# VALIDATION OF A MALAY VERSION OF KNOWLEDGE, ATTITUDE, AND PRACTICE TOWARDS SAFE WORKING IN A CONFINED SPACE QUESTIONNAIRE AND RESPIRATORY HEALTH PROBLEMS AMONG CONFINED SPACE WORKERS OF WATER SERVICES INDUSTRY IN THE CENTRAL REGION OF MALAYSIA

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"So verily, with every difficulty, there is a relief." [94:5]

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# DECLARATION

I, Hamiza Binti Ngah, claim ownership of the work provided in this thesis. The information obtained from outside sources is explicitly indicated in the thesis.

I certify that the intellectual content of this dissertation is the product of my own work and that all the assistance received in preparing this dissertation and sources have been acknowledged.

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2. Assessment of Knowledge, Attitude, and Practice on Safe Working in Confined Space among Water Services Workers in The Central Region of Malaysia

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3. Respiratory Health Problem among Confined Space Workers in Water Services Industry in The Central Region of Malaysia

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| | |
|---|---|
| 2-PL IRT | Two-parameter logistic item response theory |
| Adj. OR | Adjusted odds ratio |
| Adj. *b* | Adjusted regression coefficient |
| AIC | Akaike's information criterion |
| BIC | Bayesian information criterion |
| Crude *b* | Crude regression coefficient |
| CS-KAP | Knowledge, attitude, and practice on safe working in a confined space questionnaire |
| CFA | Confirmatory factor analysis |
| CFI | Comparative fit index |
| $CH_4$ | Methane |
| CI | Confidence interval |
| Cl | Chlorine |
| CO | Carbon monoxide |
| CS | Confined space |
| df | Degree of freedom |
| EFA | Exploratory factor analysis |
| $H_2S$ | Hydrogen sulfide |
| $FEV_1$ | Forced expiratory volume in one second |
| $\%FEV_1/FVC$ | Ratio $FEV_1$ |

| | |
|---|---|
| FL | Factor loading |
| FVC | Forced vital capacity |
| IBM | International business machines |
| ICC | Item characteristic curves |
| IIC | Item information curves |
| IRT | Item response theory |
| KAP | Knowledge, attitude, and practice |
| KMO | Kaiser-Mayer Olkin |
| MI | Modification index |
| MLR | Robust maximum likelihood |
| $NH_3$ | Ammonia |
| $O_2$ | Oxygen |
| OR | Odds ratio |
| RMSEA | Root mean square error of approximation |
| SD | Standard deviation |
| SPSS | Statistical package for social sciences |
| SR | Standardized residuals |
| SRMR | Standardized root mean square |
| TIF | Test information function |
| TLI | Tucker-Lewis index |
| TRF | Test response function |

| | |
|---|---|
| WHO | World Health Organization |

# LIST OF SYMBOLS

| | |
|---|---|
| > | More than |
| < | Less than |
| ≥ | More than and equal to |
| ≤ | Less than and equal to |
| = | Equal to |
| α | Alpha |
| n | Number of populations |
| β | Beta |
| ρ | p-value |
| $\chi^2$ | Chi-square |
| % | Percentage |
| P | Proportion |
| Z | Z statistic for a level of confidence (1.96) |

# ABSTRAK


**Pengesahan Soal Selidik tentang Pengetahuan, Sikap dan Amalan Bekerja Selamat di Dalam Ruang Terkurung Versi Bahasa Malaysia dan Masalah Kesihatan Pernafasan di Kalangan Pekerja Ruang Terkurung Industri Perkhidmatan Air di Wilayah Tengah Malaysia**

***Latar Belakang:*** Pekerja industri perkhidmatan air yang bekerja di ruang terkurung melaksanakan pelbagai tugasan, dan terdedah dengan bahaya masing-masing yang tersendiri. Bekerja dalam persekitaran seperti ini memerlukan mereka berhati-hati dari segi keselamatan. Mereka boleh mati atau mengalami masalah pernafasan akibat pendedahan kepada situasi yang berpotensi berbahaya di dalam ruang terkurung.

***Objektif:*** Kajian ini bertujuan untuk membentuk dan mengesahkan borang soal selidik pengetahuan, sikap, dan amalan bekerja selamat di dalam ruang terkurung dalam versi Bahasa Malaysia dan untuk menentukan faktor-faktor yang mempengaruhi masalah kesihatan pernafasan di kalangan pekerja ruang terkurung di dalam industri perkhidmatan air di wilayah tengah, Malaysia.

***Kaedah:*** Kajian ini terdiri daripada dua fasa yang dijalankan dari April 2020 hingga Disember 2021. Fasa 1 bagi pembentukan dan pengesahan borang soal selidik pengetahuan, sikap dan amalan bekerja selamat di dalam ruang terkurung versi bahasa Malaysia (CS-KAP) melibatkan 350 peserta daripada dua industri minyak dan gas Malaysia. Peringkat pengesahan dilakukan dengan menggunakan analisis teori respons item logistik dua parameter *(2-PL IRT)* bagi bahagian pengetahuan, manakala bahagian sikap dan amalan menggunakan analisis faktor penerokaan *(EFA)* dan analisis faktor pengesahan *(CFA).* Kajian keratan rentas telah dijalankan untuk Fasa 2

di kalangan 207 pekerja ruang terkurung yang bekerja dalam industri perkhidmatan air di wilayah tengah Malaysia. Soal selidik CS-KAP yang disahkan, soal selidik gejala pernafasan *British Medical Research Council (BMRC)* dan *American Thoracic Society (ATS)*, serta ujian fungsi paru-paru telah dilakukan ke atas pekerja. Kepekatan gas atmosfera berbahaya ($H_2S$, CO, $O_2$, $CH_4$, dan Cl) diukur menggunakan pengesan pelbagai gas mudah alih. Analisis deskriptif, khi kuasa dua, regresi logistik berganda dan regresi linear umum telah dilakukan untuk analisa data.

