Use and Effectiveness of Dust Lamps in the Workplace in New Zealand

Robyn Levinge

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School of Health / Te Wāhanga Tātai Hauora, Victoria University of Wellington
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Dr Chris Peace (Supervisor)
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Table of Contents

Table of Figures

Abstract

Dust is fast becoming a global major concern having detrimental impacts on health leading to occupational disease, property damage and pressure on prevention specialists. Global and regional reports highlight a shortage of industrial and occupational hygienists who have a primary role in assessing occupational exposure to hazardous substances like dust. Despite the concerning impact of dust on health and workplaces, there exists a significant gap in practical knowledge regarding effective mitigation strategies. This study investigates the utilisation and efficacy of dust lamps within occupational settings in New Zealand. Dust lamps can help identify and observe the movement of dust in the work environment and more importantly, worker's breathing zones.

The research aimed to highlight the current understanding, application, and effectiveness of dust lamps as part of mitigation strategies to manage dust exposure. A multi-faceted approach incorporating qualitative case studies and a survey combining both quantitative and qualitative analysis was employed. Case studies were undertaken in New Zealand workplace settings chosen for their diversity of dust generating practices, varied workplace environments and ability to test established mechanical dust control systems. The survey predominantly targeted New Zealand health and safety practitioners, occupational specialists and others who provided potential exposure to workplace dust and dust lamps.

The study findings revealed poor awareness and limited understanding regarding dust lamps, their functionality, and benefits. More concerning, the study also found a New Zealand shortage of qualified occupational hygienists and limited guidance for health and safety practitioners on dust mitigation strategies including the use of dust lamps.

The research demonstrated promising results regarding the effectiveness of dust lamps as a simple, cost-efficient tool for dust detection and monitoring. In addition, the study

advocates for enhanced awareness and understanding of the risks of dust and the use of dust lamps. This requires extending guidance and training beyond traditional occupational and industrial hygienists to a broader group of specialists such as health and safety practitioners and others. Furthermore, additional research should prioritise holistic frameworks integrating dust lamp usage within the broader occupational health and safety fraternity, financial and socio-economic impacts. The research should also seek to better understand the characteristics of dust from exogenous sources impacting New Zealand.

Although dust lamps have a promising role in prevention of worker health, their optimal use is dependent on combining with implementation of holistic strategies including training programmes and industry wide guidance and awareness.

Introduction

"Understanding is the first step to appreciation."

Dust is more than a mere nuisance (Eckhoff, 2019). It is fast becoming a major cause of occupational disease and property damage. Its origins (Eckhoff, 2019), whether from mining operations, intricate industrial procedures, or the environment in general, can dictate its potential harm. While some symptoms are innocuous like coughing or shortness of breath, prolonged exposure can lead to more severe outcomes such as asthma and lung cancer. Moreover, the threat does not end with respiratory issues. Dust can also be detrimental to the eyes, ears, and skin. This broad spectrum of health risks amplifies the need for comprehensive protective strategies in workplaces.

Dust lamps are a simple tool for visualising and detecting particulates (including respirable) in the air within many work environments and the flow of extraction systems. By making use of the Tyndall Effect (named after John Tyndall, physicist, discovered in 1859), it can show small particulates (including respirable) that would otherwise not be visible to the naked eye. The operational principle is simple yet effective: By casting intense light, these lamps accentuate the presence of dust particles and allow workers to view potential respiratory hazards through dust exposure enabling proactive measures to be taken before health complications arise.

Over three decades of the researcher working in global health and safety as well as research in accelerated silicosis have provided insights and awareness of the devastating effects continuous dust exposure has on workers. The escalating instances of accelerated silicosis in New Zealand and abroad serve as a disturbing indicator of its harmful effects (Jones, 2023). In addition, the occupational health data furthers the evidence of harm from exposure to dust (Ministry of Health NZ, 2023). There is an imperative to raise awareness

and champion the cause of promoting, equipping and skilling practitioners with tangible, practical solutions such as dust lamps to prioritise worker safety and well-being.

The general downplaying of dust's risks is a recurrent and disconcerting observation. For many, dust is not only an accepted, seemingly innocuous part of the daily work environment but a workplace cultural position of: "It is just how our workplace is". This casual stance, contrasted with the documented health repercussions of dust, signifies the need for a call for heightened awareness and proactive interventions (Eckhoff & Li, 2021).

While undertaking a Master's in Health – Workplace Health and Safety at Victoria University of New Zealand, the researcher identified a significant research gap. The understanding, or rather the lack thereof, of the implications of workplace dust in New Zealand both on worker health and broader business dynamics was evident. This study, emphasising the prospective role of dust lamps in preventing harm coupled with increased competency of safety practitioners, aspires to reduce this knowledge void. Through comprehensive assessment of these lamps, the goal is to introduce a tangible, effective countermeasure to the hazards of dust exposure.

Recent legal cases have highlighted dust is a serious risk not only to workers but to others who may be affected by work activity. In the case of Wealleans, Bay of Plenty (2020) a significant dust cloud created from crop spraying moved across a public road causing a severe accident. In the case of Precision Animal Supplements Ltd (2019), dust was continually created from work activities, which were well-known to the business through monitoring, assessment, and worker feedback. In both cases, dust from work activity was well-known as a risk and harmful, however, those risks were not managed.

As health and safety professionals we have a duty both under the Health and Safety at Work Act 2015 (HSWA) Section 45 (b) to take reasonable care of others, and the International Network of Safety and Health Professionals Organisation (INSHPO)

professional capability framework to follow a model code of conduct regardless of competency to know and understand risks in our workplace so we can advise and advocate management strategies. Dust lamps in both these cases would have been an effective, yet simple tool to highlight the risk that may have led to better health and safety outcomes. There are a plethora of tools health and safety professionals can use such as dust lamps, however, knowing such tools exist and the value they can add to risk identification is critical.

Literature Review

The literature review utilised keywords ranging from "dust" and "dust lamp" to more specific terms such as "workplace dust" in conjunction with "health and safety." The review encompassed peer-reviewed journal articles, industry documentation on esteemed platforms, including Worksafe NZ, Safework Australia, and the Health and Safety Executive (HSE) UK, to ensure a broad perspective. Due to the scarcity of literature on dust lamps, no limitations were placed on the search.

What is Dust?

In occupational health and safety, dust is an environmental complication and a significant concern. The Ministry for the Environment (2016) describes dust as embodying microscopic particles that, when inhaled, cause potential health implications. In particular, the inhalable particulate, which spans up to 100 microns, can enter the body through the nose and mouth, directly affecting the respiratory tract. On the other hand, respirable dust, a finer entity under 10 microns, can reach deeper into the alveoli of our lungs. It is particularly concerning given its invisibility in standard lighting conditions. Meanwhile, thoracic dust can impact regions beyond the larynx but does not delve as deep as the respirable kind.

Safework Australia (2020) further highlights the diverse composition and broadens our understanding of dust. Dust can arise from commonplace materials such as sand and dirt to more intricate components like industrial exhausts. Its omnipresence across industries,

whether through activities like bag filling in agriculture or material cutting in construction, highlights its significance. However, the consequences for health depend heavily on the particle size. While the larger, weightier particles tend to settle swiftly and are less concerning from an inhalation perspective, smaller particles, especially those under 10 micrometres, demand our attention. Their ability to remain airborne for extended durations, combined with their invisibility, makes them prime candidates for deep inhalation, posing threats like significant lung damage.

The Origins of Dust: Internal and External Dynamics

The origins of dust in occupational environments include both endogenous and exogenous dynamics. It is crucial to understand these origins not only for hazard identification, but also for implementing effective control measures.

Endogenous (Internal) Origins

At the core of workplace dust generation are technological processes. Baran and Teul (2007) emphasised that these processes, usually associated with machinery operations and material processing, are the primary causes of harmful dust. Specific industries, termed high-risk zones have historically been notorious for their high dust levels generation. Those undertaking drilling, cutting, and excavating activities inherent to construction sites are prime examples of such high-risk zones. As industries evolve and technological advancements influence various industry sectors, dust generation is significantly changing.

Currently, dust sources once overlooked have become a major concern. A prime example being warehouses, recognised as spaces where dust gets stirred and suspended due to their constant movement of goods. Similarly, it is common for manufacturing units that deal with fine materials to generate concentrated dust levels. Hospitality, particularly bakeries and those with airborne flour pose unique challenges. In addition to this complex situation, silica dust from kitchen bench tops has recently gained global attention due to its significant

increase (De Deckker, 2019). The internal dynamics of dust generation highlight the importance of continuous monitoring and adaptive control measures.

Exogenous (External) Origins

Internal sources contribute significantly to workplace dust, however, external factors are also having a significant impact. Particular environmental regions are exacerbating the dust problem, especially in drought-prone or desert regions. Dust generated by climatic events such as storms, can move and travel significant distances depending on conditions at the time. Australia's dust storms are a prime example of this. As a result of modern Australian land use changes and climatic events, Brahney et al. (2019) and Nguyen et al. (2019) noted increased dust levels from these events, reaching New Zealand. In addition, Koffman et al. (2021) discovered abundant evidence supporting New Zealand's south island dustiness and widespread sediment production existing from climatic events from the last glacial maximum. The transport of dust into the atmosphere poses a two-fold challenge: it increases the overall level of dust in the atmosphere and introduces foreign particles if disturbed, which may pose health risks.

Moreover, New Zealand isn't immune to local external dust sources. The New Zealand Transport Authority (NZTA) reported in 2016 the impact of unsealed roads on airborne dust. According to the report, approximately 40% of New Zealand roads are not sealed. Dust generated by these roads, especially particles with an aerodynamic diameter of less than 10 microns (PM10), poses substantial health risks. As a result, dust control involves more than managing internal sources. It demands a holistic approach that takes into account both endogenous and exogenous dynamics.

What Are Dust Lamps?

There are a variety of dust lamps manufactured, each tailored for specific conditions and requirements. While some are designed for vast, open mining environments, others cater

to the confined workspaces of manufacturing plants. Despite their undeniable simplicity, ease and ability, dust lamps do come with limitations. For instance, their efficacy might be compromised in well-illuminated environments, extremely dense dust clouds, or when the particle concentration surpasses or fails to meet a certain threshold. Understanding these nuances is crucial for optimising their application in different industrial settings (Lenk & Lenk, 2017).

Why is Dust an Issue?

In the plethora of occupational workplace hazards, dust is often underestimated and creates considerable concern. Fine respirable particles may seem inconsequential, but their harmful effects become evident when reviewing global statistics. Recent data shows 10% to 15% of lung diseases worldwide are caused by occupational dust exposure (Awoke et al., 2021; Fishwick et al. 2015; Philippova et al., 2022). These figures not only represent direct lives impacted from ill-health but extend to families and communities who bear the burden of care.

The United Kingdom's Health and Safety Executive (HSE) re-emphasises this burden noting that every year, work-related exposure to dust claims around 12,000 lives in the form of lung diseases. Each of these deaths is a testament to the potential of prolonged dust exposure. Across the globe in New Zealand, the narrative remains distressingly familiar. An estimated 700-1,000 workers die in New Zealand because of work-related disease, 200-205 attributable to respiratory disease (Driscoll et al. 2004). More recently, MBIE's data is similar reporting approximately 20% of the 600 to 900 lives lost annually to work-related health issues, attributable to respiratory system disease (MBIE, 2013).

However, these concerning statistics presented in developed nations merely scratch the surface of the global dust problem. In developing countries, where regulatory compliance may be lax or absent, the health threat of dust is potentially larger. The elevated health

incidence rates in these regions serve as a reminder: dust is not just an issue; it is a global crisis.

The Health Burden

Chronic Obstructive Pulmonary Disease (COPD) is a current global health challenge and the fourth leading cause of death worldwide (Adeloye et al., 2022). Insights into these figures show a connection to the workplace with an example of 90,000 diagnosed cases in England and Wales directly traced to occupational exposures. However, the severity of this health burden, as highlighted by the NOHSAC report (Pearce et. al 2004), transcends these numbers (Legg et al., 2009). Close to 900,000 individuals have been diagnosed with COPD globally, and even more concerning is an estimated 2 million remaining undiagnosed, due to the disease's progressive nature (Levack et al., 2023).

