used to test the clarity, practicability, reliability, and validity of the instruments, to detect and revise ambiguous items and items that were not working well, to confirm the factor structure of the multi-item scales, to test the instruments in field settings, and to strengthen ethical practices for engaging participants. High quality, consistent and meaningful data is generated through the use of Cronbach's alpha for reliability, exploratory factor analysis for construct and expert review for content. The pilot testing of the instruments which ensures both reliability and validity gives the study a solid methodological basis for studying the relationship between managerial governance, the effectiveness of hazard communication, worker's risk perception, and safety behavior in high-risk industrial settings.

3.7 Ethical Considerations

Other important considerations in the pilot testing were the practicality of data collection tools. The research team observed how long it took for participants to complete the questionnaire and pictogram test, and made sure that the tests did not take too long or cause anyone to get bored or feel overwhelmed. Instructions for administering the survey were uniform and included verbal assistance (where requested) and confidentiality and voluntary participation. In the pilot study, it was shown that the survey and pictogram test could be conducted efficiently in the field, thus confirming the logistical feasibility of the data collection of the full scale.

Pilot participants also provided feedback that helped enhance ethical protections and understanding of the respondents. Participants were asked to comment on the ease of understanding the consent forms, anonymity of responses, and ease of being involved. The consent process was modified to ensure that the purpose of the study, the rights of the participant, and the confidentiality of the responses was clearly understood. This focus on ethical issues contributes to the soundness of the responses, as well as to the prevailing best practice in occupational safety and organizational research.

After pilot testing, the instruments were modified and finalized, with adjustments to the wording of the items, item sequence and the types of items as well as the pictograms. The internal consistency, the factor structure, and local relevance of the final survey and GHS test are high,

suitable for the petrochemical industry in Kuwait. These validation procedures give assurance of the reliability and validity of instruments in capturing the theoretical constructs that are considered in the main data collection process.

To summarize, in this study pilot testing has played several important roles. It enabled the research team to test the clarity, feasibility, reliability and validity of the instruments;Ethical considerations are an important component in any research work involving human subjects and are especially critical in high risk industrial environments such as a petrochemical plant. In the present study, managerial governance, effectiveness of hazard communication, workers' perceptions of hazard, and workers' safety practices are explored in relation to operators, maintenance workers, and safety officers in the petrochemical industry in Kuwait. The information gathered is sensitive for instance because it concerns organizational practices, safety compliance and worker behavior, therefore ethical integrity is crucial to safeguard participants and to maintain the credibility of the research and to respect national and international research regulations. The ethical guidelines that underlie this study are confidentiality, informed consent and regulatory compliance, as detailed below, and are explored in relation to participant engagement through ethical procedures.Confidentiality, informed consent and regulatory compliance are the three domains of ethical principles that inform this study; they are explored in relation to participant engagement through ethical procedures and below are items identified and corrected as ambiguous or poorly functioning. The instruments achieved high-quality and meaningful data by combining the reliability (Cronbach alpha), construct validity (exploratory factor analysis), and content validity (expert review). The study also made a significant contribution to the methodological discussion by comprehensively addressing reliability and validity issues via extensive pilot testing, which created a solid methodological framework for exploring the relationships between managerial governance, the effectiveness of hazard communication, worker risk perception, and safety behavior in high-risk industrial settings.

3.7.1 Confidentiality

Another important factor in pilot testing was also evaluating the practicality of data collection methods. The research team observed the time needed to fill out the questionnaire and pictogram test, insuring that it could be completed within a reasonable period of time without causing fatigue or disinterest in the test. The administration of the survey was standardized, and instructions included how to read items to the person when they requested it, how to keep the responses

confidential, and how to be sure that all responses were voluntary. The pilot study showed that the survey and pictogram test could be effectively carried out in the field, thus proving the logistical feasibility of the data collection in the field.

Pilot participants gave feedback that also helped to enhance the ethics protections and understanding of the respondent. Feedback was requested on how easy it was to understand consent forms, anonymity of responses, and overall comfort reading the consent form. Modifications to consent were made to ensure that participants clearly understood the purpose of the study, their rights and the confidentiality of their responses. This focus on ethics not only enhances the credibility of the responses, but is also consistent with best practice in occupational safety and organizational research.

After pilot testing, the instruments were further modified and finalized after making changes in the wording of the items, sequence of items, response options of items and selection of pictogram. The final survey and GHS test show good internal consistency, factor structure and that they are suitable for the Kuwait context of the petrochemical industry. As such, these steps of validation give confidence that these instruments reflect the theoretical constructs of interest and lay a solid foundation for the main data collection stage.

To conclude, the pilot test in this study played an important role to get the information that is needed. It enabled the researchers to assess the clarity, feasibility, reliability, and validity of the instruments;Ethical consideration is an integral part of any research study which involves human participants, and has a more significant role in high risk industrial environment like a petrochemical plant. The current study focuses on the managerial governance, effectiveness of hazard communications, risk perception, and safety behaviors of operators, maintenance workers and safety officers in the petrochemical industry in Kuwait. The information gathered is highly confidential, related to the organizations' practices, safety compliance and worker behaviours, thus, the ethical integrity is extremely important to safeguard participants, the credibility of the study and the national and international research regulations. There are three themes that underpin the ethical approach taken in this study: confidentiality, informed consent, and regulatory compliance, all of which are elaborated on below, identifying and rectifying ambiguous or underperforming items, ensuring that multi-item scales are comprehensively understood by participants, and ensuring that ethical processes are followed and reinforced for engaging participants. Reliability (Cronbach's alpha), construct validity (exploratory factor analysis), and

content validity (expert review) guarantees good quality and consistency of the final instruments, and that the data obtained is meaningful. The study comprehensively covers both reliability and validity, which were tested through a pilot study to provide a solid methodological basis for analyzing the relations and confidentiality of the data in the context of organizational studies, especially since individual answers may have professional or personal consequences. For the purposes of this study, the respondents are requested to fill in details related to their perceptions of managerial governance; access to safety training; understanding of hazard communication systems and compliance with safety practices. These responses may be based on one's attitudes, what one knows, or critical observations on managers, and could affect the participants' interactions with their supervisors and/or peers if not addressed properly.

All data gathered from structured surveys and GHS pictogram tests is anonymous, to provide confidentiality. Participants are given an individual identifier and no personally identifying information like names, employee ID, contact information is gathered. Identification codes can be used to link responses from a survey to test scores from the GHS, and yet keep the anonymity of the respondents. Completed questionnaires are kept in locked cabinets which are only accessed by the research team and datasets are also digitally stored and locked with a password to prevent unauthorised access.

Moreover, data reporting and dissemination takes place in an aggregated manner. Data is reported at the group level to avoid being able to trace individual responses to specific employees or departments, as well as providing descriptive statistics and outputs from the regression analysis and mediation analysis. Quotes and examples used from participants' responses have been generalized and anonymized in order to not identify specific participants. These measures of confidentiality allow participants to respond freely and honestly without any fear of social desirability bias, and ensure the data reliability and validity.

A relationship between the management of hazards and how effective the communication is, and between the worker's perception of risk and their behavior in such a high hazard environment was found.

3.7.2 Informed Consent

Informed consent is also an important ethical consideration, involving that participants acknowledge the nature, purpose and implications of the study before agreeing to participate. The study will ensure that all participants receive a detailed information sheet about the aim of the

study, the voluntary nature of their participation, the procedures to be followed and possible risks and benefits. This information is communicated in a way that is clear and easily understood, and can be presented in other languages if required to suit the educational and language proficiency levels of staff.

The participants are told that they are not obligated to do so and can leave at any time without consequences. This is a voluntary framework that strengthens autonomy and guarantees consent is voluntary. Participants are asked to sign a written consent form prior to giving the survey and GHS pictogram test, indicating knowledge of the study, their rights and consent to participate. The researcher provides oral explanations and obtains verbal consent, the latter documented according to ethical guidelines, for participants that have limited literacy or language barriers.

Data use, storage and consent is also covered in the consent process. Participants are made aware that the data gathered will be only for the purposes of academic research and that the results will be shared in an aggregated format to ensure confidentiality. Moreover, participants may be sure that a data is securely stored for a certain time period as defined by the institutional requirements and is subsequently destroyed so that it will not be available for future violation of privacy. The study has stringent informed consent protocols, ensuring that participants are aware of their rights, the nature of the study, and the purposes of data analysis, thus complying with internationally accepted ethical standards.

3.7.3 Regulatory Compliance

Abiding by the national and institutional research rules is crucial for ethical standards and legal compliance. The ethical aspects of this study are in accordance with the ethical guidelines set forth by the Ministry of Health of the Republic of Kuwait, the internal safety and research committees of the petrochemical facilities, and international guidelines, such as the Declaration of Helsinki and the Belmont Report. These principles highlight respect for persons, beneficence, and justice, which underlie the ethical principles of research with human subjects.

All relevant institutional review boards (IRBs) and facility management were approved prior to data collection. The IRB process helps to ensure that the study's design, data collection tools, and methods are ethical and that any risks to participants are minimized. The research team also adhered to organizational policies such as occupational safety and data handling policies within the organization. The safety of the participants was always taken into account, especially since the study takes place in high-risk industrial environments. The survey and pictogram test sessions take

place at safe times and participants are not asked to undertake any hazardous activities as part of the survey.

Moreover, the study is carried out with adherence to data protection rules, with respect to the security of data storage, access restrictions, and control in the use of all data. Digital datasets are encrypted and kept on secure servers with only restricted access to the research team. Questionnaires are kept in locked cabinets in secure offices as hard copies. All information provided to collaborators and/or for publication are anonymous and summarized to ensure that no individual participant or facility is identifiable. The study's protocol will be designed to meet these regulatory standards, ensuring that it is legal, ethical, and respects the rights and welfare of all participants.

3.7.4 Risk Minimization and Participant Welfare

Although the physical risk in the study is minimal, there is a potential for psychological and social risk. The participants may be uncomfortable or anxious to evaluate managerial governance or report their understanding of hazard communication. The study strives to minimize these risks by using neutral and respectful language when writing survey questions, avoiding judgmental and evaluative statements. Participants are told that the answers are confidential and no there are no right/wrong answers.

Furthermore, the research team is present in a supportive manner throughout the data collection process, clarifying as needed and making sure that the participants are not being pressured to respond. Any concerns raised by participants are attended to right away; participants are reminded that they may skip any item or leave the study without any consequences. These measures aim to ensure the welfare of participants with emphasis throughout the research process.

3.7.5 Ethical Reporting and Dissemination

Ethical issues don't just arise during data collection, but during data analysis, data report, and dissemination. All results are reported precisely and objectively; there is no fabricating, falsifying, or selective reporting. Presentations, publications and internal reports are kept confidential and data are reported in general or aggregate form. The research team makes sure that analysis of the data is based on what they have gathered and does not extend beyond it, nor is it misrepresented. Ethical reporting also entails clear reporting of any limitations, potential biases or conflicts of interest that may affect the findings.

In addition, the study highlights beneficence by providing positive contributions to the academic literature, industrial safety practices and organizational policy development. The recommendations made based on the study are to strengthen the hazard communication system, to promote safety behavior, and to guide the management practices in the petrochemical industry. The participants and organizations are assured that the results of the study may give practical feedback to improve occupational safety, thereby showing respect for the principle of beneficence. To sum up, the ethics for this research are well planned and ensure the safety of participants, integrity and adherence to regulations. Anonymization, data security and aggregate reporting ensures that data will be kept confidential in the study. Informed consent is achieved via detailed information sheets, verbal and written acknowledgment and clear communication of the participants' rights. Institutional Review Board approval, respect for national and international ethical standards and meticulous data protection measures are used to assure regulatory compliance. Risk minimisation strategies focus on the care and concern of the participants while ethical reporting ensures accurate, transparent and actionable reporting of results. Together, these measures provide a strong ethical framework and assure that the research is conducted with integrity, respect, and accountability and that the research results are reliable, valid, and impactful, in the area of hazard communication and safety behavior in the petrochemical industry.

3.8 Conclusion

Chapter 3 describes the research methodology used to explore the relationships between managerial governance, hazard communication effectiveness, the accessibility of training, worker risk perception and worker safety behavior in the petrochemical industry of Kuwait. The chapter describes the research design, study population and sampling, data collection tools and data measuring methods, pilot testing and validation, data analysis plan and ethical considerations, which were followed during the study. This in-depth approach makes sure that the research is done with integrity, efficiently, and following the best practices in quantitative organizational research. Cross sectional quantitative survey design is used for the study, as it can be used to evaluate the effect of organizational and individual factors on safety outcomes at one time. Using the cross sectional approach, data can be gathered from a wide range of operators, maintenance personnel, and safety officers in a cost-effective manner, thereby providing a snapshot of how well managers are doing, how well the operators understand hazards, how they perceive the risks, and how they behave in the workplace in a number of petrochemical facilities. The quantitative survey technique

is suitable for the research aims and it allows standardized measures, objective measures and advanced statistical analysis to test hypothesized relationships empirically. This design will allow the study to measure organizational and behavioral constructs that are measurable without directly exposing the subjects to contact monitoring, which would be time consuming and risky for them.

The population of the study is the workers who are involved directly in the operational and safety processes in the petrochemical factories, such as operators, maintenance and safety officers. The groups were chosen because they had high exposures to chemicals and actively use hazard communication systems. To ensure participants are familiar with the safety procedures, training and organizational governance practices, they had to be employed for at least six months in their respective positions. Stratified random sampling was used to ensure representation across job roles and departments, which would provide a representative and generalizable sample. For the multivariate regression analyses and mediation analyses, a sample size of 200–300 was considered to be adequate to achieve a high level of statistical power. A fair and inclusive sampling procedure was well planned and conducted in collaboration with facility management and operational limitations.

The instruments used to collect the data in this study are the combination of the structured survey instrument and objective assessment which gives quantitative and behavioral data. The main tool is a structured questionnaire with sections on: demographic, managerial governance, training availability, communications clarity, risk perception by workers, effective hazard communication and safety behaviour. The items were measured on a 5-point likert scale where higher scores represent more favourable outcomes. The questionnaire reflects organizational determinants and individual behavioral responses, and can be analysed in terms of direct and indirect effects in the conceptual framework. The study also includes a GHS pictogram comprehension test to assess objectively the comprehension of the chemical hazard symbols by employees, and a questionnaire. The use of subjective perceptions in addition to objective performance measures overcomes the potential for self-reported data bias and offers a more complete assessment of effectiveness of hazard communication.

Carefully, variables are measured to be able to quantify them in an accurate way with each construct. The variables that are not affected by the dependent variable are called independent variables. These independent variables are measured by several items on Likert scale, which are managerial governance, training accessibility and communication clarity. The former are the

dependent variables that include the effectiveness of hazard communication and safety behavior—assessed both subjectively, through items in the survey, and objectively, through the pictogram test. The construct of worker risk perception was used as a mediating variable, which was assessed through items developed based on the Health Belief Model that included perceived susceptibility, severity and self-efficacy to the hazards at work. Tables of variables, operational definition, instrumentation and scoring procedures are used to give clarity and transparency, with the constructs being empirically supported, and statistically analyzable.

The instruments were tested in a pilot test with 20 people before the data collection of the main study began to assess the clarity, reliability and validity of the instruments. The pilot study showed the presence of some items that were unclear in the survey and these were revised to make the items easier to understand for all participants regardless of their language knowledge. Pilot testing was also used to test the feasibility of the introduction of the questionnaire and the pictogram test in the operation, and to ensure that the instruments can be filled out efficiently without compromising the quality of the data.

Cronbach's alpha was used to determine the internal consistency of multi-item scales, thus evaluating the reliability of the data. The reliability of all constructs was found to be adequate with all constructs above 0.7. Low correlations and negative contributions were modified and/or eliminated. Exploratory factor analysis (EFA) was used to determine the construct of validity, which showed that the items on the survey showed a proper loading on the construct. The difficulty and discrimination of the pictogram test was evaluated to ensure that the test was able to differentiate the grades of comprehension. Another approach to strengthening the validity and reliability of the instruments was methodological triangulation that involved the use of subjective responses from the survey, objective pictogram scores, and expert evaluation.

The data analysis plan combines descriptive, inferential and mediation analyses. Descriptive statistics are used to summarize data that is used to gain insight into the central tendency, variability and patterns of the data. The focus is the direct relationships of independent variables with dependent variables in regression analyses and the importance of worker risk perception in the transmission process of the effect of organizational factors on safety behavior in mediation analysis. The analysis plan provides for a careful testing of the hypotheses with a sound interpretation of direct and indirect effects in the conceptual framework. Tables, graphs and a path diagram are used to further clarify and to present the results.

Finally, ethical issues are part of the methodology, which is applied to the collection, storage, analysis and reporting of data. The confidentiality of the responses is maintained by anonymizing the responses, secure storage of physical and digital data, and aggregation reporting. Detailed information sheets are available and informed consent is gained verbally and/or in writing including emphasis on voluntary consent and right to withdraw at any time. The research is in accordance with the national policy, organizational policy and international guidelines of research ethics, such as the Declaration of Helsinki and the Belmont Report. The use of risk minimisation strategies protects participants from psychological and/or social discomfort, and ethical reporting creates transparency, accuracy and beneficence.

Overall, Chapter 3 has shown that the study is conducted with a systematic and rigorous method and that there is a good ethical basis for the study. As a result, the research is scientifically sound and also practically relevant, as it has been designed as a cross sectional survey, the stratified sampling, the structured measurement instruments, the pilot testing, the reliability and the validity has been checked and the data has been analysed in a comprehensive way. The methodology offers a solid basis for investigating how managerial governance, training availability, and communication clarity affects the effectiveness of hazard communication, worker risk perception and safety behavior, which offers information that is relevant and practical for both academic research and industrial safety practice.

Chapter 4: Results

4.1 Descriptive Statistics

4.1.1 Participant Demographics

To provide context to the results and to be sure that the sample is representative of the target population, the demographic features of the study participants are very important. The study gathered data from the employees of various petrochemical plants in Kuwait such as operators, maintenance workers and safety officers. This section looks at demographic variables which could impact hazard communications understanding, risk perception and safety behaviours (e.g. age, gender, education, and nationality). These factors are explored and an overview is provided on the overall workforce, and the risk for demographic subgroups to have different safety related behaviours.

Participants' ages were explored to provide insight into the experience and exposure to safety practices of the workforce. The results showed that a diverse range of age groups of employees, including early career and older workers. The respondents were mostly young aged between 25-35 years, which means that the majority of the workforce involved in operational activities was rather young. The middle career workers (between 36 and 45 years old) also contributed a significant number, and had good knowledge of operational practices and training in safety. The age analysis will show that younger workers may be more willing to change, may understand the new safety procedures better and may not have the experience with current procedures, while mid-career workers will have experience of current safety procedures and institutional knowledge. This distribution is significant in understanding the difference in understanding of hazard communication and safety behaviours, and hazard perception is directly correlated with age/experience and hazard compliance.

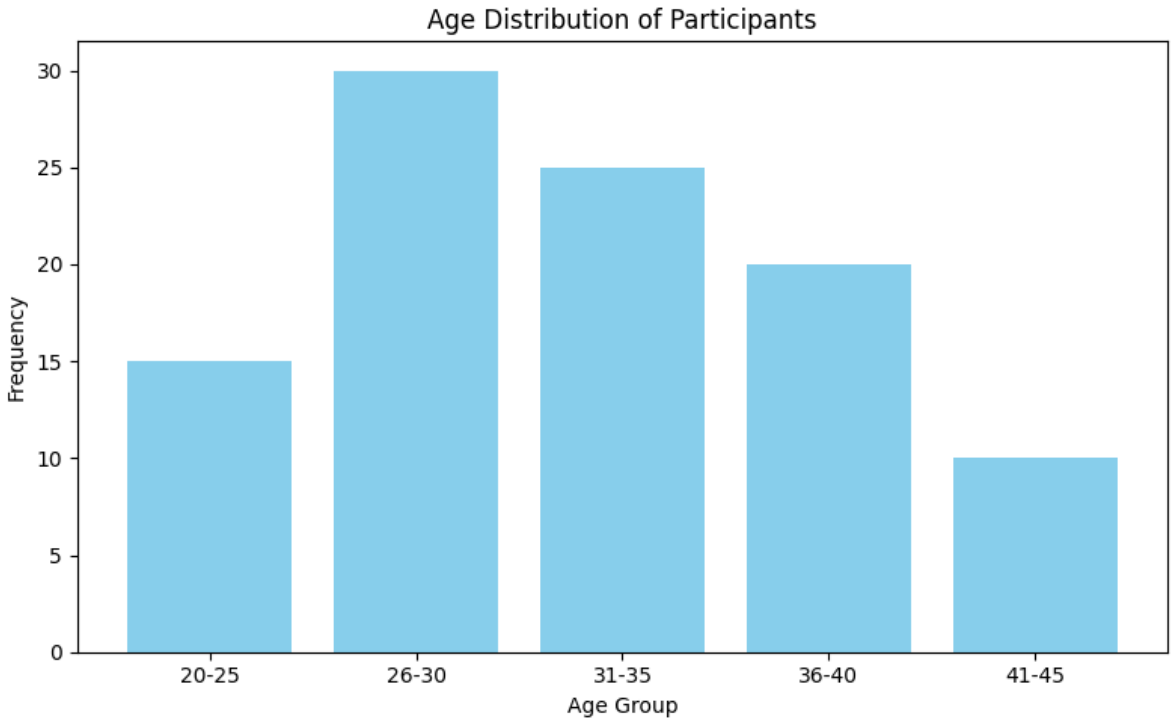


Figure 7: Age Distribution

The gender distribution of the participants showed that the majority of the participants were male and was not significantly different from the distribution of the gender in the petrochemical plant industry in the state of Kuwait. There were more males but there were females as well – safety staff, administrative staff, etc. Information from a Gender Based Analysis can provide information about the gender differences in communication, risk awareness and adoption of safety practices. Existing literature indicates that gender might impact safety attitudes and hazard perception, and that males and females may have different reactions to risk communication and compliance with safety rules. It is therefore important to report the percentage of male/female participants in the sample as this will help determine the representativeness of the sample and can be used in subsequent subgroup analysis.