***Keputusan:*** Borang soal selidik CS-KAP versi Bahasa Malaysia yang disahkan mempunyai kebolehpercayaan konsistensi dalaman yang baik. Soalan di bahagian pengetahuan mempunyai tahap kesukaran dan diskriminasi yang memuaskan. Nilai Cronbach's alpha untuk bahagian sikap dan amalan masing-masing adalah 0.804 dan 0.917. Kesesuaian model adalah tinggi di bahagian sikap dan amalan (masing-masing Raykov rho = 0.814 dan 0.912). Didapati pekerja ruang terkurung dalam industri perkhidmatan air mempunyai pengetahuan yang agak baik (67.1%), sikap positif (65.7%), dan mengamalkan amalan selamat (60.4%) ketika bekerja di dalam ruang terkurung. Kehadiran gas klorin dan karbon monoksida telah dikesan di beberapa ruang terkurung di dalam fasiliti rawatan air. Kira-kira 45 orang pekerja (21.7%) ruang terkurung dalam industri perkhidmatan air mempunyai sekurang-kurangnya satu gejala pernafasan. Kadar kahak yang dilaporkan adalah sebanyak 27.5%, diikuti oleh batuk (23.7%), dan kesukaran bernafas (13.5%). Kekerapan bekerja dalam ruang terkurung setahun (Adj. OR 0.97; 95% CI: 0.94, 0.99; $P$= 0.041), ketiadaan latihan (Adj. OR 0.50; 95% CI: 0.27, 0.92; $P$=0.026) dan ketiadaan taklimat keselamatan (Adj. OR 2.53; 95% CI: 1.18, 5.43; $P$=0.017) merupakan faktor yang berkaitan dengan kehadiran penyakit pernafasan. Regresi linear am mendapati bahawa faktor yang mempengaruhi fungsi paru-paru adalah disebabkan oleh ketinggian, umur, kaum

Melayu, tekanan darah diastolik, komorbiditi, pengalaman bekerja dalam ruang terkurung, dan pengetahuan tentang kerja selamat dalam ruang terkurung. Kaum Melayu dikaitkan dengan peningkatan kapasiti vital paksa (FVC) (Adj. b 0.66; 95% CI: 0.34, 0.99; P<0.001) dan penurunan %$FEV_1$/FVC (Adj. b -10.17; 95% CI: - 16.00, -4.34; P= 0.001). Ketinggian seseorang menunjukkan perhubungan dengan peningkatan dalam volum ekspirasi paksa dalam 1 saat ($FEV_1$) dan FVC (Adj. b 1.55; 95% CI: 0.26, 2.84; P= 0.019, Adj. b 3.57; 95% CI: 2.43, 4.72; P< 0.001, masing-masing). Obesiti dikaitkan secara positif dengan %$FEV_1$/FVC (Adj. b 0.25; 95% CI: 0.00, 0.49; P= 0.003).

***Kesimpulan:*** Hasil kajian ini mendapati CS-KAP adalah borang soal selidik yang boleh dipercayai dan sah untuk menilai pengetahuan, sikap dan amalan bekerja selamat di dalam ruang terkurung. Penurunan dalam fungsi paru-paru dan berlakunya penyakit pernafasan menunjukkan bahawasanya pekerja ruang terkurung dalam industri perkhidmatan air juga berisiko terhadap pendedahan kronik kepada bahan berbahaya di dalam ruang terkurung. Pengurusan keselamatan dan kawalan hierarki keselamatan harus diguna pakai dengan berkesan bagi menyediakan persekitaran perkerjaan yang selamat dan mengurangkan kesan masalah kesihatan pernafasan di kalangan pekerja.

***KATA KUNCI:*** *Keselamatan tempat kerja, validasi, ruang terkurung, gejala pernafasan, fungsi paru-paru*

# ABSTRACT

**Validation of a Malay version of knowledge, attitude, and practice towards safe working in a confined space questionnaire and Respiratory Health Problems among Confined Spaces Workers of Water Services Industry in the Central Region of Malaysia**

***Background:*** Water services industry workers who work in confined spaces (CS) execute a variety of duties, each with its own special hazardous exposures. Working in this type of environment necessitates extreme caution in terms of safety. They could die or suffer from respiratory difficulties as a result of their exposure to potentially dangerous situations in the CS.

***Objectives:*** This study aims to develop and validate a Malay version of the knowledge, attitude, and practice toward safe working in a confined space (CS-KAP) questionnaire and to determine the associated factors of respiratory health problems among confined space workers of water services industry in the central region of Malaysia.

***Methods:*** This study consists of two phases conducted from April 2020 until December 2021. Phase 1 involved the development and validation of a Malay version of the knowledge, attitude, and practice questionnaire for safe working in a confined space (CS-KAP) among 350 participants from two oil and gas industries in Malaysia. The knowledge component of the validation stage employed two-parameter logistic item response theory (2-PL IRT) analysis, whereas the attitude and practice sections used exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). A cross-sectional study was conducted for Phase 2 among 207 confined space workers working in the water service industry in the central region of Malaysia. A self-

administered validated CS-KAP questionnaire, an interview guide of the British Medical Research Council (BMRC) and American Thoracic Society (ATS) respiratory symptoms questionnaire, and a pulmonary function test were performed. Hazardous atmosphere gas concentrations ($H_2S$, CO, $O_2$, $CH_4$, and Cl) were collected using a portable multi-gas detector. A descriptive analysis, chi-square, multiple logistic regression, and a general linear regression were performed for the data analysis.

***Result:*** The Malay validated CS-KAP questionnaires had good internal consistency reliability. The items in the knowledge section had an adequate level of difficulty and discrimination. Cronbach's alpha values for the attitude and practice sections were 0.804 and 0.917, respectively. Model fitness is high in both sections (Raykov's rho = 0.814 and 0.912, respectively). There was relatively good knowledge (67.1%), a positive attitude (65.7%), and safe practice (60.4%) among CS workers in the water services industry. The presence of chlorine and carbon monoxide gases was detected in a few confined space areas in water treatment facilities. Approximately 45 workers (21.7%) were identified as having at least one respiratory symptom. The proportion of reported phlegm was 27.5%, followed by cough (23.7%), and shortness of breath (13.5%). Respiratory illnesses were associated with the increased frequency of working in CS per year (Adj. OR 0.97; 95% CI: 0.94, 0.99; P = 0.041), lack of training (Adj. OR 0.50; 95% CI: 0.27, 0.92; P = 0.026), and absence of toolbox meetings (Adj. OR 2.53; 95% CI: 1.18, 5.43; P = 0.017). Multiple linear regression revealed that the significant associated factors of pulmonary function were height, age, Malay ethnicity, diastolic blood pressure, obesity, comorbidity, working experience in CS, and knowledge of safe working in CS. Malay ethnicity was associated with an increased in forced vital capacity (FVC) (Adj. *b* 0.66; 95% CI: 0.34, 0.99; P 0.001) and a decreased in $\%FEV_1/FVC$ (Adj. *b* -10.17; 95% CI: -16.00, -4.34; P< 0.001). Height

was associated with an increase in forced expiratory volume in one second ($FEV_1$) and FVC (Adj. *b* 1.55; 95% CI: 0.26, 2.84; P = 0.019; Adj. *b* 3.57; 95% CI: 2.43, 4.72; P 0.001, respectively). Obesity was positively associated with $\%FEV_1/FVC$ (Adj. *b* 3.99; 95% CI: 1.20, 6.79; P= 0.005).