The latent nature of dust exposure-related health conditions must be considered as the global concern intensifies. The nature of symptoms although manifest in the prime of working life, can remain dormant for many years, therefore, presenting an unseen crisis. This latency highlights a pressing issue that demands immediate and concerted attention.

Immediate Respiratory Afflictions

In the short term, dust exposure can lead to various respiratory issues such as asthma. Anlimah et al. (2023) emphasised the hazards of respirable crystalline silica. Beyond the imminent lung health threats, this dust also compromises workers' eyesight and skin causing occupational dermatitis. In addition to workers dealing with the immediate symptoms, their productivity can also be adversely affected. Respiratory distress, coupled with reduced vision from dust clouds, can impair an operator's efficiency and increase the likelihood of workplace accidents.

Long-term Health Concerns

Long term dust exposure has not only been linked to chronic conditions, such as Chronic Obstructive Pulmonary Disease (COPD) but also lung cancers such as miner's lung and silicosis. Matheson et al. (2005) undertook studies that highlighted a concerning link 15-19% of global COPD attributable to occupational exposure. In addition, Keer et al. (2022) noted an increase in bronchitis-related symptoms among construction workers directly caused by inhaling organic and inorganic dust.

The ramifications of these health issues extend beyond those directly afflicted. Families of affected workers are also impacted with the emotional and financial strain of managing these ailments. In some cases, the health-related quality of life for entire families diminishes, as Anlimah et al. (2023) noted. On a broader scale, the strain on healthcare systems and the socio-economic impact on societies is heightened. New Zealand, for instance, recorded over 62,000 hospital admissions over 5 years, 2008 to 2013, resulting from COPD, of which some attributable to occupational exposure (Milne & Beasley, 2015). Cohen et al. (2018) further contributed to this situation, revealing that over 10% of all lung diseases globally originate from workplace exposures.

In summary, the health impacts caused from workplace dust exposure, both immediate and long-term, are profound. They highlight a pressing need for more extensive research and effective preventive measures to safeguard worker health and enhance operational efficiency.

The Economic Impacts

Occupational workplace exposure hazards and chronic disease from dust are not limited to the current health crisis; they have broader social-economic impacts as noted by Mpanza et al. (2020). The ramifications of dust exposure go beyond the immediate effects on

healthcare, with adverse effects impacting machinery maintenance, plant operations, and even the broader workplace environment.

Syamlal et al., 2020 delved into data from the United States in 2002 and highlighted an annual economic burden of $5 billion attributed solely to occupational COPD. The breakdown of this cost revealed 56% attributable to direct costs extending to healthcare outlays, insurance pay-outs, and associated medical expenditures. The remaining 44% encapsulated the indirect costs: loss of earnings, the strain on families, and the unseen expenses of home care and adjustments (Syamlal et al., 2020).

Additionally, machinery wear and tear from persistent dust exposure also contributes to the financial burden of businesses. As Anlimah et al. (2023) pointed out, persistent dust exposure can lead to premature aging and escalating maintenance costs.

The evidence of the financial burden from dust exposure is significant, not to be ignored and can be positively used as evidence to support the reduction of occupational COPD's economic strain. As Syamlal et al.'s report emphasises, a proactive approach toward safeguarding environments exposing occupational health hazards might save lives and strengthen our economic foundations.

The Role of Occupational Health Professionals

Occupational and industrial hygienists have a vital role in the complex network of occupational health. Their expertise is vital in recognising and managing health risks from hazardous exposures, particularly dust. However, their roles are not just limited to identification and control; they also undertake the role of educating and imparting technical knowledge on strategic interventions. Markiewicz's (2015) report shows the United States has a physician deficit of 20,000 and is pushing professionals like industrial hygienists towards further medical qualifications to bridge this gap. Current projections suggest that this gap could extend to 125,000 physicians by 2034. The shift in focus has unintended

consequences, pulling these professionals away from their primary role in hazard management and redirecting them toward immediate patient care.

A similar concern emerges from New Zealand with a recent report from the Health and Safety Association New Zealand's (HASANZ) 2019, "Building the Professions," highlighting a shortfall in the country's occupational hygiene expertise (Garg, 2022). Comparatively, New Zealand has only half the per capita number of qualified occupational hygienists as Australia. This creates a two-fold problem, businesses are left without technical expertise in assessing hazards like dust and creates a gap for enhanced education and training on hazard control measures. With dwindling external expertise, businesses are left to understand the intricacies of dust exposure and devise and implement effective internal controls themselves.

The Potential of Dust Lamps in Dust Management

Numerous strategies and interventions have been developed to deal with dust in workplaces, however, as with all solutions, they come with their plethora of advantages and limitations. What is apparent is a necessity for occupational environments to ensure they have dust-free atmospheres.

Technological and Protective Interventions

The advancement of dust control has seen a variety of technological innovations developed. A comprehensive review by Anlimah et al. (2023), discussed a variety of innovative inventions. The list extending from surfactants, dry dust extraction systems to water misting and air curtains. This list was further expanded by Appiah et al. (2022) and Cheng et al. (2017), discussing methods like double curtains of wind and fog, chemical dust suppression, and cutting-edge solutions like biological nano-films. Notably, not all solutions are universally applicable. The effectiveness of a measure relies on the nature, source, and intensity of the dust, as well as the cost and availability of such technical tools. For instance,

while water misting might work well in one environment, it may prove ineffectual in another due to dust characteristics or density. Therefore, the dynamic nature of dust challenges the one-size-fits-all approach, requiring tailored interventions.

The Imperative of Education and Training

Anlimah et al. (2023), noted while various dust control measures exist, successful health management is preventing exposure altogether. They also highlighted the importance of education and training as a key strategy in tackling workplace hazards such as dust. Diverse strategies can range from simple practices, such as using masks and respirators, to advanced technological interventions. However, as technology advances, so must awareness and understanding of the role dust lamps have in hazard management. This is where education and training have an important role to play. However, their efficacy depends on an individual's ability to understand and utilise them effectively. The advocation for specialised training programs on dust control mechanisms ensuring competent usage and better comprehension of their role in preventative dust control was further supported by Adams (2023).

Greenough (1988) further adds to this discussion, emphasising that effective dust control must be framed on rigorous airborne dust sampling, especially when employing tools like dust lamps. Such a methodical approach ensures that exposure level changes are observed and quantified, leading to more informed decision-making.

Harmonising Technology with Proactive Policies

Tools and technology solutions offer tangible solutions in the control of dust exposure; however, their true potential is reached when integrated with proactive policies and strategies. Regardless of their sophistication, Anlimah et al. (2023) highlighted those individual measures have varied effectiveness. The solution and challenges lay in creating a

holistic combination of technological interventions, policy frameworks, education, and human initiative.

In addition, Abas et al. (2021) contributes a valuable perspective to this discussion. Their study highlights the pivotal role of influencing worker behaviour to encourage the adoption and improve effectiveness of dust control measures, including personal protective equipment (PPE). Their approach advocates education and training that equips workers with knowledge and therefore changes behaviour, making them active stakeholders in their own safety. Furthermore, Abas et al. (2021) notes training should educate on the risks associated with dust and empower workers with the skills to not only use dust lamps but identify and implement control measures competently. A holistic approach such as this will mitigate dust exposure and foster environments where safety becomes a shared responsibility.

As dust detection technology advances, dust lamps provide a simple, cost-effective solution in controlling dust exposure. Their success, however, is dependent on the competent addition of comprehensive strategies including training, education, and proactive policies. In addition, Perret et al. (2020) advocates for optimal surveillance systems for workers exposed to occupational dust as part of a dust exposure strategy framework. This holistic approach, if strategically planned will create a proactive pathway in managing dust exposure leading to long-term improved safety and health outcomes.

Gaps and Opportunities

Existing literature clearly illustrates dust exposure's health and occupational ramifications; however, it also highlights obvious gaps yet to be explored. There are extensive studies delving into dust control measures, including mechanical interventions, as well as training and education solutions, and the efficacy of personal protective equipment (PPE). Furthermore, this review reveals that these control measures, while creditable, need to

be uniformly effective. Their efficacy varies, contingent on the specific type of dust in question and the unique dynamics of each workplace.

Moreover, a noticeable void exists in the research spectrum. The prevailing literature, and even some of the less formal 'grey material' papers, predominantly focus on industries where dust production is glaringly evident: mining, construction, and manufacturing. These sectors termed high-risk zones, notorious for their dust generation, have been studied extensively, particularly in contexts where historical data indicates a pattern of health complications from dust exposure. However, workplaces where dust is an unseen threat, yet does not categorise as an 'increased risk workplace' coupled with the latent period associated with dust-induced health issues, highlights a significantly concerning gap in our understanding of workplace dust exposure.

A particularly under-researched domain is the deployment and efficacy of dust lamps. The scarce literature suggests that while dust lamps can spotlight dust zones, their effectiveness is inconsistent. Critical questions remain unanswered: What are the optimal illumination conditions for these lamps? Are they suited for both indoor and outdoor environments? How do they fare across various dust types and sizes? Moreover, there needs to be more research tailored to the New Zealand context.

A concerning picture emerges when we connect the global and New Zealand-specific data on workplace dust exposure against businesses dealing with limited access to dust control expertise. The impacts are notably significant, not just for the workers at the frontline but also for businesses, regulatory bodies, and health agencies. The healthcare burden threatens to escalate if these research gaps are not addressed. Such concerns necessitate a deep dive into the origins of dust, as well as understanding effective mitigation strategies.

Benefits and Limitations of Dust Lamps

Introducing dust lamps into the occupational safety toolkit presents a twofold advantage. On the one hand, they may offer tangible, real-time insights into dust presence, acting as a trigger for immediate remedial actions. In addition to this, envisaging dust raises worker's sense of consciousness. This, in turn, can promote an active safety culture where workers actively protect their health.

However, this strategy can have drawbacks. As Anlimah et al. (2023) and Greenough (1988) noted, dust lamps, while influential, come with their set of limitations. Their efficiency in dust detection can vary based on many factors, including the nature of the dust and the strength of its ability to linger. Additionally, while these lamps are adept at envisaging dust clouds and sources, the predominant challenge remains: How do we change from detection to applying robust and effective regulator measures?

As concerning as the current state is, the research on dust lamps remains limited. Baldwin et al. (2019) began by exploring the effectiveness of various exposure controls, with dust lamps being one point. However, their multi-faceted approach into varied management techniques, left the efficacy of dust lamps under explored and suggesting more research is required. Elaborating further, Greenough (1988) clarified the practical applications of dust lamps. They affirmed the lamps' role as primary indicators of dust concentrations, however, presented caution. The lamps, while insightful, should be seen as a supplementary tool. For a comprehensive understanding of dust exposure and its nuances, the role and expertise should sit with occupational hygienists. Moreover, collaborations with manufacturers specialising in dust extraction equipment can provide a more competent perspective.

The complexities of utilising dust lamps go beyond their intended, essential operation. The Health and Safety Executive highlights the critical role of ambient conditions for successful outcomes (HSE MDHS82/2). The effectiveness of a dust lamp is not solely

dependent on its technological ability but is also influenced by external factors, notably background illumination. For instance, underground working environments, such as mines restricted by minimal natural light, might be challenged with the optimal functioning of a dust lamp. Conversely, well-lit, and expansive workplaces may contribute differently to this challenge.

Research and Intervention Biases

Despite the plethora of available control measures, there is a notable bias in research and interventions. While this focus is high-risk industry types, given the evident risks in these sectors, it inadvertently distracts from other vulnerable areas. Cheng et al. (2017) pointed out that while comprehensive dust control standards have been applied to prominent high-risk zones, many other sectors remain under explored. Moreover, an emerging concern is the limited exploration into newer methods, particularly dust lamps. Although conventional and current technological approaches have been studied extensively, the potential of dust lamps as an effective control measure still needs to be explored.

Furthermore, there needs to be more institutional support. For instance, in New Zealand, while industry bodies and Worksafe have proactively addressed dust issues in high-risk sectors, many other workplaces that produce harmful dust often remain overlooked. This selective focus threatens to leave a significant portion of the workforce exposed and unprotected.

In summary, while the progress made in dust control are commendable, the journey is far from complete. A more holistic approach, encompassing all vulnerable sectors and exploring under-researched workplaces and solutions, is vital.