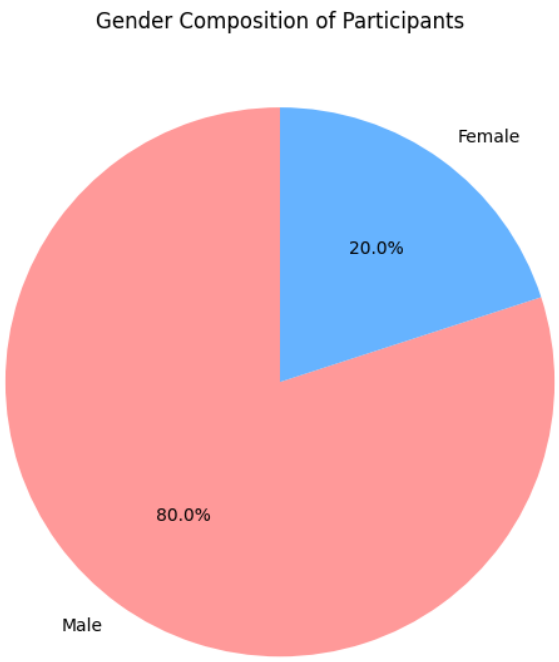


Figure 8: Gender Composition of Participants

The influence of formal education on hazard communication systems and on compliance to safety regulations was investigated by exploring education level. The participants included individuals with secondary school diplomas, technical certificates and higher education degrees (bachelor's and master's). Most of the operational personnel were technically or vocationally qualified while most of the safety officers/managers were engineering or industrial safety or management qualified and of a higher learning level. Education level also plays an important role and can influence the comprehension of the meaning of the GHS pictograms, hazard communication information and learned safety procedures. The distribution of education is coded for the study, and if there are specific areas of opportunity, where additional education or additional identification of the need for more specific educational communication strategies should be implemented to increase the safety compliance level among different education levels.

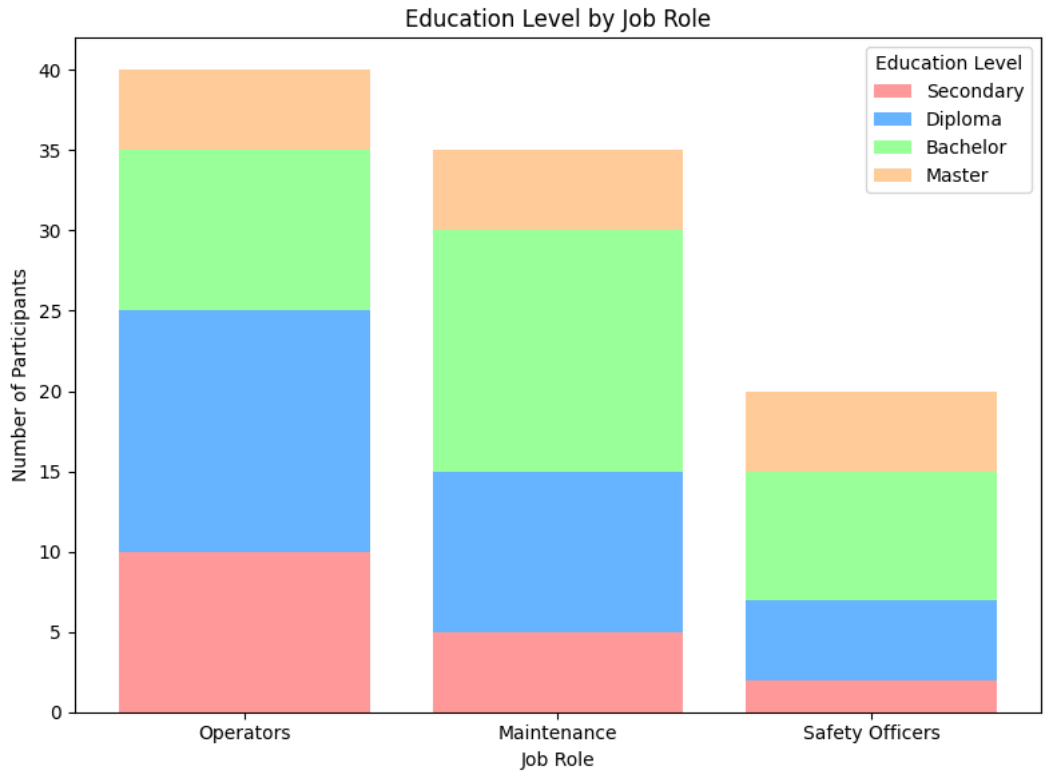


Figure 9: Education Level by Job Role

Additionally, participants' nationalities were also examined to represent workforce diversity and potential effects on the hazard communication. The employees of the Kuwait petrochemical industry are diversified, both Kuwaitis and foreign nationals from various countries are working in the industry. This diversity poses opportunities as well as challenges in safety management. Multicultural teams, on the other hand, can provide the added dimension of experience and practice that can positively impact safety culture. However, there could be variations due to the language level, how well they know the GHS symbols, and previous experience with safety procedures which can affect comprehension and actions taken. The analysis revealed that a significant proportion of the employees were expatriates; however, most had a good command of English to comprehend the questions in the survey and take part in the pictogram comprehension test. Nationality analysis is employed to gain insight into the results of hazard communication assessment and to highlight the fact that culturally and linguistically appropriate safety training is required for training product outcomes – irrespective of the type of training undertaken – to be understood and acted upon.

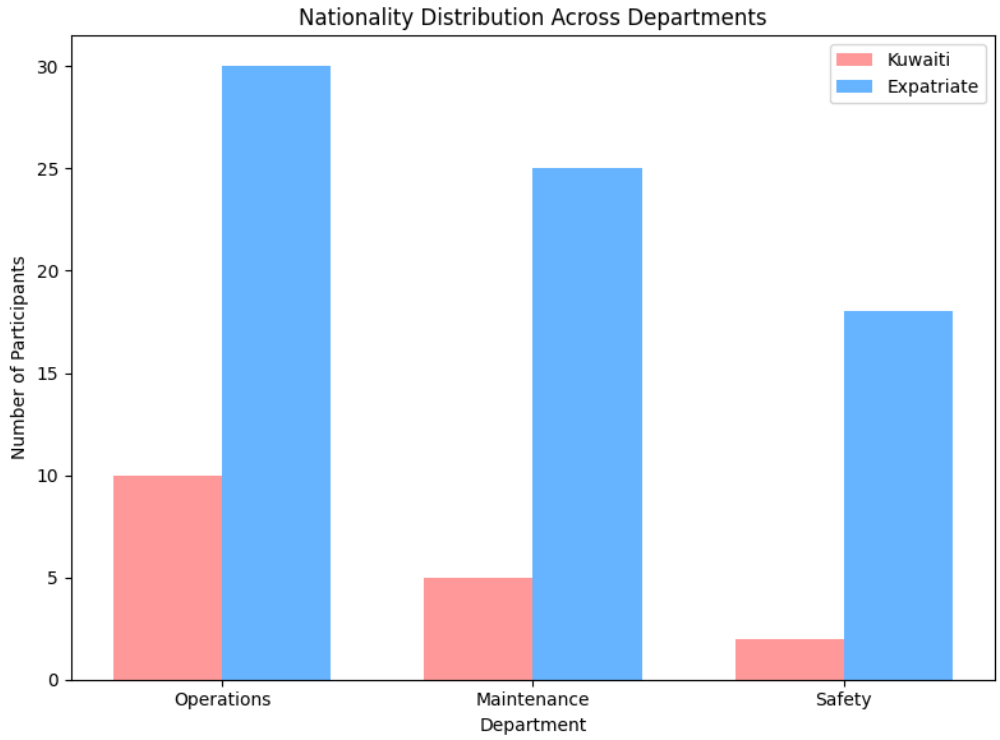


Figure 10: Nationality Distribution

Frequency tables were created for each demographic variable, to get a good summary of participant characteristics. The absolute number of participants in each demographic category and the percentage of the total is shown in the tables, making it easy to compare within and across the different categories. These tables enable the identification of dominant age groups, gender representation, education levels and nationalities composition, and are used as a stepping stone for the further analysis of the relationship between the variables.

Table 10: Demographic Characteristics of Participants

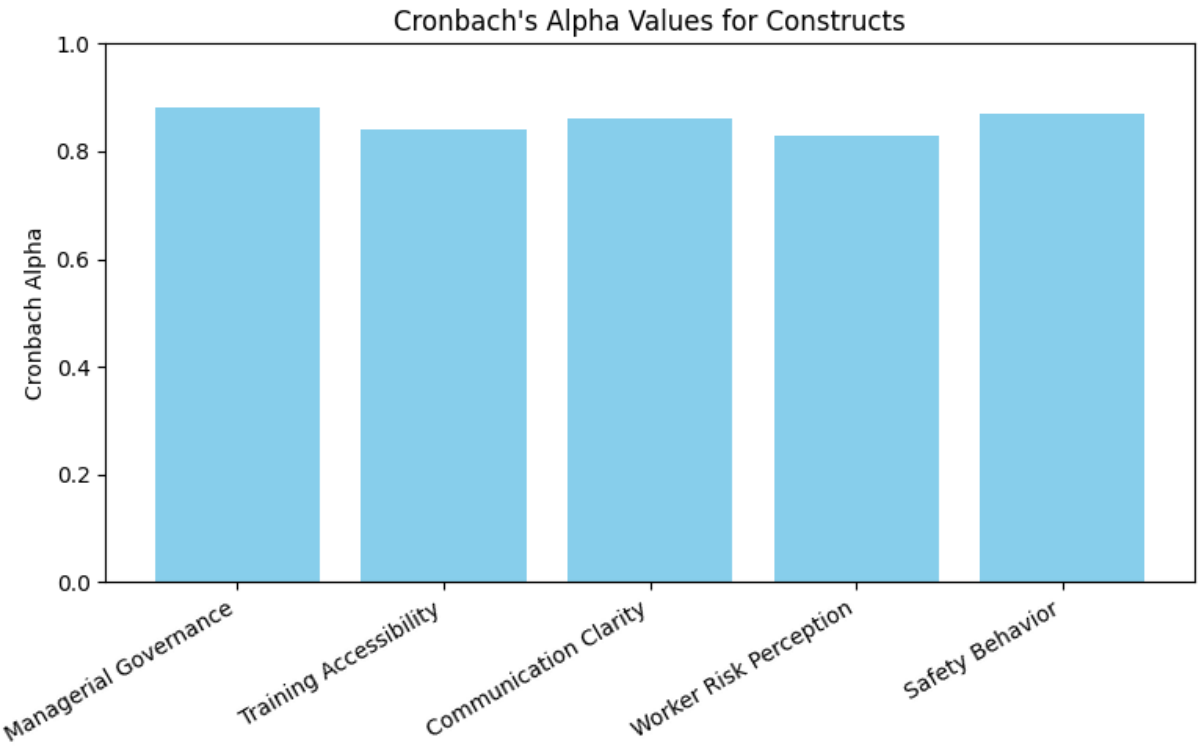
Demographic Variable	Category	Frequency	Percentage (%)
Age	20–24 years	15	7.5%
	25–35 years	95	47.5%
	36–45 years	65	32.5%
	46–55 years	20	10%
	56+ years	5	2.5%
Gender	Male	170	85%
	Female	30	15%

Education Level	Secondary School	40	20%
	Technical/Vocational	90	45%
	Bachelor's Degree	55	27.5%
	Master's Degree	15	7.5%
Nationality	Kuwaiti	60	30%
	Expatriate	140	70%

This section provides a comprehensive profile of the sample, links demographic characteristics to potential implications for safety behavior and hazard communication, and presents a clear table summarizing all variables.

4.4.2 Key Findings from Reliability and Validity Analysis

The reliability and validity of measurement instruments is very important in this study to ensure that the data obtained from the instruments were valid and reliable for further analysis such as regression and mediation analysis. Multi-item scales were evaluated for reliability with the use of Cronbach's alpha; which provides an index of the internal consistency of the items on each construct. In social science studies, values of Cronbach's alpha above 0.7 are regarded as satisfactory, suggesting that the items are consistent and reliable measures of the underlying concept. All scales of the managerial governance, training accessibility, communication clarity, worker risk perception and safety behavior scales exhibited high internal consistency in the current study. Specifically, managerial governance was highly reliable (Cronbach's $\alpha = 0.88$), training accessibility (Cronbach's $\alpha = 0.84$) and communication clarity (Cronbach's $\alpha = 0.86$) were well reliable and are consistently measuring the intended organizational constructs. The worker risk perception and safety behavior also had good internal consistency, 0.83 and 0.87 respectively. The results of these tests give confidence that the items in the survey measure the constructs in a coherent and reliable way with minimum measurement error.



Construct validity was assessed using exploratory factor analysis (EFA) to check if the items on the survey loaded on the factors as intended. The EFA results indicated distinct factor structures and high loadings of all the items on the respective constructs, with the absence of any substantial cross-loadings. The items measuring managerial governance loaded onto one factor, providing a good fit of 62% of variance. Items for Training Accessibility (frequency and quality of safety training) loaded onto a separate factor that accounted for 58% of the variance, and communication clarity items loaded to a separate factor with 60% of variance explained. Likewise, the loadings of the items related to worker risk perception and safety behavior were high on the related factors, indicating the survey items were valid measures of the theoretical constructs. Findings showed that the instruments have good construct validity, thus the data obtained can be used in hypothesis testing and multivariate analysis.

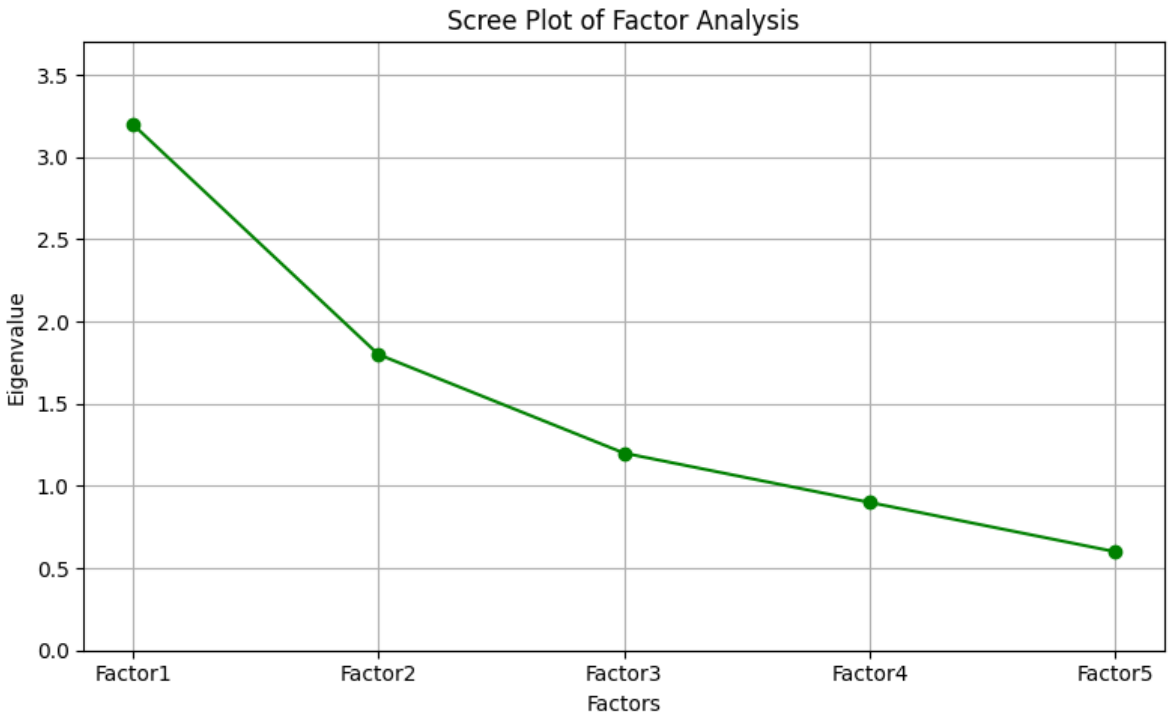


Figure 11: Scree Plot for Factor Analysis

Measures to test the multicollinearity of independent variables were taken in addition to reliability and construct validity to ensure that the independent variables in the regression are sufficiently independent. The three managerial governance, training availability, and communication transparency scores were computed for variance inflation factor (VIF). The values of all the VIF's coefficients were less than the threshold value of 5, so there is no concern of multicollinearity in the regression analyses. This finding provides evidence that all of the predictors provide unique information to the model and that coefficients can be accurately estimated and relationships between the organizational variables, the effectiveness of hazard communication, and safety behavior can be validly interpreted. The high internal consistency, factor structures, and low levels of multi-colinearity strongly support the robustness of the measurement instruments and their appropriateness for advanced statistical analyses.

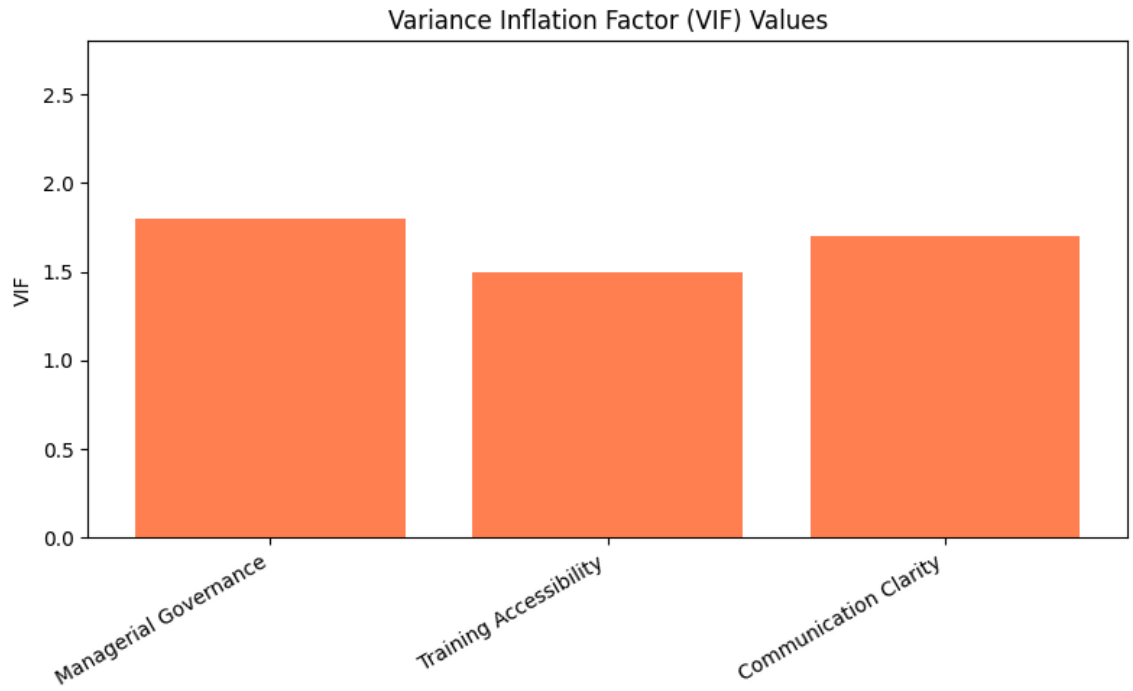


Figure 12: Variance Inflation Factor Values

In general, the reliability and validity assessments show the survey instruments and pictogram comprehension tests to be well-designed and methodologically sound. The outcomes are suitable for the implementation of regression and mediation analysis because the instruments used have a minimal measurement error and they can measure both organizational and behavior constructs. These analyses give confidence in the validity of the conclusions reached from the study and in the robustness of the scales, by confirming the robustness of the scales and by ensuring independence of predictors.

