

A ROADMAP FOR EFFECTIVE DIGITAL REPORTING OF ON-SITE CONSTRUCTION SAFETY INCIDENTS

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ABSTRACT

This dissertation determines a roadmap for improving the digital reporting of on-site construction safety incidents, focusing on the barriers and enablers that shape reporting practices. Underreporting remains a critical challenge in the construction industry, often linked to systemic, organisational, and behavioural factors. Using a qualitative multiple case study of three construction-sites in Mangaung, Free State, South Africa, the study examines current reporting practices, explores the potential of digital technologies (DTs), and proposes a structured framework to mitigate underreporting.

The findings identify key barriers, including fear of victimisation, weak management commitment, poor communication, language limitations, and low digital literacy. Enablers include supportive leadership, open communication, competent safety officers, user-friendly reporting tools, and regular training. While mobile applications, wearable devices, and other DTs demonstrate potential to improve reporting speed, accuracy, and confidentiality, their uptake is limited by inadequate infrastructure and organisational resistance.

To address these challenges, the study proposes a context-specific digital roadmap that integrates theoretical insights with empirical evidence. The roadmap is structured around four interrelated pillars: creating awareness, engaging stakeholders, promoting enablers, and removing barriers. It emphasises multilingual inclusivity, digital literacy development, and cultural alignment as prerequisites for adoption. Advanced technologies such as building information modelling (BIM), augmented and virtual reality (AR & VR), geographic information systems (GISs), unmanned aerial vehicles (UAVs), and wearable technologies (WTs) are also incorporated to strengthen proactive hazard management and data quality.

The research contributes to both academic and industry knowledge by offering a human-centred and evidence-based framework for the digital transformation of construction safety reporting. It concludes that successful digital adoption requires a balance between technological innovation, organisational readiness, and cultural acceptance. If implemented, the roadmap has the potential to enhance transparency, accountability, and safety performance in South Africa and other developing contexts.

Keywords: Effective Digital Technologies, Underreporting, Safety Incidents

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LIST OF ACRONYMS AND ABBREVIATIONS

4D	Four dimensions
5D	Five dimensions
AR	Augmented reality
BBS	Behaviour-based safety
BIM	Building information modelling
C	Case
CAD	Computer-aided design
CCTV	Closed-circuit television
DTs	Digital technologies
DOI	Diffusion of innovations
GIS	Geographic information system
GPS	Global Positioning System
H&S	Health and safety
HSO	Health and Safety Officer
I	Interviewee
IoT	Internet of Things
MoCap	Motion capture
OHS	Occupational health and safety
PPE	Personal protective equipment
RFID	Radio-frequency identification
SaaS	Software as a service
SMS	Safety management system
TAM	Technology acceptance model
TRA	Theory of reasoned action
UTAUT	Unified theory of acceptance and use of technology
UAV	Unmanned aerial vehicle
VR	Virtual reality
WMSD	Work-related musculoskeletal disorder
WSDs	Wearable sensing devices
WTs	Wearable technologies

CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 INTRODUCTION

This chapter presents the research problem's background and questions. It further outlines the research aim and objectives the study seeks to achieve. Recently published literature focusing on underreporting of safety incidents and digital technologies (DTs) related to construction occupational health and safety (OHS) were reviewed to tease out gaps that could give rise to a new study.

1.2 BACKGROUND OF THE RESEARCH PROBLEM

Contractors in the construction industry are not certain of the effectiveness of their company's safety programme since they measure and monitor the safety performance of construction projects using limited and inaccurate incident data available (Kamoli, Hamid and Bin Mahmud, 2022). Consequently, safety issues cannot be identified or addressed effectively as these contractors are hindered from designing safety programmes that are responsive to actual work conditions providing the well-being of workers and preventing injuries and possible death. These are attributed to the underreporting of occupational safety incidents which is an ever-growing concern in the construction industry (Kamoli et al., 2021). Most of the factors affecting underreporting include inadequate reporting and poor recordkeeping of safety incidents information, lack of understanding of reporting needs, deliberate failure to report incidents to authorities, and employees' fear of reprisal. These unsafe practices are common in construction projects, the safety teams of which are uncertain about the impact of reporting accuracy (Mudenha, Naicker and Singh, 2022).

Nevertheless, efforts have been made to increase awareness of these factors and their impact. Further, useful information has been provided to help construction firms and employees to improve the management of recordkeeping of construction safety incidents to underpin their reporting (Nadia, Carlos and Stephen, 2022).

Furthermore, the application of various types of digitalized and emerging technologies such as BIM, VR, GISs, UAVs, 4D computer-aided design (4D CAD), laser scanning, wearables, robotics, photogrammetry, and sensor-based technologies in construction health and safety (H&S) management has been studied significantly (Haupt, Akinlolu and Raliile, 2019). Thus, there is significant theoretical information on system design and development, field

experiment, and testing of the aforementioned technologies in the construction industry (Guo, Scheepbouwer, Yiu and González, 2017). Moreover, there are various studies in the use of DTs for incident prevention through monitoring and real-time data gathering to improve health and safety (H&S) performance (Akinlolu, Haupt, Edwards and Simpeh, 2020). Developed countries have made progress in digitalising construction safety management systems (SMSs) and see a reduction in fatal accidents (Yap, Skitmore, Lam, Lee, and Lew, 2024). However, the developing countries are lagging behind in this regard.

Construction firms are not adequately implementing reporting measures aimed to control, reduce, or eliminate occupational hazards and prevent future occurrence of accidents despite continuous development of SMS over the years to keep pace with technological and economic changes (Chandi, Kahilu and Akintayo, 2018). It is for these reasons that obtaining data related to construction H&S incidents in developing countries has proven to be challenging (Okonkwo and Wium, 2022).

The circumstance is the same for South Africa (Emuze, 2023). Moreover, where information on safety incidents is available, the data is less reliable (Kamoli et al., 2022). In South Africa, the situation is no different. Furthermore, people managing construction lack knowledge of the digitalization of safety reporting (Xu, Li, Zhang and Skitmore, 2021). As a result, current SMSs remain ineffective in reducing accidents (Okonkwo and Wium, 2022). This highlights a critical need to investigate the factors that impede the adoption of available DTs. Further, there is a need for inquiry into the enabling conditions that could facilitate the uptake of DTs and foster an environment conducive for effective and sustainable implementation, particularly to keep those people on the frontline of construction safe in developing countries such as South Africa (Kamoli et al., 2021; Ribeiro, Chodankar, Tajanpure and Pai, 2022).

1.3 STATEMENT OF RESEARCH PROBLEM

The underreporting of occupational safety incidents in the construction industry significantly constrains the ability of contractors to identify hazards and implement contextually responsive safety programmes, thereby undermining worker well-being (Kamoli et al., 2021; Mudenha, Naicker and Singh, 2022). Consequently, the persistence thereof perpetuates unsafe practices and highlights the critical need for robust, reliable incident reporting mechanisms to enable proactive and evidence-based safety management. Digitilisation in construction is progressing globally, and South Africa is no exception (Chandi et al., 2018; Guo et al., 2017). However, effective implementation of DTs for on-site construction safety

reporting remains a concern (Kamoli et al., 2022; Okonkwo and Wium, 2022). While DTs presents potential to enhance safety performance, behavioural and organizational dynamics such as the deliberate withholding of incident information and employees' fear of reprisal present challenges that would constrain implementation thereof (Mudenha, Naicker and Singh, 2022). The existence of a plan or strategy that foster an environment conducive for effective and sustainable adoption of digital reporting of construction safety incidents is lacking (Ribeiro et al., 2022; Xu et al., 2021). Thus, this study seeks to address the identified gap by developing a comprehensive roadmap that facilitate the development of an implementation-supportive organisational environment for the effective digital reporting of construction safety incidents.

1.4 CENTRAL RESEARCH QUESTION

The study seeks to answer the following research question.

- How can a digital roadmap guide the development of organizational readiness for effective adoption of digital reporting systems in construction safety?

1.5 RESEARCH SUB-QUESTIONS

To address the main research question, the study will explore the following sub-questions.

- What are the barriers to effective construction safety incident reporting?
- What are the enablers of effective construction safety incident reporting?
- What organisational readiness exists for digital reporting adoption?
- How can DTs mitigate underreporting of construction safety incidents?
- What digital roadmap would improve the reporting of construction safety incidents?

1.6 AIM OF THE STUDY

The aim of the study is to establish a roadmap that guide the development of organizational readiness for effective adoption of digital reporting systems in construction safety.

1.7 OBJECTIVES OF THE STUDY

To achieve the aim of the study, the study undertakes to carry out the following:

- Explore the barriers to effective construction safety incident reporting;
- Determine the enablers of effective construction safety incident reporting;

- Investigate organisational readiness for digital reporting adoption;
- Explore how the DTs would mitigate underreporting of construction safety incidents; and
- Determine the digital roadmap that would improve the reporting of construction safety incidents.

1.8 DEFINITION OF KEY TERMS

Construction management	The overseeing of physical construction process within the built environment, encompassing the coordination, administration, and management of resources (SACPCMP, 2006).
Construction project	The total construction development conceived by the client and had series of deliverables with start and finish dates, financial limitations, and requires resources and have a specific objective and specifications to be completed within (SACPCMP, 2006)
Digital technologies	A wide range of technologies, tools, services, and applications that use hardware and software to capture, store, transmit, process and display data and information (Tulinayo, Ssentume, and Najjuma, 2018).
Hazards	A situation or behaviour that can potentially cause illnesses, injuries and fatalities to people, damage to properties and harm to the immediate environment (Mollo, Emuze, and Smallwood, 2021).
Incident	An unintended event that ranges in severity from near misses to fatal accidents that disturbs normal operations (Safeopedia, 2019)

Internet of Things	A network of things or objects with a unique identification or Internet protocol address which are enabled to send data about its state and its environment, and receive information connected to actions in actuators (Gbadamosi, Oyedele, Mahamadu, Kusimo and Olawale, 2019).
Risk	A measure of the probability and severity of hazards (Šotić and Rajić, 2015)
Roadmap	High-level examination of the future of a chosen field of inquiry informed of the collective knowledge and vision of the brightest enablers of change in the field (Camarinha-Matos and Afsarmanesh, 2004)
Safety Management	Administration of range of policies, procedures and activities that are intended to ensure adequate control of hazards affecting humans, properties, and the environment (Kuusisto, 2001)
Safety Management System	A range of policies, procedures and activities that are aimed at ensuring adequate control of hazards affecting humans, properties, and the environment (Kuusisto, 2001)
Safety Reporting	Collecting data on safety deficiencies in the workplace and filling in of the reports of all safety information (Mollo et al., 2021).
Underreporting	The omission or neglect in documenting or communicating an incident when it takes place (Arnetz, Hamblin, Ager, Luborsky, Upfal, Russell, and Essenmacher, 2015)

1.9 DELIMITATION OF THE STUDY

The scope of this study is limited to the reporting of construction safety incidents in South Africa. Thus, the research study determined relative barriers and enablers of effective reporting of construction incidents through an extensive search of key literature published in South Africa and in other similar developing countries. The inquiry is limited to contractors and construction-sites. Further, the research investigated the extent of the use of BIM, sensing technologies and wireless networks for the reporting of H&S incidents in construction-sites within developing countries. Moreover, to determine the roadmap that would enable effective digital reporting of incidents to mitigate underreporting, the opinions of the construction professionals involved in safety management and the field workers who perform work on construction-sites were obtained and analysed. The study was based in Mangaung, Free State; consequently, data was collected from the contractors with projects taking place in the Free State province of South Africa. This limits the generalisation of the findings; therefore the roadmap will provide a strategic plan for best practices and improve the implementation of digital safety reporting in construction projects by contractors within Mangaung, Free State, South Africa.

1.10 RESEARCH DESIGN AND METHODOLOGY SUMMARY

The research process adopts a sequential and structured approach. It commences with the identification of a clearly defined research problem, which establishes the scope and focus of the investigation. This is followed by a comprehensive review of the relevant literature to situate the study within existing knowledge and to identify gaps that the research seeks to address. Subsequently, the research design phase is undertaken, outlining the methodological approach and specifying the tools, techniques, and sampling strategies to be employed, as illustrated in Figure 1.1. Data collection is then carried out using appropriate instruments to ensure the relevance, accuracy, and reliability of the information obtained. The gathered data is systematically analysed to identify patterns, relationships, and trends consistent with the research objectives.

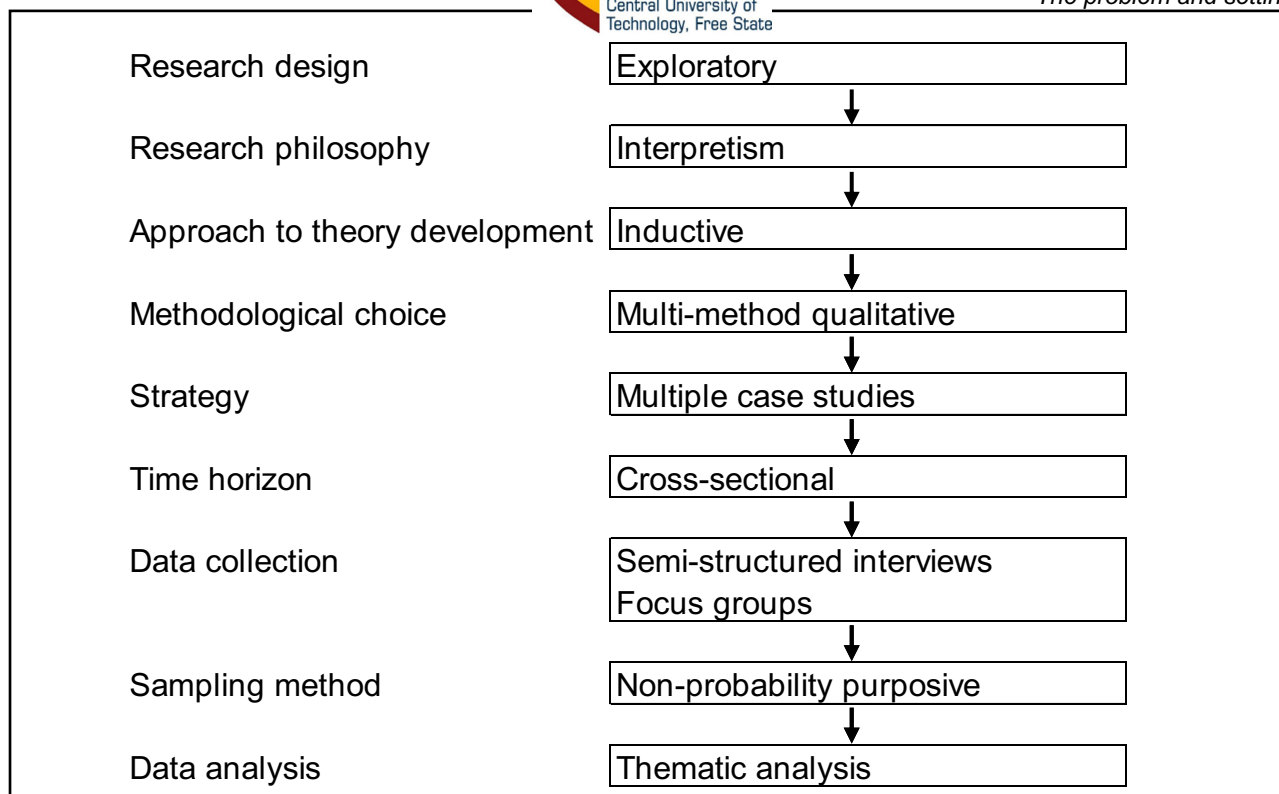


Figure 1.1: Summary of research methodology

(Researcher's construct, adopted from Mark Saunders, Philip Lewis and Adrian Thornhill, 2019)

1.11 SIGNIFICANCE OF THE STUDY

The South African construction industry has a poor record of occupational health and safety (OHS) (Mollo et al., 2021). Many South African contractors regard compliance with H&S regulations as a costly exercise; therefore, often do not make adequate provision for effective SMSs that enforce compliance with H&S regulations. The common causes of non-compliance includes negligent attitudes, worksite employees with inadequate knowledge and awareness of H&S regulations, and the profit motive (Emuze, 2023). Consequently, a number of injuries and fatalities are experienced every week and many of these cases are often unreported (Famakin, Aigbavboa and Molusiwa, 2023).

Effective recording and notification of accidents help identify their nature and support the development of preventive measures. Furthermore, DTs provide opportunities for improved safety management in construction projects by enabling effective safety data reporting across various projects and teams (Xu et al., 2021). Likewise, increased awareness can help organizations and employees understand the importance of reporting workplace incidents. They need to appreciate the value of safety data in planning safety measures,

developing policies to prevent accidents, allocating resources, understanding workplace hazards, and establishing better work practices and procedures (Kamoli et al., 2021). Therefore, it is essential to educate construction professionals and contractors in South Africa about the factors influencing safety incident reporting to enhance understanding of its impacts and the enablers that encourage the use of digital technology in safety reporting.

Safety performance is generally measured using reactive and proactive indicators (Patel and Jha, 2016). Furthermore,, having an effective reactive system can provide useful data and information to help design efficient proactive safety measures. Therefore, this study aims to contribute to knowledge toward finding potential solutions that can be adopted to overcome existing barriers in the incidents reporting process. It aims to create an inefficient reporting system by developing a roadmap for digital reporting of on-site construction safety incidents. The roadmap would clearly define the desired outcomes and include the key steps or milestones needed to implement digital reporting, potentially reducing the underreporting of construction safety incidents.

1.12 CHAPTER SUMMARY

This chapter introduced the study by identifying the gap that justified the need for the current research. It outlined the research aim, objectives, and questions that guide the investigation. The chapter also defined the delimitations of the study, clarified key terms, and provided a brief overview of the research methodology. Furthermore, it highlighted the significance of the study in addressing practical and academic concerns within the field. The next chapter, Chapter 2, offers a review of related literature, explores relevant theoretical frameworks, and develops the conceptual framework that underpins the study.

CHAPTER 2: REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

In this chapter, a logical and detailed search is conducted of published literature to observe and explain the relationship between reporting of construction safety incidents, barriers and drivers of effective construction safety incident reporting, and DTs. Further, literature is reviewed on IoT in construction to ascertain how the technology could mitigate underreporting of construction safety incidents. Furthermore, a roadmap is synthesised that would improve the reporting of construction safety incidents.

2.2 CONSTRUCTION SAFETY INCIDENTS REPORTING

The practice of safety reporting requires organizations to document incidents and unsafe working conditions that include site accidents in addition to near misses and equipment failures as well as structural collapses and hazardous material exposures (Buniya, Othman, Sunindijo, Kineber, Mussi and Ahmad, 2021). Organizations utilize construction safety incident reporting to obtain documented incident information which helps identify root causes before taking preventative steps to avoid future occurrences (Chan, Guan, Choi, Yang, Wu and Lam, 2023). Construction safety incidents require effective reporting that serves as the basis for OHS to facilitate improved workplace safety in construction-sites (Kunodzia, Bikitsha and Haldenwang, 2024).

Further, the regulatory bodies mandate the reporting of certain incidents that occur on-site, thus it becomes a legal requirement to report (Boshoff, n.d.). According to Zhang et al. (2023), the importance of reporting safety incidents also contributes to fostering a safety culture that empowers the employees to report unsafe working conditions and incidents without fear of retribution. Furthermore, transparent incident reporting encourages employees to report dangerous occurrences. This allows for the development of a positive safety culture which enables workers to report confidently, knowing that the reports will be considered and subsequently contribute to meaningful changes aimed at enhancing overall site safety.

2.2.1 Current Incident Reporting Systems

Incident reporting methods currently used in construction rely largely on paper documentation and individual virtual platforms, creating operational delays through poor database maintenance (Adekunle, Aigabvboa, Thwala, Akinradewo and Oke, 2022). Older

systems require manual data entry, resulting in lengthy administrative work that delays safety problem detection (Xu, 2014). Safety records are further compromised by the vulnerabilities of paper-based reporting systems, which are prone to human error, physical damage, and data loss (Graham, 2024). Although digital solutions outperform paper systems, their ability to generate full safety insights remains limited owing to incomplete integration within SMSs (Daniel, Oshodi, Nwankwo and Chinyio, 2024).

Another significant barrier to effective incident reporting is the complexity of current systems. Reporting platforms that are difficult to use discourage employees from filing timely and accurate reports after safety incidents (Wiele, 2016). Many professional staff avoid reporting incidents and near-misses because of time-consuming procedures, while poor levels of digital literacy among construction workers further hinder efficient incident documentation (Kubjana, Adekunle, Aigbavboa and Otasowie, 2024). Without easy and quick reporting systems, organisations fail to obtain the critical information necessary for implementing safety improvements.

A lack of standardisation in incident reporting also undermines the quality and usability of safety data. Inconsistent reporting methods between firms and programmes fragment data, making it difficult to detect trends in occupational safety research (Saqib, Hassan, Zubair and Choudhry, 2023). The absence of standard procedures leads to inconsistencies in both data collection and analysis, reducing the potential for drawing informative conclusions (Oswald, Sherratt and Smith, 2018). Furthermore, companies often fail to align their reporting standards with industry leaders and regulatory requirements, which limits compliance and comparability (Daniel et al., 2024; De Silva, Rathnayake, and Kulasekera, 2018). Standardised reporting is therefore essential for ensuring data coordination and enabling meaningful comparisons between projects and organisations (Kianda Technologies, 2024; Saqib et al., 2023).

The adoption of cloud-based systems and mobile applications for incident reporting remains limited owing to multiple barriers (Fasasi, Aminu and Ogunmilua, 2024). High implementation costs pose a significant challenge, particularly for small and medium-sized construction organisations facing financial constraints (Xu, Li and Chen, 2024). Many organisations also lack the technical infrastructure needed to support digital safety reporting tools, resulting in continued reliance on outdated methods (Daniel et al., 2024; Okpala et al., 2022). In addition, resistance to change, particularly among senior employees who prefer traditional reporting methods slows the adoption of modern technologies (Cieslak and Valor, 2024).

2.2.2 Incident reporting systems in the South African context

Construction OHS management depends heavily on incident reporting activities (Adekunle et al., 2024). However, modern DTs have not stopped South African businesses from following manual incident reporting methods that primarily consist of physical documents kept for human processing (Emuze, 2022). Standardised documentation forces both workers and supervisors to submit paperwork for reporting safety events together with near misses and dangerous incidents (Misnan, Mustapa, Ramly, Mohamed and Rahim, 2024). Conventional safety reporting methods generate limited accountability and tracking but face widespread criticism because they perform poorly and cannot link up with contemporary OHS management systems (Adekunle et al., 2024).

Inefficient operation stands as one of the main weaknesses of traditional reporting systems (Saqib et al., 2023). Incidents reporting durations grow longer as workers conduct manual document handling which jeopardises quick responses (Skilling and Smith, 2024). Most construction enterprises in South Africa review incident reports only during their weekly safety meetings, thus hindering their ability to tackle risks as they happen (Emuze, 2022). The input-time lag escalates both probable future incidents while simultaneously lowering the success rate of corrective measures (Saqib et al., 2023).

The industry faces challenges because different organizations follow non-standardized reporting procedures. The reporting of accidents uses varied methods and approaches which separate one enterprise from another and sometimes different sites within the same organisation (Guo, Scheepbouwer, Yiu and González, 2017). Broken data integration becomes difficult, mostly because inconsistent reporting processes produce complex information that hinders the discovery of safety problems and repeated hazards across multiple projects. Owing to insufficient incident classification standards, the industry faces obstacles for assessing safety performance measurements inside its operations and across different organizations (Moosaa and Oriet, 2021).

Traditional system construction projects in South Africa face significant underreporting issues (Soni and Smallwood, 2024). Workers avoid incident reporting in hostile safety environments because they must face negative reactions alongside job consequences and disciplinary action (Emuze, 2022). Contract and temporary workers experience heightened fear levels since they lack both labour union protection and equivalent workplace safeguards. A weak reporting environment in construction emerges from under-documented minor incidents along with close escapes, thus diminishing both learning capabilities and prevention mechanisms (Adekunle et al., 2024).

The traditional method of manual reporting causes various problems that negatively influence the quality and accuracy of recorded information (Xu and Luo, 2014). Errors in handwritten reports stem from human interaction and include poor training quality as well as confusing handwriting along with forgetfulness and misrepresentation (Misnan et al., 2024). Data loss occurs with paper-based incident logs since their retention system exposes safety records to failure from accidental damage or manipulation and misplacement (Xu and Luo, 2014). The industry is then unable to implement evidence-based safety management because of these problems (Misnan et al., 2024).

Reactive characteristics are the principal drawback of outdated systems. Risk anticipation is difficult for organizations because they wait until harmful incidents take place to collect incident data (Okonkwo, Okpala, Awolusi and Nnaji, 2023). The inability to predict hazards coupled with site deterioration among paper-based systems prevents warnings from being sent to manage these conditions (Awolusi, Marks, Hainen and Alzarrad, 2022). Safe workplaces develop through crew dedication to deal with existing issues before they put necessary preventive measures into place (Adekunle et al., 2024).

SMSs employing traditional methods generate intense administrative workload that negatively affects their operational capacity (Okonkwo and Wium, 2022). Building reports and acquiring compliance documents and document information require enormous amounts of time from safety authorities and managers (Kunodzia, Bikitsha and Haldenwang, 2024). Money-strapped South African small and medium construction enterprises are confronted by complications because their safety specialists handle many tasks ineffectively (Mashwama, Aigbavboa and Thwala, 2018).

The literature provides a strong basis for understanding the importance and current weaknesses of construction safety incident reporting, but several gaps remain evident. First, there is a shortage of context-specific empirical studies examining how reporting systems function in developing-country construction environments, particularly in South Africa. Second, the literature inadequately integrates technological, organisational, and human factors, often discussing them in isolation rather than as interdependent dimensions of reporting effectiveness. Third, there is limited research on how digital tools can be embedded into existing safety management systems in ways that are practical, affordable, and usable for workers across different skill levels. Lastly, underreporting is widely acknowledged, yet the literature does not sufficiently explain how reporting systems can be redesigned to reduce fear, improve trust, and encourage the reporting of near misses and minor incidents.

2.3 BARRIERS TO EFFECTIVE REPORTING OF CONSTRUCTION SAFETY INCIDENTS

Safety climate and safety culture are critical concepts used in many studies to explain safety conditions in the workplace (Kalteha, Mortazavi, Mohammadi and Salesi, 2021). Therefore, to identify the barriers of safety incident reporting, it is important to delineate and assess the safety culture and safety climate of the organization. Safety culture can be defined as “the product of individual and group values, attitudes, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation’s H&S management” (Biggs, Banks, Davey and Freeman, 2013: 5). In other words, safety culture is the assumption of a set of beliefs in an organisation. On the other hand, safety climate refers to shared perceptions among the workers about workplace safety, and how employees regard the policies of an organization, safety practices, and safe procedures that indicate the value and significance of safety within the workplace (Hecker and Goldenhar, 2014; Probst, Goldenhar, Byrd and Betit, 2019). It is therefore worth mentioning that a safety climate is an indicator of organisational safety culture; it assesses the employees’ intuitive recognition or appreciation of the way safety is engaged at the workplace (Marín, Lipscomb, Cifuentes and Punnett, 2019).

The safety climate of an organisation has a direct relationship with the occurrence of workplace accidents, injuries and underreporting of these events (Byrnes, Rhoades, Williams and Arnaud, 2022). Reporting of hazards and near misses is discouraged in a blame culture. The blame culture further prevents learning from past and current mistakes (Duryana, Smytha, Roberts, Rowlinson and Sherratt, 2020). To determine the barriers and enablers of safety reporting and classifying the factors accordingly, measurable aspects of safety climate are studied, namely (i) safety resources, management commitment, and communication; (ii) employees’ involvement and workers’ college influence; and (iii) perception of safety rules and procedures. These factors are identified in the studies of Liang and Zhang (2019) and Mosly (2019). The aforesaid factors are classifiable into (i) management elements, (ii) worksite elements, and (iii) human elements of safety climate. The worksite element and human factors can be described as worksite dynamics (Halim et al., 2020). The management and worksite dynamics elements are therefore assessed in this study to identify the barriers to reporting of occupational safety incidents on construction-sites.

2.3.1 Barriers attributed to management factors

Management is responsible for developing the H&S policy of an organisation, allocating resources for H&S training, and approving site training to workers (Okorie and Musonda, 2020). However, contractors mainly respond to project time and cost constraints while limiting investment in safety management. The human capital, plants and equipment, and the environment receive a significant amount of attention of the project management team in construction projects, whereas OHS management system is often a neglected area. Further, an OHS management system has not been systematically applied to most construction projects. These practices significantly contribute to the frequency and intensity of construction-site accidents (Maliha, Abu Aisheh, Tayeh and Almalki, 2021).

2.3.2 Barriers attributed to worksite dynamics

A strong correlation exists between competence and the rate of recurrence of accidents. This element encompasses safety experience of workers, training and education, safety information, hazard and safety awareness, skillfulness of worker, subcontractors and contractors' prequalification on safety, worker age, lack of safety awareness amongst employees, extensive subcontracting of work packages, and the absence of workers safety training which attribute to the high rate of injuries and fatalities (Halim, 2020). Most construction workers undoubtedly lack adequate safety awareness owing to training and education that merely fosters workers' cramming safety regulations to improve their competences of finishing work while not guaranteeing that they work safely. Further, insufficient awareness of safety hazard leads to higher rates of occupational accident occurrence. This is common for workers employed by small contractors and is ascribed to the poor qualifications they often possess (Mohammadia, Ghasemi, Kalatpour and Moghimbeigi, 2018).

Work pressure is also a source of H&S violations. Increased construction activities elevate work pressure on construction-sites (Emuze, 2023). Work pressure has been identified amongst the causes of unsafe behaviours and a common barrier to the implementation of safety programmes (Buniya et al., 2021). Stratmana and Youssef-Morganb (2019: 14) define unsafe behaviour "as behavior committed knowingly or unknowingly that deviates from safety compliance expectations".

Employees occasionally disregard safety rules, standards, procedures and instructions under work pressure to complete the work quickly despite their knowledge of the possible outcomes that their behaviour can negatively influence the system safety or endanger every employee on-site (Mohammadia, Ghasemi, Kalatpour, and Moghimbeigi, 2017).

Mohammadia et al. (2018) assert that work pressure results from production pressure, extreme work overload, employees' fatigue and burnout, high working pace, lengthy working time, overtime work, and tight schedules.

2.4 ENABLERS OF EFFECTIVE REPORTING OF CONSTRUCTION SAFETY INCIDENTS

Enablers of construction safety incident reporting are factors, practices, and strategies that promote and facilitate the process of documenting and reporting accidents, injuries, hazards, or other safety-related incidents on a construction-site.

Safety is impacted by four factors, namely company safety policy, the construction process, personnel management with regard to safety, and incentives. Therefore an organisation that addresses the aforementioned factors in its SMS is likely to achieve successful safety performance. Kim, Ryu and Kang (2019) suggested that safety commitment, subcontractor involvement, safety incentives, and safety accountability are regarded as the main drivers of a safety climate. The identified four drivers are classified into enablers attributed to management factors and worksite dynamics and studied to determine how they enable successful reporting of construction safety incidents, thereby contributing to improved project safety performance.

2.4.1 Enablers attributed to management factors

Management who are committed to safety recognize an organization's OHS as a fundamental component of an effective management system. Commitment to organizational H&S sets a good example for workers (Chinda, 2012). Such an example encourages safe work behaviour among employees on-site (Mohammadia et al., 2018). This enables managers to provide safety support and have better safety performance.

Effective safety communication between managers and workers is a necessary safety management practice that reduces occurrences of safety incidents (Maliha et al., 2021). Thus, open and rich communication is vital for effective risk management. Construction companies with a decent and uninterrupted flow of information tend to be safer. Therefore, it is required that effective communication be established between managers and workers to disseminate information about the workplace, its potential dangers and how best to remove them. Communication could also help the employees understand safety rules for improved compliance and commitment to safety. In addition to two-way communication, seamless access to documented organizational safety policy is another factor that could potentially stimulate companies' safety performance. However, it requires management to

train employees to adjust and practise the written safety policy. The more management commits to safety training, the fewer accidents would be reported (Kim et al., 2019).

2.4.2 Enablers attributed to worksite dynamics

Subcontractors are an important part of the construction team, although their role in safety is mostly neglected (Mohammadi and Tavakolan, 2020). Nevertheless a high rate of accidents and costs associated with occurrences of accidents on-site are directly related to the average number of subcontractors on construction projects. It is worth mentioning that subcontracting is one of main reasons for inadequate safety performance. This is often owing to a lack of safety commitment because of budget, time, and personnel constraints. In addition, the involvement of a subcontracted organisation causes workers to disconnect with the main contractor and to disintegrate progressively from their own organizational climate. The effect of subcontractors on safety should not be overlooked, especially with the increasing growth of specialization in the construction industry stimulating demand for subcontracting (Mohammadia et al., 2018). Furthermore, it should be noted that the current situation might deteriorate further; this requires subcontractors to be involved in the development of SMS and implementation. This would encourage the reporting of safety incidents (Kim et al., 2019).

Safety incentives refer to rewarding techniques employed by organizations to motivate workers' safety practices. A safety incentive is a behaviour-based safety (BBS) approach designed to strengthen safe behaviour and generally reduce time loss owing to occurrence of accidents (Carra, Bottani, Vignali, Madonna and Monica, 2024). Safety incentives are believed to be amongst the top five high-impact zero-accident approaches. Companies have employed safety incentives for several years to keep employee injuries under control. The objective of safety incentive programmes is to foster safe completion of construction projects by rewarding excellent safety performance. If safety incentives are used properly, positive reinforcement would be achieved. Additionally, integrating positive reinforcement into an organization's safety programme can help uphold high morale and loyalty among employees, thereby increasing the acceptance of a safety programme (Mohammadi and Tavakolan, 2020). Nevertheless, safety incentives may prevent workers from reporting incidents to avoid losing rewards. Therefore, organizations should integrate safety incentives to aspects of the SMS to motivate employees to implement the created criteria effectively (Kim et al., 2019). Safety accountability is important for the successful implementation of safety management. Harsh penalties could be levied to keep workers accountable for safety violations (Mohammadi and Tavakolan, 2020).

While the literature provides valuable insights into the barriers and enablers of construction safety incident reporting, several gaps remain evident. First, there is a lack of context-specific empirical studies that examine how these barriers and enablers manifest in developing countries, particularly within the South African construction industry. Second, the literature does not sufficiently integrate management, worksite, human, and technological factors into a cohesive analytical framework. Third, there is limited understanding of how reporting systems can be designed to address underreporting among vulnerable worker groups. Finally, the contradictory role of safety incentives in promoting both safety performance and reporting transparency remains underexplored.

2.5 DTS USED IN HEALTH AND SAFETY MANAGEMENT

Four-dimensional computer-aided design, or 4D CAD, and BIM are essential components of the digital revolution in construction. These technologies support a prevention-through-design approach by making it easier to create time-enabled, highly detailed digital models. By adding temporal (4D) and financial (5D) elements to traditional geometric models, they facilitate proactive safety planning and hazard zone simulation (Agyekum et al., 2022). The integration of BIM with digital twin technologies in the context of human-robot workflows is examined in a recent study by Wang, Hongrui, Wes, Menassa and Kamat (2024). The results show that this integration supports safer robotic construction methods and improves human supervision by enabling real-time, on-site model adaptation. By successfully bridging the gap between as-designed and as-built conditions, this capability guarantees dynamic alignment between the phases of planning and execution.

Technologies such as AR and VR are popular in construction safety management. These immersive technologies are frequently used to improve workers' perceptions of risk, identify hazards, and provide safety training. According to empirical data, VR and AR applications considerably increase worker engagement and lessen cognitive load, especially for workers with low levels of literacy or those working in multilingual environments (Chaaya, Sarkis and Tahmasebinia, 2025). The educational effectiveness of VR in a variety of construction-related tasks, such as masonry, material handling, and fall prevention, is further supported by a scientometric review carried out by Rahman, Hasan, Chowdhury, Syed and Farah (2024). VR's efficacy in improving construction training outcomes is also supported by earlier research by Abas, Yusuf, Suhaini, Kariya, Mohammad and Hasmori (2020).

Spatial hazard mapping, route planning, and the integration of geospatial data with BIM and digital twin models are all made possible by GIS. These capabilities are especially relevant

in complex and multimodal construction environments found in smart city developments, as they enable safety planning at both the urban and site levels (Agyekum, Pittri, Botchway, Amudjie, Kumah, Kotei-Martin and Oduro, 2022; Akinlolu et al., 2020).

In addition, UAVs are useful instruments for monitoring construction safety. They are used for thermal imaging, crack and structural deformation detection, remote inspection of dangerous areas, and high-resolution aerial site surveys. Because of these features, there is less need for manual site exposure, which lowers the risk of injury (Rachmawati and Kim, 2022). UAVs can be used to create extremely accurate three-dimensional datasets for continuous hazard assessment and the creation of comprehensive digital twins when paired with photogrammetry and laser scanning technologies (Agyekum et al., 2022).

Another crucial area of innovation in digital safety is wearable technology (WT). Real-time monitoring of workers' positional and physiological data is made possible by devices equipped with GPS capabilities, physiological sensors, proximity detectors, fatigue monitors, and intelligent PPE. By facilitating the early detection of heat stress, fatigue, poor posture, and proximity to danger zones, these technologies improve on-site safety (Newaz, Ershadi, Jefferies, and Davis, 2024). Moreover, WT is increasingly used in conjunction with fixed sensors and environmental monitoring systems on Internet of Things (IoT)-based smart construction-sites. This integration makes it possible to monitor adherence to safety regulations and provide context-aware, real-time safety alerts (Vishal, Austin, Christopher and Pandey, 2022).

Wearable exoskeletons and robotics has also been developed to help with physically taxing jobs such as pouring concrete and laying bricks. These technologies considerably decrease both the frequency of repetitive strain injuries and musculoskeletal strain. However, the deployment of these devices presents new safety challenges, such as interface risks and collision hazards, which call for the implementation of strong safety controls such as machine guarding, zoning procedures, and adherence to new robotics safety standards (Wang et al., 2024). It has been demonstrated that combining human task support with BIM-driven robotic systems fosters safer, cooperative workflows, especially when used in dynamic, real-time field settings.

The use of centralized safety databases to assist with construction H&S procedures is growing. These digital repositories make it easier to verify hazard rules, track incidents systematically, and integrate BIM or GIS datasets with safety regulations and compliance frameworks. In safety management, this feature improves decision-making effectiveness and transparency (Akinlolu et al., 2020).