The Aim of this Research

This research is designed to investigate the use and effectiveness of dust lamps within New Zealand's occupational environments. The approach is comprised of workplace case studies and a quantitative and qualitative survey, with the aim of the study seeking to comprehensively evaluate dust lamps as essential tools in workplace safety. A significant facet of this study is to highlight the variable factors influencing the adoption of dust lamps as part of general operations. The elements placing limitations on this aspect include industry awareness surrounding these devices, accessibility to technical resources, and the restrictions associated with their procurement and maintenance.

The study aims to provide employers, safety regulators, and other stakeholders with valuable recommendations by distilling the insights and data collected. The overarching purpose is to highlight the potential role of dust lamps in pre-empting and supporting the mitigation of occupational health risks, thereby fostering a safer and more informed work environment across New Zealand.

This study aims to enhance comprehension regarding the utilisation of dust lamps in New Zealand workplaces, evaluating their effectiveness as an identification tool and their role in assessing measures for dust mitigation. Additionally, it seeks to ascertain the level of awareness and understanding of dust lamps among health and safety practitioners in New Zealand.

Research Question

"What is the use and effectiveness of dust lamps in New Zealand workplaces?"

Objectives

The objectives of this study are therefore to support the research question and are as follows:

1. To carry out observations using a dust lamp in various workplaces and examine the perceptions of both workers and managers regarding the effectiveness of dust lamps in controlling and managing dust in the workplace.
2. To observe and document the dust concentration levels in the workplaces before and after a dust generating task is performed, using dust lamps.
3. To identify factors and themes that affect the effectiveness of dust lamps in controlling and managing dust in the workplace.
4. To provide best practice recommendations for the use of dust lamps and their effectiveness in different types of workplaces.

Methodology

Rationale for Chosen Methodology

The exhaustive literature review aimed at obtaining a holistic understanding of the sources, implications of dust in the workplace with specific focus on the application and effectiveness of dust lamps. A comprehensive search, primarily via the Victoria University of Wellington's Te Waharoa library and Google Scholar, also extended to databases such as Science Direct and ResearchGate. Further details are summarised on page 9.

The review noted several crucial points. Firstly, dust, its origins both endogenous and exogenous, poses a significant threat in occupational health from work environments. This threat is not just a health concern; it impacts widen to operational costs, worker productivity, and broader socio-economic ramifications. While there are existing measures to tackle this issue, their efficacy varies, emphasising the need for holistic strategies. Notably, dust lamps emerged as a tool with substantial potential, yet their application still needs to be explored, especially concerning their practical implementation and role in varied workplace environments.

Given the insights from the literature, there is an apparent necessity to delve deeper into the application, benefits, and limitations of dust lamps in the workplace. The literature points to the need for a research approach that is both exploratory to understand the nuances of dust lamp application and evaluative to assess their effectiveness. This rationale forms the foundation for the chosen research design and methodology, ensuring that the study fills a gap in the existing literature and provides actionable insights. Therefore, my chosen methodology is workplace case studies and a national survey using a mix of qualitative and quantitative methods.

Research Design

Given the limited research knowledge regarding dust lamps in New Zealand workplaces, this study will employ case studies and a survey using a mix of quantitative and qualitative techniques. This combination is positioned to comprehensively explore the research problem from numerical and experiential perspectives.

The quantitative component will involve capturing empirical data through structured observations using dust lamps and workplace examinations. This data aims to yield measurable insights into factors such as potential dust levels, dust visibility in different environments, and the effectiveness of dust lamps under varied conditions. This method intends to lay a foundation of empirical evidence that aligns with the research objectives. Simultaneously, the qualitative component of this study will involve the collection of non-numerical data both during the case studies and with parts of the survey. This survey is designed to delve into individual experiences regarding dust exposure and the potential utility and effectiveness of dust lamps. By incorporating this perspective, the study aims to enrich the empirical findings with human-centric insights, enhancing the observed aspects of this dust study.

By synergising these methodologies, this research seeks to provide a thorough and multi-dimensional understanding of the potential role of dust lamps in mitigating dust-related health concerns. The combined method design will facilitate the triangulation of findings, enhancing the overall robustness and credibility of the research outcomes.

Participants and Sampling Strategy

Participants form the centre of this research, especially as it seeks to understand perceptions, experiences, and behaviours. For this study, the participant selection has been carefully curated to ensure a diverse and representative overview of dust lamp use in New Zealand workplaces. The research actively engages stakeholders from different representations of the industrial spectrum. This includes frontline workers and managers who interact with dust daily, industrial specialists and health/safety professionals who oversee and make decisions related to workplace safety. By integrating perspectives from multiple levels of workers and professionals, the study aims to capture a multi-faceted understanding of the dust lamp phenomenon.

The case study phase focuses on four workplaces, chosen based on the diversity of their dust-generating activities. This selection criterion is representative of a spectrum of dust types, offering a comprehensive insight into the dust landscape of New Zealand industries. The crux of this phase hinges on evaluating:

1. The foundational functionality of dust lamps.
2. Their comparative performance across settings, such as: different lighting, workplace environments space set up and air flow.
3. Their adaptability across a spectrum of dust types.
4. The level and behaviour of dust required for optimal dust lamp operation.

Qualitative data was also obtained from case study participants.

Complementing this, the survey reached a broader audience. Health and safety professionals affiliated with the New Zealand Institute of Safety Management formed many survey participants. Additionally, leveraging the researcher's and their supervisor's professional network further augmented the participant pool, ensuring a richer, more diverse dataset. The anonymity of these participants was preserved, promoting genuine responses.

In essence, the participant selection strategy for this research is not just about numbers; it is about ensuring a diversity of experiences, perspectives, and insights that can collectively shed light on the central research question: "What is the use and effectiveness of dust lamps in New Zealand workplaces?"

Data Collection

The data collection phase provides a holistic perspective of the research topic using case studies and a survey. Central to this process is the amalgamation of quantitative and qualitative data, ensuring a holistic perspective of the effectiveness and applicability of dust lamps across various workplace environments. On-site visits to the selected workplaces formed the basis of the data collection strategy. This enabled real-time operation and effectiveness of the dust lamp that was closely monitored and documented, capturing nuances like the extent of dust, its behaviour, and the broader environment.

Complementing the case study insights, the survey component includes qualitative and quantitative data generating questions. Deployed through a digital platform, the survey was tailored for health and safety professionals from the New Zealand Institute of Safety Management, further enriched by contributors from the researcher's and their supervisor's professional circle.

The survey, sought insights on:

1. Geographical, professional setting.

2. Occupational specialisation.
3. Historical and present affiliations with dust-intensive environments and their specific industrial sectors.
4. Previous encounters with dust lamps and the reasons behind their usage or non-usage.
5. Primary motivations and satisfaction metrics tied to dust lamp utility.

The synthesis of insights from this survey provided a panoramic view of the perceptions, experiences, and recommendations surrounding dust lamps in New Zealand, further enhancing the depth and breadth of the research.

Data Analysis

Once the data was collected from case studies and the survey, the next phase of data analysis focused on systematically processing information to extract meaningful patterns, and insights. Simultaneously, qualitative data from survey questionnaire responses underwent thematic analysis. By coding and categorising this data, themes were identified, providing deeper insights into worker perceptions, experiences, and the broader dynamics of dust management.

Rigor/Validity Strategy

Ensuring the validity and rigor of the research findings was paramount. A multi-pronged strategy was adopted to achieve this. Triangulation, which involves leveraging multiple data collection methods, was pivotal in cross-verifying and authenticating the research findings.

Additionally, the research process and findings were periodically subjected to peer reviews, inviting feedback and critiques from experts in the domain. This iterative feedback mechanism enhanced consistency and validity. This strategy solidified the current research's facts and set a benchmark for subsequent studies by maintaining transparency and allowing for future replication.

Ethical Implications

The ethical considerations for this research are paramount and encompass a wide array of concerns, from participant anonymity and informed consent to cultural sensitivity and harm minimisation.

Ethical Statement

The University of Wellington upholds stringent ethical standards, ensuring that all research endeavours undergo thorough scrutiny via its Human Subjects Ethics Committee. The commencement of this research occurred once the requisite ethical approval was obtained. Supporting the premise of ethical standards is informed consent: every participant willingly agreed to participate in the research and gave explicit permission for data and photographic material to be used. Furthermore, to protect participants' identities, findings have been presented in aggregate form, ensuring anonymity. Special attention was given to potentially sensitive data, especially from representatives of professional membership associations or other health and safety regulators, with all such information handled confidentiality.

Treaty of Waitangi Considerations, Obligations, and Matauranga

In alignment with New Zealand's ethical framework, this research pays respect to the Treaty of Waitangi, including its core elements—partnership, participation, and protection—into the planning of the research design. The study will follow the University of Wellington's cultural policy and Treaty of Waitangi obligations. Any issues from interviewee rights to data storage will seek Human Ethics Committee approval prior to research starting and seek consultation with Maori Research Business Centre members if required.

To streamline the ethical approach:

Case Studies

- A research proposal was drafted detailing the identification process of workers in dust-exposed industries.
- Participants received an information sheet containing the research's objectives, data usage, and the broader study context.
- Workplaces participating in the study nominated an authorised representative to provide written consent, ensuring they were well informed about the research's purpose and data handling procedures.

Survey

- The researcher ensured participant anonymity at all stages, providing clear information to participants about the research, including their right to withdraw at any point.

All data sources were safeguarded rigorously to prevent unauthorised access or leaks. Participants and organisations anonymity was preserved in all research reports. The use of any case study information was contingent upon written consent from the involved parties, ensuring no unauthorised opinions or practices are presented in the research findings.

Conflict of Interest

The researcher states that there are no conflicts of interest in executing this research. Every effort was made to approach the study objectively, steering clear of biases by providing evidence to support the discussion and recommendations, and remaining objective to the research limitations.

Findings

The review of existing literature discovered considerable research concerning workplace dust and its global detrimental health effects, however, there is little research into the use and effectiveness of dust lamps to counter the detrimental effects of dust in the

workplace. Therefore, the focus of this study has been to conduct case studies to comprehend the effectiveness of dust lamps, in combination with a survey to gauge the familiarity of dust lamps as a workplace tool among practitioners.

Case Study Findings

Four workplaces were specifically chosen for selection as case studies due to each having dust types with diverse origins, varied environmental conditions and, some equipped with operational extraction systems while others lacking in such mechanisms. The selection of workplaces was deliberate and targeted to facilitate a comprehensive evaluation of the performance of dust lamps across a range of factors.

The workplaces for case study observations were also selected as they adhered closely to the predetermined research objectives. Prior to conducting on-site visits, communication was established with health and safety practitioners and/or senior managers of the selected businesses. Information sheets detailing the purpose of the case study were provided prior to visiting the site, and permission was sought before undertaking research activities.

Before entering each workplace, the researcher underwent site-specific inductions and was accompanied throughout the duration of the visit. Observations of work practices were conducted by placing a black board in the workplace carefully positioned to enable the dust lamp's light to reflect against it. The dust generating task was positioned in between the board and the dust lamp so the high intensity light was able to point through the working zone to the board, thus facilitating the best scenario for capturing dust via camera.

The dust lamp utilised was a high intensity torch procured from a commonly available hardware store in New Zealand. Photographs were captured using a standard mobile phone from various angles to document different lighting effects and patterns of dust movement. Subsequent to the cessation of dust generating activities, additional photographs

were taken, and the dust lamp was employed to visually highlight discrepancies and dust levels. The dust lamp photographs can be seen below. Insights gleaned from these observations facilitated discussions in the case study workplaces and some statements have been incorporated within this paper, with consent obtained from the observers involved.

The survey tool used for this study was an online platform, Qualtrics, and accessible through Victoria University of Wellington's platform. Careful consideration was given to develop questions tailored specifically for the intended audience, comprising health and safety professionals, occupational health practitioners, occupational and industrial hygienists, and wellbeing professionals across New Zealand. The survey questions were designed to facilitate both quantitative and qualitative data collection, providing respondents with ample space to provide comments and perspectives. The survey was distributed through the New Zealand Institute of Safety Management's New Zealand network, as well as the professional networks of the researcher and their supervisor. Following the conclusion of the survey period after two weeks, data was transferred to spreadsheets then underwent statistical and data analysis. Thematic analysis was applied to interpret commentary provided by respondents.

The outcomes derived from the combined approach of case study investigations and survey administration are detailed below.