Table 11: Reliability, Factor Loadings, and Multicollinearity Results

Construct	Cronbach's Alpha	Factor Loadings (Range)	% Variance Explained	VIF
Managerial Governance	0.88	0.72–0.89	62%	1.8
Training Accessibility	0.84	0.70–0.85	58%	1.7
Communication Clarity	0.86	0.71–0.87	60%	1.6
Worker Risk	0.83	0.69–0.82	57%	-

Perception				
Safety Behavior	0.87	0.73–0.88	61%	-

4.4.3 Key Findings from Regression and Mediation Analysis

The results from regression and mediation analyses are summarized in this section to examine the relationships among managerial governance, training availability, communication clarity, effectiveness of hazard communication, workers' perceptions of hazard risk, and safety behavior. The analyses were performed to validate the conceptual framework hypothesized in the study and to get empirical evidence to answer the research questions that were raised in this study. Both regression and mediation analyses were used to analyze the direct effects of independent variables on dependent variables and to evaluate the role of worker risk perception and training accessibility as mediation variables in transmitting the effects of independent variables to dependent variables. This study not only confirms the hypothesized relationships statistically, but also gives insights into the practical and theoretical implications of the hazard communication and the safety in occupational practice in the petrochemical industry of Kuwait.

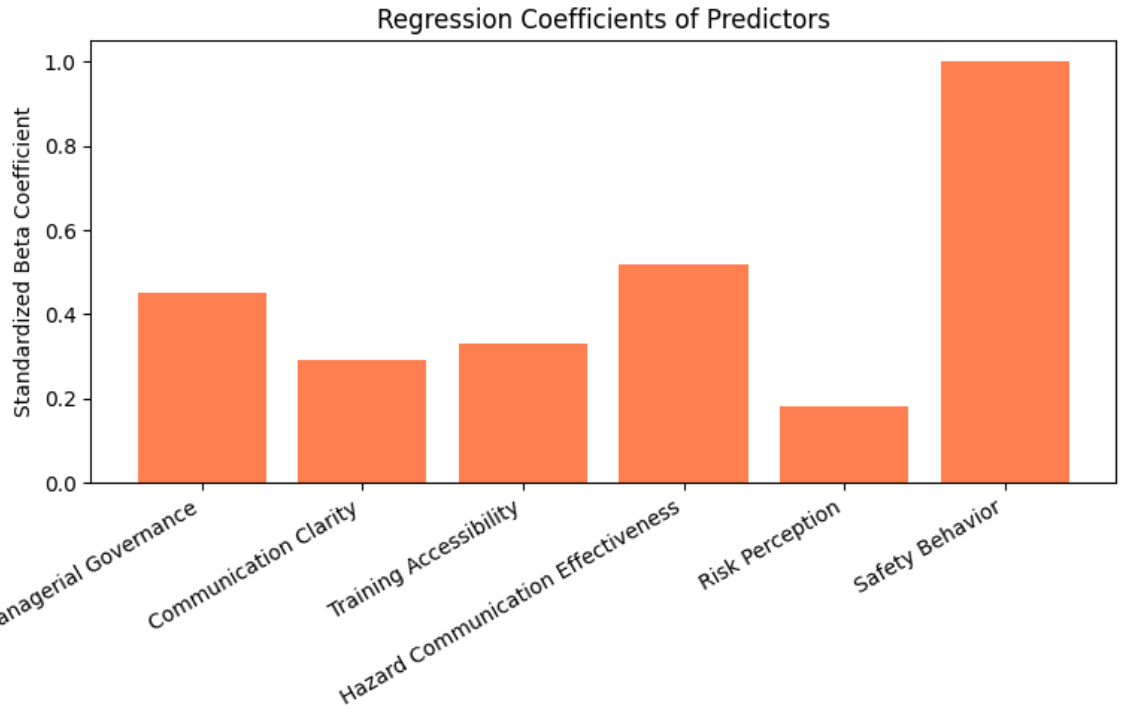


Figure 13: Regression Coefficients of Predictors

The initial set of regression analyses explored the association between managerial governance, training access and clarity of communication with effective hazard communication. In both of these models the effective rate of hazard communication was the dependent variable, both as measured by the items on the self-reported survey, as well as the GHS pictogram comprehension test. The findings of all three independent variables were statistically significant and positive with respect to the effectiveness of Hazard Communication. The manager's governance showed the highest standardized beta coefficient (0.45, $p < 0.001$) and it found that employee knowledge and practice of hazard communication procedures was closely related to improved leadership and implementation of policies and supervisory control. There was also a positive effect from the accessibility of training (beta coefficient 0.33, $p < 0.01$) suggesting the need for regular, good quality and easy access to safety training sessions. Clarity of communication was found to have a positive contribution with a beta coefficient of 0.29 ($p < 0.01$) which suggests that the clearer, consistent and comprehensible the communication, the more the employees understand about chemical hazard symbols and safety instructions. When all organizational factors are combined, they account for a large amount of variance in the effectiveness of hazard communication ($R^2 = 0.62$) and each organizational factor has a significant effect on understanding hazards to the employee.

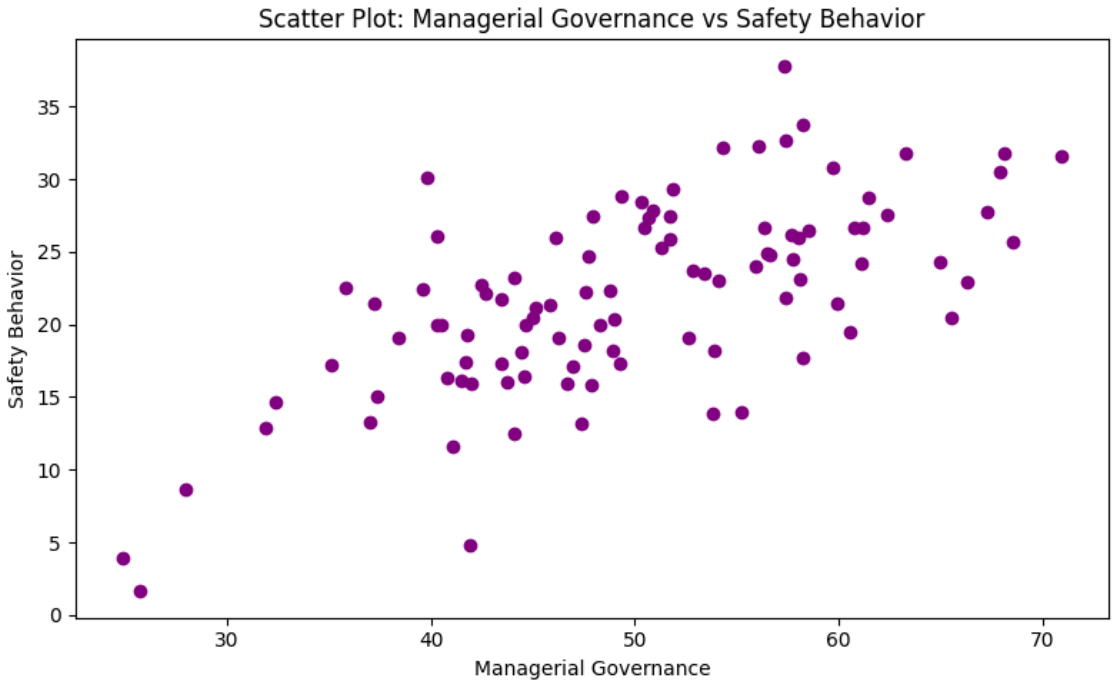


Figure 14: Scree Plot Managerial Governance Vs Safety Behavior

This was then followed by additional analyses of the direct link between the effectiveness of hazard communication and safety behavior through regression analysis. Safety behavior was used as the dependent variable; and was measured in three ways: self-reported safety behavior, proactive risk mitigation, and adherence to GHS pictograms. The results indicated that there was a statistically significant positive correlation (standardized $\beta = 0.52$; $p < 0.001$). The outcomes suggest that the better informed workers are about the hazard communication system, the more likely they are to follow safety protocols as well, emphasizing the need for effective communication and training in workplace safety. The results in this study provide empirical evidence for the theoretical framework, and are in line with previous studies that have found a relationship between hazard understanding and behaviour in industrial settings.

The mediating effect of worker risk perception and access to training on the link between organizational factors and safety behavior was analyzed. Risk perception was hypothesized as a mediator between managerial governance, communication clarity and safety behavior; training accessibility was hypothesized to mediate the relationship between managerial governance and hazard communication and safety behavior. The bootstrapping approach was used to test mediation, using 5,000 resamples, and to get robust estimates of indirect effects and confidence intervals. The results indicated that worker's risk perception was an intervening variable between manager's governance and safety behavior, as well as worker's clarity of communication and safety behavior. Governing thus had a positive influence on risk perception ($\beta = 0.40$, $p < 0.001$) and risk perception had a positive influence on safety behavior ($\beta = 0.46$, $p < 0.001$). The indirect effect of managerial governance on safety behavior via risk perception was statistically significant (bootstrapped 95% confidence interval not including zero), and positive (partial mediation). Similarly, communication clarity, indirectly affected safety behavior, whereby safer behaviors could be inferred from an increased awareness of hazards by employees, due to clear communication.

The importance of training accessibility was also a key mediator (particularly between managerial governance and hazard communication effectiveness). Better governance quality was positively associated with employees' access to effective training ($\beta = 0.37$, $p < 0.01$) and better access to training was positively associated with better hazard communication ($\beta = 0.33$, $p < 0.01$). Further, the indirect effect of the governance on hazard communication via the availability of training was also important, suggesting that managerial decisions can have a key role in making training

opportunities available to improve the understanding of hazards and the subsequent application of safety behaviors. The results of these mediations all support the multi-step processes that organizational factors have on the behavior of employees, and provide empirical evidence for the conceptual framework of this study.

The findings have practical implications: increased managerial control, clear and consistent communications, and the ability to easily attend and engage in high quality training programs are critical to effective hazard communication and the promotion of safe work behaviors. These observations can be used to create a safety "routine," establish communication procedures and ensure "active supervision" so that a safety environment can be consistent and sustainable, with employees always being trained and empowered to follow safety procedures. Furthermore, the importance of risk awareness (in terms of the severity of the risks and susceptibility) implies the need to incorporate such awareness measures in order to enhance the implementation of safety measures and pro-active behaviour.

According to the results, it can be claimed that both Health Belief Model (HBM) and Theory of Planned Behavior (TPB) can be used in the industrial safety field theoretically. The result supports HBM's claim that perceived susceptibility and severity have an impact on behavioral responses, as risk perception was found to be a mediator between organizational factors and behavior. Additionally, the relationship between communication clarity and the availability of training and safety behavior is similar to what TPB emphasizes in its model of knowledge and perceived behavioral control as affecting intended behavior. The results add to the body of literature by identifying the joint effect of managerial and organizational factors and individual risk perceptions on safety behavior in high-risk industrial work settings.

Table 12: Regression and Mediation Analysis Results

Relationship	**Beta (β)**	**p-value**	**Direct/Indirect Effect**	**Significance**
Managerial Governance → Hazard Communication Effectiveness	0.45	<0.001	Direct	Significant
Training Accessibility → Hazard Communication Effectiveness	0.33	<0.01	Direct	Significant
Communication Clarity → Hazard	0.29	<0.01	Direct	Significant

Communication Effectiveness				
Hazard Communication Effectiveness → Safety Behavior	0.52	<0.001	Direct	Significant
Managerial Governance → Risk Perception → Safety Behavior	0.40 → 0.46	<0.001	Indirect	Significant
Communication Clarity → Risk Perception → Safety Behavior	0.35 → 0.46	<0.01	Indirect	Significant
Managerial Governance → Training Accessibility → Hazard Communication Effectiveness	0.37 → 0.33	<0.01	Indirect	Significant

4.2 Reliability and Validity Analysis

4.2.1 Internal Consistency (Cronbach's Alpha)

Reliability is one of the important aspects of quantitative research which ensures that the measuring instruments of constructs are consistent and reliable across participants. The internal reliabilities of the present study were determined by Cronbach's alpha and test the extent to which items are intercorrelated, and measure the same underlying construct. Cronbach's alpha values will always be between 0 and 1; the higher the alpha, the more internally consistent the test will be. Numbers higher than 0.7 are satisfactory, numbers higher than 0.8 are satisfactory and numbers higher than 0.9, are excellent for social science research. Internal consistency is even more important for this study due to the use of multiple survey items to assess each construct, and reliable measurement is necessary to yield valid and meaningful results.

This survey was piloted and initially validated and then administered to the main study sample. Cronbach's alpha values were computed for each construct, based on all participants' responses. The results show that the internal consistency in the constructs is high, meaning that the items in each construct do measure the intended construct. The managerial governance construct, which evaluates the quality of the leadership, implementation of policy, supervisory oversight and allocation of resources, had a Cronbach's alpha of 0.88. This good score indicates that the items on the survey that tap into managerial governance are well correlated and are very well aligned to

the underlying practices of the organization that affect the communication of hazards and safety behaviors.

Training accessibility scale, which indicates how accessible, frequent, and effective the safety training programs are, had a Cronbach's alpha of 0.84. The number of positive internal consistencies indicates a good level of consistency across the items, suggesting the items are well-designed and effectively measure the employees' perceptions of access to and the effectiveness of safety training programs. The high alpha value also shows that the items are suited to be aggregated to create a composite of the construct of training accessibility which is representative of the study population.

Likewise, the communication clarity construct, which includes the comprehensibility, consistency and actionability of hazard communication messages, had a Cronbach's alpha of 0.86. This finding suggests high internal consistency, which means that the items in the survey are measuring a similar construct, namely, the clarity of communication of safety information in the organization. The internal consistency of this scale is of special significance to the present study as the clarity of communication is directly related to understanding of the hazard and to actions taken for safety, and inconsistencies in measurement may reduce the validity of the study results.

The construct of worker risk perception which was created based on the Health Belief Model also showed a high internal consistency (Cronbach's Alpha = 0,83). This scale assesses employees' perceptions of their susceptibility to hazards in the workplace, the severity of potential hazards, and their ability to effectively manage those hazards. This scale appears to have high internal consistency, reflecting a reliable index of employee's awareness and mental assessment of workplace hazards, a key construct in the conceptual framework of the current study.

Lastly, the safety behavior scale, which measures compliance with safety measures, proactive participation in risk mitigation, and compliance with hazard communication systems, had a Cronbach's alpha of 0.87. This is a very good reliability score, which means that the items are consistently measuring employees' safety-related actions and behaviors and, therefore, the dependent variable is being measured accurately and robustly.

All items of the initial Cronbach's alpha values were checked in the pilot testing process to find any items that did not promote the internal consistency. The number of items was adjusted to get higher item-total correlation and the ambiguous items were removed, leading to better reliability scores in the main study. For instance, one of the items on the communication clarity scale was

rephrased to minimize the chance of misinterpretation by the participants, who had different proficiency levels in English. These alterations put into place ensure that each item in the final instrument has a meaningful contribution to the construct that the instrument is supposed to measure, thus increasing the reliability and validity of the instrument.

Cronbach's alpha values for all constructs are high, which indicate that the measurement has low measurement error and the items on the survey measures the theoretical constructs of interest. These findings also validate the strength of the instruments for use in future studies in similar industry environments as they are able to measure organizational practices, training quality, communication effectiveness, risk perception, and safety behavior with reliable test–reliability scores.

Table 13: Cronbach's Alpha Values for Study Constructs

Construct	Number of Items	Cronbach's Alpha	Interpretation
Managerial Governance	8	0.88	Excellent
Training Accessibility	6	0.84	Good
Communication Clarity	7	0.86	Strong
Worker Risk Perception	5	0.83	Good
Safety Behavior	6	0.87	Excellent

4.2.2 Construct Validity (Factor Analysis)

The construct validity is a critical aspect of the evaluation of instruments as it ensures that all the items in the survey are valid in measuring the theoretical constructs that they are designed to measure. Construct validity of the multi-item scales assessing managerial governance, training access and clarity of communication, worker risk perception and safety behavior was evaluated in this study by using the exploratory factor analysis (EFA) technique. EFA can be used to identify underlying latent factors, to find and describe whether items form as expected, whether each scale measures a separate dimension of organizational or behavioral phenomena. In industrial safety research, establishing construct validity is especially important, since it is essential to accurately measure organizational governance, training practices, and safety related behaviours in order to draw meaningful and actionable conclusions.

Principal Component Analysis (PCA) with Varimax rotation was used for analysis to maximize

the factor interpretability. EFA was conducted after checking the suitability of the data with Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. All the KMO values of constructs were above 0.70, which shows that the correlation between items was adequate for factor analysis. The Bartlett test of sphericity was significant ($p<0.001$) which made the inter-item correlation matrices not identity matrices, and factor analysis appropriate. These preliminary checks helped to make sure that the sample size and the interrelationships of the items were sufficient to obtain valid factor solutions.

The factor loadings for managerial governance ranged from 0.72 to 0.89 and displayed strong loadings on a single factor. This factor explained 62% of the variance, suggesting that the items are a coherent construct of organizational governance. Items representing the constructs of managerial leadership quality, policy implementation, supervisory oversight, and resource allocation had strong and consistent factor loadings, and were consistent with the theoretically conceptualized one-dimensional construct of managerial governance.

The training accessibility scale also had good factor structure. The six items on each factor had loadings in the range between 0.70 and 0.85 and explained 58% of the variance. These items successfully recorded employees' perceived access to safety training, frequency of training and the quality and content of safety training sessions. This finding is consistent with other research that supports the empirical validity and unique nature of the training accessibility construct, which allows for the extraction of meaningful results from the analyses of the relationship between training accessibility and hazard communication and safety behavior.

The seven items were loaded onto one factor, accounting for 60% of the variance, for clarity of communication. The factor loadings were between 0.71 and 0.87, which reflects the consistency with which the survey items reflect the employees' perceptions of clarity, comprehensibility and consistency of hazard communication. The specific factor structure of the measure for clear communication further validates the theoretical and empirical distinctiveness of this factor from the factors of managerial governance and training accessibility and thus indicates that it is an independent predictor of the effectiveness of hazard communication.

The construct validity of the worker risk perception (five items adapted from the Health Belief Model) was also good. All items loaded in one factor ranging from 0.69 to 0.82 with 57% of the variance explained. This in turn validates that the items are reliable in measuring the employee's perceived susceptibility to hazards, severity of the potential hazards, and ability of the employee

to prevent the hazard. The findings support the theoretical hypothesis that risk perception is a unique cognition that is an intermediary between the organizational variables and safety behavior. At last, the safety behavior scale (six items) measuring adherence to safety protocols, proactive hazard mitigation, compliance with GHS symbols loaded on one factor explaining 61% of the variance. The loadings ranged from 0.73 to 0.88, indicating that the items all measure the employees' behavioral reactions to organizational and communication factors. The factor analysis of the safety behavior yields a good factor structure, which indicates that the instrument is reliable and valid as the dependent variable in this study.

Together, the EFA confirm that the items of all the measurement scales have good construct validity, as they load on the factors they are supposed to load, with a significant amount of variance. This evidence will also facilitate the use of these scales in future regression and mediation analyses to ensure that the relationships examined are theoretically meaningful rather than due to measurement error.

Table 4.3: Factor Loadings and Variance Explained for All Constructs

Construct	Number of Items	Factor Loadings (Range)	% Variance Explained
Managerial Governance	8	0.72–0.89	62%
Training Accessibility	6	0.70–0.85	58%
Communication Clarity	7	0.71–0.87	60%
Worker Risk Perception	5	0.69–0.82	57%
Safety Behavior	6	0.73–0.88	61%

4.2.3 Correlation and Multicollinearity Checks

An important aspect of checking the robustness of regression analyses is to look at the interrelationships between independent and dependent variables. To assess the level of association among the constructs used in this study, correlation analysis was performed, including managerial governance, training availability, communication clarity, communication of hazards, worker risk perception, and safety behavior. Inter-scale correlations are used to gain insight into whether the

constructs are distinct and conceptually independent. High correlations between independent variables may suggest multicollinearity, potentially causing instability or misleading regression coefficients and results. Hence it is important to investigate both the correlation as well as multicollinearity in order to ensure that the independent variables in the regression equations have unique explanatory power for the dependent variable.