Lastly, motion capture (MoCap) technologies have drawn increasing interest, especially in the context of Industry 5.0 advancements. To support ergonomic risk assessments and the prevention of work-related musculoskeletal disorders (WMSDs), MoCap systems are used to analyze worker movements, such as lifting and climbing. Because markerless MoCap systems are less invasive and more appropriate for dynamic construction environments, recent research suggests that they are preferred in real-world applications (Rahman et al., 2024). Table 2.1 summarizes the technologies used for H&S management:

Table 2.1: Technologies used for H&S management

Technology	H&S Applications	References
BIM and 4D CAD	Enables prevention-through-design and proactive safety planning. Simulates hazard zones. Supports real-time site adaptation and robotic workflows through integration with digital twins.	Agyekum et al. (2022); Wang et al. (2024)
VR and AR	Enhances risk perception and hazard identification. Used for immersive safety training. Improves engagement and reduces cognitive load, especially for low-literacy or multilingual workers.	Chaaya et al. (2025); Rahman et al. (2024); Abas et al. (2020)
GIS	Enables spatial hazard mapping. Supports planning of safe site routes. Integrates geospatial data with BIM and digital twins for safety planning. Effective in smart city and multimodal construction environments.	Agyekum et al. (2022); Akinlolu et al. (2020)
UAV Photogrammetry, and laser scanning	Conduct high-resolution aerial surveys Perform remote inspections of hazardous areas Detect cracks and deformations. Capture thermal images. Generate accurate 3D models for hazard assessments and digital twin development.	Rachmawati and Kim (2022); Agyekum et al. (2022)
WT and IoT-based smart sites	Enable real-time monitoring of worker physiological and positional data. Detect fatigue, heat stress, posture issues, and proximity to hazards. Provide real-time, context-aware safety alerts.	Newaz et al. (2024); Vishal et al. (2022)

	Enhance compliance monitoring through integration with environmental sensors.	
Robotics and wearable exoskeletons	Reduce musculoskeletal strain and repetitive strain injuries. Support heavy tasks such as bricklaying and concrete pouring. Require safety protocols owing to interface and collision risks. Foster safe human-robot collaboration through BIM integration.	Wang et al. (2024)
Centralised safety databases	Track incidents systematically. Verify hazard control rules. Link with BIM and GIS data for regulatory compliance. Improve safety decision-making and transparency.	Akinlolu et al. (2020)
MoCap systems	Analyse worker movement patterns such as lifting and climbing. Support ergonomic risk assessment. Aid in preventing work-related musculoskeletal disorders (WMSDs). Markerless systems preferred for dynamic construction environments.	Rahman et al. (2024)

2.6 HOW DTS WOULD MITIGATE THE UNDERREPORTING OF CONSTRUCTION SAFETY INCIDENTS

The underreporting of safety incidents remains a persistent and deeply rooted challenge in the construction industry, driven by a mix of cultural stigma, fear of disciplinary action or job loss, procedural inefficiencies, and technological limitations (Byrnes et al., 2022; Duryana et al., 2020). These systemic barriers affect the accuracy of safety performance data and hinder the implementation of effective preventive measures. In response, DTs have emerged as transformative tools capable of tackling many of the root causes of underreporting through increased transparency, automation, and real-time response.

Technologies such as BIM, WSDs, mobile applications, radio frequency identification (RFID) systems, IoT-enabled smart sites, and cloud-integrated databases provide construction stakeholders with better tools for incident detection, documentation, communication, and analysis (Alzarrad, Al-Mhdawi and Chowdhury, 2023). These technologies not only allow for accurate and timely collection of safety-related data but also enable smooth integration into

daily construction workflows, supporting proactive risk reduction and promoting a culture of safety compliance.

DTs operate through interconnected platforms that act as middleware between sensor-enabled devices and cloud-based data systems. This setup allows for real-time data collection, transmission, and analysis without the need for constant human oversight (Chung, Tariq, Mohandes and Zayed, 2023). Wearable devices, RFID readers, and low-power wireless protocols such as Zigbee are compact, affordable, and increasingly used on-site to monitor worker activity, ensure compliance, and dynamically identify hazards. These tools improve both reactive and predictive safety strategies by providing detailed, site-specific data.

While these innovations offer significant potential, their successful implementation depends on supportive organizational policies, updated infrastructure, digital literacy among workers, and reliable connectivity (Katiyar and Kumar, 2021). Therefore, effectively reducing underreporting requires not only technological adoption but also the creation of a strategic plan for digital safety incident reporting, supported by institutional commitment and regulatory coordination.

This section builds upon the technologies reviewed in Section 2.5 and explores how their application specifically addresses the complex causes of underreporting in construction H&S management.

2.6.1 Addressing the cultural barrier of underreporting

Byrnes et al. (2022) and Duryana et al. (2020) cited that the main reasons for underreporting are fear of victimisation, disciplinary action, or job loss. DTs can help mitigate these fears by enabling anonymous or confidential reporting through mobile apps or cloud-based systems. These platforms allow workers to submit incident reports without direct managerial confrontation, thereby reducing psychological barriers (Halimuzzaman, Rubel and Mahedi, 2024). Furthermore, by standardising the reporting process and making it part of routine workflows, DTs can shift the organisational culture towards transparency and accountability (Daniel et al., 2024).

2.6.2 Enhancing incident identification and real-time monitoring

DTs such as wearable sensors and RFID tags allow for the continuous monitoring of workers and environmental conditions. These systems can detect abnormal patterns such as falls, high-stress levels, or proximity to hazardous zones and automatically log such occurrences

as potential safety incidents (Alzarrad, Al-Mhdawi and Chowdhury, 2023). As these technologies do not rely on self-reporting alone, they serve as an additional layer of incident identification, particularly useful in cases where workers may be unconscious or unwilling to report an incident. This shift from reactive to proactive safety monitoring can significantly reduce the likelihood of unreported near misses and injuries (Thaleparambil, Biju, Krishna, Prathap, Rekha and Reddy, 2025).

A digital SMS can integrate mobile applications, sensors, and wireless networks to monitor workers and detect entry into hazardous zones. These systems provide scalable, cost-effective solutions suitable for both large-scale and small-scale construction projects (Kim et al., 2019). However, the adoption of such technologies remains limited, even in more technologically advanced regions. This limitation is attributed less to technological constraints or safety concerns and more to the perceived high costs of implementation. Despite the clear operational and safety benefits, a shift in strategic investment and policy support is needed to realize the full potential of DTs in construction safety management.

2.6.3 Improving incident documentation and accuracy

Accurate documentation is central to safety management and regulatory compliance. Traditional paper-based reporting is prone to loss, inconsistencies, and delays. Digital platforms facilitate real-time data entry, photo or video uploads, voice recordings, and geo-tagging, all of which contribute to richer and more reliable documentation (Datta, Sarker, Shikdar, Halimuzzaman and Karim, 2024). For example, mobile apps integrated with BIM can allow safety officers to annotate hazards or incidents directly onto the digital model, creating a spatially and temporally precise safety log (Pereira, González García, and Poças Martins, 2025).

2.6.4 Enabling efficient notification and communication

Timely communication following a safety incident is essential for coordinating emergency responses, investigating root causes, and implementing corrective measures. Digital systems enable automated alerts and notifications to be sent to relevant personnel when incidents are recorded or thresholds are breached (Halimuzzaman et al., 2024). These notifications can be configured through mobile apps, emails, or integrated dashboards, significantly reducing response times and enabling quicker containment of risks.

2.6.5 Facilitating in-depth investigation and data analytics

Post-incident investigation is often hindered by incomplete or inaccessible data. The integration of DTs allows for centralised databases where incident histories, environmental

sensor data, closed-circuit television (CCTV) footage, and worker logs can be analysed collectively. Predictive analytics, a sub-domain of artificial intelligence, can identify patterns and precursors to incidents, enabling organisations to implement preventative measures before accidents occur (Kim, Yum and Bae, 2025). These insights also feed into performance metrics and compliance reporting, ensuring alignment with regulatory requirements.

2.6.6 Overcoming technological and operational barriers

Despite their potential, the adoption of DTs in construction safety management remains uneven. High implementation costs, lack of technical expertise, resistance to change, and concerns over data privacy are notable barriers (Daniel et al., 2024). Nonetheless, studies have shown that modular and scalable solutions such as cloud-based software-as-a-service (SaaS) models can reduce upfront investment costs. Additionally, the promotion of digital literacy among construction workers and the presence of user-friendly interfaces are key to overcoming usability barriers (Construction Industry, Innovation, 2025).

The literature highlights the significant potential of DTs to improve construction health and safety management and reduce underreporting, many studies present technologies such as BIM, WTs, IoT systems, and mobile applications as effective solutions based on their functionalities, rather than on strong empirical evidence demonstrating their consistent success in real construction environments. This creates an assumption that technological capability directly translates into improved safety outcomes, which may not always be the case.

Also, a considerable portion of the existing literature is based on controlled or experimental settings. For example, technologies such as virtual reality, motion capture, and sensor-based monitoring are frequently tested in laboratory or simulated environments. While these studies provide useful insights, their findings may not fully reflect the complexity, unpredictability, and constraints of actual construction sites. There is therefore limited evidence on how these technologies perform over time in real-world conditions, particularly in developing-country contexts where factors such as limited infrastructure, cost constraints, and low digital literacy may affect implementation.

In addition, some studies emphasise the benefits of digital tools without critically examining their limitations, costs, or practical challenges. This raises concerns about the reliability and objectivity of the reported outcomes, posing a risk of overestimating the effectiveness of DTs in addressing construction safety challenges, including underreporting.

Addressing this gap requires more empirical, field-based context-specific studies that assess the long-term effectiveness, usability, and impact of digital technologies in live construction environments, human and organizations. This is particularly important for developing a realistic and context-sensitive understanding of how DTs can be used to improve construction safety incident reporting and reduce underreporting.

2.7 THE MODELS AND THEORIES OF TECHNOLOGY ADOPTION RELATED TO THE STUDY

A critical review of technology adoption literature reveals that the field is grounded in a wide range of theoretical models developed over several decades. Yadegari et al. (2024) provide a comprehensive synthesis of 21 major models and theories, highlighting their underlying structures, evolution, and interrelationships. Their analysis emphasises the cumulative nature of these models, demonstrating how earlier behavioural theories have informed the development of more advanced and technology-specific frameworks. Similarly, Sharma and Mishra (2014) trace the evolution of technology adoption models from early frameworks such as the Diffusion of Innovation (DOI) theory to more integrated models like the Unified Theory of Acceptance and Use of Technology (UTAUT), further reinforcing the progressive development of this field.

In a construction-specific context, Nnaji et al. (2023) extend this understanding by examining the factors influencing the adoption of emerging technologies such as BIM, WTs, and mobile applications. Their findings indicate that technology acceptance is primarily driven by perceived usefulness, perceived ease of use, social influence, and facilitating conditions. The study further confirms that models such as the Technology Acceptance Model (TAM), Theory of Planned Behaviour (TPB), and the Unified Theory of Acceptance and Use of Technology UTAUT are widely applied in explaining and predicting the adoption of construction technologies.

2.7.1 Technology Acceptance Model (TAM)

The TAM, developed by Davis (1985), is a widely used framework for explaining user acceptance of information systems. TAM posits that technology adoption is primarily determined by two key constructs namely, (1) perceived usefulness and (2) perceived ease of use. Perceived usefulness refers to the extent to which an individual believes that using a particular system will enhance their performance, while perceived ease of use relates to the degree to which the system is perceived as effortless to use. These constructs shape

users' behavioural intention, which subsequently influences actual system usage. Over time, the model has been refined to establish a direct relationship between these beliefs and behavioural intention (Lai, 2017).

In the context of this study, TAM provides a useful foundation for understanding the adoption of digital technologies for construction safety incident reporting, particularly in explaining how users' perceptions of system usefulness such as improving reporting efficiency and accuracy. While ease of use influence the willingness of the organisations and workers to adopt the technologies. Although the Technology Acceptance Model (TAM) is widely used due to its simplicity and focus on individual perceptions, it has notable limitations. The model does not adequately account for social, organisational, and environmental factors, which are critical in complex contexts (Nnaji et al., 2023). This limitation is particularly relevant in construction environments, where factors such as safety culture, organisational support, and site conditions (Biggs et al., 2013; Emuze, 2023; and Kamoli et al., 2021), play a critical role in technology adoption. Therefore, although TAM serves as an important theoretical base, this study extends beyond by incorporating additional context-specific factors to better address the complexities inherent in the organisations in order to facilitate adoption of technology for reporting in construction safety.

2.7.2 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB), developed by Ajzen in 1991, extends the earlier Theory of Reasoned Action by incorporating an additional construct namely, perceived behavioural control. The additional construct aimed to better explain human behaviour in situations where individuals may not have full control. TPB proposes that behaviour is determined by behavioural intention, which is influenced by (1) attitude towards the behaviour addressing the individual evaluation of performing the behaviour, (2) Subjective norms looking at perceived social pressure from others and (3) Perceived behavioural control looking at individual perception of their ability to perform the behaviour. Perceived behavioural control also directly influences actual behaviour, reflecting real-world constraints such as resources, skills, and opportunities (Yadegari et al., 2024). Notably, perceived behavioural control also directly affects actual behaviour, reflecting real-world constraints such as resources, skills, and opportunities (Lai, 2017).

In the context of this study, TPB provides a valuable lens for understanding the adoption of digital technologies for construction safety incident reporting, particularly by capturing the influences such as safety culture, lack of training, and limited access to digital tools

(Halim, 2020). Findings from this study further reinforce the significance of these factors, revealing that underreporting is not only a technological issue but is also shaped by workers' perceptions of organisational expectations, fear of repercussions, and limited capacity to engage with digital systems. These findings align with TPB's emphasis on subjective norms and perceived behavioural control as key determinants of behaviour. However, despite its strength in incorporating social and contextual influences, the theory is less focused on the technological characteristics of systems themselves, making it less precise in explaining how features of digital tools influence user adoption (Lai, 2017). Consequently, while TPB enhances understanding beyond individual perceptions, it requires integration with technology-specific models to fully explain adoption in construction safety contexts.

2.7.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

The unified theory of acceptance and use of technology (UTAUT), introduced by Venkatesh, Morris, Davis and Davis (2003), serves as a thorough and empirically grounded model for examining the key factors that influence the adoption and utilisation of technology. It integrates components from eight well-established theoretical frameworks, including the technology acceptance model (TAM), the theory of reasoned action (TRA), and the diffusion of innovations (DOI), to provide a cohesive understanding of user behaviour concerning emerging technologies.

This theoretical model is particularly useful for evaluating how construction professionals engage with and adopt DTs designed for reporting safety incidents. The model centres on four main constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. These constructs together enable a detailed assessment of both personal and environmental factors that influence the acceptance and ongoing use of digital systems. These constructs are summarized in Table 2.2 alongside the related indicators as identified by Popova and Zagulova (2022).

Therefore, UTAUT acts as a useful perspective for developing a strategic digital guideline to implement and optimize digital reporting technologies effectively in the construction industry, ultimately improving safety results and compliance.

2.7.3.1 Performance expectancy

This construct describes the extent to which a person believes that using a particular system will lead to improvements in job performance (Venkatesh et al., 2003). It evaluates the anticipated advantages of applying a new technological solution. Within the scope of this study, it is important to assess whether the implementation of DTs enhances the efficiency

of safety incident reporting. When individuals perceive the technology as beneficial and capable of improving outcomes, the likelihood of adopting it increases (Popova and Zagulova, 2022).

2.7.3.2 Effort expectancy

This refers to the level of ease associated with the use of a system (Venkatesh et al., 2003). It considers how much effort is required from users to learn, operate, and comprehend the functionality of the technology. When a system is perceived as easy to use, it typically results in a higher acceptance rate. This is largely because users are more confident and less prone to making errors when navigating a system that is straightforward and user-friendly (Popova and Zagulova, 2022).

2.7.3.3 Social influence

This construct reflects the extent to which individuals perceive that people who are important to them think they should use the new system (Venkatesh et al., 2003, p. 451). In many cases, even if a technology is considered effective and easy to use, users may not fully commit to it unless they receive encouragement or endorsement from influential individuals within their social or professional circles. Social influence comprises subjective norms, social factors, and perceptions of image (Sugandini et al., 2022). As Taiwo and Downe (2013) contend, such influence can play a critical role in shaping users' attitudes and behaviours toward new systems.

2.7.3.4 Facilitating conditions

This construct addresses the belief that sufficient organisational and technical support is in place to enable effective use of the system (Venkatesh et al., 2003). It includes access to necessary resources such as infrastructure, equipment, training, and technical assistance, all of which contribute to a smoother implementation and sustained use of the technology.

Table 2.2: Summary of constructs and indicators

Construct	Indicator
Performance Expectancy	Anticipated advantages from using DTs. Improvement in task completion efficiency. Enhanced ability to perform duties effectively.
Effort Expectancy	Simplicity in navigating and interacting with the system. Effortlessness in acquiring the necessary skills to use the system. Overall user-friendliness of the system.

Social Influence	Perception that peers value the use of DTs. Personal belief in the relevance or usefulness of DTs. Perceived necessity of applications for effective communication.
Facilitating Conditions	Availability of necessary technological tools to support system use. Awareness of how to operate the digital application. Having adequate information to use the system competently. Availability of support when encountering difficulties with the system.

Table 2.3: Summary of constructs and strategic recommendations

Construct	Strategic recommendations	Supporting evidence
Performance Expectancy	Automate reporting, use mobile apps, integrate wearables, and enable real-time data analysis.	Popova and Zagulova (2022)
Effort Expectancy	Design simple interfaces, provide language options, and include embedded help features.	Venkatesh et al. (2003)
Social Influence	Involve supervisors, encourage peer support, and embed DTs within company safety culture.	Sugandini et al. (2022); Taiwo and Downe (2013)
Facilitating Conditions	Provide infrastructure, continuous training, support systems, and clear data governance.	Popova and Zagulova (2022)

2.8 SUMMARY OF LITRATURE REVIEW RELATED TO RESEARCH OBJECTIVES

Table 2.4 illustrates the direct alignment between the research objectives of this study and the relevant sections of the literature reviewed. This structured approach ensured that each objective was thoroughly grounded in existing scholarship, providing a clear framework for the investigation. The first objective focused on identifying barriers to effective construction safety incident reporting, which was addressed in sections 2.2 and 2.3, examining organisational, behavioural, and systemic challenges. The second objective explored the enablers that facilitate accurate and timely reporting, discussed in section 2.4 through managerial and cultural perspectives. The third objective investigated organisational

readiness for digital reporting adoption, drawing on empirical evidence presented in section 2.2 and 2.5. The fourth objective considered how DTs could mitigate the underreporting of safety incidents, with insights drawn from section 2.6, which reviewed innovations such as wearable devices and mobile reporting platforms. Finally, the fifth objective aimed to determine a digital roadmap for enhancing safety incident reporting, supported by section 2.7's synthesis of strategic frameworks and best practices. This alignment reinforced the coherence of the research design and ensured that the literature review comprehensively supported the study's aims and methodology.

Table 2.4: Summary of literature review related to research objectives

Reserch objectives		Litrature review sections
1	Identify the barriers to effective construction safety incident reporting.	2.2 and 2.3
2	Determine the enablers of effective construction safety incident reporting.	2.4
3	Investigate organisational readiness for digital reporting adoption.	2.22.5
4	Explore how the application of DTs would mitigate underreporting of construction safety incidents.	2.6
5	Determine the digital roadmap that would improve the reporting of construction safety incidents.	2.7

2.9 GAPS IN LITERATURE

Despite the growing body of research on construction safety incident reporting and the adoption of DTs, several important gaps remain. Firstly, there is a lack of context-specific empirical studies, particularly in developing countries such as South Africa, where construction environments are often resource-constrained, labour-intensive, and fragmented. Many existing studies are based in developed countries and may not reflect these realities, making their applicability uncertain. Secondly, the literature often treats technological, organisational, management, worksite, and human factors separately, rather than as interconnected elements, which limits a full understanding of how reporting systems function in practice. In addition, there is limited research on how DTs can be practically implemented within existing safety management systems, especially considering issues such as cost, usability, and low digital literacy among workers.

While DTs are widely presented as solutions to underreporting, the literature remains largely focused on their potential rather than their proven effectiveness. Many studies highlight the capabilities of technologies such as BIM, WTs, IoT systems, and mobile applications without strong empirical evidence of their consistent success in real construction environments. As a result, there is often an assumption that technological capability directly leads to improved safety outcomes, which may not always be the case. Furthermore, a significant portion of the literature is based on laboratory or controlled settings, such as studies on virtual reality, motion capture, and sensor-based systems, which may not reflect the complexity and unpredictability of actual construction sites. This is particularly important in developing contexts, where infrastructure limitations, cost constraints, and low digital literacy may affect implementation.

Although advancements such as WTs and mobile reporting platforms show promise, there is limited evidence on their long-term effectiveness in real-world settings. At the same time, underreporting remains a major challenge, yet there is insufficient research on how reporting systems can be redesigned to address its root causes, such as fear, lack of trust, and organisational culture. Vulnerable workers, including subcontracted and temporary workers, are also underrepresented in existing studies.

In addition, some contradictions in the literature remain unresolved. For example, safety incentives are seen as improving safety performance, yet they may discourage honest reporting if workers fear losing rewards. There is limited research on how such approaches can be balanced.

Overall, the literature reveals key gaps related to contextual relevance, integration of influencing factors and practical implementation of digital technologies. These gaps highlight the need for more empirical, field-based, and context-sensitive research, as well as the development of a holistic and practical digital roadmap to improve construction safety incident reporting. digital roadmap that not only leverages emerging technologies but also addresses the complex interplay of barriers, enablers, stakeholder needs, and organisational factors. Such a roadmap would facilitate creating an environment that enables adoption of digital reporting, ultimately contributing to safer construction workplaces.

2.10 CHAPTER SUMMARY

This chapter reviewed literature on the underreporting of construction safety incidents, revealing that the issue stems from factors involving human behaviour and systems. Barriers such as lack of resources, weak management commitment, poor communication, and negative perceptions of safety procedures were identified. However, drivers such as strong leadership, a positive safety culture, and incentives can improve reporting. The chapter also highlighted the digital technologies benefits thereof, including real-time data, better accountability, and improved communication. The next chapter, Chapter 3, outlines the research methodology used to explore these issues in real-world settings.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research methodology adopted for this study, outlining the approach used to address the research aim of exploring barriers and enablers to digital construction safety reporting and developing a context-specific roadmap for the Mangaung construction environment. The methodology explains how both primary and secondary data was collected and analysed to generate insights that are practical, reliable, and aligned with the study objectives. The chapter also introduces the research onion framework, which guided the methodological choices for this study. Each layer of the research onion, including research philosophy, approach, strategy, time horizon, and data collection methods, is considered carefully

3.2 RESEARCH ONION FRAMEWORK

The framework was developed using the research shown in Figure 3.2. which illustrate alternative choices for each layer. Table 3.1 summarises the layers of the research methodology and the rationale for each choice. It highlights how the study's interpretivist philosophy, inductive approach, qualitative multi-method design, and multiple-case strategy, collectively support the exploration of barriers and enablers in construction safety reporting and the development of a digital roadmap. The table also outlines the data collection methods, analysis approach, and time horizon, showing how each element aligns with the study's objectives.

Table 3.1: Layers of the research methodology and the rationale for each choice

Layers	Choice and Rationale
Research philosophy	Interpretivism to understand participants' experiences and perceptions in context, exploring barriers and enablers of safety reporting.
Epistemology	Focused on knowledge collection and subjective meanings to identify factors affecting safety reporting and support roadmap development.
Research approach	Inductive approach to allow theory and insights to emerge from empirical data, suitable for exploratory objectives.

Methodological choice	Qualitative, multi-method design enabling in-depth understanding and rich descriptive data.
Research strategy	Multiple-case study to investigate practices across three construction projects, enhancing depth and contextual understanding.
Case selection	Purposeful selection of three diverse projects to capture variations in type, scale, and scope.
Time horizon	Cross-sectional (April 2023 - June 2024) for efficient single-point data collection.
Primary data collection	Semi-structured interviews and focus groups to gather perspectives from skilled professionals and unskilled workers, enabling triangulation.
Secondary data collection	Literature, journals, and organisational documents to provide theoretical context and inform primary data.
Data analysis	Thematic analysis to code transcripts, identify patterns, and derive themes supporting roadmap development.

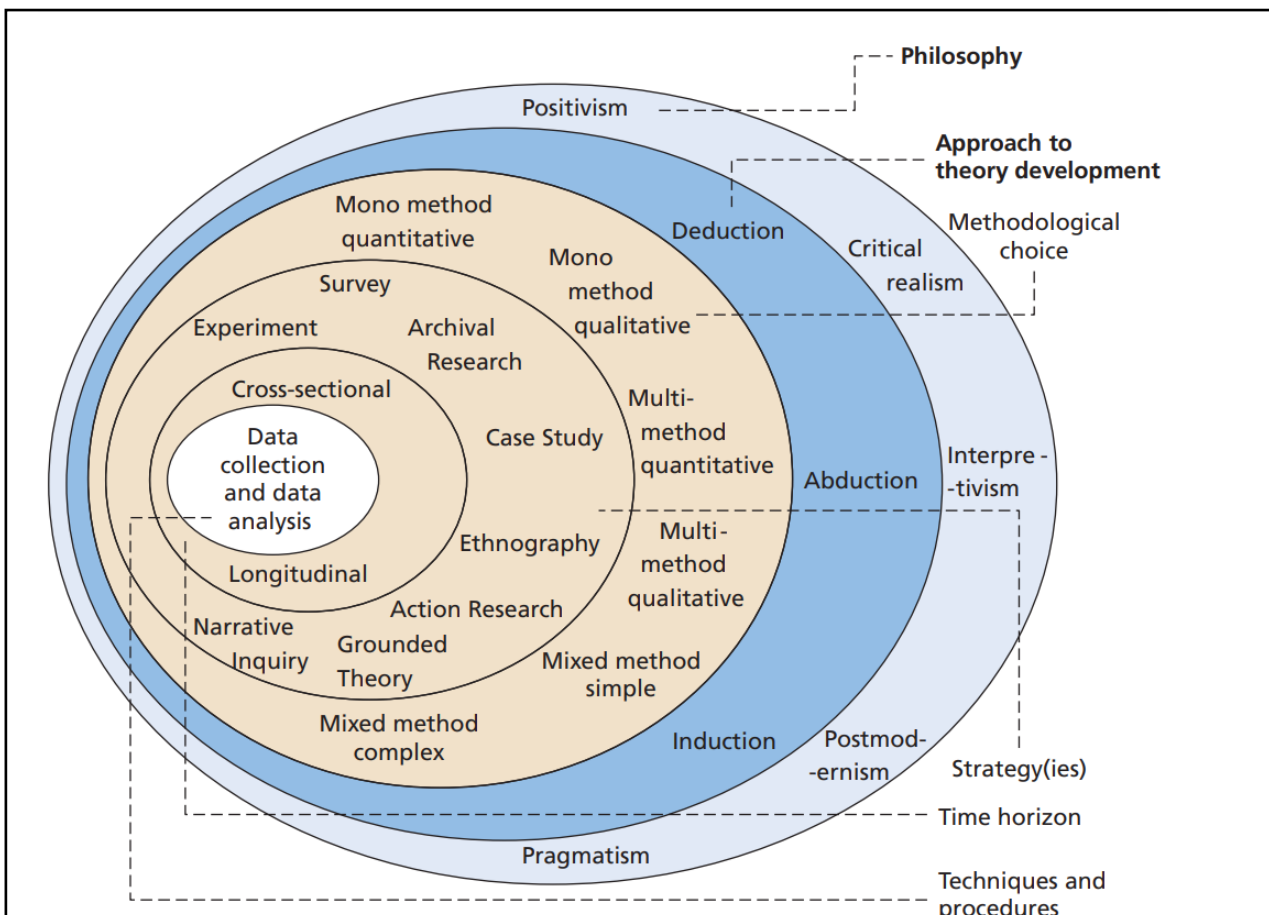


Figure 3.1: The 'research onion' (Source: Saunders, Lewis, and Thornhill, 2019)

3.3 RESEARCH PHILOSOPHY

Research philosophy refers to “a system of beliefs and assumptions about the development of knowledge” (Saunders et al., 2019:130). It narrates knowledge development and the nature thereof. In other words, when a researcher conducts research, the intent is to develop knowledge in the area of study or field of practice. The knowledge developed may address a defined problem in an organisation or lead to a new theory. The research philosophy influences how the researcher designs and conducts a study. In addition, the research philosophy helps to determine a philosophical position, which in turn frames the theoretical perspective, such as the ideas, concepts, and assumptions that the researcher brings to the conducted study, further influencing the kinds of questions to ask and how to seek answers for the questions. Moreover, these elements inform the methodologies that will best suit the philosophy, and define how theories and the desired research outcomes are integrated, as well as the justification for the chosen methods.

The research philosophy adopted for the current study is interpretivism. This philosophy highlights approaches that stress the significance of individuals’ lived experiences and their participation in social and cultural contexts. Accordingly, the study sought to uncover the underlying meanings and motives that influence people’s actions in relation to the reporting of safety incidents. This philosophical stance was considered more appropriate than critical realism which seeks to explain observable phenomena by identifying underlying causal mechanisms and the interaction between social structures and human. It views reality as stratified, with deeper mechanisms generating observable events. However, this study does not aim to uncover such underlying causal mechanisms, but rather to understand participants’ lived experiences and perceptions of safety incident reporting (Stutchbury, 2021).

The focus of this research is on how construction stakeholders interpret and experience reporting practices within their organisational and cultural contexts. While critical realism explains how structures shape behaviour, this study prioritises understanding participants’ interpretations of these influences, such as fear of reprisal, safety culture, and digital literacy. Therefore, interpretivism was deemed more appropriate, as it supports the exploration of subjective meanings and context-specific realities (Saunders et al., 2019; Creswell and Poth, 2018).

Therefore, interpretivism is well-suited for investigating complex social phenomena such as construction safety reporting practices. Interpretivism emphasises understanding the subjective experiences and perceptions of individuals within their natural context, enabling

the capture of rich, nuanced insights (Saunders et al., 2019). This philosophy aligns with the study's objective of exploring the barriers and enablers of digital safety reporting in the construction industry, as it allows for an in-depth understanding of the practical realities faced by project members. Furthermore, interpretivism enables the researcher to explore how organisational culture, fear of reprisal, and management practices shape reporting behaviours, which are central to the problem of underreporting identified in this study.

In the research process, a number of assumptions were made. The assumptions were either ontological assumptions, which are about the reality encountered in the research process; epistemological assumptions, which are assumptions about human knowledge; or axiological assumptions, which are assumptions about the manner or extent to which the researcher's beliefs influenced the research (Muhaise et al., 2020; Saunders et al., 2019). Epistemology was adopted in the current study. According to Al-Ababneh (2020), epistemology described how knowledge was collected and focused on details of situations, the reality of those details, subjective meanings, and motivating actions. It dealt with the manner in which knowledge was gained from different sources (Khatri, 2020). An interpretivist epistemological position was therefore adopted, as it supports the generation of knowledge through participants' experiences and interactions within construction environments. The factors affecting the reporting of construction safety incidents were identified and validated in order to develop a theory that enabled the development of a roadmap.

It is acknowledged, however, that interpretivism may limit the generalisability of findings due to its context-specific and subjective nature. To address this limitation, the study incorporated multiple case studies and cross-case analysis to enhance the robustness and transferability of the findings.

3.4 RESEARCH APPROACH TO THEORY DEVELOPMENT

Saunders et al. (2019) have demonstrated that research can follow a deductive, abductive, or inductive approach. With a deductive approach, existing literature is reviewed to develop a theory and hypothesis and design a research strategy and subsequently, to test the hypothesis. Conversely, with inductive approach, data is collected and analysed to develop theory from data analysis. Alternatively, an abductive approach can be adopted in which data is collected to explore a phenomenon, identify themes, explain trends, and to generate a new theory or contribute to the existing body of knowledge, which are subsequently subjected to evaluation through additional data collection.

The current study adopted an inductive research approach to enable the emergence of grounded insights directly from empirical data, rather than relying on a predefined framework. This methodological choice is particularly appropriate given the exploratory nature of the study and the limited context-specific empirical evidence on digital safety reporting practices within developing country construction environments such as South Africa. In this regard, the inductive approach allows for a deeper understanding of the social, organisational, and behavioural factors influencing safety incident reporting, which may not be adequately captured through a deductive approach.

This methodological choice aligns with the literature review's emphasis on the complexity and variability of safety incident reporting practices in construction. The inductive approach facilitated the exploration of key themes such as barriers to effective safety reporting, drivers that enhance reporting practices, the use of construction DTs including BIM, sensing devices, and wireless networks for incident reporting, as well as the prospects of IoT in facilitating digital reporting of on-site safety incidents. In addition, the inductive approach enabled the study to capture participants' lived experiences and perceptions, thereby providing contextually grounded insights into why underreporting persists despite the availability of technological solutions. This is particularly important as the study recognises underreporting as a socio-organisational phenomenon rather than solely a technological challenge.

The data collected through this approach was analysed to inform the development of a comprehensive roadmap for effective digital reporting of safety incidents in the construction sector. While the study is primarily inductive, the findings were further interpreted in relation to existing theoretical frameworks, such as technology adoption models, to enhance analytical depth and support analytical generalisation.

3.5 RESEARCH METHODOLOGICAL CHOICE

The study addressed the lack of a comprehensive roadmap that foster an implementation-ready environment for digital safety reporting of safety incidents by adopting a qualitative multi-method approach. Leavy (2017) specified that a qualitative approach was often used in exploratory or descriptive research. A qualitative study was designed to enable a researcher to understand a phenomenon by observing or interacting with the interviewees of the study. In addition, qualitative researchers are interested in exploring phenomena as they occur in their natural settings (Lelissa, 2018). In other words, qualitative researchers intended to comprehend the topic or phenomenon rigorously and unpack the meanings

attributed to lives, activities, situations, circumstances, people, and objects. This approach relied on inductive research designs intended to generate meaning and produce substantial descriptive data (Leavy, 2017).

The adoption of a qualitative multi-method approach in this study is justified by the complex and context-dependent nature of construction safety incident reporting, which involves organisational, behavioural, and technological dynamics that cannot be adequately captured through quantitative methods alone. Specifically, the use of multiple qualitative methods enabled the collection of rich and complementary data from different participant groups, thereby enhancing the depth and credibility of the findings.

Furthermore, the qualitative approach aligns with the interpretivist research philosophy adopted in this study, as it facilitates an in-depth exploration of participants' lived experiences and perceptions regarding safety incident reporting practices. This is particularly important given that underreporting is recognised in this study as a socio-organisational phenomenon influenced by factors such as fear of reprisal, safety culture, and management practices.

3.6 RESEARCH STRATEGY

According to Saunders et al. (2019), a research strategy establishes the link between the researcher's philosophical orientation and the subsequent methodological choices for data collection and analysis. The authors emphasise that a research strategy represents a plan of action designed to achieve defined research objectives. In this sense, it provides a structured pathway for answering the research questions. A variety of strategies may be employed depending on the research context and objectives, including surveys, case studies, ethnography, action research, grounded theory, and narrative inquiry, or combinations of these (Saunders et al., 2019).

For this study, a case study research strategy was adopted. This approach was considered most appropriate as it enables the generation of insights through intensive and in-depth investigation into the reporting of construction safety incidents. Case studies are particularly valuable in applied fields such as construction management, where contextual nuances are critical to understanding practice (Yin, 2018). The strategy facilitated the development of rich, empirical descriptions of the barriers and drivers influencing incident reporting, while also allowing for exploration of the extent to which digital reporting systems are currently utilised in South African construction projects. Importantly, the case study approach

provided an evidence base from which to develop a roadmap for digital construction safety reporting.

Although grounded theory was considered, it was not adopted for this study. Grounded theory is primarily aimed at generating new theory through iterative data collection and analysis, often with minimal reliance on existing theoretical frameworks (Creswell and Poth, 2018). However, the current study does not seek to develop a new theory, but rather to explore construction safety reporting practices and develop a context-specific digital roadmap informed by both empirical findings, existing literature and theories.

Furthermore, grounded theory typically requires continuous data collection until theoretical saturation is achieved and is not confined to predefined case boundaries (Saunders et al., 2019). In contrast, this study is structured around clearly defined case study sites, making the case study strategy more appropriate for addressing the research objectives. The selection of a case study strategy was further justified by the need to examine safety reporting practices within their real-life context, where organisational culture, management practices, and workforce dynamics interact in complex ways. Unlike alternative strategies such as surveys, which may provide breadth but lack contextual depth, the case study approach enables a deeper understanding of “how” and “why” underreporting occurs within specific construction environments.

3.6.1 Case Selection

In order to strengthen the validity and robustness of the findings, a multiple-case design was employed. A multiple-case design enhances the generalisability of findings through comparative analysis, while reducing the limitations inherent in single-case studies, such as context-specific bias. By examining similarities and differences across cases, the study was able to derive more credible and transferable insights into the systemic barriers and enablers of construction safety reporting. The decision to include three case studies was guided by the need to balance depth and comparative analysis. While additional cases could increase coverage, three cases were considered sufficient to identify recurring patterns and variations without compromising the depth of qualitative inquiry.

Three construction-sites were purposefully selected as case studies. Purposeful selection ensured that the projects represented different contexts within the construction industry, thereby reflecting variations in project type, scale, and scope. Selection criteria were aligned with the research objectives and included (i) the relevance of the project to construction safety reporting practices, (ii) the presence of safety management systems, and (iii) the opportunity to observe the role of DTs in incident reporting. This diversity enhanced the

potential for comparative analysis and increased the depth of insights derived from the research. Data collection continued across the selected cases until no new themes or insights emerged from additional data, thereby confirming the adequacy of the selected cases.

3.6.2 Case Descriptions

The three selected cases are presented in Table 3.3 to illustrate the research settings and contextual diversity of the study. Collectively, these cases provided a comprehensive perspective across distinct project typologies, thereby enabling the exploration of a broad spectrum of barriers, drivers, and opportunities for the digitalisation of construction safety incident reporting. The three projects chosen as case studies represents different project types within the South African construction industry. The projects include a conventional building project, a refurbishment project, and a large-scale mixed-use development. The inclusion of these varied contexts ensured that the study examined safety incident reporting practices across different operational environments, ranging from new construction to complex, multi-stakeholder developments and refurbishment works characterised by inherent constraints and unique hazards. This diversity enriched the dataset and strengthened the study's ability to identify both commonalities and context-specific factors influencing safety incident reporting. This diversity also supports analytical generalisation, whereby findings are interpreted across cases to develop broader insights into construction safety reporting practices, rather than relying solely on statistical generalisation.

- **Case 1:** A building project located in Universitas, focused on the construction of new office facilities. This project provided an opportunity to examine safety reporting practices in a conventional building environment, with emphasis on formal office development.
- **Case 2:** A major refurbishment project undertaken for the renovation and upgrading of Thusanong existing office building in Bloemfontein. This case provided the context to explore safety reporting in refurbishment projects, where unique hazards and constraints arise from working within existing structures.
- **Case 3:** A mixed-use integrated project in Vista Park, involving the construction of housing units alongside supporting infrastructure. This case offered insights into incident reporting within a large-scale, multi-stakeholder environment characterised by diverse activities and subcontractor involvement (See Table 3.2):

Table 3.2: Summary of case selection

Project case sudy	Type of Project	Key Focus
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Case 1	C1	New office building	Safety reporting in a standard building project.
Case 2	C2	Office refurbishment	Reporting in refurbishment with unique hazards.
Case 3	C3	Mixed-use housing and infrastructure	Reporting in a large, multi-stakeholder project.

3.7. RESEARCH TIME HORIZONS

This study adopted a cross-sectional time horizon, which allowed for the collection of data within a relatively short period. Data for this research was collected from April 2023 to June 2024, supporting the cross-sectional nature of the study. The cross-sectional design enabled information to be gathered at a single point in time without the need for follow-up with participants. As a result, findings were produced more quickly and at a lower cost, making the approach both efficient and practical for addressing the research objectives (Zangirolami-Raimundo, Echeimberg and Leone, 2018).

3.8 RESEARCH TECHNIQUES AND PROCEDURES

Data for this study were collected using a combination of primary and secondary sources to provide a comprehensive understanding of construction safety reporting practices.