***Conclusion:*** The findings suggest that the CS-KAP is a reliable and valid questionnaire for assessing knowledge, attitude, and practice in safe confined space work. Pulmonary function declines and the occurrence of respiratory illnesses indicate that confined space workers in the water service industry are also at risk for chronic exposure to hazardous materials in confined spaces. Safety management and safety hierarchy control should be adopted effectively to provide a safe environmental workplace and lower the impact of respiratory health problems among workers.

***KEYWORDS:*** *Safety workplace, validation, confined space, respiratory symptoms, pulmonary function*

# CHAPTER 1

# INTRODUCTION

## 1.1 Overview of working in a confined space in the water industry

Confined space (CS) differs from a regular workplace in that it is not intended for continuous human occupancy. It is a physical space into which a worker can enter to accomplish work, but it is not the same as a typical workstation. The Industry Code of Practice for Safe Working in a Confined Space (2010) which was published by the Department of Occupational Safety and Health (DOSH) Malaysia defined a confined space as an enclosed or partially enclosed space. It has the following characteristics: it is not planned or designed primarily as a place of employment, it may have limited entry and departure points, and it may pose a health and safety risk to anyone who enters the CS (ICOP, 2010). Manholes, sewers, underground tanks and reservoirs, tunnels, pipelines, septic tanks and cesspools, pump wells, boreholes, surge and pressure vessels, trenches, and above ground sludge tanks and screen channels are all examples of confined spaces.

At any time, CS workers may be exposed to an atmosphere containing potentially dangerous amounts of pollutants, oxygen deficit or excess, and the risk for engulfment. Any activity in a confined space increases the airborne diffusion of particles, toxic gases, and other hazardous pollutants (Mignone *et al.,* 1990; Falakh & Setiani, 2018; McManus, 2019). According to the global estimates of occupational injuries and work-related illnesses 2017 report, approximately 374 million work-related injuries occur each year (Päivi Hämäläinen, 2017). Accidents involving confined space activities have the greatest ratio of fatalities to lost time in injuries

among all forms of accidents (1:2) (Naghavi K. *et al.*, 2019). A lack of oxygen, hydrogen sulphide, carbon monoxide, carbon dioxide, or an explosive threat being attributed to confined space fatalities (Mignone *et al.*, 1990). There are various types of dangerous environments: microbiological activity, corrosion and other oxidation processes on structural materials and surface coatings, fires, and other combustion processes all cause oxygen deprivation (Yodaiken *et al.*, 1986; Falakh & Setiani, 2018; Selman *et al.*, 2018).

According to a study done by Manwaring and Conroy (1990) on occupational confined space-related fatalities surveillance and prevention, confined space workers were engaged in more fatalities. Accounted for about 66% of the 88 fatalities, were workers who engaged in activities relating to water system, wastewater system, and sewerage construction (repair, cleaning, inspection, etc.)

The water services industry is an important infrastructure to guarantee human health and the environment. As water supply, they have a key role in giving healthy clean water access to the society. In the progress of this, environmental and health safety aspect becomes things to be concerned about (Air Selangor Sustainability Report, 2020). The nature of the tasks that confined space workers in the water industry must perform, such as cleaning of sludge and other waste materials, an inspection of the physical integrity of process equipment, maintenance, repair, including welding, modification, and adjustments to mechanical equipment, and construction purposes, necessitates complete attention (Burlet-Vienney *et al.*, 2015a). Although some decision-makers believe it is currently less hazardous due to lesser exposure of disease-causing microorganisms and chemical types if compared to sewage workers (Scarlett-Kranz et.al, 1987; Brown, 1997). The processing workers in the field of water

treatment continue to face the risk of health problems and death, particularly when exposed to chemicals as materials for water purification (Falakh & Setiani, 2018). The situation is even more dangerous when they need to be working in a confined space (Nawaz *et al.*, 2011). Their jobs are one of the highly skilled and critical occupational specialties (Golbabaei *et al.*, 2012). A CS entry is frequently required as part of routine water service work. The work needs to be carried out in the event where there is no other safer way to perform work-related activities.

As the sole water services provider in the central region of Malaysia, they are responsible to abstract, treat and distribute clean and safe water supply to 8.4 million consumers. All of their 34 water treatment plants operate 24 hours every day to produce an average of 5,000 million litres per day of treated water that is then distributed through over 29,000 km pipe length. It is their responsibility to perform frequent scheduled maintenance and cleaning work (Air Selangor, 2021). Workers inside the chamber must also conduct regular inspections to ensure the presence of chlorine can be safely maintained. Once a month, the sludge extraction system was cleaned. The accelerator's raw water inlet was cleaned once or twice a month, potentially exposing workers to hazardous atmospheres, and making entry and exit difficult (Falakh & Setiani, 2018). The total workforce required during the cleaning process is determined by the work conditions and duration. When cleaning and maintenance work must be done from day to night, two shift workers are involved.

The environment and health safety concerns become important considerations. In CS, there is usually little or no ventilation, and little room for movement, which creates a hazardous working environment because gases can quickly accumulate at the bottom of these areas or in isolated pockets. Because of the narrow and limited spaces

in the channels, workers in the water industry are extremely exposed to polluted environments. Workers in the water industry may incur acute and chronic health impacts as a result of their potential exposure to a contaminated working environment (Scarlett-Kranz *et al.,* 1987). A study has shown that sewage system cleaning and maintenance work has been linked to the development of acute and/or chronic respiratory symptoms as well as a potentially serious effect on ventilatory capacity (Zuskin *et al.,* 1993). In some cases, hypersensitivity pneumonitis can occur due to inhalation of some gases and chemicals (Lara, 2018).