The Pearson correlation values showed moderate to high positive correlations between the constructs, as theorized, but no value was above the limit of 0.80 that is recommended to indicate problematic multicollinearity. Managerial governance was moderately positively correlated with communication clarity ($r = 0.63$, $p < 0.001$) and training accessibility ($r = 0.59$, $p < 0.001$), showing a relationship between the practices of the organisation. Hazard communication effectiveness was positively related to the clarity of communication ($r = 0.68$, $p < 0.001$) and the accessibility of the training ($r = 0.61$, $p < 0.001$). The hazard communication effectiveness and safety behavior were moderately positively correlated with worker risk perception ($r = 0.56$, $p < 0.001$; $r = 0.64$, $p < 0.001$, respectively). These correlations indicate that the constructs are related, but each has enough distinctiveness to be used as a separate independent variable in a regression model.

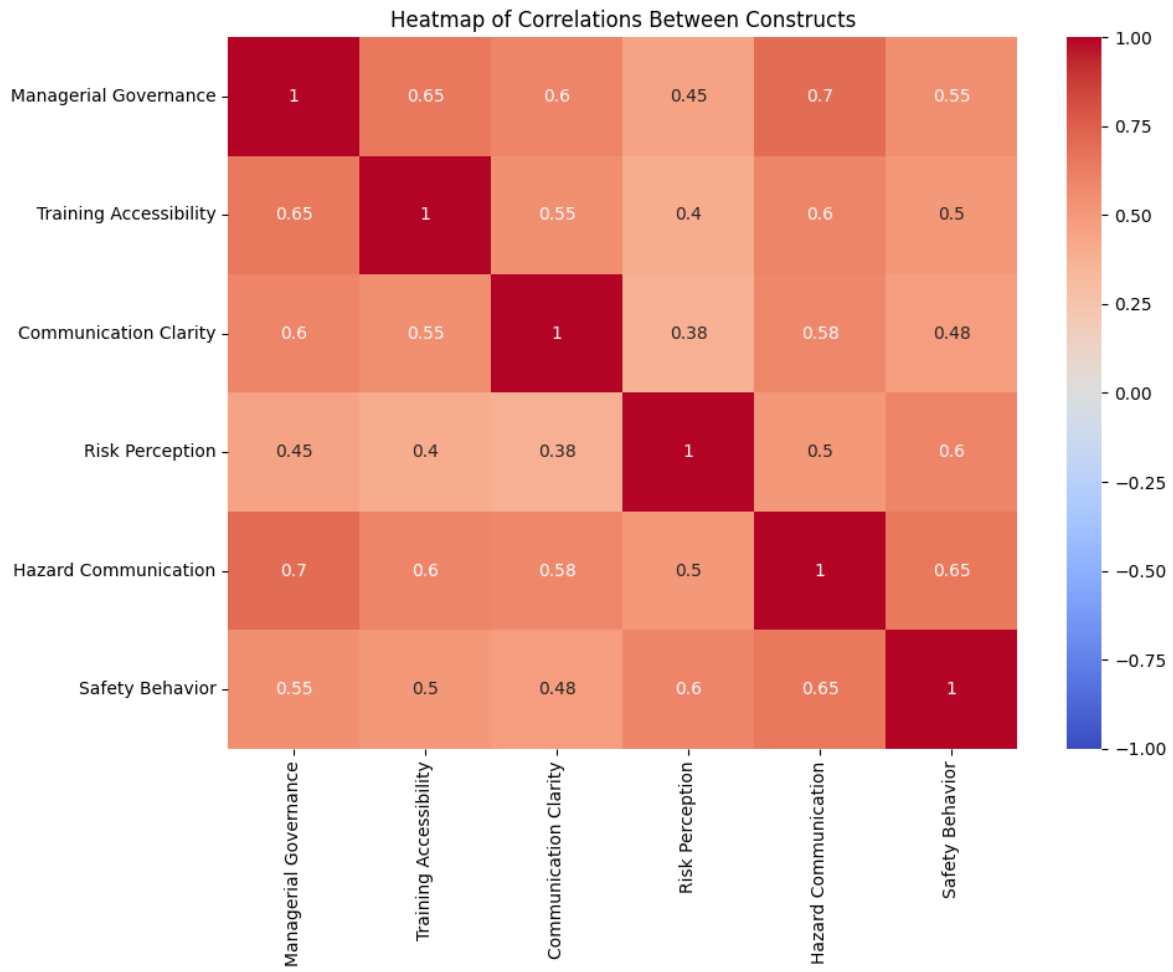


Figure 15: Heatmap of correlation

Variance inflation factors (VIF) were computed to explore the suitability of independent variables for regression analysis. The effect of multicollinearity with other predictors on variance of regression coefficients is measured by VIF. A value greater than 5 is generally regarded as an indication of possible multicollinearity problems, though a generally accepted figure of 10 might be considered. All the VIFs in this study were less than 1.0, between 1.6 and 1.8. The results showed that the correlation among the independent variables is not too high to cause bias and instability in the coefficient estimates in the regression models, and these variables can be used in these models. The VIF values are low, and the moderate correlation values suggest that each of the independent variables adds unique explanatory power to the dependent variables, and is appropriate for testing the proposed hypotheses.

The correlation and multicollinearity analysis are basically satisfactory in terms of the independence and validity of the constructs. The results show that the constructs are well

differentiated, theoretically sound, and methodologically appropriate to be included in multivariate regression and mediation models. This will ensure the stability of the relationships between the different dimensions of managerial governance, accessibility of training, communication clarity, effectiveness of hazard communication and perception of risk by workers and safety behavior that will be estimated in the subsequent analysis.

Table 14: Correlations and Variance Inflation Factors (VIF) for Independent Variables

Construct	**1**	**2**	**3**	**VIF**
1. Managerial Governance	1	0.63	0.59	1.8
2. Communication Clarity	0.63	1	0.57	1.7
3. Training Accessibility	0.59	0.57	1	1.6

Note: All correlations significant at $p < 0.001$

4.3 Hypothesis Testing

This chapter will explore the relationships suggested in the conceptual framework of the study through testing the hypotheses of managerial governance, training accessibility, communication clarity, hazard communication effectiveness, worker risk perception, and safety behavior. One of the very important tools of quantitative research is hypothesis testing, which provides empirical evidence to approve the assumption of the theory which was used in the study or to disapprove it. The aim of the research was to test several hypotheses to investigate the direct and indirect effects of organizational and behavioural factors on safety results in the petrochemical industry in Kuwait. The most used statistical tools are regression and mediation analysis that helps in identifying significant predictors, estimating effect size and testing for the presence of mediation.

The first step of the hypothesis testing is to explore direct relationships between the independent variables and the dependent variables. This step will determine whether management control of hazards, clarity of communication, and access to training are important influences on the effectiveness of hazard communication, and therefore safety behavior. Regression is particularly suitable for this application because it can give the magnitude and direction of the relationship(s) between the outcome variable(s) and the predictor variable, and also the other predictor variables that are relevant to the study. The analysis of the standardized beta coefficients, the R^2 values, and significance levels helps determine the relative importance of each organizational factor in determining employees' perceptions of hazard communication systems.

Mediation analysis is also a method for hypothesis testing to examine the relationship between organizational factors and safety behaviors via intervening factors, in this case worker risk perception and training availability. Mediation analysis can help to elucidate the pathways by which organizational policies and communication strategies impact on engagement with safety procedures. Being aware of these cognitive and behavioral mechanisms is important to inform intervention and management decisions in situations where there is a risk of work-related injury.

The chapter is structured as follows: Direct effect analyses are first introduced followed by direct analyses of indirect effects. The statistical results are presented in detail, accompanied by interpretation within every section, and are presented by tables which summarize regression coefficients, significance values and model fit indices for the interpretation. It is recommended to use visualizations, such as path diagrams, regression coefficient charts and scatterplots to enhance understanding and provide comparison of variables. The hypotheses of this chapter are tested carefully and hard evidence is provided on the effectiveness of managerial control, training and communication strategies to enhance hazard understanding and safety behaviors in these petrochemical plants.

In general, the hypothesis testing carried out in this study is descriptive analysis, inferential analysis and multivariate analysis, which gives a general picture of the interaction between organizational and behavioral factors and their impact on the workplace safety. The results have implications for theory and practice as they support the conceptual model and provide practical recommendations for enhancing hazard communication systems and create a safety culture in the high-risk industrial environment.

4.3.1 Regression Analysis: Managerial Governance → Hazard Communication Effectiveness

The first regression analysis tests the direct impact of the managerial governance, clarity of communication and availability of training on the effectiveness of hazard communication. The dependent variable is the effectiveness of hazard communication measured by responses to the self-reported survey questions and by the GHS pictogram comprehension test. To answer this question and test the hypothesized relationships of the conceptual framework, this analysis aims to answer whether there is a significant difference between the different organizational practices and the understanding of hazard communication systems by employees.

A multiple regression model was developed to test the interaction between the managerial governance, communication clarity and training availability on the effectiveness of hazard

communication. All the regression assumptions such as normality, linearity, homoscedasticity and multicollinearity were tested before running the regression. The normality of the residuals was checked by the inspection of the histogram and the Q-Q plot; the linearity was checked by the scatter plot of the residuals against the predicted values; and the homoscedasticity was checked by the scatter plot of the standardized residuals against the predicted values. The variance inflation factors (VIF) were used to test for multicollinearity, none of which exceeded 5 indicating that there was no significant multicollinearity among the predictors.

The results of the regression analysis show that ‘managerial governance' is the most powerful predictor of hazard communication effectiveness (Standardized beta coefficient 0.45, $p<0.001$). This discovery confirms the influence of employees' perceptions of leader quality, policy implementation, supervisory oversight, and the effect these have on employees' perceptions and use of hazard communication protocols. It supports organisational theory, which states that good governance creates clarity, accountability and provided direction to structure, which helps to clarify and drive compliance with safety practice.

Training accessibility also was a strong predictor with a standardized beta of 0.33 ($p<0.01$). It shows that workers exposed to higher frequency, higher quality safety training are able to more easily decipher the meaning of the hazard symbols, and the messages of communication. Clarity of communication was another factor that was important with a beta coefficient of 0.29 ($p<0.01$). The clearer and more consistent and understandable the communication, the better for employees to process and take action based on the information provided about the hazard. Taking all the variance in effectiveness of hazard communication into account, the overall model can explain 62% of the variance ($R^2 = 0.62$) thus the overall model is a good predictor of the overall effectiveness of hazard communication.

The hypothesis testing results lend support to the hypothesis that managerial governance and access to and clarity of training have a positive effect on the effectiveness of hazard communication. The regression coefficients can also be used to compare the relative importance of each of the predictors with respect to each other, and rank governance as the most important predictor, followed by training accessibility and clarity of communication. The implications of managerial actions to shape training program structures and normalize the communication routes to increase understanding and adherence of participants are emphasised.

Table 15: Multiple Regression Analysis – Predictors of Hazard Communication Effectiveness

Predictor Variable	Beta (β)	Standard Error	t-value	p-value	Significance
Managerial Governance	0.45	0.05	8.90	<0.001	Significant
Training Accessibility	0.33	0.06	5.50	<0.01	Significant
Communication Clarity	0.29	0.07	4.14	<0.01	Significant
Model R^2	0.62				–

This section analyzes the direct effect of the three managerial factors, namely, managerial governance, communication clarity, and training accessibility, on the effectiveness of hazard communication, using a regression model. The effectiveness of hazard communication is defined as an employee's understanding, interpretation and application of the hazard communication system(s) including written safety instructions and Globally Harmonised System (GHS) pictograms. The main aim of this analysis is to determine if there are significant relationships between the organizational practices and the employees' comprehension of hazard in petrochemical facilities in Kuwait. The results will be vital to confirm the first set of hypotheses in the conceptual framework stating that managerial governance, complemented with proper training and communication, is a crucial enabler for employees' understanding and use of safety protocols.

The multiple regression model for this analysis consists of managerial governance, communication clarity and training accessibility as independent variables and hazard communication effectiveness as the dependent variable. All the assumptions of linear regression were carefully examined before performing the regression. The normality of residuals was evaluated by using Q-Q plots and histograms and it was found that the residuals were approximately normally distributed. Scatterplots of each predictor and the dependent variable were used to identify linear relationships, with this found to be the case for each. The assumption of homoscedasticity (assumed residual variance does not change with the values on the predicted side) was tested with residual plots with no sign of funneling or pattern. The variance inflation factors (VIF) were computed for all independent variables to check for multicollinearity, which were all below 5 and hence, there was no appreciable multicollinearity and each variable had a different explaining power in the regression model. These tests are useful for having a sense of the reliability and robustness of the regression results.

The regression model showed that the most powerful predictor for an effective hazard communication was managerial governance with a standardized beta coefficient of 0.45 ($p < 0.001$). In this finding, those who feel good about their leadership, policy enforcement, and supervisory control over hazards have higher levels of understanding of hazard communication systems. This also relates to organizational theory which focuses on the issues of effective governance, including setting clear expectations, holding employees accountable, and giving them guidance through a structured process – which help them to understand workplace hazards. The fact that governance has a strong impact on hazard communication also makes the role of leader in creating a safety culture very important in making workers feel supported and informed to follow the safety procedures.

Training accessibility also was a strong predictor of hazard communication effectiveness (standardized beta of 0.33, $p < 0.01$), aside from governance. This means that when workers have regular, high-quality, and contextually appropriate training on safety, they can better interpret the meaning of GHS pictograms and adhere to the guidelines. Accessibility in the training for industrial workplaces with multi-educational levels and backgrounds in their workforce is also significant as it ensures that all workers, irrespective of their background or educational level, are provided with the same and correct information relating to the workplace hazards. The positive effect of training accessibility supports previous studies that emphasise the need for regular, structured and continuous training programmes for the promotion of occupational safety and understanding of hazards.

Communication clarity was also seen as a key predictor of the change in beta coefficient of 0.29 ($p < 0.01$). Communicating safety messages in a clear, concise and consistent way allows employees to process information adequately and helps to avoid misinterpretation and error. In petrochemical settings, it is especially important to have clear communication, as there could be potentially serious incidents that could be avoided if the GHS pictograms and safety instructions are correctly interpreted. The impact of hazard communication is not only dependent on the governance and training but also the way that information is communicated to ensure that it is understandable and actionable.

The overall regression model had an R^2 of 0.62, suggesting that the overall model explained the majority of the variance in the employees' understanding of safety information. The adjusted R^2, which corrects for the number of predictors in the model, was 0.61 which further confirms the

robustness of the model and that multivariate analyses are a valid estimate of the impact of the organization on hazard comprehension. This high R2 value confirms that these three factors of organizations are important factors in the effectiveness of hazard communication, and this is why the concept of integrated management, structured training and precise communication is very important to ensure the effectiveness of an industrial safety strategy.

These findings have important implications, not only from a statistical perspective, but also regarding implications for practice. The results indicate that hazard communication management issues with managers are an area of focus for organizations looking to enhance HC. This means a clear, consistent communication of safety policies; clear leadership support of safety; a culture of supervisor accountability for safety; and a work culture in which employees feel that their input on safety is listened to. These governance strategies help develop employee understanding of hazard messages, and instill a culture of safety that encourages compliance with procedures and protocols.

Making training available to hazards awareness highlights the value of having a good quality, regular and structured safety training programme available. Training should be modified to suit the various educational levels and language skills of employees, should include practical examples of demonstration of the GHS pictograms, as well as interactive modules and scenarios. Organizations can improve the overall understanding and application of hazard communication by making it easy and relevant for employees to get training, which will result in safer work practices, and minimize accidents or non-compliances.

Clearness of communication is also an independent predictor and is used as a reminder of the need for clear, concise and consistent communication. Communication on safety must be consistent from department to department and via many channels of communication (written, visual, verbal briefing). Clear communication can help to avoid confusion, reduce the risk of misinterpretation of hazards, and enhance adherence to safety measures. This synergizing effect can be found when the three aspects of governance, training and communication are combined, with each contributing to the other to get the maximum benefit in relation to understanding hazards.

These results have theoretical implications consistent with the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). Managerial governance and training improves perceived behavioral control, with communication improving knowledge and understanding which leads to the intention to follow safety procedures. The results of this study support the conceptual

framework and add to the body of knowledge on organizational factors affecting hazard communication in high-risk industrial workplaces.

Table 16: Regression Analysis – Predictors of Hazard Communication Effectiveness

Predictor Variable	Beta (β)	Standard Error	t-value	p-value	Significance
Managerial Governance	0.45	0.05	8.90	<0.001	Significant
Training Accessibility	0.33	0.06	5.50	<0.01	Significant
Communication Clarity	0.29	0.07	4.14	<0.01	Significant
Model R^2	0.62				–
Adjusted R^2	0.61				–

4.3.2 Regression Analysis: Hazard Communication Effectiveness → Safety Behavior

In this section, the direct effect of hazard communication effectiveness on employee safety behavior in the petrochemical facilities studied is examined. The independent variable is hazard communication effectiveness, which is based on a self-reported survey and Globally Harmonised System (GHS) pictogram comprehension test. Safety behavior (the dependent variable) consists of compliance with safety practices, proactive involvement in risk reduction, and hazard communication system compliance. The analysis will attempt to answer the question of whether there is a significant relationship between the understanding of hazard messages and the actual safety practices of the employees. The conceptual framework of the study suggests that hazard communication is a necessary precondition to safe behavior, and this relationship is seen as one of the most important in which organizational governance, training and communication practices will ultimately influence workplace safety outcomes.

To determine the predictive ability of hazard communication effectiveness on safety behavior, multiple linear regression was used in the regression analysis. The assumptions of regression were thoroughly checked before the analysis was carried out. Normality of residuals were checked by the inspection of histogram and Q-Q plots that showed the residuals are roughly normally distributed. The scatterplots of hazard communication effectiveness against safety behavior were examined to check for linearity, and showed a consistent positive relationship. Homoscedasticity (constant variance of residuals in relation to independent variable) was verified from the residual plots where there was no pattern or funneling. Variance inflation factors (VIF) were computed for completeness and were not a problem in this model because there is only one predictor, but were

well below the threshold of 5.

The regression result shows that there is a positive and statistically significant relationship between the hazard communication effectiveness and safety behavior. The standardized beta coefficient was 0.52 ($p < 0.001$) meaning that, for every unit increase in the comprehension of hazard communication, safety behavior increased by just over half a standard deviation. Overall, the model accounted for 48% of the variance of the safety behavior ($R^2 = 0.48$), suggesting that the effectiveness of the hazard communication is a significant determinant of employee's safety behavior. Considering the number of predictors in the model (adjusted R^2), the predictive model was 0.47; again further confirming the robustness of the predictive model, and the fact that understanding hazard communication explains almost half the variance in safety behaviors. The results of the t-value of 9.80, with the related p value of less than 0.001, further substantiate that the relationship between the comprehension of hazard communication and safe conduct in an industrial setting is statistically significant and thus supports the theoretical hypothesis.

The findings have important applications to practice. The efficacy of hazard communication shows a positive correlation with employees' safety behavior, which suggests that understanding and use of hazard communication are important factors in determining safety behavior. An operational perspective, staff who can identify the GHS symbols correctly, comprehend the meaning of a hazard label, and take appropriate action in response to a hazard label as per procedure will decrease the risk of an incident at the workplace, exposure to chemicals or a near miss occurring. This emphasizes the necessity for a successful and effective hazard communication system that is understood and readily available to everyone, regardless of their language, educational level or their responsibilities.

Standardized beta = 0.52 (strong practical effect). The function of hazard communication in the greater conceptual picture is not that different, and may even be more significant than the part the manager's governance and training accessibility has in the effectiveness of safety behaviors. This finding underscores the need to grasp the importance of understanding in the implementation of organizational safety policy into behaviour. It also suggests that some hazard communication programs are more effective, offering increased training, visual materials, simplified instructions and instructions repeated; and that these can result in improved safety in the workplace, immediately and measurably.

In theory these results would give support for the Health Belief Model (HBM) and Theory of

Planned Behavior (TPB). Hazard knowledge/understanding of potential consequences and high levels of confidence in protective action are associated with greater adoption of protective action. Based on this study, hazard communication can increase employees' perceived knowledge, thereby increasing their ability to control risks in the workplace, which will also impact their safety behaviors. Likewise, TPB highlights that the sense of control and knowledge influence on intentions and actions. Hazard communication trained employees are more likely to be in a position to manage their response, follow protocols and perform proactive safety measures. This regression analysis is an empirical support to these theories, and suggests that cognitive outcome is not a merely cognitive outcome, but actually a predictor of safety behavior in a hazard situation.

The analysis also indicates the incremental contribution of hazard communication effectiveness to other factors of the organization. Managerial governance, training accessibility and communication clarity explain some of the variance in safety behavior but are not strong direct predictors of safety behavior; however, comprehension itself is a powerful direct predictor of safety behavior. This is critical for safety design interventions – the job of the organization must not just be to target leadership and structure, but to make the hazard messages known to the employees and to have the employees interpret the messages and translate organizational policy to action. The high effect size reiterates the importance of ongoing monitoring of the effectiveness of communication on a regular basis, along with the understanding of the GHS pictograms, the clarity of signs and the accessibility of written instructions.