3.8.1 Primary data

Primary qualitative data was collected through interviews and focus groups to address the research objectives comprehensively. Interviews are verbally administered questionnaires that can be structured, semi-structured, or unstructured. In this study, semi-structured interviews were adopted, which consisted of several key questions organized into themes to guide the areas explored. This approach allowed participants to deviate from the main questions, providing detailed responses and sharing ideas not previously considered but deemed important by the interviewees. Semi-structured interviews thus enabled the discovery and explanation of insights that enriched the understanding of construction safety reporting practices (DeJonckheere and Vaughn, 2019).

Focus group interviews were conducted following the same interview protocols designed for the semi-structured interviews. While the questions remained aligned with the themes in the semi-structured interviews, the focus groups allowed for more interactive discussions among participants. Focus group discussions involved a few unstructured, generally open-ended questions designed to gather views and opinions from participants (Lim, 2024). This method was specifically used to collect data from unskilled to semi-skilled workers on construction-

sites, capturing practical experiences and perceptions that may not have emerged in individual interviews.

The semi-structured interviews, in contrast, focused on professionals, supervisors, and skilled personnel on construction-sites, including project managers, architects, engineers, quantity surveyors, construction managers, site agents, site managers, and HSOs. By applying the same protocols across both methods, the study ensured consistency in data collection while allowing adaptation to the different participant groups. This approach enabled triangulation of data across hierarchical levels within the project teams, enhancing the credibility, depth, and richness of the findings.

However, it should be noted that although both semi-structured interviews and focus group discussions were initially incorporated into the research design, the primary data presented and analysed in this study were predominantly derived from semi-structured interviews. While focus groups were considered valuable for capturing collective perspectives, they proved less effective in generating detailed, consistent, and analytically robust data within the context of this study.

Consequently, semi-structured interviews were prioritised as the principal data collection method, as they enabled deeper probing, clarification of responses, and a more comprehensive exploration of organisational, behavioural, and technological factors influencing construction safety incident reporting. This was particularly important given the sensitivity of the topic, where issues such as fear of reprisal, safety culture, and reporting practices required individual reflection rather than group-based responses.

Furthermore, the use of semi-structured interviews ensured alignment with the interpretivist research philosophy, which emphasises understanding participants' lived experiences and subjective meanings. The depth and richness of the interview data supported more rigorous thematic analysis and the development of well-grounded themes across the case studies.

Although focus group discussions did not form the primary basis of analysis, their inclusion during the exploratory phase contributed to enhancing the researcher's understanding of key issues related to digital safety reporting. This, in turn, helped confirm that the semi-structured interview data collection instrument was contextually relevant and appropriately aligned with the practical realities of construction site practices.

Methods of primary data collection

Table 3.3 presents the link between the research objectives, methods of primary data collection, and methods of data analysis. In research, data can be collected using

different/various methodological strategies. A mono-method involves a single qualitative or quantitative technique. When researchers apply more than one technique within the same tradition (i.e., only qualitative or only quantitative), it is referred to as a multi-method approach, further distinguished as multi-method qualitative or multi-method quantitative. In contrast, a mixed-methods approach integrates both qualitative and quantitative techniques concurrently.

For the current study, a multi-method qualitative design was adopted (Al-Ababneh, 2020). This means that several qualitative-oriented instruments were employed to collect data. Specifically, semi-structured interviews and focus groups were used as the main sources of primary data collection. The adoption of a multi-method qualitative design was considered appropriate for this study, as it allowed for the exploration of construction safety reporting from multiple perspectives, thereby enhancing the depth and richness of the data collected.

Interview protocol in appendix 1 with set of questions that guided the interviews and focus groups' discussions was designed. The use of a structured interview protocol ensured consistency across data collection while allowing sufficient flexibility for participants to elaborate on their experiences and perceptions. According to Creswell and Poth (2018), qualitative data collection can be achieved through approaches such as interviews, observations, documents, and visual materials, with interviews and focus groups being particularly effective for capturing participant perspectives in depth.

However, in practice, semi-structured interviews constituted the primary source of data for analysis, as they proved more effective in generating detailed, consistent, and contextually rich responses compared to focus group discussions. While focus groups were initially considered to capture collective perspectives, their role was primarily exploratory, contributing to the refinement of the interview instrument and enhancing the researcher's understanding of key issues related to digital safety reporting.

The use of semi-structured interviews further enabled probing and clarification of responses, which was essential for exploring sensitive issues such as underreporting, safety culture, and organisational practices. This approach ensured alignment with the interpretivist research philosophy and supported the development of well-grounded themes during the analysis phase.

Table 3.3: Data collection methods alignment with the research objectives and analysis

Research objectives		Methods of primary data collection		Method of data analysis	
		Semi-structured interviews	Focus groups	Thematic	
1	To explore the barriers to effective construction safety incident reporting	X	X	X	Compare different cases
2	To determine the enablers of effective construction safety incident reporting	X	X	X	
3	To investigate the status of digitalised reporting of construction safety incidents	X	X	X	
4	To explore how the application of IoT would mitigate underreporting of construction safety incidents	X	X	X	
5	To determine the digital roadmap that would improve the reporting of construction safety incidents	X	X	X	

3.8.2 Secondary data

Secondary data comprise both raw data and published summaries (Saunders et al., 2019). Articles, journals, magazines, books, and periodicals are sources of secondary data. These sources provide second-hand information since data have already been collected by earlier researchers and authors (Kelly, Martin-Peters and Strohm-Farber, 2024). Thus, to achieve the research objectives of this study, descriptive and narrative information were extracted. The following databases were consulted for the collection of secondary data throughout the study:

- EBSCO Host
- Emerald
- ScienceDirect
- ProQuest

- Taylor and Francis Online
- Google scholar
- Research gate

3.9 DATA COLLECTION PROCEDURES AND ANALYSIS

3.9.1 Population

Etikan, Musa and Alkassim (2016: 1) define a sample as “portion of population or universe”, which refers to the subject of the study such as total matters, objects or cases. The population of the current study comprised construction projects identified as cases in Mangaung, Free State province, South Africa. This population included project managers, architects, engineers, quantity surveyors, construction managers, site agents, site managers, HSOs, contractors, subcontractors, supervisors, artisans, trade-skilled workers, and general workers. These participants were deliberately selected because they are directly involved in the planning, execution, and oversight of construction activities, and therefore possess the practical knowledge and expertise necessary to provide meaningful insights into safety reporting practices. By engaging this population, the study ensured that the perspectives gathered were grounded in the realities of the construction environment and relevant to the subject area under investigation. This approach strengthens the validity of the findings, as it confirms that the participants are familiar with, and knowledgeable about, the processes and challenges associated with construction safety reporting.

3.9.2 Sampling method

In research where it is often impractical to engage the entire population owing to its size or difficulties in identification and access, sampling is employed to collect data from a targeted group. The commonly used sampling techniques are probability sampling and non-probability sampling (Stratton, 2021). This study adopted a non-probability sampling approach.

“Non-probability sampling is a sampling procedure that will not bid a basis for any opinion of probability that elements in the universe will have a chance to be included in the study sample” (Etikan and Bala, 2017: 215). In other words, participants in the population have unequal chances of inclusion, unlike probability sampling methods where sample units are randomly selected and have equal chances of being included. Etikan, Musa and Alkassim (2016) emphasise that data collection is imperative in research as it contributes to a deeper understanding of the theoretical framework.

For this study, a non-probability purposive sampling design was employed. This technique was selected because it allows the deliberate targeting of participants who are directly involved in or influence construction safety performance, which aligns closely with the study's objective of understanding safety reporting practices. By focusing on those with practical experience and responsibility in safety management, the research ensures that the data collected is relevant, rich, and directly applicable to achieving the research objectives.

Interviews were conducted with project members across three case study projects to capture comprehensive insights into safety reporting practices across diverse construction contexts. Table 3.4 presents the distribution of interview participants across the three case study projects. A total of twenty-seven (27) individuals were interviewed, representing a broad range of roles within the construction project teams, including management and supervisory staff, health and safety officers, skilled tradespersons, and technical specialists. Case 1, involving the construction of new office facilities in Universitas, accounted for 37.04% of responses; Case 2, covering the renovation and upgrading of an existing office building in Bloemfontein, contributed 33.33%; while Case 3 focused on the construction of mixed-use housing units and infrastructure in Vista Park, representing 29.63% of responses. This distribution ensured that the study captured diverse perspectives from different project contexts, enhancing both the credibility and depth of the findings while directly supporting the achievement of the research objectives.

Table 3.4: Research sample

Project case study	Members of the project team			Frequency	Percentage (%)
C1: Construction of new office facilities in Universitas	Construction inspector	Interviewee 1	I1	10	37.04%
	Site general foreman	Interviewee 2	I2		
	Junior H&S officer	Interviewee 3	I3		
	Plumber	Interviewee 4	I4		
	Site manager	Interviewee 5	I5		
	H&S officer	Interviewee 6	I6		
	Health, safety and environment officer	Interviewee 7	I7		
	Junior wet works foreman	Interviewee 8	I8		
	Electrical workers	Interviewee 9	I9		
	Bricklaying workers	Interviewee 10	I10		
C2: Renovation and upgrading of existing office building in	Assistant project manager	Interviewee 11	I11	9	33.33%
	Engineer	Interviewee 12	I12		
	Tractor loader backhoe operator	Interviewee 13	I13		
	H&S representative	Interviewee 14	I14		
	Construction supervisor	Interviewee 15	I15		

	Trades supervisor	Interviewee 16	I16		
	Equipment operator	Interviewee 17	I17		
	Site administrator	Interviewee 18	I18		
	Electrician	Interviewee 19	I19		
C3: Bloemfontein Construction of housing units and infrastructure	Project specialist	Interviewee 20	I20	8	29.63%
	Civil engineer	Interviewee 21	I21		
	OHS practitioner	Interviewee 22	I22		
	Senior site agent	Interviewee 23	I23		
	H&S officer	Interviewee 24	I24		
	Project manager minor works	Interviewee 25	I25		
	H&S officer	Interviewee 26	I26		
	Site foreman	Interviewee 27	I27		
TOTAL				27	100.00%

3.9.3 Data analysis

The qualitative data collected were analysed using thematic analysis, a method that allows researchers to organise and interpret complex data sets systematically (Dawadi, 2020: 62). Thematic analysis was selected because it provides a structured approach to identifying patterns and themes within qualitative data, enabling the researcher to draw meaningful insights that directly address the research objectives.

All interviews were audio-recorded with participant consent and then transcribed verbatim. The transcription process ensured that the responses were captured accurately and in detail, preserving the nuances of participants' experiences. These transcripts formed the primary dataset for analysis.

Thematic analysis was conducted in a stepwise manner. The researcher first familiarised themselves with the transcripts, reading and re-reading the data to gain a holistic understanding. Initial codes were then generated to label significant statements, actions, or ideas, both based on the study objectives and emergent insights from the data. Example codes included but were not limited to 'stakeholder engagement,' 'training,' 'digital technologies,' 'barriers to reporting,' and 'safety culture.'

Coding decisions were informed by a combination of deductive and inductive approaches. Deductive coding was guided by the research objectives and existing literature on construction safety reporting and digital technologies, while inductive coding allowed new themes to emerge directly from participants' responses. This ensured that both theory-driven and data-driven insights were captured. A coding framework was developed and applied consistently across all transcripts. Codes were iteratively reviewed, refined, and, where necessary, merged to eliminate duplication and improve clarity. This iterative process

ensured consistency in how codes were applied and enhanced the transparency of coding decisions.

Codes were then grouped into broader themes representing key patterns across the cases. Decisions about what constituted a theme considered frequency, relevance to research objectives, and depth of insight. These themes were iteratively refined to ensure they accurately reflected the data while providing a coherent framework for interpretation. Theme development followed a structured process in which related codes were grouped into sub-themes, which were then synthesised into overarching themes aligned with the research objectives. Each theme was continuously checked against the original data to ensure that it was supported by sufficient evidence and accurately represented participants' perspectives.

Figure 3.2 summarises the thematic analysis procedure, illustrating the steps from transcription to coding, theme identification, and refinement. Each theme was analysed in relation to the research objectives and cross-case comparisons, allowing the study to identify patterns, enablers, and barriers in construction safety reporting practices. This approach ensured that the findings were grounded in participants' experiences while remaining systematically organised for rigorous academic analysis.

To validate the interpretation of findings, cross-case analysis was conducted, comparing themes across the three case studies to identify recurring patterns and context-specific variations. In addition, themes were verified against multiple participant responses to ensure that interpretations were not based on isolated views but reflected broader trends within the dataset.

Researcher bias was managed through reflexivity and systematic analytical procedures. The researcher remained aware of potential personal assumptions and ensured that interpretations were grounded in the data rather than preconceived expectations. The use of verbatim transcripts, iterative coding, and continuous comparison across cases further reduced the risk of subjective bias influencing the findings. Furthermore, an audit trail documenting coding decisions, theme development, and analytical processes was maintained throughout the study. This enhanced transparency and allowed the analytical process to be traced and evaluated, thereby strengthening the overall rigor and credibility of the research.

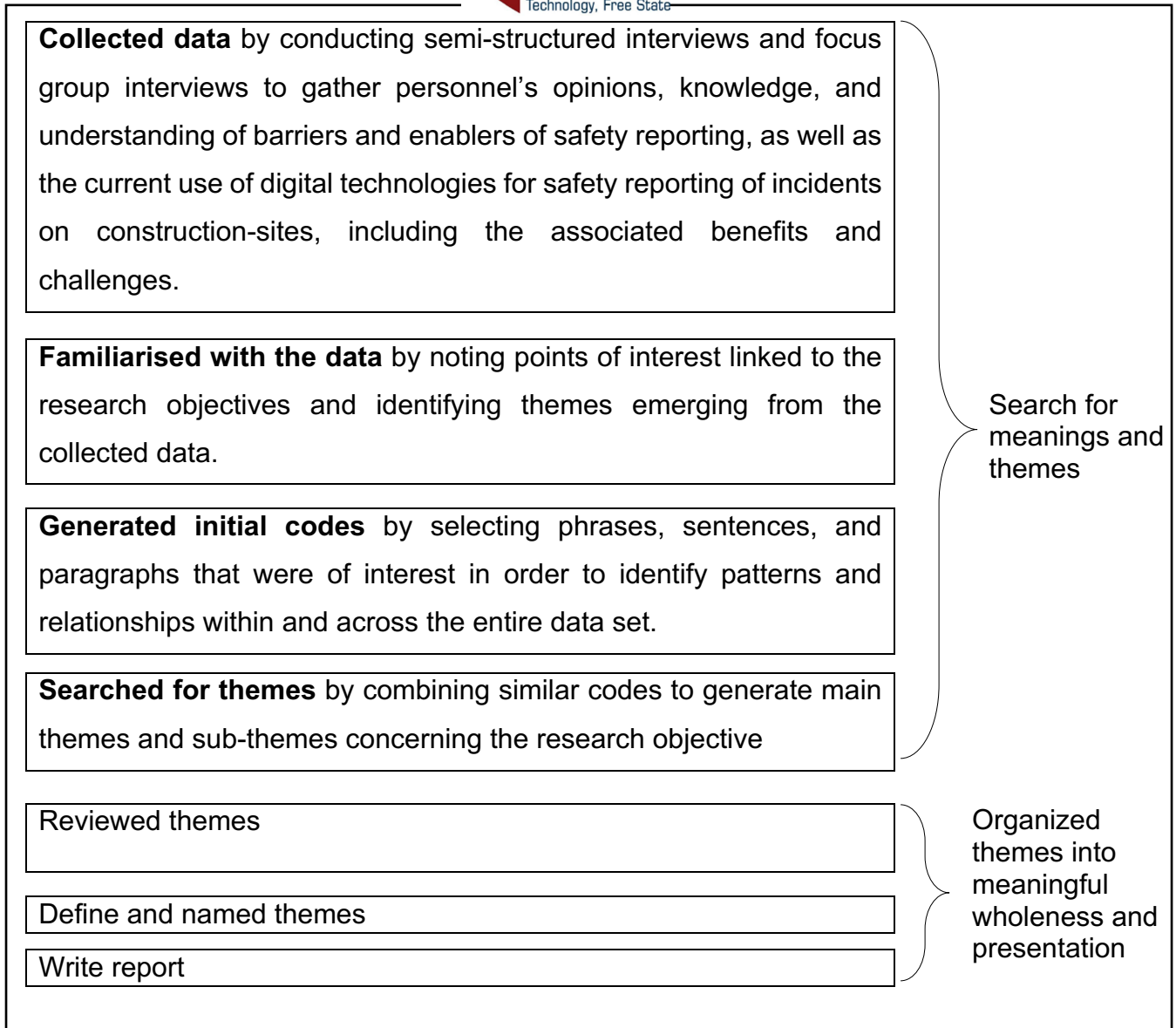


Figure 3.2: Thematic data analysis

(Researcher's construct, adopted from Saraswati Dawadi, 2020)

3.10 RELIABILITY AND VALIDITY OF DATA

Reliability in qualitative research refers to the degree to which data collection and analysis procedures produce consistent and dependable results over time (Creswell and Poth, 2018). In this study, reliability was enhanced by employing a multiple case study approach, which ensured that data was not drawn from a single construction-site but across different cases. This approach strengthened the consistency of findings by allowing comparison of patterns and themes across varied contexts. Furthermore, the reliability of the data was aligned with the thematic analysis procedures adopted in this research. During analysis, themes were systematically identified, coded, and reviewed, thereby reducing bias and enhancing the dependability of the results. Reliability was further strengthened through the consistent

application of the coding framework across all cases, ensuring that similar concepts related to digital safety reporting such as technology adoption, reporting barriers and enablers, and organisational and human practices were interpreted uniformly. The practical implication of this approach is that reliability was not measured in abstract terms but through methodological consistency, transparency of coding, and the replication of thematic patterns across different cases.

Validity in qualitative research was ensured by addressing several dimensions of validity, as suggested by Hayashi Jr et al. (2019). These include the following:

- **Descriptive validity:** Care was taken to report accurately what was heard without exaggeration or distortion. This was achieved through careful use of digital audio recordings to capture information faithfully during interviews and focus groups. This ensured that participants' accounts of reporting practices were represented accurately and without misinterpretation.
- **Interpretive validity:** The meanings and perspectives of participants were thoroughly captured through verbatim transcription of interviews and focus group discussions using a mobile electronic device. This ensured that the interpretations remained faithful to participants' intended meanings of their experiences with reporting systems and digital technologies, ensuring that findings reflected real-world practices rather than researcher assumptions.
- **Theoretical validity:** The explanatory power of the findings was assessed by relating emerging themes to relevant theories and recent scholarly publications. This provided a means of checking the consistency between the empirical data and the theoretical insights developed during analysis. This was particularly important in explaining the adoption of digital reporting technologies using established theoretical frameworks of technology adoption.
- **Generalization validity:** While qualitative research does not aim for statistical generalisation, this study applied analytic generalisation, extending findings to comparable contexts by drawing on existing literature and situating the results within broader debates on digital safety reporting and construction incident management.
- **Evaluative validity:** The findings were critically examined in relation to both participants' perspectives and existing research. This reflexive approach ensured that alternative viewpoints were not overlooked and that the evaluation of the results was balanced and comprehensive.

Additionally, triangulation across multiple case studies and diverse participant roles enhanced the credibility of the findings by incorporating different perspectives on construction safety reporting practices.

By aligning the procedures for reliability with thematic analysis and systematically applying multiple forms of validity, the study ensured that its findings are both credible and trustworthy.

3.11 ETHICAL CONSIDERATION

Ethical integrity was a core priority throughout the research process. Ethical approval for the study was secured from Central University of Technology (CUT) Ethics Committee before data collection began. The research was issued with ethical clearance number FRIC:28/09/2023 (See appending 2). In line with the ethical guidelines for qualitative research, as outlined by Leavy (2017), the study was supported by a solid ethical framework that addressed the researcher's value system, ethical practice, and reflexivity. Informed consent was obtained from all interviewees after they had been fully informed through the cover letter in annexure 1 about the study's goals, procedures, their voluntary participation, and their right to withdraw at any point without penalty. Interviewees were also assured that their anonymity and confidentiality would be protected, and that all data collected would be used solely for this research.

To promote respectful engagement, the researcher committed to avoiding the use of offensive or sensitive language during all interactions. Efforts were also made to ensure that no misleading impressions, inappropriate emotional expressions, or prejudiced assumptions were conveyed. The design of the interview questions reflected sensitivity to the diverse educational and occupational backgrounds of interviewees, ensuring that they were phrased in an inclusive and accessible manner for workers at all levels. Given the multilingual context of the research, a trained assistant proficient in both Sesotho and English was enlisted to facilitate translation during interviews and transcription. Before undertaking any tasks, the assistant was thoroughly briefed on all relevant ethical protocols to ensure that ethical standards were upheld during their involvement. Careful attention to ethical considerations, particularly in relation to power dynamics, cultural sensitivity, and confidentiality, was crucial in safeguarding interviewees' dignity and autonomy. This ethical rigour contributed significantly to the trustworthiness, credibility, and overall quality of the research findings.

3.12 CHAPTER SUMMARY

This chapter presented the research methodology employed. A qualitative case study approach was adopted to allow for an in-depth understanding of how organisational, behavioural, and systemic factors on construction-sites and DTs influence H&S reporting practices. Data was primarily collected through semi-structured interviews with purposively selected participants. Furthermore., thematic analysis was employed to identify patterns and themes aligned with the study's objectives. Ethical considerations, including informed consent and confidentiality, were strictly upheld throughout the research process. The next chapter, Chapter 4, will present and analyse the data collected, linking key findings to the research objectives and existing literature.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter presents and analyses the findings collected from primary data across three construction-sites selected as case studies in this research. The sites are located in Mangaung, Free State, South Africa. Interviews were conducted with participants directly involved in construction activities and safety reporting processes, providing rich, context-specific insights.

The findings for each case are presented and analysed individually to capture the unique context and practices of each site. This is followed by a cross-case comparison that highlights similarities, differences, and emerging patterns across the three projects. The presentation of results is structured according to the research objectives, ensuring that each objective is systematically addressed and clearly linked to the data collected.

The qualitative findings are organised into the following three main sections:

1. *Demographic Information and Participant Profiles*: This section describes the primary education, field of study and the current occupation of the interviewees.
2. *Safety Incident Reporting Practices*: Data are analysed in relation to Objective 1 (exploring barriers to effective reporting), Objective 2 (identifying enablers of reporting), and Objective 3 (investigating the current status of digitalised reporting). This alignment ensures that each aspect of safety reporting is examined through the lens of the study's aims.
3. *Application and Use of Digital Technologies (DTs)*: This section addresses Objective 4 (examining how IoT can mitigate underreporting) and Objective 5 (developing a digital roadmap to improve reporting). Findings related to DT adoption, benefits, and challenges are discussed, providing evidence to support roadmap development.

By structuring the chapter around the research objectives, the presentation of findings directly demonstrates how the data collected through multiple case studies contributes to understanding barriers, enablers, and digital innovations in construction safety reporting.

4.2 INTERPRETATION OF INTERVIEW RESULTS

This section presents the views of interviewees from cases 1 (C1), case 2 (C2), and case 3 (C3) as findings. The results demonstrate their understanding of safety reporting and its processes, the benefits of effective construction safety incident reporting, enablers of

successful reporting, the status of digital reporting of construction safety incidents, and the challenges faced when using DTs on construction-sites.

4.2.1 Results from C1

The case study is a building project located in Universitas, focused on the construction of new office facilities. This project provided an opportunity to examine safety reporting practices in a conventional building environment, with emphasis on formal office development.

4.2.1.1. Demographic information

This section presents the analysis of the demographic profiles of the C1 interviewees based on the critical characteristics considered during the interview. These characteristics include educational level, primary field of study, and current occupation.

Educational level

Table 4.1 shows the highest qualifications obtained by the interviewees. A total of 10 interviewees were interviewed; the findings show that the highest number of interviewees, namely three, obtained diplomas as their highest qualification. In contrast, only one obtained a postgraduate diploma, the highest qualification among the interviewees. Further, two of the interviewees completed bachelor's degrees, another two completed certificates at the tertiary level, and another two have matric as their highest qualification.

This distribution of qualifications indicates that the study captured perspectives from participants with varying levels of formal education, ranging from basic schooling to postgraduate level. This diversity is important for the study as it reflects the different levels of understanding, awareness, and engagement with construction safety reporting practices across the workforce. In particular, participants with lower qualifications may provide insights into practical challenges, such as digital literacy and accessibility of reporting systems, while those with higher qualifications may contribute to understanding organisational and managerial perspectives. Therefore, the range of qualifications enhances the depth and representativeness of the findings by ensuring that both technical and experiential viewpoints are considered in analysing construction safety incident reporting.

Table 4.1: Highest levels of education completed by C1 interviewees

Highest qualification	Frequency	Percentage (%)
Postgraduate diploma	1	10.0
Bachelor's degree	2	20.0

Diploma	3	30.0
Tertiary certificate	2	20.0
Matric certificate	2	20.0
TOTAL	10	100.0

Primary fields of education

Table 4.2 shows the primary fields of education completed by the interviewees. Ten interviewees were interviewed; the findings revealed that five of the interviewees, the majority, completed their qualifications in OHS. Only one interviewee completed the qualification in Environmental Management, two out of 10 interviewees completed qualifications in engineering fields, whereas the remaining two interviewees completed only basic education.

This distribution of qualifications indicates that the study captured perspectives from participants with varying levels of formal education, ranging from basic schooling to postgraduate level. This diversity is important for the study as it reflects the different levels of understanding, awareness, and engagement with construction safety reporting practices across the workforce. In particular, participants with lower qualifications may provide insights into practical challenges, such as digital literacy and accessibility of reporting systems, while those with higher qualifications may contribute to understanding organisational and managerial perspectives. Therefore, the range of qualifications enhances the depth and representativeness of the findings by ensuring that both technical and experiential viewpoints are considered in analysing construction safety incident reporting.

Table 4.2: Primary fields of education completed by C1 interviewees

Primary fields of education	Frequency	Percentage (%)
Occupational H&S	5	50.0
Engineering	2	20.0
Basic education	2	20.0
Environmental management	1	10.0
TOTAL	10	100.0

Current occupations

Table 4.3 indicates the current occupation of the 10 interviewees. The interviewees interviewed were employed as a construction inspector and safety co-ordinator, site general foreman, junior H&S officer, plumber, site manager H&S officer, H&S environment officer,

junior wet-works foreman, electrician, and bricklayer. It is notable that four interviewees are directly involved in H&S aspects on-site.

This distribution of occupations demonstrates that the study incorporated perspectives from a wide range of roles within the construction environment, including both managerial and operational personnel. The inclusion of participants directly involved in H&S functions ensures that the data captures informed insights on safety policies, reporting procedures, and compliance requirements. At the same time, the participation of skilled and trade workers provides practical perspectives on how safety reporting is experienced and implemented on-site. This diversity strengthens the study by enabling a holistic understanding of construction safety incident reporting across different levels of responsibility and practice.

Table 4.3: Current occupations of C1 interviewees

Occupation	Frequency	Percentage (%)
Construction inspector and safety co-ordinator	1	10.0
Site general foreman	1	10.0
Junior H&S officer	1	10.0
Plumber	1	10.0
Site manager	1	10.0
H&S officer	1	10.0
Health, safety and environment officer	1	10.0
Junior wet-works supervisor	1	10.0
Electrical worker	1	10.0
Bricklayer	1	10.0
TOTAL	10	100.0

4.2.1.2 Reporting of safety incident

This section outlines the interviewees' responses about safety reporting. The findings show their understanding of safety reporting, the process they follow, the procedures followed during safety incident reports, the perceived benefits, and the challenges faced on-site when reporting safety incidents.

Understanding of safety reporting by C1 interviewees

Interviewees I1, I3, I4, I6, I8, and I9 understand that reporting safety incidents or sites helps create a safe working environment. I1 mentioned that "it makes a difference to recognize work-related wellbeing and security risks and dangers." Similarly, interviewee I3 said that "reporting safety incidents on-site is important as it ensures the safety of workers." Likewise, interviewee I4 stated that reporting safety incidents "ensures a safe working environment for

everyone on-site.” Additionally, interviewees I6, I8, and I9 emphasized that reporting safety incidents helps ensure workers' safety on-site.

These responses indicate a general awareness among participants that safety reporting is directly linked to maintaining a safe working environment. This suggests that workers recognise the immediate benefits of reporting, particularly in preventing harm and improving site conditions. However, this understanding appears to be primarily focused on safety outcomes rather than the broader role of reporting in organisational learning and system improvement.

In contrast, interviewees I1, I3 and I6 understand that safety reporting is essential in preventing future occurrences of safety incidents. Interviewee I1 stated safety reporting could ensure that “appropriate controls can be put in to anticipate and discourage events of such occasions”. In addition, I3 added that reporting safety incidents helps to find ways to improve their safety on-site. Further, sharing the same sentiments, interviewee I6 expressed that the view that “findings to be shared with all employees and remedial measures must also be in place to avoid re-occurrence of such”.

This perspective reflects a deeper level of understanding, where safety reporting is viewed not only as a reactive measure but also as a proactive tool for continuous improvement. It highlights the role of reporting in identifying root causes, informing corrective actions, and supporting knowledge sharing across the organisation.

However, according to interviewees I2, I3, I4, I6, I7, and I8, timely and appropriate reporting of safety incidents is significant. Interviewee I2 commented, “It is important to report safety incidents on-site for the H&S officer to come to the rescue” while interviewee I3 highlighted that “Section 24 of the Occupational H&S Act states that all incidents that have occurred on-site must be reported immediately or before the shift ends”.

This emphasis on timeliness indicates an awareness of both operational and regulatory requirements associated with safety reporting. It also suggests that reporting is often driven by compliance and immediate response needs rather than being fully integrated into a proactive safety management system. This finding highlights a potential gap between compliance-driven reporting and the broader objective of leveraging reporting

Process of reporting on-site safety incidents by C1 interviewees

According to interviewees I1, I3, I4, I5, I6, and I7, reporting safety incidents involves completing the necessary documentation, including filling out forms and writing reports with all details of the incidents. These include the type of occurrence, date and time, injuries to

personnel, visitors, or passersby, as well as damages to property, equipment, and tools. Additionally, interviewees I10, I1, I2, I3, I6, and I9, emphasized that incidents must be reported to the on-site H&S Officer to ensure appropriate actions are taken.

This indicates that the reporting process is largely formal, documentation-driven, and structured around established procedures, which supports compliance with safety regulations and ensures that incidents are properly recorded. For the research, this demonstrates that reporting systems are in place; however, the reliance on detailed manual documentation may introduce administrative burdens that can discourage timely and consistent reporting. Furthermore, the emphasis on reporting incidents to the H&S Officer highlights a centralised and hierarchical reporting structure. While this may ensure accountability and control, it also suggests that reporting is dependent on specific individuals, which may delay response times and limit worker participation. This is significant to the study as it points to potential inefficiencies and barriers within existing reporting systems.

Benefits of reporting safety incidents to a project by C1 interviewees

Interviewees I1, I2, I3, I4, I5, I6, and I7 agree that reporting safety incidents helps develop procedures and preventive measures to prevent similar incidents from happening again on construction-sites. According to I1, reporting safety incidents “helps to reduce other types of incidents that may occur again at the construction-site.” Additionally, it can help avoid cost overruns related to accidents and time loss caused by incidents. This indicates that participants view reporting as a mechanism for improving safety procedures and reducing both operational risks and financial losses, highlighting its role in enhancing project efficiency and cost control. This reflects a predominantly operational view of reporting, where its value is linked to immediate safety outcomes and cost reduction. However, the emphasis remains on short-term benefits rather than on the strategic use of reporting data to drive long-term safety performance and organisational learning.

Similarly, interviewee I2 commented that reporting of safety incidents “prevents similar incidents from happening again”. Likewise, I3 indicated that when incidents are reported, workers “become aware of potential hazards and thus can avoid any future incidents”. Similarly, I4 commented that reporting safety incidents helps identify hazards and provides safety measures to reduce the likelihood of accidents occurring again. Interviewee I5 added that reporting helps by “preventing the same mistakes that caused the incident in the first place”. This suggests that reporting contributes to learning and knowledge sharing among

workers, enabling hazard identification and behavioural change that supports safer work practices. The learning described here appears largely informal and experience-based, relying on individual awareness rather than structured systems for capturing and analysing incident data. This indicates a gap between reporting as a learning activity and its potential as a systematic tool for data-driven safety improvement.

Interviewee I6 stated that reporting ensures that “corrective and preventative actions are determined and assessed to ensure immediate compliance and the prevention of future non-compliance”. In addition, I7 indicated that “reporting safety incidents alerts the reporter of some safety hazards that were not noticed before and can be avoided in the future”. This highlights a strong compliance-oriented perspective, where reporting is primarily associated with meeting regulatory requirements. While this supports accountability, it may limit the broader use of reporting systems for proactive risk management and predictive safety practices.

However, interviewees I8, I9, and I10 noted that reporting safety incidents helps raise awareness of safety hazards to ensure workers are aware of the surrounding construction materials, processes, tools, machines, and associated risks. According to I8, reporting safety incidents improves safety awareness, which “...helps everyone to be alert at all times. ” Similarly, I10 stated that “it helps keep people safe on-site. ”

This demonstrates the behavioural impact of reporting in promoting vigilance and safety consciousness; however, its use appears limited to influencing immediate worker behaviour rather than informing broader organisational decision-making. This points to the need for more integrated approaches where reporting supports both behavioural safety and strategic safety management through enhanced use of digital technologies.

Enablers of safety incidents reporting on-site by C1 interviewees

Interviewees I1, I2, I3, I4 and I6 noted efficient communication and an easy communication system enable safe reporting of incidents on construction-sites. Interviewee I1 stated that safety reporting is made possible by “having a communication tool as systems in place for workers to report incidents and having an incidents documentation”. Similarly, I2 cited that safety reporting is enabled when workers can “communicate with other workers when the incident occurs”. This reflects a strong reliance on communication infrastructure as a primary enabler, suggesting that reporting effectiveness is closely tied to how easily information can be exchanged. However, the focus remains on basic communication functionality, indicating that more advanced, integrated digital systems may not yet be fully utilised to support structured and efficient reporting processes.

Interviewee I3 highlighted that construction-sites comprise different organisations with different in-house policies. Thus, having “effective communication makes it possible for employees to report site incidents” despite having different organisational backgrounds. Sharing the same sentiments, I4 and I6 emphasized the need for a clear and user-friendly communication system to ensure workers report incidents. This highlights the complexity of reporting in multi-stakeholder environments, where inconsistent policies and practices can hinder reporting. Effective communication systems therefore function as a unifying mechanism; however, the reliance on communication alone may not fully address deeper structural inconsistencies across organisations.

Moreover, Interviewees I3, I5, I6, I7, I8, I9 and I10 outlined that an environment that encourages safety reporting and compliance enables effective reporting of incidents. According to I3, “The most important thing is the inductions as they act as a guideline for the employees; it lets them know what to do in case of an incident”. In addition, interviewees I5, I8, I9, and I10 cited that having a competent H&S Officer present on-site creates an environment that values safety and, therefore, encourages workers to report incidents when they occur. Interviewee I6 added that the display of safety signs on-site has the same effect and further indicated that incentives and compliance recognition are other enablers of safety incident reporting. These findings emphasise that reporting is strongly influenced by socio-organisational conditions, particularly safety culture, leadership, and worker motivation. While communication systems enable reporting, sustained participation appears to depend on trust, guidance, and reinforcement through organisational practices. This suggests that technological solutions alone are insufficient without parallel improvements in safety culture and management commitment.

Challenges of reporting on-site safety incidents by C1 interviewees

According to Interviewees I1, I3, and I4, the challenges faced in safety reporting include a lack of awareness and disregard for the importance of reporting all on-site safety incidents. Interviewee I1 stated, “having a lack of awareness on reporting the incidents and having a frustration”. Similarly, I3 mentioned that “the challenge is that some employees do not report incidences because they think it is just a minor incident.” Interviewee I4 revealed that employees “just don't know how to report properly. ” This reflects a fundamental limitation in reporting practices, where the absence of adequate knowledge and training weakens the consistency and quality of reporting. It also suggests that reporting systems may not be

sufficiently user-friendly or supported by adequate guidance, which can discourage participation, particularly among less experienced or lower-skilled workers.

In contrast, I1 and I4 noted challenges encountered when reporting safety incidents, including a lack of trust in the reporting process and fear of victimisation. According to I1, workers lack trust in the reporting process and thus fail to report incidents. Interviewee I4 similarly indicated that workers are “scared of what might happen if they speak up.” This highlights deeper cultural and organisational issues, where reporting is perceived as risky rather than supportive. Such conditions can create a blame-oriented environment that suppresses transparency and limits the effectiveness of any reporting system, regardless of its design or technological sophistication. The language barrier has been identified as a challenge in reporting. I4 stated, “Some people might find it hard to report incidents because they are not fluent in the language.” This suggests that reporting systems may not adequately accommodate workforce diversity, which can exclude certain groups from fully participating in safety processes and reduce the completeness of reported data. In addition to the language barrier, deliberate underreporting has been observed. Interviewees I5, I6, and I7 explained that employees and contractors intentionally do not report, hide, or provide limited information to avoid being held accountable. Interviewee I5 revealed that the biggest challenge is “when victims lie to protect their fellow colleagues in case of negligence.” Similarly, I6 noted that “some employees or contractors hide information as they are trying to run away from being accountable for their actions.” Likewise, I7 pointed out that “people tend to lie, sometimes incident reports are not done immediately, so people tamper with the area making it difficult to conclude.” This demonstrates that underreporting is embedded in workplace behaviour and social dynamics, where accountability avoidance and peer protection influence reporting practices. Such behaviour significantly compromises the integrity of safety data, limiting the ability of organisations to identify risks, analyse trends, and implement effective interventions. It also suggests that technological solutions alone may be insufficient unless accompanied by cultural and organisational changes that promote trust, transparency, and accountability.

4.2.1.3 DTs

The findings in this section show the interviewees' comprehension of DTs, their practical applications, and the perceived benefits and challenges associated with their use.

Understanding of DTs by C1 interviewees

Interviewees I1, I2, I3, and I10 described DTs as electronic systems that improve communication efficiency and the efficiency of completing tasks. Interviewees I1 and I2 commented that DTs enable quicker information collection and passing. According to I3, DTs play a huge role and make working easier, allowing the electronic reporting of incidents to H&S consultants. This reflects a limited conceptualisation of DTs, where their role is confined to facilitating communication and task efficiency rather than enabling data-driven decision-making and integrated safety management. Such a narrow understanding may constrain the effective adoption of more advanced digital reporting systems that rely on analytics and system integration.

Contrarily, Interviewees I5, I6, and I7 stated that DTs enable the management of information or data using online platforms, including but not limited to storing, sharing, and seamless access. Interviewee I5 commented that DTs are “devices used to access some information from the Internet”. Interviewee I6 mentioned that “digital technology helps to share, store and manage information effectively”. Proportionately, I7 stated that DTs are a form of technology that enables the storage of information online rather than physically. This indicates a transition from a purely functional view of technology to a more information-centric perspective, where DTs are recognised as enablers of data storage and accessibility. However, the emphasis remains on basic data handling rather than advanced functionalities such as data integration, analysis, and predictive capabilities.