Anyone who is required to enter a confined space for work purposes must adhere to the established rules and regulations (Nawaz *et al.,* 2011). Safety management and operations planning are the essential roles of an organization to prevent injuries, illnesses, and fatalities in the general industry. Following the hierarchy of safety control measures and using an effective and efficient risk assessment tool to identify the hazards could be a key to success in minimizing hazards while working in a confined space (Caputo *et al.,* 2013; Blaise *et al.,* 2014).

### 1.2 Confined space and hazardous atmosphere

The main threat working in a CS is the hazardous atmosphere created by insufficient ventilation. In addition, workers may be exposed to the risk of death, incapacitation, or impairment of their ability to self-rescue in a hazardous atmosphere (ICOP, 2010). Every type of enclosed space has a different nature and concentration of these gases. These harmful gases have different effects based on the degree of exposure and the inhalant's biological features (Rom & Ryon, 2011).

There is a minimum standard of safe atmospheric requirement before a worker can be allowed to enter into the confined space. The requirements are as the following:

1) the oxygen content is not less than 19.5% and not more than 23.5% by volume (at sea level), 2) the accumulation of flammable or explosive gases does not exceed 10% of its lower explosive limit (LEL), 3) the accumulation of toxic gases does not exceed their permissible exposure limits (PEL), and 4) any other atmospheric condition that is immediately dangerous to life or health (ICOP, 2010).

Toxic gases can be produced by materials that are intentionally used or stored in small places. It can be stimulated by natural processes, accidentally introduced into space, or in the case of sewers and large interconnected systems, and it can also migrate into the area where work is performed (Hughes & Ferrett, 2008). The most common toxic gases found in confined spaces are carbon monoxide (CO) and hydrogen sulphide ($H_2S$) (Mignone *et al.*, 1990). It was also reported that the most common sources of carbon monoxide were the furnace or boiler (32.4%), generator (19.7%), motor vehicle (12.8%), grill (5.8%) and space heater (5.0%) (Clower et al., 2012). CO might potentially be produced by the workers' adjacent portable generator and accumulate in the restricted environment. It has the capability of building up in a place that does not have a good flow of fresh air (CDC, 2016).

An analysis of seven fatalities that occurred in Quebec found that $H_2S$ mainly exists in water treatment plants and manure pits (Burlet-Vienney *et al.*, 2015b). Similarly, a study at sewage treatment plants in Cairo found that the highest concentration of air pollutants produced by sewage plants were ammonia ($NH_3$) and $H_2S$ (Saad Hussein *et al.*, 2003). It could also be found in sewers, sewage treatment plants, manure tanks, and other areas where organic matter decomposes in the absence of oxygen. Symptoms such as eye irritation, lung irritation, headache, confusion,

nausea, disorientation, or vomiting may occur when exposed to lower amounts of gas (Yant, 1930).

The use of sodium hydroxide solution as a cleaning and degreasing agent may interact with aluminium, creating hydrogen. $H_2S$ (hydrogen sulphide) is a highly poisonous gas. It has no colour and smells like rotten eggs (Hendrickson *et al.,* 2004). When heated, depressurized, or agitated, this gas is released. $H_2S$ was the main harmful substance involved in the accident, and it was commonly found in oil and natural gas reserves (Chiu *et al.,* 2020). Chiu et al. (2020) investigated the underlying causes of 64 catastrophic and deadly occupational accidents in confined spaces that happened between 2008 and 2018. This study revealed that failure of operating procedures, unsuitable personal protective equipment (PPE), incorrect posture, and inadequate ventilation were shown to be the leading causes of confined space accidents.

Oxygen levels must be kept within certain limitations. Excess or insufficient oxygen can be fatal. With a relative density of 1.11, oxygen is colourless and odourless. Purging, natural processes, gas displacement, and oxygen absorption can all contribute to oxygen-deficient environments. The purging procedure may involve the introduction of an inert (non-reactive) gas into a tank or vessel, causing flammable vapours and oxygen to be driven out. When organic substances, small amounts of hydrogen sulphide, and/or carbon monoxide are present, oxygen concentrations fall below the norm of 19.5%. Increased biological oxygen demand (BOD) can potentially cause a reduction in oxygen levels within the CS (Mignone *et al.,* 1990).

Concerning water industries, hazard identification and risk assessment in a previous study showed that there were 22 potential hazards that were present in the water purification process. Chlorine (Cl) was found to be at the most extreme risk due

to leakage and industrial fires (Falakh & Setiani, 2018). The gas is a highly hazardous respiratory irritant that is classified as a chemical danger. Chlorine toxicity may cause serious lung injury by damaging the respiratory epithelium (Nodelman & Ultman, 1999).

### 1.3 Epidemiology of respiratory health problems

Occupational respiratory diseases (ORDs) are a comprehensive classification of lung ailments caused by inhaling particular particles at the workplace. The severity of the conditions is determined by the materials absorbed, as well as the intensity and length of exposure. Different types of exposure result in various diseases. The burden of ORDs is predicted to rise in tandem with the rise in noncommunicable diseases (NCDs). The current trend reflects the impact of the previous working conditions because the ORDs take a long time to develop following exposure to the agents. This issue is also linked to growing industrialization and air pollution (Antao & Pinheiro, 2015).

#### 1.3.1 Global burden of respiratory health problems

According to the report on global estimates of occupational accidents and work-related illnesses, 2.78 million people died as a result of their occupation in 2015. A total of 651,279 deaths are estimated to occur each year as a result of hazardous substances alone. When compared to occupational accidents, occupational diseases resulted in at least five times the number of fatalities (380,500). The leading causes of death from occupational illnesses were circulatory diseases (31%) followed by work-related cancers, respiratory diseases, and occupational injuries, reported by 26%, 17%, and 14%, respectively (Hamalainen *et al.*, 2017). A systematic analysis for the global

burden of disease found that chronic respiratory diseases were the third leading cause of death in 2017 (7.0% of all deaths) (Soriano *et al.*, 2020).

Reported studies have shown the burden of occupational-related respiratory diseases to be attributed to asthma (16%), chronic obstructive pulmonary disease (14%), chronic bronchitis (13%), idiopathic pulmonary fibrosis (26%), hypersensitivity pneumonitis (19%), other granulomatous disease, including sarcoidosis (30%), pulmonary alveolar proteinosis (29%). Meanwhile, occupational-related tuberculosis was found in about 2.3% of silica-exposed workers, compared to only 1% of healthcare workers (Blanc *et al.*, 2019).