Case Study Characteristics

Case Study A (Figures 1, 2, 3, 4, 5, 6, 7, 8, 9)

A medium-sized business engaged in vacuum cleaner cleaning operations as one aspect of its customer service offerings. The business recently acquired a dust cabinet to undertake the cleaning tasks due to workers reporting coughing. The cleaning process involved two stages: dismantling vacuum parts near an open door and cleaning the parts with a high pressure air hose within the dust cabinet. The effectiveness of the dust lamp was assessed during both

phases under varying lighting conditions, namely, in the presence of open workshop doors facilitating augmented natural light and closed doors with sole reliance on workshop illumination.

Figure 1: Case Study A - Vacuum cleaner dust, no natural light

Figure 2: Case Study A - Vacuum cleaner dust, no natural light, with black backboard

Figure 3: Case Study A - Vacuum cleaner dust, with natural light, using black backboard Position 1

Figure 4: Case study A - Vacuum cleaner dust, with natural light, using black backboard Position 2

Figure 5: Case Study A - Vacuum cleaner dust, with natural light, using black backboard Position 3

Figure 6: Case Study A - Vacuum cleaner ambient dust - Worker breathing zone.

Figure 7: Case Study A - Vacuum cleaning worker breathing zone, dust extraction cabinet in use.

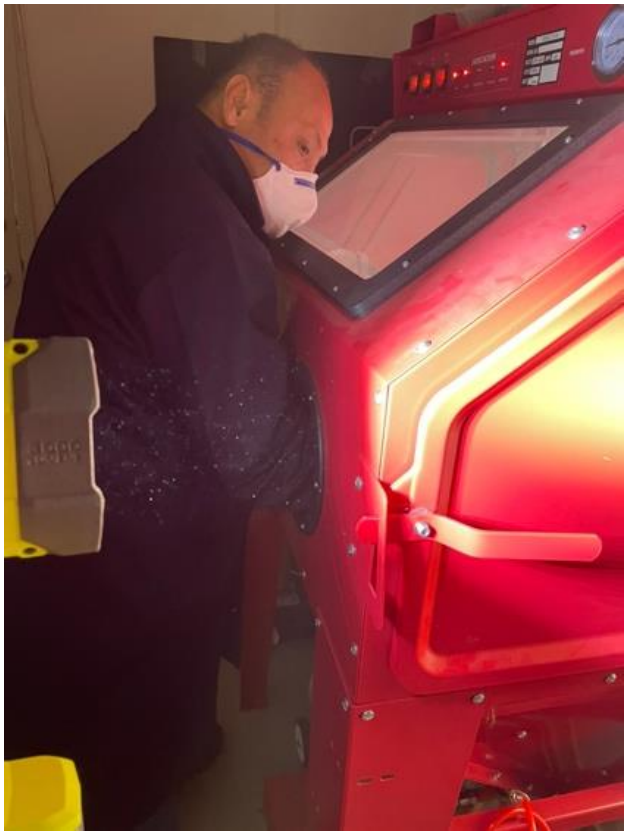


Figure 8: Case Study A - Vacuum cleaning ambient dust, extraction cabinet in use, Position 1

Figure 9: Case Study A - Vacuum cleaning ambient dust, extraction cabinet in use, Position 2

Case Study B (Figures 10, 11, 12, 13, 14, 15, 16, 17, 18)

A medium-large curtain manufacturing facility presented several opportunities for observing the dust lamp across diverse operational activity. The principal operational process encompassed the cutting of materials with industrial-grade cutters, the packaging of bulk curtains into cardboard containers, and the utilisation of the circular saw for cutting wooden battens intended for curtain rods. All operational zones were adequately illuminated by both natural light and workshop lighting. In addition, this workplace was supported by the presence of industrial strength fans aimed at mitigating heat stress among workers. These fans, conceivably influenced the movement of dust particles within the facility.

Figure 10: Case Study B - Curtain Manufacture - Cutting Material using black backboard, Position 1

Figure 11: Case Study B - Curtain Manufacture - Cutting material using black backboard, Position 2

Figure 12: Case Study B - Curtain Manufacture - Cutting Material using black backboard, Position 3

Figure 13: Case Study B - Curtain Manufacture, Packing Boxes

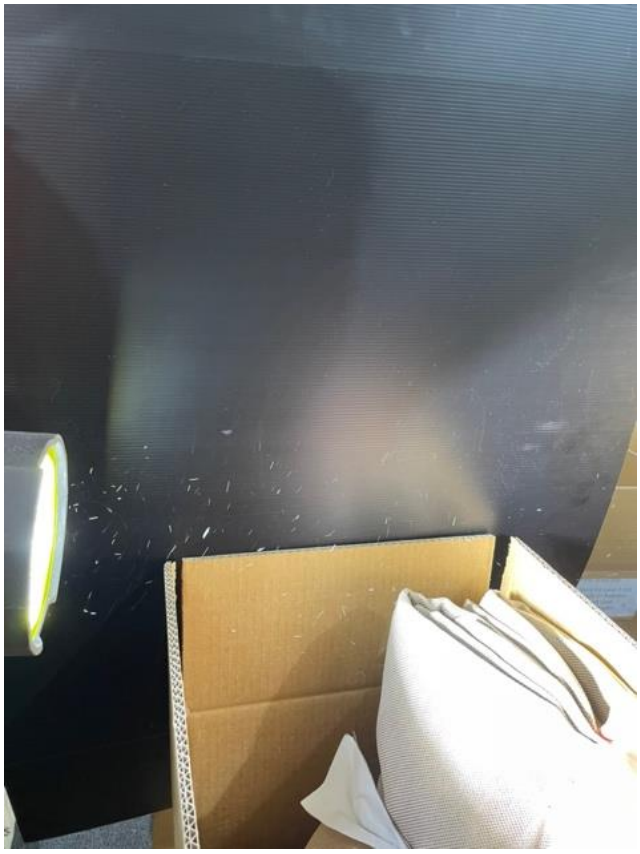


Figure 14: Case Study B - Curtain Manufacture, packing boxes, worker breathing zone.

Figure 15: Case Study B - Curtain Manufacture, Mechanised material cutter.

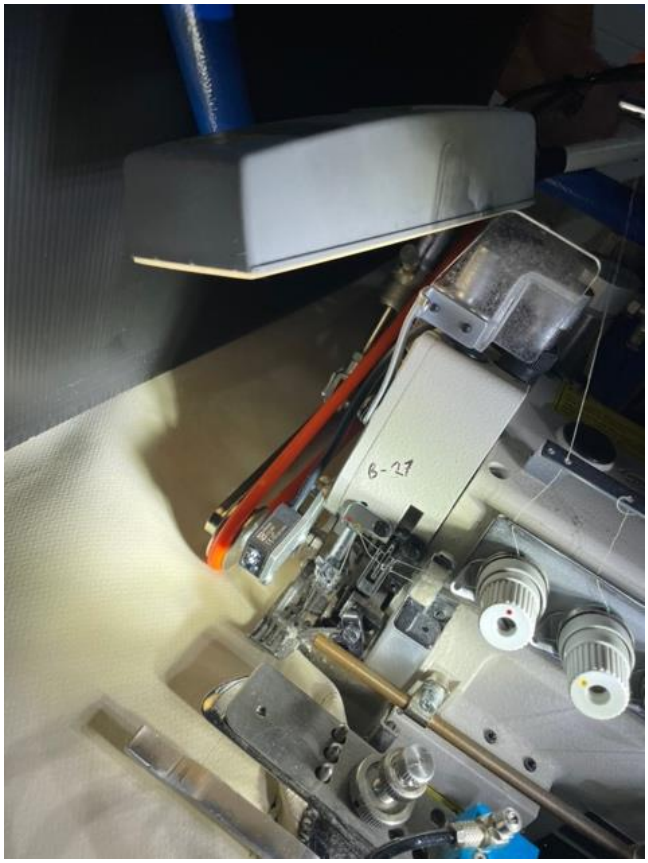


Figure 16: Case Study B - Curtain Manufacture, circular saw, Position 1

Figure 17: Case Study B - Curtain Manufacture, circular saw, Position 2

Figure 18: Case Study B - Curtain Manufacture, circular saw, Position 3

Case Study C (Figures 19, 20, 21, 22)

A large multi-level residential construction site in the process of development was chosen as part of this case study due to its significant natural light in the working zones. The floor that was used for this case study was having wooden framing undertaken which was the main operation at this level and central to the observation was a circular saw utilised for the cutting of large timber components used for wall framing. Notably the spatial arrangement included situating the sawing table proximate to an expansive wall of glass windows, strategically leveraging natural illumination. Furthermore, the saw apparatus featured an extraction mechanism comprising a hose fixed to a vacuum bag designed for collection of sawdust and debris.

Figure 19: Case Study C - Construction Site, circular saw, with natural light.

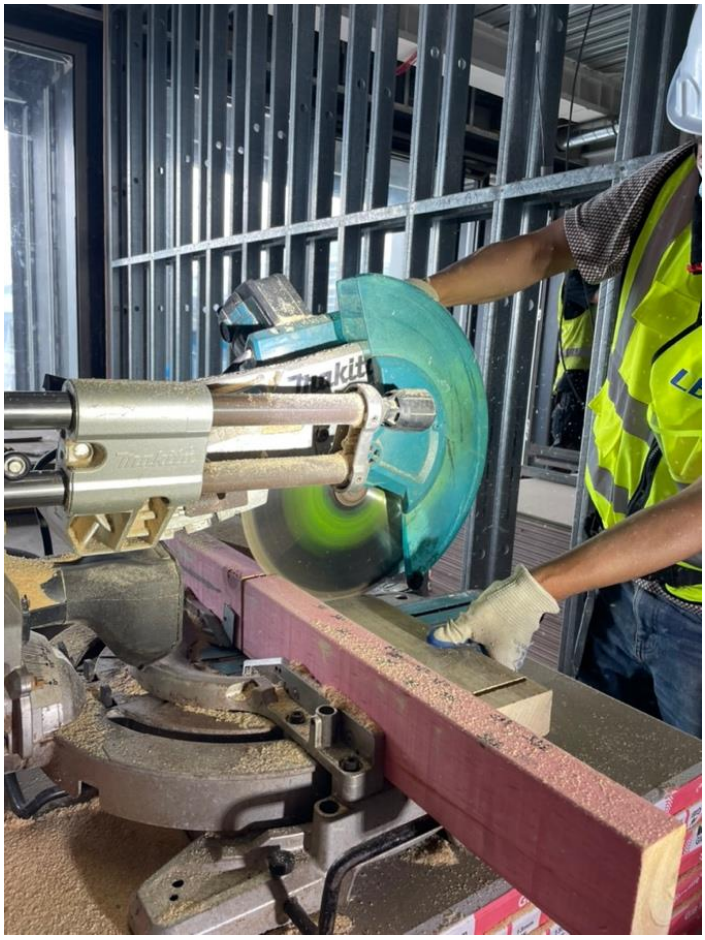


Figure 20: Case Study C - Construction Site, circular saw with black backboard blocking natural light, Position 1

Figure 21: Case Study C - Construction Site, circular saw using black backboard, blocking natural light, Position 2

Figure 22: Case Study C - Construction Site, circular saw, breathing zone observation.

Case Study D (Figures 23, 24, 25, 26)

A small scale patisserie pastry shop was the focus for this case study, in particular, its production and preparation activities in the rear section of its store. Of particular interest was the segment of the production process involving the transfer of flour from its original packaging to a commercially sized mixing vessel. The ambient illumination within the workspace was predominantly derived from internal lighting fixtures as opposed to natural sources. Moreover, the ventilation within the vicinity was notably constrained, attributable to the absence of sufficient windows and the lack of any form of air flow and air-conditioning.

Figure 23: Case Study D - Patisserie, ambient flour dust.