Interviewees I4 and I9 specified that DTs are intelligent and wearable, such as watches that can monitor human body behaviour, such as heartbeat rate. This awareness suggests that there is some level of readiness to engage with emerging technologies; however, such technologies appear to be conceptualised at a superficial level, with limited evidence of their practical integration into existing safety reporting processes. This highlights a gap between awareness and actual implementation of advanced digital solutions in construction safety management.

DTs used on-site by C1 interviewees

Interviewees I3, I4, I5, I6, and I7 indicated that internet-enabled devices such as computers and mobile devices are the DTs used. Interviewee I3 commented, "Digital technologies used on-site include laptops, cell phones, and telephones that we use to communicate and share updates or any documentation needed. " Similarly, I4, I5, and I6 stated that on-site DTs,

including cell phones, laptops, and tablets, are used for communication, and I6 also added that online platforms are used. However, I1 stated that BIM is used on-site for visualizing the project. This highlights a low level of digital maturity on-site, where readily available technologies are primarily used for communication rather than integrated safety management. The limited use of advanced tools such as BIM suggests that the potential of DTs to support structured, data-driven safety reporting and analysis remains underutilised.

Perceived benefits of using technologies in reporting safety incidents by C1 interviewees

Interviewees I1, I2, I5, and I9 stated that DTs reduce errors in reporting safety incidents. I1 commented that DTs "can improve time and help to minimise errors and help with better planning of the construction project. " Similarly, I2 said that DTs ensure the safe "handling and storage of important documents that might be misplaced or lost. " Additionally, I5 and I9 mentioned that using DTs enhances the quality of processes and work, and enables safe storage of information, reducing the risk of losing incident data and underreporting. This reflects a recognition of the operational advantages of DTs, particularly in improving accuracy and reducing information loss. However, the perceived benefits are largely confined to administrative improvements, with limited emphasis on the role of DTs in supporting advanced safety analytics and proactive risk management.

Additionally, I2, I3, I6, I7, and I9 noted that DTs ensure seamless data storage, making it easy for all project participants to access information. Interviewee I3 mentioned "using digital help when it comes to accessing information remotely. " Similarly, I6 and I7 stated that DTs enable workers, project stakeholders, and interviewees who need incident information to access it easily at any time, even when they are not present. Meanwhile, I4, I5, and I9 said that using DTs allows for timely reporting of incidents. While improved accessibility and timeliness support more responsive safety practices, the use of DTs appears to remain focused on information sharing rather than on integrating data across systems for comprehensive safety monitoring. This indicates that the current use of DTs may improve reporting speed but does not fully exploit their potential to transform safety management into a proactive and predictive process.

Challenges encountered when using DTs on-site by C1 interviewees

According to interviewees I1, I2, I3, and I4, technical issues such as malfunctions and connectivity problems are challenges faced when using DTs. Interviewee I1 mentioned that “challenges include connectivity issues such as poor internet on rainy days.” Likewise, I3 said that it “takes a while to process information if there is a poor connection.” Similarly, I4 pointed out that challenges include network issues and load shedding. This highlights the dependency of digital systems on stable infrastructure, where inconsistent connectivity and power supply disrupt the reliability and timeliness of digital reporting. Such conditions can discourage consistent use of DTs and reinforce reliance on traditional or manual reporting methods.

Other than technical issues, lack of training and adequate skills is also a challenge, as mentioned by interviewees I1, I5, I6, and I7. Interviewee I1 commented that using DTs demand semi-skilled and trained individuals. Interviewee I6 added that. “some employees not uploading information as required or expected” is another challenge. Interviewee I7, on the other hand, stated that technology keeps evolving, and other devices, such as computers, often have newer operating systems that they are not familiar with. This indicates that digital adoption is not only constrained by infrastructure but also by human capacity, where insufficient training and low digital literacy limit effective utilisation. The difficulty in adapting to evolving technologies further suggests that continuous training and support mechanisms are necessary to sustain the effective use of DTs in safety reporting.

DTs are used to report site safety incidents by C1 interviewees

Interviewee I1 noted that mobile applications such as WhatsApp installed on smartphones are used to communicate incident information. The interviewee also mentioned that H&S software on computers is used to report safety incidents. Similarly, interviewees I2, I3, I4, I7, I8, I9, and I10 stated that smartphones are mainly used to report on-site safety incidents. Additionally, I4, I5, I7, and I8 said that software applications on computers are used for reporting. However, Interviewee I7 pointed out that digital cameras are used when reporting safety incidents.

This indicates that reporting practices rely heavily on readily available and familiar technologies, particularly smartphones and messaging applications, which support quick and accessible communication. However, the use of such tools suggests a fragmented approach to reporting, where information is shared across multiple platforms rather than through a centralised and integrated reporting system.

The reliance on informal tools such as WhatsApp further suggests that reporting processes may lack standardisation, traceability, and structured data capture, which are essential for effective analysis and decision-making. While these technologies improve immediacy and convenience, they may limit the ability to generate consistent and reliable safety data across projects.

While the use of multiple devices and platforms, including cameras, smartphones, and computer-based software, reflects flexibility in reporting practices, also indicates a lack of integration between systems. This fragmentation may hinder the consolidation of incident data, reducing the potential for comprehensive safety monitoring, trend analysis, and the development of proactive safety strategies.

How DTs are used to report safety incidents on-sites, as reported by C1 interviewees

Interviewees I1, I5, and I8 stated that DTs help to capture accurate images and details of incidents. In contrast, I2, I3, I4, I5, I6, I7, I8, I9, and I10 indicated that the technologies are used to instantly share safety incident information and reports with all project interviewees.

This indicates that DTs are primarily used for documentation and real-time communication, improving the accuracy and speed of reporting. However, their use appears to be limited to capturing and sharing information rather than supporting structured data processing, integration, or analysis. This suggests that while DTs enhance the immediacy of reporting, their potential to support comprehensive safety management and data-driven decision-making remains underutilised.

4.2.2 Results from C2

The case study is a major refurbishment project undertaken for the renovation and upgrading of Thusanong existing office building in Bloemfontein. This case provided the context to explore safety reporting in refurbishment projects, where unique hazards and constraints arise from working within existing structures.

4.2.2.1 Demographic information

This section analyzes the demographic profiles of the interviewees from case 2 (2), focusing on key characteristics considered during the interviews. These include educational level, primary field of study, and current occupation.

Educational level

Table 4.4 shows the highest qualifications completed by the nine interviewees participating in the study. The findings show that the highest number of interviewees, namely three, obtained certificates from higher education institutions as their highest qualifications, while one interviewee completed an honours degree, which is the highest qualification among all interviewees. Additionally, two interviewees completed bachelor's degrees, and two others completed diplomas. Only one interviewee has matric as the highest qualification.

This distribution indicates a workforce with varied educational backgrounds, with a stronger representation of vocational and certificate-level qualifications. This suggests that safety reporting practices in this context are likely influenced by practical, experience-based knowledge, with potential limitations in formal training related to advanced or digital reporting systems.

Table 4.4: Highest qualifications completed by C2 interviewees

Highest qualification	Frequency	Percentage (%)
Honours degree	1	11.0
Bachelor's degree	2	22.0
Diploma	2	22.0
Tertiary certificate	3	33.0
Matric certificate	1	11.0
TOTAL	9	100.0

Primary fields of education

Table 4.5 indicates the primary fields of education completed by the interviewees. 9 interviewees were interviewed, and the findings show that the highest number of interviewees, namely three, completed their qualifications in Engineering. Eight interviewees each completed their qualifications in OHS, heavy equipment operation, quantity surveying, construction management, basic education, and construction project management, respectively.

This indicates a multidisciplinary workforce with diverse technical and non-technical backgrounds. The presence of engineering and OHS-related qualifications suggests some level of technical competency in safety practices; however, the diversity of fields may also result in varying levels of understanding and consistency in safety reporting practices across participants.

Table 4.5: Primary fields of education completed by C2 interviewees

Primary field of education	Frequency	Percentage (%)
OHS	1	11.0
Engineering	3	33.0
Heavy equipment operation	1	11.0
Quantity surveying	1	11.0
Construction management	1	11.0
Basic education	1	11.0
Construction project management	1	11.0
TOTAL	9	100.0

Current occupations

Table 4.6 presents the occupations of the nine interviewees who participated in the study. The interviewees held positions such as engineer, construction supervisor, H&S representative, equipment operator, assistant project manager, trades supervisor, site administrator, and electrician. The H&S representative is mainly responsible for the H&S of workers on-site.

This distribution reflects the inclusion of both managerial and operational roles, enabling insights from different levels of responsibility within the construction environment. The presence of H&S-focused roles alongside technical and operational positions suggests that the data captures both policy-level and practical perspectives on safety reporting, enhancing the depth and contextual relevance of the findings.

Table 4.6: Current occupations of C2 interviewees

Occupation	Frequency	Percentage (%)
Engineer	1	11.0
Construction supervisor	1	11.0
H&S representative	1	11.0
Equipment operator	2	22.0
Assistant project manager	1	11.0
Trades supervisor	1	11.0
Site administrator	1	11.0
Electrician	1	11.0
TOTAL	9	100.0

4.2.2.2 Reporting of safety incidents

This section outlines the interviewees' responses concerning safety reporting. The findings indicate the interviewees' understanding of safety reporting, the processes and procedures

involved in reporting safety incidents, the recognized benefits of such reporting, and the challenges faced on-site during the reporting of safety incidents.

Understanding of the reporting of safety incidents by C2 interviewees

Interviewees I11 and I16 indicated that reporting safety incidents is about raising awareness of hazards among site workers. Interviewee I11 commented that safety reporting “makes people aware of hazardous that might occur daily. Similarly, interviewee I16 mentioned that safety reporting “brings attention to incidents that have harmed, currently harming, or may harm workers on-site”. This reflects a behavioural and awareness-oriented understanding of safety reporting, where its primary role is to inform and alert workers rather than to support structured analysis or long-term safety improvement.

Interviewees I14, I15, I16, and I17 stated that reporting safety incidents is a measure to reduce future incidents. This indicates recognition of the preventive function of reporting; however, the emphasis remains on reactive prevention following incidents rather than on proactive or predictive safety management approaches.

However, interviewees I12, I13, I18, and I19 noted that reporting safety incidents involves following the proper channels to communicate the details of the incidents that occurred. Interviewee I18 mentioned that “as the H&S officer on-site, it's crucial to assess the situation thoroughly before taking further steps. Once I've analyzed the incident's scope, I start by following the required procedures for reporting safety incidents”. This highlights a procedural and compliance-driven perspective, where reporting is framed as a formal process governed by established protocols. While this supports accountability and standardisation, it may also introduce rigidity and delays, limiting the responsiveness and effectiveness of reporting systems in dynamic construction environments.

Process of reporting safety incidents on-site by C2 interviewees.

Interviewee I11 mentioned that reporting safety incidents entails “properly documenting injuries or illness that may occur while the project is being done”. Similarly, interviewees I12, I14, and I15 stated that the reporting process involves completing forms, and the method comprises recording details of the incidents, such as the type of occurrences, date, time, and extent of damages to properties and injuries sustained. This indicates that reporting is largely documentation-driven, with emphasis placed on recording incident details for formal

record-keeping and compliance purposes rather than on real-time response or data integration.

Interviewees I13, I16, I17, and I19 stated that the reporting process involves notifying the H&S officer about the incidents to ensure that designated and trained personnel respond accordingly. This reflects a hierarchical reporting structure where information flows through designated authority figures, reinforcing accountability but potentially introducing delays in communication and response. Such structures may limit the immediacy and efficiency required for effective incident management in dynamic construction environments.

Benefits of reporting safety incidents to a project by C2 interviewees

Interviewees I11, I14, I15, I16, and I18 stated that reporting on-site safety incidents helps prevent the recurrence of similar incidents in the future. Interviewee I11 noted that reporting safety incidents "minimise the accident or incidents from occurring again". Equally, I14 stated that reporting safety incidents "helps us be aware of similar incidents that might arise in the future, and we can prevent them". Likewise, I15 stated that reporting "ensures that the same incident does not occur again". This indicates that reporting is primarily perceived as a preventive mechanism, with emphasis on avoiding recurrence through awareness and corrective action. However, the focus remains on reactive prevention following incidents rather than on proactive or predictive safety strategies.

Interviewee I18 commented that reporting safety incidents on-site "prevents similar incidents from happening again. By having a system where workers can easily report what they observe, we can identify the root causes of incidents and implement measures to avoid them in the future". Interviewee I16 said that reporting "prevents the risk of the site being closed, therefore, delaying the project". Similarly, I11 and I19 added that reporting incidents on-site can help avoid delays and save costs associated with accidents such as claims. This reflects both safety and operational motivations for reporting, where incident reporting is linked not only to risk reduction but also to project continuity and cost control. The emphasis on root cause identification suggests awareness of deeper analytical potential, although it is not clear whether this is systematically implemented in practice.

According to I14, I15, I17, I18 and I19, reporting incidents also aids in the maintenance of a safe working environment. I18 commented that reporting safety incidents is a "proactive approach is essential for maintaining a safe working environment for everyone". This highlights the role of reporting in reinforcing safety culture and promoting a safer work

environment. However, the characterisation of reporting as “proactive” contrasts with earlier indications of reactive practices, suggesting a conceptual understanding of proactive safety that may not yet be fully reflected in actual reporting systems and processes.

Enablers of safety incidents reporting on-site by C2 interviewees

Interviewee I17 stated that well-organized and active communication enables reporting safety incidents on-site. This indicates that communication structures remain a fundamental enabler of reporting, facilitating the timely exchange of information; however, the effectiveness of reporting appears to depend largely on the clarity and accessibility of these communication channels.

However, according to I11, I13, I14, I15, and I18, an environment that encourages safety reporting and compliance promotes reporting of safety incidents. Interviewee I18 also added that training workers on H&S facilitates reporting and supports it. This highlights the importance of organisational culture and training in shaping reporting behaviour, where supportive environments and informed workers are more likely to participate in reporting processes. It also suggests that behavioural and cultural factors play a critical role alongside formal systems in enabling consistent reporting.

Interviewees I12, I14, and I19 noted that easy and efficient reporting systems enable reporting safety incidents on-site. This reflects the role of system design in influencing reporting practices, where user-friendly and efficient systems lower barriers to participation. However, the emphasis on simplicity suggests that current systems may not yet incorporate more advanced or integrated functionalities required for comprehensive digital safety reporting.

Challenges encountered by C2 interviewees when reporting safety incidents on-site

Interviewees I12, I16, and I17 indicated that the main challenge in reporting safety incidents is the lack of complete incident information. Interviewees I12 and I14 added that another issue is the inefficient filing system. This indicates that reporting challenges are not only related to participation but also to data quality and system inefficiencies, where incomplete information and poor record management undermine the reliability and usefulness of safety data.

However, I11 mentioned that the language barrier is a challenge. This highlights communication limitations within a diverse workforce, where language differences may restrict the clarity and accuracy of reported information, leading to inconsistencies in incident documentation. Interviewee I15 and I18 said that deliberate underreporting is also a challenge. This reflects deeper behavioural and organisational issues, where intentional withholding of information compromises transparency and limits the effectiveness of reporting systems. Such practices reinforce underreporting as a systemic challenge influenced by workplace dynamics and accountability concerns.

4.2.2.3. DTs

The findings in this section show the interviewees' comprehension of DTs, their practical applications, and the perceived benefits and challenges associated with their use.

Understanding of DTs by C2 interviewees

According to interviewees I17 and I18, DTs are systems and devices that improve communication efficiency. Interviewee I18 added that DTs are systems that will enhance the efficiency of performing tasks; similarly, I11 commented that “these technologies assist in speeding up the work, to meet project deadlines and to save costs”. Interviewee I12 also mentioned “tools and systems that help to lessen the work and make the overall work easier”. Likewise, I14 indicated that DTs are innovative online and internet tools that make our work more accessible and manageable. I16 stated, “these are modern uses of computerised systems meant to increase production”. Interviewees I13, I14, I16, I17, I18, and I19 indicated that DTs encompass computers and network systems.

This reflects a predominantly functional and productivity-oriented understanding of DTs, where their role is associated with improving efficiency, reducing workload, and supporting communication. However, this perspective places limited emphasis on the role of DTs in enabling integrated data management, analytics, and proactive safety decision-making.

DTs used on-site by C2 interviewees

Interviewee I1 highlighted that BIM is used on-site. However, interviewees I18 and I19 stated that internet-enabled devices are used on-site, while interviewees I14, I15, and I16 said that online systems are utilised on-site. Interviewees I11 and I12 indicated that digital measuring

tools are used on-site. This indicates that while a range of digital tools is present on-site, their use is largely fragmented and task-specific, with limited evidence of integration across systems. The isolated use of BIM alongside general communication tools and measuring devices suggests that digital technologies are not yet fully leveraged as part of a cohesive safety reporting or management system.

Perceived benefits of using technologies in reporting safety incidents by C2 interviewees.

According to interviewees I11, I12, and I14, using DTs minimises errors. Interviewee I11 commented, "of the most important benefits of the digital total station is that it provides more accurate measurements than other surveying instruments". Similarly, I12 stated that "it ensures that you work more precisely, and it lessens the risk of making mistakes". Equally, I14 mentioned that "safety files are audited accurately, ensuring that nothing left behind can cause an issue going forward". This indicates that DTs are strongly associated with improving accuracy and precision, particularly in technical and documentation processes. However, the focus remains on operational accuracy rather than on enhancing data-driven safety analysis or predictive risk management.

Interviewee I14 added that DTs ensure seamless data storage and easy access to information across all project interviewees. Likewise, I15 cited those DTs "ensure we can access all plans when we need them and do not have to wait for hard copies to be sent to the site." This reflects the role of DTs in improving information accessibility and reducing delays associated with manual processes, supporting more efficient workflow and coordination across project teams.

Additionally, I11 stated that "the benefit of the digital technology on-site is that it saves time and makes our work easier." Equally, I13, I16, and I18 stated that DTs improve work productivity. This highlights the productivity-driven perception of DTs, where their value is primarily linked to efficiency gains and reduced effort, reinforcing their role as tools for operational improvement rather than strategic safety management.

Interviewees I14, I15, I16, I17, and I18, DTs ensure efficient communication and on-site reporting. Interviewee I14 commented that DTs "prevent delays in my submissions that are supposed to be done", whereas I15 cited that using DTs "makes it a lot easier to communicate with the project team at any time to ensure we get answers as soon as possible". Interviewee I17 mentioned that "information is communicated thoroughly and

reaches everyone, and in Cof reporting incidents, it works as a faster method". This suggests that DTs enhance the speed and reach of communication, supporting more timely reporting of incidents. However, the emphasis on speed and communication indicates that DTs are primarily used to facilitate information exchange rather than to support integrated reporting systems or comprehensive safety data management.

Challenges encountered when using DTs on-site by C2 interviewees

Interviewees I11, I12, I14, I15, I16, I17, and I18 cited technical issues such as malfunctions, faults, and connectivity problems as challenges encountered when using DTs on-site. Interviewee I11 commented that "often issues we encounter on-site with the Digital laser measuring tape and a digital total station are technical problems; the devices sometimes encounter faults that affect their operation and cause delays " Similarly, I12 stated that "a lot of areas where new development happens, the signal is awful, and it isn't always possible to have Internet connection on-site." Interviewee I14 mentioned that "the issue would always be the network, as I had mentioned that everything is accessible online; when the network fails, work delays." Interviewee I18 also mentioned that "network on-site can sometimes be a problem for some service providers". This indicates that the effectiveness of DTs is highly dependent on reliable infrastructure, where connectivity and device performance directly influence their usability. Frequent technical disruptions can reduce trust in digital systems and hinder consistent application in safety reporting.

Interviewees I13, I16, and I18 indicated that a lack of skills and rigorous training requirements to enable workers to use DTs was another challenge encountered. Interviewee I13 commented that "technology is complicated for someone like me, so not understanding how it works will be frustrating." Similarly, I16 stated that "there are not enough skilled workers to use and operate DTs on-site."

This reflects a human-capacity constraint, where limited digital literacy and insufficient training reduce the effectiveness of DT adoption. It also suggests that technological implementation is not adequately supported by continuous skills development, which is necessary for sustained use.

Interviewees I17 and I19 indicated challenges such as a lack of power in remote areas and running out of mobile batteries. Interviewee I17 commented that "battery dies or becomes low, that time you may find there's no power." Equally, I18 noted that "sometimes batteries get flat." This highlights practical operational limitations associated with the use of DTs in

construction environments, particularly in remote or resource-constrained settings. Dependence on power supply introduces additional vulnerabilities that may disrupt reporting processes and limit the reliability of digital tools.

DTs are used to report site safety incidents C2 interviewees

Interviewees I12, I17, I18, and I19 stated that smart mobile phones are used to report safety incidents, while I17, I18, and I19 added that computers are also used for reporting. Similarly, I11, I15, and I16 mentioned the use of computer systems for reporting safety incidents. I14 uses an online platform called SharePoint. Additionally, I11, I12, I14, I15, and I16 reported using software applications to report incidents, while I13 mentioned that a digital camera is also used in incident reporting. This reflects the use of DTs for documentation and formal communication, where images and written reports are used to convey incident details. However, the reliance on email-based communication suggests a linear and potentially fragmented reporting process rather than a centralised and automated system.

How DTs are used to report site safety incidents, as reported by C2 interviewees

Interviewees I18 and I19 indicated that DTs capture virtual images and details of the incidents. Interviewee I18 commented that “depending on the severity and nature of the incident, we send out emails to the relevant parties, informing them about what happened and any necessary follow-up actions. This ensures timely communication and appropriate response to the incident”. This reflects the use of DTs for documentation and formal communication, where images and written reports are used to convey incident details. However, the reliance on email-based communication suggests a linear and potentially fragmented reporting process rather than a centralised and automated system.

However, I11, I12, I13, I14, I15, I16, I17, and I18 stated that the technologies are used to share incident information and report when incidents occur on-site instantly. This highlights the role of DTs in enabling real-time information sharing, improving the speed of reporting and response. Despite this, the use of DTs appears to be primarily focused on communication and information transfer, with limited evidence of integration into structured systems that support data aggregation, analysis, and proactive safety management.

4.2.3 Results from C3

The case study is a mixed-use integrated project in Vista Park, involving the construction of housing units alongside supporting infrastructure. This case offered insights into incident

reporting within a large-scale, multi-stakeholder environment characterised by diverse activities and subcontractor involvement.

4.2.3.1 Demographic information

This section provides an analysis of the demographic profiles of the interviewees in case 3 (C3) across the key characteristics considered during the interview. These include educational level, primary field of study, and current occupation.

Educational level

Table 4.7 presents the highest qualifications obtained by the interviewees. The findings indicate that five interviewees, making up the majority, held bachelor's degrees as their highest qualification, whereas only three, as a minority, had obtained diplomas. The bachelor's degree is the highest qualification obtained by interviewees. This indicates a relatively higher level of formal education among participants compared to other cases, suggesting a workforce with stronger theoretical and technical knowledge. This may influence the understanding and application of structured safety reporting practices, including the potential adoption of digital systems.

Table 4.7: Highest level of education completed by C3 interviewees

Highest qualification	Frequency	Percentage (%)
Bachelor's degree	5	63.0
Diploma	3	38.0
TOTAL	8	100.0

Primary fields of education

Table 4.8 shows the primary fields of education completed by the interviewees. 8 interviewees were interviewed, and the findings revealed that two interviewees completed their qualifications in OHS. Three other interviewees completed the qualification in engineering, while the remaining three of the eight interviewees completed their qualifications in construction management. This reflects a balanced distribution of technical and safety-related expertise, with representation from engineering, construction management, and OHS disciplines. Such diversity suggests the presence of both operational and safety-oriented perspectives, which may contribute to more structured and informed approaches to safety reporting.

Table 4.8: Primary field of education completed by C3 interviewees

Primary field of education	Frequency	Percentage (%)
OHS	2	25.0
Engineering	3	38.0
Construction management	3	38.0
TOTAL	8	100.0

Current occupations

Table 4.9 indicates the current occupations of the 8 interviewees. The interviewees interviewed worked as civil engineers, project specialists, OHS practitioners, HSOs, project managers, minor works, senior site agents, and site foreman. This distribution reflects a concentration of professional and supervisory roles, indicating that the data is largely informed by individuals with decision-making responsibilities and oversight functions. This may result in a more strategic and system-oriented perspective on safety reporting compared to cases with higher representation of operational workers.

Table 4.9: Current occupation of C3 interviewees

Occupation	Frequency	Percentage (%)
Civil engineer	1	13.0
Project specialist	1	13.0
OHS practitioner	1	13.0
H&S officer	2	25.0
Project manager minor works	1	13.0
Senior site agent	1	13.0
Site foreman	1	13.0
TOTAL	8	100.0

4.2.3.2 Reporting of safety incidents

This section presents the interviewees' responses regarding safety reporting. The findings reveal the interviewees' comprehension of safety reporting, the process followed, procedures adhered to during reporting safety incidents, the perceived benefits of such reporting, and the challenges encountered on-site when reporting safety incidents.

Understanding of reporting safety incidents by C3 interviewees

According to interviewees I20, I21, I23, I25, and I26, reporting safety incidents refers to documenting and communicating incident information. Interviewee I21 stated that safety reporting "involves documenting and communicating any accidents, near-misses, or hazardous situations during construction". Similarly, I25 indicated that it involves documenting and informing of any cases of harm or injury that occurred to workers on-site".

Equally, I26 indicated that reporting safety incidents is the “process of documenting and communicating any accidents, near-misses, or unsafe conditions observed on the construction-site”. This reflects a clear and structured understanding of reporting as a formal process involving both documentation and communication. Compared to other cases, this suggests a more system-oriented perspective, where reporting is recognised as a defined and organised activity rather than an informal practice.

However, interviewees I22), I24, and I27 stated that reporting safety incidents is a measure that helps address safety issues on-site. Interviewee I21 added that reporting safety incidents “is a crucial aspect of maintaining a safe working environment on construction-sites.” According to I22, “reporting incidents assists organizations in developing measures to prevent possible injuries or loss of life for others.” Similarly, I23 further stated that reporting is intended “to address any safety issue that occurred on-site properly.” Interviewee I24 commented that reporting safety incidents “allows us to better prepare and prevent such occurrences in the future.” Likewise, I26 additionally noted that “by diligently reporting these occurrences, we contribute to maintaining a safe working environment for everyone involved in the construction project.” This indicates a broader and more integrated understanding of reporting, where it is linked not only to documentation but also to prevention, safety improvement, and organisational learning. The emphasis on preparation and prevention suggests a shift towards a more proactive perspective, although it remains unclear whether such understanding is fully supported by corresponding systems and practices.

Process of reporting safety incidents on-site by C3 interviewees

Interviewees I21, I22, I25, I26, and I27 noted that reporting safety incidents involves completing necessary documentation. In addition, I26 and I27 further indicated that reporting safety incidents encompasses recording incident details such as the type of occurrence, date, time, injuries sustained, fatalities, and damages. This indicates a structured and comprehensive documentation process, where detailed incident recording supports accountability and facilitates thorough incident investigation. Compared to other cases, this reflects a more formalised and systematic approach to capturing safety data.

In addition, interviewees I20, I21, I22, I24, I25, and I26 highlighted that the process involves informing the personnel in charge of H&S on-site when incidents occur. According to I20 and I21, information about safety incidents is reported to the site safety manager, relevant authorities, and superiors above the interviewee’s rank through established reporting channels. Interviewee I24 commented that.

“When reporting the incident, we identify people involved or affected. We then record their names and occupations, identify all the witnesses, and take their statements. We then note the time and location of the incident and details on how the incident occurred”.

This reflects a multi-layered and procedural reporting system that incorporates both documentation and verification through witness accounts and detailed incident reconstruction. While this enhances the reliability and completeness of data, it also suggests a formal and potentially time-intensive process that may affect reporting speed in urgent situations.

Interviewee I25 added that in the event of an incident, “the health and safety manager of the contractor on-site will inform the principal occupational H&S officer.” Similarly, I26 noted that “the process involves immediately notifying the H&S officer.” This highlights a clearly defined hierarchical reporting structure, ensuring that incidents are escalated through appropriate authority levels. Such structure strengthens compliance and oversight but may also introduce dependency on designated personnel, which can influence the efficiency and responsiveness of reporting processes.

Benefits of reporting safety incidents to a project by C3 interviewees

Interviewees I21, I22, I21, I22, I25, and I26 stated that reporting safety incidents helps prevent similar incidents' re-occurrence. This indicates that reporting is strongly perceived as a preventive mechanism, with emphasis on reducing recurrence through corrective action and improved awareness. This reflects a more structured understanding of reporting as part of continuous safety improvement.

In addition, I21 and I22 mentioned that reporting promotes compliance with H&S policies and helps avoid time loss and costs associated with accidents and investigations. This highlights both regulatory and operational benefits of reporting, where adherence to safety standards is linked to improved project performance through reduced delays and financial losses. This suggests that reporting is recognised not only as a safety requirement but also as a project management tool.

Interviewee I21 further highlighted that reporting safety incidents helps "foster a culture of safety awareness among workers. " Similarly, I20, I22, and I27 cited that reporting safety incidents raises awareness of safety hazards to maintain workers' safety and safety on-site. This reflects the role of reporting in shaping safety culture and reinforcing behavioural

awareness among workers. The emphasis on safety culture suggests a more integrated view of reporting, where it contributes to both organisational practices and individual behaviour, supporting a safer and more proactive work environment.

Enablers of safety incidents reporting on-site by C3 interviewees

According to interviewee I17, efficient and effective communication enables the reporting of safety incidents. This indicates that clear communication channels remain a foundational enabler of reporting, supporting the timely exchange of information and coordination among project stakeholders. I20, I21, I22, and I24 cited an environment that encourages safety reporting and compliance, which allows reporting. Interviewee I21 commented that incident reporting is enabled when “fostering a culture of transparency and accountability”. Similarly, I22 mentioned that reporting safety incidents is promoted when “having agents responsible for auditing and playing oversight roles to monitor compliance”. Interviewees I20 and I21 noted that a supportive safety culture enables effective reporting of safety incidents.

This reflects a strong organisational and cultural dimension, where transparency, accountability, and oversight mechanisms actively promote reporting behaviour. The presence of auditing roles and compliance monitoring suggests a more structured and enforced reporting environment compared to other cases.

Interviewee I21 also mentioned that H&S training amongst workers could aid safety reporting. This highlights the importance of knowledge and competence in enabling reporting, indicating that trained workers are more likely to understand procedures and participate effectively in reporting processes.

On the other hand, I20, I21, I23, I25, and I26 stated that the availability of reporting resources and accessible safety files permits the reporting of safety incidents. This suggests that access to tools, documentation, and resources is a key structural enabler, ensuring that workers are equipped to report incidents without procedural or logistical barriers.

However, I20, I21, I22, I24, I26, and I27 indicated that an easy and user-friendly reporting system allows for efficient reporting of safety incidents. This indicates that system design plays a critical role in facilitating reporting, where simplified and accessible systems reduce effort and encourage participation. Compared to other cases, this reflects a more integrated view of how systems, culture, and resources collectively enable effective reporting.

Challenges encountered by C3 interviewees when reporting safety incidents on-site

According to interviewees I20, I21, I22, I23, I24, and I26, workers often fail to report incidents due to fear of appraisal, while others do not see a necessity to report minor incidents. Additionally, other workers do not report because of non-compliance associated with professional registration status. Interviewee I20 commented, "People are afraid to report as they think they will be victimised and fired". Similarly, I22 mentioned "the total disregard of such incidents described as minor, when essentially it could be a detriment in the future". Interviewee I24 stated that incidents are not reported owing to "fear of reprisal and lack of educated staff members". Interviewee I27 also indicated that.

"It is difficult to report a safety incident as a site manager if I, the site manager, also didn't ensure a safe working environment for the workers before any work commenced. It is also difficult if workers do not report incidents they may encounter while working".

This indicates that underreporting is strongly influenced by behavioural and organisational factors, including fear of victimisation, perceived severity of incidents, and accountability concerns among management. The reluctance to report minor incidents and the fear of blame suggest a reactive safety culture where reporting is associated with negative consequences rather than learning and improvement.

However, I21 mentioned "dealing with language barriers or literacy issues among the workforce" as another significant challenge. This highlights communication and educational constraints that limit effective participation in reporting processes, particularly in diverse and multi-skilled construction environments. Such barriers contribute to inconsistencies in reporting and reduce the completeness and accuracy of safety data.

4.3.3.3 DTs

Understanding of DTs

Interviewees I20, I21, I24, I26, and I27 explained DTs as systems and electronic devices that store, transmit, and process information. Interviewee I20 commented that DTs are "electronic systems that store, process, and transmit data." Similarly, I21 mentioned that DTs are "electronic tools, systems, and devices utilised on-sites for data processing and communication." This reflects a technical and system-oriented understanding of DTs, where their role is associated with data handling and communication functions. Compared to other cases, this suggests a more informed perception of DTs as part of structured information

systems rather than solely as operational tools. However, interviewees I22, I23, I25, I26, and I27 identified DTs as systems and devices that improve the efficiency of performing tasks. Interviewee I26 added that DTs are computer devices and networks. The interviewee indicated DTs are “tools or systems that utilise electronic or computer-based platforms to streamline processes.” This highlights a complementary efficiency-driven perspective, where DTs are viewed as tools for improving productivity and simplifying processes. The combination of technical and functional understandings suggests a relatively higher level of digital awareness, although the emphasis still leans towards operational efficiency rather than advanced integration or analytical capabilities.

The DTs used on-site by C3 interviewees

Interviewees I21, I24, I26, and I27 stated that BIM is used. Interviewee I27 added that internet-enabled devices and systems are used on-site. However, according to I25, I26, and I27, computers and mobile applications are utilised, while I26 also stated the use of GPS systems. This indicates a broader and more advanced range of digital technologies compared to other cases, including the use of BIM and GPS systems alongside conventional tools such as computers and mobile applications. The presence of these technologies suggests a higher level of digital adoption; however, their use still appears function-specific rather than fully integrated into a unified safety reporting system.

Perceived benefits of using technologies in reporting safety incidents by C3 interviewees

Interviewees I23, I25, I26, and I27 indicated that using DTs minimises errors and thus improves quality. Interviewee I27 commented that DTs “impose quality of inspections and accuracy”. This indicates that DTs are associated with enhancing accuracy and quality assurance, particularly in inspection and reporting processes. Compared to other cases, this reflects a more developed appreciation of DTs in improving the reliability of safety data.

Interviewee I24 mentioned that DTs “have enabled us to access information rapidly.” Similarly, Interviewee I11 shares the same sentiment that DTs provide a platform for seamless data storage and easy access to information. The interviewee mentioned that DTs “create a database that is easily accessible and makes it easy to store information with all personnel and the lessons that can be learnt.” This reflects a stronger emphasis on data centralisation and knowledge retention, where DTs support not only access to information but also the accumulation of organisational learning. This suggests a more advanced use of DTs in supporting continuous improvement in safety management.

However, interviewees I21, I25, and I26 cited that these technologies improve work productivity. According to I26, the benefits include “task automation and reduced paperwork”. Interviewee I26 stated that these technologies enable “real-time communication and collaboration”. Similarly, I22 and I24 further mentioned that DTs can ensure efficient on-site communication and reporting. I22 commented that when using DTs, “the communication is almost intentional, and you can store documents online, easier to retrieve when you want to go back”. This highlights the integration of efficiency, automation, and real-time communication, indicating that DTs support both operational performance and coordination among project stakeholders. The combination of productivity gains and improved communication suggests a more integrated use of DTs, although their full potential for predictive and analytical safety management may still be underutilised.

Challenges encountered when using DTs on-site by C3 interviewees

Interviewees I20, I21, I20, I21, I22, and I26 mentioned technical issues such as malfunctions, faults, and connectivity problems as challenges encountered when using DTs on-site. Interviewee I20 commented, “When the network is down, using the app becomes difficult”. Interviewee I21 also noted that “some sites have poor connectivity, which makes it impossible to utilize these appropriately. Additionally, I26 stated that “challenges may include technical issues. This indicates that the effectiveness of DTs remains highly dependent on stable infrastructure, where connectivity and system reliability directly influence usability. Despite higher levels of digital adoption in this case, infrastructural limitations continue to constrain consistent application.

In addition, interviewees I22 and I26 stated that data privacy and security concerns were another challenge when using DTs. This reflects a more advanced awareness of digital risks compared to other cases, indicating that as DT adoption increases, concerns extend beyond functionality to include data protection and system security. However, extensive training requirements and a lack of skills to implement and operate DTs effectively are noted as a challenge by I21, I25, I26, and I27. According to I21, “there is a lack of adequate training in implementing this resource successfully”. I25 also mentioned that “most workers cannot use the technologies”. Further, I27 noted that it can be difficult for some workers to use DTs, mainly if they are not used to them. This highlights persistent human-capacity constraints, where insufficient training and digital literacy limit the effective utilisation of DTs, suggesting that technological advancement is not matched by adequate skills development.

Interviewee I24 stated that “low batteries with no electricity or energy backup” is another challenge when using DTs. This underscores operational limitations related to power

dependency, particularly in construction environments where access to reliable energy sources may be inconsistent, thereby affecting the continuity of digital reporting processes.

DTs used to report site safety incidents by C3 interviewees.

Interviewees I25, I26, and I27 indicated that smart mobile phones are used to report site safety incidents. I20, I21, I22, I24, I26, and I27 mentioned that computers with software applications are used for reporting. I23 highlighted that digital cameras are used to report safety incidents on-site. This indicates that a combination of mobile and computer-based technologies is used for reporting, enabling both on-site data capture and formal documentation. The inclusion of digital cameras further supports detailed evidence collection; however, the use of multiple standalone tools suggests that reporting processes may still be fragmented rather than fully integrated within a unified digital system.

How DTs are used to report safety incidents on-sites, as reported by C3 interviewees

Interviewees I20, I21, I22, I23, I24, and I26 indicated that DTs are used to record and store images and details of the incidents. This indicates that DTs support detailed documentation and evidence-based reporting, enhancing the accuracy and completeness of incident records compared to traditional methods. However, I22, I25, and I27 stated that DTs are used to communicate information and reports promptly. This reflects the role of DTs in enabling timely communication, facilitating faster reporting and response to incidents across project teams.

Interviewee I25 commented that “both site sensors detect motion and WTs report when workers are in restricted areas because sensors help with sensing motion in restricted areas, while the WTs help detect the location of workers”. This highlights the use of advanced technologies such as sensors and wearable technologies, indicating a shift towards real-time monitoring and proactive safety management. Despite this, such technologies appear to be used in isolation, suggesting that their potential for integration into comprehensive reporting and analytics systems remains underutilised.

4.3 CROSS-CASE ANALYSIS

4.3.1 Understanding of safety incident reporting

A shared understanding across all three cases is that reporting safety incidents is key to maintaining a safe work environment. Interviewees repeatedly stressed this point. For example, interviewee I3 from C1 said, “Reporting safety incidents on-site is important as it ensures the safety of workers,” a feeling that interviewee I18 from C2 also shared when they

noted that “reporting safety incidents prevents similar incidents from happening again.” The recurrence of this view across all three cases suggests literal replication, as participants from different project contexts consistently associated reporting with worker safety, hazard awareness, and incident prevention. This repeated pattern indicates that safety reporting is widely recognised as a necessary component of site safety management, regardless of project type. The consistency of this finding strengthens the argument that awareness of the purpose of reporting exists across construction settings, even where actual reporting practices remain uneven.