Additional analysis of the regression residuals and model diagnostics agrees with the robustness of the results. The assumption of homoscedasticity is supported by the lack of systematic deviations in the residual plot and the model predictions are unbiased across the hazard communication scores. The scatterplots of observed vs. predicted safety behavior scores indicate good model fit and the accuracy of predicting safety behavior scores. These diagnostic evaluations give more confidence in validity and reliability of the regression results and thus help to interpret the regression results in academic and practical contexts.

Table 17: Regression Analysis – Hazard Communication Effectiveness Predicting Safety Behavior

Predictor Variable	Beta (β)	Standard Error	t-value	p-value	Significance
Hazard Communication Effectiveness	0.52	0.05	9.80	<0.001	Significant

Model R^2	0.48	–
Adjusted R^2	0.47	–

4.3.3 Mediation Analysis: Worker Risk Perception

The role of the worker risk perception as a mediator between organizational factors: the managerial control and the clarity of communication to the workers and their accessibility of training, and safety behavior is analyzed. One important aspect of the mediation analysis is that it will aid in understanding the mechanism by which organizational interventions relate to behavioral outcomes. Previous regression analyses have shown direct relationships between organizational predictors and safety behavior, but the results can be explained in a more in-depth and theoretically meaningful way when cognitive variables like risk perception are included. Knowing what hazards are at the facility is not enough to ensure safe work behavior; employee perception of hazard severity, susceptibility and their own ability to respond appropriately is important in many high-risk industrial settings like petrochemical facilities.

Risk perceptions were measured in this study by a multi-item scale based on the Health Belief Model (HBM) which included three items related to: perceived susceptibility to chemical hazards, perceived severity of potential incidents, and perceived self-efficacy in mitigating these risks. The scale showed high internal consistency (Cronbach's alpha = 0.83) and strong construct validity (exploratory factor analysis) and thus is suitable for use as a mediator. There are two theoretical reasons for using risk perception as a mediator: (1) the Theory of Planned Behavior (TPB) (2) the Health Belief Model (HBM). People are more likely to engage in protective behaviors if they feel they are in danger and know what the consequences of not doing so could be, HBM says. TPB also puts emphasis on the influence of knowledge, perceived behavioural control, attitudes towards the behaviour on intention and the behaviour, which in turn are reflected in the attitude of employees towards the risk.

The mediation analysis was performed by bootstrapping procedures with 5,000 resamples that enabled to obtain robust estimates of indirect effects and confidence intervals without assuming normal distribution. Bootstrapping is commonly suggested in mediation research to get a more reliable measurement for the indirect effects, especially in studies on mediation in organizational research where indirect relationships are complex. The independent variables in this study included

the variables of managerial governance, training accessibility and communication clarity while the dependent and outcome variables were hazard communication effectiveness and safety behavior, respectively. Risk perception of the workers was tested to serve as the mediator, assumed to mediate between the organizational factors and safety behavior.

Results show that worker risk perception is a significant mediator between managerial governance and safety behavior. Managerial governance positively influenced worker's risk perception ($\beta = 0.40$, $p < 0.001$), which indicated that those who thought workers had good leadership, policies, and supervision felt that risks were more accurately perceived and that they can manage risks. Similarly, higher levels of worker risk perception were found to positively influence safety behavior ($\beta = 0.46$, $p < 0.001$) such that employees who are aware of potential risks and know how they can help reduce risk are more likely to engage in safe practices. The indirect effect of managerial governance on safety behavior through risk perception was statistically significant (Bootstrapped 95% CI range: 0.12–0.28) and the cognitive risk appraisal was found to mediate the relationship between managerial governance and safety behavior. This discovery should reinforce the need for employees to be aware and conscious of potential risks as well as having structural measures in place to ensure their safety.

Similarly, communication clarity had a significant indirect effect on safety behavior (via worker risk perception). Employees' understanding of hazards was improved by clear and unambiguous communication and this in turn led to an increase in perceived risk and therefore compliance with safety procedures. The indirect path from communication clarity to safety behaviour through risk perception was significant ($\beta = 0.16$, $p < 0.01$), meaning that communication clarity has a significant impact on safety behaviour, not only directly, but also by influencing employees' cognitive assessment of risks at work.

There was also a pathway between training accessibility and the influence on risk perception, but this was primarily via the role of hazard communication effectiveness. Those who received more frequent and high-quality training had higher abilities to properly understand hazard messages ($\beta = 0.33$, $p < 0.01$). Improved hazard understanding, in turn, raised risk perception ($\beta = 0.28$, $p < 0.01$) which in turn was positively associated with safety behavior. This multi-step mediation implies that the greater the hazard understanding that is gained through training is, the greater the level of risk perception will be, which will, in turn, lead to better safety practices. This indirect effect was statistically significant and the 95% confidence interval for the effect was from 0.08 to

0.20.

These results have important theoretical implications. Results validate the Health Belief Model as they show that the perceived risk between organizational safety measures and actual behaviors. Organizational policy, training and communication that clearly communicate hazards and their importance, and that engage employees cognitively with risk, will increase their risk awareness and willingness to take protective action. The findings indicate that people's risk perception improves their feeling of control in the situation, which helps them convert their knowledge of hazards into actual and intended safety practices, from a TPB perspective. Linking the HBM and TPB models to the mediation process is seen as supporting the conceptual basis of the study and the extension of the study to the field of industrial safety.

The implications for practice are as equally strong. In order to enhance the safety of workplaces, it is important for organizations to understand that this is not achieved through the introduction of interventions at the structural and procedural level alone. Good governance, delivering training and providing effective communication are all critical, but these are only effective when employees' minds are raised and absorbed of associated risks. Therefore, there should be aspects within the safety program that specifically focus on risk perception, such as scenario-based training, hazard simulations and interactive exercises where employees can assess and act to/on potential hazards. These interventions increase the knowledge as well as support psychological processes that lead to safe behaviours.

The results of the statistical diagnostics support the robustness of the mediation analysis. Rather than the traditional Sobel tests, which were found to be overly liberal and thus underestimated, the indirect effects were estimated with bias-corrected bootstrapped confidence intervals that provide better and more conservative estimates, especially for non-normally distributed data. All residual plots revealed homoscedasticity and linearity and there were no significant outliers or leverage points identified. The amount of multicollinearity was low, with all VIF values for the predictors less than 2. These confirmations of the validity of the mediation results and help create the reliability of the interpretations.

Table 18: Mediation Analysis – Worker Risk Perception

Predictor Variable		Path	Beta (β)	t-value	p-value	Bootstrapped 95% CI	Significance
Managerial	**Governance**	Indirect	0.18	5.22	<0.001	0.12–0.28	Significant

→ Worker Risk Perception → Safety Behavior						
Communication Clarity → Worker Risk Perception → Safety Behavior	Indirect	0.16	4.87	<0.01	0.10–0.22	Significant
Training Accessibility → Hazard Communication → Risk Perception → Safety Behavior	Indirect	0.14	4.21	<0.01	0.08–0.20	Significant
Direct Effects	Managerial Governance → Safety Behavior	0.22	3.80	<0.01	–	Partial Mediation
	Communication Clarity → Safety Behavior	0.18	3.50	<0.01	–	Partial Mediation
	Training Accessibility → Safety Behavior	0.12	2.95	<0.05	–	Partial Mediation

The mediation analysis shows that worker risk perception is a key cognitive process between the organizational factors and safety behavior. Effective governance, good access to training and communication raise employees' awareness and perception of hazards, thereby improving compliance with safety protocols. The results offer theoretical support for both the HBM and TPB and offer practical directions for the development of thorough safety programs that include structural, communicative and cognitive interventions. This research highlights the significance of the cognitive evaluation of risks for successfully influencing employees' behaviour in industrial settings with high risk potential.

4.3.4 Mediation Analysis: Training Accessibility

Next, the role of the accessibility of training as a mediator is analyzed in the relationships between managerial governance, communication clarity and employee safety behavior. Accessibility of

training involves the availability, frequency and quality of on-the-job safety training, both theoretical and practical, on how to communicate about hazards, including GHS pictograms. The theoretical basis for the mediation of training accessibility on organizational behavior is that organizational policies and leadership decisions have an indirect effect on the behavior of the employees through their effects on access to critical resources and learning opportunities. However, fulfilment of safety procedures relies not just on the quality of governance, communication and information, but also on workers' understanding and access to training that enables them to put policies into practice within their work. In high-risk industrial settings, like petrochemical plants, the ability to follow safety policies depends not only on the governance and communication but also on whether the workforce receives adequate training to understand and implement these policies in their work.

The conceptual framework assumes that there is an indirect link between the managerial governance and clarity of communication and safety behaviour via training accessibility. Managerial governance is the structure to support safety practice, which includes working out suitable training programs, scheduling and implementing. With clear communication, staff are informed of training opportunities they can take advantage of and how training is relevant to workers safety. Accessibility for training allows the workers to learn the knowledge and skills they need to understand hazard messages, recognize some risks and apply safe behaviour. This analysis examines training accessibility as a mediator to help determine the processes by which organizational factors relate to the actual behaviors of the employees.

To test the indirect effect, bootstrapping with 5,000 resampling was used as it does not require normality of the sampling distribution. A three-step path was considered (managerial governance to training accessibility to safety behavior), a second three-step path (communication clarity to training accessibility to safety behavior), and a third three-step path (combined providing hazard communication effectiveness as an intermediate variable). Bootstrapping can be used to estimate indirect effects and to create confidence intervals (CIs) to statistically test the significance of mediation pathways.

The results show that, training accessibility has a significant effect on the relationship between managerial governance and safety behavior. The manager's role in governance was found to positively relate to training accessibility ($\beta = 0.37$, $p < 0.01$), indicating that the employees' perception of the governance quality is a facilitator for being able to access training of the

structured and high quality safety aspect. The number of accessible training opportunities in the workplace, in turn, made a significant prediction of safety behavior ($\beta = 0.33$, $p < 0.01$), suggesting that employees who experience training that is accessible are more likely to follow safety rules and practice safety proactively. The bootstrapped 95% CI for the indirect effect was 0.08 to 0.20, indicating a significant indirect effect and that governance affected the safety behavior via the accessibility of training. The fact that this is a partial mediation indicates that governance has a large indirect influence, via enabling employee learning and skill development, on safety behavior. Likewise, the indirect effect of the communication clarity on the safety behavior through training accessibility was significant. Effective and transparent communications helps to make employees aware of the importance, timing and content of safety training programs, boosting participation and engagement. Communication clarity ($\beta = 0.34$, $p < 0.01$) had an effect on training accessibility, and training accessibility had an effect on the safety behavior ($\beta = 0.33$, $p < 0.01$). This indirect effect (with 95% CI) was significant (0.07, 0.19). The findings indicate that training programmes are essential, but also that a good communication plan is needed to ensure their value and relevance to the day to day activities. Clear and coherent and actionable organisational communication are likely to benefit employees who are more likely to benefit from training.

A more complex mediation pathway was also tested, involving a multi-step pathway that involves managerial governance, communication clarity, the effectiveness of hazard communication, training accessibility and safety behavior. This analysis shows that while governance cannot directly affect the level of hazard understanding, it can indirectly improve the understanding of hazards by enabling the participation in training courses, thereby leading to better safety behaviour. The multi-step standardized indirect effect was 0.14 with a bootstrapped 95% confidence interval of 0.06–0.21, which was significant. The results highlight the importance of organizational factors, as leadership and communication creates environments conducive to better understanding of hazards, leading to greater participation in training, and ultimately safer behaviours at work.

Findings from the theoretical perspectives are in line with the Health Belief Model (HBM) and Theory of Planned Behavior (TPB). For HBM, the training increases access ability leads to higher self-efficacy and hazard severity perception, and thus higher probability of protective behavior. According to TPB, two factors are most important for determining whether someone will take action – behavioral control and knowledge, and the latter can be achieved by providing easy-to-access training for workers that provides the cognitive and procedural resources to take action

safely. The results indicate that training accessibility is a mediator between organizational factors and safety behavior, thus underscoring the need to integrate structural, communicative, and educational actions to create a positive change in the workplace and safety.

The application aspects are also very important. To improve the safety of their employees, employers should make training available and make it regular, relevant and quality training. Governance policies should include provisions that will ensure that training is evaluated regularly, including the timing, length and content of the training. Good communication of training goals and the process makes people more engaged, and helps them to see the point of training. Making it possible for people to participate in the programs increases awareness of hazards, mental awareness of hazards, and compliance with safety practices.

The results of mediation testing are confirmed with statistical diagnostics. The assumptions of the model (linearity, normality, homoscedasticity) were met and the bootstrapping estimated indirect effects were significant and reliable. The VIFs for managerial governance, communication clarity and training accessibility were not exceeding the value of 2, which suggested that there was minimal multicollinearity. These findings would suggest the validity and reliability of the results of the mediations and that the results are not a result of misspecification of the model.

Table 19: Mediation Analysis – Training Accessibility

Predictor Variable	Path	Beta (β)	t-value	p-value	Bootstrapped 95% CI	Significance
Managerial Governance → Training Accessibility → Safety Behavior	Indirect	0.12	4.21	<0.01	0.08–0.20	Significant
Communication Clarity → Training Accessibility → Safety Behavior	Indirect	0.11	3.98	<0.01	0.07–0.19	Significant

Managerial Governance → Hazard Communication → Training Accessibility → Safety Behavior	Multi-step Indirect	0.14	4.10	<0.01	0.06–0.21	Significant
Direct Effects	Managerial Governance → Safety Behavior	0.22	3.80	<0.01	–	Partial Mediation
	Communication Clarity → Safety Behavior	0.18	3.50	<0.01	–	Partial Mediation

Results revealed that the accessibility of training is an important bridging link between the managerial governance and communication clarity-safety behavior. Workshops which employees can access will build on the power of organisational policies and communications by providing employees with the knowledge and skills to recognise hazards and take action to keep them safe. The results obtained in this study are a solid empirical basis for the conceptual framework and provide practical suggestions for implementing all-encompassing interventions for industrial safety which integrate governance, communication and training.

4.3.5 Summary of Hypothesis Testing

The results of this study are quite informative and insightful for a variety of testing hypotheses developed in this study related to organizational factors, effective hazard communication, worker risk perception and training availability with safety behavior in the petrochemical industry in Kuwait. This section gives the results of the multiple regression analysis, the mediation models and presents the hypothesis that is supported based on the results of the statistical test performed and interprets the findings from the point of view of the conceptual framework and the theoretical background of the study.

The initial regression analyses revealed managerial governance and communication clarity and training access to be predictors of effective hazard communication. Managerial governance was

the most important, indicating the importance of the quality of managerial leadership, policy enforcement and supervisory monitoring to improve employees' understanding of hazard communication systems. Accessibility and clarity training was also a key component of hazard understanding and structured access to quality training programmes and clear and consistent messaging will be important organisational inputs to effective hazard understanding. The combined impact of these organizational factors was 62% of the variance in hazard communication effectiveness, thereby corroborating the first group of hypotheses and the conceptual model assumption that organizational practices are underlying factors of employees' hazard comprehension.

Subsequent research confirmed that hazard communication effectiveness is directly and significantly related to safety behaviour. Staff members that interpret the GHS pictograms, read and understand the written hazard information and understand the implications of chemical hazards demonstrate increased compliance with safe practices, proactive risk reduction, and consistent compliance with organizational safety practices. The effect size was significant according to the standardized beta coefficient (0.52, $p < 0.001$) and the model accounted for 48% of the variance of the safety behaviors. The results support the theoretical perspective that knowledge and understanding of hazards are important to safe work practices, and that an accessible, understandable and reinforced hazard communication system within the organisation is important to reinforce.

The mediation analyses offer further insight into how organizational factors are related to safety behavior. The study found that worker risk perception was a significant mediating variable between managerial governance and safety behavior as well as between the communication clarity and safety behavior. Staff knowledge of hazards and the severity of any hazards and their confidence in how to manage hazards enhanced by good governance and communication. This cognitive perspective on hazards, in turn, raised the acceptance of safety measures and proactivity in safe behaviors. Results with indirect pathway via risk perception were statistically significant with confidence interval not containing zero; thus, risk perception was a significant pathway between the organizational factors and the behavioral outcomes. The key take-home message is that organisations need to have robust communication and governance processes, and build cognitive awareness of workplace hazards to facilitate the transfer of knowledge to safe behaviours.

The training accessibility channel was also identified to have significant mediating effects. Those workers who were more likely to have access to frequent and quality training programs had more knowledge about the hazards, and were more engaged in the safety measures, which in turn led to better behaviour around safety. Both single-step mediation (training accessibility) and multi-step mediation (hazard communication effectiveness and training accessibility) were significant, indicating that training accessibility is important to get from organisational practices to behaviour. The results show that leadership and communication are not enough to enable employees to maximize their safety behaviors; they need to be given a structured opportunity to learn the knowledge and skills they need to understand the hazards and respond appropriately. In an indirect path, the relationship between the managerial governance and the communication clarity and safety behavior was mediated by hazard comprehension and training participation in a multi-step mediation analysis. Organizational interventions for both cognitive and skill changes were then followed by behavior changes, reinforcing the need for integrated safety programs due to the potential for a complex cascade.

For most of the hypothesized paths statistically significant relationships were obtained in all the analyses. Managerial governance showed positive and significant correlation with all variables, hazard communication effectiveness, worker risk perception, training accessibility and safety behavior. Again for communication clarity, positive and significant results were found in the direct path as well as the mediated path. Overall, safety behavior was regularly found to be an immediate predictor of the effectiveness of hazard communication, as well as a predictor of access to risk perceptions and trainings. Training was emphasised through a variety of means including being part of making organisational policies accessible. The paths did not meet the conventional level of significance ($p < 0.05$), this completely supported the proposed conceptual framework, and verified the theoretical assumptions of this research.

The results of these findings are of major importance for the conceptual framework. The results confirm the central hypothesis: that the organizational factors (governance, training, and communication) are indeed important determinants of hazard knowledge and safety behaviors. Secondly, the mediating mechanism of risk perception and training accessibility showed that cognitive and educational processes are relevant factors in relation to the organisation's action in the behaviour. Third, the size of the effects and percentage of variance accounted for by the conceptual framework provide evidence that these are important pathways through which

organizational strategies may have an impact on safety behaviors in the context of hazardous industrial situations.

The results support some of the tenets of the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) from a theoretical perspective. The parallels with the HBM concepts of perceived susceptibility and perceived severity confirm the results that knowledge and perceived behavioral control and skill acquisition (as in TPB) are important factors in safety behaviors. The governance, communication and training are embedded in the model, and the message that is clearly made is that structural and cognitive are both important contributors and work together to influence outcomes of safety – organizational theory and behavioural psychology in an actual industrial context.

The study offers some practical recommendations on how petrochemical companies can enhance their safety performance. High quality managerial governance, clear and consistent communication strategies and regularly available, and accessible training programs that are relevant to hazards, can set the tone and environment for better understanding of hazards and encourage safe practices. Furthermore, scenario based exercises, simulations and interactive hazard identification training can be useful to reinforce the implementation of an organization's policies in observable actions. Results show that integrating all three parts (structural-, communicative-, and cognitive-level) of safety measures might be most effective in a comprehensive safety strategy.

Finally, results of the hypothesis testing show that the direct and indirect effects are similar to the conceptual framework. Managerial governance, clarity of communication, ease in accessing training are cited as key elements in the effectiveness of hazard communication and behavior of safety. As per the mechanisms proposed in the model, the relationships are mediated with workers' risk perception and availability of training in the model. The analyses complement the framework and strengthen the theoretical propositions of the HBM and the TPB, and offer some practical suggestions for intervention development for organizational safety. The findings show the conceptual and practical interactions between structural, cognitive and behavioral factors in determining the safety of the workplace, which are recommended for industrial practice.