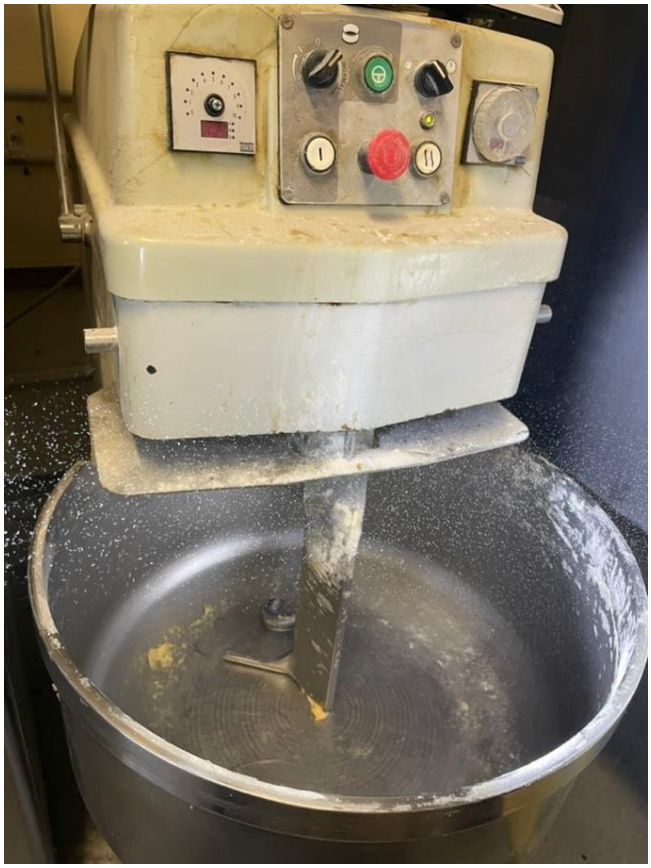


Figure 24: Case Study D - Patisserie, flour dust during task activity.

Figure 25: Case Study D - Patisserie, ambient flour dust after activity, worker breathing zone.

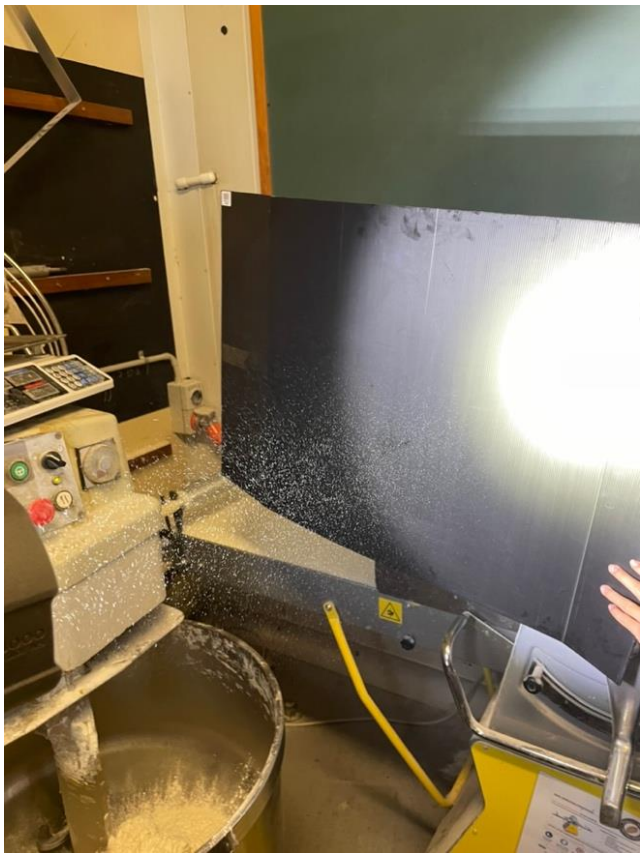


Figure 26: Case Study D - Patisserie flour dust movement after activity, nearby mixing bowl.

Case Study Themes

The analysis of the case study findings through observations of operational dust generating practices resulted in the identification of several emerging themes. These identified themes are expanded upon below.

Theme 1: Dust Identification

The dust lamp consistently enabled the detection of dust particles across various work environments, irrespective of lighting conditions. Particularly noteworthy was its ability to reveal dust particles, both residual and generated from tasks, which were invisible to the naked eye. Notably, in all four case studies, airborne residue dust was observed even in the absence of activity. This occurrence is clearly illustrated in Figures 6, 13, and 23 above. Furthermore, it was observed that areas with limited natural air flow or lacking air conditioning, such as in case study D, exhibited the highest concentration of ambient dust.

In addition, the dust lamp effectively detected different types of dust and illustrated the movement of dust particles from their source to the workers breathing zones. This observation is crucial, as it highlights the significance of natural air flow in mitigating dust accumulation and workspaces and preventing exposure to hazardous particles. The presence of ventilation systems, fans, or air flow in the vicinity of work areas was found to influence the dispersal of dust, thereby indicating potential areas for improvement and dust control measures.

Throughout the case studies, dust observations were conducted before, during, and after operational tasks. In all instances, dust particles that were invisible to the naked eye were detected. Although some dust generated during tasks was visible without the aid of the dust lamp, the levels observed were notably higher and denser when illuminated by the lamp. This disparity prompted discussion and action regarding existing practises, air flow management, cleaning protocols, and the implementation of more effective control measures,

particularly in areas where dust accumulation and exposure and breathing zones were evident.

> "It was a surprise to see via a single powerful light the volume of dust (material) naturally in the air and the dust volume increase when matched to a task or use of a tool." Manager Case Study B.

Theme 2: Dust Particle Characteristics and Movement

Collectively, the case studies yielded unexpected insights into the dynamics of dust particle size and movement. Post dust-generating observations revealed visible dust residue, highlighting the accumulation of dust within working areas following task completion. While the primary focus of the case studies did not revolve around residual dust and its implication for workers, certain instances, as depicted in Figures 10, 19, and 26 above, shed light on the persistent presence of dust in the work environment even after the cessation of dust generating activities. All case study sites had established cleaning protocols in place, however, despite this the findings prompted discussions regarding the quality and frequency of cleaning. Therefore, advocating the importance and necessity of rigorous cleaning protocols as part of a dust control management strategy.

Distinct disparities between various dust type settling rates were considered when observing exposure levels near worker breathing zones. The observation of dust settling rates provided valuable insights into particle weight, with heavier particles exhibiting faster descent and lighter ones tending to linger within the proximity of worker breathing zones. The way the dust moved and its formation provided valuable insights into comprehending the airborne potential of dust particles within workplaces and worker breathing zones, as illustrated in Figures 6 and 22 above.

Furthermore, focus was drawn to the timing aspect of dust setting rates. Following the initiation of operations or tasks resulting in the dispersion of dust, the duration required for

dust to settle was observable. Notably dust particles originating from wood sawing exhibited shorter settling rates compared to those emanating from flour and vacuum cleaning. Vacuum cleaning residues, in particular, demonstrated prolonged suspension in the air, albeit they exhibited faster mobility rates when subjected to external air flow facilitated by open doors, as evidence by their directional movement from one end of the building towards the external environment. In contrast, Case Study D, characterised by minimal air flow, illustrated the lingering presence of ambient dust in the vicinity of workers subsequent to task completion.

Theme 3: Illumination

The dust lamp showed varying levels of capability in highlighting the presence of dust in different environment lighting conditions, i.e. both well-lit and low-lit areas. The dust lamp performed better in lower lit environments where the natural light was not as prominent as evidenced in Figures 1, 2, 22, 24, 25 above. However, the performance of the dust lamp was not compromised by lighting generated from internal sources as evidenced in Figures 6, 9, 13, 17 above. The lamp also highlighted dust in environments well-lit from natural light, however, required careful positioning of the lamp in relation to the direction of the natural light when carefully positioned to support capturing of photographs.

The position of the dust generating practice, presence of natural light extremes on this particular day for Case Study C made capturing the observations on camera a challenge. Multiple methods were trialled to overcome this challenge with the most effective being the use of a black blackboard to assist in highlighting the dust more effectively and allowing the dust lamp beam to be seen more clearly. In this case, the dust lamp was placed in multiple positions to optimise the observations and capturing of photographs, taking into account the natural light direction and how well the lamp contrasted with the surroundings. This enabled optimal viewing of dust using the dust lamp and the capturing of this evidence on camera.

Furthermore, what is unknown is whether the dust captured on camera in this case was only the larger particles as these were easily seen in these lighting conditions. This highlights an important discrepancy that is still unknown suggesting that there is uncertainty regarding the composition of the dust that was captured by the camera and whether in this case the dust is solely composed of larger particles that tend to reflect more light, making them more visible and apparent by camera. Consequently, when capturing images in well-lit environments from natural light, it was common for larger particles to appear more prominently. However, it is important to note that this does not imply that the dust captured was solely composed of larger particles as evidenced in case study A. It is possible that there were also smaller particles present, but they may have been less noticeable due to the lighting conditions, position on the sun to work space or the cameras capabilities.

Theme 4: Extraction Systems

Extraction systems were present in two of the observed workplaces. Case study A utilised an enclosed cabinet for cleaning vacuum cleaner parts and case study C's circular wood saw had a vacuum attached to a collection bag. In case study A, the effectiveness of a vacuum cabinet in containing dust was evident with little dust shown by the lamp when in operation. In contrast, case study C's observation using the dust lamp revealed significant dust emissions from a circular saw. This prompted the practitioner to inspect the extraction system and found the suction hose was disconnected to the collection bag.

The dust lamp proved valuable in both case studies in highlighting ambient dust when utilising extraction systems and also how effective the system was in reducing dust from the operations. The validation of extraction equipment efficacy prompted discussions and actions by practitioners and other workers present during the observations, emphasising the importance of proper equipment usage, checking and maintenance.

> "It was very reassuring for us to validate that the thousands of dollars we have spent on extraction equipment to protect our staff were so worthwhile. It was amazing how your reasonably priced, high-powered torch showed up the minimal amounts that still manage to escape and re-emphasised the importance of our insistence on using the equipment properly and clearing it regularly!" Manager Case Study A.

Theme 5: Practitioners Perspective

Practitioners across all case studies, except one, had no prior experience with dust lamps, however, they acknowledged the prevalent issue of dust in their workplaces and its adverse impact on occupational health and operational cleaning costs. The use of dust lamps in this study elicited surprise among all practitioners and workers involved, who recognised the simplicity, cost effectiveness and value in highlighting dust presence as well as its behaviour characteristics. Consequently, after the observations and citing of the dust lamp in use, all were prompted to make immediate adjustments in the workplaces to educate their workforce and better manage controls.

> "A light of this type is a good, simple, immediately usable tool, to consider having in a workplace. Effective for workers due to the visual results." Manager Case Study C.

Theme 6: Unexpected Findings

The case studies having significant natural light during observations prompted the researcher to utilise a black board as a background to project the dust lamp's light onto it. This resulted in improved visibility of dust and yielded unexpected insights, revealing patterns of dust accumulation and movement. This serendipitous discovery provided valuable information on dust dispersion patterns, both from the dust lamp itself and also by way of the dust adhering to the board.

The dust patterns on the board were captured in case studies A and B as seen in Figures 3, 4, 10, 12 above, both in density and quantity. This was an unexpected discovery

and went some way in identifying how dust settles relative to the worker and environment positioning. Notably, the finer dust particles in well-lit areas that were not completely visible by the dust lamp alone, were visible on the black board once the dust generating activity was complete. These findings can only enhance the use of the dust lamp and provided valuable additional insights into the capturing and understanding of dust in working environments.

Survey Findings

The survey set out to provide analysis to support the research objectives by delving into practitioner experience with dust lamps in the workplace and exposure to dusty environments. The questions were designed to capture both qualitative and quantitative data. The quantitative component detailed country practitioners predominantly work in, industry types, numbers of dust lamp usage, numbers of usage effectiveness. The qualitative aspect allowed respondents to provide comments targeted at usage experience and general information relevant to the survey topic.

The survey was open for 21 days with an excellent response rate totalling 116 respondents. Of those, 33 provided commentary on experience and/or general feedback to the researcher. A further 9 mentioned wishing to know more about dust lamps and wanting to be more actively involved in this research.

The analysis of the survey findings resulted in the identification of specific experience data as well as several emerging themes. The data and themes are expanded upon below.

Respondent Profile

The survey was targeted predominantly within New Zealand; however, the results did capture practitioners from other regions. For the purposes of this study, the survey findings will focus on the data covering the New Zealand landscape and experience.

The majority of survey respondent's primary place of work was New Zealand, see Figure 27. This was expected due to the survey tool focusing participants via online New Zealand network channels being New Zealand Institute of Safety Management, the researcher and supervisor's professional network. The researcher and supervisor's network membership predominantly consisted of practitioners within New Zealand.

