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World Safety Organization

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The Prague General University Hospital

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The hospital, which is on the verge of its third century of existence, has employed dozens of famous personalities in medicine and health care.

The surgical and medical procedures carried out at the hospital have received international recognition on par with those produced in controlled laboratory settings.

All of the above contributed to making the hospital a special place in the Czech Republic.

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The World Safety Journal (WSJ) is a quarterly refereed journal (ISSN: 1015-5589) that includes original full-length papers, review articles and case studies on the most recent outcomes of advanced research in any occupational safety and health fields.

All articles shall be written in concise English and typed with a minimum font size of 12 point. Articles should have an abstract of not more than 300 words. Articles shall be submitted as Times New Roman print and presented in the form the writer wants published. On a separate page, the author should supply the author's name, contact details, professional qualifications, current employment position, a brief bio, and a photo of the author. This should be submitted with the article.

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Medical inpatient facilities' susceptibility within the context of the COVID-19 pandemic. Case study of the Czech Republic!

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KEYWORDS

Risk management
Inpatient medical facility
Domino effect
Threat
COVID-19

ABSTRACT

One of the key conditions for the effective protection of residents is ensuring the sufficient capacity and functionality of inpatient medical facilities. However, they can fail or even collapse in some situations for many reasons, such as external disasters, internal dysfunctions, and also because of the surrounding infrastructure's malfunction or an overloaded health system. This vulnerability, which was often overlooked in the past, proved critical during the COVID-19 epidemic, but it can still manifest itself in a variety of other crisis situations. The "domino effect" is also a significant phenomenon, i.e., the spread of impacts to other facilities. Inpatient-oriented medical facilities thus have a function as infrastructure at the level of a large territorial unit, and the experience with COVID-19 provides the knowledge that it is in fact a critical infrastructure. These conclusions are illustrated in the presentations of case studies in the Moravian-Silesian Region of the Czech Republic.

1. INTRODUCTION

Critical infrastructures are systems with complex links that directly interfere with disaster risk reduction and prevent not only life loss and damage to health but also provide the background that an economic, physical, social, cultural, and environmental society needs. But each system can, and even must, react with other systems in different ways, including by reacting to the possibility of a cascading so-called "failure chain" or "domino effect" (United Nations Office for Disaster Risk Reduction [UNISDR], 2017).

Many states, cities, or municipalities can identify their critical systems, but only a few can understand how interconnected they are. Indeed, in an extreme case, it may also be "the infrastructure of infrastructures." Achieving critical infrastructure resilience requires efforts to identify and evaluate these links, but the required data may be in different ownership than, for example, the relevant authorities, i.e., another public authority or even the private sector. Critical infrastructure resilience must be treated as a process in which levels change and are restored or degraded over time, if only

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because, for example, climate or societal changes occur. This means that resilience must be understood in terms of resilience as an adaptive process and not as the often-used notion of resistance as a passive property. Therefore, all risks need to be regularly assessed and comprehensively addressed. As a result, many developed countries include all risk areas that may endanger their populations, including health care, in their critical infrastructure. In the Czech Republic, the health sector falls under the so-called crisis legislation, especially in Laws No. 240/2000 Coll., No. 241/2000 Coll., and No. 239/2000 Coll., and in related regulations, implementing decrees, and government regulations. The operator must take several measures to ensure that the operation of such equipment is not interrupted, even in the event of an emergency or extraordinary event, including the establishment of criteria for identifying a critical infrastructure element.

Health is regulated only by the fact that the cross-cutting criteria are, among other things (Štěpán, 2018, p. 11–12):

> *The public's impact is limited to a significant reduction in the provision of necessary services or other significant interference in daily life affecting more than 125,000 people.*

However, most regional hospitals, let alone even smaller health establishments, do not meet this criterion. Thus, formally, it follows that an in-patient medical facility, e.g., with a catchment rate of perhaps 50,000 inhabitants, is not important. But according to the sectoral criteria of the regulation (point IV, "health"), a medical establishment whose total number of acute beds is at least 2500 is considered an element of critical infrastructure. However, our health service has no officially critical infrastructure element, and hospitals and/or inpatient health facilities do not then have to process crisis preparedness plans, which is in dramatic contrast to the experience of the COVID-19 crisis (Štěpán, 2018).

2. HISTORICAL MEDICAL FAILURES

We present the great Lisbon earthquake of 1755 as the imaginary dividing line for determining the first modern disaster. This event was also the trigger for some of the first scientific research into the causes of earthquakes and whether these disasters can be predicted and thereby ensure greater population safety (Etkin, 2015). Historical records describe events that were associated with disease disasters that ended in the deaths of large populations. Most of the time, they were called epidemics, and when they were recorded, they were called the plague or "Black Death" and were said to be God's punishment.

One of the earliest accounts of an epidemic believed to be an actual plague was the Antonine Plague (165–180 AD). The so-called Justinian Plague, which occurred in 558 AD, was the next recorded event. Millions died in this epidemic, with 5-10,000 people dying every day in the capital city of Constantinople alone, and the health service was completely destroyed at the time. In the Middle Ages, the plague hit all of Europe, and also the Czech Republic in three waves. In 1357-1363, the first documented wave hit Europe and the Czech Republic. The consequences were catastrophic. An estimated one-third to one-half of Europe's population has died. The second, stronger wave in Europe, which also affected the Czechs, was in 1380-1382. Its effects were no longer as drastic for the Czechs, but preserved records suggest tens of thousands of casualties. More plagues came in 1711-1715 and struck most of Europe. Around 200,000 people died of this disease in the Czech Republic alone. All these events were accompanied by the health service ceasing to perform its normal functions at the time level. After 1828, plague epidemics were no longer present in Europe, but other insidious diseases

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began to appear, such as cholera, which reached Europe by sea from India (Svoboda, 1995). In all the major plagues, the failure of health services has also proved to be part of the crisis.

Modern pandemics in the 20th and 21st centuries include the Spanish flu (1918–1920). Hospitals were hopelessly overcrowded during the epidemic and faced shortages of doctors and nursing staff. There were as many deaths as patients admitted in a day. Other disciplines were closing, e.g., otorhinolaryngology and dentistry, and specialists had to switch to general practice. People often died at home without medical care or assistance, which was also lacking due to wartime events. There were major shortages in medicines and raw materials necessary for the manufacture of medicines, mainly quinine at the time, such as sweeteners, alcohol, and preparations, or even the necessary production aids, e.g., medical glass. Here is a parallel with the lack of oxygen during the COVID-19 pandemic. The unbearable situation occurred in the congestion of cemeteries, as there were few gravediggers, and carpenters. Small morgues were overcrowded, and some of the deceased remained outside. Due to the lack of coffins, the dead were buried in communal, so-called "mass graves" (Salfellner, 2017). Other pandemics in the world included, e.g., the Asian flu (1957–1958), Hong Kong influenza (1968–1969), the swine flu pandemic caused by the H1N1 influenza virus (2009–2010), and COVID-19 (SARS-CoV-2) which commenced in 2019.

Disasters affecting the health service are innumerable, which is why only a small sample of selected disasters since the beginning of the 21st century that have interfered with the activities provided by health services were included. Disasters include floods that forced the evacuation of patients and led to the closure of critical services at Burkina Faso's main hospital in the capital, Ouagadougou (9/2009). National and local health systems providing health services to millions of people have been affected by the damage and destruction of thousands of medical facilities in Gujarat, India (2001), the northern Indonesian province of Aceh (2004), Pakistan (2005), and Myanmar (2008) (The Department of Health of the Philippines, 2013). The earthquake that struck China (2008) damaged or destroyed more than 11,000 medical facilities.

In Haiti in 2010, an earthquake left 230,000 people dead, and cholera spread, killing 10,000 people and then spreading to the neighbouring Dominican Republic (Štětina, 2014). In August 2021, another large earthquake occurred in Haiti, as the local doctor reported (Kedroň, 2021, p. 4):

> *We didn't have time to count the dead and we treated many of the wounded. There were cracks in the walls of the emergency department at the hospital; so, we worked in the yard of the hospital for fear of collapse.*

Hurricanes and typhoons also cause disasters. A typical example is Hurricane Katrina (2005), which damaged protective dams and completely flooded the city of New Orleans with water from the ocean and nearby Lake Pontchartrain. Before the impending catastrophe there was a failure to evacuate the city in time, infrastructure collapsed, including health care, and civil unrest occurred. The lights in the hospitals were without emergency backup power, the use of toilets was forbidden, water had to be saved, and every patient was equipped with a flashlight. Patients were given a zero-dry diet and bottled water from reserves, according to United Nations Disaster Assessment and Coordination (UNDAC) standards (Baldwin et al., 2006).

About 432 medical facilities were damaged by Typhoon Haiyan (Yolanda) in the Philippines in 2013, including 296 barangay medical stations, 97 rural health units, and 38 hospitals in the Eastern Visayas region, including the office of the Ministry of Health (The Department of Health of the Philippines, 2013). Tropical Storm (Allison, 2001) devastated southeast Texas. Most of the damage was downtown, where water flooded hospitals and other buildings. There were floods along Allison's passage, and the resulting electrical failure forced the evacuation of University Hospital, Houston. The hospital had 450 adult beds and 150 children's beds. 169 patients were discharged, and 406 were gradually evacuated to 29 hospitals (Cocanour et al., 2002). During the three-week emergency in the Gaza Strip in 2008–2009, 16 medical workers were killed and 25 injured in the line of duty, 15 hospitals, 41 primary health centres and 29 ambulances were damaged (Štětina, 2014). Cyberattacks are becoming more common these days, including in the Czech Republic; health workers and medical facilities tend to be targeted by attackers or terrorists.

When Russian Federation troops attacked Ukraine in early 2022, many medical workers who worked in hospitals and war zones were killed. Neither the children's hospital nor the maternity hospital in Mariupol, as well as the psychiatric hospital in the Kharkiv region, escaped the military aggression. Not only staff but also newborns, children, parents, and patients were killed or seriously injured in medical facilities (iROZHLAS, 2022). Births of newborns also took place in shelters, such as the Kyiv metro. Ukrainian doctors tried to get as many children as possible to Western Europe who were in an advanced stage of oncological disease or patients who required immediate care, which they could not receive during the ongoing conflict (e.g., dialysis). The doctors were in contact with several international medical organizations and, with their help, tried to transport the sick. Currently, the numbers of all the deaths in the war are not accurately counted. In March 2022 alone, according to the WHO, there were 72 attacks on medical facilities in Ukraine, with 71 dead and 37 injured. These were mostly attacks on hospitals, medical convoys, and convoys with supplies of medical supplies, but there are also suspicions of the kidnapping of medical personnel and patients (Novinky. cz, 2022). It can therefore be summarised that inpatient healthcare facilities are generally vulnerable to a variety of disasters and events, and their possible dysfunction exacerbates the crisis.

3. THE IMPORTANCE OF INPATIENT HEALTH FACILITIES FOR THE POPULATION AND THEIR PROTECTION

Medical facilities are premises intended for the provision of medical services. Health services can be divided according to the form and type of health care provided. Bedside care is health care that cannot be provided on an outpatient basis, requires the patient to be hospitalized, and is provided as part of a continuous operation. The buildings of medical facilities, which are specific, are also very important. These are frequently combined outpatient facilities (polyclinics) and institutional care facilities (hospitals with inpatient units, examination and treatment units, and other spaces required for the medical facility's operation, such as warehouses, boiler rooms, garages, outbuildings, and so on). In hospitals, there are many people of various ages who may be in a critical health condition, patients after major operations, immobile patients, or mentally ill patients. At the same time, there are patients under the influence of pharmacological treatment, including mothers and newborns, in hospitals at any hour of the day or night. Persons moving into these spaces are not only patients but also other people who are not medical professionals but contribute to the running of the organization, e.g., nonmedical staff of the facility, employees of construction companies, maintenance, shops, and also people accompanying the sick, visitors, etc.

The function and importance of health facilities to the population are primarily to provide health care, which consists of a set of activities such as prevention, detection, and elimination of disease; maintenance, restoration, or improvement of health and function; maintenance and prolongation of life and suffering; provision of palliative care; assistance in reproduction and delivery; and provision of preventive, diagnostic, therapeutic, therapeutic rehabilitation, and nursing care. Its other activities include educational, scientific-research, economic, operational, technical, investment, administrative, and pharmacy care provision.

Losses of function, such as the critical vulnerability of inpatient health facilities, include threats that are external, e.g., floods, prolonged droughts, extreme temperatures (heat waves), extreme wind, epidemics (COVID-19, influenza, etc.), disruption of large-scale electricity supply (blackouts), or internal threats such as fires, a lack of qualified staff, and inadequate logistical security (e.g., oxygen, pharmaceuticals, water, food, materials, etc.). Other things that could go wrong at an inpatient medical facility include an attack by a hostile person, either in person or online. This could be in the form of a booby trap, a violent crime with a gun, which could be done by a terrorist or a person with a mental illness, or a cyberattack on the hospital's information system.

When inpatient medical facilities don't do what they're supposed to, it can set off a chain reaction that can lead to the collapse of the system (e.g., a lack of medical staff) and cause devastation, full beds, a breakdown in logistics, an economic impact on health care, etc.

4. EXAMPLES OF VULNERABILITY DURING THE COVID-19 EPIDEMIC, INCLUDING THE DOMINO EFFECT

Mapped data shows that hospitals are vulnerable to both internal and external risks, which often lead not only to the failure of a single hospital but also to the collapse of the entire health system, which can have fatal results.

> *Due to the closeness of devices, objects, or groups of objects and the location of dangerous substances, there could be a domino effect that makes it more likely that a major accident will happen or that its effects will be worse. (Major Accident Prevention Act in the Czech Republic, Section 2, p. 2763)*

In the current coronavirus epidemic, there is also a domino effect in health care. A result has been a collapse of the system and consequent problems such as a shortage of medical staff and a lack of beds, not only in intensive care units, which are not sufficient in their capacity, but also in dissection rooms and morgues. Doctors may find it difficult to choose which patients to provide artificial pulmonary ventilation, a bed, oxygen, or medication. Other downstream health needs that are necessary to maintain activity and functionality are the supply of pharmaceuticals, food, medical supplies, especially sterile ones, laundry, waste collection, and also energy supply (water, electricity, heat, etc.) that can go into logistical meltdown.

During the COVID-19 epidemic, overloading of incinerators with infectious waste from health care increased due to the increased use of protective equipment during the epidemic. This was due to infectious materials, surgical or bandage materials, sharp objects, drug residues, protective equipment, etc., which must be largely burned as they are considered hazardous waste. At the University Hospital in Ostrava, for instance, the amount of waste increased by seven tonnes. The collection company had to transport infectious waste three times a day. In normal operation, the waste is collected once or twice a day (Vlčková, 2021).

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5. COVID-19 AS AN EXAMPLE OF INPATIENT HEALTH FACILITIES' VULNERABILITY AND INFRASTRUCTURE

5.1 Participants

At the beginning of the COVID-19 epidemic in March 2020, the Dashboard application was created by the regional office of the Department of Health of the Moravian-Silesian Region for immediate access to information about free capacities and the state of hospitals in the region, which were regularly evaluated by the crisis staff. Data were entered daily by the selected staff of 22 inpatient medical facilities, who were the only ones with access to the application. Access passwords were generated by the IT of the Moravian-Silesian Region Regional Office.

All the results of the entered data in the dashboard application were accessed by selected employees of the health department, who constantly checked all the data, and when the situation worsened, they immediately informed the management of the health department. At the same time, the management of the health department, the governor, the Integrated Security Center of the Moravian-Silesian Region, representatives of the regional hygiene station, and hospital directors could check the data.

5.2 Procedure

The data collection offered data on all inpatient organizations in the region and the most important information for the management of the epidemic. It provided data on the total bed capacity, allocated beds for COVID patients, and occupancy (hospitalization) of both intensive and standard wards for COVID positive patients, including information on suspected patients in whom the disease has not yet been confirmed in a laboratory, but symptoms of this disease have already appeared, or it was assumed that they were in contact with a sick person and their state of health already required hospitalization. The load was presented in the form of a wheel and for easier orientation. It was coloured and there was immediately visible signalling for all persons who had access to the dashboard application that the situation was serious and required an urgent, timely and fast solutions.

5.3 Analysis

At the same time, the data collected information on the number of patients connected to artificial lung ventilation, extracorporeal membrane oxygenation, oxygen and the number of devices still available. Another section was information on current stock (protective work equipment, medical material, disinfection, etc.) for a period of 2 months, the absence of medical personnel (medical and nonmedical - nurses, including other important employees who do not have a medical education), the workload of laboratories, which were testing for COVID-19. This data was further converted into a visual form through a dashboard application. The application presented the current situation using pie charts. At the same time, percentage parameters were given for faster and easier orientation in the displayed data, e.g., in the case of insufficient capacity of standard beds, the entire figure was coloured yellow (60% of capacity exhausted) and in the case of exhausted/almost exhausted staff capacity was coloured red (80% or more of capacity exhausted). The white colour of the "tile" showed that the capacity was within the norm. Thanks to these indicators, the state of the entered items was immediately visible upon opening the application, and any crisis had to be resolved immediately, e.g., by increasing the capacity of beds or searching for capacity in another medical facility or region. Other steps taken according to the results from the dashboard application included the Administration of state material reserves and equipment transfers to increase the capacity of laboratories (approaching private companies - laboratories), and moving medical personnel from closed departments to acute beds.

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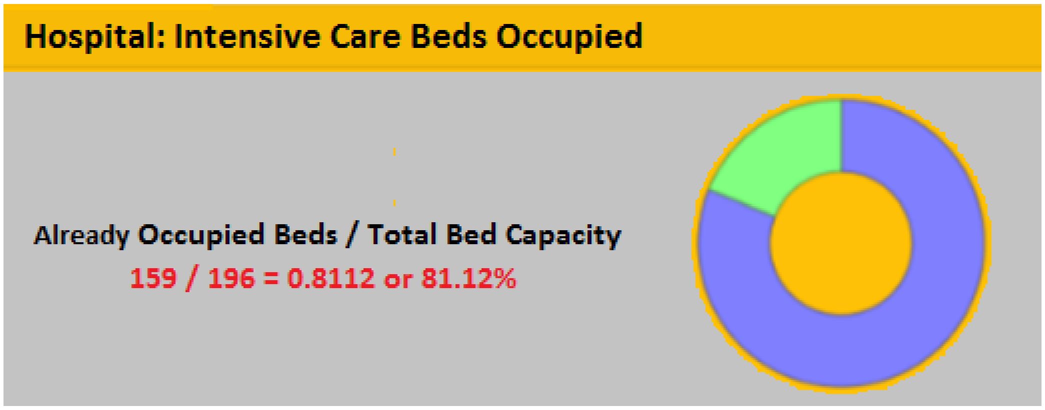

Figure 1. Data gathering example from the dashboard application in the Moravian-Silesian Region, Czech Republic, 2020

Figure 1 demonstrates that the 60% occupied intensive care bed capacity was surpassed. The "tile" was yellow in color.

5.4 Results

As an example of the vulnerability of inpatient medical facilities, data from the application of the COVID-19 dashboard portal, created by the Moravian-Silesian Region, are presented, when up to 1,013 standard beds were occupied by COVID-positive patients (Figure 2), 189 intensive care beds and 120 breathing apparatus were in use for artificial pulmonary ventilation (Figure 3).

