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Sources and Control Measures of Crystalline Silica Dust in a Road and Building Project in Zambia

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Abstract

Construction works bring about silica dust hazards, part of the dust produced by staple materials such as concrete and sand. Silica dust, when inhaled in high quantities or for an extended period, is lethal to workers as it causes silicosis, which has no known cure. Several studies have reported high exposures of silica dust in construction, especially where there are no controls. As Zambia sets to become a middle-income country by 2030, increased projects have increased exposure to silica dust and chemicals that cause diseases. There is a likelihood of an increase in the generation of dust and possible contact with silica dust and chemical irritants. Therefore, the paper examines the controls used in the construction industry in Zambia and recommends improvements for silica dust exposure controls to safeguard workers' health. A cross-sectional study was conducted on a building and a road project as two case studies. Carpenters, butchers, tilers, bricklayers, demolition workers, painters and labourers were purposively sampled. The total sample size was 100 workers, 50 for each case study. The sample size was established at 10% of the estimated population of 1012. Moreover, the sample size was limited to 100 because the number of workers was reduced due to Covid-19 by the Ministry of Health. Data was collected using overt observation using an observation schedule and a camera as data collecting tools. The data were qualitatively analysed using the constant comparative method. The results showed that the combination of water and dust or face masks was the common control used on both sites. Despite the use of water and facemasks, there was still high exposure to dust and chemicals because of inadequate controls. Skilled well-fitted, recommended personal protective equipment was rarely provided. Moreover, the respiratory masks commonly used were Covid-19 facemasks which were inadequate for silica dust reduction. The only controls used were engineering control and the use of PPE. The findings suggest that workers are at risk of health problems in the Zambian construction industry brought about by inhaling dust. The combination of all methods in the hierarchy of controls and the incorporation of all construction stakeholders in ways of silica dust exposure controls are recommended. The study serves as an awareness to construction stakeholders of the health concern of high dust exposure levels and inadequate controls. There is a need for measuring actual concentrations of crystalline silica dust with and without controls.

Keywords: Controls, Construction, Observation, Silica Dust, Zambia

1.0 Introduction

The importance of the construction industry is evidenced in many infrastructure developments, such as roads, bridges, housing units and shopping malls (Tente and Muya, 2014). However, a staple hazard of construction activities is respirable crystalline silica dust (RCS). The RCS is part of dust, which is generated from many processes in different industries of the world economies, such as agriculture, mining, construction and manufacturing. During land tilling, agriculture dust is generated (Swanepoel, 2012). The mining industry generates dust from crushing, extraction, drilling and stone breaking. Gholami et al. (2012) found high dust concentrations in the Iron-stone mine in Iran. The construction industry generates dust from breaking, cutting and crushing concrete (Normohammadi et al., 2016). Dust is also generated in the dental laboratory from sanding and sandblasting through porcelain and polishing (Kim et al., 2002). As part of construction dust, silica dust is the most hazardous part of dust (Li et al., 2019). It is contained in commonly used construction materials such as concrete and sand. Silica dust is produced when materials that contain

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silica are being worked on, like cutting, breaking and grinding (Flanagan et al., 2003). However, silica dust has not been well characterised because of the frequent turnover of personnel and continually changing workplaces, tasks and environmental conditions (Flanagan et al., 2003). Several studies, such as Kirkeskov et al. (2016), Normohammadi et al. (2016) and Li et al. (2019), have shown that construction dust contains high silica concentrations that pose health risks of occupational diseases such as renal disease, tuberculosis, chronic obstructive pulmonary disease, lung cancer and silicosis (HSE, 2012).

The evidence of the prevalence of respiratory symptoms and skin diseases in Zambia's construction industry indicates that workers are exposed to dust and chemical irritants that are harmful to them (Nsunge, 2019; Tente, 2016). Inhaling silica dust above Permissible Exposure Limits (PELs) causes symptoms of respirable diseases. When exposure is high, or for a long time, it leads to silicosis, which has no known cure. On the other hand, exposure to chemical irritants causes skin disease symptoms common in construction in Zambia (Tente, 2016). Symptoms of respirable and skin diseases are caused by exposure to silica dust and chemical irritants that affect workers' health. Moreover, they may lead to death and cost projects regarding lost man-hours, hospital bills and compensations.