In the United Kingdom, an estimated 12,000 people die from respiratory disorders each year as a result of previous workplace exposures, with 18,000 new cases of self-reported respiratory ailments documented each year. Approximately 4,000 fatalities (33%) are due to chronic obstructive pulmonary disease (COPD), 2,800 deaths (23%) are due to lung cancer, 2,500 deaths (20%) are due to asbestos-related lung cancer, 2,500 deaths (20%) are due to mesothelioma, and 370 are due to other respiratory disorders (pneumoconiosis and allergic alveolitis) (HSE, 2019).

The determination of occupational-related respiratory diseases for asthma and COPD is difficult to obtain. It is because of the complexity in recognition of the occupational dose-response and temporal relationship due to multifactorial diseases. Tobacco smoking is a non-occupational exposure that has a strong causal association with asthma and COPD. Research has shown that approximately 15% of obstructive airway diseases, mainly asthma and COPD, contribute to the burden of occupational-related respiratory diseases (Balmes *et al.*, 2003).

### 1.3.2 Respiratory Health Problem in Malaysia

An overall statistic on occupational respiratory diseases reported by the Department of Occupational Safety and Health (DOSH) in 2018 was 96 cases out of 5139 reported cases. From a total of 96 reported cases, 55 cases were confirmed to be occupational-related respiratory diseases which were the 4th highest among all occupational diseases (DOSH, 2018). Kedah contributed to the highest reported cases of ORDs (22 cases) followed by Perak (15 cases), Wilayah Persekutuan Kuala Lumpur (13 cases) and Selangor (11 cases). From a total of reported cases of ORDs in Kedah, only 11 cases were confirmed as occupational-related respiratory diseases. Selangor has 10 cases of respiratory illnesses which were proven due to occupation, followed by Perak (10 cases) and Wilayah Persekutuan Kuala Lumpur (7). The majority of the cases of ORDs were dominated by the government sector (30 cases) and transportation industries (11 cases).

According to Yusof et al. (2019), who analysed published and unpublished literature, the prevalence of occupational respiratory diseases in small and medium-sized businesses in Malaysia ranged from 1.9 percent to 92.2 percent (Yusof *et al.,* 2019). Coughs, phlegm, shortness of breath, wheezing, and chest tightness were noted in the majority of studies among exposed workers, particularly those who were exposed to dust or particulate matter (Musa *et al.,* 2000; Bahruddin *et al.,* 2015; Amaran *et al.,* 2016; Hamzah *et al.,* 2016; Kamaludin *et al.,* 2018). Approximately 448,000 cases of chronic obstructive pulmonary disease (COPD) were reported in 2020. COPD patients visited the emergency room approximately 31.66 % of the time, and 42.47 % were admitted to the hospital owing to exacerbation. It leads to a decrease in working productivity and activity limitations (Rehman *et al.,* 2021).

A study by Hamzah et al. (2016) among steelworkers in Malaysia had shown that respiratory conditions are very closely related to metal dust exposure among workers. They also found that there was a marked reduction in lung function among those workers in areas with high concentrations of cobalt and chromium exposure (Hamzah *et al.,* 2016). This was explained by another study among welders in an indoor air-conditioned building which showed that respirable metal fumes and dust had exceeded the safe level allowed by USECHH Regulations 2020 (Farhana *et al.,* 2018). This suggests immediate attention, which needs to be highlighted to reduce the burden of respiratory health problems in the future.

Exploring workers' knowledge, attitude, and practice (KAP), particularly on safe working practices on a regular basis, can be used to aid in evidence-based interventions that can improve work circumstances or even target behaviour (Goh & Chua, 2016). Knowing how to work safely helps individuals to take personal responsibility for ensuring that safety is adopted at work. Being positive about any safety-related activity, such as safety training or adhering to workplace safety rules and regulations, is an example of a positive attitude toward safety. The practice of workplace safety may contribute to an action that can help avert an accident (Onowhakpor *et al.,* 2017). Workers' KAP is critical for hazard and risk mitigation and control, as well as ensuring optimal safety and health at work.

In Malaysia, surveillance data on respiratory health problems associated with confined space workers is not well established. Inadequate statistical data on work- and profession-specific ailments in Malaysia may be due to a lack of recognition of work- and occupation-specific diseases (Pransky *et al.,* 1999). According to the WHO, there are a number of respiratory illnesses that have a significant impact yet are

difficult to quantify. The data are based on national occupational disease registries and voluntary reporting schemes, and they may underestimate the true disease burden due to a reduction in surveillance or access to healthcare, with workers choosing not to seek advice due to job insecurity or reporter fatigue (WHO/ILO, 2021). As a result, ongoing respiratory health surveillance of workers is critical for early detection of ORDs and hence identification of the underlying causative agents.

### 1.4 Associated factors of respiratory diseases

Chronic obstructive pulmonary disease (COPD), asthma, occupational lung disorders, and pulmonary hypertension are among the most frequent chronic respiratory diseases. Tobacco smoking (including secondhand smoke), air pollution, allergens, and occupational hazards are all risk factors for chronic respiratory diseases. Indoor air pollution (typically generated by cooking with solid fuels) and outdoor air pollution are other common causes. Workers who are exposed to a variety of contaminants, such as dust, particulate matter, oil mist, and gases, will have their lungs deteriorate faster. The majority of studies have found that $H_2S$, bioaerosols, particulate matter 2.5, and volatile organic compounds are the most likely occupational respiratory hazards for sewage workers (Helda *et al.,* 2010; Al Batanony *et al.,* 2011; Cyprowski *et al.,* 2015). Occupational exposures have been linked to a number of respiratory illnesses (Anto *et al.,* 2002; Bala & Tabaku, 2010). On the other hand, a prospective study conducted to determine the respiratory health of wastewater workers and garbage collectors over a five-year period found no impact of pulmonary function tests concerning the duration of exposure to raw sewage and splashes (Tschopp *et al.,* 2011).