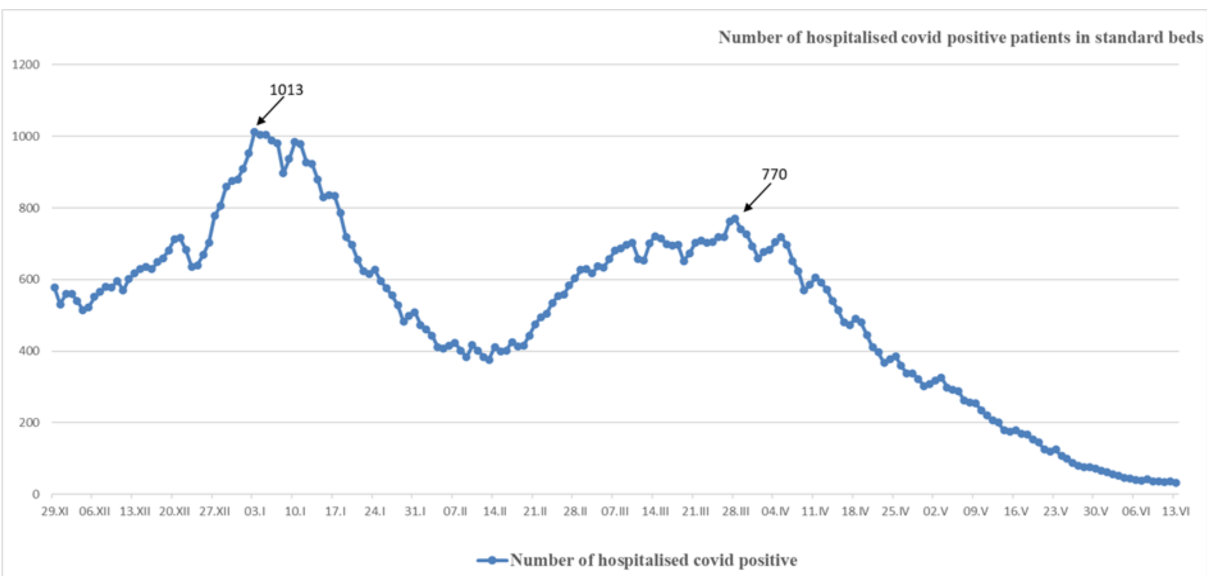

Figure 2. Number of hospitalized patients in the COVID-19 department of standard beds in the Moravian-Silesian Region of the Czech Republic (29/11/2020 — 13/06/2021)

The graph shows that there are 22 in-patient health facilities providing acute in-patient care in the Moravian-Silesia Region, the total capacity of beds by the date 31.05.2021 was, 6773 (updated by the Moravian-Silesia Health Department). According to the Czech Statistical Office, till 31.12.2020, there were 1 192 834 inhabitants in six districts in the territory of the Moravian-Silesia Region (Dehner, 2020, pp. 1-2).

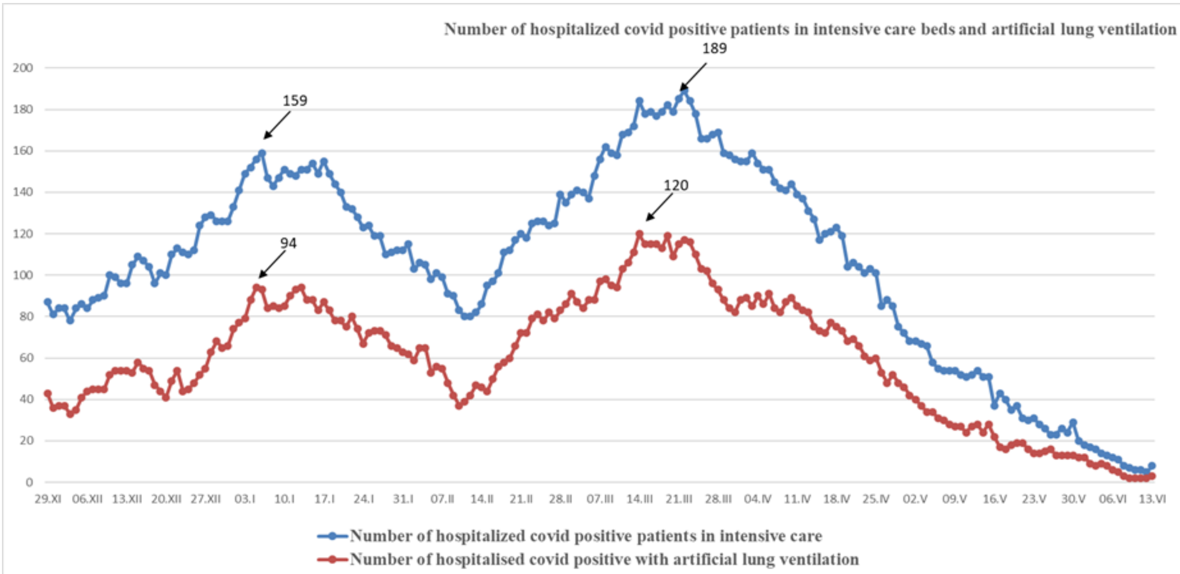

Figure 3. Number of hospitalized patients in intensive care units and on artificial pulmonary ventilation during COVID-19 in the Moravian-Silesian Region of the Czech Republic (29/11/2020 — 13/06/2021)

Another vulnerable link during the epidemic was the absence of medical staff due to COVID-19 (disease, quarantine, caring for a family member). Up to 149 doctors (Figure 4) and 886 nonmedical staff - nurses (Figure 5) were absent in the Moravian-Silesia Region. There was also a monitored group of nonmedical staff (not medical education - for example, economists, and accountants) also involved in the functioning of the organization.

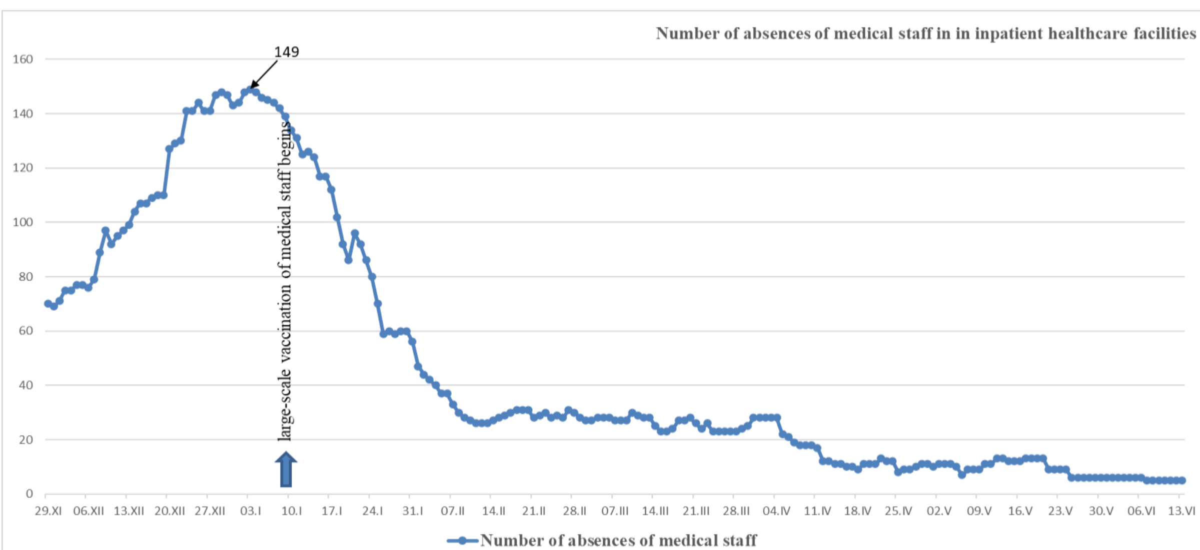

Figure 4. Medical staff absence due to COVID-19 — medical personnel (doctors) at Moravian-Silesian inpatient health facilities (29/11/2020-13/06/2021).

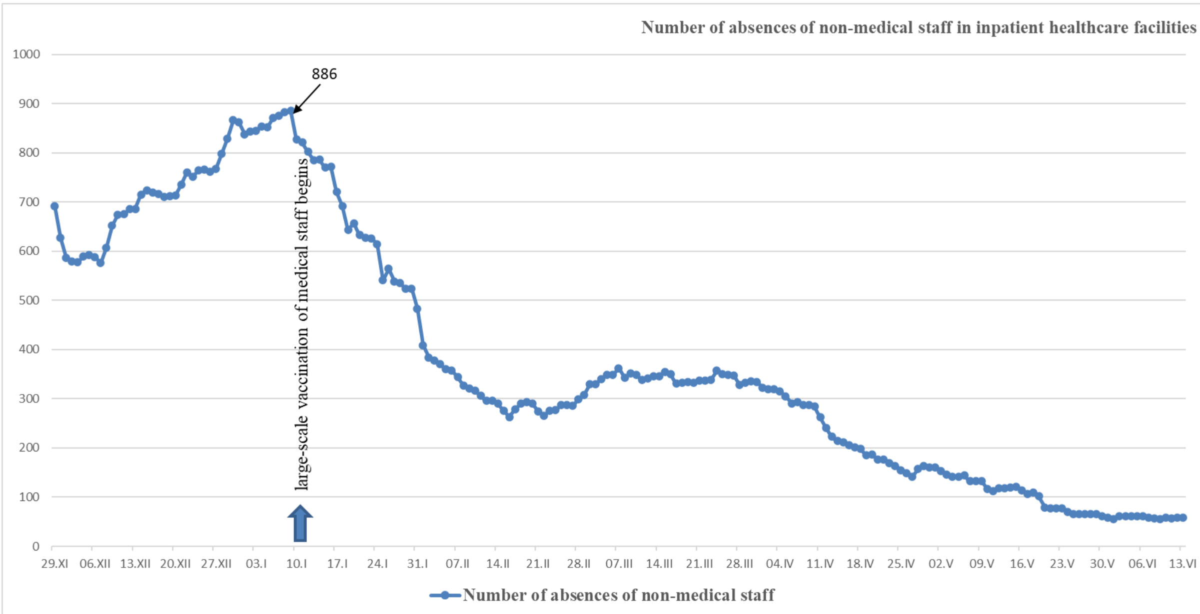

Figure 5. Medical staff absence owing to COVID-19 — nonmedical medical personnel (nurses) at Moravian-Silesian inpatient health facilities (29/11/2020-13/06/2021). (Moravian-Silesian Region, the Czech Republic, 2020).

In In-patient medical facilities there were no planned operational services, specialised departments were closed, and staff were concentrated in wards with acute care beds or earmarked so-called COVID-19 departments. Only emergency care was provided by a government order. Hospital visits were banned or individual visit exceptions (e.g., palliative care) were provided. In the first week of January 2021, the vaccination of medical staff began to increase and the absence from inpatient health facilities decreased sharply, as shown in both Figures 4 and 5. Despite the vaccination of medical staff, nonmedical staff remain absent in greater numbers during the spring months of 2021, due to the still persistent lockdown, closure of schools, nurseries and use of the infirmary, as nonmedical staff are mainly composed of women (nurses). Therefore, there was also a significant social impact.

The created application of the dashboard portal also presented other sections important for maintaining the activity of the network of inpatient health facilities in the Moravian Region, namely the already presented overview of bed aberrations of COVID-positive patients, including prospects, an overview of missing staff, a supply of protective work equipment and medical supplies, the number of COVID-19 tests performed, and the workload of laboratories. The provided data from the dashboard was used for decision-making by the crisis staff during the epidemic.

6. NEED FOR A SYSTEMATIC SOLUTION, INCLUDING THE INCLUSION OF A WIDER SOCIETY

For many decades, international organisations have sought to reduce the risks of disasters, for example by holding regular conferences. In 2015, the Third World Conference took place in Sendai, Japan, establishing the Sendai Disaster Risk Reduction Framework 2015–2030, which it calls for in its Priority 3 concept: invest in disaster risk reduction leading to resilience, aiming at investing in disaster prevention and reduction. At that point, the Sendai Framework directly seeks to reduce disaster risks for inpatient healthcare facilities, which means improving the resilience of national healthcare systems, including integrating disaster risk management into primary, secondary, and tertiary healthcare, especially at the local level; developing the capabilities of health professionals to understand disaster risks and implement disaster risk reduction approaches in their work; supporting and strengthening resources for disaster medicine training; and supporting health in communities through disaster risk reduction approaches in health programs (Sendai, 2015). In the Czech Republic, the Sendai Framework for Disaster Risk Reduction is implemented by the Ministry of the Environment and is also dedicated to environmental safety. The basic document consists of the Concept of Environmental Safety 2021–2030 with a view to 2050 (Ministertvo životního prostředí, 2020).

7. HELPING A SOCIETY IN CRISIS – CONCRETE EXAMPLES

An example of the possibility of helping companies have business continuity is the RESIMAS Security Research Project. It includes the involvement of Local Action Groups and the creation of working teams to create a local disaster risk reduction platform. Verification of the effectiveness of crisis planning through tactical exercises in Moravian Region regional hospitals (exercises already completed in 2015-2019), analysis of the emergency impacts on the Moravian-Silesian Region population, and incorporation into the crash plan. Additional support for large-scale process electronification and projects (e.g., training of health professionals, ambulances) is one of the current challenges in the Moravian-Silesian Region, which also includes IT systems, emergency revenue construction, and so on. This project is continuing to make further use of collaborations with scientists and doctors, components of the Integrated Rescue System, the army of the Czech Republic, and by developing emergency plans for the Moravian-Silesian Region.

8. CONCLUSION

Bedside health facilities are an integral part of the protection of residents and critical infrastructure and should be understood as such. Governments wishing to implement the Sendai framework must keep many critical infrastructure systems operational, including health, which is essential for the country's population. Monitoring the health system is crucial for managing emergencies and evaluating risk areas. Equally important are human resources, which form a strong link between the health service, their continuing education, and ensuring their safety and quality, which are essential for their work. The work of health professionals, and sometimes even their lives, are threatened by natural disasters, epidemics, and attacks, which are often also located on healthcare buildings and consequently lose their function (providing health care). Other difficult situations for health workers include waves of migration, difficulty in evacuating the sick due to threats, or insufficient logistical supply of key health commodities, which are important components and form a complex part of the health care they provide for the population of a given country. For the overall monitoring of the healthcare system, the essential link is the medical staff, who are key to handling both extraordinary events and the standard operation of the healthcare facility. An application control panel can be used to monitor these risk areas.

9. LIMITATIONS

Data collection continued until April 1, 2022, and even though there was a re-increase in hospitalized patients during the fall and winter of 2021, the values indicated in the figures were no longer exceeded, and therefore additional figures are not presented. All data on the COVID-19 situation was subsequently converted into national statistics, and it was no longer necessary to collect data for the regions. Still, at the start of the epidemic, the application and the information that could be found right away about how the epidemic was going in inpatient medical facilities in the area were very important for the crisis staff to make decisions.

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From truck driver to systems engineer: transforming the human contribution

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KEYWORDS

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Role transformation.
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ABSTRACT

Driverless haul trucks represent a significant transformation for the mine site workers in the Western Australian (WA) Mining Industry. Research within the industry is yet to explore the experiences of frontline workers transitioning to driverless truck operations. The study aimed to investigate the role transformation of mineworkers, their residual workloads and local adaptions when working with automated systems. A sample of 25 employees, from a WA mine site, were interviewed face-to-face on the research site using a mixture of open and close-ended questions. A comprehensive understanding of the risk perspectives was developed through a convergent parallel design. Multiple cases were analysed thematically through cross-case displays, utilising complex reasoning to accommodate the emerging themes. Participants reported the introduction of new roles, while conventional roles were redefined. The residual work included building virtual mine models, clearing detected objects and calling trucks into the loading area. Although truck driving drastically reduced, new technology and computer-based skills developed. The results confirm that haul truck automation transforms mining roles, with residual tasks that require local adaptions to overcome non-designed situations.

1. INTRODUCTION

The introduction of automated technology marks the beginning of the replacement of truck drivers for machines. This alternative intends to substitute driving activities that have been reversed engineered into a computer. Engineering maturity has enabled mining haul trucks to drive from A to B, which appears on the surface to be performing the task like a truck driver. What is not always visible are the inputs and local adaptions that make driverless performances possible. Local adaptions fulfilled by residual roles help the technology through non-designed situations. Despite recent reports of mineworkers removed from the mining operation, there are still routine and adaptive tasks performed to make driverless technology a reality. Therefore, there is a real need to understand the transformation of functions and skills required to complete tasks post-automation.

Driverless technology requires numerous data inputs to perform, with goals and fleet allocations determined at the start of the shift. Not only must the technology be pre-programmed to perform truck driving tasks, but the system-based role must also provide instructions on what material is to move.

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Material movement includes the tonnes required from each load unit and associated destinations. For this to occur, the driverless system requires a virtual mine model to operate. Driverless trucks need these data points to compare incoming LiDAR, radar and GPS data with the virtual model. The mining model contains travel lanes, intersections, active mining areas, exclusion areas and speed zones. These digital aspects must be computer generated and designed by new formed roles, which then physically verify data in the field. Once the model is available, the driverless trucks can operate within that model, providing it has loading sources and associated dump locations. From there, the system can generate truck assignments between those locations. Within the cycle, a truck may be confronted with an object in the lane, which requires a human to clear. Those objects can be centre dividers that are not surveyed, wildlife, spillage or vehicles that lost communications. Trucks may also lose connections, which requires the machine to be recovered by humans. Once the haul truck arrives at the loading source, the excavator must call the truck into a loading bay designated by the operator. The operator must then press a button when the truck is fully loaded. The driverless machine can then travel at full speed unless restricted otherwise by speed zones. For example, a speed zone may be in place near potholes or slippery roads conditions from a downpour of rain. These are just some examples of the types of inputs, which locally adapt to the changes and complexities in the practical constraints of a mining environment.

Through the substitution of personal work for a machine, research has investigated the repercussions of residual tasks on humans. Leftover jobs are often unspecified and require human supervisors to overcome the situation (Dekker & Woods, 2002). Furthermore, automated systems can provide little feedback on what is happening and rarely offer a safe way forward (Reason, 1990). Therefore, not only is the human suddenly reintroduced back into the control loop, they must determine how to safely proceed within the confines of the system's design (Banks & Stanton, 2016). Automation may not even hand back control, functioning beyond the parameters that requires humans to take control (Endsley, 2019). Therefore, double-binds can emerge, where humans may intervene to create an incident, or fail to intervene to allow an incident to occur (Dekker, 2003). The human is therefore, monitoring the performance of the system, with skills in performing designed tasks, yet developing improvised skills only in times of malfunction.

More recent studies analysed the role of humans in self-driving cars (Fridman, 2018; Wessel et al., 2019), yet these findings are vastly different from a haul truck with no safety driver. Despite recent guidance and warnings surrounding driverless haul truck technology, there is little understanding of the transformation of support roles (Department of Mines and Petroluem, 2014; 2015). The original assumption was that the replacement removed the human contribution (Glover, 2016). However, when comparing residual human tasks across various high-risk industries, it is clear that human tasks and skills continue to play a significant role (de Visser et al., 2018; Lewis et al., 2018). Those skills include computer interfaces and data outputs to monitor the performance of the system (Sarter et al., 2007). For the mining industry, this represents a significant shift for operators who may never have used a computer before. In addition to learning new skills, existing conventional techniques can diminish overtime (Billings, 2018; Bravo Orellana, 2015). These techniques can include driving haul trucks or operating an excavator without an in-cab display. Therefore, it is evident that there is a need to explore the roles and skills changes that may be transforming the human contribution.

Research in aviation and manufacturing have analysed the residual tasks post-automation. Remaining duties include activities that designers are yet to automate. As a result, they are rarely conceived and developed with humans in mind (Reason, 1990). Human-centred approaches have advocated in designing human tasks that are leftover (Billings, 2018; Fridman, 2018). The design adopts skills and attributes from multiple disciplines, promoting the interests of humans in a joint system approach.

What occurs, in contrast, is that the machine becomes the primary focus—optimising the pre-conceived ideas and efficiencies of the designers' one-best method, limiting the exploration, cooperation and learning capabilities (Giacomin, 2015). The workload can, therefore, be a residual set of tasks that are short and intensive, followed by long periods of inactivity (Ferris et al., 2010). After periods without activity, suddenly people are reintroduced to recover the system from failure. Research is yet to explore these experiences in a driverless truck operation, given that driverless technology is in early development in the mining industry.

The purpose of this research was to explore the role transformation of mine workers through the introduction of driverless technology. Face-to-face interviews were conducted on the mine site using semi-structured questions. The quantitative and qualitative aspects of the issues enable the research to gather the perspectives and lived experiences on the mine site. Data from the interviews were transcribed and analysed individually, then synthesised in themes to represent the participant views of the transformation.

2. METHOD

2.1 Design

A convergent parallel designed was used to develop a comprehensive understanding of different risk perspectives (Creswell & Clark, 2011). Multiple reasoning accommodated theory inductively for emerging themes and deductively for testing and validation. The process worked back and forth until data saturation and research significance were achieved (Creswell & Poth, 2017). The interview data were compared and contrasted for grouping and allocation of themes. Quantitative and qualitative methods were mixed to strengthened results by quantifying 'Yes' and 'No' responses. Quantified data was supported by the context and explanations contained in the qualitative data (Creswell, 2014a). The multi-method increased the likelihood of making empirical generalisations about the phenomenon, measuring qualitative variables and contextualising the quantitative aspects. The research did not attempt to over-generalise the population, therefore supporting each inference with distinct experience when concluding. This approach preserves the inherent complexity of each lesson by maintaining social context, with the raw expressions and perspectives on the transformation of roles (Miller & Crabtree, 2005).