The survey limited the respondent type to those having the most likely exposure and experience with dust lamps, health and safety practitioners, occupational and industrial hygienists, and wellbeing practitioners, see Figure 28. The predominant respondent profession type participating in the survey was health and safety practitioners operating in New Zealand. In addition, these practitioners indicated a qualification, however, it is not specified in the data for type and level of qualification.

Figure 27: Survey Respondent residing Workplace Country

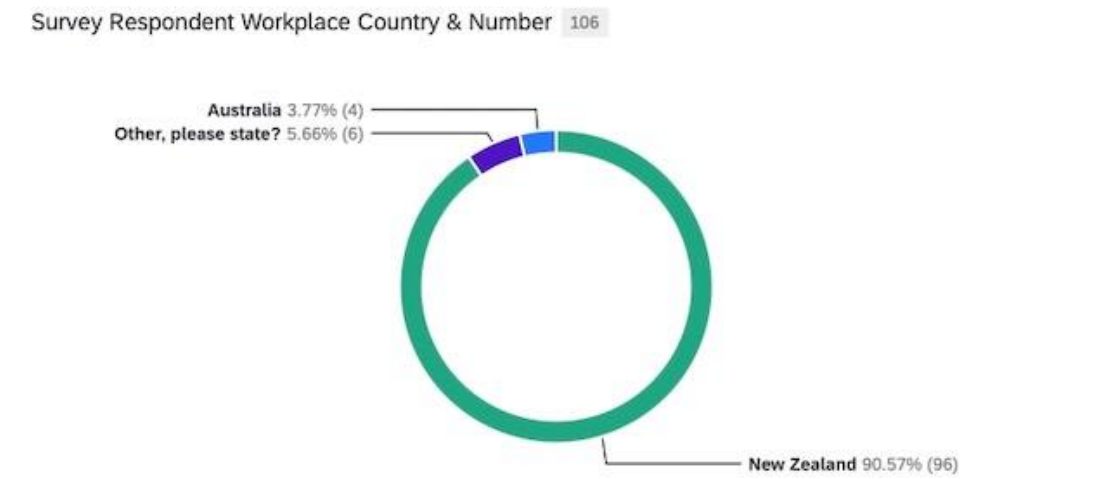
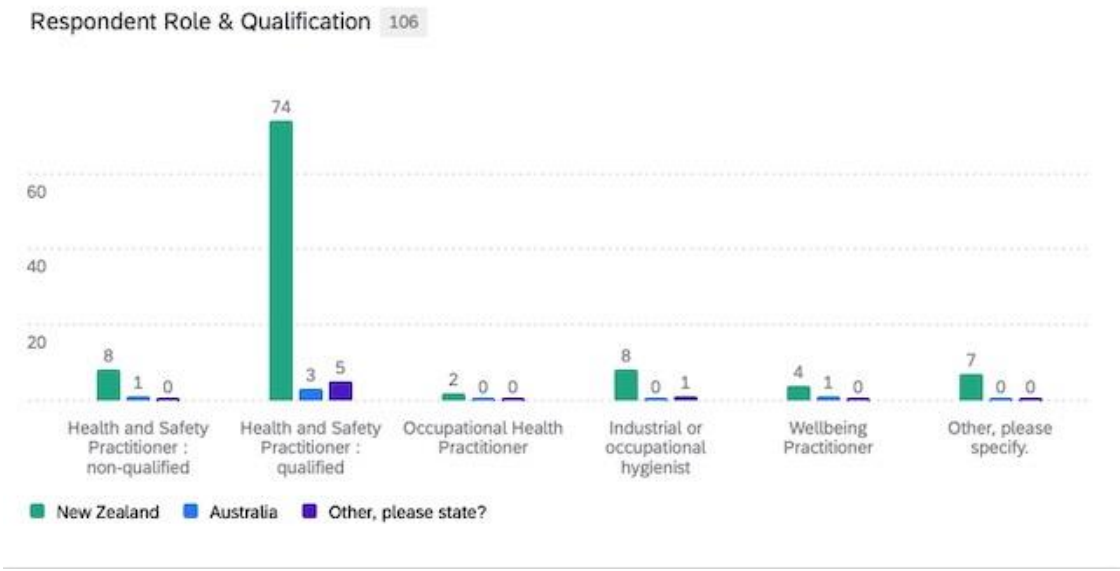


Figure 28: Survey Respondent Role & Qualification



Workplace Dust Environments

The largest proportion of survey respondents experienced working in one or more dusty environments, see Figure 29. The predominant industry type recorded in the survey having a dusty environment is construction followed closely by manufacturing. Other industry categories not specified in figure 30 make up 16% of dusty workplace environments, mainly from warehousing and farming. Other industries, not included in Figure 30 were boat building, military, mining, waste management, quarries, and fabrication.

Figure 29: Number of respondents worked in dusty environments.

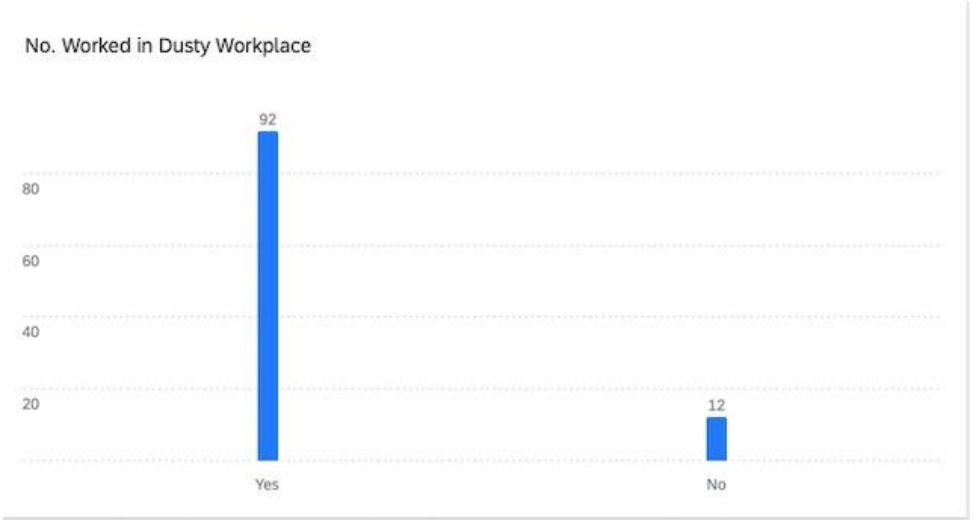
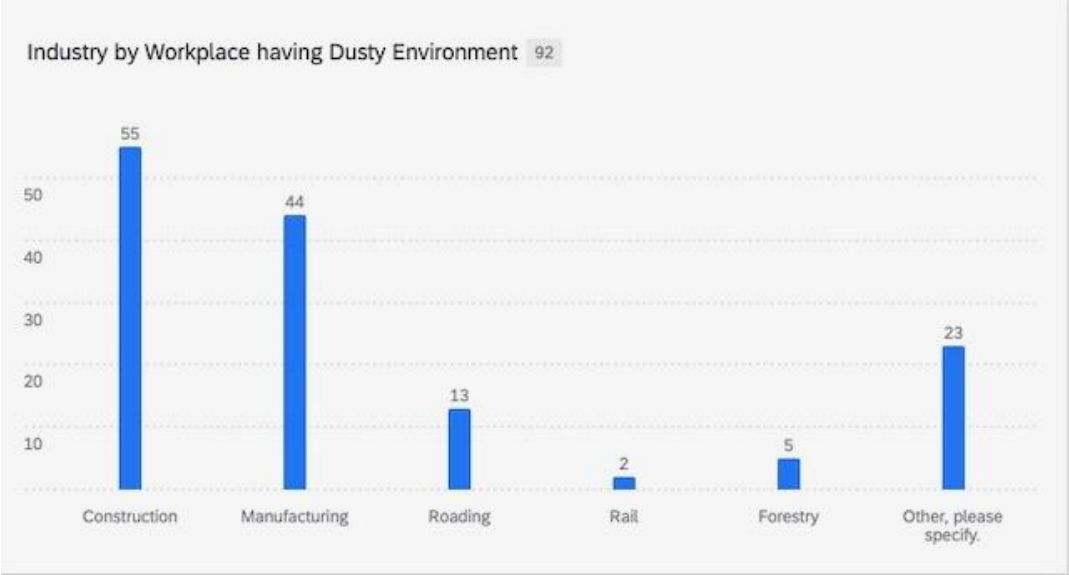


Figure 30: Dusty Workplace Industry Type



Dust Lamp Utility

In proportion to the large number of practitioners having worked in dusty environments, only a small proportion have either heard of or used a dust lamp, see Figure 31. The occupational specialty having experience using dust lamps was equal with qualified Health and Safety practitioners and Industrial or Occupational Hygienists, see Figure 32. Industries where dust lamps were used are predominantly found in construction and manufacturing, see Figure 33.

Figure 31: Dust Lamp usage.