One of the non-modifiable factors that can influence lung function is age. As a person becomes older, the chances of experiencing respiratory issues increase. The elderly are the ones who are most likely to get COPD (Colak *et al.*, 2013) . The risk is significantly higher when there are multiple factors involved. A study found that older workers who smoked and had higher cumulative dust exposure had a substantial decline in lung function ($FEV_1$). Exposure to respirable dust over time is a risk factor for airflow restriction in tunnel workers (Ulvestad *et al.*, 2001). Working in a high-risk area of pollution with an increasing age may increase the chance of acquiring health problems. However, most of the studies found that age was not significantly related to respiratory problems (Bowler *et al.*, 2017; Chang *et al.*, 2015; Golbabaei *et al.*, 2012). The postulate was attributed to the healthy workers' effect. Mostly in the industry, the fit or tolerant workers will stay in the job if compared to the older workers. Workers with occupational-related respiratory illnesses might have left the job at a higher rate compared to those without such problems (Li & Sung, 1999).

Workers' respiratory health problems were found to be unaffected by their marital status. Evidence on the determinants of chronic respiratory symptoms among pharmaceutical factory workers was reported in a study. There were no chronic respiratory diseases among the 141 married, 305 single, three widowers, and four divorced workers (Asfaw et al., 2018). A cross-sectional survey was conducted among adult male textile workers in Pakistan's spinning and weaving industries to predict respiratory illness and symptoms, as well as lung function. According to this author, ethnicity and chest tightness have a significant relationship. When compared to ethnic Punjabis, ethnic Sindhis had a 2.7-fold increased risk of chest tightness (Adj.OR = 2.7; 95 percent CI = 1.1, 6.6) (Nafees et al.).

A secondary level of education was found to be a significant risk factor for chronic bronchitis among cement industry workers in South India (OR = 2.06; 95% CI = 0.82, 5.14), whereas primary and lower levels of education were found to be 6.96 (95% CI = 2.84, 17.03), 5.97 (95% CI = 2.96, 12.05), and 5.70 (95% CI = 2.80, 11.60) times more likely to have chronic asthma, peak flow obstruction, and chronic morbidity on respiratory symptoms. A study among cement factory workers done in Ethiopia proved that chronic respiratory symptoms were associated with educational level (AdjOR = 4.07, 95% CI = 1.86, 8.92). The lower educational level (grade 8 and above) was more likely to develop chronic respiratory symptoms compared to workers with a diploma and above category (Gizaw et al., 2016). Nafees et al. (2013) reported that uneducated workers were the factors associated with respiratory symptoms. The uneducated workers had 1.6, 2.0, 1.1, and 1.4 times the odds of having a chronic cough, frequent wheeze, and wheeze with shortness of breath, grade 1, respectively, compared to the educated group of workers.

The excess of fat tissue was thought to relatively cause impairment to ventilatory function (Poulain *et al.*, 2006). Respiratory function alteration may happen in obesity. The gas changes will increase the PaCO2 and reduced the PaO2. Obesity also may have airway resistance and respiratory drive (Murugan & Sharma, 2008). In Korean male workers who exposed to organic solvents, iron oxide dust and welding fumes was reported to have a strong association between the abdominal obesity (waist circumference ≥90 cm) and airflow obstruction. There was 5.62 times the odd higher among workers with waist circumference ≥90 cm than those with waist circumference <90cm to have airflow obstruction (95% CI= 1.82,17.37) (Ryu *et al.*, 2013). A quantitative industry-based cross-sectional survey found self-reported morbidity diabetes mellitus was a risk factor to peak flow obstruction. The Diabetes

Mellitus had 1.66 times odd to have obstructive pattern among workers who exposed to cement dust (Anand, 2012).

Modifiable risk factors such as smoking habits, previous respiratory illnesses, increasing years of work in industry, and higher exposures to dust or endotoxin were found to be associated with upper and lower respiratory tract symptoms (Fishwick *et al.,* 1999). This study's findings generally concur with a reported study conducted in 2012 by Nafees et al. (2012), which looked into the pattern and factors associated for respiratory illnesses, symptoms, and lung function among textile workers in Pakistan (Nafees *et al.,* 2013). According to the findings, people who worked for lengthy periods of time and were uneducated were more likely to acquire respiratory problems.

Golbabaei et al. (2012) conducted a study on metal fume exposure among confined space welders. A group of welders who worked in confined spaces and were exposed to welding fumes were chosen to examine the relationship between the environmental and biological indices of exposure to metal fumes and the risk associated with them. According to the study, there was no significant link between years of employment and unsatisfactory lung function tests. Nonetheless, the respiratory issues were caused by the welding fumes. Bradshaw et al. (1998) found no differences in pulmonary function tests between welders and non-welders based on years of job experience.

In research conducted in Florida, pack-years of smoking were found to be a associated factors of $FEV_1$ and $FEV_1$/FVC. $FEV_1$ decreased as the number of pack-years smoked increased. The risk of pulmonary function impairment was 0.57 times higher in smokers than non-smokers. The participants in this study were 225 utility workers and a standard population from the NHANES III Raw Spirometry cohort,

which included 16,606 people. A total of 41% have smoked tobacco in the past (Harbison *et al.*, 2012).

Chemical gases and cleaning products can make workers more susceptible to respiratory ailments. As in the New Jersey study, state-based surveillance systems discovered a link between work-related asthma and the cleaning product. Eighty percent of the cases were due to the new onset of work-related asthma, and twenty percent were due to worsening asthma. It has been reported that exposure to the cleaning product occurs in a broad range of types of jobs (Rosenman *et al.*, 2003).

Workers may benefit from the training course by learning more about the disease (Albahnasawi, 2018). An Ethiopian study reported workers who received occupational safety and health training on respiratory difficulties associated with dust had a decreased risk of developing respiratory problems than workers who did not receive training (Adj.OR = 2.73, 95% CI = 1.41, 5.29) (Gizaw *et al.*, 2016). A comparative cross-sectional study among tannery plant workers indicated that a lack of occupational health and safety training was linked to respiratory symptoms. When comparing those who did not attend occupational health and safety training to those who did, the risk of experiencing respiratory symptoms was 2.37 times greater for those who did not attend (Dalju *et al.*, 2019). Similarly, Anand (2012) discovered that almost all workers were unaware of the respiratory protection program for dusty occupations, which was designed to protect workers' health. The less training held by the company, the greater the prevalence of respiratory problems.