2.2 Participants

The population of the study involved employees and contractors who work with driverless haul trucks. The size of the population was approximately 450 people who performed specific functions and characteristics pertinent to the research. A single-stage sampling procedure provided the investigation with direct access to the participants and the population under study (Teddlie & Tashakkori, 2009). The characteristics of the population were understood to enable stratification to occur. Therefore, the following roles and features identified: control room operators who monitor the performance of the trucks and make decisions via computer interfaces; pit technicians who attend to truck recoveries and system builders who build and verify the virtual mine model; ancillary and haul class operators manually controlling equipment; supervisors of system-based roles and auxiliary equipment operators who check and inspect work; and the professionals who include the designers and specialist in the function and pre-programming of the trucks. Specific characteristics targeted by a random selection may not represent the entire population (Creswell, 2014a). There was saturation by recruiting 25 participants, which represented 5.5% of the operation when validating results.

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2.3 Data collection

Interviews were digitally recorded on audiotape and took appropriately 45 minutes to 1.5 hours to complete. The duration depended on whether the participant elaborated on their experience relating to each question. Participants participated in interviews between January 2018 and February 2019. The interviews were conducted on the mine site itself and were held within a quiet room. Each meeting was digitally recorded and transcribed by one of the researchers verbatims.

During face-to-face interviews participants were asked to describe their role and whether it changed through automation. Participants elaborated on how it changed and what activities need to be completed. Moreover, each participant was provided with questions surrounding the workload of support roles, remedial actions, interpretation of system information and understanding of the systems' modes and features. Understanding local adaptions had participants asked whether they had confronted situations beyond procedures. Furthermore, how people remain in the loop with what is happening. The decision-making to determine whether to intervene or not when something does not seem correct. The set of questions (Table 1) remained consistent for all participants across the stratified sample.

Table 1: Interview questions specific to role, workload and adaptions when working with driverless haul trucks.

Topic	Question
Role transformation	– How would you describe your role in the driverless operation? – Did your role change through the introduction of driverless trucks? – Have your skills changed or diminished through the introduction of driverless trucks?
Residual workload	– How would you describe the workload of system-based roles that support the driverless operation? – Are there activities that need to be complete because the driverless system is limited in what it can do? – Have you ever misinterpreted information that was given to you by the driverless system?
Local adaptions	– Have you ever been faced a situation that required you to think outside of a process or procedure? – How do you remain in the loop with what is happening in the driverless system? – How do you determine when to intervene or not when something doesn't seem right?

2.4 Data analysis

Interview data was uploaded and transcribed into an online database. Interpretive data collected from multiple cases analysed through a cross-case display. The display compared the interview responses for patterns and themes when coding abductively (Tashakkori & Teddlie, 2010). A mixed-method analysis provided statistical and analytical generalisations about the phenomenon (Creswell et al., 2011). Descriptive analysis organised and summarised the responses to enhance understanding of worker experiences. The technique was applied to represent natural clusters, grouping and dimensions (Onwuegbuzie & Combs, 2010). Statistical results were, therefore justified rather than predicted, comparing different perspectives drawn from qualitative and quantitative data (Creswell, 2014b).

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Participants rated their understanding of the systems' modes and features, comparing their reasons why with responses that may have been higher. An inclusive design framework calculated statistics from the emerging themes. Therefore, the numerical properties of the results stemmed from the stratified sample taken in the population (Onwuegbuzie & Combs, 2010). Cross-case analysis facilitated the simultaneous facilitated the analysis of multiple perspectives to avoid being bound by individual factors (Onwuegbuzie & Combs, 2010). The raw data were sorted into groups and did not distinguish between independent and dependent variables (Miles & Huberman, 1994).

Furthermore, to enhance the investigation, this approach enabled the researcher to identify patterns and variables. The variables compared against the participants' perspectives working with driverless haul trucks (Wainer, 2005). A graphical analysis reported the results and highlight how they relate to the questions, which assisting in presenting the statistical information in visual form. Bar graphs developed for the visualisation of practical significance and trends in the worker experiences.

2.5 Ethical considerations

The Curtin University Research Ethics Committee (HRE2017-0844) approved the study to be undertaken. The participants were all provided with written and verbal information about the study. Participants provided written consent to participate in the research and given to opportunity to choose the interview location. The interviewees assured that interviewed records were kept confidential, with the participants able to stop the interview at any time.

3. RESULTS

The findings of mineworkers' roles transformations were synthesised under three main headings. Those three headings include; the role changes through the introduction of automation, the residual workload and the local adaptions that occur to assist driverless trucks in non-designed situations. The headings describe the workers' primary response to the question of their thoughts and personnel experiences.

3.1 Role changes through the introduction of automation

3.1.1 Role description

Participants' role descriptions ranged from loading trucks to monitoring the performance of the system. Professionals developed reports from the system to analyse truck performances. The analysts work attempts to understand truck cycles and associated delays. The information was used to educate the operation on how to optimise the automated system. Training roles described their position upskill operators to transition from the manual to driverless truck operations. The upskilling involves teaching the additional layers and processes associated with automation. For example, setting a loading location and how to direct a truck into the bay. Therefore, people are taught how to react to a situation and how driverless systems are likely to respond. The activities that were described be more involved:

> *Quite a lot more involvement with the trucks from an autonomous standpoint, for a digger driver. You've got to put in spot points. Make sure you've got one called all the time. Make sure you're always thinking three or four trucks ahead as to where the truck is going to be…* [P4]

The most challenging component of this was explained to be the shift in responsibility. In particular, the operational and spatial awareness to be successful in those changes. An excavator operator, for instance, previously loaded trucks, maintained the bench and pulled batters. The introduction of

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driverless technology, however, introduced additional buttons and screens to interface with driverless trucks. When it comes to controlling the fleet, participants highlighted how they closely monitor the fleet to ensure machines perform as expected. The assignments are monitored to ensure the fleet is cycling through the loading units:

> *Mainly just watching the trucks. So just making sure that they're doing what they are supposed to be doing. Their assignments, their cycling through the diggers correctly, going to the correct dumps. Those sorts of things, yeah.* *[P7]*

Mine controllers described their role as directing the fleet across the mine in the most efficient way possible—the trucks controlled from a central location, which manages 25 machines for every control room operator. In comparison, machine operators are in charge of a single area. As a controller, one person can be responsible for multiples areas at any one time. Therefore, maintaining positive communication has been described as crucial step since truck drivers were removed. The daily plan, compliance, production, safety, and emerging issues all need to be managed. When breakdowns occur, the fleet is to swap around to maintain operations and completed manually. Controllers utilise field-based personnel to provide physical dump locations, including the validation of the virtual mine model to suite the physical mine:

> *All your processes, you got to ensure your onto your builders and make sure you've got somewhere for the trucks to go. The system at the start is pretty overwhelming; it's really complicated. But once you sort of figure it all out, it's pretty simple.* *[P9]*

Participants described how automation forced improvements in road compliance. Road compliance involved maintaining road standards, intersections and windrows. Additional technology layers require design standards to reflect the mine model. Virtual models that do not reflect the physical world creates risks and extra work for humans. Where a manual truck traditionally drove around road spillage, driverless systems identify the spillage as an object. However, the practice increased compliance as those conditions were unlikely to be raised by truck drivers. Production technicians attend to object that are identified in the field since driverless trucks are unable to classify objects. The role monitors and supervises truck cycles, mode changing machines and undertaking tasks that automation cannot perform:

> *Mode changing, manning them up when we had to go manned, to take them to the workshop, clearing obstacles. If we had to do manual tips, or refuelling... Taking care of the trucks, while not being in the truck.* *[P11]*

Wheel dozer operators keep the dumps pushed and the loading floor clean for driverless trucks. Areas around the crusher are maintained to remove built-up material that could be identified as an object. Despite a virtual model, physical dividers exist for separation and protection in the mine. More importantly, to prevent manually operated equipment from cutting corners and colliding with other machines. Supervisors monitor the performance of the truck system and oversee the mine plan to ensure the operation is meeting site targets. Since a large workforce remains, a significant portion of the supervisor's work is verifying the work that operators perform. Some tasks need to be allocated to people to provide an environment for automation to operate. As a result, verifications are frequent, and operators supervised to validate the entire system. Not only do supervisors oversee the work, but they also authorise to control trucks and build virtual models, playing a role in every discipline to ensure people have the tools and information they need:

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> *I do quite a bit of running around to make sure that people are getting the knowledge they need and helping them to perform their role properly.* [P20]

The supervisor role described as being a role between every function. Communicating inside the control room and having a close connection to the pit. The pit described as being heavily reliant on the decisions that are made in the control room. Field roles require the virtual mine model to be build and maintained. Therefore, system-based duties are critical to running a driverless operation:

> *Without our role, the trucks don't run. So, we build all the road networks, all the dumps, get them into the digger and park ups, that sort of thing… We got to update surveys, make sure the trucks can do their thing.* [P23]

The most crucial task is making sure the virtual mine matches up to the physical mine. It is identifying hazards or situations that could damage trucks or put personnel in danger. Therefore, new roles monitor and compare the model to validate against physical intersections, corners, ramps and dump locations.

3.1.2 New and transformed roles

New roles were explicitly designed for automation, while others transformed. Those roles included analysts and system-based roles, while conventional roles upskilled with new interfaces. Analysts taught themselves how to get into the system to understand automation. The data is analysed while replaying the actions of the machine. What has changed is the quality of data that comes with automation. Everything a driverless truck performs recorded and stored somewhere in the system, much more than a manual haul truck. Therefore, there is more to analyse and understand the technology-based layers. Similar experiences were shared with excavator operators, with far more involvement in how trucks enter the loading area:

> *Now you've got to put in your spot points, make sure you've got one called all the time. Make sure you are always planning 3 or 4 trucks as to where the trucks have to be and where its gotta go… looking at floor conditions, bench conditions… yeah, it's quite involved.* [P4]

The most challenging component has been developing peoples' spatial awareness. Participants described having to think a lot more about their tasks. The trucks may be automated, yet they require humans to provide additional instructions in certain situations. This required manual equipment operators to learn how to plan for upcoming machines and how to coordinate them safely:

> *Yeah, you've got to plan where you want those trucks to a certain degree, but you just hang your bucket there, and the trucks come. With autonomy, you know, you've got to progress your spot point, you've always got to be putting where you are going to put the trucks.* [P4]

In a manual truck operation, truck drivers would reverse themselves based on the excavator's position. However, now trucks are driverless; the excavator operator needs to physically identify where they would like trucks to be loaded. Excavator operators described this move as a positive step, enabling them to take responsibility for loading the trucks. Participants expressed enables them to know exactly where the trucks are going to travel:

> *Previously, Betty could back over one part, and John could back over another part. There was an element of doubt sometimes where they were going to go.*
>
> *But now you know exactly where they are going to go with the lanes and stuff that is generated on the screens. [P5]*

Participants described how the floor conditions must be kept smooth in driverless operation. If floors are rough, the obstacle detection system will identify objects and stop short of the excavator. The positive is that there is far more data is available through in-cab displays. However, the operators had to learn how to observe and interpret the information displayed on the screen. The screen provides information and functions that allows operators to control the fleet. Participants explained how comfortable they have become now they have been empowered to manage the fleet. Driverless trucks that end up in the wrong loading position were explained to be the operators' fault, now that automation follows the instructions given by the operator. The screen also provides information about what trucks are doing and when they are coming. Operators can identify a loading location before trucks even arrive, which did not exist in manual:

> *Whereas, with a trucky, well he is sort of stopping there, he's waiting, you know. 'Oh, where do you want me to go?' And you're like come on get under the bucket here; this is where I want you. No more of that, you don't wait for the trucky, you tell the trucky exactly what you want him to do. [P6]*

For participants who previously drove a truck, they explained how they were either trained in other equipment or upskilled in system-based roles. Therefore, the experiences were vastly different depending on where the participants transitioned. Participants were either taught how to operate other machines with in-cab displays, developing the virtual mine model and controlling the fleet:

> *Definitely, yeah. So, I was just driving trucks before. Very manual. It was physically driving the truck, refuelling and doing all the tasks that are involved with that. And then yeah, now it's just like sitting behind a computer, more technical-based, keeping the fleet online, those types of things... [P7]*

Despite the transition, some participants believed similar mining principles still apply in automation. They're also fewer people to manage within the operation, therefore managing crib breaks and hot seating arrangements reduced. However, participants noted that driverless systems are far more labour intensive than manual trucks. Where a manual machine would drive around broken-down trucks, driverless trucks will stop and wait. In addition, if a driverless system loses communications, it must be manually recovered and relocated to a safe location. These were the types of additional practices learnt. More importantly, some of the roles in the manual operation described as reasonably simple in comparison. Moving from operating equipment in a manual to driverless meant the introduction of computer-based tasks and practices. As a result, if personnel moved into a system-based role, there were more changes involved:

> *Loading trucks like in the autonomous world, because you then became the truck driver as well the load unit operator… And in the sense of pit tech (technician), yeah, we didn't require those in the manned world. So, it was a new skill, new role. [P11]*

Participants described how there were more aspects to take onboard. For instance, mode changing a truck and recovering it manually when it broke down. Operators also had to be mindful where the machines were driving, given that the system could not determine the type of terrain. Therefore, load unit operators were responsible for guiding driverless trucks into their loading position. Participants highlighted how new starters used to begin driving haul trucks. Since there are no more trucks drivers, operators need to be upskilled initially on more complex machinery. In addition to learning equipment functions, they must also learn how to interact with the driverless trucks. Despite this, driverless trucks were described to be more predictable in what they perform, with lanes indicating the direction of a machine. Participants involved in the early stages explain how they had to learn the system prior to developing safety procedures and inductions:

> *Number one I had to learn the system. Number two, then I had to go and start writing procedures, processes and inductions for autonomous operations… Because we actually had upgrades every, you know, twice/ three times a year… so, therefore, it changed processes and the way we actually operated. So, it did actually change the way I moved around, well part of my tasks within autonomy.* [P13]

Participants reported how the training documents needed to evolve with the operation. Despite the manufacturer offering a system, the site developed their ways of working. With software and functionality, upgrades came better safety and engineering controls. When the system was upgraded, the processes needed to be changed. Therefore, the practices required a shift in the way the mine site operated. When the procedures established the standard, those practices eventually stabilised. However, automation had introduced levels of complexity within existing processes. In manual truck operations supervisors relied heavily on the control room. Now with automation, people can monitor the activity much more closely:

> *Manned relied a lot on control in Perth to run the trucks and run the system. And we just kind of overseen what they were doing and contacting them. Whereas now with autonomy, we can actually see for ourselves what's going on, where the trucks are going, where the dig units are. And we can help assist them with it.* [P9]

Supervisors previously managed a lot of hot seating arrangements. The task is now limited to excavator operators, with the people who remain. For supervisors leading the operation, participants described how there was not a lot of change for them. Primarily their role is to supervise people doing the work, so unless they are actively participating in tasks, automation did not change a whole lot for supervision. However, they must still drive vehicles amongst driverless trucks and follow all the new processes introduced. Before the final development, supervisors were far more involved until the residual roles evolved:

> *It definitely changed. In the beginning it was more around problem-solving and sorting and understanding the system. And then of course, as the system grew and as we grew as a mine site, it went more to the supervision of the people and delegating those other roles to the actual people that were doing it.* [P19]

As the system matured, supervisors were performing similar tasks—for example, pre-shift briefings, daily meeting and workplace inspections. Depending on what tasks people performed, some adjustments made in the way the tasks were executed. A grader, for instance, needed to change the way they maintained the road. Participants highlighted how graders no longer take control of their entire route; they must work in smaller sections to work in with the trucks. Similarly, with dozer operators working on the pit floor, operators need to work around the machines, rather than automation working around them. Therefore, for a supervisor, it was more about verifying that these tasks were performed correctly. Furthermore, there was more to confirm in a driverless operation, including load plans, survey lines and speed zones. Supervisors needed to adapt and plan their work through the system:

> *… you now have a lot more visibility. So, you can see a lot more without having to do the k's (kilometres) in the pit… You don't have to be running back and forward all the time. You know you still got to do your physical inspections, but you just don't have to be doing it 24/ 7…* [P16]

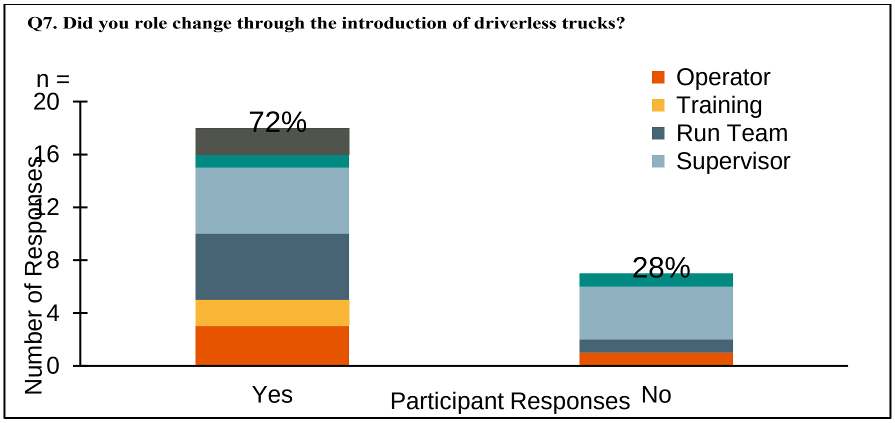

Figure 1. Responses to question whether participants' role change through the introduction of driverless haul trucks. Data collected through one-on-one interviews.

Personnel frequently described their role as being the eyes and ears for the operation. Despite trucks stopping if there was something wrong, the automated system cannot identify potholes or wet roads. Humans must intervene to slow the trucks down by putting speed zones in place. The control room requires in-field personnel to advise them of environmental conditions:

> *So that's the big change. Don't let the truck just do their thing… They might run through potholes. Like for example, now it's raining. The roads are absolutely buggered, but they will just go flat out until something breaks.* [P23]

The fact that people are dealing with the technology described to be a significant change. Personnel need to trust a computer, as well as their colleagues. The actions people make also impact on the decisions that are made by the machine. For example, anything that automation is instructed to do, the trucks will perform. In contrast, a human explained to question a lot more of the decision makings. Yet, the machines fitted with additional perception and object detection. Therefore, some people now validate those systems to ensure they are working—the system design tailored for people who like to be in control. The entire mine can be observed, including lanes and speeds within the mine. Most importantly, how to interact with a truck with no driver.