However, slight differences in emphasis exist. In C3, interviewees focused more on the procedural nature and formal documentation of incidents. Interviewee I21 noted that it “involves documenting and communicating any accidents, near-misses, or hazardous situations,” emphasizing a structured procedural approach compared to the more preventive focus in C2. This difference appears to reflect variation in organisational maturity and role composition across the cases. C3 had a stronger concentration of professionally qualified and supervisory participants, which likely contributed to a more formal and system-oriented understanding of reporting. By contrast, C2 placed greater emphasis on hazard awareness and future prevention, suggesting a more practice-based interpretation of reporting. C1, on the other hand, reflected a more basic understanding centred on worker safety and immediate site protection. These differences indicate theoretical replication, where the same phenomenon, that is understanding of reporting, appears across cases, but with different emphases shaped by contextual conditions such as education levels, management structures, and reporting culture.

4.3.2 Processes followed during reporting

All three cases demonstrated a consistent procedural framework that involves documenting the incident details and informing relevant H&S personnel. Interviewee I24 from C3 reported, “We identify people involved or affected... record their names... take statements... and details on how the incident occurred,” showcasing a meticulous approach mirrored across cases. This commonality reflects a shared institutional logic in construction safety reporting, where formal documentation and escalation to designated H&S personnel form the backbone of incident management. The recurrence of this pattern across cases suggests that reporting is not informal or arbitrary, but embedded within established procedural expectations. This supports analytical generalisation by indicating that construction sites, irrespective of project type, tend to rely on documentation and designated reporting channels as core reporting mechanisms.

Despite this similarity, the use of formalised channels appeared more emphasized in C3, where hierarchical reporting (i.e., reporting to the site manager and relevant authorities) was more commonly mentioned than in C1 and C2. This difference may be explained by the larger scale and multi-stakeholder nature of C3, where more complex project arrangements require stronger control, accountability, and reporting hierarchy. In C1 and C2, reporting processes were also structured, but they appeared less layered and less procedurally elaborate. This suggests that reporting formality increases with project complexity, subcontractor involvement, and the need for coordination across multiple actors. While stronger hierarchy may improve accountability and traceability, it may also slow down decision-making and reduce flexibility, especially when rapid response is needed.

4.3.3 Benefits of incident reporting

The benefits acknowledged across all cases included the prevention of similar future incidents, improved safety awareness, and the mitigation of project delays and costs. Interviewee I1 from C1 stated that incident reporting “helps to reduce other types of incidents that may occur again.” In contrast, I16 from C2 stressed that it “prevents the risk of the site being closed, therefore, delaying the project.” The repeated identification of prevention, awareness, and cost reduction across all three cases represents another clear instance of literal replication. Across the projects, reporting was consistently valued not only as a safety mechanism but also as a practical tool for maintaining productivity and avoiding disruptions. This suggests that participants do not view reporting solely as a compliance requirement, but also as a process with operational and economic value. Such convergence strengthens the claim that the benefits of reporting are broadly understood in construction practice, even when reporting implementation remains imperfect.

However, C3 also highlighted cultural change, as I21 noted that reporting helps to “foster a culture of safety awareness among workers.” This aspect of behavioural change was less prominent in the other cases. This difference is important because it shows that C3 linked reporting not only to immediate incident prevention but also to broader organisational culture. This suggests a deeper level of reporting maturity, where reporting is viewed as part of shaping behaviour and reinforcing collective safety values. In C1 and C2, the benefits were more strongly framed in terms of avoiding recurrence, delays, and losses. The stronger cultural emphasis in C3 may be attributed to a more formal management environment and greater professional oversight, which enabled reporting to be seen as part of long-term safety improvement rather than merely a response to incidents.

4.3.4 Enablers of reporting

Enabling factors were consistent across all three cases, with effective communication, the presence of safety officers, and user-friendly reporting systems being essential. Interviewee I3 from C1 noted, “Effective communication makes it possible for employees to report site incidents,” and I17 from C2 highlighted “well-organized and active communication.” Training and a safety culture were also emphasized in Cases 2 and 3, with I21 from C3 mentioning that reporting is supported by “fostering a culture of transparency and accountability,” pointing to a broader systemic and cultural aspect of enabling reporting.

The recurrence of communication, H&S leadership, and system usability across all three cases indicates that effective reporting depends on both structural and relational enablers. This repeated pattern suggests that reporting is facilitated when workers can communicate easily, know who to report to, and have access to systems that are simple to use. Replication across the cases strengthens the analytical conclusion that reporting effectiveness is not determined by technology alone, but by the interaction between communication systems, leadership presence, and organisational support.

At the same time, the more explicit emphasis on transparency, accountability, and safety culture in C3 suggests that enabling conditions become more sophisticated as organisational maturity increases. In C1, enablers were framed more practically in terms of communication systems and H&S presence. In C2, they expanded to include compliance and training. In C3, they incorporated oversight roles, accountability, and supportive culture. This progression indicates that enabling factors evolve from basic operational support to broader organisational conditions that sustain reporting behaviour over time.

4.4.4 Challenges in reporting

Challenges were generally similar, particularly language barriers, lack of training, underreporting owing to fear, and inadequate systems. Fear of victimization was especially strong in C3. Interviewee I20 lamented, “People are afraid to report as they think they will be victimized and fired.” This concern was also mentioned in C1 by I4, who said workers are “scared of what might happen if they speak up.” The repetition of fear, language barriers, and training deficits across the cases indicates that underreporting is not an isolated problem but a systemic challenge. This represents strong replication logic, as the same underlying barriers appeared in different project settings. These recurring barriers suggest that reporting problems are rooted as much in organisational culture and workforce conditions as in reporting systems themselves. In particular, fear of reprisal points to a blame-oriented environment in which workers perceive reporting as risky, thereby suppressing transparency and undermining the reliability of safety data.

A key challenge in C3 involved managers' professional accountability, as I27 stated, "It is difficult to report a safety incident... if I, the site manager, also didn't ensure a safe working environment." This difference is especially significant because it extends the challenge beyond worker reluctance to include managerial self-exposure and accountability. In C3, reporting appears to be constrained not only by worker fear but also by the implications of reporting for supervisors and managers whose responsibilities may be scrutinised. This adds a deeper organisational dimension to underreporting and suggests that reporting reluctance may increase in contexts where accountability is tied closely to professional standing and oversight. Such findings explain why improving reporting requires more than a technical solution; it also requires organisational conditions that reduce blame and support honest disclosure.

4.4.5 Understanding and use of DTs

A common understanding across cases is that DTs improve communication, information sharing, and storage. Interviewee I3 from C1 stated that digital tools "make working easier, allowing electronic reporting," while I18 from C2 described them as "systems that will enhance the efficiency of performing tasks." This commonality suggests that DTs are primarily understood in practical and functional terms across all cases. Participants generally associated DTs with communication, efficiency, and information management rather than with higher-order functions such as analytics, integration, or predictive safety management. The recurrence of this pattern indicates that digital awareness exists across the projects, but it is still largely framed around immediate operational usefulness.

BIM, mobile phones, computers, and software platforms were mentioned across all cases. However, C3 was notable for emphasizing WTs and GPS system features that were less common in C1 and C2. This difference indicates variation in digital maturity across the cases. C1 and C2 were dominated by basic digital tools used mainly for communication and documentation, while C3 demonstrated awareness and use of more advanced technologies such as wearables and GPS. This suggests that digital adoption is shaped by project complexity, available resources, and the strategic orientation of the site. The presence of more advanced DTs in C3 does not necessarily imply full digital integration, but it does indicate a stronger foundation for adopting more sophisticated digital reporting systems.

4.4.6 Benefits of DTs

Benefits such as reducing errors, storing data, timely reporting, and better communication were consistently observed. For example, Interviewee I11 from C2 stated, "It ensures that you work more precisely, and it lessens the risk of making mistakes." This repeated

emphasis on accuracy, storage, and speed suggests that the perceived benefits of DTs are largely administrative and operational. Across all cases, DTs were valued for improving record-keeping, reducing mistakes, and accelerating communication. This consistency indicates that participants recognise the immediate efficiencies of digital tools, which provides a practical basis for broader digital adoption.

C3 further emphasized operational efficiency, as I26 highlighted “task automation and reduced paperwork.” The real-time aspect of communication was also prominent in C3 but only somewhat discussed in other cases. This suggests that C3 had moved beyond viewing DTs merely as storage or communication tools and was beginning to recognise their role in streamlining workflows and reducing manual effort. The stronger emphasis on automation and real-time coordination points to a more advanced appreciation of digital functionality. However, across all cases, there was still limited reference to analytics, dashboards, or integrated safety intelligence, indicating that the full strategic potential of DTs remains underdeveloped.

4.4.7 Challenges with DTs

Across the cases, common challenges included technical faults, poor connectivity, lack of training, and low digital literacy. Interviewee I20 from C3 mentioned, “When the network is down, using the app becomes difficult,” and I7 from C1 highlighted that “technology keeps evolving... computers often have newer operating systems” which users may not understand. The recurrence of these challenges across all three cases indicates that digital adoption is constrained by both infrastructural and human-capacity limitations. This repeated pattern supports analytical generalisation that technical readiness alone is insufficient; stable connectivity, reliable devices, and digitally competent users are all necessary for effective digital reporting. These findings also show that the digital divide in construction is not only about access to devices, but also about the ability to use them effectively in demanding site conditions.

A unique issue noted in C3 was data security and privacy, indicating a more mature consideration of digital governance than in other cases. This difference suggests that as digital maturity increases, concerns shift from basic usability to governance issues such as data security, privacy, and system integrity. While C1 and C2 focused mainly on access, connectivity, and skills, C3 revealed awareness of more advanced digital risks. This indicates that the design of a digital roadmap must be staged: early phases should address infrastructure and training, while more advanced phases must consider governance, privacy, and system integration.

4.4.8 Application of DTs in reporting

All cases are reported using smart mobile phones, computers, and cameras. Interviewee C3 was clear about incorporating WT's and sensors. I25 noted, "Wearable technologies help detect the location of workers," suggesting more advanced technological integration. The cross-case evidence indicates partial but uneven digitalisation of reporting across the three sites. Basic reporting technologies such as mobile phones, computers, and cameras were common to all cases, showing that a digital foundation already exists. However, the continued reliance on multiple standalone tools also suggests fragmentation, with information shared across separate devices and platforms rather than through unified reporting systems.

C3 stands out as the most digitally mature case because it extends beyond communication and documentation to include real-time monitoring technologies such as wearables and sensors. This difference provides theoretical replication, where more advanced digital use emerges under conditions of greater organisational maturity and project complexity. At the same time, the persistence of fragmentation across all cases indicates that the central challenge is not merely introducing technology, but integrating it into coherent reporting and safety management processes.

4.4.9 Summary of commonalities and differences across cases

Table 4.10 shows a summary of the cross-case analysis, highlighting that the three cases exhibit both literal and theoretical replication. Literal replication is evident where similar patterns recur across all cases, such as the recognition that reporting promotes safety, the use of formal documentation, the importance of communication, and the presence of barriers such as fear, language, and inadequate digital skills. Theoretical replication is evident in the differences across cases, where C1 reflects a more basic and operational understanding, C2 demonstrates a moderate level of procedural and organisational awareness, and C3 shows relatively stronger formalisation, professionalisation, and digital maturity. Together, these patterns support analytical generalisation by showing that while the core challenges and enablers of safety reporting are consistent across sites, their expression and intensity are shaped by contextual factors such as project complexity, organisational structure, workforce composition, and digital capability.

Table 4.10: Summary of commonalities and differences across cases

Theme	Commons across cases	Differences across cases	Primary Data (Interviewee Reference)
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Understanding of Safety Reporting	Maintains a safe environment; helps identify hazards and prevent incidents	C3 emphasised formal documentation; C2 stressed hazard awareness	C1: I3, I1; C2: I16, I18; C3: I21, I26
Reporting Process	Involves documentation and notifying H&S personnel	C3 provided more detailed hierarchical processes	C1: I1, I4; C2: I12, I14; C3: I24, I25
Benefits of Reporting	Prevents recurrence, raises awareness, avoids project delays and costs	C3 highlighted cultural transformation	C1: I1, I3; C2: I15, I16; C3: I21, I22
Enablers of Reporting	Communication, trained HSOs, user-friendly systems	C3 added 'safety culture' and oversight agents	C1: I3, I6; C2: I18, I19; C3: I21, I24
Challenges in Reporting	Language barriers, fear of reporting, underreporting, inadequate systems	C3 included professional accountability and data literacy	C1: I4, I7; C2: I12, I15; C3: I20, I27
Understanding of DTs	Tools that support communication, efficiency, data storage	C3 had deeper emphasis on systems integration and wearable tech	C1: I1, I3; C2: I14, I16; C3: I21, I26
Benefits of DTs	Reduced error, timely access, streamlined reporting	C3 stressed automation, real-time comms, and data governance	C1: I5, I9; C2: I12, I14; C3: I26, I27
Challenges with DTs	Technical faults, low skills, connectivity	C3 added data privacy concerns	C1: I1, I6; C2: I13, I14; C3: I20, I26
Use of DTs in Reporting	Mobile phones, software, computers, and cameras	C3 uniquely used wearables and sensors	C1: I1, I7; C2: I17, I19; C3: I23, I25

Overall, the cross-case analysis shows that the three sites share a common recognition of the importance of safety incident reporting, but they differ in the maturity of their reporting culture, procedural formality, and digital capability. C1 reflects a more practical and immediate understanding of reporting, C2 demonstrates moderate procedural awareness, and C3 exhibits the strongest formalisation and digital sophistication. These variations do not weaken the findings; rather, they strengthen them by showing that the same underlying reporting challenges and opportunities persist across different project environments, while manifesting differently according to context. This provides a strong empirical basis for the proposed digital roadmap, which must therefore be flexible enough to address common sector-wide barriers while also accommodating differences in organisational readiness and digital maturity.

4.4 ROADMAP FOR DIGITAL REPORTING OF SAFETY INCIDENTS

The roadmap for digital reporting of safety incidents outlines structured, progressive steps aimed at enhancing the efficiency, accuracy, and reliability of safety incident management within the construction industry. Based on a cross-case analysis of three construction-sites in Mangaung, this roadmap combines both theoretical intent and practical experiences to guide a context-specific approach to digital transformation in safety reporting. As Figure 4.1 shows, the key aspects of the roadmap involve strategically creating awareness, engaging key stakeholders, promoting key enablers, and removing significant barriers.

While these components may appear sequential, the cross-case findings suggest that digital transformation in safety reporting is not strictly linear. Instead, these elements are interdependent and must be implemented iteratively, as weaknesses in one area, for example, lack of trust or poor infrastructure can undermine progress in others. The roadmap therefore challenges the assumption that the introduction of digital tools alone is sufficient to improve reporting, highlighting instead that organisational, behavioural, and technological factors must be addressed simultaneously.

4.1.1 Creating awareness

Creating awareness is fundamental to establishing a safety-first culture and increasing digital adoption across all levels of the workforce. The cross-case analysis confirms that effective communication and regular safety education are key enablers of reporting.

“Effective communication makes it possible for employees to report site incidents.”
(Interviewee I3, C1)

“Reporting fosters a culture of transparency and accountability.” (Interviewee 21, C3)

This phase should include multilingual communication materials and recurring digital literacy workshops to accommodate the industry’s diverse, multilingual workforce. The findings in C1 and C3 highlight how language and a lack of technological familiarity hinder reporting, reinforcing the importance of inclusive communication strategies.

However, the data also reveal that awareness alone does not necessarily translate into reporting behaviour. Across all cases, workers demonstrated an understanding of the importance of reporting, yet underreporting persisted due to fear, mistrust, and organisational pressures. This suggests that awareness campaigns, if implemented in isolation, may have limited impact. Therefore, awareness must be critically positioned not

as an end in itself, but as a supporting condition that must be reinforced by trust, accountability, and supportive reporting environments.

4.1.2 Engaging stakeholders

Stakeholder engagement is essential for jointly developing functional and relevant reporting systems. In all cases examined, the reporting process proved to be more effective when incorporated into the organization's formal structure.

“We identify people involved or affected... take statements... and document the details.” (Interviewee I24, C3)

C3 notably established a hierarchical reporting chain, ensuring accountability at both managerial and worker levels. Involving site managers, supervisors, IT personnel, and HSOs in the design and implementation of DTs allows the system to accurately reflect both operational and cultural realities on-site. Stakeholder engagement also promotes buy-in and ensures that reporting tools are aligned with user expectations and organisational workflows.

Nevertheless, the cross-case analysis suggests that increased formalisation and hierarchy may have unintended consequences. While structured reporting channels, as observed in C3, enhance accountability, they may also reinforce fear of blame and discourage open reporting, particularly where accountability is linked to performance evaluation or professional liability. This raises a critical tension between control and openness, indicating that stakeholder engagement must balance formal oversight with psychological safety to avoid reinforcing underreporting.

4.1.3 Promoting key enablers

To ensure successful digital reporting, key enablers like training, infrastructure, and incentives must be strategically promoted. The cross-case findings show that trained safety officers, easy-to-use platforms, and DTs (mobile phones, software, and cameras) directly enhance reporting results.

“Systems that enhance the efficiency of tasks make it easier to report incidents.”

Interviewee I18, C2: “Wearable technologies help detect the location of workers.”

(Interviewee I25, C3)

Investing in intuitive digital platforms, offering periodic hands-on training, and recognizing staff contributions can motivate reporting participation. Furthermore, fostering a culture that values transparency, as highlighted in C3, helps reinforce consistent use of digital reporting systems. However, the findings also suggest that the presence of enabling technologies

does not automatically result in effective use. Across all cases, digital tools were available, yet their application remained fragmented and largely limited to communication and documentation. This indicates that the challenge is not merely the provision of technology, but its integration into coherent workflows and decision-making processes. Without such integration, digital tools risk replicating existing inefficiencies in a digital format rather than transforming reporting practices.

4.1.4 Removing key barriers

The roadmap acknowledges that digital transformation will falter unless fundamental challenges are systematically tackled. The cross-case analysis uncovered ongoing issues such as underreporting caused by fear, insufficient training, and technological difficulties.

“People are afraid to report as they think they will be victimised and fired.”
(Interviewee I20, C3)

“Technology keeps evolving... users struggle with newer systems.” (Interviewee I7, C1)

To mitigate these issues, the roadmap proposes the following:

- Integrating digital safety reporting training into onboarding processes
- Promoting a no-blame culture to combat fear and underreporting
- Ensuring technical support for malfunctioning devices and software
- Providing offline options to counter connectivity issues
- Embedding data security protocols to address privacy concerns (especially highlighted in C3)

Such strategies are essential to create a resilient, inclusive, and sustainable digital safety environment across varied construction settings. The persistence of these barriers across all three cases indicates that they are deeply embedded within organisational practices rather than being isolated technical issues. In particular, fear-driven underreporting reflects a broader culture of blame and accountability, which cannot be resolved through technological interventions alone. Similarly, infrastructural and skill-related constraints highlight the uneven readiness for digital transformation within the construction sector. Therefore, removing barriers requires a systemic approach that addresses organisational culture, workforce capability, and technological infrastructure simultaneously, rather than treating them as separate challenges.

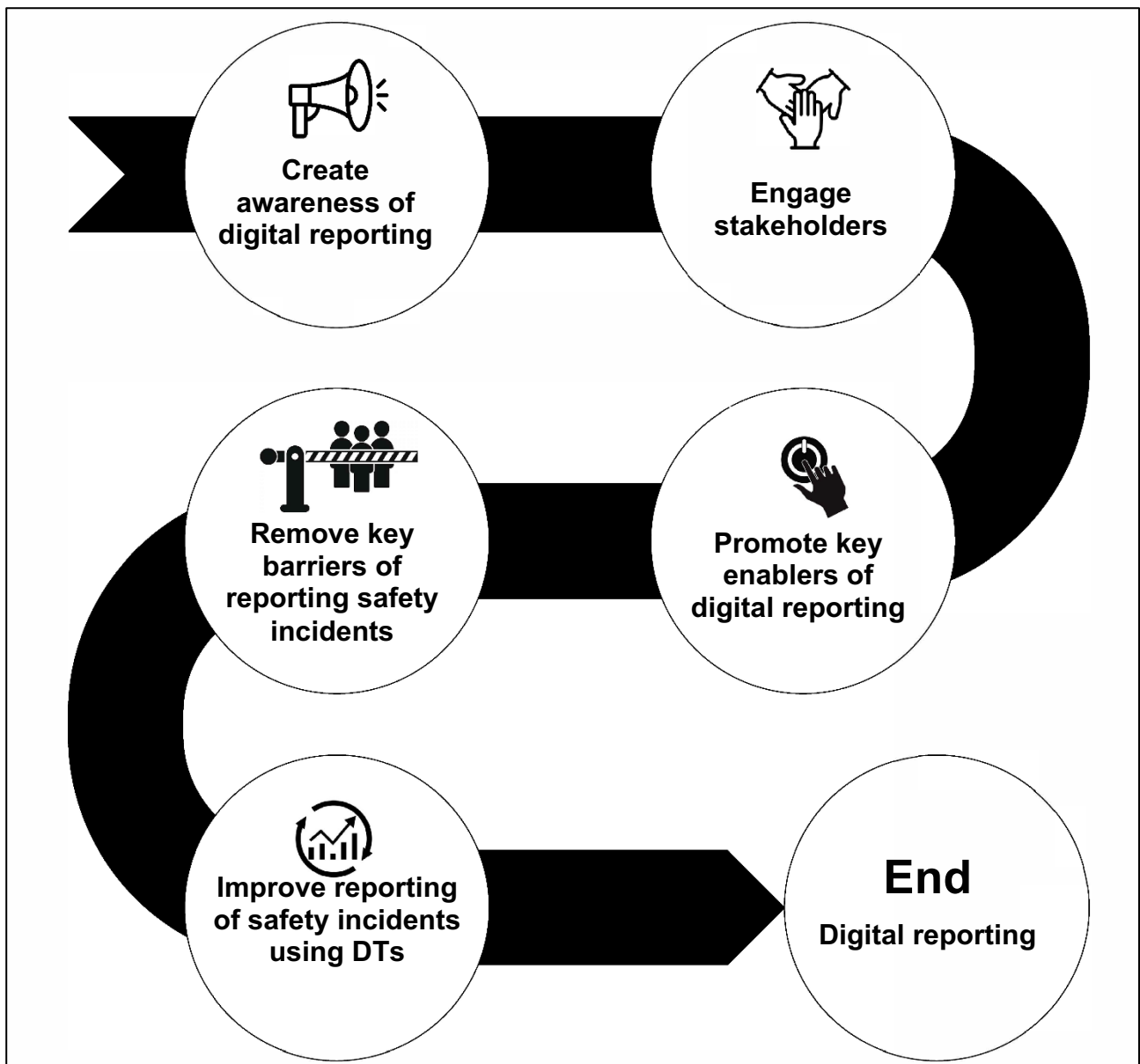


Figure 4.1: Roadmap for digital reporting of Safety Incidents

(Researcher's construct)

The proposed roadmap is not a one-size-fits-all model but a dynamic prototype grounded in real-world challenges and successes across three Mangaung construction-sites. By using stakeholder voices to inform each stage, especially those from C3, where advanced integration and cultural alignment were most evident, the roadmap advocates for a balanced blend of technological adoption and human-centred design. This positioning challenges the assumption that digital transformation can be achieved through standardised solutions, highlighting instead that effective implementation must be responsive to varying organisational contexts, levels of digital maturity, and workforce capabilities observed across the cases. As one site manager aptly put it:

“It is difficult to report a safety incident... if I, the site manager, also didn’t ensure a safe working environment.” (Interviewee I27, C3)

This insight reveals a critical tension between accountability and transparency, where reporting is not only a technical or procedural act but also a socially and organisationally embedded process. It underscores that leadership practices, power dynamics, and perceived consequences significantly influence reporting behaviour. As such, the effectiveness of the proposed roadmap depends not only on the introduction of digital tools but also on the extent to which organisational cultures support openness, reduce fear of reprisal, and promote shared responsibility for safety.

Furthermore, this finding highlights that digital competence alone is insufficient if not accompanied by systemic readiness, including supportive leadership, clear reporting structures, and aligned organisational values. The roadmap therefore rests on the assumption that sustainable improvement in safety reporting requires the simultaneous alignment of technological capability, human behaviour, and institutional structures, rather than isolated interventions.

4.5 CHAPTER SUMMARY

Chapter 4 presented the findings, analysis, and a cross-case analysis of three construction-sites in Mangaung, Free State, South Africa, focusing on safety incident reporting practices. The findings show a shared understanding of the importance of reporting for hazard prevention and improved safety, although C3 emphasised formal documentation and cultural transformation more than the others. This suggests that while awareness of reporting is consistent across cases, the depth of implementation and integration into organisational practice varies depending on contextual factors such as structure, leadership, and project complexity.

Common processes included documentation and notifying safety personnel, with C3 demonstrating a more hierarchical structure. This indicates a progression in reporting maturity, where more formalised structures may enhance accountability but also introduce additional procedural layers. Key enablers identified were communication, trained officers, and user-friendly systems, while challenges included language barriers, fear of victimisation, inadequate training, and low digital literacy. The persistence of these challenges across all cases highlights that barriers to effective reporting are systemic rather than site-specific, reflecting deeper organisational and behavioural constraints.

DTs were widely understood to improve efficiency and accuracy, though C3 adopted more advanced tools such as wearable tech and faced unique concerns such as data privacy. This demonstrates that increasing digital adoption introduces both opportunities and new complexities, particularly in relation to integration, governance, and user capability.

The findings highlight factors underscoring the need for a context-specific, inclusive, and sustainable approach that a digital roadmap should incorporate to improve incident reporting. Importantly, the evidence shows that technological solutions alone are insufficient without addressing human and organisational dimensions. These factors include creating awareness, engaging stakeholders, promoting enablers like training and technology, and addressing barriers such as fear and technical challenges. Chapter 5 discusses the findings of Chapter 4 in line with the research objectives.

CHAPTER 5: DISCUSSION OF FINDINGS

5.1 INTRODUCTION

This section discusses the findings of the study in relation to its research objectives, drawing on data collected from three construction-sites in Mangaung. The discussion is structured around the key objectives: identifying barriers and enablers of safety incident reporting, assessing the current status of digitalised reporting, exploring how digital technologies (DTs) can mitigate underreporting, and establishing a digital roadmap for improvement.

The analysis integrates both individual case results and cross-case comparisons to identify patterns, similarities, and key differences across the three case studies. In doing so, the chapter moves beyond descriptive reporting by interpreting the findings in relation to existing literature, while also highlighting areas of alignment and divergence. This approach enables a more critical understanding of how organisational culture, human behaviour, and technological factors interact to shape safety reporting practices.

Overall, the discussion provides a context-sensitive interpretation of the findings, demonstrating that safety incident reporting is influenced by the dynamic interaction of social, organisational, and technological conditions. These insights inform the development of practical recommendations and a digital roadmap aimed at improving reporting practices, promoting inclusivity, and supporting a more proactive and technology-enabled approach to construction safety management.

5.2 DISCUSSIONS

5.2.1 The barriers to effective construction safety incident reporting

Objective 1 aimed to identify the barriers to effective construction safety incident reporting. The discussion demonstrates that barriers are not limited to technical or procedural issues, as often emphasised in literature, but are strongly influenced by socio-organisational and cultural factors such as fear of victimisation, lack of trust, and communication challenges. The findings therefore extend existing studies by showing that underreporting in the South African construction context is more strongly shaped by behavioural and organisational dynamics than by system complexity alone.

5.2.1.1 Socio-organisational and systemic barriers to reporting

The findings revealed systemic, behavioural, and cultural barriers that align closely with those documented in prior research, reinforcing the broader relevance of the case study

results. Across all three cases, a lack of awareness and understanding emerged as a central barrier. In C1, knowledge gaps among workers were particularly prominent, with many employees demonstrating limited understanding of the reporting process and its importance. This reflects the contention by Mohammadia et al. (2018), who highlighted poor qualifications and inadequate training as major contributors to underreporting.

Addressing this barrier requires structured training and awareness programmes tailored to different categories of workers, ensuring that employees not only understand the reporting procedures but also appreciate their role in improving safety outcomes. Incorporating practical demonstrations and regular refresher sessions could further bridge these gaps. While this finding supports prior studies, the present study shows that lack of awareness should not be interpreted only as a training deficit. Across the cases, workers often understood that reporting was important for safety, yet many still lacked procedural clarity on how, when, and why to report certain types of incidents, particularly near misses and minor events. This suggests that awareness in this context is fragmented: workers may recognise the value of reporting in principle, but not fully understand its operational requirements. In this regard, the findings extend earlier research by showing that underreporting is sustained not only by absence of knowledge, but also by weak translation of knowledge into everyday reporting practice.

Fear of reprisals and blame was another dominant barrier across the cases, with C3 showing the strongest evidence of intentional underreporting due to concerns about victimisation and job security. This indicates the persistence of a blame culture within the construction environment, where workers perceive reporting as a risk rather than a protective measure. The findings mirror the work of Duryana et al. (2020) and Byrnes et al. (2022), who argue that punitive environments suppress open communication and obstruct learning from past incidents. However, the present findings also depart from a large portion of international literature that places stronger emphasis on technical and administrative shortcomings as the main barriers to reporting. In the three Mangaung cases, fear, mistrust, and organisational culture were more dominant than system complexity alone. This contradiction is significant because it suggests that in developing-country construction contexts, underreporting may be more strongly influenced by labour insecurity, hierarchical management relations, and blame-oriented accountability structures than by technology deficits. In this sense, the study challenges explanations that treat reporting barriers primarily as technical problems and shows that social risk may be more immediate than procedural inconvenience.

To counter this, organisations should adopt non-punitive reporting systems that prioritise learning over punishment. Establishing clear policies that protect workers from retaliation, combined with transparent communication from management, could foster a culture of trust where safety incidents are openly discussed and used as opportunities for improvement.

Language and literacy barriers also played a significant role, particularly in C2, where general workers often struggled to navigate reporting procedures. The prevalence of multilingual teams and limited proficiency in the dominant reporting language created communication breakdowns that inhibited reporting. These challenges support the observations of Liang and Zhangb (2019), who identified language-related barriers as a major inhibitor of safety compliance. A practical intervention would be to introduce multilingual reporting tools, such as translated forms, visual reporting aids, or digital platforms with voice-based input options. By making reporting accessible to workers with different language and literacy levels, organisations could significantly improve inclusivity and participation in the reporting process. This finding also expands the discussion by showing that language barriers are not simply communication problems, but participation barriers that shape who can report effectively and whose experiences are represented in safety records. In practice, workers with lower literacy or weaker language proficiency may become excluded from formal reporting processes, which means incident data can become skewed towards those with higher levels of education and confidence. This has implications for both data completeness and equity in safety management.

Finally, management-related shortcomings were evident across the cases, with C1 and C3 showing particular weaknesses in documentation and filing processes. Inadequate safety systems, incomplete incident information, and inefficient record-keeping undermined the effectiveness of reporting. These findings are consistent with those of Okorie and Musonda (2020) and Maliha et al. (2021), who link managerial neglect to systemic underreporting. Strengthening managerial practices should therefore be a priority. Introducing digital incident reporting platforms, supported by centralised databases, could reduce inefficiencies, ensure completeness of records, and enhance accountability. Furthermore, regular audits of reporting processes and feedback loops from management to workers would close the gap between incident documentation and actionable safety improvements. The findings further suggest that management-related barriers are not limited to poor administration, but reflect deeper organisational readiness issues. Where documentation systems are weak and feedback is absent, workers may see little value in reporting because reports do not visibly

translate into action. This indicates that managerial shortcomings can indirectly reinforce underreporting by weakening confidence in the usefulness of the reporting process itself.

Taken together, these findings underscore the multi-dimensional nature of barriers to safety incident reporting and point to the need for holistic interventions that address worker knowledge and skills, organisational culture, communication practices, and managerial systems. Without tackling these interrelated factors, safety reporting in the South African construction sector is likely to remain inadequate. Nevertheless, implementing comprehensive training programmes, non-punitive reporting mechanisms, multilingual support systems, and digital management tools could collectively strengthen incident reporting practices, enabling proactive risk management and more effective accident prevention.

Overall, the study demonstrates that reporting safety incidents in construction is not merely a procedural task but a complex interaction of organisational culture, human behaviour, and systemic inefficiencies. By integrating empirical findings with theoretical insights, the study makes a strong case for shifting from a blame-oriented culture to a learning-focused safety culture, reinforced by effective communication, visible management commitment, and inclusive training initiatives.

5.2.2 The enablers of effective construction safety incident reporting

Objective 2 focused on determining the enablers of effective safety incident reporting. The findings confirm the importance of communication, training, and accessible reporting systems, as highlighted in previous research. However, the discussion further shows that these enablers operate through both structural and behavioural mechanisms. For example, communication not only facilitates information flow but also reduces uncertainty and builds confidence among workers. This refines existing understanding by showing that enablers are most effective when organisational culture, systems, and human factors are aligned.

5.2.2.1 Organisational, procedural, and cultural enablers of reporting

Drawing on the findings from three case studies in Mangaung, supported by the literature review, the study confirmed several enablers that significantly influence reporting practices. These enablers operate both at management level and within day-to-day worksite dynamics, reflecting broader SMS considerations.

One of the most consistent themes across all cases was the critical role of communication. The findings showed that having structured communication systems in place for incident reporting, combined with effective peer-to-peer communication during and after incidents,

strongly supports timely reporting. This aligns with the argument by Maliha et al. (2021) that open and two-way communication forms a fundamental pillar of effective SMSs. When communication is clear and well-structured, workers are better equipped to report promptly, thereby reducing delays in corrective action. Yet the findings indicate that communication in these cases functioned not only as a channel for transmitting information, but also as a mechanism for reducing uncertainty about reporting expectations. This is important because it shows that communication enables reporting when it clarifies roles, procedures, and responsibility. In this sense, communication is not merely an operational support factor but a social condition that shapes workers' confidence to report.

Another important finding was the influence of a positive reporting environment. All three cases revealed that workers are more likely to report incidents when organizational culture promotes transparency, accountability, and trust. Induction processes were also highlighted as an enabler by providing clear guidance on reporting expectations. These observations echo those of Kim et al. (2019), who emphasized that a supportive organizational culture fosters accuracy and timeliness in reporting. The study therefore reinforces the contention that reporting behaviour is strongly shaped by cultural and organizational contexts. At the same time, the findings nuance this view by showing that transparency and accountability can operate in both enabling and constraining ways. In C3, stronger formal accountability structures supported reporting consistency, but they also coexisted with fear of reprisal. This suggests that accountability alone is not inherently enabling; it becomes enabling only when balanced with psychological safety. This point complicates previous literature that treats accountability as unambiguously positive.

The role of competence, particularly in relation to HSOs and safety-related training, also emerged as pivotal. Across cases, the presence of qualified HSOs contributed to a proactive safety culture where reporting was both encouraged and monitored. Moreover, continuous training was shown to empower workers, equipping them with the knowledge and confidence to engage in reporting. This supports the views of Chinda (2012), who argued that safety training is essential for enhancing compliance and strengthening worker participation in safety management systems. However, the findings also suggest that competence should not be limited to technical expertise. HSOs were effective not only because they understood safety procedures, but because they were visible, accessible, and able to reinforce trust in the reporting process. This extends earlier studies by showing that competence in safety reporting includes relational and communicative dimensions, not just formal qualification.

User-friendly and accessible reporting systems were another enabler repeatedly observed across the cases. Reporting practices improved when systems were simple, easy to navigate, and supported by clear documentation, such as safety files. This finding aligns with those of Xu and Luo (2014), who argued that simplicity in reporting tools helps remove barriers that often discourage reporting. It is therefore clear that technological and procedural accessibility plays a central role in incident reporting effectiveness. Nevertheless, the findings also suggest that what counts as “user-friendly” differs by worker profile and site conditions. A system that is simple for professionals may remain difficult for workers with lower literacy, weaker digital skills, or limited language proficiency. This means accessibility should be understood as context-dependent rather than universally designed.

Finally, the findings highlighted the complex role of incentives. While safety incentives can motivate compliance and participation, they also pose risks of underreporting if workers fear losing rewards. This dual effect aligns with findings by Mohammadi and Tavakolan (2020), who cautioned that incentives must be carefully designed and integrated into broader SMSs to prevent unintended consequences. This suggests that while incentives can be valuable, they should not replace a strong cultural and procedural foundation for reporting.

Overall, the enablers identified in this study, communication, a positive reporting environment, competent HSOs and training, accessible reporting systems, and carefully managed incentives, form a robust basis for improving safety reporting practices. Integrating these factors into construction-site management can enhance transparency, strengthen safety performance, and reduce risks. Importantly, these findings provide practical guidance for policymakers, contractors, and site managers in establishing proactive, transparent, and sustainable incident reporting cultures.

Collectively, these enablers show that effective reporting is enabled by the alignment of systems, culture, and people. Where one dimension is weak, the contribution of the others is reduced. This supports a socio-technical understanding of safety reporting, rather than a purely procedural one.

5.2.3 Organisational readiness for digital reporting adoption

Objective 3 sought to investigate organisational readiness for digital reporting adoption. The findings reveal a clear gap between the advanced digital technologies proposed in literature and their actual use in practice. While previous studies emphasise technologies such as BIM, IoT, and digital twins, the findings of this study show that construction-sites rely mainly on basic tools such as mobile phones and messaging platforms. This challenges assumptions of widespread digital maturity and suggests that readiness should be

understood as gradual, uneven, and context-dependent, particularly in developing construction environments.

5.2.3.1 Partial and uneven digital readiness

From the findings from the literature and empirical evidence from three case studies, the research confirms that significant progress has been made towards adopting digital DTs in construction safety incident reporting. However, the implementation is still partial and inconsistent, reflecting both advancements and persistent challenges.

From the literature, it is clear that a wide range of DTs are theoretically available to enhance construction safety incident reporting. These include BIM, 4D and 5D CAD, VR/AR, GIS, UAVs, MoCap systems, and IoT-integrated wearable devices (Agyekum et al., 2022; Chaaya et al., 2025; Wang et al., 2024). The potential of these tools lies in benefits such as real-time data collection, immersive safety training, dynamic hazard simulations, and improved communication (Rahman et al., 2024; Vishal et al., 2022). Together, these technologies represent the backbone of a comprehensive digital ecosystem capable of supporting proactive and real-time incident management.

In contrast, the case studies reveal that the actual application of DTs in practice is far more modest. Across all three cases, the most common tools employed in safety reporting were smart mobile phones, digital cameras, laptops, and computers equipped with basic communication and documentation software such as WhatsApp and SharePoint. Rather than advanced hazard detection or analytics, the digitalisation of reporting primarily centred on facilitating communication, document sharing, and record keeping.

This contradiction between theory and practice is one of the strongest contributions of the study. Much of the literature presents advanced DTs as central to digital safety transformation, yet the present findings show that everyday tools dominate actual practice. This suggests that organisational readiness in the South African construction sector is less about access to sophisticated technologies and more about the ability to embed even basic tools into consistent reporting workflows.

Despite the reliance on basic technologies, the cases demonstrated clear benefits. These included a reduction in reporting errors, faster access to information, improved document storage, and enhanced communication efficiency. Such findings affirm claims in the literature that digitalisation improves the reliability, accessibility, and timeliness of safety incident reporting (Newaz et al., 2024). At the same time, the benefits identified were mainly operational and administrative, not transformative. This differs from literature that often

frames DTs as catalysts for proactive safety intelligence. In the present study, DTs improved speed, storage, and communication, but were rarely used for predictive analytics, automated risk modelling, or integrated learning systems.