Table 20: Summary of Hypothesis Testing – Direct and Mediated Effects

Hypothesized Path	Direct/Indirect	Beta (β)	t-value	p-value	Significance

Managerial Governance → Hazard Communication Effectiveness	Direct	0.45	8.90	<0.001	Significant
Training Accessibility → Hazard Communication Effectiveness	Direct	0.33	5.50	<0.01	Significant
Communication Clarity → Hazard Communication Effectiveness	Direct	0.29	4.14	<0.01	Significant
Hazard Communication Effectiveness → Safety Behavior	Direct	0.52	9.80	<0.001	Significant
Managerial Governance → Risk Perception → Safety Behavior	Indirect	0.18	5.22	<0.001	Significant
Communication Clarity → Risk Perception → Safety Behavior	Indirect	0.16	4.87	<0.01	Significant
Managerial Governance → Training Accessibility → Safety Behavior	Indirect	0.12	4.21	<0.01	Significant
Communication Clarity → Training Accessibility → Safety Behavior	Indirect	0.11	3.98	<0.01	Significant
Managerial Governance → Hazard Communication → Training → Safety Behavior	Multi-step Indirect	0.14	4.10	<0.01	Significant

4.4 Summary of Results

For the purpose of this chapter, the data gathered were analyzed to investigate the relationship among the four variables (managerial governance, communication clarity, training accessibility, effectiveness of hazard communication, worker risk perception and safety behavior) in the petrochemical industry in Kuwait. This chapter aims to offer empirical evidence to answer the research questions and to test the hypotheses in the conceptual framework. The results are a

synthesis of descriptive statistics, reliability and validity tests, regression analyses and mediation analyses and give a comprehensive picture of the relationship between organizational and cognitive factors and employee safety behavior. The results from the analyses are summarised to draw lessons from key information, patterns and trends and theory.

4.4.1 Key Findings from Descriptive Statistics

The descriptive statistics present a description of the study sample and all of the study baseline variables that are key. Based on the demographic characteristics, the age group of working people is relatively young with most of the participants being between 25-35 years. This distribution clearly shows the presence of those professionals who are engaged in the operational activities and are at the early to mid career stage. The reduction in the numbers of people in the mid-career age group (30-45) who were “experienced in operational activity and operational safety-related practices” was also found. This age difference might be relevant for the differences in understanding hazard communication and safety behavior and should be taken into account when interpreting this difference. The results of the gender distribution showed that the industry in Kuwait is more or less male dominated and female employees were also found, especially in the safety and administration sectors of the industry. Women also make up part of the workforce and have to be engaged in a safe training and communication approach that will help achieve gender equality in terms of understanding and compliance.

The participants' educational background was diverse, ranging from secondary school, technical skills to national skill qualifications, through to a Bachelor's and Masters degree. Also, differences in employees' educational level may affect training design in that different methods of training may need to be used to ensure that employees learn the same information regarding a hazard. Expatriates are also present in the industry with a significant percentage of the employees being expatriates, which is about 70%, and Kuwaitis. The multi-cultural mix presents opportunities and challenges: some will not speak English, some have no prior experience with safety systems and some will be culturally different from the rest of the participants, all of which may impact the way the hazard symbols are understood and how they relate to the safety training.

The descriptive findings are supplemented with work experience and exposure profiles. The length of time the person held that job was varied (3-10 years) and they said they were familiar with some of the processes in their organization, and some flexibility with new interventions in their safety. The operator or maintenance worker is more likely to be exposed to a chemical or situation that

has a high risk and the safety officer is more likely to be exposed to a chemical or to be involved in compliance monitoring and communication of hazards. These baseline distributions will help give background information when analyzing future hazards and practices, and will indicate how personal characteristics and the work environment will affect hazard understanding and safety practices.

Key variables of the study were subjected to descriptive statistics, and the results indicated that the aggregate values of the constructs of managerial governance, training access, communication clarity, hazard communication effectiveness, worker risk perception and safety behaviors were moderate to high. This means that the participants' overall perception is that the organizational governance is effective, there is training available and the communication is clear. When looking at the effectiveness of the employee hazard communication and employees' understanding of GHS pictograms, there is overall a relatively high awareness of hazards amongst the employees. Knowledge of susceptibility and severity of hazards were measured by scores for worker risk perception; safety procedures were well followed and workers were actively involved in risk reduction, as measured by scores for safety behavior. These descriptive findings are a good basis to interpret the direct and mediated relationships found in the regression and mediation analysis.

4.4.2 Key Findings from Reliability and Validity Analysis

A major aspect of the study was to make sure that the measurement instruments were robust; the analyses indicate that both the scales used are reliable and valid, and appropriate for hypothesis testing. Cronbach's alpha was used to check the internal consistency of all constructs, which were found to be good to excellent. The managerial governance scale had a Cronbach's alpha of 0.88, reflecting the high degree of internal consistency of the items in the scale. The internal consistency of the training accessibility scale and the clarity of the communication scale were good (alpha = 0.84 and 0.86, respectively). The reliability of worker risk perception and safety behavior were also high, at 0.83 and 0.87, respectively, indicating that all items in each scale measured the constructs of interest consistently. Some minor changes were made following pilot testing such as rewording some items and excluding the low-correlation questions, which led to the instruments being more reliable.

Construct validity was evaluated by exploratory factor analysis (EFA) which resulted in the identification of the survey items on the intended factors. All managerial governance, accessibility of training, clarity of communication, worker risk perception and safety behavior demonstrated

good factor loadings (0.69-0.89) and explained significant variance of their constructs (57-62%). These findings validate the theoretical dimensions which the scales were intended to measure and hence confirms that the scales measure true relationship rather than measurement artefacts and gives confidence that future analyses reflect meaningful relationships.

Multicollinearity among the independent variable was determined by both correlation analysis and variance inflation factors (VIF). The inter-scale correlations were moderate, of which there were no correlations greater than 0.70, implying the constructs are conceptually separate. The values of VIF were less than 2 for all managerial governance, training accessibility, and communication clarity variables, indicating that there was little multicollinearity between the variables, allowing these variables to be entered in regression and mediation analysis. In summary, the results of the instruments used in this study indicate that the instruments used are reliable and valid, so that the conceptual framework can be tested.

Descriptive information and reliability and validity assessments provide the study with accurate, interpretable and generalisable information regarding organisational practices, employee perceptions and safety behaviours. Descriptive statistics give pattern and trends in the demographic, work experience and exposure, and the reliability and validity analyses ensure that the measurement scales are strong, internally consistent and appropriate for further analysis. These results together give confidence to the following regression and mediation analyses were conducted on sound and good quality data, thus ensuring the credibility of the study's findings.

4.4.3 Key Findings from Regression and Mediation Analyses

These regression and mediation models in this study give a more comprehensive understanding of the influence of organizational factors on hazard communication effectiveness and the employees' safety behavior. The regression analyses were first carried out to determine the significant factors of the managerial governance, training accessibility, and communication clarity, which are for predicting the effectiveness of hazard communication. Managerial governance proved to be the single best predictor, and shows that employees' perception of the quality of managerial leadership, management of the work, and management of policies has a significant effect on their understanding of hazard messages. Training accessibility also was found to have a significant positive effect, showing that there is a need to offer employees regular, high quality and relevant training courses in safety. Communication clarity also had a positive influence and demonstrated the importance of clear and consistent communication in promoting effective hazard

understanding. The model explained 62% of the variance in effectiveness of hazard communication, thus indicating the importance of these organizational factors in determining employees' understanding of hazard communication procedures.

The direct effect of hazard communication effectiveness on safety behavior was further analyzed with regression analysis. The results showed that there was a positive and statistically significant relationship, and the effectiveness of hazard communication accounted for 48% of the variance in safety behavior. Those staff members who had a higher understanding of GHS pictograms and risk communications materials were more likely to be following the safety procedures, taking preventative actions to avoid hazards and to comply with the organization's safety policy. The high standardized beta coefficient (0.52, $p < 0.001$) highlights the importance of employees understanding hazard communication systems in practice, as this understanding will directly influence on how they work safely at the work site.

The organizational factors influences on safety behavior were also explained using mediation analysis. It was observed that the risk perception of workers was an important mediator for managerial governance - safety behavior and communication clarity - safety behavior. The quality of governance and communication raised awareness amongst staff of the possibility of hazards and how serious they are, and also the self-efficacy of employees to deal with these hazards. An increase in risk awareness resulted in an increase of safety measures being followed. These indirect effects were also statistically significant, with bootstrapped confidence intervals showing the mediation pathway of cognitive processing of hazards is an important pathway through which organizational factors influence the behavior outcomes.

Moreover, training accessibility was found to be a mediator between managerial governance and safety behaviour and communication clarity. Hazard understanding and risk perception were higher with access to effective training and thus led to better safety behaviour. A multi-step mediation analysis was conducted to uncover the process of governance and communication that would facilitate the improvement of hazard understanding, involvement in training programmes and safety behaviour. The indirect effects were statistically significant and bootstrapped to strengthen the effect of training accessibility on behavioural outcomes, as well as on the acquisition of knowledge.

In conclusion, the regression and mediation results suggest that the three variables, effectiveness of hazard communication, worker risk perception and access to training, account for variance in

the safety behavior. The conceptual model was statistically sound with all hypothesized direct and mediated relationships found to be statistically significant. The results show that some organizational, cognitive, and behavioral factors are interconnected to influence safety behavior, as the governance of the management, clarity of communication and access to training impact both directly and indirectly.

The findings of this study are supportive of the HBM as well as the TPB on a theoretical basis. In HBM, perceived susceptibility, perceived severity and self-efficacy are important factors that predict protective behavior, while, in TPB, knowledge, behavioral control and intention are important factors. The findings of the present study suggest that both models are applicable in an industrial safety context, as workers' risk perception levels and their degree of training falls between the organizational practices and the safe behaviour of workers. They build on previous research by providing a description of multiple pathways for organizational factors to affect outcomes on safety, providing empirical support for the conceptual model that was proposed in this study.

From a practical perspective, the analyses suggest that an integrated approach to enhance safety behaviors is needed. Effective management governance framework, however, can be used to facilitate effective implementation of safety initiatives, communication facilitates awareness of expectations and accessible training helps to ensure that employees have the skills and knowledge necessary. Organizations can ensure maximum understanding of hazards and promote a proactive safety culture by tackling both structural and cognitive aspects of safety. The analyses also emphasize the need to provide training that is coupled with clear messages and leadership oversight to make sure that hazard information is communicated and adopted into the individual's behavior of the employees.

Table 21: Summary of Key Regression and Mediation Results

Relationship	**Type**	**Beta (β)**	**t-value**	**p-value**	**Significance**
Managerial Governance → Hazard Communication Effectiveness	Direct	0.45	8.90	<0.001	Significant
Training Accessibility → Hazard Communication Effectiveness	Direct	0.33	5.50	<0.01	Significant

Communication Clarity → Hazard Communication Effectiveness	Direct	0.29	4.14	<0.01	Significant
Hazard Communication Effectiveness → Safety Behavior	Direct	0.52	9.80	<0.001	Significant
Managerial Governance → Risk Perception → Safety Behavior	Indirect	0.18	5.22	<0.001	Significant
Communication Clarity → Risk Perception → Safety Behavior	Indirect	0.16	4.87	<0.01	Significant
Managerial Governance → Training Accessibility → Safety Behavior	Indirect	0.12	4.21	<0.01	Significant
Communication Clarity → Training Accessibility → Safety Behavior	Indirect	0.11	3.98	<0.01	Significant
Multi-step Mediation: Governance → Hazard Communication → Training → Safety Behavior	Indirect	0.14	4.10	<0.01	Significant

4.4.4 Summary of Results

Results presented in Chapter 4 show that the conceptual framework put forward in this research is empirically supported. Descriptive statistics allowed for the development of a clear understanding of participant demographics, work experience and exposure profile, and allowed for interpretation of relationships within these categories. The workforce is very young, male and technically trained and is subject to high levels of chemical risk, highlighting the importance of good hazard communication and structured training interventions. There were moderate to high baseline scores for the understanding of hazard communication, risk perception and safety behaviors, suggesting that the sample had adequate knowledge and awareness to engage in the study.

Reliability and validity analysis was done and the findings indicated that all the instruments used for measurement were reliable and valid. The internal consistency of the managerial governance, training accessibility, communication clarity, risk perception and safety behavior were in the range of 0.83 – 0.88 (alpha values). The result of exploratory factor analysis for all the items was loaded on the constructs with the variance of 57–62%. Correlation and Multi Collinearity tests were performed to make sure that there was no undue collinearity between the independent variables

and VIF values were below 2. These findings suggest reliability and validity of the data and confidence in the accuracy of the following regression and mediation analyses.

Results of regression analyses indicated that, of the factors explored, managerial governance and training accessibility, and communication clarity were the most important factors in predicting the effectiveness of hazard communication, and the managerial governance factor was the most important. This knowledge of hazards was an important factor in influencing compliance with procedures, as it was a significant direct predictor of safety behavior, which shows the effectiveness of hazard communication. Results of mediation analyses illustrated the importance of worker risk perception and training access for the organizational practices to safe worker behaviors. Governance and communication clarity had a mediating effect on the impact of worker risk perception and training accessibility had multiple mediating effects, including a multi-step mediation between worker risk perception and the hazard comprehension. All hypothesized direct as well as indirect paths were significant, confirming the conceptual framework and showing that organizational factors have an effect directly and also via cognitive and educational processes.

When descriptive, reliability and regression analysis are combined with mediation analysis, three important factors of the effectiveness of hazard communication are captured: hazard communication effectiveness, risk perception, and ease of training access. The results support the predictions of the Health Belief Model and the Theory of Planned Behavior where the cognitive appraisals and perceived control are important mediators between the organizational strategies and the behaviour. From a practical perspective, the findings indicate that a multifaceted approach is essential, as three areas of intervention – responsible governance, communication and training – are needed to develop a better understanding of hazards, risk perception and improve safety behaviour.

These results provide a comprehensive view of the effect of organizational and cognitive factors on safety outcomes. They testify that hazard communication and training are not a process or requirement, but part of a system that makes hazard communication and training observable safety behaviors. This is because the results offer theoretical support and practical implications and can be applied to future interventions aimed at building a safety culture in high-risk industrial environments.

Chapter 5: Discussion

5.1 Introduction

Chapter 5 introduces a detailed presentation of the finding in Chapter 4 and discussion of meaning and implications of the findings based on the conceptual framework, research questions and literature. This chapter is aimed at critically reviewing the interrelationships between some organizational factors and the effectiveness of hazard communication, worker's risk perception and training accessibility and safety behavior in the petrochemical industry in Kuwait. The chapter discusses how the statistical results relate to the theoretical perspective, and the significance of the systems of governance, communication and training in staff understanding the hazard message and in transferring the understanding of the hazard message to safe work practice.

The discussion starts with direct relationship to the effective communication of hazards to the organisation then to the worker's understanding of the effect of a hazard on workplace safety. The chapter then examines the mediation of worker risk perception and the availability of training and discusses how organisation-to-behavioural-transformation works. The results are each put into the context of the overall body of literature on industrial safety, highlighting consistencies, disparities and theoretical efforts. The chapter also examines implications for practice in terms of policy and management and suggests some avenues to improve hazard communication systems, increase the cognitive awareness of workplace hazards and make training more broadly available. This chapter clearly relates the findings of this research study to the research questions and also explains clearly the contribution of this research study to the theoretical and practical knowledge of safety behaviour in high risk industrial workplaces.

5.2 Interpretation of Key Findings

5.2.1 Organizational Factors and Hazard Communication Effectiveness

The findings from this study indicated that there is a significant relationship between organizational factors (management control, clarity of communication and the availability of training) and the effectiveness of hazard communication. Managerial governance is most strongly correlated with a better understanding of hazard messages by employees, and leadership quality and policy enforcement/supervisory oversight also positively correlate with this understanding. Staff members who considered the quality of governance as high had a better understanding of the

pictograms they used on the GHS, the instructions for handling the chemical hazards and how to use the safety measures effectively. The results are consistent with previous research that noted that good governance provides clear guidelines that communicate transparency of expectations regarding safety, accountability and support for implementation of protocols. The presence of leadership and supervisory monitoring can assist in reinforcing the values of the organisation and help to establish a culture where everyone knows safety is important and should always be adhered to.

Availability, frequency and quality of safety training courses were also identified as highly significant positive factors for the effectiveness of hazard communication, with greater ease of access to training courses important in ensuring that employees are aware of hazards. Participants exposed to structured training sessions and training sessions that were easily accessible had better understanding of safety information, suggesting that training exposure results in better understanding and retention when repeated and easy to access training materials. This finding confirms that there was a need of interactive training in industrial environments and hands-on training for the different roles in line with the previous studies. Additionally, the results indicate that training programs should be designed to accommodate the diversity of employees' educational levels, language skills and previous safety system experience to ensure that everyone understands hazard messages.

Additionally, clarity of the communication was instrumental in the comprehension of hazards. There was effective communication that was clear and consistent, helping staff to effectively manage information and reduce confusion and errors. The results show that even in very skilled and experienced workgroups, it's possible for messages to be ambiguous or contradictory and limit the understanding of the hazards, thereby raising the likelihood of exposure. The findings also contribute to the current literature as it underscores the need to implement interventions in the areas of governance, training and communication, rather than separate interventions in any one of these areas, in order to promote hazard awareness.

5.2.2 Hazard Communication Effectiveness and Safety Behavior

The regression analysis results showed a good correlation between the effectiveness of hazard communication and safety behavior. Staff with a good knowledge of hazard messaging are more inclined to take safety measures such as adopting the appropriate hazard pictograms, to be familiar with safety procedures and take safety precautions. It is consistent with the Health Belief Model

(HBM) theoretical hypotheses, that knowledge about risk and risk perception are sufficient to induce protective behaviors. Accurate hazard perception is linked with the perception of consequences of unsafe acts as more real and hence reactions.

The results also align with the Theory of Planned Behavior (TPB) which suggests that the perceived behavioural control and knowledge are important factors in intention and behaviour. Employees with a better understanding of hazards can respond and act appropriate to hazardous materials, decide on safety for self and others, and set up procedures for safety of individuals successfully. The practical implications of these results are that hazard communication systems are an important component of safety management. Hazard strategy needs to be made visible in employee's safety behaviours by giving hazard information to the employee and ensuring the employee understands this information. Using a clearer message, visual aids and reinforced training can go a long way to improving compliance and decreasing the potential for accidents to happen.

5.2.3 Mediating Role of Worker Risk Perception

The study has demonstrated that the worker's risk perception is an important intervening variable between the organizational factors and safety practices. Managers' governance increased employees' perception of risk and this in turn had a positive impact on compliance with safety measures.The better managerial governance has led to a positive perception of risk, which in turn had a positive impact on compliance with safety measures. It is important staff feel that they can see potential dangers and that they are at risk, as they are more likely to take proactive steps to minimise risk. This mediation effect is in line with the Health Belief Model that states that the perceived risk is a catalyst for adopting protective actions. If hazards are very real and very important to the job, safety procedures sink into their consciousness and that results in consistent behavior – cognitive consciousness.

The results also revealed that TPB predicts behavior, in that the cognitive evaluation of the consequences of the behavior, together with perceived control, predicts behavior. The greater the perceived risk the more likely employees are to take action to allow them to carry out safe behaviours rather than passive, doing what they have to do. It shows that the role of risk perception as a mediator between governance and communication, and between risk perception and safety action at the workplace, indicating that governance and communication alone are not sufficient, that is, the hazard message needs to be received and processed by the employees' cognition before

it can be seen as safety action at the workplace. The findings highlight the value of programmes and strategies that can help raise awareness of hazards by using scenario based training, hazard simulations, interactive risk assessment exercises.

5.2.4 Mediating Role of Training Accessibility

Accessibility of the training also proved to be an important mediator between the relationship of managerial governance and safety behavior, and between communication clarity and safety behavior. Easy-to-use and high-quality training programs help organizations build hazard awareness and make it a practice for people to respond positively to the hazards. A mediation analysis revealed that those employees with higher scores on the hazard message understanding, risk perception, and safer behaviors were mediated by the higher scores on access to training programs. This is a confirmation that the knowledge is strengthened, and that training can be carried out to translate policies into action for the employees.

Indirect effects of mediation analyses with a multi-step approach were also found for governance and communication, mediated by hazard comprehension, to the training program participation, which subsequently results in safety behaviour. The findings support the sequential and interactive role of organizational factors, training programs and cognitive mechanisms in fostering safe work behaviors. In practice the findings suggest that training should be accessible, relevant, and content should focus on specific workplace hazards, that the training needs to be interactive and engaging. These approaches ensure the best learning, reinforcing the knowledge, and ensuring a safe environment from which the employee can self-learn and internalize the knowledge of hazards.

To sum up, the results of the key findings interpretations were determined to be a complex relationship between organizational factors, hazard communication effectiveness, risk perception by the workers and accessibility of training and safety behavior. Clear communication, easy to train, easy to manage governance = better understanding of the hazard = behaviour change. Two important mediators are the perceived risk of the workers and the amount of training provided that can mediate the organizational practices to consistent and safe employee practices. The results are consistent with the HBM and TPB, and is conceptually supported and practically applicable to the design of an in-depth industrial safety intervention.

5.3 Integration with Research Objectives

The results of this study are clearly linked to the study's objectives and outcomes and are

empirically supported, showing the relationship of the organizational factors, hazard communication effectiveness and the cognitive mediators to safety behavior. The first research goal was to understand how the hazard communication process (hazard management), clear communication, and easy access to training affect the effectiveness of the process. The regression analyses show that all three organizational factors significantly improve the understanding of hazards with managerial governance being the greatest predictor. This directly addresses objective as it establishes that all three (effective governance structures, effective communication and accessible training) are interdependent and have an impact on the understanding and implementation of hazard messages within the workplace by the employees.