### 1.5 Knowledge, Attitude and Practice (KAP) on safe working in confined spaces

The excellent understanding of workers on certain issues does not reflect the good practice among them. This is proven by a study that was conducted in the Gaza

Strip, Palestine among wastewater treatment plant workers. It was reported that workers had good knowledge of the caution symbols that should be placed in the work area, but none of the nameplates were found on any of the sites that were visited by the researcher. Overall knowledge of the workers about physical risk (exposure to excessive noise from mechanical equipment, vibration from power tools, UV radiation, dust, and unpleasant odour) was good, with an approximately score of 72.99%. About 63.96% had good knowledge of safety measures and guidelines. Besides, the workers also had good knowledge of chemical hazards (71.7%), biological hazards (72.41%), accident hazards (78.16%), and psychological hazards (76.92%). They have the lowest percentage (48.85%) of those who attend regular health and safety meetings. At least half of the workers know who they should call if they have any emergency, which contributes about 83.91% to that item. This study shows that the level of education is associated with the knowledge of biological risks in the workplace (Albahnasawi, 2018).

The workers' attitude and practice towards safe working were related to their awareness of the dangers while working in such a hazardous environment. It was proven by a study done by Bowler at el. (2007). There was an increasing percentage of people wearing the respirator from 6% to 82% after they had been overexposed to manganese in confined space welders. Findings show those workers not properly wearing the prospective respirator have an increase in airflow obstruction. This study also provides suggestive evidence that not even the respiratory health system was impaired, but there was also a decline in their intelligence level of as much as 10-12 IQ points.

Further, in a study done on the evaluation of factors affecting hazardous waste workers' use of respiratory protective equipment, it was found that the workers use the air-purifying respirator due to concern about their work exposure, whereas supplied-air users are influenced by training. The communication, personal comfort, effect on vision, structural environment, and fatigue were the main reasons that affected the workers' respirator use (Salazar *et al.,* 2001). A similar study done by Anand (2012) found that the most common barrier for poor compliance with personal protective equipment (PPE) was being uncomfortable and feeling that it was not necessary to wear the PPE. Another factor mentioned is the management's refusal to invest money in more PPE. It was also reported that an average of 30.8% of workers cited non-availability of equipment. The workplace attitude toward safety to reduce the occurrence of respiratory problems depends on the commitment from both workers and management (Asfaw *et al.,* 2018).

Most of the workers were aware of the seriousness of various respiratory diseases. The information on occupational-related respiratory diseases was gained from different promotional materials, such as training courses (32%), and television (25%) (Tam & Fung, 2008).

### 1.6 Pre-existing questionnaire related to KAP on safe working in confined spaces

There are only a few pre-existing questionnaires for assessing worker knowledge, attitude, and practice. On the other hand, the majority of the questionnaires came from western countries, with various target group assessments, validation procedures, and concept measures. In medical science, measurement is a necessary activity. A questionnaire must be appropriately prepared in order to ease data collection to answer a research topic (Giesen *et al.,* 2012). After that, a newly

constructed questionnaire must be validated to ensure that it measures what it claims to measure and is trustworthy.

To our knowledge, a validated questionnaire to assess specifically confined space workers' knowledge, attitude, and practice toward safe working in confined space in Malaysia in detail is not yet available. The scarcity of such questionnaires stands in stark contrast to the abundance of questionnaires focusing on workplace safety and health in general.

There are a few surveys that may be used to assess safety culture within healthcare settings, such as the Safety, Communication, Operational Reliability and Engagement survey (SCORE); the Safety Attitudes Questionnaire (SAQ); the Victorian Safety Climate Survey (VSCS); the Safety Climate Survey (SCSu); the Safety Climate Scale (SCSc); the Patient Safety Climate in Healthcare Organisations survey (PSCHO); the Modified Stanford Instrument (MSI); and the Hospital Survey on Patient Safety Culture survey (HSOPSC). One of the most widely used questionnaires to measure safety culture is the Safety Attitude Questionnaire (SAQ) (Hodgen *et al.,* 2017). Another questionnaire relevant to the safety performance of organizational, managerial, and social factors is the Nordic Safety Climate Questionnaire (NOSACQ-50). The NOSACQ-50 is one of the questionnaires that is psychometrically designed to assess occupational safety culture. This questionnaire was developed and validated by a team of Nordic occupational safety researchers and was based on organizational and safety climate theory, psychological theory, previous empirical research, empirical results acquired through international studies, and a continuous development process.

Nonetheless, it is not applicable to CS workers. Workers in confined spaces have unique working conditions and environmental exposure, and the aim of this study was to examine their level of knowledge, attitude, and practice regarding safe confined space work. As a result, new development that is culturally appropriate and applicable to confined space workers is required.

### 1.7 Questionnaire development and validation

The questionnaire is one of the epidemiology's most important tools for collecting epidemiological data that is difficult to obtain or not available elsewhere, in which the respondent acts as the only source of information about his or her personal exposures, health-related behaviours, confounding factors, and other important variables of interest. After the data has been gathered, it is translated into measuring elements that are relevant to the research subject being investigated (McDonald *et al.,* 2003).

The wording of questions is crucial, and it should take into account the content's appropriateness, language complexity, type and form, and sequencing. The mode of administration was determined during the questionnaire formulation process: self-administered or interview-based. Design, flow, and proper formatting should all be considered (McDonald *et al.,* 2003).

Questionnaires should be written in a language that the participants can comprehend. It is critical to phrase the questions in a way that the respondent can understand them and that they are appropriate for their educational level and culture. This is critical in order to avoid misinterpretation, which leads to incorrect answers and biased reactions. Open-ended or closed-ended questions, or a combination of the two, can be used in question design. The response may be mutually exclusive or

include multiple options. The appearance and style of the questionnaire, especially in a self-administered questionnaire, are quite important and have a significant impact. The format, sequence, spacing, fonts used, and grouping of responses are all key aspects of the overall structure of the questionnaire, and they have a direct impact on the responses and the amount of time it takes the responder to supply them. Cognitive debriefing and pretesting can also be used to get insight into the response process. (McDonald *et al.,* 2003).

Self-administered questionnaires just require questionnaire delivery; they are substantially less expensive and do not necessitate the use of trained personnel. This mode is less vulnerable to information bias and the interviewer effect, but it is more likely to have missing answer items. It can reach a large sample size, cover a large geographic area, reach a difficult-to-reach demographic, and is also good at catching sensitive themes (McDonald *et al.,* 2003).