Reduction in exposure levels to silica dust and chemical irritants reduces symptoms of respirable and skin diseases. This, in turn, safeguards workers' health and improves production on construction projects (Tente and Mwanaumo, 2022). Moreover, in line with Sustainable Development Goal number three of achieving good health and well-being by 2023, it is a requirement that the number of deaths and illnesses caused by hazardous chemicals and air pollution and contamination are reduced. The high global estimated number of workers exposed to silica dust in the construction industry is a serious concern (Bello et al., 2019; IOM, 2011; Motshelanoka, 2005). As Zambia sets to become a middle-income country by 2030, there has been an increase in construction projects and a likelihood of an increase in the generation of dust and possible contact with silica dust and chemical irritants. This is evidenced in the studies by Nsunge (2019) and Tente (2016), who reported 43% and 22% prevalence of symptoms of respiratory diseases, respectively. The prevalence of respiratory diseases was attributed to exposure to dust.

The symptoms of respiratory and skin diseases affect workers' health and negatively impact projects through lost man-hours, low productivity, hospital bills and compensations. Therefore, the study examines the sources of silica dust and controls used in a road and building project in Zambia. The findings and recommendations would provide knowledge on the dust prevalent on projects towards enhancing good safety culture among construction stakeholders in the construction industry in Zambia.

2. Literature Review

2.1 Respirable Crystalline Silica Dust Exposures in Construction

Silica is found in construction materials such as sand, stone, brick, mortar and concrete (Occupation Safety and Health Administration-OSHA, 2017). Therefore, when working with these materials, silica dust is produced. Since silica dust is produced from construction staple materials, it is one of the important hazards in the industry (Flanagan et al., 2003; Wiebert et al., 2012; Kirkeskov et al., 2016). Some of the common construction activities that produce silica dust are surface grinding and finishing, tuck-point grinding (mortar removal), rock and surfacing grinding, sanding of drywalls, tile cutting, brick and concrete block cutting and abrasive blasting (HSE, 2012).

Several studies have found that skilled construction workers such as demolition workers (Lumens & Spee, 2001; Normahammadi et al., 2016; Kirkeskov et al., 2016), abrasive blasters, surface and tuck-point grinders, jackhammers, rock drills, masons and labourers (Flanagan et al.,2003); and painters (Rappaport et al., 2003) experience silica dust concentrations higher than the PELs. In addition, several countries have recorded high silica exposures that pose a high risk of respiratory diseases to construction workers. In Switzerland, 80% of the measurements of exposure levels for demolition and reconstruction were above the PEL (Moser, 1992), Finland recorded high silica exposure levels during the dry season (Riala, 1988), and the Netherlands recorded high silica exposure concentrations (Lumens and Spee, 2001).

2.2 Respirable Crystalline Silica Dust Controls in Construction

There are five controls in the hierarchy of controls for respirable crystalline silica dust, namely, elimination, substitution, engineering control (use of Local Ventilation Exhaust (LEV), administration control (provision of training/personal hygiene) and the use of Personal Protective Equipment (PPE) (Tente et al., 2022). The order of importance or most effective controls are from the bottom up to the top, as shown in Figure 1.

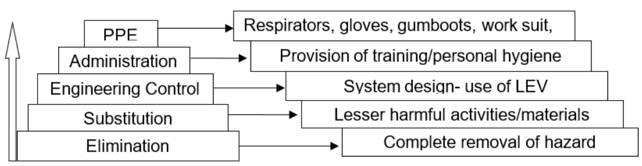

Figure 1: Hierarchy of controls (Source: Tente et al.2022)

According to Thorpe et al. (1999), the method of elimination is the most effective control, yet it is not recommended in construction as silica-content materials such as sand and cement are staples. The second in the hierarchy is the substitution method. One example of a substitution method is the replacement of the onsite mixing of concrete with ready-mix concrete (Wu et al., 2016). Engineering control involves the removal of the hazard at the source before it enters the air, such as wet suppression (Thorpe et al., 1999; Lumens and Spee, 2001; Flanagan et al., 2003) and the use of LEV (Hasan et al., 2012). An LEV system consists of a hood or enclosure to capture a contaminant, an air pollution control device to clean the air, and an air mover to provide airflow through the system (Raynor and Peters, 2016).