3.1.3 New technology and computer-based skills

Participants explained how the introduction of driverless haul trucks increased their skills. The base level of operational understanding remains, while automation took it to a whole new level:

> *The way I look at it is you know; this is the next level for operators. It's how they can use their current skill level and integrate it with a new technology.* [P2]

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Participants reported how people that apply the system are the ones who are more comfortable; they also work-in the system. The ability to interface effectively with automation explained as one of the differences. There was no doubt that some participants created new skills. Personnel now have to observe visual displays to monitor the virtual system. Some operators need to manipulate loading points and where they want the truck to go. The most challenging part is that the physical world may not always represent the virtual model. Therefore, skills developed to observe the screen and visualise where you want to position the truck. Work areas may be tight, yet the operator must be able to get trucks into narrow areas. Driverless systems need more room to maneuver, yet the adaptive skills are difficult to teach:

> *So, you've got to be able to imagine how you're going to get the truck in there and manipulate sometimes your spot points and all that sort of stuff to try and get the truck to come in and do what you need it to do. So it's definitely created another skill because you've got to think outside the square sometimes, you've got to load the truck where you wouldn't usually load a truck, or how you wouldn't usually load a truck, but to get a truck loaded you will just deal with what you've got to get it in there.* [P4]

Operators also explain how they must be thinking ahead of the game. The skill is changing boundary lines to give driverless trucks more space to operate. As a result, the excavator operator can avoid getting stuck in a corner and start to plan where they are moving to next. Its forward-thinking developing skills and working with the technology. Participants explained how personnel must want to be good at learning technology. Those who do not wish to excel simply are not interested, nor are they effective. People were reported to need time to understand how to interact with the technology. Participants did note, however, that frontline workers soon became reliant on technology. Reliance claimed to remove some of the abilities to excavate without a screen. In addition, the tolerances for loading a truck narrowed, where operators were more cautious with truck drivers behind the wheel. While dig patterns and wall compliance remained unchanged, it is the interface with the truck fleet where transformations occurred. Described as a learning curve in interfacing with computers and planning further ahead:

> *Yeah… changed dramatically. Like I said before I'm a basic guy, but you know learning these computer things I'm like wow… man, I didn't even lift up a pencil, I didn't even know how to lift up a pencil and write on a piece of paper when I was at school… For me, the autonomous side has sort of taught me you know how to be like a, what do you call those things? Not like a Pac-Man, Technoman…* [P6]

Learning how to interact with driverless haul truck increased the confidence of people in the use of the technology. Participants highlighted how they had purchased new technology on the back of learning screen interfaces at work. Learning the system and implementing their adaptions, refining their skills and improving their performance. Technology has opened new pathways and methods of thinking:

> *Well, you know in my mining career I've never worked with screens before, everything has been eyeballing. Use your eyeballs, and those are the screens you use. But you know, getting to know how to use the screens and how to use the system properly. I think that's the main thing, hey, the system.* [P6]

Driving haul trucks was described as a monotonous and unchallenging. More importantly, there were little problem-solving aspects in the role. Supervising a driverless fleet in the control room now offers

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controllers the opportunity to develop new methods. Conventional techniques such as refueling a truck may take participants a little longer they did before, however the skill is yet to diminish. For personnel already in the control room, participants explained how the fundamental skills were relatively the same. Automation simply added another layer onto their routine, with an emphasis on positive communication. A truck driver would previously enter a delay if the truck broke down—however, this is managed by a control room operator. The layer of automation introduced new skills in fleet management. The fleet management system taught people how to enhance truck performances through the virtual mine model. In particular, how speed zones and lane designs can impact on a truck's reaction. Computer interfaces inside light vehicles allow the system-based role to learn how to use a computer. The more people used this system, the more they learnt. With the ability to lift computer skills, personnel develop how to reduce and increase truck speed. Moreover, there are simultaneous activities needed to be completed at the same time. More importantly, learning what the trucks can and cannot perform, while understanding the boundaries in a safe environment:

> *One thing about autonomous is that it introduces new skills. It affects everybody in the pit and actually affects everybody as a whole… It affects water cart operators, affects every machine operator in the field; it affects all your mine controllers. Now it introduces new roles, your pit operator competency, you got your field builder, you got you, system builder, you got your autonomous mine controller…* *[P13]*

Those roles learn how to mode change a truck and interact with them safely in the pit—learning how to survey and verify high walls. They are creating virtual environments that are important to the operation. Physically mapping the mine site digitally and mapped to coordinates. If the virtual environment does not match the actual mine, then risks can emerge. Therefore, system-based roles were described as the cog in the wheel for the operation:

> *So, here you've got one person who is the driver of 30 trucks. And I think that takes a skill, because not only are you monitoring those trucks and you're assigning them… you gotta monitor their health as well too, because if a truck stops, you don't have a trucky calling up…* *[P13]*

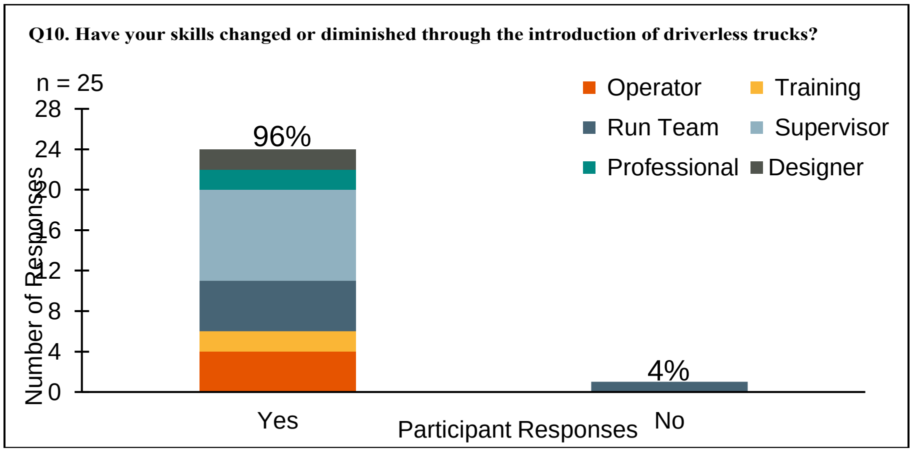

Figure 2. Responses to question whether participants' skills had changed or diminished through the introduction of driverless haul trucks.

Computer interfaces alert system-based roles of what trucks are performing. Those interfaces did not exist in a manual truck operation. Every role has been touched by automation, whether it is multiple

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screens in the control room or small interfaces in cabs. Supervisors taught how to mode change and recover trucks when they lose communications. Furthermore, how to build a virtual dump model, a lane network and implement hazard zones. The system was described as a large computer game that participants needed to understand. Instead of driving around and physically observing things, the system allows people to look at the area through a device. They are learning how to use a tool that enabled personnel to be more efficient and plan what they wanted to do next.

3.2 Residual workload

3.2.1 Bunching workload

The workload of residual tasks can be short and intensive, followed by long period of inactivity. If a driverless truck breaks down or identifies an object, people must respond immediately. The workload compounds with machines queuing when a broken-down truck is not cleared. Balance comes with keeping on top of clearing objects, validating and surveying dumps. Core operational activities are part of routine tasks, planning work based on what is happening. For system-based roles, this means driving around the site, following trucks and improving their cycle times. Changing lanes angles to increase truck speed and monitoring the way truck turns a corner. At times, the workload is described as high stress, with constant interruptions and breakdowns. From a users' perspective, since there is much going on at one point, system-based roles need to be across it:

> *Previously for a manned operation you wouldn't, you have 40 trucks drivers that can think about it and do it yourself. You've got one controller, on average, looking after 25 trucks, with one builder. Planning all the work for those 25 trucks, as well. So, it's constant just churn; it doesn't stop; it's relentless… [P2]*

When a driverless truck loses communications, it immediately stops. There is a lot of interaction and intervention to keep the operation moving. Controllers, for example, have to intervene when something happens. Whether it is an obstacle detection or a close interaction with a light vehicle. Moreover, a driverless truck may also lose its assignment, which can also compound issues. Particularly when production pressure is placed on top of everything as well. Delivering outcomes for the business with high expectations on Key Performance Indicators (KPIs). Participants explained how it is not a job that people can do for a very long time. On average personnel fulfil such a role for two to three years. People are moved around every couple of days, which reduces their internal stress levels. Some people described to be able to handle such workload, while others have lower tolerances:

> *Some people can handle it better than others, but you got to try and keep that balance right for them as well.*
>
> *Otherwise, people just get frustrated and get burn out, make mistakes. There's this whole other piece that we have to consider now, which we never did before. [P2]*

Participants highlighted how the control room no longer has people in the cab to witness activities unfold. Therefore, local adaptions by truck drivers to avoid situations are no longer there. The workload in responding to those needs now reside with system-based roles. For example, if a machine broke down on a section of road, a manual machine would use an alternative route. However, with automation, the driverless fleet would continue to use that same pathway and wait behind the broken-down truck. Manually operated equipment could also navigate around the truck; automation is unable to perform this function. With set planned routes in the system assignment, driverless trucks are unable to react to emerging situations.

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> *What can tend to happen there… if a scenario like that is unfolding and it's not identified soon enough, suddenly is potentially a simple solution or recovery, suddenly compounds and becomes bigger and bigger and bigger.* [P3]

The intensity to resolve driverless truck issues can be quite high. In particular, when the physical environment is not overly stable with rough roads and low network coverage. When the situation is unstable system-based roles can always be recovering trucks. Furthermore, dump spaces need to be allocated to the fleet evenly across the mine. The workload can increase to rebuild dumps, surveying and modifying the dump plans. The high workload follows extended periods of inactivity:

> *Short intensive moments. Like so you'll have a lot of not a lot. Then you will have a whole lot of outages… there will be bloody trucks falling off the thing (network) everywhere that you gotta go fix… get trucks and put them back into manual mode and move them out of areas and stuff like that. It's very sporadic.* [P4]

The workload on the excavator operator described as one of the most straightforward tasks on site. The role explained as dull in comparison to system-based roles and functions. Particularly when the excavator is benching, and there are a limited number of trucks presenting. When operating the dozer, participants found it challenging to avoid machines while trying to perform their work. In preventing driverless truck interactions, a grading task can take three or four times longer when maintaining the road where driverless trucks travel. Participants explained how the control room should always be busy. There is data retention or tasks to follow up on with maintenance when the system is running smoothly. Despite this, there are only two people designated for the entire haulage fleet:

> *So, it is a busy thing, and I think a lot of people forget you've taken away the thirty truck drivers and left one person in charge now.* [P8]

A higher workload noted to take away their attention from what personnel need to focus on. Participants described how merely looking at the virtual mine model; participants can determine how their day is likely to unfold. When the excavators are in tight areas or drop cuts, the system-based workload is going to be high. Close areas do not flow as the automated system needs space to reverse trucks under the loading unit. Setting the goals in a group of excavators and haul trucks can be difficult, taking approximately an hour to complete.

> *If nothing happens in an hour, all your processes, all your dumps are fine, all your dig units just miraculously go. It would be really good, but it never happens in a drop cut, it never happens in a reverse drop cut, there's a lot of cleanups, there's not a lot of room there, so you are mucking around with builders. The trucks are stuck, and you can't get cusps. So yeah there's a lot of workload in situations like that.* [P9]

The driverless system described as being designed for opened spaces, with big dumps and short runs. In those situations, it is more effective than manual operation. Although communication with field-based roles is crucial, calling people by phone and using messaging applications. The control room is not only managing in-field interfaces, but they also communicate with plant control. The roles become the voice for the system in and advise others where the material is heading:

Yeah, you can have hours where you don't stop... Being on the radio, talking on communicator, talking to maintenance, talking to supervisors and all that. Then you might have four hours flat out and then nothing. Ha-ha. So, it really does fluctuate a lot [for a controller]. [P9]

Participants noted that it depends on the conditions. There might be perfect conditions with a limited number of detected obstacles. Whether there is a full crew, or the team is short of people for the shift. Therefore, with the balance of potential obstacles and road conditions, the workload can differ:

One shift you could be recovering trucks, clearing obstacles none stop, and you are just getting calls for two-ways both of them don't stop all night. Then other nights when the system is running well, and the roads are maintained well; spillage is low. You could be cruising around, waiting for something to happen. [P11]

The workload described as moving from one extreme to the other. System-based roles can also fulfil simultaneous activities, including hot seating, calling trucks into maintenance bays or covering breaks. While it was described to be balanced a majority of the time, it is the intense moments that can increase the cognitive workload. Those moments appear to all come at once:

Like yesterday, at one stage we had the scraper broken down and 100 metres, couple hundred metres up the ramp we had a dump truck broken down. Then another 150 metres we had another dump truck broken down. We are trying to build bunds behind the dump trucks that are broken down on the ramps and get the Mine 5s and 6s, with the maintenance guys to come and fix them. [P12]

The main activities include verifying dumps, travel lanes and speed zones. More importantly, following the trucks around the mine and ensure they are optimising the cycle. When the cycle is efficient, there are limited abnormal reactions to situations. Participants reported how this is rarely the case, despite the workload balance improving. The problem is that if one of the variables is taken out of the equation humans must intervene. For example, if a dump is full, the truck cannot think for itself in terms of where it needs to go. Therefore, the workload increases for system-based roles to provide a new location. If a truck stops for an obstacle and is not cleared, the oncoming machines will sit behind the truck and wait. When the system is running smoothly, the workforce is calm. However, when workloads increase from disruption, the situation becomes tense. The health events, truck stoppages, network loses, and truck recoveries all come at once.

3.2.2 Executing tasks that driverless trucks cannot perform

There are several roles performed by humans that are the by-product of automation. Personnel must take surveys of the real mine site and upload them into the mine model. The task drives the physical parameter of the area with a mobile machine. Despite the development of LiDAR technology to gather this data, it is not there yet. The trucks also need to be recovered after losing communications or breaking down, manually driven out of the haul road.

Road obstacles detected within the lane visually inspected before clearing. Moreover, since the trucks do not retain that information, the human can be back to the same location moments later. Since the driverless system has improved, the residual work overtime argued to have improved. However, with the operation expanding, the driverless fleet was moving into areas designed for a manual truck operation. The spaces were tighter and developed on smaller fleet classes. Therefore, the participants needed to assist driverless trucks more through those areas.

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A lot of the newer areas we're going into were designed for told me whereas a lot of the areas we originally moved into were designed for manned fleets and they're even designed for manned fleets of a smaller truck class. So that was constantly causing issues. *[P3]*

There also several tasks that personnel would like to perform, yet they are restricted. They are undertaking maintenance on roads reduced due to surveys, interactions and obstacles it can create. When it comes to loading a truck, a virtual spot must be placed by the excavator with the bucket. The system accepts that spot if it is within the survey boundary. Excavator operators need to press a button on the joystick to authorise the truck to enter the mining area. The location commonly used twice before the operator needs to reset the spot as they move along the bench. When leaving the excavator, there are settings and adaptions put in place:

I have to slow them down because of the floor conditions. It can't recognised that there are big bumps in the floor and it just goes charging through. Generally, I use the system on office selection. I will use preferences when I am in tight areas. *[P5]*

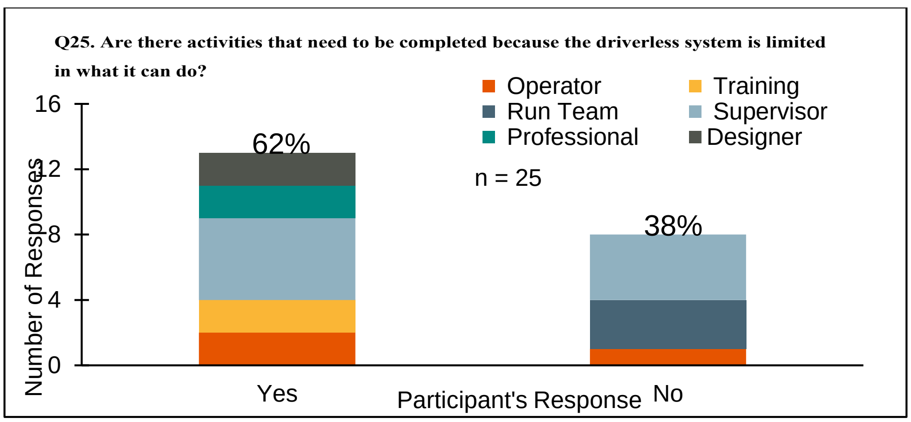

Figure 3. Responses to question whether participants had observed a driverless truck perform something that they did not anticipate. Data collected through one-on-one interviews.

It is not only individual tasks that the trucks cannot perform, but it is also coordinating their movements. At times the fleet needs to be locked to a particular area. Otherwise, the logic would direct trucks to the excavator moving the most tons. It was described as a very manual task to assist the system. Therefore, goals were introduced into the system to determine where trucks are allocated. The dumps will also go full, whereas, in the manual operation, this would not be the case. Therefore, people do not have to re-plan and area and shut the dumps off to resurvey the model. The trucks are then moved around to accommodate the work, which requires personnel to think more ahead.

We do a lot of surveying and verifying of the real world. The autonomous truck, they could do a lot of the surveying as well, I sort of like having the human intervention and ownership of the area.

We have to go and physically or virtually clear a non-obstacle. *[P11]*

The participants believe that there is a suitable level of human-machine interaction. However, participants noted that there is a lot of remedial work. For example, a truck may fail to tip on a waste a dump truck multiple times, which requires the dozer to push more material. The practice can result in

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weak spots, yet the dozer operator needs to keep pushing. Participants describe how they need to think outside of the box for the trucks:

> *I guess we are the eyes for them, and the brains for them. Because they just do what we tell them to. You gotta be pretty onto it… Monitoring where they are going, make sure the trucks with high grade are going high-grade dumps or crushers. And the trucks with waste are obviously going to waste dumps.* [P12]

The system was noted not to be perfect from the beginning. Participants explained it would be nice to identify objects and classify them appropriately, instead of waiting for a person to clear the object. Moreover, the trucks are yet to identify potholes; therefore, personnel must put in speed zones in hazardous areas. Automation could be more intelligent, rather than merely travelling quickly back to the digger only to queue. Therefore, the system could be a lot smarter and limit the workload on humans. There other examples, such as trucks being unable to lower their tray, with the truck's tray getting stuck on the windrow. Despite this limitation, the focus can soon turn to the people supervising, whether they are planning and enabling the trucks to perform. Since the system requires more room to maneuver, the system is limited in tight spaces. When comparing them to manual operations, there was no need for human intervention.

3.2.3 Interpretation of system information

Humans may misinterpret the information outputs from the driverless system. Operators may interpret some warnings and codes in a particular way. More detailed analysis is usually said to be provided by engineering, mainly when they are the designers of the codes. The design in practice can create situations that are not reflective of the intended design. As a result, video footage and snapshots are taken by people to compare the outputs with actions. There is diagnostic information presented to display fault codes, which must be interpreted by the people supervising the system. Without the background information, the users can be left confused about what the truck is trying to tell them. Depending on the person's role, they may have access to diagnostic information. Therefore, they rely upon in-cab interfaces or system-based personnel. Some of the indications are even more passive, with a change in lane colour or truck function:

> *So, you get an obstacle; the lanes go green. You may not read that this is happening or take notice. You may misinterpret it or be prompted by control. You might also be in the body boundary and be in its lane. Sometimes people don't know they're in the lane, and the truck won't come back.* [P4]

There are other examples where trucks do not reverse into position because it is already in a loading sequence. The excavator operator presses the send button and truck backs under the excavator. Operators must also learn what the lanes colours represent. For example, if a truck does not reverse into position and the lane colour is blue, it means that the digger bucket is blocking the lane. The in-cab display may also indicate that a truck is 10 minutes away. However, the truck does not arrive when the system stated it would on the screen. There may be specific errors or messages that operations do not understand; therefore, personnel are required to read maintenance manuals to understand the data:

> *There is some information there that doesn't make sense. You are troubleshooting, you might troubleshoot it three or four times, and all of sudden it works. I've had instances where I can't figure out why the trucks are doing what they are meant to be doing, and all of a sudden worked. And I can't even explain it.* [P9]

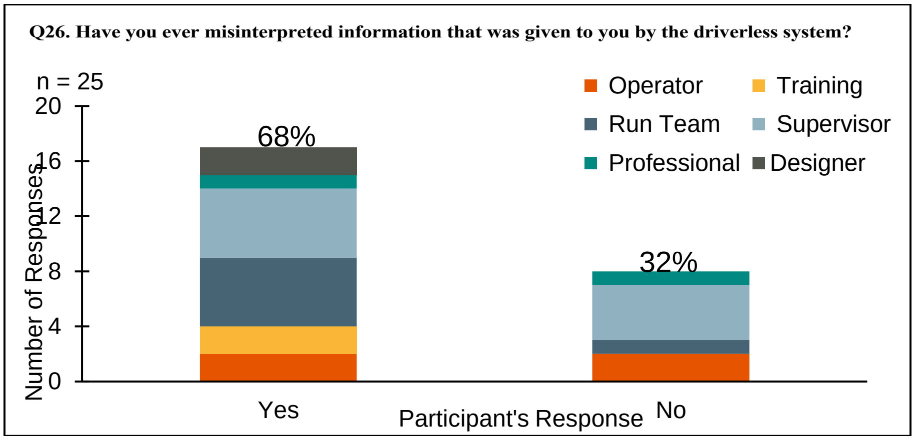

Figure 4. Responses to question whether people had misinterpreted the information given to participants by the driverless system. Data collected through one-on-one interviews.

Participants explained how, at times, driverless trucks do not know where to go. A truck that is stationary with a green tile, and there is no information to highlight the issue. People described those situations as errors in the details outputted that do not make any sense. Therefore, personnel troubleshoot it by pressing stop/ play and the truck drives away. There were also instances where the system highlighted that a truck in operation, yet it was reversing back to the loading bay. Deadlocks can occur in the loading area, despite no additional instructions given by the digger operator:

> *So, I suppose like when you are looking at what you are seeing, like the information you are receiving, you can't explain why it is doing it… Sometimes in a dig unit and all that you can have a truck on your screen but it's not actually there.* *[P9]*

Despite some of the information or glitches that are unable to be interpreted, participants believed the information is always accurate. Everything that is presented on screens to operators and is available in real-time. The labels, acronyms and the types of data were noted by participants to be understood once they understood them. However, the language is new, which highlights terms with little meaning:

> *Like the new people that come over, you'll hear: 'Can you power cycle that truck?' Which is basically can you turn that truck on and off again. They like to use stuff like that.*

There are help pages available to personnel to interpret system information. Moreover, the predicted pathways of the trucks were argued by participants to be accurate. For example, if the blue lanes indicate that the truck is going straight through the interaction, the truck always travels straight. However, it was noted by participants that misinformation can be provided, such as updated survey files or the system is not transmitting the positions of equipment. Road lanes can be observed on the right-hand side of the screen, yet the paths are actually on the left-hand side. Therefore, not necessarily misinterpretation of information, more the fact that the correct information needed to be displayed to operators. Designers label the codes used with terms that personnel do not always understand:

> *Not in autonomous run mode. What does that mean?... Unload assignment request. So, no one knows what that means, and it (the driverless truck) just sits there in red (red tile).* *[P14]*

Participants in system-based roles explain how it takes time to learn the systems' information outputs. Once those terms are understood, personnel can start to determine what the system is attempting to

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explain. The understanding of the information was argued by participants to be underpinned by experience, attaching the reference or warning to a specific meaning from previous interactions.