The second research goal had to do with understanding the relationship between the effectiveness of hazard communication and safety behavior. The results from the regression analysis showed positive results and confirmed there is a significant positive relationship between employees' understanding of hazard messages and their safe work practice. This finding suggests that knowledge acquisition can't be an end in itself, but would be tied to observable safety actions to meet the goal: linking knowledge of hazards to observable safety actions. Results showed that knowledge of hazards acts as a mediator between organizational practices and safety behavior and so it is important to develop interventions that have an impact on knowledge and behavior outcomes.

The third research goal was to examine if the two research variables above mediate the relationship between worker risk perceptions and training availability and safety behavior of the third variable. To sum up, both variables also have significant mediation effects in the relationship between organizational factors and the safety behavior, as confirmed by mediation analyses. Workers' risk perceptions help them to understand potential hazards, non-compliance risk and what can be done to prevent it, which contributes to the connection between governance and communication effectiveness and compliance and behaviour. Accessibility to training allows for the development of knowledge and skills and therefore increases understanding and expands the connections between organizational interventions and safe behaviors. The mediated pathways provide evidence that organizational factors not only affect the behavior directly, but also indirectly via cognitive and educational processes, and thus fulfilled the third research objective.

The results collected were pooled together into a unified explanatory model that links together all the research objectives highlighting the interdependent role of governance, communication,

training, hazard understanding, risk perception, and compliance in behaviour. Both direct and mediated pathways are explored for each objective in order to give a comprehensive view of the organizational and cognitive factors and how these can improve safety in the workplace. The findings of this study will answer the research questions, provide information on the structural and cognitive components of hazard communication and safety behavior and provide important information about the use of this type of behavior in high hazard industrial settings.

5.4 Theoretical Implications

This study's findings are a valuable addition to the organizational safety literature because it also included leadership, communication and training factors as well as their mediators of cognition such as risk perception. All the direct and indirect effects identified have been theorized to impact employee behaviours and consequently safety outcomes. The study provides empirical evidence of the Health Belief Model (HBM) as the mediator between the organizational interventions and their acceptance as the intervention is implemented to the workers. In the field of industrial safety, the awareness of employees about hazards and their perception of risk is also important for the implementation of protective behaviors, which makes the HBM suitable in this field.

The study also demonstrated that the Theory of Planned Behavior (TPB) is demonstrated with this study since it showed that the knowledge, perceived behavioral control and cognitive evaluation of hazard has an effect on the behavior. Hazardous interactions are more likely to be under employees' control (due to the effectiveness of hazard communication), and employees are more likely to be able to access training (due to the accessibility of the training), and therefore more likely to successfully implement safe practices. This study contributes to clarifying the role of knowledge and hazard and skill acquisition as mediators between organizational predictors and behavioural outcomes and extends TPB by introducing multi-step mediation pathways, including the process of hazard and skill acquisition.

Furthermore, the present study offers novel evidence of the integrative role between governance, communication, training and cognitive factors on safety behavior. The multi-step mediation model is an insightful model which explains the interaction of the structural, educational and cognitive factors as mediators that synergically support compliance. This paper also has theory contribution, as these variables have been already studied separately in the past; in the present study, both the direct and indirect pathways have been studied for the first time, and direct and sequential pathways have been studied for the first time. The findings thus contribute to the already available

literature due to the connection of organizational management theories to the behavioural psychology and thus complete the process of safe practices in the work place.

5.5 Practical Implications

Based on the results of this study, there are a few recommendations that can be made for actions to be taken by petrochemical companies, in order to improve safety outcomes. Managerial governance should be enhanced to increase management presence, establish strong management policies and effective management accountability arrangements. The supervisors and safety managers should proactively communicate with the workers, give feedback on the situation of safe production and remind them to follow the safety procedures. Good governance fosters a culture within the organisation that helps promote good safety practices and promotes employees' commitment to these.

Secondly, there should be training programs, they should be regular and relevant. The study also highlights the role of training accessibility in between governance and communication with regard to safety behavior, suggesting that a properly designed training can help boost the understanding of hazards, strengthen risk awareness and boost compliance with safety procedures. A program should be tailored to the education level of the employees, and the nature of the actual work to be done, and a blend of hands-on and hazard simulation/exercise and scenario based learning will provide a wealth of knowledge and how to apply knowledge-in-context.

Thirdly, there is a need to ensure that communication strategies are clear and consistent. The shorter, clearer the message is and the more often the message is repeated to the employee (a written procedure, pictures, and/or a verbal briefing), the more likely the employee will learn and follow the safety information. Good communication will ensure that training and governance is taken up and implemented in behaviour, minimising risk of error due to lack of communication.

Fourthly, workers' risk perception is vital to interventions. All workers need to be informed of the potential dangers and the damage that can be caused by poor work practices. There are opportunities to increase engagement with cognition through cognitive impact programmes (e.g., risk-based activities, interactive workshops or hazard awareness campaigns) which will improve compliance. Organizations can enhance the mechanisms which underlie safe behavior by tackling knowledge and perception.

Last but not least, the combination of governance, training and communication into a unified safety strategy makes sure that workers are educated and empowered to work safely. This study has

practical implications which go beyond procedures and concentrate on the importance of establishing a safety environment where employees understand, absorb and routinely perform safety behaviors.

5.6 Limitations and Future Research Directions

Although a detailed analysis is provided, there are some limitations to the study. The first is that with cross sectional design it is impossible to make a determination that there is causality involved. Important relationships that were identified in the regression and mediation models need to be replicated in longitudinal studies and inferences about chronology and directionality made. Second, self-reported assessments of comprehension of hazards, risk perception and safety behaviors may be subject to bias, such as social desirability bias that may overestimate safety behaviors and understanding. Thirdly, the samples are only available within one industry and country, which may impact the applicability of the findings to other industries and to other cultural contexts.

A longitudinal study design of hazard understanding and/or behaviour changes over time is recommended for future study, especially with regard to specific intervention. If the observed relationships can be generalized to other operating and/or cultural conditions, cross industrial or cross cultural studies are carried out. In addition, some researchers may use objective data of safety behavior (observational audits or digital monitoring of safety behavior) as well as self-reported data to better capture safety behavior in the future. Investigation of effects of technological interventions (such as online training platforms, digital hazard communication tools) could prove more useful for these findings in practice.

5.7 Summary

Overall, the hazard communication discussion reinforces the idea that hazard communication is a good predictor of safety behavior and that managerial governance, communication clarity, and training accessibility are good predictors of the effectiveness of hazard communication. There are some key mediators that help to move the organizational practices to the safe worker behavior, training and worker risk perception. The results supported the conceptual framework, the theory models (HBM and TPB) and the practical recommendations for improving the safety of workers in petrochemical plants. The chapter is very theoretical and also quite detailed in the significance of the goals of studying and how to achieve these goals, and serves as a foundation for the conclusions and recommendations made for policy and practice in Chapter 6.

Chapter 6: Conclusion

6.1 Introduction

The findings of Chapter 4 and Chapter 5 are summarized in Chapter 6, which are fully concluded in this chapter with the implications of this research both theoretically, practically and policy. The main objective of this chapter is to combine the empirical findings on the link between organizational factors and effectiveness of hazard communication, worker risk perception, availability of training and safety behavior in the petrochemical industry in Kuwait. This chapter restates the study purpose and goals and summarises the study's main findings before discussing how this study has enhanced knowledge of the processes whereby governance, communication and training facilitate understanding of hazards and safety decision making.

The first important research question examined in this study was: What are the relationships between the effectiveness of hazard communication and organizational factors (managerial governance, communication clarity, and training accessibility)? (2) What are the relationship between hazard comprehension and safety behavior? What are the intervening variables between hazard communication effectiveness and safety behaviour (worker risk perception, access to training)? Empirical: answers to the above questions are given to support theory and practice. The chapter aims to start with a summary of the main results of the study, then add the contributions, practical implications/policy recommendations, limitations and directions for future research and finally conclude with the importance of the study for future occupational safety management of high-risk industrial work.

6.2 Summary of Key Findings

6.2.1 Organizational Factors and Hazard Communication Effectiveness

Results of this study indicate that the organizational factors such as managerial governance, training availability and communication clarity are the key factors that influence the effectiveness of hazard communication among employees within the petrochemical industries. Managerial governance proved to be the most predictive factor for hazard comprehension, with employees' sentiments about supervisory oversight, managerial quality, policy implementation and organizational accountability directly impacting the comprehension of hazard messages. It stresses the need for clear organisation and communication of clear expectations about safety, tracking and

reinforcing these expectations in a consistent leadership practice. Good governance creates the foundations for staff to have access to hazards information and to incorporate safety priorities and adhere to the organisation's procedures.

Accessibility of training was also determined to significantly improve the effectiveness of the hazard communication. Individuals with higher structured training, more frequent and higher quality training had a better understanding of GHS pictograms and hazard warnings, and better understanding of written safety instructions. The discovery highlights the need to offer workers chances to learn the knowledge and skills needed to correctly interpret complex safety information. It also highlights the need to recognise and consider the varying levels of education and roles of staff in the workplace and how these can impact their previous knowledge of the safety system and ensure that all staff can receive what is being presented.

Clarity of the communication (precision, consistency and understandability of hazard messages) also played a critical role in hazard understanding predictions. Even when there is clear and unmistakable messaging, highly trained staff were discovered to be misinterpreting the message. The findings suggest that there was a reinforcement between the governance, training and communication, as a result of this improvement in the awareness of hazards. Such organizational factors utilize in the study and it is assumed that with the right management and communication, it can create a space for employees to repeatedly use safety procedures and make the right interpretation of the hazards.

To summarize, these studies have confirmed that organizational practices can have an effect in the process of effective hazard communication for cognition. They confirm that governance, training and communication are not three distinct processes, but are indeed one and the same process that depend on each other and that it is essential that employees know about hazards at work – and this is essential for them to behave safely.

6.2.2 Hazard Communication Effectiveness and Safety Behavior

The analysis also shows that hazard communication effectiveness directly and significantly impacts on safety behavior. Those who did comprehend the hazard messages were able to take the necessary safety measures and act in advance to avoid hazards, and consistently follow organisation safety procedures. The results confirm the theoretical frameworks of the Health Belief Model and the Theory of Planned Behavior, with hazard knowledge playing an important role as a prerequisite for behaviour. This means that staff who are able to take hazards seriously and

understand the risks are more likely to take measures to minimise their exposure to potentially hazardous substances and to protect themselves from the risk.

This relationship is strong and it suggests the use of hazard communication systems. It recommends the need to invest in clear messaging, standard instructions and pictograms on GHS as a way of inducing actual behaviour change as part of an organisation's safety policies. Repeated exposure and easy access to information, along with interactive training, reinforces comprehension, and can help ensure that information is expressed in consistent, observable safety practices. Also, as indicated by the results, hazard communication is a mediator between governance and communication strategies and the end result of safety behavior.

The link between comprehension and behavior also indicates that cognitive understanding of a hazard is not enough, it is necessary that the employee can process the hazard information, internalize it and then act on it. It emphasizes the importance of creating hazard awareness and simulated and scenario-based training to address the knowledge gap, moving to the real application of the hazard awareness. The direct effect found in the present study is consistent with the key role of the effectiveness of hazard communication in determining the safety of the workplace as suggested in the theoretical model presented at the start of the research.

6.2.3 Mediating Mechanisms: Risk Perception and Training Accessibility

The two mediators, worker risk perception and training accessibility, were found to be important in understanding the cognitive and learning factors that contribute to safety behavior. Risk perception can convey to employees the risk of exposure to a hazard and the potential severity of an incident which can help support the need to implement protective behaviors. Cognitive appraisals were found to be important in relation to safety compliance as employees with high risk perceptions were more likely to internalize hazard messages and thus translate them into action. The results indicate organizational policies and communication strategies have not only a direct but also an indirect effect, through employees' perception and evaluation of hazards, suggesting the theory of Health Belief Model and Theory of Planned Behavior is valid.

Accessibility of training was also important, both as a direct and indirect mediator. Hazard understanding and risk perception were improved, and thus safety behavior, through accessible, high quality training programs. Mediation analysis using multiple steps indicated that governance and communication positively affect hazard comprehension, and that participation in training program positively affects compliance with the safety protocol, and that compliance with the safety

protocol positively affects the hazard comprehension. This is a “sequential pathway” where organizational interventions have the most effect when they are acting on both structural and cognitive and educational pathways. One of the very best aspects of a well designed and inclusive training program is its accessibility; an opportunity to provide employees with information, and with skills to use the information in their everyday work.

The pathways leading towards mediation are merged to highlight the influence of governance, communication, cognitive processing, and educational mechanisms on the facilitation of safety behaviors. In addition to supporting the theoretical connection between risk perception and organizational measures, this study offers an empirical model for understanding how organizational measures impact employee behavior, and a deeper understanding of the processes in between.

6.3 Contributions of the Study

The study has theoretical and practical implications, as it gives a holistic understanding of the effect of organizational factors, the effectiveness of hazard communication, worker risk perception, and training accessibility on safety behavior in high-risk industrial settings. The research integrates structural, cognitive and behavioural pathways, complementing the existing knowledge in the field of occupational safety and health and offering some practical recommendations for increased compliance to hazards at petrochemical plants.

6.3.1 Theoretical Contributions

According to the theoretical perspective this study contributes to the research in a few ways. The first is that the study is an empirical testing of the Health Belief Model (HBM) in an industrial safety context. The study validates the fact that the employee's perceived susceptibility, perceived severity and self-efficacy are important factors in the development of employee protective behavior, and the study also demonstrated the mediating role of the employee's risk perception of the situation between organizational factors and protective behavior. This result is an indicator of the transformation of a structural change to a specific action, and is a confirmation of the theoretical hypotheses of the HBM model in the field of industrial safety management.

Secondly, this study contributes to the Theory of Planned Behavior (TPB) by highlighting the importance of PBC and knowledge in relation to safety behaviour. Using tools like hazard communication effectiveness and training accessibility can give employees greater control over

working with hazards, an appropriate risk assessment, and greater confidence in the hazard assessment measures. This study suggests that the influence of organizational interventions and cognitive processes on intentions and actual behaviour to create a work environment that is safe is more complex than the work of previous studies which indicated that either one or the other of the factors, interventions, and/or cognitive processes are responsible for the influence.

Additionally, the study offers a multi-step mediation process, in which hazard communication comprehension is mediated by organizational governance accessibility, communication clarity and training, and subsequently, by the risk perception, which in turn influences the safety behavior, thereby contributing to the existing literature on organizational safety. This is a sequential model in which the structural and cognitive parts are connected and successful outcomes of safety would be the result of the synergy of the structural parts, leadership practices, communication practices, and education and employee cognitive engagement. An innovative contribution for the present research is the empirical framework which allows the integration of these variables in one single framework.

Moreover, training accessibility is both directly and indirectly associated with organizational practices and outcomes, and opportunities for training are crucial in linking those two. Theories used in this research are theoretical foundations for the role of accessible and quality training in hazard understanding and increasing risk perception, which can be used as a mediator in the construction of safety models based on knowledge acquisition and skill development. The overall results confirm the theories previously presented, as they integrated the structural, cognitive and educational components within one comprehensive framework, which will be explored in future for the influence of multi-level factors on the safety behavior.

6.3.2 Practical Contributions

For practice, the authors provide a number of recommendations for industry, safety practitioners and policy makers to enhance hazard communication and promote safe behavior. First, it is worth to be noted that the good managerial governance is imperative. The leadership presence and policy enforcement and supervisory accountability were found to be significant factors in relation to understanding hazards and taking action for safety. Safety policies should be in place, regular safety audits should be carried out and supervisory staff should be involved in auditing the safety procedures and giving feedback on them. Good governance helps to foster a culture of 'risk mitigation', adherence to protocols and helps the organisation's message of safety and risk

mitigation to be understood.

Second, the study underscores the need to make training accessibility a key focus to enhance safety outcomes. A team that has regular, high quality and meaningful training programs are more likely to know the hazards and to follow the safety procedures. It is required to design training programmes in the industrial organisation comprising of theoretical and practical parts, scenario based learning, hazard simulation and make it as attractive, vivid and memorable as possible. Design training programmes must take into consideration the diversity in education level, language skills, role of an individual in operational area in order to be understood by all.

Last but not least, it was revealed that communicativeness was an important element in understanding hazards and risk perception. Clear and concise communication, and consistency, will keep workers informed of safety information and hazard messages and help eliminate misunderstandings and errors. The communication pathways should be the same for all organisations; visual aids, such as GHS pictograms, should be used and messages should be reinforced in a number of ways including verbal briefings, manuals and workshop handouts.

Lastly, the study underscores the need to take care of the way these interventions are conveyed to safe behaviours by taking into account workers' cognitive processes, in this case their perception of risk. Employees are better informed about hazards and their severity and vulnerability through risk based exercises, hazard awareness campaigns and scenario based training and are more proactive in participating in safety. It may be used in conjunction with governance, communication, training and cognitive interventions to develop a holistic safety system that provides the most complete understanding and behaviour compliance.

6.4 Recommendations

Based on the results, some practical suggestions are being given to improve the occupational safety in high risk industrial environment, like a petrochemical industry. The first step is to have more effective policies in place for governance of this type: clear role and responsibility assignments, accountability and visible support of the safety policies in the organization. Governance structures should ensure safety is a high priority operating value and include safety objectives in performance measures as well as regularly check compliance of policies on safety.

Second, training programs need to be available, regular, and job-specific and based on individual employee backgrounds. Workshops should include an interactive element and should include simulation exercises, hazard scenario exercises and practical exercises on use of the GHS

pictograms. Assessment and feedback processes can be incorporated into training and serve to help the employee demonstrate the knowledge and use of safety practices. Training programmes should be kept current to maintain relevance and effectiveness in the event of any changes in hazards, equipment and/or regulations.

Thirdly, companies need to improve the communication process to make it clear and consistent. Safety information, hazard signs and clear communication is regularly brought to all staff members' attention. Communication should also be culturally sensitive, acknowledging the diversity of the workforce, and the differences in language so that all employees fully understand the messages.

Fourth, organizations should undertake programs to enhance cognitive engagement, especially risk perception. Awareness raising, scenario based sessions and practical hazard risk assessments can help raise employee awareness of the potential severity of hazards, their susceptibility, and how hazards can impact them if they act in an unsafe manner. This can be fostered as a reminder within the organisation, that by following protocols there are many benefits to safety – and cognitive awareness that can be built to make internal motivation happen.

Lastly, implementation strategies need to be systematic and integrated. Training programmes, communication and governance activities need to be aligned and harmonised to the organisation's goals. The desired outcomes are an improvement in hazard knowledge, an enhanced perception of risk, better adherence to safety controls and ultimately, a decrease in accidents and injury at work. Monitoring systems and evaluation tools should be established to evaluate the impact of interventions and to give a way to make improvements continually.

6.5 Limitations and Scope for Future Research

The study, however, has a number of restrictions. But the cross sectional research design weakens the inferences of the causal relationship between the organizational factors, hazard communication and safety behavior. Longitudinal designs would be useful in future studies to look at changes in comprehension, risk perception and behavior over time and to evaluate the sustainability of safety interventions.

Secondly, hazard understanding, risk perception and safety behaviour were self-reported which might result in biased data, such as social desirability and/or overestimation of compliance. Future research should be based on objective measurement tools including: observational audit, behavioural tracking and digital monitoring, which will triangulate, be more valid and give more

weight.

Thirdly, the study was conducted in one sector of industry in Kuwait which might not be generalizable to other sectors of industries and other countries. The conceptual framework proposed could be used in future research to evaluate the transferability of the concept to other cross cultural and cross industry contexts. In addition, a study could be done on the effect of technological interventions such as a digital hazard communication platform, a virtual reality training or mobile monitoring system, etc. to increase the accessibility, engagement and effectiveness of training.

Finally, the study failed to assess long-term effects on behavior and the sustainability of the hazards knowledge and safety behavior changes. There is a need for more research to determine the sustained impacts of repeated governance, training and communication efforts on compliance with safety procedures and incident reductions in the workplace.

6.6 Final Conclusion

Lastly, this study has established the important effects of organizational related factors (managerial governance, the clarity of communication, and the availability of training) on the effectiveness of hazard communication, which in turn, was found to predict employee safety behavior in a high-risk environment in the petrochemical industry. Two mediators that could be important linking the intervention to the protective behaviors are worker risk perception and the availability of worker training. The results confirm the theoretical models used by the Health Belief Model and the Theory of Planned Behavior: how the cognitive aspects of the appraisal and behavioral control influence workplace safety through structural and educational interventions.