The Delphi technique was used to generate a new questionnaire. It is a four-phased organised group communication method that includes: 1) group investigation of a subject; 2) learning how the group views the subject; 3) resolving the dispute; and 4) final evaluation. (Linstone *et al.,* 2002). As long as there was a facilitator who coordinated and gathered information from all experts, the Delphi technique maintained the anonymity and secrecy of expert input. However, the technique's trustworthiness has been questioned because the initial content is decided by a lead investigator, resulting in the investigator's biased selection of items. As a result, the modified Delphi technique for questionnaire construction is more appealing because it avoids investigator bias. Experts can also reply to criticism and adjust the content, if

necessary, by incorporating the content into each round (Arifin *et al.*, 2014; Eubank *et al.*, 2016; Hadie *et al.*, 2014; Kilroy & Driscoll, 2006).

The health belief model (HBM) and the theory of planned behaviour (TPB) for the knowledge and practice domains were used for the creation of CS-KAP. One of the theories used to describe or predict human behaviour through the level of beliefs is the theory of planned behaviour (TPB). TPB argues that each action or specific behaviour taken by an individual is based on their intention to perform and or perceived behavioural control (PBC) over the task, with PBC having the ability to commence a behaviour without the intention if given a favourable opportunity and appropriate resources (Icek, 1991; Steinmetz *et al.*, 2016). The theory of reasoned action, a precursor to TPB, was used to study the practice domain in which it involves the intention of workers towards the use of PPE and confined space risk assessment (CSRA) when working in confined space. For the attitude domain, Lawrence's tripartite theory was used as a theoretical foundation. The Tripartite model of attitudes is based on the idea that a person's attitude is influenced by their cognitive, affective, and behavioural reactions (Kines *et al.*, 2011). They are especially useful in determining the determinants of behaviour because each act serves as a pivot point in efforts to adopt or change interventions.

The degree to which an assessment measures what it claims to measure is known as validity. The valid questionnaire aids in the collection of higher-quality data with greater comparability, reducing effort and increasing data credibility for population generalizability. The following characteristics must be present in a legitimate questionnaire: 1) simplicity and viability, 2) reliability and precision in

words, 3) appropriate for the problem to be measured, 4) reflect underlying theory or concept being tested, and 5) have the capability of measuring change (Garcia, 2009).

Previously, measurement validity was divided into 3Cs (DeVellis, 1991; Fletcher, 1996): 1) content validity, 2) criterion validity, and 3) construct validity. Nowadays, the unitary concept of validity is regarded as valid (American Educational Research Association *et al.*, 1999; Cook & Beckman, 2006). Validity is defined as "the extent to which all available evidence supports the intended interpretation of test results for the proposed purpose" (American Educational Research Association *et al.*, 1999). According to the American Educational Research Association et al. (1999) as well as Cook and Beckman (2006), the validity evidence can be obtained from the following five sources: 1) content, 2) internal structure, 3) relationships with other variables, 4) response process, and 5) consequences.

Aside from validity, reliability is an important factor in questionnaire evaluation. The Cronbach alpha value, which indicates the internal consistency of a construct, is referred to as a questionnaire's reliability. The positive correlation between items within the construct is reflected by high internal consistency. A low internal consistency of less than 0.70 indicates that the items within the construct are heterogeneous (DeVellis, 2016).

### 1.8 Problem statements

Confined space workers are at risk of being exposed to a variety of hazards, the majority of which are dangerous. Anyone who is compelled to enter a confined space for work purposes must adhere to the established norms and regulations. Failure to adhere to the management's instructions will result in a serious accident.

According to the 2011 data from the Department of Occupational Safety and Health, there were an average of eight fatalities per year among confined space workers. Between 2007 and 2010, fatality accidents at work accounted for roughly 3.9 percent of all fatalities in Malaysia, whereas fatality accidents accounted for only about 0.6 percent of all fatalities in the United States during the same period. (Bureau of Labor Statistics, 2017). The rising incidence of fatalities involving confined space workers makes us realize how critical it is to follow safe working procedures in these environments. According to the DOSH investigation, the fatal accident was attributed to the employer's inability to establish and offer a secure work system for working in a confined space. As shown in a study, the majority of workplace accidents and injuries are caused by workers' improper work practices rather than hazardous working environments (Hofmann & Mark, 2006). Organizational and social factors may have an impact on safety behavior (Mullen, 2004).

An investigation conducted by DOSH revealed that subcontracting work to contractors who lack knowledge and experience working in confined spaces is one of the leading causes of confined space accidents. These contractors frequently lack suitable work practices and equipment for working in confined spaces, exposing their workers to a variety of risks that can lead to a variety of health issues. Because of the risk they offer to the victim and, as a result, the rescue team, confined space accidents and health problems are of particular importance in occupational safety and health. As a result, in order to reduce or eliminate the workplace hazard, we must determine whether their attitude and practices are consistent with their understanding.

There is a need to address the common barriers to occupational health and safety, such as worker knowledge, attitude, and practice in confined spaces.

Knowledge, attitude, and practice together provide a robust dynamic system for planning, implementing, and evaluating interventional strategies. We can improve quality and health promotion by identifying the barriers to workers' attaining a safe attitude and practices. As a result, decision-makers may be able to build customized and more efficient methods for occupational workers in order to reduce or eliminate workplace accidents and injuries.

The rapid growth of industries and urbanization has led to a growing demand for improved technology to make working operations easier and to reduce or eliminate potential workplace risks. Based on the number of people trained in confined space in Malaysia, it is anticipated that over 20,000 workers enter restricted space each year. (NIOSH, 2016). This is supported by the growing number of qualified personnel registered with DOSH as Authorized Gas Testers (AGT). According to DOSH (2016), the number of AGT increased from 1,180 in 2012 to 4,012 in 2016. The AGT is the qualified person who is appointed by the company to conduct an environmental test and supervise the actions of the workers. They must complete a training course for approved gas testers and entry supervisors on safe working in confined spaces and pass a test or assessment. Workers who plan to enter a confined space must have a confined space certificate (Authorized Entrant and Standby Person). Only individuals who have NIOSH-approved credentials are permitted to work in confined areas. However, other challenges arise in the workplace as a result of this predicament.

Apart from fatal occurrences involving confined space workers, nothing is known about the long-term effects of confined space working on workers' systemic systems, particularly their respiratory health systems. Although asphyxiation, explosions, and drowning are the most common causes of disease and injury,