3.3 Local adaptions

3.3.1 Situations emerge outside of processes and procedures

In the initial stages of driverless truck development, there we situations the technology had never faced before. In particular, when the operation first attempted drop cuts, participants described them as a 'nightmare'. Since the space was so tight, the trucks could not turn around and reverse back to the excavator. Without the trucks being able to reverse to the loading point, the trucks were unable to be correctly loaded. This phenomenon forced excavator operators to adapt and change their techniques. Also, the system functionality was adjusted to accommodate the mining environment. Design criterion created by operations for engineers to design the system to match the environment and work more effectively. Upgrades allowed the trucks to perform in tighter spaces and allow trucks to reverse back to the excavator:

> *Early on, it was a lot of manual intervention to do that before. You know, you'd have a builder focused on that the whole time. Just sitting there, tweaking the lanes or moving the spot point or just doing a whole pile of manual click work to make that happen. And that gets pretty onerous when you are doing that for 12 hours, consistently.* *[P2]*

The practical experiences faced since the implementation have enabled the technology to evolve. Participants reported that this is where a lot of the improvements came from; working through the pain points. Participants explained how operators consistently confront with novel situations. Since the structured processes were designed for operators to broadly cover scenarios, embracing the dynamic and fluid environment of mining. The scenarios faced may not be the same every single time:

> *You get variations of that scenario. That's the situations when I say constantly. It is how to match the scenario and slightly modify your response but following the process in principle. Depending on what is happening and where the truck has stopped. They may have to get a little bit creative within the area to resolve the issue.* *[P3]*

Participants noted that mining procedures were re-written in the early stages every day of the week. What was executed by people, in the beginning, would not be sensible in the future. The operation was said to be continuously improving upon safety and productivity. Moreover, participated reported thinking outside the box when troubleshooting trucks. A truck may remain stationary, and system-based roles are unable to move the truck. They are figuring out why the truck was not and working through a process of elimination. There was no manual or instruction for unique situations that arise. Therefore, the participants are adapting their experiences in those situations:

> *Or you have to do silly things like override it to sit on the correct lane, or you know. Or it could be as in-depth as… getting a power cycle for the truck to reset. Kind of what was, system-wise was happening on that truck… Outside the box like it happens all the time. I can't really say one thing.* *[P7]*

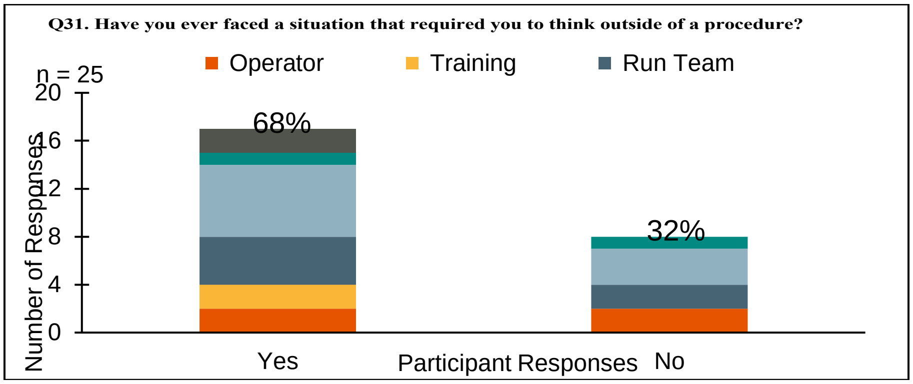

Figure 5. Responses to question whether participants had ever faced a situation that required them to think outside of a procedure. Data collected through one-on-one interviews.

Since personnel are adapting in novel situations, there were reports of inconsistencies across the shift. The participants argued that every shift should be performing the same tasks. The differences were explained by participants to be as simple as handing back control of a truck. A chain of command that informs personnel controlling the fleet that the mine is safe for driverless equipment. Participants noted that for an operator, there was not a lot of adaption outside of the available functions. Although some operators have the flexibility to play within the parameters, for example, selecting what side the trucks should reverse to the excavator. Therefore, operators usually lean on system-based roles for technology support. More importantly, when attempting to recover the truck from a situation, utilising learned functions to influence truck performances:

> *... there's definitely a few tricks you can do here and there to get trucks out of situations that wouldn't be like textbook... you might not have lanes to get a truck out, but you can still... plan-exit-forward or reverse a truck. So, you can actually deal with an issue with the truck and get rid of it without the input of anyone else.* *[P9]*

The participants explained how vital thinking outside the box could be. Particularly given that if automation is to be successful, the trucks need to keep moving. Therefore, if a truck faces a situation that it cannot overcome, it is the human who is troubleshooting the case. Participants describe that it is something they get better out, and it is challenging to teach. In the early stages, participants described how there were many situations where standards were still being developed. Some minimal people understood driverless technology. As time has evolved, more processes and systems were developed by professionals for people. The gaps were covered, and personnel began to know how to perform those tasks. Over time, as situations have emerged, the systems for working with machines to prevent incidents from occurring:

> *That's the thing with autonomous the processes have been developed because of things. To prevent that happening against we have developed those processes. Activities outside of the processes eventually become the structured process.* *[P23]*

Participants explained how the processes also attempt to cater to the masses. Therefore, participants argued that methods would never cover for all situations. As a result, there will be times where personnel need to provide a level of adaption to suit the scenario.

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3.3.2 Remaining in-the-loop with the system

There remained opportunities to assist people in understanding what the trucks are performing. Different roles also have separate displays. Where a system-based position may have an in-depth assignment engine display, an operator of a machine has far less. Therefore, operators are not necessarily informed by the system of what function the truck is performing. Operators simply have the lanes displayed and identify the mode light function. For example, If a truck performs a U-turn, the operator will not receive information on why the truck performs the task. Additionally, if a truck stops, a machine operator will not be informed of why. There could be various reasons why it stopped, including obstacle detections or loss of communication.

> *They don't have any feedback point currently to understand some of those things. I think that's where our next generation of software for in-cab displays will start to change. We want to be able to give the operators a level of detail and understanding so they can see some of the stuff. And potentially engage at a certain level.* *[P2]*

Remaining in the loop appeared to depend on the level of visibility in the system. Without a computer-screen interface, it can be challenging to determine what the truck will do next. That is, of course, is unless personnel understand the pattern of the truck cycle. For example, a person may intuitively know what the next step is in the sequence maybe. However, the surprising component of this is when the truck performs something different. A driverless truck, for instance, may turn around while waiting in queue to be loaded. Participants explain how it comes down to visual displays in the field and understanding the basics of mining:

> *The truck's travelling it's either full, or it's empty, it's queuing or its spotting, loading or tipping. I think if you were new to mining and didn't really understand the basic cycle of a truck. Even if you didn't know what each element was called, then you may think it is unpredictable behaviour.* *[P3]*

Participants describe how driverless trucks can only perform tasks within the cycle sequence. Actions are not completed without the correct instructions from the system, indicating that the information is available somewhere in the system. A truck cannot physically move without a valid lane to drive on. Therefore, rather than being informed, the truck's actions are observed to determine what cycle the truck is performing. This experience, however, depends on the persons' experience and role. There, participants who grapple with the interfaces to know what is happening:

> *I struggle with those pages that tell you where the truck has been and where it is coming from the loading unit and process. What dump it's going and how it is going and where it's going. I think those pages are fairly technical. For a digger operator (their type of interface) it's fine, it's basic.* *[P4]*

For simpler interfaces in manually operated equipment, the screen is described by participants as straightforward. Operators can observe the lanes coming towards them and the colour changes as it gets closer. Operators without technical displays seek guidance from system-based roles to inform them of truck performances. Those roles relay messages to enable operators to remain in the loop. For example, a request may be made over the radio to determine why a truck is not reversing. A controller may advise operators to move their bucket out of the way when it was detected as an object. Experiences of control room operators can be much different, particularly given that they now supervise up to 25 trucks.

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Yes, you may be looking at one truck on this side but then like 20 seconds later you're back at the side... like it's constantly flicking between the two, because of your screens... I literally have two screens, and then I'm looking at both at the same time (to remain in-the-loop). *[P5]*

The participants explained how they do not disconnect from the situation; instead, they direct their attention to where they are needed. For example, if the flow of the daily plan changes and the excavator is moving locations. Monitoring the screens and scanning the situations to stay in touch. Despite actively involved in an activity, participants in the control room utilise their peripheral to observe any abnormalities. Furthermore, the radio calls enable personnel to hear what is happening and get an indication of what is coming next:

I listen to my two-way. That's a big indication… like with the trucks you can watch and observe, so that's how you stay in the loop thereby watching that. But if you're not told what's going on, you can only do what you can do then. *[P8]*

Radio communications were noted by participants to provide essential information. The difficulty, however, is predicting what the system will do next. After truck tips, for example, the system generates its assignment based on the goals provided. If the truck is heading in the wrong direction, it gives system-based roles minimal time to redirect the fleet. A controller may also decide to lower the production of an excavator to avoid trucks favouring one machine over another. Despite the indication of the current function and listening to the radio, the system was reported not to indicate what it is going to do next. However, in terms of what a truck is currently performing, it was argued to be reasonably straightforward:

The trucks are doing what they are supposed to do—the lane colours and what not you know where's its going. You know where it is turning. I think it generates itself. You can tell by the lane colours. It's just being familiar with the truck. *[P3]*

There are other queues outside of the system that participants use to remain in-the-loop, including identifying the material type they are carrying and through pre-shift briefings. The material type indicates whether the truck is going to a waste dump or crusher. The system also can send messages between personnel or inform them of a site-wide stop. If there is an emergency, an alert is presented on the screen to indicate that operation is to cease. Participants described how detailed information is provided to system-based roles through in-cab displays, yet remain limited for operators:

I'd say you are not really informed unless you have a client (technical screen) in the car at all. You'll have dump spots close on you for no apparent reason. Dumps close, dump reopen and that. I'd say there's no feedback in that sense. *[P12]*

The technical displays provide more information on what is happening, which is different from the predicted pathways provided to operators on every in-cab display. There are several pages to enable personnel to monitor the performance of the trucks. Travel progress monitoring pages tell people where the truck is going and where it has been. The status page provides haul routes for all trucks and is monitored by operators to determine where it was loaded. A yellow route path indicates the truck's destination. Furthermore, the viewing options provide travel pathways and continuously monitored for performance issues:

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Let's say if I'm driving around, I see a truck stop. I'll bring up the autonomy status page. Boom I'll click on the truck. Why is that truck stopped? What is it doing? That information is fed to me immediately. So, I know what's going on with it. It's having a comms loss; it'll turn green and go in a minute. It's crapped out it's not going to move, so I know we have to recover it. So constantly using all that data on the monitor to tell me what's going on in any one point. *[P5]*

The in-cab displays are used by personnel to determine what is happening. The status page highlights whether the trucks are in operation or on delay. Radio communication is used by people to provide additional context to the status of the machines. Therefore, participants emphasise using various means to remain in the loop.

3.3.3 Human intervention

There are various diagnostic tools that driverless trucks use to self-analyse functional issues. The self-analysis assists people to understand the health of the machine. Despite the sensors located on driverless trucks, humans are still required to intervene when the trucks face novel situations. From a diagnostic point, if a truck appears to be performing not as intended, personnel monitor the system in the back and dial into the truck live. Observing the actions and evaluate the responses to the desired design, attempting to understand what is influencing the actions. For more immediate effects, participants describe not trying to intervene unless someone is at risk. Participants explained that humans do not have to intervene unless the truck does something beyond what it is programmed to do. Therefore, in the event of an emergency, personnel are provided with an emergency stop device. The device enables people to stop the fleet when activating the device.

The AHT, for whatever reason, hadn't identified as a potential risk at the time. Maybe it is a situation where the AHT had and based on what the individual piece of equipment was doing it didn't believe it would interact with it or it may have already performing he necessary steps to avoid the situation. However, as a reactionary measure, I would have hit the emergency stop. *[P3]*

The driverless truck has been observed stationary with their tray in the air. When observation like this is by personnel, intervention is required to put the truck back into the operation. Despite the control room attempting to send a script to recover the truck, the truck was unresponsive. The truck was mode changed to manual and driven to a safe location. When it comes to deciding whether to intervene, participants describe that it comes down to chronic unease. If a situation does not look right, the participants explained the feeling they got to intervene. When asked what indications participants look for, people pointed to their experiences that reinforce their confidence in taking control.

I've made some stupid calls; I've called up and asked what that truck doing is. It's alright it's just doing this. It's about being proactive; if something is not right, you react to it. Whether you call control or press the emergency stop and have a discussion with control. *[P4]*

From an excavator point of view, if I don't see anything, I don't like I'm up against them straight away to get it fixed or ask them why—some a driven by data, while others explain using their instincts when deciding whether to intervene. For example, if a truck is bouncing over a rough floor, participants revealed that truck speed is reduced by operators to avoid truck damage and false overloads. Personnel intervene by placing speed zones across the loading floor. Participants argued that people must take ownership when working with driverless trucks:

We are the eyes and ears for it, like I tell everybody. So, don't be afraid to question it if it's not right. Fix it. Chronic unease. If it doesn't feel right, then it's probably not right. [P4]

There were reports of choosing to intervene when identifying incorrect lane colours or trucks not moving. The control room is called by operators to analyse the diagnostic page and determine what has occurred. Participants highlight making calls when they believe is not safe enough to operate. Trucks may be shut down by the control room to reboot the system. Additionally, driverless trucks observed travelling over the rough ground are stopped by personnel until the road surface has improved. Participants explained how system-roles monitor the actions of the trucks when determining to intervene, particularly in comparing settings to the conditions:

I was at the top of a waste dump putting in a centre island. That's when I saw the truck; it got sent away because all the dump spots were full and I saw that it was about to go down the ramp. I checked my screen, saw that there was a zone on it, zone had 42 k's (kilometers an hour), so I tried getting a hold of mine control. Couldn't in time so I [emergency stopped] it. Called control and told them the situation. And yeah got the speed limit on the way down. [P12]

The participant explained how the settings did not accommodate a loaded truck descending the ramp. Although speed zones would be in place heading away from a loading unit, it is usually not in place heading away from a dumping area. When safety is the primary issue, people intervene. However, when it comes to the assignment engine, personnel avoid intervening and re-assigning trucks where possible. The reason is that the cycles can be interrupted and lead to more trucks bunching. There are instances where there is no choice to intervene when excavators go down:

Sometimes, that's not feasible... sometimes this digger will have four trucks and the trucks are still wanting to go back there, and I don't want any more trucks to go back there so I'll hard assign them away. [P7]

When the assignment engine chooses to send a bunch of trucks to one excavator and not another, there will be people who intervene. Participants describe also wanting to avoid incidents and prevent harmful situations from occurring. Moreover, if participants observe a potential interaction with a person in the field, people will intervene.

I'll just stop that truck. "can you please move out of the lane." and then we'll be able to proceed with you know... preventing something before it happens. That's the duty of care I guess your operators... like you want to look after them they look after you, they help you out, they clear obstacles, they do everything that we need them to do so do the same for them. [P8]

If a truck is broken down in the middle of the road, it was explained how personnel intervene to send them manually to another load unit. Since the trucks cannot drive around one another, a person needs to intervene to build a virtual lane to allow trucks to overtake. Participants noted that is can be challenging to intervene since there is so much going on. Unless a truck is observed getting into an awkward situation, it is unlikely that people will have the opportunity to intervene:

If I had of been watching a truck go over the edge, I could have intervened with my [emergency stop]. When I saw it just go over the windrow, we could have [emergency stopped] it. That would have intervened with that truck, and we would have stopped the truck, and it wouldn't have gone over the edge. *[P23]*

Participants also explained how witnessing a truck reversing into a paddock dump and the wheels spinning. In those clear cases, participants highlighted that people would intervene. They are adding that there is no real science behind the intervention, other than intervening when there are flames, or there is smoke coming from the truck. It is, however, a different scenario than in a manual operation. Rather than contacting the driver, the truck is emergency stopped, or system-based roles stop the truck:

Other incidents where a truck was trying to back through a windrow, and you could see it trying to get through the windrow. A water cart spotted it and was like copy mine control this truck is trying to get through the windrow. He should have just [emergency stopped] it. So, it's fairly obvious if there's something going on, hit you're [emergency stop] and call mine control. *[P11]*

The participants reported that there are people who are afraid to intervene and activate the emergency stop device. With experience and time comes the confidence to take over control. There are instances where rocks can fall behind the wheel. The truck would not identify that large rock caught under the tire; therefore, participants highlight that they would intervene. Limitations also include pedestrians on the pit floor and trucks entering the loading area. The fact that someone is at risk triggers personnel to intervene.

Same goes if there was someone on the floor for whatever reason. A person, I wouldn't hesitate to use my [emergency stop] straight away to stop a truck. Anything like that. Anywhere where you think it is going to hurt somebody I just wouldn't even hesitate. *[P15]*

The in-cab displays also allow people to foresee potential interactions of safety incidents. Also, if a person identifies a truck going to an area where it should not be, a person will intervene. As soon as trucks stop or perform a task that is inconsistent with scripts, a human intervenes. There have been instances where trucks are cleared by personnel to proceed, yet it does not drive away. A human must intervene to send the truck another instruction as to where it must travel to. Whether a truck is backing up to a tip head and a person is unsure whether it is going too far unless the person had a full display they would not know. A technical display provides people with an in-depth understanding of the where it is going to stop, how much further and what speed it is doing. It was explained by participants how experience in observing truck performances underpins whether people will intervene:

I think with experience watching everything constantly; you know that you don't have to intervene. I've never intervened other than an a-stop, wet road or escort. I think its experience, being showed and taught what to do. And wanting to know the system. If you don't want to know the system, you are not going to know what to look for. *[P14]*

Participants revealed how personnel need to be more proactive. Currently, it was noted by participants how people are reactive and what for something to happen. For example, rather than intervene in a situation, wait until the driverless truck needs assistance. Field participants ring system-based roles to ask them for me details behind a truck's performance, increasing their understanding. There were contrasting views on whether people should intervene or not, only intervening when trucks step out of their parameters. A truck may have lost communications or breach its travel lane and stopped.

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Personnel will dial into the truck and change the mode to manual. Participants explained that people learn by making mistakes, developing the skills to intervene with the technology. If something does not look right, people are encouraged to stop a truck.

> *Having the trust of the operators as well if they see something that's not right, they say it. And this is another big one, and I guess this is all to do with training and confidence. What each role does, knowing when the time is right to make a change.* *[P25]*

Participants explain how people in the field at the eyes to identify situations. Despite a central control room that monitors truck performances through the screen, they cannot see everything. The more eyes that are looking for novel situations, the less likely personnel will miss safety issues. Positive communication is key to contacting a person to check on circumstances and devise whether to intervene. Participants explain how it is easy to get distracted with operational duties. Since everyone has different priorities, personnel can overlook driverless truck activities. Unless there is a pothole in the road and there is nothing to slow it down, people will intervene. They were stopping trucks, placing speed zones over the area and letting them go again. The intervention has occurred previously during escorts, with the vehicle being escorted not visible in the system. If a breach in the escort vehicles occurs, it was explained by participants how people intervene to stop the truck from interacting with a vehicle with fewer safety layers in place.

4. DISCUSSION

The roles described by the participants highlight the residual positions introduced through the replacement of truck drivers. Conventional roles were upskilled by trainers to learn how to interface with a machine. The transformation of functions highlights the activities that are yet to be automated. Also, it underpins the capability of humans to examine, monitor and modify processes that cannot be executed by automation (Miller & Parasuraman, 2007). The new roles are included in the run team and consist of builders and technicians. The builders design and maintain the virtual mine model, while the technicians monitor trucks cycles, mode change trucks and recover them from non-designed situations. While there were new roles introduced, conventional roles were transformed by technology to accommodate the introduction of automation. Excavator operators explained now owning the load plan, which required them to identify a loading point, set reverse location preferences and instruct the truck on when it is suitably loaded. An in-cab display highlighted travel lanes, arrival times and system messages to interface with while continuing routine tasks. Therefore, there were additional tasks and activities to monitor introduced through automation, which reflects the cognitive demands of monitoring computer systems (Wickens, 2008).