Nevertheless, several gaps and limitations became apparent. Firstly, there was little evidence of adoption of advanced DTs such as BIM, VR/AR, IoT-based systems, and digital twins, despite their well-documented potential for proactive safety management and detailed incident analysis (Rahman et al., 2024; Wang et al., 2024). Secondly, adoption across projects was uneven, with most cases equating digitalisation with the use of everyday tools rather than specialised safety management systems (SMSs). This illustrates a persistent disconnect between the theoretical possibilities outlined in the literature and actual usage in practice.

This unevenness also reveals that digital readiness varies by project context. C3 demonstrated a relatively higher level of digital maturity, but even there the technologies remained only partially integrated. This indicates that readiness is not binary; rather, it exists on a continuum shaped by project complexity, management commitment, technical support, and workforce capability.

The cases also revealed a range of technical and human resource challenges. Frequent connectivity disruptions, unstable power supply, and recurring device malfunctions hindered consistent use of digital systems, particularly in projects located in remote areas. Equally significant was the lack of digital competence among construction workers, which restricted the ability to exploit available technologies fully. This observation aligns with the view of Akinlolu et al. (2020), who stress the importance of digital skills in successful technology integration. Furthermore, issues of data security and limited battery reliability emerged as additional operational constraints, raising concerns about the sustainability and trustworthiness of digitalised reporting systems. These findings suggest that organisational readiness should be understood as socio-technical readiness rather than technological readiness alone. Even where tools are present, weak infrastructure, low skills, and poor support conditions limit meaningful digital adoption. This contradicts studies that assume infrastructure and skill barriers are secondary once technologies are introduced.

Overall, the findings confirm that while the adoption of DTs has brought tangible benefits to construction safety incident reporting, digitalisation remains at an early stage within the South African construction sector. The current landscape is marked by partial uptake, dependence on basic tools, and persistent infrastructural and human resource challenges.

A clear gap exists between the advanced technologies promoted in the literature and the limited, fragmented use of DTs observed in practice.

To close this gap, the findings underscore the need for a strategic roadmap that promotes the broader and deeper integration of advanced DTs into safety management. Such a roadmap should prioritise investment in infrastructure to ensure reliable connectivity and power supply, as well as capacity-building initiatives to enhance digital competence across the workforce. In addition, organisational strategies must align with Industry 4.0 and 5.0 paradigms to foster a culture of proactive, data-driven safety management. Only through such efforts can the construction industry in South Africa fully realise the benefits of digitalised safety incident reporting and move towards a more resilient and future-ready safety culture.

5.2.4 How DTs would mitigate underreporting of construction safety incidents

Objective 4 aimed to explore how digital technologies can mitigate underreporting. The findings confirm that DTs improve communication, documentation, and data accessibility. However, the discussion also shows that DTs are more effective in addressing procedural barriers than deeper cultural barriers such as fear and mistrust. This challenges deterministic views in literature that present technology as a complete solution and highlights the need to integrate DTs with supportive organisational practices.

5.2.4.1 DTs mitigate procedural barriers more readily than cultural barriers

The findings across the three cases confirm that DTs have substantial potential to reduce underreporting of construction safety incidents by enhancing communication, automating data capture, enabling confidential reporting, and streamlining documentation. These capabilities address both human and systemic barriers, aligning with literature that identifies cultural stigma, fear of punishment, procedural inefficiencies, and limitations of traditional reporting systems as primary causes of underreporting (Byrnes et al., 2022; Duryana et al., 2020).

In practice, DTs such as mobile applications, BIM, wearables, and IoT-connected systems were observed to improve accuracy, ensure timely data sharing, and allow anonymous reporting (Alzarrad et al., 2023; Chung et al., 2023). Across all cases, DTs were used predominantly for on-site communication, incident reporting, and data storage. The cases collectively demonstrated that DTs enhance report completeness, reduce human error, and provide seamless access to information, directly supporting the literature's emphasis on technology mitigating human and procedural limitations. However, the findings also indicate

that DTs are more effective in reducing procedural barriers than in resolving deeper cultural barriers. Technologies can simplify report, improve documentation, and reduce omission, but they do not automatically eliminate fear, mistrust, or blame. This means that DTs mitigate underreporting only partially unless they are introduced within supportive reporting cultures.

A particularly strong theme is the ability of DTs to overcome fear-related reporting barriers. Both literature and the three cases highlight that mobile and site-specific platforms facilitate confidential submissions, thereby reducing the cultural and psychological hesitancy associated with reporting (Daniel et al., 2024; Halimuzzaman et al., 2024). The cases showed that these tools enabled quicker and less intimidating reporting processes, reinforcing the theoretical role of DTs in addressing human-centered barriers. Yet this point also requires caution. Confidential reporting systems can only reduce fear if workers trust that anonymity or protection is genuine. If digital systems are perceived as traceable or still controlled within punitive environments, fear may remain. Thus, the mitigating effect of DTs is not only technical but also social.

Real-time monitoring emerged as another critical advantage. Sensors and wearables detected incidents independently of worker reporting, addressing situations where underreporting may occur owing to unwillingness or incapacity (Thaleparambil et al., 2025). In all cases, real-time detection supported proactive safety management, confirming literature that emphasizes the value of automated incident identification in reducing underreporting. This represents one of the most significant ways in which DTs can challenge existing reporting limitations, because automated monitoring reduces exclusive dependence on worker willingness to report. However, such advanced tools were unevenly present across the cases, indicating that this potential remains stronger in theory than in routine practice.

Digital documentation further strengthened reporting practices. Features such as digital photos, GPS tagging, and instant uploads improved data accuracy and timeliness, consistent with literature advocating for technology-enabled reporting systems (Datta et al., 2024; Pereira et al., 2025). Across cases, these functions facilitated immediate communication with stakeholders, demonstrating the operational impact of DTs in enhancing both the quality and speed of incident management.

However, gaps in implementation persist. Consistent with literature, challenges related to infrastructure, digital literacy, and organizational support were evident (Daniel et al., 2024; Katiyar and Kumar, 2021). Cases highlighted connectivity issues, limited worker proficiency, and resistance to technological change, showing that technological capability alone does

not guarantee improved reporting outcomes. These findings underscore the need for ongoing training, institutional support, and adaptation strategies to ensure successful adoption. This contradicts any deterministic assumption that digitalisation necessarily leads to reporting improvement. Instead, the findings show that DTs are enabling tools whose effect depends on the organisational and infrastructural environment in which they are deployed.

Overall, the integration of DTs in all three cases demonstrates their capacity to mitigate underreporting through improved communication, automation, and data management. Nevertheless, realizing their full potential requires addressing infrastructural, skill-based, and organizational barriers. Developing a digital incident reporting roadmap, tailored to the South African construction context, is crucial to bridging these gaps and ensuring that technology adoption translates into safer and more transparent site practices.

5.2.5 The digital roadmap that would improve the reporting of construction safety incidents

Objective 5 focused on developing a digital roadmap for improving safety incident reporting. The roadmap is grounded in both empirical findings and theoretical insights, and it reflects the need for a context-specific and human-centred approach to digital transformation. The findings show that successful implementation requires not only technological investment but also organisational readiness, workforce training, and a supportive safety culture.

5.2.5.1 Integrating technology with organisational, human, and procedural factors in digital reporting

The main theme emerging from this objective is that effective digital reporting is not merely a matter of introducing technology, but of aligning technology with organisational culture, workforce capability, and reporting structures. The cross-case findings showed that while digital tools were already present across the three cases, their use remained fragmented and uneven. This suggests that the challenge is not technological absence alone, but the absence of an integrated framework capable of linking tools, people, and processes into a coherent reporting system.

This finding both supports and challenges the literature. It supports studies that advocate integrated digital solutions for improving reporting efficiency and data quality. However, it also contradicts literature that assumes that adoption of advanced DTs will naturally lead to proactive safety management. In the present study, even where digital tools were available, they were mostly used for communication, documentation, and storage rather than for

analytics, predictive monitoring, or strategic learning. This indicates that technological availability does not automatically translate into digital transformation. Rather, transformation depends on whether organisations are able to embed such tools into everyday reporting practices and decision-making structures.

5.2.5.1 Roadmap for Digital Reporting of Safety Incidents

The roadmap for digital reporting of safety incidents provides a structured and progressive approach designed to enhance efficiency, accuracy, and reliability in construction safety management. Based on a cross-case analysis of three construction-sites in Mangaung, the framework integrates theoretical propositions from contemporary literature with practical site realities, producing a context-specific strategy for digital safety reporting. As illustrated in Figure 4.1, the roadmap is organised around four interlinked pillars, namely creating awareness, engaging stakeholders, promoting key enablers, and systematically removing barriers. The strength of this roadmap lies in its grounding in both repeated cross-case patterns and contextual differences. Through replication logic, barriers such as fear, weak training, communication gaps, and technical limitations recurred across all three cases, while differences in hierarchy, digital maturity, and organisational formality helped explain why some sites were more prepared than others. As a result, the roadmap is not presented as a universal model, but as a flexible and staged framework that responds to common sector-wide challenges while remaining sensitive to different levels of site readiness.

Creating Awareness

Creating awareness constitutes a foundational step in fostering a safety-first culture and supporting digital adoption across all levels of the workforce. The cases demonstrated that communication effectiveness directly influences reporting practices, confirming the literature on the role of open and rich communication in reducing incident occurrence and strengthening risk management (Kim et al., 2019). Language barriers and limited technological familiarity were observed to impede reporting, highlighting the importance of multilingual materials and ongoing digital literacy initiatives (Halim, 2020). Therefore, awareness initiatives, such as recurring workshops, targeted communication campaigns, and accessible instructional materials, are essential to cultivate a culture where safety reporting is understood, encouraged, and consistently practised. However, the findings showed that awareness alone is insufficient. Across the cases, workers often understood that reporting was important, yet underreporting still occurred because of fear, uncertainty, and mistrust. This suggests that awareness initiatives should not be treated as stand-alone

interventions, but as part of a broader strategy that links knowledge to practice. In other words, awareness is necessary for reporting improvement, but it is not sufficient unless accompanied by trust-building, procedural clarity, and supportive management behaviour.

Engaging Stakeholders

Effective stakeholder engagement is critical for ensuring that reporting systems are both technologically robust and operationally relevant. Across the cases, reporting was most effective when embedded within formal organisational structures and hierarchies, fostering accountability at managerial and worker levels. This aligns with the views of Okorie and Musonda (2020), who emphasise the centrality of management responsibility in formalising safety processes. Engagement must encompass a broad range of stakeholders, including site managers, supervisors, IT personnel, and health and safety officers, to ensure that DTs align with operational realities, promote user buy-in, and support consistent reporting practices. Collaborative approaches of this nature bridge the gap between safety policies and site-level implementation, reinforcing the importance of participation and shared responsibility (Kim et al., 2019). However, the findings also suggest a tension within stakeholder engagement. In C3, stronger hierarchy and formal accountability improved reporting structure, yet fear of blame remained evident. This indicates that stakeholder engagement must move beyond formal inclusion and address the quality of participation. If managers and supervisors are involved only as control agents, digital reporting systems may reinforce underreporting instead of reducing it. Stakeholder engagement is therefore most effective when it creates shared ownership of the reporting process rather than simply extending oversight.

Promoting Key Enablers

The successful adoption of digital reporting relies on the strategic promotion of key enablers, such as training, infrastructure, and incentives. Across the cases, the presence of trained personnel, intuitive platforms, and readily available DTs, including mobile devices, software, and cameras, contributed to improved reporting outcomes. These findings support existing research on the benefits of wearable devices, BIM, and IoT-enabled systems in streamlining reporting while facilitating proactive safety management (Agyekum et al., 2022; Newaz et al., 2024). Additionally, periodic hands-on training (Chinda, 2012) and carefully structured incentive mechanisms can motivate participation, provided that systems are designed to avoid suppressing incident reporting for reward purposes (Carra et al., 2024).

Collectively, these enablers enhance both operational efficiency and the broader safety culture. Yet the cross-case findings indicate that enablers should not be considered

independently. In the three cases, communication, training, and technology were valuable only when they reinforced one another. For example, the availability of digital tools did not produce strong reporting outcomes where digital literacy was weak or where reporting culture remained punitive. This suggests that enablers are cumulative and relational rather than isolated. Their effectiveness depends on alignment across organisational, human, and technological dimensions.

Removing Key Barriers

Addressing persistent barriers is essential for sustaining digital transformation in safety reporting. Across the cases, fear of victimisation, limited technological familiarity, and difficulties in adapting to evolving systems were recurring challenges. These observations align with prior studies that identify blame cultures as discouraging hazard and near-miss reporting (Byrnes et al., 2022; Duryana et al., 2020). The roadmap therefore recommends embedding reporting processes into onboarding programmes, fostering a no-blame culture, providing ongoing technical support, offering offline reporting options, and implementing robust data privacy measures, particularly in contexts where workforce turnover and hierarchical structures may amplify underreporting. This pillar is especially critical because the findings suggest that barriers were more deeply rooted in organisational behaviour than in technology alone. Fear, mistrust, low digital literacy, and weak infrastructure appeared across all cases, indicating that underreporting is systemic rather than incidental. In this respect, the roadmap departs from narrowly technological solutions by recognising that digital systems will fail unless the underlying behavioural and cultural barriers are addressed simultaneously

Integration with DTs

The roadmap is further strengthened by integrating advanced DTs. Tools such as four-dimensional CAD, BIM, and digital twins enable proactive hazard simulation and real-time site model adaptation, supporting preventive safety planning (Wang et al., 2024). AR and VR applications enhance hazard recognition and training effectiveness, particularly for low-literacy or multilingual workforces (Abas et al., 2020; Chaaya et al., 2025). GIS enables spatial hazard mapping and large-scale safety planning, while UAVs reduce physical site exposure, lowering injury risks (Rachmawati and Kim, 2022). Wearable technologies provide real-time physiological and locational data, facilitating rapid hazard detection and compliance monitoring (Newaz et al., 2024). Centralised safety databases improve decision-making efficiency and transparency (Akinlolu et al., 2022). Collectively, these innovations address the root causes of underreporting by automating incident detection, improving data

quality, and reducing administrative burdens (Okonkwo and Wium, 2022). Although this integration is strongly supported by the literature, the empirical findings show that advanced technologies were only partially reflected in actual site practices. C3 displayed the strongest evidence of advanced digital use, including wearables and sensors, but C1 and C2 remained largely dependent on mobile phones, computers, cameras, and basic software. This contradiction suggests that the roadmap should be interpreted as both responsive to current site realities, but aspirational in charting a path towards more advanced and integrated digital reporting systems.

A Human-Centred and Context-Specific Approach

Ultimately, the roadmap adopts a human-centred and context-specific perspective, recognising the interdependence of leadership commitment, cultural readiness, and technological adoption. The cases indicate that leadership accountability and alignment of safety initiatives with site realities are crucial to the success of digital reporting. By balancing technical innovation with human-centred design, the roadmap ensures that digital reporting is inclusive, resilient, and adaptable to evolving industry demands. These findings highlight that technology alone is insufficient; successful implementation requires active workforce engagement, strong leadership, and a safety culture that emphasises transparency, trust, and shared responsibility.

This human-centred emphasis is one of the study's key contributions, because it shows that the success of digital reporting depends as much on organisational behaviour as on technological sophistication. In contrast to studies that foreground digital functionality, the present findings indicate that leadership accountability, fear of reprisal, communication quality, and trust are equally decisive. The roadmap therefore extends existing approaches by embedding digital reporting within the social realities of construction work, rather than treating reporting as a purely technical system design problem.

5.2.5.1 Guideline for construction safety incident reporting based on unified theory of acceptance and use of technology (UTAUT) framework

Pilot test DTs

The implementation of DTs for construction safety incident reporting requires a structured approach that addresses user perceptions, organisational culture, and available resources. The following guideline is based on the constructs of the UTAUT, specifically performance expectancy, effort expectancy, social influence, and facilitating conditions, and is informed by insights from multiple case studies.

Performance expectancy: Demonstrating value and efficiency

Construction stakeholders are more likely to adopt DTs when clear performance benefits are evident. DTs should enhance operational efficiency by enabling real-time reporting, tracking, and analysis of safety incidents. Automation of repetitive tasks through digital forms, templates, and dashboards reduces manual errors, minimizes reporting fatigue, and improves overall task efficiency. Where feasible, integrating wearable technologies and automated risk detection can further enhance job performance. To support adoption, construction firms should prioritise demonstrating measurable efficiency gains and performance improvements that align with workflow objectives (Popova and Zagulova, 2022; Venkatesh et al., 2003).

The findings strongly support performance expectancy, as participants consistently associated DTs with faster communication, reduced errors, and easier information handling. However, usefulness alone does not guarantee full adoption. In contexts where fear of reporting remained high, even useful systems would unlikely achieve their full reporting potential.

Effort expectancy: Ensuring ease of use and simplicity

Ease of use is critical, particularly in environments with varying levels of digital literacy. Digital platforms should feature intuitive interfaces, simple navigation, visual guidance, and language flexibility to accommodate all users. Embedding skill-based tutorials, guided prompts, and instructional videos within applications supports confident and consistent use. Systems perceived as easy to operate encourage broader participation in reporting processes and reduce barriers associated with unfamiliarity or evolving technology (Popova and Zagulova; Venkatesh et al., 2003, 2022). This construct was strongly reflected in the cases, especially where simple and user-friendly systems were identified as enablers. However, the findings also suggest that effort expectancy is shaped by more than interface simplicity; rather it is influenced by literacy levels, language diversity, and exposure to technology.

Engage managers and supervisors and scale-up based on feedback

Social influence: Leveraging cultural and organisational endorsement

Adoption increases when digital reporting is endorsed by supervisors, managers, and peers. Construction firms should encourage managerial staff to model digital reporting behaviour and create peer advocacy networks by identifying and mentoring tech-savvy personnel. Embedding digital reporting within the organisational safety culture, emphasizing

accountability, transparency, and non-punitive reporting strengthens acceptance. Establishing social norms that promote consistent use of DTs ensures that workers are supported and motivated to engage with the system (Sugandini et al., 2022; Venkatesh et al., 2003). The present study suggests that social influence may be especially influential in construction safety reporting because workers' reporting behaviour is strongly shaped by organisational culture and managerial attitudes. In this setting, peer and supervisory endorsement do not merely encourage use; they help define whether reporting is seen as safe, legitimate, and worthwhile.

Roll out training and devices/systems

Facilitating conditions: Providing resources, training, and infrastructure

Successful implementation depends on access to technology, infrastructure, and ongoing support. Construction-sites should be equipped with mobile devices, reliable network connectivity, and charging facilities. Continuous digital literacy training, hands-on workshops, and help desk support empower users to interact confidently with systems. Establishing governance protocols for data privacy, protection, and user authentication enhances trust in DTs. Providing channels for user feedback enables iterative improvement of platforms, addressing usability challenges and system limitations Popova and Zagulova, 2022; Venkatesh et al., 2003). Table 5.1 details the steps for implementing the roadmap. These steps are based on the constructs of the UTAUT, specifically performance expectancy, effort expectancy, social influence, and facilitating conditions. Facilitating conditions were uneven across the cases, especially in relation to connectivity, power supply, training, and technical support. This indicates that facilitating conditions in this context extend beyond access to devices and include the broader organisational capacity to sustain digital reporting over time

Table 5.1: Steps for deploying roadmap for digital reporting of incidents

Steps	Construct	Strategic recommendations	Literature Review	Primary Data (Interviewee Reference)
Pilot test digital technologies	Performance expectancy	Automate reporting, use mobile apps, integrate wearables, and enable real-time data analysis.	Popova and Zagulova (2022)	I1, I18, I25, I26
	Effort expectancy	Design simple interfaces, provide language options, and include embedded help features.	Venkatesh et al. (2003)	I4, I7, I18;

Engage managers and supervisors and scale up based on feedback	Social influence	Involve supervisors, encourage peer support, and embed DTs within company safety culture.	Sugandini et al. (2022); Taiwo and Downe (2013)	I4, I20, I21, I27;
Roll out training and devices/systems	Facilitating conditions	Provide infrastructure, continuous training, support systems, and clear data governance.	Popova and Zagulova (2022)	I6, I19, I20, I21;

Figure 5.1 shows a guideline on how technology can be implemented for effective safety reporting using DTs. The roadmap for DT adoption should follow a structured sequence: pilot testing, iterative refinement based on user feedback, training and capacity building, and full-scale deployment. By addressing performance and effort expectancy, leveraging social influence, and ensuring adequate facilitating conditions, construction firms can establish efficient, inclusive, and proactive safety reporting systems. This approach not only improves compliance and worker safety but also fosters a culture of continuous learning and proactive risk management. Importantly, the findings suggest that implementation should be iterative rather than fixed. Because barriers and readiness differ across sites, the roadmap should allow for adjustment as feedback emerges, technologies evolve, and reporting cultures mature.

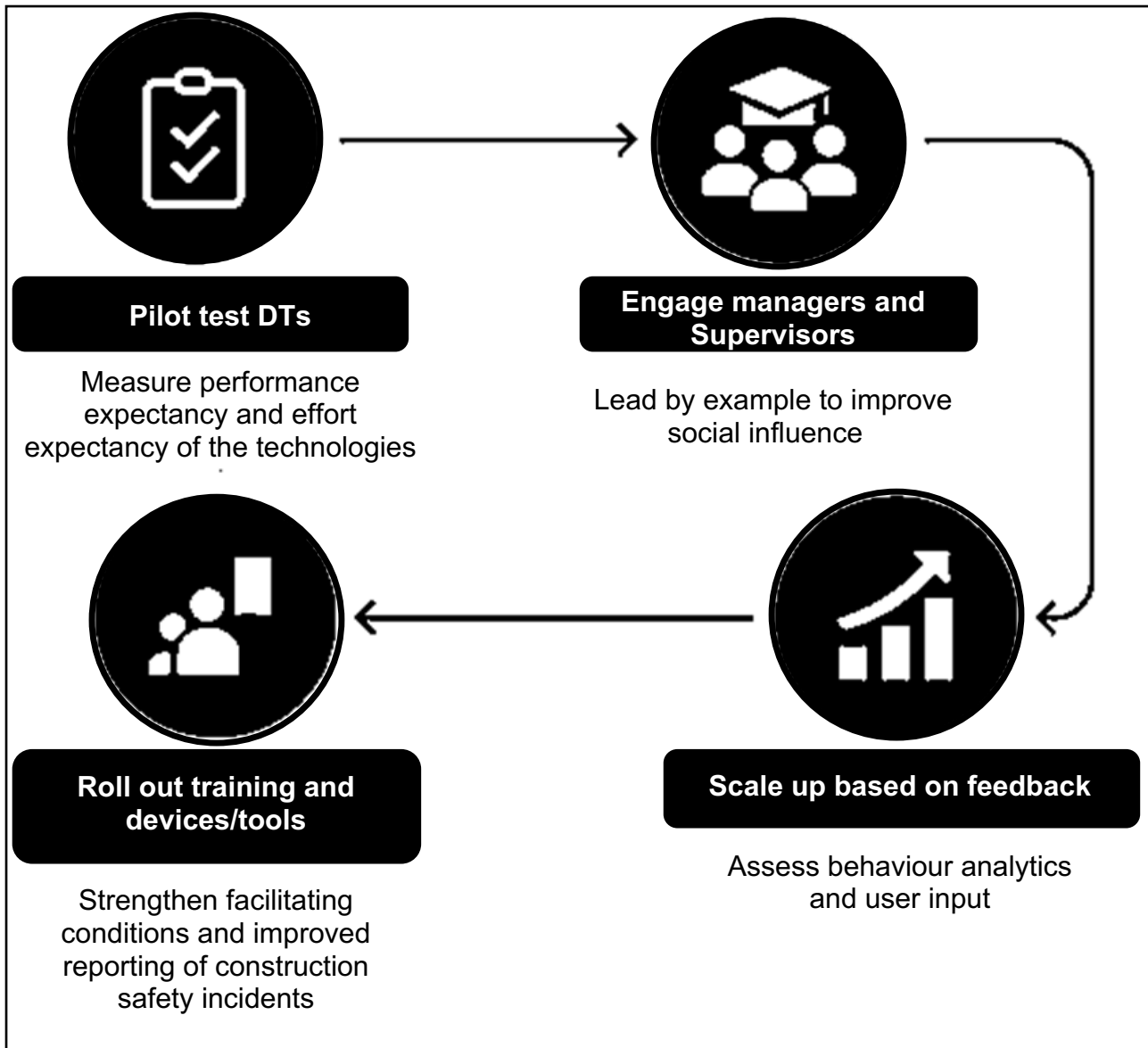


Figure 5.1: Guideline for effective reporting of safety incidents on-site

(Researcher's construct)

5.3 CHAPTER SUMMARY

This chapter summarised the key findings of the study in relation to the research objectives, highlighting major barriers and enablers to safety incident reporting. It also emphasised the potential of DTs to enhance reporting practices. Practical recommendations were provided to improve safety communication, resource allocation, and digital adoption. In addition, the chapter highlighted gaps that may require further studies to strengthen safety management in the construction industry. The chapter furthermore demonstrated that safety incident reporting is influenced by a combination of organisational, behavioural, and technological factors. While digital technologies provide clear benefits in improving efficiency and

accuracy, their impact is shaped by the context in which they are implemented. The findings therefore emphasise the need for an approach that integrates technology with organisational practices and workforce capabilities to improve reporting outcomes in construction environments.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter presents the overall conclusion of the study and offers recommendations to inform both future research and practical implementation.

6.2 CONCLUSIONS

6.2.1 General conclusions

The overarching aim of this research was to establish a roadmap for digital reporting of construction safety incidents that promotes effective incident reporting. This aim has been achieved through a systematic exploration of the barriers and enablers to reporting, an assessment of the current state of digitalised reporting in the construction sector, an investigation of how DTs can address underreporting, and the formulation of a context-specific digital roadmap tailored to the needs of the Mangaung construction industry. While the aim has been achieved, the findings further indicate that improving safety incident reporting is not a once-off outcome but an ongoing process shaped by organisational practices, worker behaviour, and technological conditions. This suggests that the proposed roadmap should be applied flexibly and continuously adapted to different construction contexts.

From this study, it is now understood that safety incident reporting in construction is not only a technical or procedural activity, but a complex socio-technical process influenced by the interaction between people, organisational systems, and technology. This provides a more integrated understanding of reporting practices, particularly within developing construction environments such as Mangaung.

The identification of barriers in Objective 1 provided the foundational understanding required to address the factors that undermine effective safety reporting. Thematic analysis revealed that knowledge and awareness gaps, cultural resistance, communication difficulties, and management deficiencies contribute significantly to underreporting. The majority of interviewees confirmed that fear of victimisation and lack of procedural clarity were central deterrents to reporting. Mapping these barriers ensured that the roadmap was grounded in the practical realities of the industry.

Beyond identifying these barriers, the findings show that they do not operate independently but interact to reinforce underreporting. For example, fear of victimisation is strengthened by weak management responses, while communication challenges further limit workers' ability to report incidents. This highlights that underreporting is embedded within everyday site practices rather than being caused by isolated factors.

This contributes to knowledge by showing that underreporting is not simply the result of individual worker behaviour, but rather a systemic issue shaped by organisational culture, management practices, and communication structures. This shifts the understanding of reporting from an individual responsibility to a shared organisational process.

The identification of enablers in Objective 2 further supported the aim by providing actionable drivers for change. Organisational support, procedural simplicity, accessible communication channels, and targeted training emerged as critical components. Many interviewees highlighted the importance of a supportive safety culture, competent health and safety officers, and continuous training. These enablers were not only theoretically robust but also empirically relevant to the Mangaung construction context.

However, the findings also indicate that these enablers are most effective when they are implemented together. Where communication, training, and systems are not aligned, their impact on reporting remains limited. This suggests that improving safety reporting requires an integrated approach rather than isolated interventions. The study therefore contributes by demonstrating that effective reporting is enabled through the alignment of organisational, human, and system-based factors, rather than through single interventions. This highlights the importance of integration in safety management practices.

The investigation of the current status of digitalised reporting in Objective 3 revealed partial adoption of DTs, with mobile phones and messaging applications being widely used while advanced technologies such as BIM, VR/AR, and IoT systems were far less prevalent. While interviewees acknowledged the benefits of speed, accuracy, and accessibility offered by digital methods, many also reported infrastructure challenges and limited digital skills. These findings ensured that the roadmap addressed the industry's actual digital maturity rather than assuming readiness for immediate advanced implementation. This finding highlights a gap between the potential of digital technologies presented in literature and their actual use in practice. It suggests that digital transformation in construction safety reporting is gradual and influenced by contextual constraints such as infrastructure, cost, and skills availability.

This adds to existing knowledge by showing that digital adoption in construction safety is uneven and context-dependent, particularly in developing environments. It challenges assumptions that advanced technologies are readily applicable across all construction settings.

The exploration of how DTs mitigate underreporting in Objective 4 directly informed the roadmap's integration strategies. Interview evidence showed that mobile applications, wearables, and IoT-connected systems have the potential to reduce errors, enable anonymous reporting, and improve real-time communication. The majority of interviewees confirmed that such technologies can help address both procedural and cultural barriers. By linking specific technological capabilities to identified challenges, the research ensured that the roadmap maintained a targeted, problem-solving focus. At the same time, the findings indicate that the effectiveness of DTs depends on organisational conditions. While technologies improve reporting processes, they do not fully address underlying issues such as fear, mistrust, and reluctance to report. This suggests that technological solutions must be supported by organisational and cultural changes. This demonstrates that while DTs are important tools, they are not standalone solutions. The study contributes by showing that technology must be combined with organisational readiness and cultural change to effectively improve reporting practices.

Finally, the roadmap developed in Objective 5 consolidates findings from all objectives into a strategic and practical framework. Built on four interlinked pillars including creating awareness, engaging stakeholders, promoting enablers, and removing barriers, the roadmap outlines a pathway for industry-wide digital transformation in safety reporting. It balances the use of advanced tools such as BIM, AR/VR, GIS, UAVs, and wearables with foundational measures such as training, infrastructure provision, and the promotion of a no-blame culture. By applying an adoption framework that considers performance expectancy, effort expectancy, social influence, and facilitating conditions, the roadmap aligns ambition with feasibility. The roadmap therefore reflects both current practices and future possibilities within the construction industry. Its strength lies in combining practical realities with long-term digital goals, although its success will depend on how it is adapted to different site conditions and levels of readiness. The key contribution of this study is the development of a context-specific digital roadmap that integrates both human and technological factors. Unlike generic models, this roadmap is grounded in real construction site experiences, making it more applicable to similar developing construction environments.

Through this integrated approach, the study not only identified the systemic issues contributing to underreporting but also demonstrated how DTs can be deployed to address them within a structured, context-sensitive implementation plan. The aim of establishing a roadmap for digital reporting that promotes effective construction safety incident reporting has therefore been achieved. Importantly, the study does not suggest that all challenges have been fully resolved. Instead, it provides a structured understanding of safety reporting practices and offers a direction for improvement, recognising that reporting systems will continue to evolve alongside organisational and technological changes. Overall, the study contributes to both theory and practice by providing a deeper understanding of safety incident reporting within construction and offering a practical framework that can guide future improvements in similar contexts.

6.2.2 Conclusions on Objective 1: Identify the barriers to effective construction safety incident reporting

This objective has been successfully achieved through the integration of insights from the literature with thematic analysis across three case studies in Mangaung. The study revealed several key barriers to effective incident reporting, which can be understood in terms of knowledge and awareness gaps, cultural and behavioural challenges, communication limitations, and management-related deficiencies. While these barriers are consistent with those identified in previous studies, the findings further show that they do not operate in isolation but interact in ways that reinforce underreporting. This suggests that reporting challenges are embedded within everyday site practices rather than being caused by single factors. From this objective, the study now shows that underreporting is a systemic issue rather than an individual failure. It is influenced by the interaction between organisational culture, management behaviour, and worker perceptions, which together shape how reporting is practiced on-site.

Knowledge and awareness gaps emerged as a critical factor limiting reporting. Across the cases, employees demonstrated limited understanding of reporting procedures, and training on incident reporting was often insufficient. This lack of preparation and familiarity directly restricted their ability to comply with established safety protocols. However, the findings also indicate that awareness alone does not guarantee reporting, as some workers understood the importance of reporting but were still uncertain about how to apply procedures in practice. This suggests that knowledge must be supported by practical guidance and continuous reinforcement on-site. This contributes to knowledge by showing that training

alone is not enough to improve reporting. Instead, practical application, ongoing support, and reinforcement are required to translate knowledge into reporting behaviour.

Cultural and behavioural challenges also played a significant role. In the cases examined, there was a pervasive fear of negative consequences, including disciplinary action, which discouraged workers from reporting incidents. Such environments where blame and reprisal are anticipated were shown to inhibit open communication and transparency. This demonstrates that reporting behaviour is influenced more by perceived risks than by formal reporting systems, indicating that organisational culture plays a critical role in shaping reporting practices. The study therefore highlights that fear and organisational culture are dominant drivers of underreporting, particularly in this context, extending existing literature that often emphasises technical barriers.

Communication barriers, including language and literacy limitations, further compounded the problem. Cases where workers struggled to comprehend reporting forms or lacked the language proficiency needed to communicate incidents highlighted how such barriers can impede safety compliance and timely reporting. This suggests that reporting systems may not be equally accessible to all workers, particularly in multilingual construction environments, which can result in incomplete safety data and limited understanding of site risks. This shows that inclusivity in communication is essential, and that reporting systems must be designed to accommodate diverse workforces.

Management-related deficiencies were another consistent theme. Across the case studies, reporting systems were often poorly structured, documentation processes were inefficient, and record-keeping was inconsistent. These weaknesses in the management of safety reporting created additional obstacles for employees, contributing to underreporting of incidents. The findings further indicate that when reporting does not lead to visible action or feedback, workers may perceive the process as ineffective, reducing their willingness to report future incidents. This adds to knowledge by showing that perceived management responsiveness influences reporting behaviour, meaning that workers are more likely to report when they see outcomes from previous reports.

By synthesising these findings, the study provides a comprehensive mapping of the multidimensional barriers to incident reporting. The analysis demonstrates how organisational, cultural, and procedural factors intersect to influence reporting behaviour, thereby fully achieving the first research objective. This highlights that addressing

underreporting requires a holistic approach that considers organisational systems, worker behaviour, and communication processes together rather than treating them as separate issues.

6.2.3 Conclusions on Objective 2: Determine the enablers of effective construction safety incident reporting

Objective 2 was achieved through the identification of organisational, procedural, and cultural enablers that facilitate effective construction safety incident reporting. Across the cases, efficient and effective communication consistently emerged as a critical enabler. Organisations that maintained clear and accessible communication channels reported higher engagement in incident reporting and smoother information flow. The use of appropriate communication tools and practices proved essential in ensuring that reporting processes were understood and consistently followed. This indicates that communication not only supports the transfer of information but also influences how workers understand and engage with reporting responsibilities on-site. From this objective, it is now understood that communication is not only a technical process but also a behavioural enabler that shapes worker confidence and willingness to report incidents.

A supportive reporting culture was also identified as a key factor. Cases with a transparent and accountable environment demonstrated higher reporting rates and more accurate incident records. In these organisations, employees were more willing to report incidents without fear of reprisal, indicating that cultural reinforcement is vital to operationalising reporting practices. However, the findings also suggest that accountability structures must be carefully managed, as they can both support and discourage reporting depending on how they are implemented. This contributes to knowledge by showing that organisational culture is a central enabler of reporting, and that trust and transparency are critical conditions for effective safety management.

Competent health and safety officers and the provision of regular training were further enablers observed across multiple cases. Organisations that invested in capacity-building and procedural training saw improved understanding of reporting requirements and greater adherence to safety protocols. This highlights the role of training, not only in procedural knowledge, but also in empowering personnel to actively participate in the reporting process. This shows that competence includes both technical knowledge and the ability to engage and support workers, which strengthens participation in reporting processes. The study

therefore shows that training must be continuous and supported by leadership to remain effective in practice.

The design and accessibility of reporting systems also influenced reporting effectiveness. Cases with user-friendly, intuitive systems experienced fewer procedural barriers, suggesting that simplicity and accessibility are important considerations when implementing digital reporting tools. This suggests that system effectiveness depends on how well it aligns with users' skills and capabilities, particularly in environments with varying levels of literacy and digital proficiency. This highlights that system design plays a critical role in enabling reporting, particularly in diverse and resource-constrained environments.

Finally, the careful integration of incentives within broader safety management systems was observed to enhance reporting engagement without undermining the integrity of incident data. Where incentives were strategically aligned with safety objectives, reporting improved and reinforced the overall safety culture. However, the findings also indicate that poorly designed incentives may discourage reporting if workers associate reporting with negative consequences, highlighting the need for balanced implementation. This shows that incentives must be carefully structured to support, rather than distort, reporting behaviour.

Overall, the enablers identified across the cases demonstrate that organisational, procedural, and cultural factors are actionable and contextually relevant, providing a robust foundation for improving digital safety incident reporting in construction environments. This reinforces the idea that improving reporting practices requires coordinated interventions that integrate communication, culture, training, and system design.

6.2.4 Conclusions on Objective 3: Investigate organisational readiness for digital reporting adoption

Objective 3 was partially achieved, as the study was able to identify the current use, benefits, and limitations of DTs for construction safety reporting within the study context. The findings indicate that while a range of advanced DTs, such as BIM, VR/AR, IoT-based systems, and drones have the potential to transform safety reporting, their practical adoption in the cases examined remains limited. In practice, the majority of reporting relies on more basic DTs, including mobile phones, digital cameras, and messaging applications. This indicates that digital adoption in construction safety reporting is still developing and influenced by practical constraints such as cost, infrastructure, and skills availability. From this objective, the study

shows that digital readiness in construction is uneven and context-dependent, rather than consistent across projects.

The research demonstrated several benefits associated with the use of DTs, including more accurate reporting, improved storage and management of safety documents, and faster communication of information across project teams. Such benefits contribute to more efficient reporting processes and help reduce delays and errors. However, these benefits are largely operational, suggesting that current digital practices improve efficiency but do not yet fully support proactive and predictive safety management. This contributes to knowledge by showing that digital technologies are currently used for basic functions rather than advanced safety management, highlighting a gap between potential and practice.

Despite these advantages, several limitations were observed. Advanced DTs are underutilized across the cases, partly owing to technical challenges such as unreliable internet connectivity, and partly to limited digital literacy among workers. These gaps indicate that, while digitalisation is present, it is uneven and not yet fully embedded in safety reporting processes. This highlights that digital readiness is not only about technology availability but also about the capacity of organisations and workers to effectively use these technologies.

Overall, the study provides a clear picture of the current status of DTs for construction safety reporting in the cases examined. It highlights both the practical benefits achieved and the persistent challenges that need to be addressed, fulfilling Objective 3 while identifying areas for further improvement and potential for greater adoption of advanced tools. This suggests that future improvements should focus on strengthening both technological infrastructure and user capability. This highlights that successful digital adoption requires both infrastructure and human capability development.