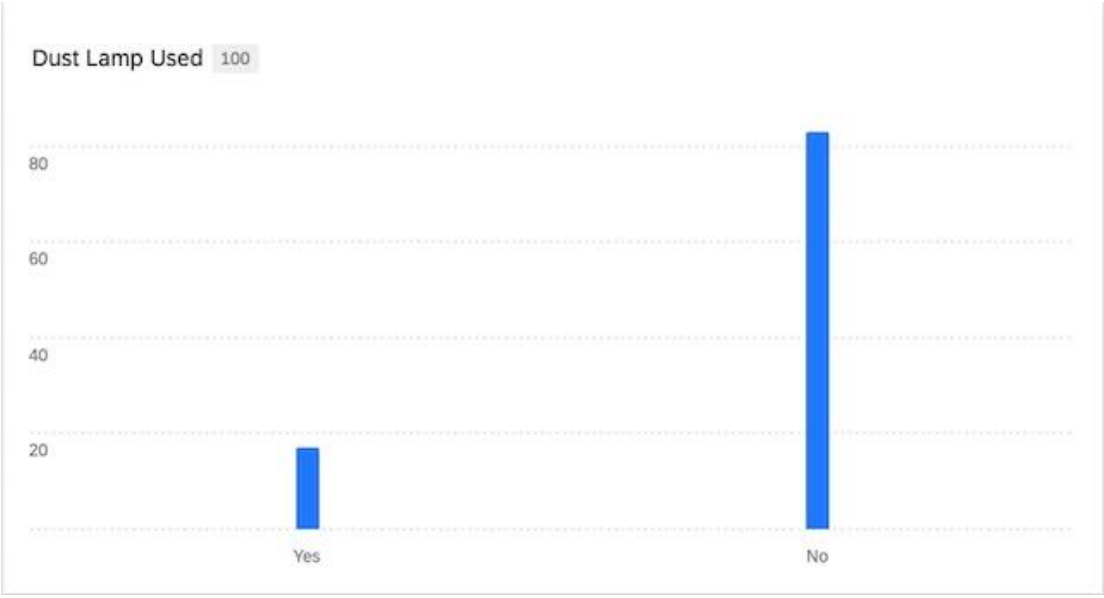


Figure 32: Occupation Specialty having used a Dust Lamp

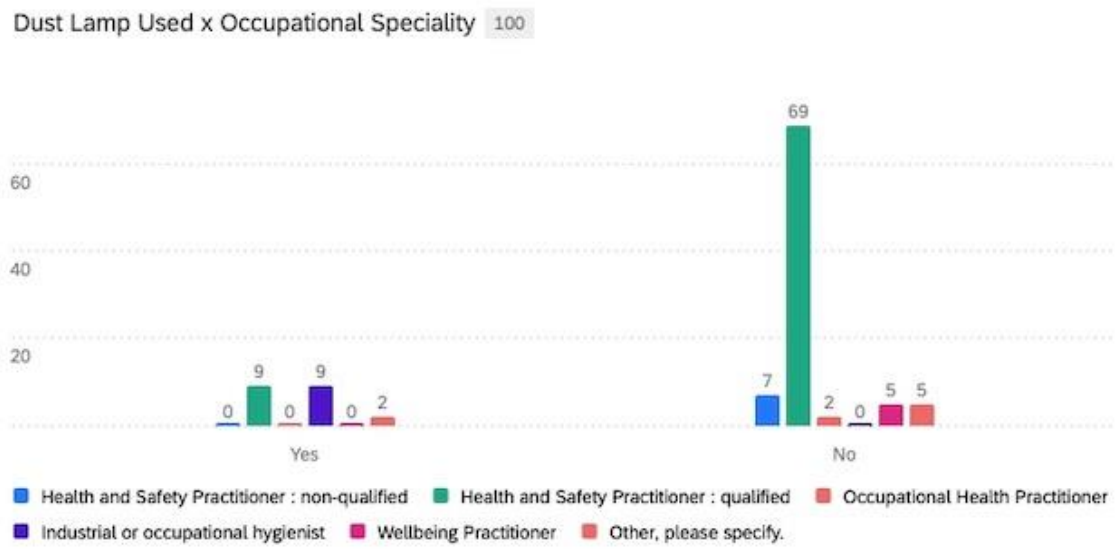
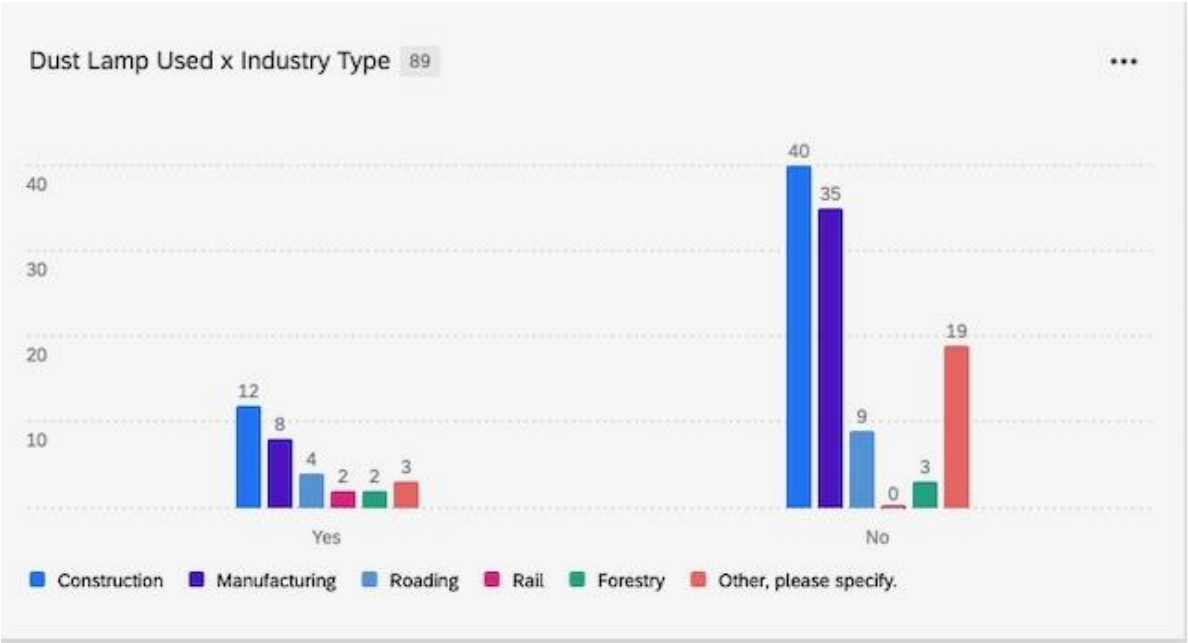


Figure 33: Dust Lamp used by Industry Type

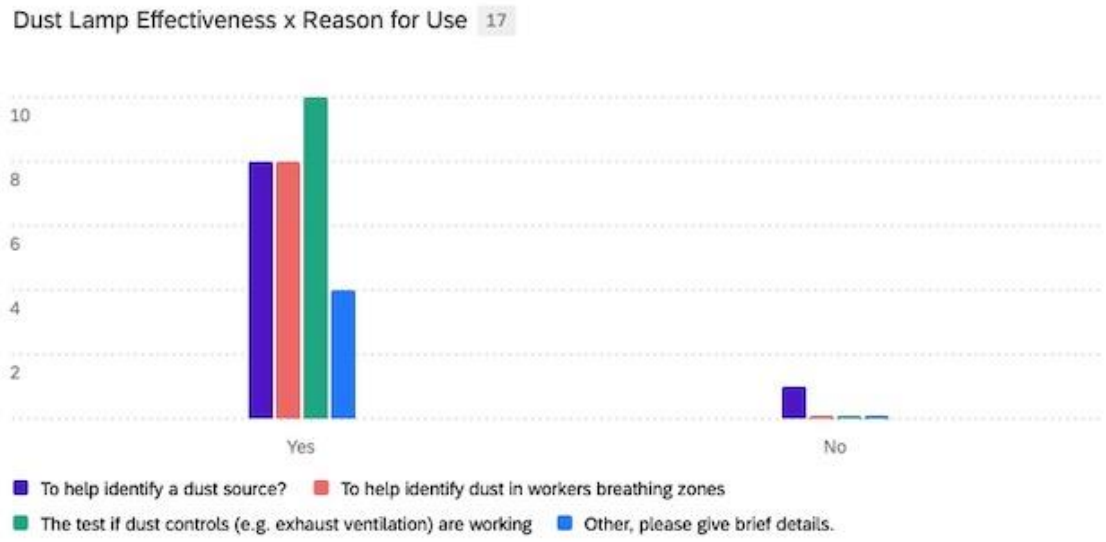


Dust Lamp Effectiveness

Despite the small number of practitioners having used a dust lamp, those that did found the tool very effective as evidenced in Figure 34. The majority stated they found the lamp effective in testing if current dust exposure controls were working. Furthermore, identification of dust sources both in the workplace and at workers breathing zone, were

equally found to be reasons for effective use of the dust lamp. The other reasons for dust lamps to be used not depicted in Figure 34, involve education and awareness as a visual means of informing workers as well as displaying particle size.

Figure 34: Dust Lamp Effectiveness by Reason for Use



Practitioner's Perspective

The survey presented two opportunities for practitioners to provide comments and feedback, including remarks on dust lamp utility and general feedback at the conclusion of the survey. A considerable number of respondents effectively utilised this opportunity providing comprehensive insights ranging from the shared level of dust-related risk exposure within occupational workplaces and their experiences with dust lamps along with their significance. The predominant theme within the commentary highlighted a lack of awareness regarding purpose and functionality of dust lamps, evidenced by numerous remarks indicating a lack of widespread knowledge of dust lamps within the workplace context of New Zealand. Summarised by Respondent 1, "Definitely a case of you don't know what you don't know".

Of the participants who have experienced using a dust lamp, they additionally provided feedback indicating its efficacy in illuminating dust particles otherwise not seen by the naked eye. In addition, the visual capability of the dust lamp predominantly enabled attention to be drawn to dust in the workplace otherwise not seen, thereby taking a role of raising awareness through identification. As articulated by Respondent 2, "Great tool for yourself and showing others what they can't see".

There were numerous similar remarks supporting the dust lamp's ability for practitioners as a tool for the purposes of awareness and education in their workplaces. This theme was consistent across all feedback opportunities provided to respondents, highlighting an additional benefit of the dust lamp beyond simply dust detection and assessment of established control systems. As expressed by Respondent 3, "I value them as a tool to inform and influence".

The collective feedback indicated a widespread acknowledgement of dust as a current, pressing issue across a diverse range of workplaces and industry sectors. Concern regarding lack of management and broader need for legislative action expressed by some respondents perceiving attention to this issue is inadequate and/or existence of a lack of appreciation for its potential harm. In addition, some respondents reported instances of health conditions such as coughing, eye irritation and respiratory issues attributed to dust exposure without remedial activity and/or formal investigation.

The survey feedback captured significant support, encouragement, and optimism regarding the continuation of this research, with some respondents expressing a perceived urgency and more comprehensive action in New Zealand to address this health issue. Furthermore, the respondents' comments highlighted an eagerness and encouragement regarding the research topic, reflecting a broader requirement for increased support and

industry-wide awareness and knowledge concerning dust, its impacts on workers and workplaces, and strategies for mitigating associated risks on health.

To conclude, the findings from case studies and the practitioner perspectives corroborated the responses obtained through the survey, further emphasising the utility and effectiveness of dust lamps as a practical tool for health and safety practitioners. Notably, the use of a black backboard enhanced dust visibility, particularly in discerning smaller particles and in well-lit areas enhancing the dust lamp's capability. Furthermore, the case studies serendipitously provided an opportunity to potentially use black backboards themselves as dust identification tools.

Discussion

The research aimed to investigate the use and effectiveness of dust lamps within New Zealand's occupational environments. The objectives focused on providing employers, safety regulators, and other stakeholders with valuable insights and recommendations to highlight the impacts of dust in the workplace context. The primary purpose being to highlight the potential role of dust lamps in pre-empting and supporting the mitigation of occupational health risks, and its value as part of specialist practitioner's toolkit. In addition, raising the level of awareness and understanding among health and safety practitioners in New Zealand.

Is dust a problem in New Zealand?

Global literature has comprehensively documented research and studies on the presence of dust and its impacts, unlike New Zealand which has limited research attention on the subject. There is some evidence in the literature indicating the prevalence of dust in New Zealand workplaces, such as New Zealand Transport Authority (NZTA)'s examination of roading dust (Waka Kotahi New Zealand Transport Agency (NZTA) (2016). New Zealand is predominantly composed of small, medium enterprise businesses spanning the country across

various industry sectors making it difficult to manage and educate on health and safety risks (Lawrence et al. 2006).

Dust in workplaces is attributed to multiple sources such as, operational practices, disturbance from external environment, lack of cleaning and workplace dust that persists even after operational activities have ceased. In addition, as Eckhoff, (2019) notes, dust also has a broad spectrum of health risks as well as broader impacts on operational costs that were evidenced through the case studies and survey feedback. In particular, the survey respondents highlighted dust as a nuisance leading to health issues and cleanliness challenges.

Baran and Teul (2007) noted dust originating predominantly from machinery operations and material processing, supported by the study findings also noting significant dust generated from machinery operations both through the case studies and survey. Their research further documented dust was commonly sourced from high-risk zones such as construction and machinery plant industry sectors. In contrast, the case studies illustrated that dust is generated and can originate from non-high-risk zones, presenting a greater risk for workers. Cheng et al. (2017) further supports the point of non-high-risk zones as potential sources of concern, a finding corroborated by the case studies and survey results. The survey results noted the presence of dust in broader industry sectors including warehousing, military, roading and smaller organisations experiencing dust-related issues not being classed as high-risk.

Dust Harm

Professional practitioners expressed in the survey despite being aware of the presence of dust-related issues, there was some uncertainty about the specific composition of dust they were encountering. In some cases where the dust concern was not recognised and unaware of the potential harmful nature of dust particles, individuals reported experiencing symptoms such as coughing. There was a lack of understanding regarding the long-term exposure risks

and what constitutes hazardous dust in these instances. Noteworthy, was the broader recognition among industry practitioners of the harmful effects of dust in high risk sectors. However, there was surprise among practitioners regarding the extent of dust accumulation and what are considered lower risk organisations or those not subject to specific legislative requirements, such as the case study of material manufacturing.

In workplaces featured in the case studies who implemented mechanised control systems, these measures were introduced either in response to employees reporting health issues or because of legislative requirements. Mechanised dust control measures were observed in high risk industrial sectors, like wood sawing operations, where regulations mandate guidance for dust control. Notably, feedback from the survey revealed instances where respondents reported experiencing health effects due to dust exposure but mentioned a lack of proactive measures taken by their employers. These reports are a testament to Levack et al. (2023)'s concerning estimation of 2 million undiagnosed people with COPD and more concerning Matheson et al. (2005)'s study linking 15-19% of these diagnoses to occupational exposure.

The case studies and the survey both documented workers currently expressing or having a history of lung problems, ranging from coughing to more serious lung conditions during their active working years. This finding supports Levack et al.'s (2023) identification of undiagnosed individuals at risk of developing chronic obstructive pulmonary disease (COPD) due to a latency period for symptom manifestation. Additionally, the survey highlighted a worker reporting adverse effects on their eyesight causing irritation, consistent with Anlimah et al. (2023) findings on the impact of dust exposure on workers vision and skin. It is concerning that affected workers are unaware of the full extent of their exposure and the potential long term repercussions, given the documented latency period associated with the onset of such respiratory conditions.

Furthermore, research from Brahney et al. (2019) and Nguyen et al. (2019) underlines the risks posed by exogenous dust sources in Australian climatic conditions, emphasising their lack of knowledge regarding the dust composition. Although the dust lamp used was effective in the majority of instances, it failed to identify the type of dust particles and their harmful effects.