The most significant transformation was found in participants who previously drove trucks and transitioned to system-based roles. Where driving a truck was described as being quite monotonous, the new position is actively involved in operational tasks. A system-based role promotes to a higher level of supervisory control, which passively received information and intervenes when required (Stanton et al., 2001). Humans are not known to be effective passive information receivers; they need to acquire, interpret and respond to data. Researchers have pointed out that people are not overly skillful in responding to this data (Endsley, 2017). Despite this, every role in the operation now interfaces with a computer screen and engages with the automated system. Participants had to learn how to interact safely with driverless trucks and determine their operating parameters. More importantly, routines previously undertaken by manual equipment were forced by automation to change, graders reduced their road maintenance footprint and excavator needed to manage trucks in the loading area. Equipment practices also shifted, which required dozers to be mindful of their boundary to avoid interacting with

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oncoming trucks. Although there are studies of skills degenerating due to automation, participants described gaining new skills in addition to conventional capabilities (Bravo Orellana, 2015).

The new skills developed included computer-related techniques interfacing with driverless trucks. Techniques that involved interpreting system information, instructing automated trucks and nimble handling of buttons and levers. Participants also increased their understanding of the computerised system's functionality. They discovered how a driverless system performs within its system limitations. The system influenced the participants to think further ahead than they would previously, otherwise personnel could find themselves unable to respond quick enough to novel situations. Automation increased participant problem-solving skills, enabling them to utilise technology to overcome conventional limitations. There was an added benefit in being able to control the truck fleet, with automation introducing the capability to reduce speed and increase traction controls. Also, the introduction of modes increased the ability of participants to change truck modes and functionality. Personnel were learning how to build and maintain virtual mine model, which was described by participants to have significant implications on operations. These skills enabled people to plan and become more efficient.

Participants described supervising driverless trucks as creating work that was short and intensive. This experience reflected similar experiences observed by researchers across various industries, where the workload becomes more bunched (Billings, 2018). Following short and intense moments that can be cognitively demanding for humans, there can be long periods of inactivity (Li et al., 2014). Long periods of inactivity can strain the attention of people supervising the system. The sudden reintroduction into the control loop can be challenging to navigate, particularly when participants shared managing multiple trucks in various pits. Despite the confidence of participants in monitoring an entire truck fleet, the passive roles appear to be far removed from pit operations. Therefore, it was reported by the participants how vital field personnel are in being the 'eyes and the ears' for the driverless trucks. Those roles play a crucial role in soothing disruptions with local adaptions to avoid sharp increases in workload. Residual tasks can be routine, as well as reactive in helping automated trucks navigate complex situations.

Novel situations were faced by the participants that required them to think outside the box. Processes and procedures were reported by participants to evolve as the operation learnt more about the technology. Local adaptions included situations where a truck does not respond to requests, or the truck needs to be recovered by personnel from a location. Participants described the systems of work as a general guideline for interacting with the fleet, with instructions on how automation works by design. However, it is up to the human supervising the system in how that process is adapted. Therefore, participants describe intervening in driverless truck activities when situations did not appear to be correct. There were no real signs other than drawing from previous experiences. It was necessary, however, that participants remained in the loop with what was happening. Participants highlighted how this was dependent on the person's screen interface. Personnel with less technical displays were less informed of truck assignments and underlying zones influencing truck function. The participants shared how they would rather more information than less on what the truck is performing. However, this can be difficult to achieve, particularly when designers are trying to provide people with the information relevant for their role (Salas et al., 2010). Moreover, achieving this objective without inundating them with non-essential details that do not know how to interpret (Endsley, 2016).

5. CONCLUSIONS

The study results highlight the role transformations that have occurred through truck automation on a mine site. Mineworkers transitioned into new roles or had new technology-based interfaces included. The role descriptions were to support the driverless operation by giving the system direction on where to haul and assisting them through non-designed situations. Conventional roles were fitted with computer screen interfaces and learnt how to interact with automated systems. There were additional tasks learnt, including how to perform surveys and interpret system information. Automated tasks boosted the repertoire of skills and capabilities in computerised systems. Everyday activities such as driving trucks remain; however, it is only in slight instances when trucks need to be recovered manually by personnel. Therefore, the automation of driverless trucks enhances capabilities rather than diminish traditional techniques. Leftover workloads supervising driverless systems were reported to be short-intensive, which left periods of inactivity. Despite other activities being able to be completed, supporting roles can suddenly introduce people to situations that are novel and complex. The human role remains to apply unconstrained thinking to recover from non-designed situations. This exposure has evolved the problem-solving aspects of humans and influencing frontline personnel to think further ahead. The transformation of roles from the participants' experiences appears positive, with the ability to operate a computer and learning more about how automated systems operate.

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A Cross-Sectional Study to Assess the Adult Lebanese Population's Knowledge, Attitudes, and Practices Regarding Annual Influenza Vaccination

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ABSTRACT

Introduction and Goals: Annual influenza vaccination has been shown to be one of the most effective ways of preventing influenza and its complications. In Lebanon, national data on influenza vaccination rates are still unavailable. Furthermore, there are no well-defined national educational programs to raise awareness. The study's main goals were to evaluate influenza vaccination rates among the Lebanese adult population, to understand the factors that influence people's attitudes toward influenza vaccination, and to develop effective strategies to increase influenza vaccination awareness, knowledge, and acceptance.

Method: A quantitative cross-sectional design was used to figure out how many people got a flu shot during the 2018-2019 flu season. A total of 570 people aged 18 and up were randomly selected from various locations in Beirut via phone calls, including large shopping malls, recreational areas, and universities. A questionnaire with 27 questions was used to assess knowledge, attitude, and habits.

Results: The overall influenza vaccine uptake rate in 2018–2019 was 21%. Males (27%), the elderly (100%), widowed (72%), employed (37%), those in good financial circumstances (42%), healthcare workers (63%), and those with a low level of education (57%) all had significantly higher immunization rates. Furthermore, those who sought medical advice on a regular basis (47%), as well as those with one or more chronic disorders (29%), had high vaccination rates. Moreover, higher vaccination rates were associated with increased awareness of influenza and its vaccine ($p < .001$).

Conclusion: In Lebanon, influenza vaccine uptake remains unsatisfactory. This is primarily due to a misunderstanding of the severity of influenza and the effectiveness of influenza vaccination. As a result, national awareness and immunization efforts are urgently needed. Additional cause-and-effect research studies in Lebanon would yield more reliable indicators of the influenza vaccine's effectiveness. Such research would boost confidence in the vaccine's protective and positive effects.

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1. INTRODUCTION

Influenza viruses are what cause seasonal influenza, a respiratory infection. It occurs primarily in the winter in temperate climates and all year in tropical and subtropical climates. The influenza A and B viruses are the most common cause of human influenza infections, afflicting people of all ages and causing symptoms such as fever, dry cough, sore throat, runny nose, headache, and muscle aches. The severity of illness varies from person to person, ranging from mild respiratory symptoms to severe infections such as pneumonia, which may necessitate hospitalization and can result in death, especially in high-risk patients such as people 65 and older [1] and young infants under the age of 5 years [2]. Seasonal influenza can affect anyone, but some people are more vulnerable than others. These people include healthcare workers (HCW) who are at high risk of being exposed to suspected or confirmed influenza patients for an extended period of time, as well as people who are at a higher risk of serious complications, such as young infants under the age of five, the elderly, pregnant women, asthmatics, diabetics, immunocompromised patients, and patients with heart or lung diseases [3].

The flu vaccine is one of the most important ways to stop the flu and its effects during flu season. The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) both recommend an annual flu vaccine as the most effective way to prevent infection, particularly in people who are predisposed to influenza complications [3, 4].

The influenza season in Lebanon typically lasts from September to April, with a noticeable peak during the winter months. During this time, many people are affected by suspected or confirmed influenza, leading to absenteeism from school and work. Furthermore, people suffering from serious illnesses or high-risk patients may require hospitalization due to increased morbidity and its consequences. Moreover, a significant number of Lebanese people live abroad and visit the country frequently during the summer, with a noticeable increase during the summer. Furthermore, "this population mix, with different demographic characteristics, makes the country prone to co-circulation, thereby increasing the danger of mutation of different influenza viruses," according to the WHO. It is possible for the virus to spread from person to person via droplets or indirect contact routes, particularly in congested areas such as schools, nurseries, and healthcare facilities. This risk is greater in poorer areas of Lebanon, where infection control and prevention measures, such as safe food and water, and access to personal hygiene services, are lacking.

Furthermore, there is no national data on influenza vaccination rates. Additionally, national vaccination programs and educational campaigns to raise influenza awareness and prevention are ill-defined or non-existent. "What are the measures that persuade Lebanese people to receive the annual influenza vaccination in light of this?" As a result, the spread of influenza infections is reduced, as are costs and hospitalizations, as well as morbidity and mortality among the vulnerable population.

The main point of our research was to find out how many adults in Lebanon got a flu shot during the 2018-2019 season. Furthermore, the goals of our study were to:

- Identify factors that influence Lebanese people's and HCW's decision to get a seasonal influenza vaccine, and
- Come up with effective ways to get more people vaccinated against the flu in Lebanon through vaccine education and awareness programs.

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2. METHODOLOGY

2.1 Study design and sample size

During the 2018–2019 flu season, a quantitative cross-sectional design was used to find out what percentage of the Lebanese population got a flu shot. The research was carried out in Beirut, Lebanon's capital. A total of 570 adults aged 18 and up were chosen at random from various areas of Beirut. Through phone calls, interviewees were chosen at random from various regions of Beirut. Furthermore, interviews were conducted in large shopping malls, recreational areas, and universities throughout Beirut. The study's objectives were explained to the participants, and their verbal consent was obtained for their participation in the study.

2.2 Investigation tool

Based on published studies and a review of the research on similar surveys [3, 4, 5], a questionnaire with 27 questions was made. This questionnaire was used to find out how often people got flu shots for the 2018-2019 season, as well as what they knew, how they felt, and what they did about flu and vaccinations. Before being adjusted, the questionnaire was piloted and tested on 40 people.

2.3 Data analysis

For data entry and analysis, SPSS 16.0 software was used. To evaluate the 27 indicators, descriptive statistics were used. Variables were described with percentages and frequencies. The association between categorical variables was measured using a chi-squared statistical test. P values less than or equal to 0.05 were considered statistically significant for vaccine uptake.

3. RESULTS

3.1 Sociodemographic factors and medical history

Our participants were mostly female (69%) and married (62%). 61% were between the ages of 30 and 64, 37% were under the age of 30, and only 2% were 65 or older. More than half of our population (52%) had a high school diploma, 29% had a university diploma, 8% had less than a high school diploma, 6% had graduate studies, and 5% did not attend school at all. Only 40% of our population was employed, 82% reported a manageable financial situation, and 84% had public medical insurance. Only 71 (12%) of the 570 participants work in the medical field. 161 (28%) of the 570 participants seek medical advice on a regular basis, while 409 (72%) seek medical assessment only when necessary. In terms of chronic diseases, 9% of our participants had heart disease, 3% had respiratory disease, 2% were diabetic, 1% had cancer, and 1% had kidney disease; additionally, 7% had more than one chronic disease.

3.2 Influenza infections and vaccine uptake rates

Between September 2018 and April 2019, 428 of our participants, or 75%, said they had flu or an illness like flu, such as a fever, cough, sore throat, or pain in their muscles and joints. In terms of the annual flu shot, 448 of our participants did not receive one between September 2018 and March 2019. On the other hand, 122 of our participants got a flu shot. This gave us an overall uptake rate of 21% for the flu shot.

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3.3 Factors influencing participants' attitudes toward influenza vaccine use

Of the 122 people who were vaccinated, 36% said they did it to protect themselves and others from infection as well as to follow their doctor's recommendations; they also said they had previous good experience with influenza vaccination. Table 1 shows the remaining factors.

Table 1. Reasons for Getting an Influenza Vaccination

Variables	N = 122 (%)
To protect myself and others, a physician's recommendation and good experience with vaccines are needed.	44 (36%)
44 (36%)	20 (16%)
To protect myself and others, physician recommendation, having a chronic medical condition	12 (10%)
20 (16%)	12 (10%)
To protect myself and others from infection.	11 (9%)
12 (10%)	7 (6%)
To protect myself and others from infection, I followed my employer's recommendation.	7 (6%)
12 (10%)	5 (4%)
To protect myself and others, physician recommendations, national recommendations.	2 (2%)
11 (9%)	2 (2%)

On the other hand, 37% of the 448 people who were not vaccinated against influenza said it is a mild illness, 16% said the vaccine is unnecessary and there are no national recommendations to take it, 15% said the vaccine is expensive and unnecessary, and 8% said they are afraid of needles. Table 2 depicts the various reasons why our population is declining in influenza vaccination.

Table 2. Reasons for Low Vaccination Rates Against Influenza

Variables	N = 448 (%)
Influenza is a mild illness.	166 (37%)
166 (37%)	75 (17%)
The vaccine isn't necessary, and there aren't any national recommendations to get it.	68 (15%)
75 (17%)	36 (8%)
The vaccine is expensive, and it is not important.	25 (5%)
68 (15%)	23 (5%)
Fear of needles.	13 (3%)
36 (8%)	13 (3%)
Influenza is a mild illness, and the vaccine is expensive.	9 (2%)
25 (5%)	4 (1%)
The vaccine is not important.	4 (1%)
23 (5%)	4 (1%)
There are no national recommendations for taking it.	4 (1%)
13 (3%)	4 (1%)

Also, the things that made our population (570 people) want to get a flu shot in the future were looked at (table 3). 33% believe that physician recommendations are an important factor in influenza vaccination uptake; 22% believe that national recommendations and awareness programs on television and radio are important; 8% believe that the government should provide the vaccine free of charge; and 6% believe that all the previous reasons could encourage them to get the vaccine in the future. However, 11% of our population stated that nothing could persuade them to get the flu vaccine in the future.

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Table 3. Motivating Factors for Getting Vaccinated in the Future

Variables	N = 570 (%)
Physician recommendations	183 (33%)
183 (33%)	125 (22%)
National recommendations and awareness programs on TV and radio	60 (11%)
125 (22%)	44 (8%)
Nothing can encourage me to take it in the future.	36 (6%)
60 (11%)	36 (6%)
National recommendations and awareness programs on TV and radio, if free	28 (5%)
44 (8%)	18 (3%)
Physicians' and national recommendations; awareness programs on TV/radio, if free	18 (3%)
36 (6%)	14 (2%)
Physicians and national recommendations	8 (1%)

3.4 Knowledge about Influenza Infections

The vast majority of people in our country (96%) could describe the signs of having the flu. Half of the people polled thought that influenza can cause serious illness in some way, while 24% said that influenza is "not at all" linked to serious illnesses. Furthermore, 59% of our population thought that pneumonia and death were among the complications caused by influenza infections, while 35% said there were no complications. In terms of high-risk people for influenza, 39% of our population recognized that HCW, infants under the age of five, the elderly, and immunocompromised patients were at high risk. Only 23% thought only immunocompromised patients were at risk, while 19% thought infants under five and the elderly were at greater risk. Concerning ways to avoid getting influenza, the vast majority of people (72%) knew that good hand hygiene and how to cough properly can help, and 23% added getting vaccinated against influenza to the list.

3.5 Knowledge about the influenza vaccine

Almost half of our population (54%) was aware that the influenza vaccine is available in Lebanon, and 47.5% thought it was effective and safe. However, only 26% were aware that the vaccine is required annually. In terms of the likelihood of contracting influenza if vaccination is not obtained, nearly half of our population (52%) thought it was "very low," 24% thought it was "low," and 15% thought it was "high." When it comes to cost, nearly half of people (46%) do not know how much the influenza vaccine costs, 37% believe it is expensive, and 17% believe it is "not expensive." In terms of where people learned about the influenza vaccine, 38% learned about it from schools, neighbors, and Internet searches; 26% learned about it from social media; 11% from family members, friends, or colleagues; 10% from physicians; and 6% from pharmacists.

3.6 Association between sociodemographic factors and vaccination

Table 4 depicts the relationship between sociodemographic factors and influenza vaccination uptake. Except for the health insurance factor, there was a statistically significant association between all tested sociodemographic factors and influenza vaccination uptake among the Lebanese population. Males ($p = 0.035$), the elderly ($p < .001$), widowed ($p < .001$), employed people ($p < .001$), people with a comfortable financial status, and people without schooling had significantly higher levels of vaccination, followed by those with graduate studies ($p < .001$). Furthermore, HCW had a clear and statistically significant higher level of vaccination (p.001) than nonmedical workers, with an uptake rate of 63% versus 15%.

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Table 4. Association Between Sociodemographic Factors and Influenza Vaccine Uptake

Factors	Influenza vaccine was Administered N = 122 (21%)	Influenza vaccine was not administered N = 448 (79%)	p-value
Gender			
Male	47 (27%)	128 (73%)	0.035
Female	75 (19%)	320 (81%)	
Age			
< 30 years	42 (20%)	169 (80%)	< .001
30–64 years	71 (20%)	279 (80%)	
≥ 65 years	9 (100%)	0 (0%)	
Marital Status			
Single	32 (18%)	146 (82%)	< .001
Married	71 (20%)	281 (80%)	
Divorced	6 (27%)	16 (73%)	
Widowed	13 (72%)	5 (28%)	
Educational Level			
No education	17 (57%)	13 (43%)	< .001
Below high school	5 (11%)	42 (89%)	
High school	34 (11%)	263 (89%)	
University degree	50 (31%)	112 (69%)	
Graduate studies	16 (47%)	18 (53%)	
Employment			
Yes	83 (37%)	143(63%)	< .001
No	39 (11%)	305(89%)	
Financial Status			
Comfortable	30(42%)	42 (58%)	< .001
Manageable	91(19%)	377 (81%)	
Difficult	1(3%)	29 (97%)	
Health Insurance			
None	5 (12%)	38 (88%)	0.110
Public insurance	103 (21%)	377 (79%)	
Private insurance	14 (30%)	33 (70%)	
Medical Field			
Yes	45 (63%)	26 (37%)	< .001
No	77 (15%)	422 (85%)	

3.7 Association between medical history and influenza vaccination

There is a highly significant correlation between people who seek medical advice on a regular basis and influenza vaccination (vaccination rate of 47%) and people who seek medical advice only when absolutely necessary (vaccination rate of 11%; p.001). Similarly, with a vaccination rate of 29%, a significant association (p = 0.03) was found between people with chronic diseases and influenza vaccination (table 5).

Table 5. Association between Medical History and Influenza Vaccination

Medical History	Influenza vaccine was Administered 122 (21%)	Influenza vaccine was not Administered 448 (79%)	p-value
Medical Advice			
Routinely	75 (47%)	86 (53%)	< .001
When needed	47 (11%)	362 (89%)	
The Presence of Chronic Diseases			
Yes	37 (29%)	91 (71%)	0.03
No	85 (19%)	357 (81%)	

3.8 Association between perceived knowledge about influenza and vaccination

Table 6 depicts the relationship between our population's knowledge of influenza infections and vaccination. A significant high level of vaccination ($p < .001$) was observed among people who believe influenza can cause serious illness "a lot" and those who are aware that influenza can be complicated by pneumonia and death. Concerning influenza prevention measures, a high level of vaccination (78%) was observed among people who believed that hand hygiene and influenza vaccination were effective preventive measures.

Table 6. Association between Perceived Knowledge About Influenza Infections and Vaccination

Knowledge about Influenza infections	Influenza vaccine was administered 122 (21%)	Influenza vaccine was not administered 448(79%)	p-value
Symptoms of Influenza			
Fever, cough, runny nose, sore throat	120 (22%)	431(78%)	
Runny nose	2 (25%)	6 (75%)	0.382
Nausea, vomiting, abdominal pain	0	2 (100%)	
Don’t know	0	9 (100%)	
Thinking that Influenza can cause serious illness			
Not at all	11 (8%)	127 (92%)	
A little	36 (55%)	30 (45%)	< .001
Somehow	27 (9%)	263 (91%)	
A lot	47 (67%)	23 (33%)	
Don’t know	1 (17%)	5 (83%)	
Complications of Influenza			
Pneumonia, death	93 (28%)	244 (72%)	
No complications	26 (13%)	176 (87%)	< .001
Don’t know	3 (10%)	28 (90%)	

3.9 Association between perceived knowledge about influenza vaccine and influenza vaccination

Table 7 depicts the relationship between influenza vaccine knowledge and vaccination. People who believe the vaccine is effective, safe, available in Lebanon, and needed every year have a significantly higher level of vaccination ($p < .001$). Furthermore, people who believed that the risk of getting influenza was "high" or "very high" if the vaccine was not taken had higher vaccination rates ($p < .001$). In addition, there was no difference in vaccination rate (37%) between those who thought the vaccine was "expensive" and those who thought it was "inexpensive."