6.2.5 Conclusions on Objective 4: Explore how DTs would mitigate underreporting of construction safety incidents

Objective 4 has been met by demonstrating how DTs can effectively address the root causes of underreporting in construction safety. Across multiple cases, technologies such as mobile apps, wearables, and IoT-connected systems have been shown to automate data collection, facilitate anonymous reporting, and enhance real-time communication. From this objective, the study shows that DTs can reduce reliance on manual reporting and improve the accuracy and timeliness of incident data. Case evidence indicates that these tools reduce reporting

errors, improve timeliness, and allow for more accurate tracking of worker activities, including entry into restricted zones through wearable monitoring. This indicates that DTs improve the efficiency and reliability of reporting processes, making it easier for workers to capture and share incident information. This contributes to knowledge by showing that technological solutions must be supported by organisational change to be effective.

DTs also contribute to overcoming cultural barriers that typically hinder reporting. Confidential reporting channels, including instant messaging platforms, have been shown to reduce fear of reprisals and encourage more consistent reporting of incidents. Moreover, real-time monitoring using sensors enables the detection of incidents without relying solely on human reporting, ensuring that critical safety events are captured promptly and accurately. However, the findings suggest that technology alone cannot fully eliminate underreporting, as behavioural and organisational factors such as fear and mistrust may still influence reporting decisions.

Despite these benefits, the adoption of DTs is not without challenges. Cases highlight that infrastructure limitations, insufficient training, and resistance to technological change impede effective implementation. These barriers demonstrate that while DTs have significant potential to improve reporting practices, their success is contingent on addressing these systemic and organizational constraints. This highlights that digital solutions must be supported by organisational readiness and continuous capacity building to achieve their full potential.

Overall, the analysis across the cases confirms that Objective 4 has been achieved by illustrating both the strengths and limitations of DTs in addressing underreporting, showing that their strategic deployment can enhance safety reporting processes while acknowledging the need for supportive infrastructure and capacity building.

6.2.6 Conclusions on objective 5: Determine the digital roadmap that would improve the reporting of construction safety incidents

Objective 5 was successfully achieved through the development of a context-specific digital roadmap that synthesizes insights from both literature and cross-case analysis. This roadmap is structured around four key pillars: creating awareness, engaging stakeholders, promoting enablers, and removing barriers. Across the cases, it was evident that effective implementation depends on multilingual communication, active stakeholder involvement, targeted training, adequate infrastructure provision, and the establishment of a no-blame

culture. This indicates that successful implementation of the roadmap depends on aligning organisational, cultural, and technological factors.

Advanced technologies, including BIM, AR/VR, GIS, UAVs, and wearables, were incorporated as tools within the roadmap to enhance hazard detection, improve training effectiveness, and reduce administrative burdens. The practical integration of these technologies across the cases demonstrated their potential to streamline processes and improve overall safety management. However, the findings suggest that these technologies are not yet widely used in practice, indicating a gap between proposed solutions and current industry readiness. The study now provides a context-specific roadmap that integrates human, organisational, and technological factors, offering a practical contribution to improving safety reporting in similar environments.

The UTAUT framework guided the operationalisation of the roadmap to ensure adoption feasibility. Constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions were translated into actionable strategies, ensuring that the roadmap aligns with user expectations and organisational capacity. While the framework provides a useful structure, the findings indicate that additional factors such as trust, organisational culture, and worker perceptions also influence adoption.

By grounding the roadmap in the realities of Mangaung's construction environment, the study provides a structured pathway towards digital transformation. The roadmap not only fulfils Objective 5 but also establishes a foundation for broader industry improvements in safety reporting practices, offering a replicable model for similar contexts.

6.3 RECOMMENDATIONS

6.3.1 Recommendations for practice

Drawing from the roadmap and implementation guidelines, several practical recommendations are advanced to enhance the reporting of safety incidents in the construction sector.

The first recommendation is to prioritise a phased implementation of the digital roadmap. Construction firms should commence with pilot testing of accessible DTs, including mobile safety applications, wearable devices, and real-time reporting platforms. These technologies should be selected for their potential to improve efficiency, minimise manual errors, automate documentation, and increase the speed of reporting. Pilot projects serve as an

important entry point by demonstrating the value of digital reporting in practice, thereby supporting the progressive scaling up of adoption. This recommendation is grounded in the finding that digital adoption in the studied cases is still at an early and uneven stage. A phased approach allows organisations to gradually build confidence, reduce resistance, and align technological adoption with existing site capabilities rather than imposing complex systems prematurely.

The second recommendation is to ensure user-friendliness and multilingual accessibility of reporting systems. Given the varied levels of digital literacy among construction workers, systems should be designed with intuitive interfaces, clear navigation pathways, and visual prompts. The provision of multilingual options is essential in a context such as South Africa where construction-sites are linguistically diverse. Step-by-step tutorials embedded in the applications, complemented by on-site demonstrations, will further reduce barriers associated with language and literacy. This recommendation reflects the finding that communication barriers and low digital literacy significantly affect reporting practices. Improving accessibility is therefore not only a technical improvement but also a way of making reporting systems more inclusive and usable for all workers.

The third recommendation is to embed digital reporting practices within organisational culture. Managers and supervisors must actively demonstrate and promote the use of digital reporting tools in order to reinforce values of transparency and accountability. The establishment of a no-blame culture is particularly critical to overcoming the fear of victimisation that was identified in the case studies. Peer advocacy networks, in which digitally competent employees mentor their colleagues, should be encouraged to strengthen adoption across all levels of the workforce. This recommendation is informed by the finding that fear and organisational culture are key drivers of underreporting. It highlights that successful implementation of digital systems depends not only on technology, but also on leadership behaviour and the creation of a supportive reporting environment.

The fourth recommendation is to increase investment in infrastructure and capacity-building. Construction firms must ensure that workers have consistent access to mobile devices, reliable Internet connectivity, charging points, and continuous technical support. At the same time, firms should institutionalise digital literacy training through workshops and provide ongoing assistance through help-desk services. To guarantee the responsible use of incident data, robust governance frameworks must be introduced that cover data protection, privacy, and ethical considerations. This recommendation is based on the finding that

technical challenges and lack of skills limit the effective use of DTs. Addressing these constraints is essential to ensure that digital reporting systems are not only introduced, but also effectively used in practice.

By implementing these recommendations, construction stakeholders in Mangaung, and more broadly across South Africa, will be able to adopt the digital roadmap in a structured and scalable manner. Such an approach will support the development of an inclusive and transparent reporting environment that empowers workers, strengthens organisational accountability, and facilitates the transformation of the construction industry towards proactive and digitally enabled safety management.

Overall, these recommendations contribute by translating the study's findings into practical actions that can improve safety reporting. They demonstrate how the proposed roadmap can be applied in real construction environments, particularly those with similar contextual challenges.

6.3.2 Recommendations for research

Besides practical interventions, this study highlights several areas where more research is needed. Future studies should look at the long-term effects of using the digital roadmap in different construction environments, focusing on changes in reporting rates, worker perceptions, and overall safety outcomes. Long-term case studies and mixed-method evaluations would provide stronger evidence of the roadmap's impact and durability. This recommendation arises from the limitation that the current study was cross-sectional, meaning it captured practices at a specific point in time. Longitudinal research would provide deeper insights into how digital reporting systems evolve and perform over time.

Furthermore, more empirical research is needed to examine how advanced technologies such as IoT sensors, BIM, AR, and predictive analytics can be integrated into existing site safety systems. Although the potential of these tools is well-supported in global literature, their local applicability, cost-effectiveness, and user acceptance are still not well understood. This reflects the finding that there is a gap between the theoretical potential of advanced DTs and their practical use in the studied cases. Future research can therefore help bridge this gap by focusing on real-world implementation challenges and opportunities.

Finally, future research should explore how national policy, procurement requirements, and regulatory frameworks can be aligned with digital safety reporting efforts. This includes looking at incentives for technological adoption among small and medium-sized businesses

and identifying regulatory gaps that slow down the spread of digital innovations in the construction industry.

Through continued research and refinement of digital frameworks such as the roadmap developed in this study, the construction industry can make significant strides toward safer and more resilient work environments. This reinforces the contribution of the study by positioning the roadmap as a foundation for further development rather than a final solution, encouraging ongoing improvement in safety reporting practices.

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APPENDIXES

APPENDIX 1: INTERVIEW PROTOCOLS



FACULTY OF ENGINEERING, BUILT ENVIRONMENT
AND INFORMATION TECHNOLOGY

20 August 2023

Dear Sir/Madam,

Invitation to participate in Master of Construction's research on on-site construction safety incidents reporting

I humbly request your assistance in the current Master of Construction research project by participating in an interview. The research title is "*A roadmap for effective digital reporting of on-site construction safety incidents*". The interviews will assist N. Nkuna with the data collection process for the study conducted under the supervision of Prof. F.A. Emuze in the Department of Built Environment at Central University of Technology, Free State and Dr A. Akanbi in the Department of Information Technology at Central University of Technology, Free State.

The purpose of the interviews at this stage of the study is to identify the barriers to effective construction safety incident reporting, determine the enablers of effective construction safety incident reporting and investigate the status of digital reporting of construction safety incidents. Therefore, I request your support by participating in the interviews.

Your participation is voluntary, although it is crucial for achieving the research objectives. The interview will not take more than 45 minutes on average and will be recorded; however, identifications of the company, project and interviewees will remain anonymous in the study and findings from the interviews will be confidential. Further, the information received from you will remain on the research report and any other publications that may be written in future. It is also within your rights to withdraw from the interview since it is voluntary.

If you wish to enquire about further details about the study, please get in touch with N. Nkuna on nnkuna@cut.ac.za or 0734118113, alternatively contact the research supervisor Prof. F.A. Emuze using the following email address: femuze@cut.ac.za

Sincerely



N Nkuna (M_CONS Students)



Prof. F.A. Emuze (Supervisor)

INTERVIEW QUESTIONS

Purpose of interview: To Identify the barriers to effective construction safety incident reporting; determine the enablers of effective construction safety incident reporting and investigate the status of digital reporting of construction safety incidents.

This interview consists of sections A, B and C.

Section A: Demographic information

1. What is the highest level of education you have completed?
2. What is the primary field of education you have completed?
3. What is your current occupation?
4. How best can you describe your work experience in your occupation?

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents?
6. Please take me through the process of reporting safety incidents on-site.
7. What benefits do reporting safety incidents have to a project?
8. What are the enablers of safety incidents reporting on-site?
9. What challenges do you encounter when reporting safety incidents on-site?

Section C: Digital technologies

10. What is your understanding of digital technologies?
11. Please take me through the digital technologies you use on-site.
12. What benefits does using digital technologies have for a project?
13. What challenges do you encounter when using digital technologies on-site?
14. What digital technologies are used to report site safety incidents?
15. How are digital technologies used to report safety incidents on-sites?

What are the general comments or concerns you wish to share?

Comments/concerns

— End of interview —

Thank you for participating in the interview.

APPENDIX 2: ETHICAL CLEARANCE



FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY
Department of Civil Engineering

APPLICATION FOR ETHICAL CLEARANCE TO CONDUCT RESEARCH IN THE FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

The Central University of Technology (CUT) Research Ethics and Integrity Policy applies to all undergraduate and post graduate students, and staff members who conduct research on CUT campuses and outside the campus. CUT policy bounds any person who wishes to conduct research with CUT students and/or staff but is not CUT affiliated to abide by the ethics framework. All CUT members who conduct research take responsibility to implement this Policy.

1. APPLICANT INFORMATION

1.1.	Title (Prof Dr /Mr /Mrs /Ms)	Mr	
1.2	Name(s) and Surname	Nhlanhla Nkuna	
1.3	Student / Staff number	217006394	
1.4	Department	Built Environment	
1.5	Campus	Bloemfontein	
1.6	Postal address	2 Par fe lazh 18 Parfitt avenue Willows Bloemfontein 9320	
1.7	Contact details	Office	
		Cell	073 411 8113
		e-mail	iamnkuna@gmail.com
1.8	Supervisor (s)/Project Leader	Prof FA Emuze	
1.9	Qualification registered for/Level of research	Please tick relevant option:	
		Masters qualification	x
		Doctorate	
		Independent research	

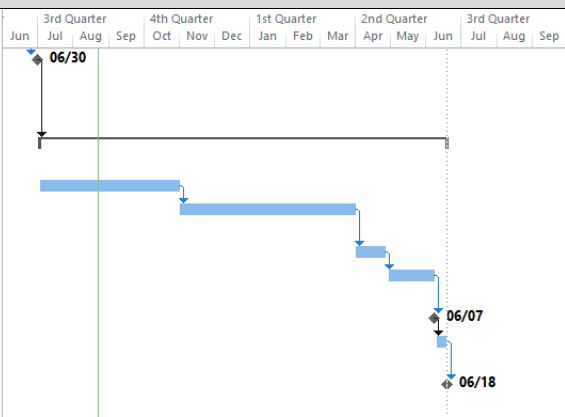
		(Non-qualification purposes)	
1.10	FRIC Approval Number (LS262a) (where applicable)		
1.11	Conflict of interest (Please underline/highlight): 1) Personal relationship Yes/ No 2) Financial benefit Yes/ No		
	<i>If yes, please provide details:</i>		

2. DETAILS OF THE STUDY

2.1	Approved/Proposed title of the study/project /dissertation/thesis		
A roadmap for effective digital reporting of on-site construction safety incidents			
2.2	Research question(s)		
- What are the barriers to effective construction safety incident reporting? - What are the enablers of effective construction safety incident reporting? - What is the status of digitalised reporting of construction safety incidents? - How can IoT mitigate underreporting of construction safety incidents? - What IoT-based digital roadmap would improve the reporting of construction safety incidents?			
2.3	Aim and objectives of the study		
Research Aim: The aim of the study is to determine how the application of a digital roadmap would promote effective reporting of construction safety incidents.			
Research Objectives: - Identify the barriers to effective construction safety incident reporting. - Determine the enablers of effective construction safety incident reporting. - Investigate the status of digital reporting of construction safety incidents. - Explore how the application of IoT would mitigate underreporting of construction safety incidents. - Determine how IoT-based digital roadmap would improve the reporting of construction safety incidents.			
2.4	Research methodology		
2.4.1	Research participants and their age brackets (where applicable, e.g. 10 Students from Civil Engineering Department)		
The research participants of the study include project managers, architects, engineers, quantity surveyors, construction managers; site agents; site managers; health and safety officers; contractors, subcontractors, supervisors, artisans, and general workers from the construction projects in Bloemfontein, Free State Province.			
2.4.2	How will participants be selected/sampled?		
The participants will be sampled using a non-probability purposive sampling design to sample participants involved in construction safety.			

2.4.3	Research site(s) (e.g. Borong Construction Site) Please list
Qualicon construction site in Bloemfontein Central Qualicon construction site in Univesitas Ruwacon construction site in Brandwag WGK construction site in Universitas	
2.4.4	Data collection instruments (e.g. questionnaire(s)/interview schedule(s)/observation schedule(s)/artefacts/other)
<i>List all instruments to be used and attach copies/a copy/ schedule</i> Semi structured interviews Focus groups Observation	
2.4.5	Data collection procedure (Please outline WHEN, WHERE and HOW data will be collected)
The researcher intends to collect data from 01 November 2023 till 31 March 2024 from construction sites identified in Bloemfontein. Data will be collected through observing the procedures used for reporting of on-site safety incidents and evidence of digital technologies used on-site, and through interviewing identified participants to identify the barriers to effective construction safety incident reporting, determine the enablers of effective construction safety incident reporting and investigate the status of digital reporting of construction safety incidents. Interviews and observation process will be recorded; however, identifications of the company, project and participants will remain anonymous in the study and findings from thereof will be confidential.	

3. PROPOSED PLAN OF STUDY/RESEARCH

Set out your intended plan of work for the research, indicating important target dates necessary to meet your proposed deadlines																
Task Mode	Task Name	Duration	Start	Finish	Timeline (Jun 2023 to Sep 2024)											
	Submission of research protocol and ethical clearance application for approval by DRIC & FRIC	0 days	2023 June 30	2023 June 30												
	DATA COLLECTION AND REPORT WRITING	253 days?	2023 July 03	2024 June 18												
	Scoping literature review	87 days?	2023 July 03	2023 October 31												
	Conducting interviews on sites	109 days?	2023 November 01	2024 March 31												
	Translating and Transcribing	20 days?	2024 April 01	2024 April 26												
	Data analysis and report writing	30 days	2024 April 29	2024 June 07												
	Submit draft dissertation	0 days	2024 June 07	2024 June 07												
	Revise and format dissertation	7 days?	2024 June 10	2024 June 18												
	Submit final dissertation	0 days	2024 June 18	2024 June 18												

4. ETHICAL ISSUES AND RISK ASSESSMENT

In order to assess whether your proposed research is ethically compliant, ethics risks are categorised into four categories:

(1) Research involving minor risk

The likelihood of projected harm or inconvenience in the research is not greater than that experienced in daily life.

(2) Research involving low risk

Research in which the only anticipatable risk is one of potential awkwardness or discomfort to the participants.

(3) Research involving medium risk

Research in which there is a possible risk of harm or discomfort, but where appropriate steps can be taken to lessen or moderate overall risk.

(4) Research involving high risk

Research in which there is a real and foreseeable risk of harm and discomfort, which may lead to a serious adverse event if not managed in a responsible manner.

4.1	Will human research participants be used in your study? <i>Please mark with an X or V in the Yes/No/N/A box</i>	✓ Yes	No	N/A
4.2	If yes, does the research study involve any of the following:			
	a) Children or youth under the age of 18 (Attach parental consent letter)		X	
	b) Individuals living with disabilities (physical, mental and/or sensory) (Attach consent letter of legal guardian)		X	
	c) Individuals that might find it difficult to make independent and informed decisions for socio, economic, cultural, political and/or medical reasons	X		
	d) Communities that might be considered vulnerable, thus finding it difficult to make independent and informed decisions for socio, economic, cultural, political and/or medical reasons		X	
	e) Individuals who might be vulnerable for age related reasons e.g. the elderly		X	

f) Individuals whose spoken language differs from the language used for the research (Make sure you translate your consent form and participant information sheet in the participants' first language – you should also have an interpreter if you do interviews – describe it below the table)	X		
g) Women considered to be vulnerable (pregnancy, victimisation, marginalised etc.)		X	
h) Other (Please explain):			

4.3	Will data collection involve any of the following:	Yes	No	N/A
a)	Access to confidential data without prior permission of participants		X	
b)	Participants expected to commit an act which might reduce self-respect or cause them to experience shame, embarrassment, or regret		X	
c)	Expose participants to worrying or upsetting questions or to processes which may have disagreeable or harmful side effects		X	
d)	The use of stimuli, errands or procedures which may be experienced as stressful, harmful, or hostile		X	
e)	Any use of materials risky to human beings		X	
4.4 If you answered "Yes", to any of the previously mentioned, explain (attach as an appendix) and justify. Explain, too, what steps you will take to minimise the potential stress/harm. (Please indicate if it is not applicable to your study)				

4.5 Confidentiality of participants' identity				
4.5.1	Will the identity and privacy of participants be protected through pseudonyms or other forms of identification and the use of an	✓ YES	NO	N/A

	informed consent form, which specifies (in a language that participants will understand): <i>Place an 'X or ✓' in the Yes/No box</i>			
4.5.2	Please note that participants should be informed about the following (where applicable)			
a)	The purpose/s of the research and how it is conducted	X		
b)	The researcher, project leader and supervisor's identity, their institutional association and their contact details	X		
c)	Voluntary participation of participants	X		
d)	Making sure that participants' responses will be treated in a confidential manner	X		
e)	Be transparent about any possible limits on confidentiality which may apply	X		
f)	Ensuring participants that they are free to withdraw from the research at any time without any negative or undesirable consequences to themselves	X		
g)	How the findings of the study will have any benefits, or may receive as a result of their participation in the research	X		
4.5.2 Please attach the proposed consent and assent documents prepared to address all the above, if not a full explanation is needed explaining how will participants be respected and protected.				

5. DOCUMENTS TO BE ATTACHED TO THE APPLICATION

<i>The following documents must be attached as a prerequisite for approval to undertake research in the Department (where applicable)</i>	
5.1	LS 262a approved by the FRIC (FEBIT)
5.2	Proof of registration/Funding received and funder reference details
5.3	Data collection instruments as identified under 2.4.4

6. DECLARATION BY THE APPLICANT

I undertake to use the information that I acquire through my research, in a balanced and a responsible manner. I furthermore take note of, and agree to adhere to the following conditions (where applicable):
--

- a) I will schedule my research activities in consultation with the relevant Company or Organisation and research participants (where relevant);
- b) I agree that involvement of participants in my research is voluntary, and that participants have a right to decline to participate;
- c) I will obtain signed consent forms from participants prior to any engagement with them;
- d) I will inform participants about the use of recording devices such as tape-recorders and cameras, and participants will be free to reject them if they wish;
- e) I will honour the right of participants to privacy, anonymity, confidentiality and respect for human dignity at all times. Participants will not be identifiable in any way from the results of my research, unless written consent is obtained otherwise;
- f) All interviews (recordings) will be transcribed verbatim and analysed as per conventional data analysis techniques (example(s) of interview transcript to be included in final dissertation)
- g) I will adhere to the principles of rigorous data collection, analysis and interpretation consistent with the design of the study;
- h) I will keep a data trail for possible auditing purposes as well as the safe keeping of raw data for a period of three years after publication of the results;
- i) I will send the draft research findings to research participants before finalisation, in order to validate the accuracy of the information in the report;
- j) I will not use the resources of the university when I am conducting my research (such as stationery, photocopies, faxes, and telephones) and
- k) I will include a disclaimer in any report, publication or presentation arising from my research, that the findings and recommendations of the study do not represent the views of the Central University of Technology.
- l) Aside from laboratory as well as consumables or materials supplied by the university needed to complete practical projects which might be central to my study (dependent on study field), I will not use the resources of the University when I am conducting my research (such as stationery, photocopies, faxes, and telephones).
- m) All practical artefacts produced in support of my study using the university's laboratories, consumables, and materials will remain the property of the University.
- n) If I supplied my own materials and consumables, I will permit access to all practical projects or artefacts to the University for a period of three (3) years for exhibition purposes.
- o) All data collected for the research (including, but not limited to, completed questionnaires; statistical analysis performed on the data; interview audio-files/transcripts; artefacts/audio-visual materials; documents) will be kept safe at a designated space at the university for a period of at least three years. Computer files will be backed-up and password-protected.

I declare that all statements made in this application are true and accurate. I accept the conditions associated with the granting of approval to conduct research and undertake to abide by them.

STUDENT SIGNATURE / PROJECT LEADER SIGNATURE / SIGNATURE OF RESEARCHER	
DATE	23 August 2023

7. DECLARATION BY SUPERVISOR(S) (where applicable)

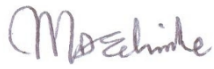
I/We declare that I/we shall oversee the student's adherence to all statements as set out above.

SIGNATURE (Main supervisor)	
-----------------------------	--

SIGNATURE (Co-supervisor)	
DATE	28 August 2023

FOR OFFICIAL USE

APPROVAL OF FEBIT ETHICAL COMMITTEE (FRIC)

<i>Please tick relevant decision and provide conditions/reasons where applicable</i>		
Decision		<i>Please tick relevant option</i>
1.	Application approved	✓
2.	Ethical clearance number FRIC:28/09/2023	
3.	Application approved subject to certain conditions. <i>Specify conditions below</i>	
4.	Application not approved. <i>Provide reasons for non-approval below</i>	
SIGNATURE: Chairperson: Ethics committee		
DATE		28/09/2023

Cc Dean: FEBIT

APPENDIX 3: INTERVIEW TRANSCRIPTS

3.1 CASE 1

Interviewee 1

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Occupational Health and Safety
3. What is your current occupation? Construction Inspector and Safety Co-Ordinator
4. How best can you describe your work experience in your occupation? Performing careful reviews of workmanship, materials, and security honest to preserve tall quality benchmarks. Arranging nitty-gritty reports recording assessment discoveries, deviations, and suggested remedial activities.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "It makes a difference to recognize work related wellbeing and security risks, and dangers. Appropriate controls can be put in to anticipate and discourage events of such occasions."
6. Please take me through the process of reporting safety incidents on-site.. "Inform crisis administrations and archive the subtle elements to depict the worksite occurrence. Distinguish contributing components and inform partners, then utilize a worksite occurrence checklist."
7. What benefits do reporting safety incidents have to a project? "The benefit of reporting incident helps to reduce other types of incidents that may occur again at the construction-site, and it aid the stakeholders to check for any other incidents at site. Helps to finish the project in time and reducing the cost of construction when dealing with safety."
8. What are the enablers of safety incidents reporting on-site? Having a communication tool-such as systems in place for works to report incidents and having an incidents documentation. Having regular review on-site.

9. What challenges do you encounter when reporting safety incidents on-site? "Having a lack of awareness reporting the incidents and having a frustration. Lacking trust in reporting process."

Section C: Digital technologies

10. What is your understanding of digital technologies? My understanding of digital technologies is that it is tools and systems and other platforms. Has information and communication which can lead the process faster.
11. Please take me through the digital technologies you use on-site. We use building information modelling for visualizing the project.
12. What benefits does using digital technologies have to a project? It can improve time and help to minimize errors and help with better planning of the construction project. You can save a lot of time and money and stopping using manual work.
13. What challenges do you encounter when using digital technologies on-site? Challenges include connectivity issues. Such as poor internet at rainy days. Have security risk where there's cybersecurity. It needs semi-skilled and trained people.
14. What digital technologies are used to report site safety incidents? We use mobile apps that can report safety incidents from the smartphone. We also have safety management software.
15. How are digital technologies used to report safety incidents on-sites? We use mobile apps that allow us as workers to quickly report the incidents. You can use your smartphone or your tablet. Some of these apps include photos and videos documentation.

Interviewee 2

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Civil Engineering
3. What is your current occupation? Site General Foreman

4. How best can you describe your work experience in your occupation? My work experience has been challenging because of the work conditions.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "It is important to report safety incidents on-site in order for the health and safety officer to come to rescue; reporting safety incidents also show that you understand the health and safety regulations."
6. Please take me through the process of reporting safety incidents on-site. "We ring a siren as a sign that there is an incident on-site, so that the workers can run to the assembly point for the issue taking place, after that, the health and safety officer will come to take care of the matter at hand."
7. What benefits do reporting safety incidents have to a project? They prevent similar incidents from happening again.
8. What are the enablers of safety incidents reporting on-site? Communicate with other workers when the incident takes place.
9. What challenges do you encounter when reporting safety incidents on-site? I haven't experienced incidents for safety so far.

Section C: Digital technologies

10. What is your understanding of digital technologies? It helps with passing news faster or making work easier.
11. Please take me through the digital technologies you use on-site. We use a walkie-talkie.
12. What benefits does using digital technologies have to a project? "Creates good workspace for the project and good communication among the workers."
13. What challenges do you encounter when using digital technologies on-site? "The walkie-talkie uses batteries, when the walkie-talkie is down; communication becomes low or poor because the walkie-talkie helps us transmit information quickly."

14. What digital technologies are used to report site safety incidents? workers said they use a cell phone.
15. How are digital technologies used to report safety incidents on-sites? We can quickly call for help using cell phones.

Interviewee 3

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Occupational Health and Safety in construction
3. What is your current occupation? Junior Health and Safety Officer
4. How best can you describe your work experience in your occupation? "Ensure compliance without compromise and should score a minimum of 90 percent on monthly audits according to the policy of the company. Checking if everything is on track and communicates with relevant subcontractor supervisor."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting safety incidents on-site is important as it ensures the safety of workers and ways to improve their safety on-site. Section 24 of the Occupational Health and Safety Act states that all incidences that have occurred on-site must be reported immediately or before the shift ends."
6. Please take me through the process of reporting safety incidents on-site. "Incidences on-site are reported to the safety officer or site supervisor. First Aid incidents are treated on-site by a first aider, and major incidents that require medical attention require filling in of necessary documentation like the WCL2 forms, employees are then sent to hospital for further medical evaluation. If employees are hospitalized or booked off work for more than fourteen (14) days, it must be reported to the Labor Department. The incident will be documented and reported to the health and safety consultant."
7. What benefits do reporting safety incidents have to a project? "It encourages workers to report incidents and they become familiar with all the procedures that should be followed

when it comes to reporting incidents to the labour department and the procedures of the company on-site. Through this, they also become aware of potential hazards thus can avoid any future incidents."

8. What are the enablers of safety incidents reporting on-site? "The most important thing are the inductions as they act as a guideline for the employees, it lets them know what to do in case of an incident. Some employees may not know the policy of the company on-site so effective communication makes it possible for employees to report site incidences. 2-way radio systems enable employees to report incidents effectively"
9. What challenges do you encounter when reporting safety incidents on-site? "The challenge is that some employees do not report incidences because they think that it is just a minor incident."

Section C: Digital technologies

10. What is your understanding of digital technologies? "Digital technologies play a huge role and make working easier as they allow you to report incidences to the health and safety consultant electronically, you do not need to draft a report first, it can be drafted after you have reported the incident telephonically."
11. Please take me through the digital technologies you use on-site. "Digital technologies that are used on-site include laptops, cell phones and telephones that we use to communicate and share updates or any documentation that is needed. We also use 2-way radio systems that enable communication amongst employees, and makes communication easier on-site"
12. What benefits does using digital technologies have to a project? "Using digital helps when it comes to having access to information remotely. It also assists in the handling and storage of important documents that might be misplaced or get lost."
13. What challenges do you encounter when using digital technologies on-site? "The computers are sometimes slow and take a while to process information if there is poor connection and you urgently need to send a report, and sometimes it updates on its own. These challenges occur seldomly and not on a regular basis."
14. What digital technologies are used to report site safety incidents? "2-way radio systems are used to report incidents. WhatsApp group"

15. How are digital technologies used to report safety incidents on-sites? "When an incident occurs, anyone who is in possession of a 2-way radio can immediately use it to inform the site supervisor or safety officer about what happened. This ensures faster communication since you don't have to directly go to the relevant person(s) to inform them about the incident. Incidents can also be reported through WhatsApp groups that they have on-site."

Interviewee 4

Section A: Demographic information

1. What is the highest level of education you have completed? Certificate
2. What is the primary field of education you have completed? Construction trades and Safety practices,
3. What is your current occupation? Plumber
4. How best can you describe your work experience in your occupation? "hands-on construction tasks, following safety protocols, and collaborating with team members to complete projects safely and efficiently."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting safety incidents is essential on a construction-site. It involves documenting any accidents, near misses, or hazards that occur during work activities to ensure a safe working environment for everyone on-site."
6. Please take me through the process of reporting safety incidents on-site. "When reporting safety incidents on-site, I follow these steps:
 - Find the safety problem, whether it's an accident, almost-accident, or something risky.
 - Tell my boss or safety person right away.
 - Give info about what happened, like when, where, and who was there.
 - Fill out any forms or papers needed, making sure they're correct.

- Check back later to see what's been done."

7. What benefits do reporting safety incidents have to a project? Reporting safety incidents quickly helps us find and fix dangers fast. This makes things safer, lowers the chances of accidents, and makes the project work better. It also shows where we need better security rules and encourages everyone in the team to care about safety
8. What are the enablers of safety incidents reporting on-site? To make sure people report incidents, we need clear ways to talk, easy forms to fill out, and a work atmosphere where it's okay to speak up about safety worries.
9. What challenges do you encounter when reporting safety incidents on-site? Some people might find it hard to report incidents because they're not fluent in the language, they're scared of what might happen if they speak up, or they just don't know how to report properly.

Section C: Digital technologies

10. What is your understanding of digital technologies? I only know about the digital stuff I use at work, like power tools, measuring tools, and things like smartphones or tablets
11. Please take me through the digital technologies you use on-site. "We use digital technologies including cellphones, laptops, tablets and two way radio systems."
12. What benefits does using digital technologies have to a project? They help by making sure information is reported on time.
13. What challenges do you encounter when using digital technologies on-site? "Some of the challenges we face are network challenges and load shedding with laptops being battery flat."
14. What digital technologies are used to report site safety incidents? Laptops and cellphones
15. How are digital technologies used to report safety incidents on-sites? Laptops via emails and cellphones.

Interviewee 5

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Engineering studies
3. What is your current occupation? Site Manager
4. How best can you describe your work experience in your occupation? "It is simply managing a construction-site in which there is plant, unskilled, semiskilled and skilled personnel."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? According to my understanding this simply is explaining the cause of the incident
6. Please take me through the process of reporting safety incidents on-site. "Detail explanation of what caused the incident including names of people involved and their injuries if there is any."
7. What benefits do reporting safety incidents have to a project? Preventing same mistakes that caused the incident in the first place.
8. What are the enablers of safety incidents reporting on-site? Having a Safety Officer who is competent.
9. What challenges do you encounter when reporting safety incidents on-site? "The biggest challenge we face is when victims lie to protect their fellow colleagues in case of negligence."

Section C: Digital technologies

10. What is your understanding of digital technologies? Devices used to access some information from the internet
11. Please take me through the digital technologies you use on-site. Cell phone, Laptop & Surveying equipment

12. What benefits does using digital technologies have to a project? Quality assurance and Quicker
13. What challenges do you encounter when using digital technologies on-site? "The biggest challenge we face is not having good internet reception as it limits the use of the digital technologies."
14. What digital technologies are used to report site safety incidents? Laptop & Tape recorder
15. How are digital technologies used to report safety incidents on-sites? "Using cell phones, our workers are able to report safety incidents through applications"

Interviewee 6

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Environmental Management
3. What is your current occupation? Health and safety officer
4. How best can you describe your work experience in your occupation? "Challenging, frustrating as you deal with new employees on daily basis, you have to guide, remind and teach them about safety compliance procedures, some have been in the industry for long but when it comes to compliance they don't want to adhere to regulations and as a safety officer you have to enforce the compliance and it becomes unpleasant for some workers. Monitoring and enforcing compliance requires one to be pro-active and manage effectively without fail."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting incidents play a big role in improving safety to our employees, when the incident has been reported incident investigator and management need to compile investigation report, findings to be shared with all employees and remedial must also be in place to avoid re-occurrence

of such. We learn and also remind workers to ensure that safety procedures are being followed."

6. Please take me through the process of reporting safety incidents on-site. "Where incident occurs must be reported on same day to site supervisor and safety officer. First aid treatment will be rendered by First aider and if need be to hospital, WCL2 form will filled and employee will be transported to clinic or hospital. A flash report will be generated on the same day of the incident and sent to the supervisor, contract manager, HSE manager and MD."
7. What benefits do reporting safety incidents have to a project? "Corrective and preventative actions are determined and assessed to ensure immediate compliance and the preventative of future non-compliance by incident investigators and HSE managers."
8. What are the enablers of safety incidents reporting on-site? " We have pocket book that issues to all supervisors to record incidents, they are friendly user not complicated. We also encourage employees to report incidents safety signs displayed all over site regarding report of incidents. On monthly basis we choose best practice employee and receive safety reward for his attitude towards safety practice."
9. What challenges do you encounter when reporting safety incidents on-site? "Some employees or contractors hiding information as they are trying to run away from being accountable for their actions."

Section C: Digital technologies

10. What is your understanding of digital technologies? Digital technology helps to share, store and manage information effectively.
11. Please take me through the digital technologies you use on-site. "On-site our company has generated share folder where all documentation or information is stored, it is easily accessible by request from IT department. It is generated from all departments and whatever information from certain departments you just go on your laptop and access information or save information."
12. What benefits does using digital technologies have to a project? "Everyone who need certain information can remotely access it. Safety storage. Save physical storage of documents that get lost all the time or misplaced."

13. What challenges do you encounter when using digital technologies on-site? Some employees not uploading information as required or expected.
14. What digital technologies are used to report site safety incidents? Site WhatsApp group
15. How are digital technologies used to report safety incidents on-sites? Sharing information via WhatsApp group. Teams meeting.

Interviewee 7

Section A: Demographic information

1. What is the highest level of education you have completed? Certificate
2. What is the primary field of education you have completed? Occupational Health and Safety
3. What is your current occupation? Health, Safety and Environment Officer
4. How best can you describe your work experience in your occupation? "My experience in my occupation is educational and challenging, as there is always shortage of PPE to accommodate all workers on-site and when we finally get hold of it most of the workers do not wear their PPE, they only wear them in my presence. This really makes my work as a safety officer more difficult."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? My understanding of reporting safety incidents is reporting incidents as they happen on-site.
6. Please take me through the process of reporting safety incidents on-site. "Observe an incident area as is, take pictures if possible, ask people who were close (eye witness) and the person involved in an incident, then make a written report stating location, time, date and how the incident happened."
7. What benefits do reporting safety incidents have to a project? "Reporting safety incident alerts the reporter of some safety hazards that were not noticed before and can be avoided in the future."

8. What are the enablers of safety incidents reporting on-site? Cooperative people and evidence (pictures)
9. What challenges do you encounter when reporting safety incidents on-site? "People have a tendency to lie, sometimes incidents reports are not done immediately, so people temper with the area making it difficult to draw conclusions."

Section C: Digital technologies

10. What is your understanding of digital technologies? It is a form of technology that allows storage of virtual information.
11. Please take me through the digital technologies you use on-site. "Personal cellphones and computers for communication. Cameras for taking videos and pictures for evidence."
12. What benefits does using digital technologies have to a project? "Safety storage where everyone can access information they need remotely. Also, one can always refer back, which sometimes makes them aware of things not recognized then."
13. What challenges do you encounter when using digital technologies on-site? "Technology keeps evolving, some computers now have OS that I do not know how to use."
14. What digital technologies are used to report site safety incidents? Computers, cellphones and cameras.
15. How are digital technologies used to report safety incidents on-sites? "Sharing incidents information through whatsapp using cellphone, making calls and attending Microsoft teams meetings."

Interviewee 8

Section A: Demographic information

1. What is the highest level of education you have completed? Post graduate Diploma
2. What is the primary field of education you have completed? Construction Health and Safety Management.
3. What is your current occupation? Junior wetworks foreman

4. How best can you describe your work experience in your occupation? "Its challenging most of the time due to non-compliance from the subcontractors. Most of the sub-contractors in my workplace have no educational background, so it is hard for them to understand the regulations in terms of safety and training."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "An investigation must be done before reporting any incidents, incident investigation must be done by someone who has training."
6. Please take me through the process of reporting safety incidents on-site. "Conduct incident investigation. Report it. Analyse the incident. Education and training in terms of safety. Find ways to mitigate incidents on-site."
7. What benefits do reporting safety incidents have to a project? "Keeps you aware of your weakness (what to do and not to do) Safety awareness. Helps everyone to be alert at all times."
8. What are the enablers of safety incidents reporting on-site? "Having enough safety reps on-site and also people who understand safety and wellbeing."
9. What challenges do you encounter when reporting safety incidents on-site? No challenges so far.

Section C: Digital technologies

10. What is your understanding of digital technologies? Wearable technology e.g. (smart vests, smartwatches and drones).
11. Please take me through the digital technologies you use on-site. "As a construction-site collectively, there are no technologies or wearable technology "
12. What benefits does using digital technologies have to a project? No experience
13. What challenges do you encounter when using digital technologies on-site? No experience
14. What digital technologies are used to report site safety incidents? Computers, cellphones

15. How are digital technologies used to report safety incidents on-sites? "A cell phone is utilized to call an ambulance.
16. A laptop is used to write a report and narrate incidents to appropriate/relevant individuals based on the nature of the situation."

Interviewee 9

Section A: Demographic information

1. What is the highest level of education you have completed? Basic Education - High School
2. What is the primary field of education you have completed? -
3. What is your current occupation? Electrical workers
4. How best can you describe your work experience in your occupation? "It has been a month since i worked as an electrician so i can't really say much about work experience."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? Reporting safety ensures safety working.
6. Please take me through the process of reporting safety incidents on-site. approach the health and safety officer so that they will call an ambulance.
7. What benefits do reporting safety incidents have to a project? It prevents us from severe injuries.
8. What are the enablers of safety incidents reporting on-site? "The health and safety office is close by I can easily access the health and safety officer."
9. What challenges do you encounter when reporting safety incidents on-site? Haven't experienced incidents for safety.