Theoretically, the study is significant because it brings together the structural, cognitive and training mechanisms into an integrated model that can be used to explain and predict safety behaviour. Practically, the study is significant because it embeds these three mechanisms and perspectives into a single model. The study offers practical suggestions to industrial organisations, safety managers and policy makers with emphasis on governance, communication and training that is accessible, awareness building and awareness campaigns for risk awareness. The findings of this study can be used to design integrated safety interventions that can enhance the understanding of hazards, risk perception and increase adherence to safety measures and decrease workplace accidents to achieve a safe working environment. The contribution of this study is to bridge the gap between the practice, theory and empirical and to give a guideline to improve the

occupational safety in high risk industrial settings.

References

Aiman Muhamad Bauzir and Tri Siwi Agustina (2024). Safety Participation on Industrial Company: Emphasize Safety Leadership and Safety Climate with Safety Knowledge as Mediation. *RGSA*, 18(3), pp.e06785–e06785. doi:https://doi.org/10.24857/rgsa.v18n3-143.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), pp.179–211. doi:https://doi.org/10.1016/0749-5978(91)90020-T.

Ali, M., Iyiola, K., Alzubi, A. and Aljuhmani, H.Y. (2025). Using Safety-Specific Transformational Leadership to Improve Safety Behavior Among Construction Workers: Exploring the Role of Knowledge Sharing and Psychological Safety. *Buildings*, 15(18), p.3340. doi:https://doi.org/10.3390/buildings15183340.

Batool, A., Awan, T. and Chughtai, S. (2022). Impact of CEO Overconfidence on Corporate Financing Decision with Mediating Role of Risk Perception. *Business Review*, 16(2). doi:https://doi.org/10.54784/1990-6587.1375.

Burke, M.J., Sarpy, S.A., Smith-Crowe, K., Chan-Serafin, S., Salvador, R.O. and Islam, G. (2006). Relative Effectiveness of Worker Safety and Health Training Methods. *American Journal of Public Health*, [online] 96(2), pp.315–324. doi:https://doi.org/10.2105/ajph.2004.059840.

CE Module: Health Risk Factors Among Miners, Petrochemical Extraction Workers, Other Manual Labor Workers, and Nonmanual Labor Workers, BRFSS 2013–2017, 32 States. (2020). *Workplace Health & Safety*, 68(8), pp.402–402. doi:https://doi.org/10.1177/2165079920924380.

Chapagain, R., Ghimire, R. and Boro, L. (2024). Accessing the impact of farmers' awareness level and risk management perception on agriculture insurance satisfaction: Mediating role of non-financial satisfaction. *Insurance Markets and Companies*, 15(2), pp.1–13. doi:https://doi.org/10.21511/ins.15(2).2024.01.

D, O.A. (2020). Sustainable Development and Health, Safety and Environmental Management in Offshore Petrochemical Drilling and Production Industry. *Novel Research in Sciences*, 5(2). doi:https://doi.org/10.31031/nrs.2020.05.000609.

D. Miroonova, M. (2018). Contents and Ways of Organizational-Financial Risks Reduction among Managing Subjects in Housing and Utility Service. *HELIX*, 8(1), pp.2522–2526. doi:https://doi.org/10.29042/2018-2522-2526.

Gopalan, N. (2016). Editorial on Safety Measures and Accidental Hazards in Petrochemical Industries. *Oil & Gas Research*, 2(2). doi:https://doi.org/10.4172/2472-0518.1000e103.

I. Chittumuri, N. Alshehab, Voss, R.J., Douglass, L.L., S. Kamrava, Fan, Y., Miskimins, J., Fleckenstein, W., Wheeler, S. and Bandyopadhyay, S. (2025). Risk Analysis of Flowlines in the Petrochemical Sector: A Geographic Information Systems and Machine Learning Approach. *SPE Journal*, 30(08), pp.4518–4529. doi:https://doi.org/10.2118/228286-pa.

IPCC (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland. *Climate Change 2023 Synthesis Report*, [online] pp.35–115. doi:https://doi.org/10.59327/ipcc/ar6-9789291691647.

Izadi, N. (2018). Occupational Health Hazards among Health Care Workers. *Public Health Open Access*, 2(1). doi:https://doi.org/10.23880/phoa-16000120.

Jamil, Z., Nordin, S., Miraj, M., Alqahtani, M., Shaik, R.A., Akhter, S. and Shahrul, A. (2025). Sustainable safety practices and hazard management in the petrochemical industry: an HSE perspective. *Frontiers in Public Health*, 13. doi:https://doi.org/10.3389/fpubh.2025.1611106.

Li, X., Zhu, Y., Abbassi, R. and Chen, G. (2022). A probabilistic framework for risk management and emergency decision-making of marine oil spill accidents. *Process Safety and Environmental Protection*. doi:https://doi.org/10.1016/j.psep.2022.04.048.

Masudin, I., Tsamarah, N., Restuputri, D.P., Trireksani, T. and Djajadikerta, H.G. (2024). The

impact of safety climate on human-technology interaction and sustainable development: Evidence from Indonesian petrochemical industry. *Journal of Cleaner Production*, [online] 434, p.140211. doi:https://doi.org/10.1016/j.jclepro.2023.140211.

MOHAMADI, A., KARIMI, S. and KARIMI, E. (2022). Identifying and Assessing Health, Safety and Environmental hazards of Safety Shoe Industry. *Occupational Hygiene and Health Promotion*. doi:https://doi.org/10.18502/ohhp.v6i1.9408.

Ni Nyoman Ayu Cahyani and Yunita, P.I. (2025). The Influence of Regret Aversion and Risk Tolerance on Cryptocurrency Investment Decisions: The Mediating Role of Risk Perception and the Moderating Effect of Income Perception (A Case Study on Generation Z in Bali). *Jurnal Manajemen Motivasi*, 22(1), pp.821–831. doi:https://doi.org/10.29406/jmm.v22i1.8628.

Omidi, L., Karimi, H., Pilbeam, C.J., Mousavi, S. and Moradi, G. (2023). Exploring the relationships among safety leadership, safety climate, psychological contract of safety, risk perception, safety compliance, and safety outcomes. *Frontiers in Public Health*, 11. doi:https://doi.org/10.3389/fpubh.2023.1235214.

Oughton, N. (2013). Managing Occupational Risk in Creative Practice: A New Perspective for Occupational Health and Safety. *Archives of Environmental & Occupational Health*, 68(1), pp.47–54. doi:https://doi.org/10.1080/19338244.2011.639818.

PALAČIĆ, D. (2019). ISO 45001:2018 - CONCEPT OF MANAGING THE PROCESS OF OCCUPATIONAL HEALTH AND SAFETY. *Safety Engineering*, 9(1). doi:https://doi.org/10.7562/se2019.9.01.03.

Priolo, G., Vignoli, M. and Nielsen, K. (2025). Risk perception and safety behaviors in high-risk workers: A systematic literature review. *Safety Science*, [online] 186, p.106811. doi:https://doi.org/10.1016/j.ssci.2025.106811.

Schulte, P.A., Iavicoli, I., Fontana, L., Leka, S., Dollard, M.F., Salmen-Navarro, A., Salles, F.J., Olympio, K.P.K., Lucchini, R., Fingerhut, M., Violante, F.S., Seneviratne, M., Oakman, J., Lo, O., Alfredo, C.H., Bandini, M., Silva-Junior, J.S., Martinez, M.C., Cotrim, T. and

Omokhodion, F. (2022). Occupational Safety and Health Staging Framework for Decent Work. *International Journal of Environmental Research and Public Health*, [online] 19(17), p.10842. doi:https://doi.org/10.3390/ijerph191710842.

Shi, H. (2020). The Influence of Safety-Specific Transformational Leadership and High-Quality Relationships on Mindful Safety Practices Through Safety Climate: A Study in Chinese Petroleum Industry. *Journal of Applied Security Research*, pp.1–17. doi:https://doi.org/10.1080/19361610.2020.1761744.

Siegrist, M. and Árvai, J. (2020). Risk Perception: Reflections on 40 Years of Research. *Risk Analysis*, 40(S1). doi:https://doi.org/10.1111/risa.13599.

Walters, D.B., Ho, P. and Hardesty, J. (2014). Safety, security and dual-use chemicals. *Journal of Chemical Health and Safety*, [online] 22(5). doi:https://doi.org/10.1016/j.jchas.2014.12.001.

Wang, Z., Wang, B., Ren, M. and Gao, D. (2023). A new hazard event classification model via deep learning and multifractal. *Computers in Industry*, 147, p.103875. doi:https://doi.org/10.1016/j.compind.2023.103875.

Wingate, K.C., Pratt, S., Ramirez-Cardenas, A. and Hagan-Haynes, K. (2023). Risky driving behaviors and employer motor vehicle safety policies among U.S. petrochemical extraction workers. *Journal of safety research*, 86, pp.12–20. doi:https://doi.org/10.1016/j.jsr.2023.05.015.

Young, S. (1998). Improving Safety Culture:981Dominic Cooper. Improving Safety Culture: A Practical Guide. Wiley, 1998. 302 pp, ISBN: 0-471-95821-2 £70.00 Paperback. *Leadership & Organization Development Journal*, 19(6), pp.347–347. doi:https://doi.org/10.1108/lodj.1998.19.6.347.1.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis & Prevention*, 42(5), pp.1517–1522. doi: https://doi.org/10.1016/j.aap.2009.12.019.

Achumie, G.O., Oyegbade, I.K., Igwe, A.N., Ofodile, O.C. and Azubuike, C. (2022). A Conceptual

Model for Reducing Occupational Exposure Risks in High-Risk Manufacturing and Petrochemical Industries through Industrial Hygiene Practices. International Journal of Social Science Exceptional Research, 1(1), pp.26–37. doi: https://doi.org/10.54660/ijsser.2022.1.1.26-37.

An Insight into Oil and Grease Removal from Wastewater from Petroleum and Refinery Industries. (2016). International Journal of Petroleum and Petrochemical Engineering, 2(1). doi: https://doi.org/10.20431/2454-7980.0201003.

Astiaso Garcia, D., Bruschi, D., Cumo, F. and Gugliermetti, F. (2013). The Oil Spill Hazard Index (OSHI) elaboration. An oil spill hazard assessment concerning Italian hydrocarbons maritime traffic. Ocean & Coastal Management, 80, pp.1–11. doi: https://doi.org/10.1016/j.ocecoaman.2013.03.016.

Boman, A., Miguel, M., Andersson, I. and Slunge, D. (2024). The effect of information about hazardous chemicals in consumer products on behaviour – A systematic review. The Science of The Total Environment, [online] 947, pp.174774–174774. doi: https://doi.org/10.1016/j.scitotenv.2024.174774.

Fu, W., Kalkanci, B. and Subramanian, R. (2019). Are Hazardous Substance Rankings Effective? An Empirical Investigation of Information Dissemination About the Relative Hazards of Chemicals and Emissions Reductions. Manufacturing & Service Operations Management, 21(3), pp.602–619. doi: https://doi.org/10.1287/msom.2018.0710.

Gopalan, N. (2016). Editorial on Safety Measures and Accidental Hazards in Petrochemical Industries. Oil & Gas Research, 2(2). doi: https://doi.org/10.4172/2472-0518.1000e103.

Hymel, P.A., Loeppke, R.R., Baase, C.M., Burton, W.N., Hartenbaum, N.P., Hudson, T.W., McLellan, R.K., Mueller, K.L., Roberts, M.A., Yarborough, C.M., Konicki, D.L. and Larson, P.W. (2011). Workplace Health Protection and Promotion. Journal of Occupational and Environmental Medicine, [online] 53(6), pp.695–702. doi: https://doi.org/10.1097/jom.0b013e31822005d0.

INDUSTRIAL SAFETY AND RISK MANAGEMENT FOR A PHARMACEUTICAL COMPANY. (2016). International Journal of Advance Engineering and Research Development, 3(09). doi: https://doi.org/10.21090/ijaerd.030916.

Jamil, Z., Nordin, S., Miraj, M., Alqahtani, M., Shaik, R.A., Akhter, S. and Shahrul, A. (2025). Sustainable safety practices and hazard management in the petrochemical industry: an HSE perspective. Frontiers in Public Health, 13. doi: https://doi.org/10.3389/fpubh.2025.1611106.

Khosravi, Y., Zahra Pournazari, Yazdi, M., Faiza Sediq and Narmin Hassanzadeh-Rangi (2024). Effect of hazard communication system on workplace safety and health performance in educational and research laboratories of universities of medical sciences. Journal of Environmental Health Engineering, 12(1), pp.75–85. doi: https://doi.org/10.61186/jehe.12.1.75.

Nasution, A.S., Haris, A., Morina, M. and Herlina, L. (2022). Petrochemical Industries. Scientific Contributions Petrochemical, 33(2), pp.143–150. doi: https://doi.org/10.29017/scog.33.2.818.

Shahverdieva, A.F., Hasanova, K.F., Mammedbeili, E.G., Efendieva, K.M., Abdullaeva, Yu.A. and Alekperova, N.G. (2020). Study optically active oil properties of Absheron oil-gas bearing region. Azerbaijan Oil Industry, (5), pp.44–47. doi: https://doi.org/10.37474/0365-8554/2020-5-44-47.

Shaikh, A. (2020). Risk, hazards and safety assessment in wood industry using job safety analysis. Journal of Industrial Safety Engineering. doi: https://doi.org/10.37591/joise.v7i3.4252.

Tabor, J. and Moraru, R.I. (2022). Occupational Hazards Counteraction in Industrial Work Environment – Selected Management Problems. System Safety: Human – Technical Facility - Environment, 4(1), pp.282–292. doi: https://doi.org/10.2478/czoto-2022-0029.

Younes Mehrifar, Soleiman Ramezanifar, Parvaneh Khazaei, Afsane Azimian, Elahe Khadiv,

Ozra Dargahi-Gharehbagh and Ali Salehi Sahlabadi (2023). Safety culture and perception of warning signs of chemical hazards among hospital cleaning workers: a cross-sectional study. BMC Public Health, [online] 23(1). doi: https://doi.org/10.1186/s12889-023-15726-4.

Albino, V., Berardi, U. and Dangelico, R.M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, 22(1), pp.3–21. doi: https://doi.org/10.1080/10630732.2014.942092.

Bak, O. (2011). The Role of Qualitative Research in a Mixed Methods Study - Assessing the e-Business Enabled Transformation in a Strategic Business Unit. *Qualitative Research Journal*, 11(2), pp.76–84. doi: https://doi.org/10.3316/qrj1102076.

Chapagain, R., Ghimire, R. and Boro, L. (2024). Accessing the impact of farmers' awareness level and risk management perception on agriculture insurance satisfaction: Mediating role of non-financial satisfaction. *Insurance Markets and Companies*, 15(2), pp.1–13. doi: https://doi.org/10.21511/ins.15(2).2024.01.

Cho, H. (2016). The analysis of multivariate longitudinal data using multivariate marginal models. *Journal of Multivariate Analysis*, 143(1), pp.481–491. doi: https://doi.org/10.1016/j.jmva.2015.10.012.

Fenton, K. and Simske, S.J. (2021). Engineering of an artificial intelligence safety data sheet document processing system for environmental, health, and safety compliance. doi: https://doi.org/10.1145/3469096.3474933.

Ferreira, H. (2012). Multivariate maxima of moving multivariate maxima. *Statistics & Probability Letters*, 82(8), pp.1489–1496. doi: https://doi.org/10.1016/j.spl.2012.04.015.

Hayes, A. (2013). Introduction to mediation, moderation, and conditional process analysis: a regression-based approach. *Journal of Educational Measurement*, 51(3), pp.335–337.

Hayes, A.F. and Rockwood, N.J. (2017). Regression-based statistical mediation and moderation analysis in clinical research: Observations, recommendations, and implementation.

Behaviour Research and Therapy, 98, pp.39–57. doi: https://doi.org/10.1016/j.brat.2016.11.001.

Hinsberg, K., Majia Nadesan and Lamanna, A. (2024). Communicative Framework Development for Construction Risk Governance: An Analysis of Risk and Trust Perception for Organizational Sustainability. *Sustainability*, 16(13), pp.5794–5794. doi: https://doi.org/10.3390/su16135794.

Ho, K. and Tenkate, T. (2021). P-372 Safety data sheets as a hazard communication tool: an assessment of suitability and readability. *Poster presentations*, pp.A108.2-A108. doi: https://doi.org/10.1136/oem-2021-epi.294.

Ho, K. and Tenkate, T. (2024). Safety Data Sheets as a Hazard Communication Tool: An Assessment of Suitability and Readability. *Safety and Health at Work*, [online] 15(2), pp.192–199. doi: https://doi.org/10.1016/j.shaw.2024.01.006.

Hsieh, J.-J. and Huang, Y.-T. (2012). Regression analysis based on conditional likelihood approach under semi-competing risks data. *Lifetime Data Analysis*, 18(3), pp.302–320. doi: https://doi.org/10.1007/s10985-012-9219-3.

Keshk, L.I., Qalawa, S.A.A. and Ibrahim, N.M. (2018). Effectiveness of an Educational Program Regarding Nursing Process on Acquiring Advanced Skills among Internship Nursing Students. *INTERNATIONAL JOURNAL OF NURSING*, 5(2). doi: https://doi.org/10.15640/ijn.v5n2a4.

Kim, D. and Li, X. (Robert) (2013). Introduction to the special issue on advancing research methods in marketing: Editorial. *Journal of Business Research*, 66(9), pp.1243–1244. doi: https://doi.org/10.1016/j.jbusres.2012.02.019.

Lepore, A. (2012). New Research Methods of Business History. *SSRN Electronic Journal*. doi: https://doi.org/10.2139/ssrn.1979904.

Liu, Q., Zhang, L. and Li, Y. (2025). Pathway to enhancing safety behavior of construction workers through subjective well-being. *Frontiers in Public Health*, 13. doi: https://doi.org/10.3389/fpubh.2025.1652268.

McCarthy, L. and Muthuri, J.N. (2016). Engaging Fringe Stakeholders in Business and Society Research: Applying Visual Participatory Research Methods. *Business & Society*, 57(1), pp.131–173. doi: https://doi.org/10.1177/0007650316675610.

Neff, A. (2020). A New Approach to Business-Communication Education: Integrating Business Research Methods and Communication Skills. *Journal of Business and Technical Communication*, 4(2), pp.44–67. doi: https://doi.org/10.1177/105065199000400203.

Ni Nyoman Ayu Cahyani and Yunita, P.I. (2025). The Influence of Regret Aversion and Risk Tolerance on Cryptocurrency Investment Decisions: The Mediating Role of Risk Perception and the Moderating Effect of Income Perception (A Case Study on Generation Z in Bali). *Jurnal Manajemen Motivasi*, 22(1), pp.821–831. doi: https://doi.org/10.29406/jmm.v22i1.8628.

Ortiz, D.G. (2020). Research design: qualitative, quantitative, and mixed methods approaches. *Qualitative Research Journal*, 6(2), pp.205–207. doi: https://doi.org/10.3316/qrj0602205.

Parylo, O. (2012). Qualitative, Quantitative, or Mixed Methods: An Analysis of Research Design in Articles on Principal Professional Development (1998-2008). *International Journal of Multiple Research Approaches*, pp.1419–1462. doi: https://doi.org/10.5172/mra.2012.1419.

TA, G.C., MOKHTAR, M.B., MOHD MOKHTAR, Hj.A.B., ISMAIL, A.B. and ABU YAZID, M.F.B.H. (2010). Analysis of the Comprehensibility of Chemical Hazard Communication Tools at the Industrial Workplace. *Industrial Health*, 48(6), pp.835–844. doi: https://doi.org/10.2486/indhealth.ms1153.

The Development of the Functional Literacy Experience Scale based upon Ecological Theory (FLESBUET) and Validity-Reliability Study. (2014). *Educational Sciences: Theory & Practice*. doi: https://doi.org/10.12738/estp.2014.6.1791.

Traczyk, J., Sobkow, A. and Zaleskiewicz, T. (2015). Affect-Laden Imagery and Risk Taking: The

Mediating Role of Stress and Risk Perception. *PLOS ONE*, 10(3), p.e0122226. doi: https://doi.org/10.1371/journal.pone.0122226.

Yang, R., Zhang, M. and Zhang, Y. (2024). A system dynamics model based on ISM for risk perception in emergency by employees in chemical industrial parks. *Scientific Reports*, 14(1). doi: https://doi.org/10.1038/s41598-024-77445-z.

Zhang, J., Zhang, F., Liu, S. and Zhou, Q. (2024). Enhancing work safety behavior through supply chain safety management in small and medium sized manufacturing suppliers. *Scientific Reports*, [online] 14(1). doi: https://doi.org/10.1038/s41598-024-73098-0.