The Efficacy of Dust Lamps

Both the case studies and survey findings substantiate the effectiveness of dust lamps in identifying and monitoring dust exposure. They specifically highlight how these lamps revealed dust that is not perceptible to the naked eye, having a positive influence on practitioners. Dust lamps not only enhanced visibility of dust particles but also shed light on their movement and density, including the time taken for them to settle. However, Greenough (1988) emphasised that while dust lamps play a pivotal role in assessing dust concentrations, they should be utilised as a complementary tool by qualified professionals such as occupational hygienists. It is noteworthy that the researcher conducting the case studies and employing the dust lacked formal training in its usage but adeptly operated the device with minor adjustments, leading to successful outcomes.

The effectiveness of dust lamps may be compromised in varying illumination settings, as evidenced in the case studies where different environments posed challenges in detecting dust, requiring numerous attempts to capture on camera. Lenk and Lenk (2017) argue that understanding these intricacies is crucial for optimising the devices application, also supported by the case studies. While survey respondents mostly rated dust lamps effective, Greenough (1988) stressed the importance of integrating airborne dust sampling and dust control practises, particularly when utilising dust lamps. However, limited availability of specialist hygienists for undertaking such sampling, coupled with its high cost and time intensive nature, poses challenges. In addition, the size, demographic and make up of New

Zealand businesses adds to the challenge of utilising and maintaining consistent airborne dust monitoring. Despite these constraints, the case studies conducted in small businesses demonstrate that dust lamps offer a cost effective, easily operated, and immediately visible solution, prompting immediate investigations, attention and improvement action.

The role of health professionals and practitioners

The survey has unequivocally brought attention to the insufficient representation of occupational industrial hygienists within New Zealand. This finding was also supported by Garg (2022) who pointed out a shortage in New Zealand's occupational hygiene expertise. Albeit, potential limitations of this study targeting these specific specialists may have arisen through the unavailability of the survey tool on their targeted network. The survey was distributed primarily through health and safety practitioner networks.

A large proportion of health and safety practitioners participating in this study noted their unfamiliarity with dust lamps and their efficacy highlighting a deficiency and knowledge gap of professionals within this field. Although the study identified a significant gap in awareness and knowledge (even among qualified practitioners) some respondents endorsed dust lamps as being a valuable tool. Specifically the lack of proficient practitioners and health professionals well versed in dust lamps is evident. Importantly, there is a pressing need for enhanced awareness of dust related hazards to promote the utilisation of identification tools like dust lamps.

Education and awareness are essential.

There is a pressing need for a comprehensive approach to promote awareness and education regarding the health risks associated with exposure to dust as emphasised by Adam (2023). Importantly, individuals must be equipped with knowledge on dust lamp utilisation and effective strategies to mitigate the hazards posed by dust exposure. This necessity was evidenced in the analysis of case studies, finding a general lack of awareness among

participants regarding the presence of dust particles visible through dust lamps as well as unfamiliarity with their operation. Survey results further reinforced the imperative for heightened awareness and education, emphasising the importance of recognising dust in the workplace, understanding appropriate responses, and proficiently utilising dust lamps. This is further supported by Greenough (1988) who advocate for the implementation of specialised training programmes to ensure the competent utilisation of dust lamps and a comprehensive understanding of their role in dust management and prevention.

The survey data and practitioner feedback indicate the need for further changes in workplace behaviours to improve awareness, knowledge, and the integration of tools such as dust lamps into routine workplace assessments. Failure by management to acknowledge dust related issues or prioritise employee health concerns hinders the advocacy and acceptance of dust lamps. Abas et al. (2021) further supports this by offering insights affirming the significance of addressing behaviour related aspects to facilitate the acceptance of dust as a workplace concern and the implementation of dust control measures. Accordingly, addressing psychological and sociological factors among both workers and management is crucial in overcoming barriers to prioritising dust management and prevention measures in workplaces.

In conclusion, enhancing education and awareness regarding the health risks associated with dust exposure, alongside promoting the proper use of dust lamps for mitigation purposes, emerges as a crucial aspect in addressing the challenges posed by dust in New Zealand workplaces. Efforts to improve workplace behaviour, increase awareness, and incorporate tools like dust lamps into routine assessments are essential steps towards ensuring a healthier and safe working environment. Moreover, the need for specialised training programs, increased competency in health and safety practitioners and increased numbers of occupational hygiene expertise in New Zealand is vital for effective dust control and prevention strategies.

Current literature and these research findings suggest that New Zealand is experiencing a significant dust problem, warranting further attention and focus on mitigation strategies. In light of the evidence presented, it can be inferred that New Zealand, supported by this research and findings from other global regions, faces a significant dust related challenge.

Limitations

It has been a limitation of this research to focus on New Zealand participants, although the survey did capture some respondents from outside of New Zealand. The survey was only targeted at specific industry specialists who would have the most likely experience with dust lamps or dusty environments. The survey respondents were narrowed to the New Zealand Institute of Safety Management network, the researcher and their supervisors network. Similarly, the case studies were also limited to New Zealand workplaces and to those who gave the best opportunity to test the research objectives.

Several considerations constrained the scope of the case studies. The numbers were limited to four due to availability and also were chosen as they had multiple factors that supported the research objectives observations, i.e. various lighting, various dust sources, different sized organisations and varied control mechanisms. In addition, these workplaces had all factors to support the objectives in each so gave the researcher a good overview to test the dust lamp in use.

Furthermore, the case studies were primarily limited to instances where dust emanated from operational tasks rather than environmental sources. Environments with external sources of dust or where dust was generated by disturbances to the surroundings were not observed. The observation of dust during the case studies was confined to the period of dust lamp utilisation, precluding an assessment of the duration and broader geographical dynamics of dust generation and accumulation in the workplace.

It is pertinent to note that the research did not delve into the categorisation or differentiation of dust particulates or their specific health hazard composition but rather focused on parameters such as dust density, particle size, and movement characteristics. Although two of the examined workplaces featured mechanised dust extraction systems, the effectiveness of these measures over time was not extensively explored.

Recommendations

Managing and mitigating dust exposure in New Zealand workplaces is currently challenging and requires continuous research to broaden awareness and understanding. Considerable progress has been made in recent years, however, several areas still require deeper understanding and exploring, to provide opportunity for continued future improvements. The discussion highlights the potential of dust lamps in identifying and managing dust exposure in the workplace. The existing literature lightly discusses their potential, however, a gap remains in comprehension and understanding of these tools. Future studies are needed with a meticulous focus into the varied types of dust lamps, their operational intricacies, and how they fit into diverse environmental workplaces. This will expand their ability, increase knowledge and awareness, and provide clear guidelines on their optimal usage.

The current health and safety legislation in New Zealand, while it focuses on the identification and management of risks that would include dust, does not offer specific guidance on dust mitigation strategies such as dust lamps. Worksafe New Zealand provides multiple guidance and support on dust management, albeit, targeted at high-risk zone workplaces or known dust such as silica. In addition, there is no provision of specific guidance on the use of dust lamps. The World Health Organisation's (WHO) occupational and environmental health department, as part of its Prevention and Control Exchange (PACE) has a guide: 'Hazard Prevention and Control in the Work Environment: Airborne Dust'. This

comprehensive guide published in 1999 sets out to aid dust control and in turn reduce disease associated with dust exposure.

The Health and Safety Executive published guidance on ‘The Dust Lamp (Health and Safety Executive United Kingdom (HSE). MDHS82/2): A simple tool for observing the presence of airborne particles as part of its health and safety laboratory, Methods for the Determination of Hazardous Substances. This guide is targeted at health and safety practitioners, occupational hygienists, ventilation engineers and others working with exposure to airborne particles. As a minimum, it is recommended Worksafe New Zealand adopt the HSE UK and the WHO guidance’s, encouraging practitioners and others to not only raise awareness of dust lamps but promote their adoption as part of a hazard mitigation strategy.

Holistic strategies, particularly those blending technological interventions with proactive policies and training, are still in their infancy requiring emphasis on their potential. Further, longitudinal studies as a line of research would be beneficial, capturing the long-term impacts of these strategies. Studies of this nature could offer insights into the sustained benefits of these approaches on both dust mitigation and the broader health outcomes of workers.

Abas et al. (2021) provide compelling insights and direction from a behavioural perspective. Exploring and understanding the psychological and sociological aspects of worker behaviour will reveal and better comprehend barriers to adopting dust control measures. Employing methodologies grounded in behavioural science, researchers can design interventions that resonate more deeply with workers, ensuring better compliance and effectiveness.

In addition, another underexplored research domain is the economic implications of dust control. The literature is well-versed with the health consequences of dust exposure;

however, a comprehensive financial analysis still needs to be discovered. Future research can record the economic benefits of industries that competently implement dust control measures. This type of analysis would encompass direct healthcare savings and the indirect benefits of enhanced worker productivity, therefore, further influencing the uptake of dust lamp utility as well as targeted approaches to mitigation strategies.

New Zealand's unique geographical environment, combined with its exposure to climatic conditions such as Australian exogenous dust storms, suggests that the dust here may have a distinct composition. Further studies into regional variations and these different dust types pose opportunities to provide invaluable insights into the specific health implications for New Zealanders and better enable targeted, tailored dust control strategies. In addition, knowing and understanding the type of dust found in the environment will support specific industries and workplaces like roading, to further strengthen their dust mitigation controls.

Finally, as rapid technological advancements are made, dust control measures and applied holistic approaches to management must evolve in tandem. Extending beyond dust lamps, is a range of encouraging technologies focused on designing out the risk, that hold promise in this domain. Maintaining current knowledge and awareness of such innovations ensures our strategies remain cutting-edge, offering the best protection against dust exposure.

As New Zealand strives for improvements in occupational health of workers, particularly from dust exposure, a holistic, approach considering technological advancements in design and maintaining accessible, simple, modern tools such as dust lamps and processes is required. Further research in simple, accessible, and pragmatic solutions that include perspectives from broadly diverse fields like occupational health, engineering, and behavioural science are required. Collaboration from industry stakeholders, academic researchers, health and safety regulators, and policymakers, ensures research remains focused on current challenges and presents practicable recommendations. At a minimum, the adoption

of dust lamps as part of health and safety practitioner's toolkit combined with training in its use is a must.

Conclusion

Existing across New Zealand's workplace landscape lie the constant challenge of dust exposure rapidly advancing from an occupational concern to an emerging public health crisis. The nature of this threat is extending from traditional high-risk sectors to more unsuspecting workplaces like warehousing and bakeries. The resultant health implications, ranging from immediate respiratory afflictions to debilitating long-term conditions, highlight the gravity of the situation and the urgency for concerted intervention.

Currently, across the existing broad range of dust management solutions, the role of dust lamps is emerging as both promising and vital. These tools, whilst not a solution in isolation, can be effective when integrated into a broader, holistic strategy. They offer a promising solution of detection and awareness, by aiding in making invisible dust visible. However, their full potential is dependent on awareness of the tool, broader usage and necessitating comprehensive training and awareness programmes. However, an obvious gap remains as we begin to broaden and find improvements in dust management. The absence of comprehensive research tailored to the New Zealand context and utility of dust lamps as a mainstream solution highlights urgency. What is necessary is the joining forces of researchers, regulators, and industry stakeholders, furthering studies to ascertain dust lamps' efficacy and a holistic approach to improved health from dust exposure.

This research contributes to effectiveness of practice for health and safety, occupational health, and other professionals. Practitioners and professionals working within dusty environments would benefit from having a dust lamp or high-intensity torch in their toolkit. Supporting these tools, training programmes or at least a simple webinar for practitioners and professionals on how to use dust lamps and integrate them into their

mitigation strategies is necessary in New Zealand. As evidence highlights, the current shortage of occupational hygienists means we must learn to take on these roles within businesses and, train others to do so.

In conclusion, while the challenge posed by dust exposure in New Zealand is concerning, it is manageable. With tools like dust lamps in safety practitioner's toolkit and a proactive, research-driven approach, we can envisage a future where occupational health issues from workplace exposures are not a mere aspiration but a tangible reality. If we are to see occupational health statistics improve, we must respond to the current crisis with action and proactively, collectively, shape a safer, healthier future for all New Zealand workers.

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