Section C: Digital technologies

10. What is your understanding of digital technologies? They help with solving problems.

11. Please take me through the digital technologies you use on-site. We use lasers to measure the distance and to mark points.
12. What benefits does using digital technologies have to a project? Makes our jobs easier for us.
13. What challenges do you encounter when using digital technologies on-site? haven't encountered challenges when using digital technologies.
14. What digital technologies are used to report site safety incidents? We use a cell phone.
15. How are digital technologies used to report safety incidents on-sites? We do phone calls.

Interviewee 10

Section A: Demographic information

1. What is the highest level of education you have completed? Basic Education - High School
2. What is the primary field of education you have completed? -
3. What is your current occupation? Bricklaying workers
4. How best can you describe your work experience in your occupation? very experienced with bricks and building.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? Safety officers are responsible for ensuring safety on-site.
6. Please take me through the process of reporting safety incidents on-site. I approach the health and safety officer regarding the incident for help.
7. What benefits do reporting safety incidents have to a project? It helps keep people safe on-site.
8. What are the enablers of safety incidents reporting on-site? Nearby and accessible safety office.

9. What challenges do you encounter when reporting safety incidents on-site? Haven't experienced incidents for safety.

Section C: Digital technologies

10. What is your understanding of digital technologies? Digital technologies help with better communication.
11. Please take me through the digital technologies you use on-site. None have been used so far.
12. What benefits does using digital technologies have to a project? No experience
13. What challenges do you encounter when using digital technologies on-site? No challenges so far.
14. What digital technologies are used to report site safety incidents? Cellphones.
15. How are digital technologies used to report safety incidents on-sites? We call for help.

3.2 CASE 2

Interviewee 11

Section A: Demographic information

1. What is the highest level of education you have completed? Honours Degree
2. What is the primary field of education you have completed? Quantity Surveying
3. What is your current occupation? Assistant Project manager
4. How best can you describe your work experience in your occupation? "The level of experience is intermediate based on the number of the previous project done before."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? They make people aware of hazardous that might occur on a daily basis.

6. Please take me through the process of reporting safety incidents on-site. "Properly documenting injuries or illness that may occur while the project being done."
7. What benefits do reporting safety incidents have to a project? "Minimize the accident or incidents from occurring again and therefore saves cost for such, for example should there be an accident on-site where there has not been an inspection for a scaffold people gets injured, this will cost the company as they will be responsible for covering medical expenses of the injured and will also experience a decline in production due to shortage of labour."
8. What are the enablers of safety incidents reporting on-site? A good and healthy working environment means that people on-site will be able to report hazards, injuries and accidents.
9. What challenges do you encounter when reporting safety incidents on-site? "Language barrier, sometimes you find that the worker knows and understand a certain language different from the language of the person he//she is reporting to about safety."

Section C: Digital technologies

10. What is your understanding of digital technologies? "These are technologies that assist in speeding up the work, to meet project deadlines and to save costs."
11. Please take me through the digital technologies you use on-site. Digital laser measuring tape and a digital total station.
12. What benefits does using digital technologies have to a project? "The benefit of the digital technology on-site is that it saves time and makes our work easier. One most important benefit of digital total station is that it provides high accurate measurements than other surveying instruments."
13. What challenges do you encounter when using digital technologies on-site? "Often issues we encounter on-site with the Digital laser measuring tape and a digital total station is technical problems the devices sometimes encounter fault that affect the operation and it causes delays."
14. What digital technologies are used to report site safety incidents? "On our site we have an online reporting portal or a software, called site docs. But normal in an urgent case we use WhatsApp or send safety incident reports via text messages"

15. How are digital technologies used to report safety incidents on-sites? With the use of the software, we are able log in and send the report from any location with internet so this is an efficient way to report safety incidents

Interviewee 12

Section A: Demographic information

1. What is the highest level of education you have completed? Baccalaureus Technologies
2. What is the primary field of education you have completed? Civil Engineering
3. What is your current occupation? Engineer
4. How best can you describe your work experience in your occupation? 30 years experience as a civil engineer.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "All information regarding the incident needs to be uploaded to COIDA (Compensation for Occupational Injuries and Diseases Act)."
6. Please take me through the process of reporting safety incidents on-site. "First the employee needs to be tended to. This includes getting them to a hospital and ensuring they get medical attention. After that the paper work starts. All the information of the employee and the Employer needs to be filled out. Then you need to give all the information about where and when the accident happened including what time and what they were doing at that moment that the incident accrued. Then you need to add all the documents into the incident report, a copy of their ID and the employers ID, and medical report, and statements from witnesses as well as the employee themselves and bank statement showing that the company paid for the medical expenses. This report is sent to COIDA and then they evaluate the report and in most cases pay compensation to the employee that was injured."
7. What benefits do reporting safety incidents have to a project? The injured employee gets compensation.

8. What are the enablers of safety incidents reporting on-site? "Technology make it possible as you can call the needed emergency response personnel and all documents are send in through and online website."
9. What challenges do you encounter when reporting safety incidents on-site? "It is a struggle to get all the documents that are required like getting the doctor to send the medical report. In many cases you don't know exactly wat they were doing or at what time the incident happened, because in an emergency you focus on getting the injured what they need not what time it is and what they were doing."

Section C: Digital technologies

10. What is your understanding of digital technologies? "It is tools and systems that help to lessen the work and to make the overall work easier."
11. Please take me through the digital technologies you use on-site. "We use measuring instruments like a laser tape measure and we use lasers to ensure we are working on a straight line. Drones are used to get a bird's eye view of sites. We use digital scales to measure the weight of materials."
12. What benefits does using digital technologies have to a project? It ensures that you work more precise and it lessens the risk of making mistakes.
13. What challenges do you encounter when using digital technologies on-site? "A lot of areas where new development happens the signal is very bad and it isn't always possible to have internet connection on-site."
14. What digital technologies are used to report site safety incidents? "Online forms need to be filled out and phone calls are made to communicate that there is an emergency."
15. How are digital technologies used to report safety incidents on-sites? An online form is filled out and documents are uploaded to and website.

Interviewee 13

Section A: Demographic information

1. What is the highest level of education you have completed? Tractor Loader Backhoe - Certificate
2. What is the primary field of education you have completed? Heavy Equipment Operator
3. What is your current occupation? Tractor Loader Backhoe Operator
4. How best can you describe your work experience in your occupation? My job is very hands on and need a lot of concentration.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? That it is important especially when serious accidents occurred.
6. Please take me through the process of reporting safety incidents on-site. "If one of my colleagues get injured everything must stop and I will go get my supervisor but if they are not around, I will go straight to the office and get a health and safety officer"
7. What benefits do reporting safety incidents have to a project? It informs those who are in charge about how dangerous our work is.
8. What are the enablers of safety incidents reporting on-site? There is a mobile office nearby, so I can inform them.
9. What challenges do you encounter when reporting safety incidents on-site? I have not had a challenge since the safety officers are always on-site.

Section C: Digital technologies

10. What is your understanding of digital technologies? Things that have to deal with computers.
11. Please take me through the digital technologies you use on-site. Well, there is not a lot I have seen but I have seen drones on-site.
12. What benefits does using digital technologies have to a project? I think they help with things to work faster.
13. What challenges do you encounter when using digital technologies on-site? Technology is complicated for someone like me so not understanding how it works will be frustrating.

14. What digital technologies are used to report site safety incidents? I haven't seen any digital technology they use two-way radios.
15. How are digital technologies used to report safety incidents on-sites? Maybe if someone gets hurt it would alert people faster.

Interviewee 14

Section A: Demographic information

1. What is the highest level of education you have completed? National Diploma
2. What is the primary field of education you have completed? Safety Management
3. What is your current occupation? Health and Safety Representative
4. How best can you describe your work experience in your occupation? "Safety is really important in construction work. But making sure everyone follows safety rules isn't always simple. People have different ways they think safety should be done. But the rules are there and we can't change them. We need a system to make sure everyone follows the rules. People need to be trained regularly so they know what safety is and how to do it right at work. This helps prevent accidents, injuries, and even deaths."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting safety incidents is very important as it forms part of our investigation and ensures how we know the root cause of the incident, to use the report to ensure that we eliminate or mitigate that particular cause/hazard/risk to avoid future reoccurrences."
6. Please take me through the process of reporting safety incidents on-site.. First there must be clear explanations of the incident, investigation of the potential and identified causes, provision of solutions to the incident and monitoring to guarantee safety on the site.
7. What benefits do reporting safety incidents have to a project? "It helps to be aware of similar incidents that might arise in the future, and we are able to prevent them and improve the safety of the site and any other construction."

8. What are the enablers of safety incidents reporting on-site? "Knowing who to report to in case of emergencies and the engagement of the management team, this encourages the workers to report as some might be scared to do so but when the management is involved it becomes easier to report."
9. What challenges do you encounter when reporting safety incidents on-site? "Times have changed and we are in our 4th industrial revolution where everything is online. Also, we still have a filing system, however things have been made readily available online."

Section C: Digital technologies

10. What is your understanding of digital technologies? I can say that digital technologies refer to the scientific and smart online and internet tools that we use to make our work easier and more manageable.
11. Please take me through the digital technologies you use on-site. "We use what we call SHAREPOINT where we get all our SHEQ MHSA documentation from SOPs, to MSDSs and all vital documentation. We use this system to report incidents which people who have access to this system can also see all the reports made."
12. What benefits does using digital technologies have to a project? "Everything is readily accessible. This prevents delays in my submissions that are supposed to be done. Safety files are audited accurately ensuring that there is nothing left behind that can cause an issue going forward."
13. What challenges do you encounter when using digital technologies on-site? "The issue would always be network as I had mentioned that everything is accessible online. When the network fails, work delays. When there are upgrades, this system is inaccessible."
14. What digital technologies are used to report site safety incidents? SharePoint
15. How are digital technologies used to report safety incidents on-sites? "We use a platform such as SharePoint for convenience and to report incidents at work. This helps us handle investigations swiftly by enhancing transparency at work."

Interviewee 15

Section A: Demographic information

1. What is the highest level of education you have completed? Certificate
2. What is the primary field of education you have completed? Construction and Project Management.
3. What is your current occupation? Construction Supervisor
4. How best can you describe your work experience in your occupation? "It has been challenging at times, but all the experience I got till this point has made me a better leader and taught me a lot of lessons. It has been a privilege to be able to climb the ranks within the company with the experience I accumulated."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "It is necessary to report safety incidents immediately to ensure the right steps are taken to rectify the incident and to ensure it does not happen again."
6. Please take me through the process of reporting safety incidents on-site. "Report the incident to the safety officer and supervisor. Take note of any injuries or damages to assist the injured person. Take statements of the incident from witnesses and the person/persons involved. Take action to ensure the same thing does not happen in the future. Compile a close out report."
7. What benefits do reporting safety incidents have to a project? "It ensures that the same incident does not occur again, and it helps to sharpen up the safety measurements implemented."
8. What are the enablers of safety incidents reporting on-site? "It is important to make sure people that are working on-site to know who to go to report an incident and feel free to do so, also ensure there is a system in place to make reporting as effortless as possible."
9. What challenges do you encounter when reporting safety incidents on-site? "People sometimes do not feel the need to report incidents, because they are afraid of getting in trouble or feel it is not necessary to report it."

Section C: Digital technologies

10. What is your understanding of digital technologies? I have a fairly good understanding of digital technologies.
11. Please take me through the digital technologies you use on-site. "On-site we use Microsoft office, Adobe to read plans, and synergy where all the engineers and architects upload there plans for us to download and use."
12. What benefits does using digital technologies have to a project? "It makes it a lot easier to communicate with the project team at any time to ensure we get answers as soon as possible, it also ensures we can access all plans when we need them and do not have to wait for hard copies to be sent to site."
13. What challenges do you encounter when using digital technologies on-site? "As with all technologies they can be slow at times that can be challenging, or when they are completely off it makes it difficult to access the information we need."
14. What digital technologies are used to report site safety incidents? We manly use email to report safety incidents.
15. How are digital technologies used to report safety incidents on-sites? "As soon as incidents occur a simple report is emailed to all party's involved in the project, where after a detailed report end close out report will follow, with steps to improve."

Interviewee 16

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Construction Management
3. What is your current occupation? Trades Supervisor
4. How best can you describe your work experience in your occupation? Challenging and continuously learning.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "To bring attention to incidents that have harmed, currently harming or may harm workers on-site in order to mitigate them."
6. Please take me through the process of reporting safety incidents on-site. "The OHS rep present on-site is made aware of the said incident who then report to the OHS officer."
7. What benefits do reporting safety incidents have to a project? "Minimise the risk of injury occurrence on-site and prevent the risk of site being closed therefore delaying the project."
8. What are the enablers of safety incidents reporting on-site? Having witnesses and proof for details.
9. What challenges do you encounter when reporting safety incidents on-site? Lack of credible witnesses and sufficient proof for details.

Section C: Digital technologies

10. What is your understanding of digital technologies? These are modern use of computerized systems meant to increase production.
11. Please take me through the digital technologies you use on-site. CCTV, emails, MS office tools, breathalyser, radio, etc
12. What benefits does using digital technologies have to a project? Increased work rate, less theft, improved communication, increased productivity
13. What challenges do you encounter when using digital technologies on-site? Not enough skilled workers to use and operate digital technologies on-site.
14. What digital technologies are used to report site safety incidents? Emails and camera/photos or 2 ways - radios
15. How are digital technologies used to report safety incidents on-sites? They act as means of communication to pass message from one person to the other.

Interviewee 17

Section A: Demographic information

1. What is the highest level of education you have completed? Basic Education
2. What is the primary field of education you have completed? -
3. What is your current occupation? Equipment Operator
4. How best can you describe your work experience in your occupation? "My experience in the construction industry has been a very good one even though there are challenges. It is a great feeling to know that as a skilled operator I play a crucial role in ensuring the project's success."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Because I work with safety sometimes, I believe that it is important to report any incident so that investigations can be made, and control measure be implemented to avoid such in the future."
6. Please take me through the process of reporting safety incidents on-site. "When an incident occurs on-site, we report the matter to a higher position safety officer which is health and safety manager, after reporting to him the issue is reported to the construction manager."
7. What benefits do reporting safety incidents have to a project? Reporting incidents helps the injured to get proper medical help immediately to avoid any further complications
8. What are the enablers of safety incidents reporting on-site? Proper communication
9. What challenges do you encounter when reporting safety incidents on-site? "Sometimes there is not enough details on how an incident has occurred making it difficult for investigations to be carried through or making the investigations to take long."

Section C: Digital technologies

10. What is your understanding of digital technologies? It is the use of phones, laptops, computers, or walkie-talkie to communicate with others.

11. Please take me through the digital technologies you use on-site. While on-site, we use walkie-talkies and laptops and personal cell phones.
12. What benefits does using digital technologies have to a project? "Information is communicated thoroughly and reaches everyone and in case of reporting incidences, it works as a faster method."
13. What challenges do you encounter when using digital technologies on-site? The digital technologies we use their battery dies or becomes low that time you may find there's no power on-site and sometimes it can network problems.
14. What digital technologies are used to report site safety incidents? Walkie talkie, cell phones and laptops.
15. How are digital technologies used to report safety incidents on-sites? "By making phone calls by cell phones, sending emails via laptops or communication through walkie talkie."

Interviewee 18

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Civil Engineering
3. What is your current occupation? Site Administrator
4. How best can you describe your work experience in your occupation? I would describe my work experience as very educational and intriguing. Even today, I still see myself as a student of the construction industry. It's always changing, and each project is unique, which makes it really interesting.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? I understand that as the health and safety officer on-site, it's crucial to assess the situation thoroughly before taking any further steps. Once I've analyzed the incident's scope, I start by following the required procedures for reporting safety incidents.

6. Please take me through the process of reporting safety incidents on-site. I believe that one of the most crucial aspects of safety incident reporting is the involvement of the general laborers. Sometimes, they might not report an incident that occurred on-site because of disobedience or not following the site's health and safety rules. This can make it challenging to deal with the risks involved. That's why I always encourage workers to report any incidents they witness. This makes it easier for us to identify and address the factors leading to incidents on-site. Whenever an incident happens, our first priority is to secure the area to prevent further injuries. Then, we attend to any injuries as quickly as possible. After that, we conduct a safety analysis. If necessary, we contact emergency services for medical assistance. Additionally, we hold regular toolbox meetings to discuss safety procedures and address any concerns raised by the workers.
7. What benefits do reporting safety incidents have to a project? I firmly believe that when workers can report incidents on-site, it not only enables us to take action promptly but also helps us prevent similar incidents from happening again. By having a system in place where workers can easily report what they observe, we can identify the root causes of incidents and implement measures to avoid them in the future. This proactive approach is essential for maintaining a safe working environment for everyone.
8. What are the enablers of safety incidents reporting on-site? "Training the workers about the health and safety practices on-site and workers reporting incidents are deemed as very effective ways of making site incident reporting possible but also creating a conducive environment for incident reporting on-site is also significant and you create this environment by giving feedback and solutions to workers who reported hazardous conditions on-site."
9. What challenges do you encounter when reporting safety incidents on-site? One of the challenges I face on-site is dealing with incidents that go unreported because workers are afraid of losing their jobs. This fear often stems from situations where workers are using the wrong tools for a task or not using PPE correctly. It's important to address this issue and create a culture where workers feel safe to report incidents without fearing repercussions. This way, we can ensure that safety protocols are followed correctly and prevent accidents from occurring due to negligence.

Section C: Digital technologies

10. What is your understanding of digital technologies? I understand the value of digital technologies like cellphones and laptops, especially with Microsoft apps such as Word and MS Projects. As a site administrator, these tools make planning much more convenient. I can easily organize tasks, create schedules, and communicate with team members efficiently. Additionally, as a quantity surveyor's assistant, Excel is a game-changer. It simplifies tasks like calculations, data organization, and budget tracking, making my job much easier and more effective.
11. Please take me through the digital technologies you use on-site. "We rely heavily on cellphones and laptops for communication on-site, and Microsoft apps play a crucial role in making our work easier and better planned for optimal efficiency. Using apps like Word and MS Projects helps us streamline tasks and keep everyone on the same page. Additionally, CAD-designed plans and sections are much easier to interpret. Their clarity and precision aid in our understanding and execution of projects on-site."
12. What benefits does using digital technologies have to a project? "cellphones make it easier to communicate and its faster because you can contact someone immediately to tell them to read your email pertaining clarity on the drawings as an example and that when it comes to planning. Microsoft apps have made it easier to manage the project and that CAD has made it easier to interpret the designs. What we can take from this is that digital technologies increase efficiency and productivity."
13. What challenges do you encounter when using digital technologies on-site? "Learning to use the Microsoft apps. Network on-site can sometimes be a problem for some service providers."
14. What digital technologies are used to report site safety incidents? Cellphone and laptops
15. How are digital technologies used to report safety incidents on-sites? "We use our cellphones to quickly contact an ambulance in case of an emergency on-site. Then, we utilize Word on our laptops to type up detailed incident reports. Depending on the severity and nature of the incident, we send out emails to the relevant parties, informing them about what happened and any necessary follow-up actions. This ensures timely communication and appropriate response to the incident."

Interviewee 19

Section A: Demographic information

1. What is the highest level of education you have completed? Certificate.
2. What is the primary field of education you have completed? Electrical Engineering
3. What is your current occupation? Electrician
4. How best can you describe your work experience in your occupation? Challenging and interesting at the same time because you have to use critical thinking.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? Reporting is always the first thing to do when an incident occurs to inform the safety people. When there's an accident, we call Health and Safety Office.
6. Please take me through the process of reporting safety incidents on-site. If incident occurs there are health and safety people and a foreman and first aid kit. The safety officers inspect if the conditions are harmful or good.
7. What benefits do reporting safety incidents have to a project? It benefits the project because the delays are avoided. It helps people to be safe.
8. What are the enablers of safety incidents reporting on-site? Knowing where to go when accidents happen and having safety people on-site.
9. What challenges do you encounter when reporting safety incidents on-site? It minimizes high chances of injury, no challenges.

Section C: Digital technologies

10. What is your understanding of digital technologies? Work on screens and automated.
11. Please take me through the digital technologies you use on-site.
12. What benefits does using digital technologies have to a project? Laser level used to measure and mark point.

13. What challenges do you encounter when using digital technologies on-site?
Sometimes batteries get flat.
14. What digital technologies are used to report site safety incidents? Cellphones.
15. How are digital technologies used to report safety incidents on-sites? Used to take photos for evidence.

3.3 CASE 3

Interviewee 20

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma.
2. What is the primary field of education you have completed? Engineering Science and Technology.
3. What is your current occupation? Project Specialist.
4. How best can you describe your work experience in your occupation? Challenging (needs a lot of research and learning).

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "The safety incident need to be reported, and investigation presentation then needs to be done to the stake holders. There are PTOs and Risk verifications that needs to be done regularly to ensure that all work on-site is executed safely and successfully."
6. Please take me through the process of reporting safety incidents on-site. "Incident happens, report to immediate supervisor. If the person cannot move make sure the person is stable, if you have first aid framing. If not call for help (OCC to be called, sent to the EMS sent to attend the incident, clinic for assessment, Doctors recommendations"
7. What benefits do reporting safety incidents have to a project? "Reporting an incident eliminates the possibility of a fidelity on-site and raises awareness to all the employees."
8. What are the enablers of safety incidents reporting on-site? "Open culture and all the tools to report and structures of reporting."

9. What challenges do you encounter when reporting safety incidents on-site? People are afraid to report as they think they will be victimized and fired.

Section C: Digital technologies

10. What is your understanding of digital technologies? Electronic systems that store, process and transmit data.
11. Please take me through the digital technologies you use on-site. Pivot for recording safety incidents and PDS sensors
12. What benefits does using digital technologies have to a project? Creates a data base that is easy accessible also makes it easy to share information with all personnel and the lessons that can be learnt.
13. What challenges do you encounter when using digital technologies on-site? When the network is down, using the app becomes difficult.
14. What digital technologies are used to report site safety incidents? Pivot and PDS.
15. How are digital technologies used to report safety incidents on-sites? "They are not used to report but rather log after it has been reported so that the incident can be tracked investigated accordingly"

Interviewee 21

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Civil Engineering
3. What is your current occupation? Civil Engineer
4. How best can you describe your work experience in your occupation? "My responsibilities include scheduling and overseeing daily activities on-site, ensuring adherence to set project objectives, milestones, and safety protocols, managing, and supervising the workforce, coordinating with contractors, and ensuring timely project progress."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? It is a crucial aspect of maintaining a safe working environment on construction-sites. For the Civil Lab, it involves documenting and communicating any accidents, near-misses, or hazardous situations that occur during the construction process on the digital platform provided and documenting all aspects associated with the incident and reporting as required.
6. Please take me through the process of reporting safety incidents on-site. "typically involves immediately securing the affected area and providing necessary first aid to any injured personnel. Next, I would gather all relevant information, including details of the incident, witnesses, and evidence like photographs or video footage. This information is then reported to the site safety manager and relevant authorities and superiors directly above me through established reporting channels, which may involve filling out incident report forms and using digital reporting tools"
7. What benefits do reporting safety incidents have to a project? "Identifying potential hazards taking corrective and appropriate measures to prevent future occurrences, maintaining compliance and adherence with safety regulations, ensuring a culture of safety awareness is fostered among workers. Analyzing existing incident patterns, implementing improved safety protocols accordingly, and potentially reducing project delays & costs associated with accidents or worse, the complete closure of the site"
8. What are the enablers of safety incidents reporting on-site? "clear reporting procedures and channels in place, providing proper induction to workers on Incident reporting, fostering a culture of transparency and accountability, and ensuring the availability of necessary resources (the use of ArcGIS app on-site to ensure timeous reporting of incidents)"
9. What challenges do you encounter when reporting safety incidents on-site? "Ensuring accurate and timely reporting, overcoming reluctance from workers to report incidents due to fear of repercussions, dealing with language barriers or literacy issues among the workforces"

Section C: Digital technologies

10. What is your understanding of digital technologies? "Electronic tools, systems, and devices that are utilized on-sites for data processing and for communication, at civil lab this refers to the ArcGIS app we must record our daily site diaries, quantities and evaluation of works done."
11. Please take me through the digital technologies you use on-site. "The ArcGIS app utilized by the civil lab allows for the personalization of the different surveys on the app to suit the different types of work done on-site. On our site, we have processes to repair the existing base, to repair the existing pavement surface that differ from completely removing the existing surface for a stretch of the road to either applying a binding slurry seal to only seal a fatigued stretch of the surface. The digital technology we use accommodates all these and takes geographical locations of works done and the quantities (in meters squared and volumes) to ensure simplified recording of Quantities, progression and if necessary, it allows us to go back and review how the road responds to prevailing conditions. It allows for enhanced safety through real-time monitoring and hazard detection, accurate data collection and analysis for decision-making, and reduced project costs and timelines through optimized processes and resource management."
12. What benefits does using digital technologies have to a project? Safety incident mapping
Progress monitoring Spatial data management Site mapping and visualization
13. What challenges do you encounter when using digital technologies on-site? "Ensuring data accuracy and quality, as the effectiveness of ArcGIS relies heavily on accurate spatial data input, can be difficult on dynamic sites. Seamlessly integrating ArcGIS with other digital platforms, e.g., project scheduling is done using Project Libre and there is not a way to enable collaboration and sharing of information between the two apps. Reliable connectivity to meet infrastructure requirements across sites, especially in remote areas, poses challenges. Some sites have poor connectivity, and it makes it impossible to utilize these appropriately. There is a lack of adequate training in implementing this resource successfully."
14. What digital technologies are used to report site safety incidents? ArcGIS
15. How are digital technologies used to report safety incidents on-sites? "The process typically starts with a worker or supervisor using a mobile app or web interface to log the

details of the incident, including location information. If the incident occurred at a specific coordinate on the site, they could use the ArcGIS mapping interface to pinpoint the exact location, which is then automatically captured in the incident report. Relevant photos, videos, or other media can also be attached to the report"

Interviewee 22

Section A: Demographic information

1. What is the highest level of education you have completed? Baccalaureus Technologies
2. What is the primary field of education you have completed? Safety Management
3. What is your current occupation? Occupational Health and Safety Practitioner
4. How best can you describe your work experience in your occupation? "have experience both in the public and the private sector. Both operate differently, the private sector is profit driven and at times cuts safety for productivity without being mindful of the consequences of such. The public sector cuts down on implementing safety by bulldozing at times, instead of adhering to the set prescriptions."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting of Safety Incidents, is fundamental in any organization. Reporting incidents assists organizations to develop measures to prevent possible injury or loss of a life for others."
6. Please take me through the process of reporting safety incidents on-site. "The process of reporting incidents is verbal, then an incident report will be filled up. If their incident is severe the laws necessitate us to report to the Department of Employment & Labour as per the applicable act."
7. What benefits do reporting safety incidents have to a project? "The benefits of reporting incidents are various, like preventing future incidents, saving company money, the company's reputation is preserved, loss of production for the organization, the company adhering to the laws of the country."

8. What are the enablers of safety incidents reporting on-site? "The client representatives that are mandated by the terms of the contract that are used as mechanisms to ensure incidents are reported, having agents that are responsible for auditing and playing oversight roles to monitor compliance."
9. What challenges do you encounter when reporting safety incidents on-site? "The total disregard of such incidents described as minor, when essentially it could be detrimental in the future. The client representatives that are mandated by the terms of the contract that are used as mechanisms to ensure incidents are reported, having agents that are responsible for auditing and playing oversight roles to monitor compliance."

Section C: Digital technologies

10. What is your understanding of digital technologies? "Digital technology are the tools of trade, my understanding is that it is these devices we use to execute our work."
11. Please take me through the digital technologies you use on-site. Laptops/ Desktops, Flash drives/ USBs, Servers to store documents and phones
12. What benefits does using digital technologies have to a project? "The benefits make it easier to communicate internally and external. The communication is almost instantaneous and you are able to store documents online, easier to retrieve when you want to go back."
13. What challenges do you encounter when using digital technologies on-site? "The phishing by scammers, network challenges and distortion when communicating via email."
14. What digital technologies are used to report site safety incidents? "We use Comp Easy which is easier to report incidents/ accidents to the Department of labour."
15. How are digital technologies used to report safety incidents on-sites?
"Information is gathered such as reports of an accident, medical reports by the medical practitioner (First, progress and final reports) submitted via Comp Easy, follow ups are done with the administrators of COID."

Interviewee 23

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Construction
3. What is your current occupation? Senior Site Agent
4. How best can you describe your work experience in your occupation? "Satisfying because you are creating something. However, high workload because of multiple projects"

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? It involves all documents required to properly address any safety issue that occurred on-site. Any small or big injuries need to be reported
6. Please take me through the process of reporting safety incidents on-site. "All team roles players or individuals involved with the project need to initially have a letter of good standing which helps when an incidence occurs. A safety induction takes place with individuals to let them know what is happening on-site on that specific day. A daily toolbox talk is done by the safety officer where the current risks on-site are identified."
7. What benefits do reporting safety incidents have to a project? "The most important benefit is human life, the main priority on-site is the safety and wellbeing of everyone included in the project."
8. What are the enablers of safety incidents reporting on-site? "Cameras and Walkie-Talkie on-site can make it possible to report an incident on-site"
9. What challenges do you encounter when reporting safety incidents on-site? "A challenge that has occurred in practice is of someone on-site who gets injured and gets taken to the hospital, but it is discovered that the individuals' letter of good standing is fake which is a problem."

Section C: Digital technologies

10. What is your understanding of digital technologies? Digital technologies are tools that make the objectives we have on-site much easier than it is
11. Please take me through the digital technologies you use on-site. "The first digital object is the Lazer Level and we have a tripod which connects to a satellite to receive coordinates from the user which is most of the time the Land Surveyor, on where to plot accurately on a site. There are drones which are used to track the progress of a project from start to finish from a high or top point of view. The last object is a tripod that digitally maps 3D motion pictures of rooms in a building."
12. What benefits does using digital technologies have to a project? The Land surveyor can produce accurate results regarding the Lazor Level. The drone can bring satisfaction by observing how your building or projects develops over a period.
13. What challenges do you encounter when using digital technologies on-site? Digital transformation can be costly.
14. What digital technologies are used to report site safety incidents? Camera.
15. How are digital technologies used to report safety incidents on-sites? "Cameras are generally installed and used to report site safety incidents cause it provides evidence on how the incident occurred and who might be the responsible for the incident"

Interviewee 24

Section A: Demographic information

1. What is the highest level of education you have completed? Diploma
2. What is the primary field of education you have completed? Civil Engineering
3. What is your current occupation? Health and Safety Officer
4. How best can you describe your work experience in your occupation? "am responsible for developing and implementing OH&s and risk management initiatives, both site-specific and across the business. My experience in training has really developed my communication skills enabling me to communicate well with other people or other professionals."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? "Reporting an incident is an important part of an effective occupational health & programme as it involves capturing and managing the incident that occurred on-site, thorough investigations are made to have solutions. This allows us to better prepare and prevent such occurrences. in the future."
6. Please take me through the process of reporting safety incidents on-site. "When reporting the incident, we start off by identifying people who were involved or affected in the incident. We then record their names, their occupation and identify all the witnesses and take their statements. We then note the time and location the incident and details on how the incident occurred. Thorough investigation will then be made."
7. What benefits do reporting safety incidents have to a project? "Reporting safety incidents allows us to improve on the safety measures taken and implementing more safe procedures. It also helps us to reduce the possible risks."
8. What are the enablers of safety incidents reporting on-site? Having enough resources to conduct reports. Workers who are not afraid to be interviewed.
9. What challenges do you encounter when reporting safety incidents on-site? Time constraints, Fear of reprisal and lack of educated staff members.

Section C: Digital technologies

10. What is your understanding of digital technologies? They are electronic tools, devices and systems that process, transmit and store data.
11. Please take me through the digital technologies you use on-site. Building Information Modelling.
12. What benefits does using digital technologies have to a project? "It has enabled us to access information rapidly. Share resources and keep track of tasks of the project."
13. What challenges do you encounter when using digital technologies on-site? Poor Internet network connections and low batteries with no electricity or energy backup.
14. What digital technologies are used to report site safety incidents? Incident Reporting Software.

15. How are digital technologies used to report safety incidents on-sites? It allows for the collection and analysis from reported incidents.

Interviewee 25

Section A: Demographic information

1. What is the highest level of education you have completed? Baccalaureus Technologies
2. What is the primary field of education you have completed? Construction Management
3. What is your current occupation? Project Manager Minor Works.
4. How best can you describe your work experience in your occupation? "Project manager on works below 1 million, closely working with professional quantity surveyor, architects etc. In projects below R250 000 compiling all procurement documents adjudicate and act as the project architect, project manager and quantity surveyor."

a. Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? Documenting and informing of any cases of harm or injury that can happen to workers on-site.
6. Please take me through the process of reporting safety incidents on-site. "The health and safety manager of the contractor on-site will inform the principal occupational health and safety officer, and he or she will write his report according to how the situation was assessed on-site as well as further to assessing the degree of injury on-site and determining whether the person will then need to stop working, hospitalized, or formally be sent to the doctor."
7. What benefits do reporting safety incidents have to a project? They help identify, avoid, or decrease the possibility of having any injuries on-site.
8. What are the enablers of safety incidents reporting on-site? Keeping records of site activities in a safety file.
9. What challenges do you encounter when reporting safety incidents on-site? Ensuring to get regular feedback from safety officer after safety audits to ensure compliance.

Section C: Digital technologies

10. What is your understanding of digital technologies? "Digital technologies are technologies that are used help improve safety, accuracy, quality and decrease the overall time in construction."
11. Please take me through the digital technologies you use on-site. project management software.
12. What benefits does using digital technologies have to a project? They help improve accuracy, reduce risks, reduces the overall cost and time.
13. What challenges do you encounter when using digital technologies on-site? Most of works are unable to use the technologies.
14. What digital technologies are used to report site safety incidents? Site sensors and intelligent wearable technologies.
15. How are digital technologies used to report safety incidents on-sites? "Both site sensors detect motion and wearable technologies report when workers are at restricted areas because sensors help with sensing motion in restricted areas while the wearable technologies help detect location of workers."

Interviewee 26

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Occupational Health and Safety.
3. What is your current occupation? Health and Safety Officer
4. How best can you describe your work experience in your occupation? "Extensive experience in occupational health and safety, particularly in overseeing safety protocols and incident reporting on construction-sites."

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? I understand reporting safety incidents as the process of documenting and communicating any accidents, near-

misses, or unsafe conditions observed on the construction-site. It's crucial to ensure that every detail is accurately recorded and promptly shared with the relevant stakeholders to prioritize safety and prevent future incidents. By diligently reporting these occurrences, we contribute to maintaining a safe working environment for everyone involved in the construction project.

6. Please take me through the process of reporting safety incidents on-site.. The process involves immediately notifying the health and safety officer, completing an incident report form with detailed information, and submitting it to the management team for further investigation and action.
7. What benefits do reporting safety incidents have to a project? "Early hazard identification, proactive risk mitigation, transparency, accountability, and overall improvement of safety performance."
8. What are the enablers of safety incidents reporting on-site? "Factors enabling incident reporting include clear protocols, accessible incident report forms, effective communication channels, and a supportive safety culture."
9. What challenges do you encounter when reporting safety incidents on-site? "Challenges include potential underreporting, technical issues with digital tools, and training needs."

Section C: Digital technologies

10. What is your understanding of digital technologies? "Tools or systems that utilize electronic or computer-based platforms to streamline processes and enhance communication and efficiency in construction projects."
11. Please take me through the digital technologies you use on-site. "mobile applications for safety reporting, digital inspection tools, GPS tracking systems, and Building Information Modeling (BIM) software."
12. What benefits does using digital technologies have to a project? "Benefits include improved data accuracy, real-time communication, collaboration, task automation, reduced paperwork, and valuable insights through data analytics."
13. What challenges do you encounter when using digital technologies on-site? "Challenges may include technical issues, resistance to adoption, training needs, and data privacy/security concerns."

14. What digital technologies are used to report site safety incidents? "Digital technologies used include mobile applications or software specifically designed for incident reporting."
15. How are digital technologies used to report safety incidents on-sites? Digital technologies make reporting incidents easier. They provide a simple way to enter details about what happened, add photos or documents, and send the report online. This helps speed up how quickly people respond and makes sure we document incidents better.

Interviewee 27

Section A: Demographic information

1. What is the highest level of education you have completed? Bachelor's Degree
2. What is the primary field of education you have completed? Construction Management
3. What is your current occupation? Site Foreman
4. How best can you describe your work experience in your occupation? My experience so far has been great. I consider myself dedicated to my job, overseeing and managing project timelines, budget, and ensuring team members complete their work on time and to the best quality. I've handled many aspects of construction projects, from planning and scheduling to quality control.

Section B: Reporting of safety incidents

5. What is your understanding of reporting safety incidents? It's incredibly crucial for me to maintain a safe working environment on-site. If anything were to happen, I'd be questioned about why I didn't report safety incidents. It's part of my job to report every safety issue that occurs on-site and make sure we improve and prevent them from happening again.
6. Please take me through the process of reporting safety incidents on-site. If a safety incident occurs on-site, my immediate priority is to ensure the safety of the individuals involved and provide any necessary medical assistance. Once everyone is safe, I work to prevent similar incidents from occurring again by either reporting or replacing what could have caused the incident. Next, I document the incident, taking pictures if applicable, and recording the time, date, and location. I then report the incident to

regulatory authorities, who conduct an investigation to determine its root cause. Afterwards, I prepare a formal report of the incident and present it to the stakeholders. I follow up on the measures taken to fix or prevent the incident, ensuring they are effective and safe, and won't allow anything similar to happen again

7. What benefits do reporting safety incidents have to a project? "Reporting safety incidents have many benefits on a project but most importantly it benefits to the well-being of workers and the overall safe success of a project."
8. What are the enablers of safety incidents reporting on-site? "Having an easier to follow process of reporting safety incidents makes everything easy to report a safety incident that may or have occurred on-site."
9. What challenges do you encounter when reporting safety incidents on-site? "It is difficult to report a safety incident as a site manager if I, the site manager also didn't ensure a safe working environment for the workers before any works commenced on-site. It is also difficult if workers do not report incidents that they may or encounter while working."

Section C: Digital technologies

10. What is your understanding of digital technologies? "Digital technologies in construction increase efficiency, safety, communication and also help on risk management."
11. Please take me through the digital technologies you use on-site. "The use of software tools to streamline work. The use of digital platforms to store information. Using digital technologies to present physical structures of buildings like the BIM model (Building Information Modelling) Autodesk construction cloud for collaboration."
12. What benefits does using digital technologies have to a project? "It improves efficiency, safety, imposes quality of inspections and sustainability and accuracy."
13. What challenges do you encounter when using digital technologies on-site? They are very "expensive" (cost-effective), can be difficult to use for some of the workers especially if they are not used to them and its maintenance can be costly and time consuming.
14. What digital technologies are used to report site safety incidents? We mostly use phones, apps, and software to report site safety incidents.

15. How are digital technologies used to report safety incidents on-sites? "We make phone calls using our cellphones and walkie talkies to make other team members on-site aware so they can also find or send help."