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Table 7. Association Between Knowledge About Vaccines and Vaccination

Knowledge about the Influenza vaccine	Influenza Vaccine was administered 122 (21%)	Influenza vaccine Not was not administered 448(79%)	p-value
Availability of the vaccine in Lebanon			
Yes	107 (35%)	200 (65%)	< .001
No	15 (6%)	248 (94%)	
Effectiveness of the vaccine			
Yes	120 (44%)	150 (56%)	< .001
No	2 (1%)	298 (99%)	
Safety of the vaccine			
Yes	120 (43%)	156 (57%)	< .001
No	2 (1%)	292 (99%)	
Every year, a vaccine is required			
Yes	115 (76%)	36 (24%)	< .001
No	7 (2%)	412 (98%)	
Likelihood of getting Influenza if there is no vaccination			
Very low	4 (1%)	291 (99%)	
Low	18 (13%)	120 (87%)	< .001
High	63 (72%)	25 (28%)	
Very high	31 (94%)	2 (6%)	
Don’t know	6 (38%)	10 (62%)	
Thinking that vaccines are expensive			
Yes	78 (37%)	131 (63%)	
No	36 (37%)	61 (63%)	< .001
I don’t know the cost	8 (3%)	256 (97%)	

3.10 Association between sources of information about influenza vaccine and influenza vaccination

People who learned about the vaccine from "media, family, friends, and colleagues" (90%), followed by those who learned about it from pharmacists (89%), and physicians (78%), had a highly significant level of vaccination rates (p < .001).

3.11 Association between influenza-like illness and vaccination

The relationship between influenza-like illness and vaccination is depicted in Figure 1. According to this figure, 20% of those who reported influenza-like illness were vaccinated, while 25% of those who reported no influenza-like illness were vaccinated. This link is not considered statistically significant (p = 0.3).

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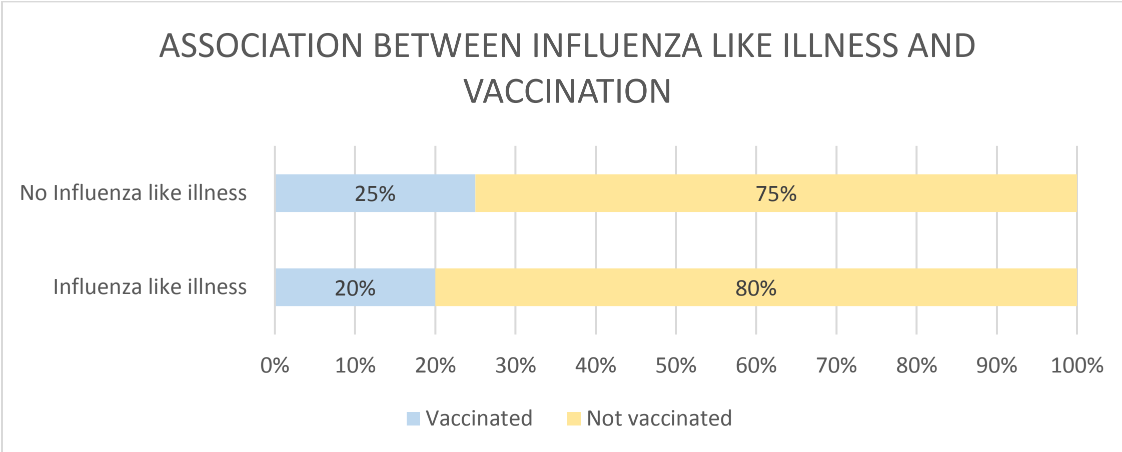

Figure 1: Association Between Influenza-Like Illness and Vaccination

3.12 Influenza vaccination rates through social media

We conducted a survey poll on Twitter in November 2018 and August 2019 to assess influenza vaccination rates for the 2018–2019 influenza season among Lebanese people. At the start of the 2018–2019 season (N = 208), there was a low vaccination rate of 7%, which increased to 12% by the end of the season (N = 149).

4. DISCUSSION

National data on influenza vaccination rates are not available in Lebanon. Similarly, few studies have been conducted worldwide to assess the overall vaccination rates, knowledge, and practices of the general population regarding seasonal influenza vaccinations. However, several international studies have been conducted to assess these factors among healthcare professionals.

4.1 Vaccination rates for influenza

Between September 2018 and March 2019, our study found that only 21% of the Lebanese population received influenza vaccinations. Lower influenza vaccination rates were also observed among Lebanese Twitter users, with 7% at the start of the 2018-2019 season and 12% at the end. There is no Lebanese national data to compare our findings to; however, these rates are lower than the overall influenza vaccination rates assessed in El Khoury and Salameh's study conducted in Lebanese pharmacies during the 2014–2015 season, which was 27.6% [5]. Low vaccination rates were also observed in the United States, with influenza vaccination coverage among adults ranging between 40 and 45% in CDC studies conducted over the last 6 years [6].

4.2 Social determinants

Our study found that Lebanese men had higher influenza vaccination rates than men in other published studies [7–9]. Similar to what the CDC found, our data showed that the highest vaccination rates were among people 65 and older. In contrast to the findings of El Khoury and Salameh's [5] Lebanese study, the highest vaccination rates were also found among the least educated. This difference could be because samples were only taken from Beirut and not from other cities or rural areas. Most of the people with the least education got the vaccine because their doctor or pharmacist told them to. Also, our study found that the highest rates of vaccination were among people who were working and had stable finances.

In terms of the patient's medical history, our study found a strong link between the number of medical visits and the presence of chronic diseases in relation to the flu shot. This is not surprising, since patients can get advice or the flu shot during medical visits [10]. But 29% of high-risk patients with one or more chronic diseases were not vaccinated as often as they should have been. This demonstrates that this group requires more education and vaccinations.

As expected, the rate of flu vaccination was higher among health care workers (HCW) than among people in other nonmedical jobs. This is mostly because health care workers now know more about influenza and how to stop it. Employer-mandated vaccination requirements also play a role.

Vaccination rates were also higher among widows and divorcees. This could be due to a greater awareness of the importance of maintaining good health among this population, as the majority of them (75%) received the vaccine based on their doctors' recommendations. Several international studies, however, found that being married with social support was associated with higher vaccination rates [11–13] when compared to people living alone with limited assistance, who may have less access to health care facilities and less support from family members. In contrast, one study found that single people had higher vaccination rates than married, widowed, or divorced people [14].

4.3 Influential factors influencing influenza vaccine uptake

Most of the people who have been vaccinated (93%) believe that the flu shot will protect them. In the same way, most people who got vaccinated (75%) did so because their doctors told them to. Also, 36% of people who were vaccinated said they had consistently good experiences with the vaccine, which explains why they keep getting the flu shot. On the other hand, our unvaccinated population (N = 448) didn't want to get flu shots because of two big problems. This population's misconceptions included thinking of influenza as a "mild illness" and believing that the influenza vaccine is "not important" or "expensive."

The assessed factors that made people more likely to get flu shots in the future are suggested as an important tool for the Lebanese MOPH to use. Such a tool could help put into place effective plans to increase the number of Lebanese people, especially high-risk patients, who get flu shots. The role of Lebanese doctors and pharmacists in promoting and encouraging vaccinations, especially among high-risk patients, must be emphasized in these plans. Influenza vaccination recommendations that are disseminated nationally and included in the national vaccination program are critical in increasing trust and uptake rates. The Lebanese government may be able to overcome the cost issue with the assistance of the WHO by providing the vaccine for free or at a low cost.

Because people don't seem to know that vaccines are available, work well, and are safe, an effective education and awareness campaign is needed. Vaccination rates could go up if there were more educational campaigns and programs on TV and radio to raise awareness. In the same way, the people who were studied didn't know that they needed a vaccination every year. In contrast, our study showed that people who think the vaccine works, is safe, is available in Lebanon, and is required every year, are much more likely to get it. People who were aware that influenza could cause serious illness, including pneumonia and death, were much more likely to get vaccinated.

4.4 Influenza-like illness and vaccination

Our study found no statistically significant link between influenza-like illness and influenza vaccination. The most likely explanation is that people incorrectly label any respiratory illness as influenza without performing confirmatory laboratory tests. Human Coronavirus, Parainfluenza,

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Rhinoviruses, and Respiratory Syncytial Viruses can all present with clinical symptoms similar to influenza. Multiple studies, however, have found a reduction in influenza infections associated with influenza vaccination in adults [15, 16], children [17], and pregnant women and their infants [18, 19]. One study found a link between influenza vaccination and a reduction in the severity of community-acquired pneumonia during influenza seasons [20]. Another study found that the influenza vaccine reduced severity in hospitalized adult patients with community-acquired influenza [21]. Following the emergence of the novel coronavirus COVID-19, an increase in influenza vaccination rates is thought to be extremely beneficial during influenza seasons, especially among high-risk groups. Improving herd immunity would reduce influenza hospitalizations and increase hospital bed availability for patients with COVID-19 and other respiratory diseases.

5. RECOMMENDATIONS

The Lebanese Ministry of Health (MOPH) can come up with a variety of plans and actions to increase the number of high-risk patients and residents of Lebanon who get flu shots. Such strategies must be accompanied by action plans and follow-ups in order to be implemented on an annual basis. These strategies can be divided into three categories:

- **Education** is a critical component of national influenza vaccination programs. To educate the public about the importance of the flu vaccine, educational awareness campaigns must be well-defined and structured. These campaigns aim to raise public awareness about influenza infections, symptoms, risks, complications, and preventive measures. Campaigns must address all aspects of the importance of getting the flu vaccine every year, such as removing all misconceptions and barriers that keep people from getting vaccinated. Details like where to get the vaccine, as well as its safety and effectiveness, must be addressed. The MOPH may broadcast these campaigns using existing media. Ads on television and radio, newspapers, billboards, pop-up messages on the internet, and the most visited websites in Lebanon can all be used. Email messages and mobile phone text messages, as well as social networks like Facebook and Twitter, are all effective communication methods. Healthcare facilities, dispensaries, schools, and universities are critical components that must be recruited as partners to support national campaigns. Furthermore, pharmacies can be involved because they can play an important role in improving vaccination rates by increasing vaccine awareness and administration throughout the influenza season.
- **Access to vaccines**: The Lebanese government, along with the WHO, plays a key role in making sure that people can get vaccines when they need them. By allocating and reserving the necessary funds, the MOPH should be able to provide the necessary amounts of vaccines at the lowest possible cost. Having enough vaccines available for free or at a low cost will eventually lead to more people getting the flu shot. Also, putting the flu vaccine on the list of vaccines that everyone must get as part of national vaccination programs is a big step toward getting more people to use it. On the other hand, there should be enough vaccines in rural and remote areas. Finally, and most importantly, campaigns should run throughout the flu season rather than just at the beginning.
- **Surveillance**: Beginning in 2014, the MOPH began monitoring for severe acute respiratory infections in several countries as part of the WHO project (SARI). The main goals of this surveillance system were to find the flu virus and track its spread. The main goal of this kind of monitoring is to find out if the viruses' antigenic properties have changed. Every year, these changes are incorporated into the development of global vaccination. As a result, the WHO issues alerts whenever a potential public health threat of global significance manifests. Additional surveillance at the national level is recommended to track and report influenza

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vaccination uptake rates. These statistics are critical for prioritizing efforts to increase the population's vaccination rate each year and to reduce the burden and severity of influenza infections, particularly in high-risk groups. The government may make phone calls to gauge uptake rates among a representative sample of the general population.

6. LIMITATIONS

Despite the fact that the survey was conducted only in Beirut and excluded rural areas, the majority of its recommendations are applicable to the public. This constraint may have resulted in selection bias, which may or may not have affected the conclusions and outcomes. To determine representative overall influenza vaccination rates at the national level, a more thorough phone survey that includes residents of remote and rural areas as well as other important Lebanese cities is required. Furthermore, additional correlations may have been statistically validated by a multivariable analysis to assess the relationship between various parameters and outcomes. Another factor that could have influenced the link between vaccination rates and flu infections is a lack of data on hospitalizations caused by flu-like symptoms. Future polls may find it useful to resolve these constraints.

7. CONCLUSION

The uptake of influenza vaccine in Lebanon remains below average. This is primarily due to a misunderstanding of the severity of influenza and the preventive value of the influenza vaccine. As a result, national awareness and immunization efforts are urgently needed. More cause-and-effect research studies (pre- and post-intervention) in Lebanon would provide more robust measures of influenza vaccine effectiveness. Such studies will increase trust in the vaccine's protective and beneficial effects.

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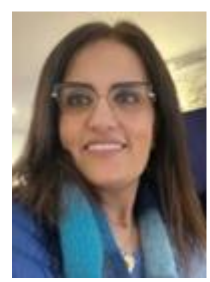

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Strengthening a positive safety culture despite underlying fear and peer pressure!

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KEYWORDS

Fear
Pressure
Safety
Culture
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Workplace

ABSTRACT

Peer pressure and workplace anxiety may have a global impact. Organizations of all sizes and industries may be affected by their damaging effects. This paper's goal is to provide recommendations for businesses looking to improve their current work cultures. The two biggest barriers to developing a culture of safety are fear of consequences and peer pressure to conform, according to a recent survey of 222 experts on workplace culture. The survey revealed five variables that were prevalent across all manufacturing industries; management implications highlighted the importance of promoting a safe and healthy workplace for all employees. The study also discovered that regular quantitative audits should be conducted and that everyone from the top management on down should be included in any actions.

1. INTRODUCTION

A debate is still going on about whether the term "safety climate" should be used at all because it suggests that it could be separate from the parts of an organization's culture that have major effects on health and safety (H&S). Various maturity models can be utilized to facilitate the growth of robust safety cultures. Models of maturity classify development into stages, ranging from somewhat immature safety cultures to cultures that substantially support positive H&S performance. The contents and components of long-term adjustments to the safety climate enhance culture over time.

Safety science uses scientific methods, research, and investigation tools to look at and manage safety (Aven, 2014). Numerous sectors have realized that a fear-based culture does not encourage learning from errors and can result in diminished organizational culture, decreased effectiveness, and reduced safety practices (Casey, 2020). Experts have said that the culture of an organization is a big reason for large-scale, avoidable institutional failures like accidents and corruption. Failures in safety and ethics are more likely to happen before certain kinds of outcomes. For example, a loss of life is more likely to happen before management ignores warnings (Hald et al., 2021).

If there is a "just culture" where problems can be talked about freely and underlying causes can be looked into and fixed without worrying about getting in trouble, employees should feel comfortable reporting safety incidents (JPT, 2019). Duncan and Aratani (2020) found that employees were afraid to

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talk about safety concerns because they thought they would be punished, and that industry standards put a lot of pressure on them. When a safe and supportive environment and culture exists, peer pressure is typically a constructive influence. However, it can readily operate in the reverse direction (Lamendola, 2021).

Studies show that employees only speak up 39% of the time when they see conditions and practices that they think are bad. This percentage is consistent across industries, countries, and cultures (Scace, 2018). When there is fear and pressure in the organizational culture, it is difficult at best to build a positive safety climate. It requires a long-term commitment to caring about employees, communicating honestly, rewarding safe work practices, and supporting positive attitudes from all stakeholders in safety, health, and the environment. Why does the administration delay climate-related safety measures? The duty of fostering an exceptional safety culture falls directly on the shoulders of the company's executives and management staff (Lal, 2022). What options exist for resolving this dilemma? Alinier and Verjee (2015) stressed the need for fostering a culture of safety through positive peer pressure that promotes and reinforces safe work behaviors. Regarding safety, peer pressure can be a two-edged sword. It can either urge employees to behave safely and ethically or force them to take excessive risks (Moyer, 2020).

2. OBJECTIVES

A review of the relevant literature indicates that there is a need to increase the safety climate, minimize fear, and reinforce peer pressure that promotes safe work practices and strengthens business culture. This article strives to:

- examine the origins of fear and negative peer pressure in corporate work cultures; and
- propose solutions, answers and recommendations to enhance a positive safety atmosphere, climate and organizational culture.

3. METHODOLOGY

3.1 Sample

According to Eeckelaert et al. (2011), safety climate can be evaluated through surveys, interviews, focus groups, and worker observations. In reality, quantitative surveys are the simplest and least expensive method for evaluating worker perceptions and opinions about safety in their workplace. In the business world, surveys are also the most popular method for measuring progress toward achieving this goal.

For the sake of this study, a total of 560 individuals were sampled, but only 222 health, safety, and environment (HSE) professionals, including medical, education, management, and mental health experts, responded to the survey, yielding a response rate of 40%. CEOs (chief executive officers), directors, managers, department heads, and safety specialists from India's public and private industrial sectors, including chemicals, construction, gas, power, and steel, participated in the study.

3.2 Data Collection

Primary data (interviews and discussions) as well as secondary data (incidence and accident rates) were collected. Interviews were based on open-ended questions; personal, in-depth discussions were conducted over a three-month period (from April to June 2022) at various locations and in different organizations across India using remote data collection techniques. Non-random convenience sampling was used as the sampling method. Participants were recruited from the researcher's contact list and invited to complete the online survey via WhatsApp and email.

3.3 Research Design and Data Analysis

Using the qualitative descriptive framework, this was an exploratory mixed-methods research design with field professionals as study participants. The data for this study was primarily gathered through controlled interviews and questionnaire surveys.

4. RESULTS

How can a positive safety culture be strengthened when fear and peer pressure are degrading the workplace culture? A content analysis of the qualitative data revealed the following:

> *When there is fear and peer pressure, and people are afraid to speak up about safety, it is extremely difficult to develop and strengthen a positive safety culture. When work is well organized and planned, safety is never jeopardized.*

4.1 Responses from Chemical Plants

The following responses were received: The "big brother" concept of "awards and recognition" creates a ground-level communication bridge. Employees must be trained and included in company communications. Specific comments included the following:

- Help employees understand that production is done by machine and that their role is to protect the safety culture and machines.
- Motivate employees by encouraging them to think positively.
- After completing their shifts, advise them to rest and eat a nutritious diet.
- Training and education, as well as looking at examples of safe work practices that have worked well, can help change the way management thinks.

According to Singer and Vogus (2013), isolated interventions are unlikely to address the underlying causes; rather, effective strategies necessitate a systemic approach to interventions that address the interrelated processes of safety climate and organizational culture in a balanced and positive manner. Understanding the issues and causes of fear and negative peer pressure is critical for developing appropriate and effective interventions. First and foremost, collaborating and working as part of a team to create a healthy environment and culture.

4.2 Responses from construction plants:

Top management must ensure that its safety philosophy has permeated all the way down to the ground level and must show strong support and a visible commitment to safety. Management must approach safety issues from the heart, not the brain, management must convey they care about the health and wellbeing of all their employees. Management should regard safety as a core value, not just a matter of situational priority. Priorities shift over time, but safety must never be compromised. The rules can be changed, but not the values.

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Below are some of the observations and recommendations provided:

- *Organize small evening get-togethers; allow everyone to open up and speak freely with one another over a cup of tea and snacks. Play some team games indoors.*
- *There are many ways to create a safe environment on the job site, including, but not limited to:*
  - *program encouragement and participation;*
  - *willingness to report safety and health concerns;*
  - *education and access to safety and health information;*
  - *lack of fear of retaliation; and*
  - *training for all employees*

The United States Forest Service (USFS) created initiatives to improve safety outcomes and incorporate social science perspectives to enhance its understanding of emergency fire incidents and vulnerability mitigation across all fields of work. The USFS considered using three recent changes in organizational safety culture—cultural awareness, cultural management, and cultural reorganization—to show how employees question and shape the development of top-down safety initiatives. These are cultural management, cultural reorganization, and cultural awareness (Flores and Haire, 2021).

4.3 Responses from refineries:

Managers and other workers at the refinery reported the following:

> *In addition to intangible benefits, the company should present safety factors and tangible benefits. Create and implement policies and practices that permeate all business partners and create a work safety culture through innovative interventions. First and foremost, top leaders should emphasize safety rather than production targets. Line management's trust and confidence can be won back through the transformation of such mindsets, and they can become champions for a safe climate and a strong organizational culture. Because, if we think about it, where does the fear factor come from? Naturally, top leaders develop policies and procedures and set the tone for the company culture, which spreads throughout the organization. Results are highly likely if this change is implemented for at least one year.*

According to respondent feedback, effective leadership is required to foster an organizational culture that promotes safety. Leaders can protect employees by creating an environment of physical and psychological safety that encourages others to feel comfortable communicating issues and raising concerns. Lastly, Brooke et al. (2020) stated that leaders who promote a positive organizational climate make employees happier with their jobs, reduce burnout, and improve the safety culture as a whole.

4.4 Responses from academics:

Academics provided the following responses:

> *Risk-awareness and risk-taking are critical components of a positive safety culture. When there is fear and negative peer pressure, human resource (HR) training intervention is required to strengthen the positive safety climate and culture. HR departments could hold team-building exercises to make employees feel more secure and cared for at work. This will help to create a positive safety climate and culture. Continuous efforts by management and employees to improve safety practices are required.*

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Harvey et al. (2001) emphasized the use of empathy in relation to improving culture in order to increase the efficacy of changes in the safety climate and attitudes. Rio Tinto has identified caring, courageous, and inquisitive leadership as priorities for the whole organization. For real change to happen, leaders must show that they have these values (Broderick, 2020).

4.5 Safety culture: from the workplace to anywhere:

As part of the safety culture education, it was advised to strengthen the colony's positive safety culture among housewives and children, as well as contract workers and security personnel. The recommendations provided stressed the following:

> Instead of lecturing, hold monthly sessions on topics such as road safety, individual behaviours, kitchen safety behaviours, and personal risky behaviours.

5. MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Many businesses reported that participation from their support departments (human resources, procurement, finance, administration, and CSR) was insufficient and remained low at 16%. This could be because people don't see risks at sites or aren't brought into the long-term plans for intervention by the steering team. To improve the safety climate and overall organizational culture, everyone in the organization must join forces and collaborate. Long-term intervention may take years and will require the participation of all personnel and leadership teams. If, for instance, a company has a total workforce of 1000 people, but only 900 of them are participating in the positive safety climate interventions in terms of risk correction, then the organization has a stronger safety climate improvement of up to 90%.

It is critical to understand that, in order to create a positive safety climate, one must not only correct at-risk behaviors but also appreciate and reward safe behaviors. It is important to note that everyone has the ability to correct unsafe behavior; if one cares about others, they will care about him or her. It is critical to remember and emphasize that an injury is not an isolated separate outcome or hazard; it workplace impacts the entire workplace that must be handled as such (Raeve, 2011). Safer systems alone will not result in safer employees; a strong safety climate supported by a positive organizational culture is required. Long-term supportive safety climates emerge when employees collaborate (NHS, 2019).

Managers must overcome the challenges of institutionalizing a poor safety climate and organizational culture in order to make a difference in the HSE system (Farokhzadian et al., 2018). According to Noor Arzahan et al. (2022), the terms used to reflect safety issues in organizations are "safety culture," "safety climate," and "safety performance." Proactive safety climate and culture are more effective than reactive measures. The effects of the safety climate may be mitigated by safety competence and knowledge.

Across countries, manpower and workload pressures were identified as major areas for improvement (Granel-Giménez et al., 2022). It is suggested that all stakeholders establish a voluntary and/or mandatory error reporting policy and system aimed at identifying all types of errors, near misses or mistakes that may have an impact on the quality of safety care (Kaware et al., 2022). According to Key et al. (2022), following approved procedures is an important part of ensuring safety. Human error, according to experts, is a multi-level outcome of an interaction between the organizational context (culture, resources), supervisory conditions, and working environment (mental and physical state; team coordination). From the director to the contractor, supportive safety brings everyone together and helps them work together to reduce risks.

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The pressure to meet a goal is critical for businesses and must be viewed constructively. Fear can only be removed by regularly reinforcing safe work practices, having positive supportive dialogue with employees, followed by empowering workers to voice their concerns to higher-level company personnel via the appropriate channel. According to Qoronbfleh (2021), one of the major contributing factors to adverse events is a poor safety climate and culture. Organizational learning, continuous improvement, and teamwork are all signs of the highest-rated safety climate in all areas. In this respect, a top leader at MNC engineering company noted the following:

> *We have implemented ISO 45001, but still, accidents are happening at sites, and the at-risk behaviours are 25 percent. This means that it has not been behaviourally implemented. We have not fully increased internal risk control by empowering everyone on the ground. Across all sites, we must all demonstrate compliance behaviours and reinforce safe work practices. Management would provide tools and formats, but it would be up to site personnel to instil a positive safety culture and improve organizational culture throughout the organization.*

5. CONCLUSION

Safety climate and organizational culture are outcomes of corporate officers' mandates, but they must be accepted by individuals at all levels. Acceptance is measured in relation to all others who exhibit safe behaviors. Organizational leaders must understand that incidents at the sites can cause shareholders to sell their company shares, thus affecting the company's business stability and growth. So, in order to keep their business and employees safe, employers need to keep putting more emphasis on safety at work and improving and strengthening their organizational culture. According to industry professionals,

- The safety climate and organizational culture of companies have a significant impact on the actions of stakeholders;
- Companies that promote a culture of health, safety, and well-being outperform those that do not;
- Workplaces that lack the long-term intervention of a caring, supportive, positive, interdependent safety climate and organizational culture should be regarded as "non-compliant," because safety systems alone do not keep everyone safe.
- Risk is an unavoidable part of our lives. Every year, nearly 3 million people die globally as a result of common risk factors in their workplace; all of them can be saved if positive and supportive safety cultures are implemented (Azzi, 2022).

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Assessing Workplace Culture and Organizational Influencers

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KEYWORDS

Workplace
Culture
Leadership
Mentors
Peer Pressure

ABSTRACT

Workplace culture is a synthesis of the social order in which we live or work, as well as the rules that govern that environment. It is critical for ensuring a safe, supportive, and productive working environment. Leaders bear the responsibility for creating, embedding, evolving, and ultimately manipulating a positive workplace culture. Senior executives, local managers, and supervisors all contribute to the culture of any organization by how they interact with one another, with their employees, and by how they communicate their expectations on work priorities. The organization's framework should define the values that guide its operations as well as the methods used to achieve its objectives.

The purpose of this article is to examine a variety of issues associated with workplace culture and leadership, the advantages of mentors for workplace culture, and peer pressure's impact on workplace culture.

1. INTRODUCTION

Workplaces are dynamic environments with many factors to consider when building teams. Building a positive workplace culture is essential to ensuring a safe, supportive, and productive environment for workers. This is not just important for the retention of workers but also for knowledge transfer and enhanced safety practices within the organization. Instead of just focusing on the end goal of production, these basics should stress trust, respect, and equal opportunities for everyone. Workplace culture is a big and changing idea that includes a lot more than what was mentioned. There are tools available to help managers and leaders create a work culture that puts health, safety, and performance first.

Mentoring is a great way to teach new employees and future leaders new skills and help spread the best ways to do things. Mentoring relationships should be supported at all levels of an organization because they can have a culturally changing impact. Mentors are peers with similar experience who can assist employees in understanding what is expected of them and how to perform well in their jobs. A company's safety culture should include training and mentoring for new employees, because these

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things lead to more productivity, a safer workplace, and important and complementary "hands-on" learning. It also promotes a positive workplace culture and fosters good coworker relationships. Mentoring takes time and requires leadership and organizational commitment; therefore, organizations should make time for these one-on-one relationships. The effects of peer pressure in the workplace can be traced back to the effects of peer pressure in the workplace.

Peer pressure is a big part of making decisions every day, and it can be even stronger at work. Studies have shown that when friends or colleagues are present, the number of risks people take more than doubles, implying that workers may find it more difficult to control impulsive or risky behaviors. Organizations should focus on developing a positive workplace culture because research shows that doing so has significant benefits for employers, employees, and the bottom line. Leaders, supervisors, and managers play an important role in making peer pressure work in a positive way by focusing on doing things correctly, adhering to regulatory requirements and client policies, and emphasizing workplace safety and other expectations.

Everyone in an organization, from the CEO to the office administrators to the contractors and laborers, contributes to the workplace culture, and each person has a different motivation for the work they do each day. Positive communication and good communication from all leaders and supervisors in an organization make all the difference in creating a positive and safe work culture, as well as an overall environment where employees can help them achieve their production and profit goals. This can result in happier employees, a safer workplace, fewer people leaving their jobs, and more work being completed.

2. WORKPLACE CULTURE and LEADERSHIP

Workplace culture is a combination of the social order we live or work in and the rules of that environment. "Cultures tell their members (workers) who they are, how to behave toward each other, and how to feel good about themselves" (Schein, 2010). There are several core factors that contribute to the development of workplace culture, including psychosocial aspects like leadership style and management practices and how work is organized, including employee responsibility and autonomy.

According to the academic organizational culture expert Edgar Schein, leaders have the responsibility to develop and maintain a good workplace culture, as "culture is... created, embedded, evolved, and ultimately manipulated by leaders' (Schein, 2010). This is a key role for leaders that never ends, because "leadership is involved in creating the culture at every stage of the organization's growth and maturity" (Schein & Schein, 2016). It is not just the role of top leadership to shape workplace culture, as all levels of leadership are accountable regardless of title or position. Senior executives, local managers, and supervisors each contribute to the culture that is developed for any organization through how they engage with each other, their workers, and how they communicate their expectations on the priorities of the work.

So, how does an organization do this? The framework of the organization should define the values they work by. This is established through their mission, vision, values, and goals. It also includes the means used to achieve their goals. For example, how they work together, how they measure achievement of goals, and what corrective strategies are used to adjust to achieve the goals (Schein, 2010) These fundamentals must focus on mutual trust, respect, and opportunity for everyone involved, not just the final goal of production. But most importantly, the organizational framework must 'embed health and safety in every aspect of the workplace' (WorkSafeBC, 2022).

Workplace culture is a large and dynamic concept, involving multiple factors beyond those noted. Once an organization's fundamentals are in place, there are countless resources to support leaders and supervisors in creating a workplace culture that focuses on health, safety, and performance. In most jurisdictions, workplace culture and health and safety resources are available through local or national occupational health organizations and align with the expectations for health and safety programs. Some of these resources also focus on developing supervisors and workers through mentoring; let's examine these factors further.

3. THE BENEFITS OF MENTORS FOR WORKPLACE CULTURE

An experienced mentor can have a culturally changing impact within an organization, supporting the significant growth of the team. Workplace safety is directly impacted by achieving shared understanding. This makes it important to support mentoring relationships at all levels of an organization. Chances are that at some point in everyone's career, a mentor was supportive in a work role, hopefully more than once. These influences can be vital to professional growth, supporting education, training, and success in a position. Organizations routinely schedule classroom or online training for their people yet fail to allow mentors enough time to successfully mentor. This time can be a fantastic investment in the future productivity, safety, and culture of an organization.

Mentoring is about helping another person learn through a one-to-one relationship. "A mentor is a seasoned professional who informally guides a less experienced person." (D'Angelo, 2022). It's an excellent method of transferring knowledge and promoting best practices at work. As well as an effective way to develop new workers and future leaders within an organization. "A mentor is someone to look up to—someone who was once in your shoes and creates a path to success." (D'Angelo, 2022).

However, mentors are not always seasoned employees; sometimes they are peers with similar experience, advising and guiding each other as they learn the role. The best mentors are the ones who can clearly explain what is expected of them and how to do their jobs well. When someone who cares about their work shows a willingness to share this information, the team and organization benefit. There are many resources and best practices to help organizations start a mentoring program. Organizations should consider new employee training and mentoring as components of their safety culture, starting at recruitment.

Do not underestimate the value of sharing knowledge within an organization; it supports increased productivity, a safe workplace, and offers complimentary and essential "hands-on" education to supplement a training course. It also fosters good co-worker relationships within your organization and helps workers translate their job learning into practical skills. Additionally, mentoring grows leadership skills for all involved and builds on a positive workplace culture. Good intentions are not enough; mentoring takes time and requires leadership and organizational commitment. When workplace culture and overall safety benefit from mentoring, it is a clear choice for organizations to schedule time for these one-on-one relationships to take place. Organizations that communicate well are the safest places to work, and mentors can have a huge role in enhancing communication and supporting workers to do the same.

> *Show me a successful individual, and I'll show you someone who had real positive influences in his or her life. I don't care what you do for a living—if you do it well, I'm sure there was someone cheering you on or showing you the way. A mentor. (Washington, nd, p.1.).*

4. PEER PRESSURE AND ITS INFLUENCE ON WORKPLACE CULTURE

How much of the good and bad about an organization's culture can be traced back to the effects of peer pressure in the workplace? Peer pressure can be a big part of making decisions every day, and this can be even stronger at work. Comments, reactions, and body language from supervisors and co-workers have a powerful impact on decisions made in the workplace. Consider this scenario: A deadline is approaching, the job needs to get done, and the supervisor is not asking or considering questions about safety, quality, or workplace culture; they want to assure the work gets done so the organization (and the supervisor) can meet its target. The result: corners get cut, chances are taken, and if it goes right, everyone is happy and profits are made. However, if something goes wrong, there are damages: someone gets fired, or worse, someone gets hurt. This scenario demonstrates peer pressure or peer influence, which is defined as "the pressure that a peer group puts on its members to fit in with the group's norms and expectations. Peer pressure may have positive socialization value but may also have negative consequences for mental or physical health" (American Psychological Association, 2023).

Some studies have shown that the number of risks people take more than doubles when their friends or colleagues are watching, compared to when they are alone. This outcome indicates that workers may find it more difficult to control impulsive or risky behaviors when their co-workers (peers) are around. "Even though it's assumed that stress and pressure make employees work harder, better, and faster, [many] organizations don't see the hidden costs" (Seppala & Cameron, 2015, para. 3).

Injuries, illnesses, and long-term health problems caused by stress, as well as the effects of accidents at work, are examples of these hidden costs. The Seppala & Cameron says that between 60 and 80% of accidents at work are caused by stress (2015, para. 4). Since these statistics come from studies that were conducted years before COVID, the stress that workers feel from their peers may be much higher today. This makes it even more important for organizations to focus on creating a positive workplace culture. While it can be hard for workers to resist the influence of their peers, especially in the heat of the moment, this influence can also have a positive effect. According to Seppala & Cameron, research shows that "a positive environment will lead to dramatic benefits for employers, employees, and the bottom line" (Seppala & Cameron, 2015).

Leaders, supervisors, and managers play a big part in making peer pressure work in a good way. Much of the data available today on psychological safety in the workplace demonstrates that when employees feel like they matter to their employer and team, they ask for assistance when needed, communicate better about problems, are more engaged, are willing to learn and grow, and are more creative and innovative (Seppala & Cameron, 2015). As noted earlier, organization leaders set this example, leading the culture of the organization. Supervisors and managers transfer this through a focused importance on doing things the right way, following regulatory requirements and client policies, and highlighting workplace safety and other expectations that are part of the daily work. If leaders are only asking about the bottom dollar and schedule, the workplace culture and safety will suffer. Positive communication and good communication from all leaders, supervisors, and managers in an organization make all the difference.

5. CLOSING THOUGHTS

Although a complex task, managing culture must be a priority for organizations. We must not forget that everyone in an organization contributes to workplace culture, from the CEO to the office administrators to the contractors and the laborers. Do not underestimate the value of good people sharing their learned knowledge. Every person also has different motivations for the work carried out

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every day, and these motivations may change over time. Regardless, the value of a successful workplace culture doesn't just make going to work nicer; it also increases production and helps to ensure safe practices in the workplace, improving the overall workplace and safety culture of an organization. The positive effects of workplace culture can be seen in happy workers, a safer place to work, fewer people leaving their jobs, and more work getting done. Most organizations' long-term success is directly linked to how well they can create a positive and safe work culture and an overall environment where their employees can help them reach their production and profit goals. ultimate Win-Win.

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World Safety Organization (WSO)

The WSO was founded in 1975 in Manila, The Republic of the Philippines, as a result of a gathering of over 1,000 representatives of safety professionals from all continents at the First World Safety and Accident Prevention Congress. The WSO World Management Center was established in the United States of America in 1985 to be responsible for all WSO activities, the liaison with the United Nations, the co-operation with numerous Safety Councils, professional safety/environmental (and allied areas) organizations, WSO International Chapters/Offices, Member Corporations, companies, groups, societies, etc. The WSO is a non-profit, non-sectarian, non-political organization dedicated to: ***"Making Safety a Way of Life … Worldwide."***

World Safety Organization Activities

WSO publishes WSO Newsletters, World Safety Journal, and WSO Conference Proceedings.

WSO provides a network program linking various areas of professional expertise needed in today's international community.

WSO develops and accredits educational programs essential to national and international safety and establishes centers to support these programs.

WSO receives proposals from professional safety groups/ societies for review and, if applicable, submits them to the United Nations for adoption.

WSO presents annual awards: The James K. Williams Award, Glenn E. Hudson International Award, J. Peter Cunliffe Transportation Award, Concerned Citizen, Concerned Company/Corporation, Concerned Organization, Educational Award, WSO Chapter/National Office of the Year, and Award for Achievement in Scientific Research and Development.

WSO provides recognition for safety publications, films, videos, and other training and media materials that meet the WSO required educational standards.

WSO establishes and supports divisions and committees to assist members in maintaining and updating their professional qualifications and expertise.

WSO has Chapters and National/International Offices located throughout the world, providing contact with local communities, educational institutions, and industrial entities.

WSO organizes and provides professional support for inter- national and national groups of experts on all continents who are available to provide expertise and immediate help in times of emergencies.

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WSO provides a network system to its Members whereby professional assistance may be requested by an individual, organization, state, or country or a personal basis. Members needing assistance may write to the WSO with a specific request, and the WSO, through its Membership and other professional resources, will try to link the requester with a person, organization, or other resource which may be of assistance.

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Associate Membership: Individuals connected with safety and accident prevention in their work or individuals interested in the safety field, including students, interested citizens, etc. **Affiliate Membership**: Safety, hazard, risk, loss, and accident prevention practitioners working as full time practitioners in the safety field. Only Affiliate Members are eligible for the WSO Certification and Registration Programs. **Institutional Membership**: Organizations, corporations, agencies, and other entities directly or indirectly involved in safety activities and other related fields. **Sustaining/Corporate Member**: Individuals, companies, corporations, organizations or other entities and selected groups, interested in the international effort to "Make Safety A Way of Life ... Worldwide."

The WSO Membership Application is included on the following pages and is also available on the WSO website: https://worldsafety.org/quick- downloads/

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[✓] Application Fee $20.00 USD
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BIRTHDATE:	
POSITION/TITLE:	
COMPANY NAME AND ADDRESS: [ ] Preferred	
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PLEASE specify your area of professional expertise. This information will be entered into the WSO "Bank of Professional Skills," which serves as a pool of information when a request for a consultant/information/expertise in a specific area of the profession is requested.

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[ ] Construction Safety (CS)
[ ] Transportation Safety (TS)
[ ] Industrial Hygiene (IH)
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[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
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[ ] Aviation Safety (AS)
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[ ] Petroleum (PS)
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For secure Credit Card Payment, please visit the SHOP on WSO's website (https://worldsafety.org/shop) and select "WSO Membership Application Fee" to make your payment. You will receive an emailed invoice for the Membership Fee upon approval.

Check or Money Order payable to WSO may be mailed with application packet to: WSO-WMC, Attn: Membership Coordinator, PO Box 518, Warrensburg MO 64093 USA. International postal money orders or bank drafts with a U.S. routing number are acceptable for applicants outside the United States. For alternate payment arrangements, please contact WSO-WMC.

Annual dues hereafter will be billed and payable on the anniversary date of your membership. **U.S. funds only.**

By submitting this application, you are accepting that WSO will use the information provided to perform an independent verification of employer, credentials, etc.

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❑ **College/University Student Membership – FREE**

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Birthdate MM / DD / YYYY *(Application must include exact birthdate with year to be processed.)*

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Name of College/University | Campus

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Please specify your area(s) of interest. These areas of interest will allow you to connect with others who share similar interests throughout the world.

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[ ] Safety/Loss Control Science (S&LC)
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[ ] Construction Safety (CS)
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[ ] Industrial Hygiene (IH)
[ ] Product Safety (PRO)
[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
[ ] Nuclear Safety (NS)
[ ] Aviation Safety (AS)
[ ] Ergonomics (ERG)
[ ] Petroleum (PS)
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Required Signatures & Permissions

I subscribe to the above record and when approved will be governed by the Constitution and By-Laws of WSO and its Code of Ethics as I continue as a member. I furthermore agree to promote the objectives of the WSO wherever and whenever possible.

X
Applicant Signature | Date

FOR MID/HIGH SCHOOLERS ONY: WSO subscribes to the Family Educational Rights and Privacy Act (FERPA) philosophy in protecting student privacy and information. WSO may disclose "directory" information such as a student's name, WSO Student Chapter affiliation, name of school, grade in school, etc., along with group or individual photos in WSO NewsLetters, NewsFlashes, eNews, on WSO website, and on WSO's social media accounts.

❑ My student has permission to participate as outlined above.

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WSO Student Chapter Mentor Signature | Date
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World Safety Organization
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Members must be responsible for ethical and professional conduct in relationships with clients, employers, associates, and the public.

Members must be responsible for professional competence in performance of all their professional activities.

Members must be responsible for the protection of professional interest, reputation, and good name of any deserving WSO member or member of other professional organization involved in safety or associate disciplines.

Members must be dedicated to professional development of new members in the safety profession and associated disciplines.

Members must be responsible for their complete sincerity in professional service to the world.

Members must be responsible for continuing improvement and development of professional competencies in safety and associated disciplines.

Members must be responsible for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

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