Another exposure control is administrative control, which involves training the workers on the risks of silica dust and chemical irritant hazards to reduce exposures (NIOSH, 2009; Mwanaumo et al., 2014). Also, training is recommended in terms of effectively using the tools to reduce exposure to silica dust (HSE, 2012). One example of administrative control is ensuring that workers rotate the activity in terms of shifts to keep exposure under PEL (Tente and Mwanaumo, 2022). For silica dust exposure reduction, properly selecting the Respirable Personal Equipment (RPE) and proper storage is key (Radnoff and Kutz, 2013). The last in the controls that are used is the use of adequate PPE. According to Flanagan et al. (2003), using PPE alone is inadequate in controlling the exposures experienced in construction. Despite this fact, to reduce levels of exposure, it is recommended that management provide full proper PPE (Tente and Mwanaumo, 2022). This would work with other methods, especially since PPE is the most commonly used control in construction (Reed et al., 1987). Nevertheless, in Kirkeskov et al. (2016), few workers used personal respiratory protection during the dustiest work.

According to authors (Kirkeskov et al. 2016, Mwanaumo et al. 2018; Mambwe et al. 2021), exposure levels to silica dust differ from profession to profession and task to task despite working in the same environment. The fact that most studies that have been done concerning respirable crystalline silica exposure controls have been on the on-tools controls such as grinders, cut-off saws, and hand-held saws is evidence that engineering control is a practical method (Tente et al., 2022). However, in Tente et al. (2022), where results from eight studies by different researchers were analysed, no single control method adequately reduced silica dust below the PELs, as shown in Table 1. The results showed that the water control method had a higher silica dust reduction percentage compared to LEV and the use of silica substitute materials.

Carlo et al. (2010) had few concerns with water regarding slip hazards and decolouring when cutting tiles with the saw during roofing installation. According to HSE (2012), there was no statistically significant effect on control efficiency for factors such as water volume, flow rate and blade size when the water control method was used. The other control which reduced exposure to 99% was LEV on-tool. The advantage of LEV is that it reduces exposure to nearby workers and minimises clean-up due to dust exposure (Tente et al., 2022). The problem with LEV on-tool is that it adds more weight to the equipment or tool. The use of silica substitute materials is reduced by 60% of exposure. This entails that silica substitute materials should be incorporated into construction to help reduce exposure levels. The combination of LEV and water significantly reduced, below the PEL of 0.075mg/m3. This clearly showed that combining all controls, namely, LEV, water, silica substitute materials, training and the proper use of quality RPE, would reduce exposure to safeguard the workers' health which is paramount (Tente et al., 2022).

Silica content materials in their wet state produce chemicals that are irritable to the skin, and in their dry state produce silica dust during grinding, cutting, sanding and other construction activities (Tente et al., 2022; Tente and Mwanaumo, 2022). According to Tente et al. (2022) 's findings, the most common dust control method was a combination of water and dust masks (52%), followed by dust masks only (24%). The control by use of water only was 10%, and no control was five per cent. The results show that the use of PPE was common.

Table 1: Control Measures and their Silica Dust reduction Percentage

Item	Control Method	No Control (mg/m^3)	With Control (mg/m^3)	% Reduction	PEL (mg/m^3)	Source
1	LEV	1.0	0.3	70	0.075	Lumens and Spee (2001)
2	Pressure Tank	21.2	1.3	95	0.04	Thorpe et al. (1999)
	Mains Water	14.4	0.6	93		
	LEV	8	0.7	91		
3	LEV and Water	14.3	Below 0.075	99	0.075	Nij, et al. (2003)
4	LEV	4.5	0.14	92	0.075	Croteau et al. (2004)
5	LEV on-tool & Box Fan	4.87	1.42	71	0.075	Flanaga et al. (2003)
6	LEV on-tool	25.4	0.95	99	0.025	Akbar-khanzadeh, et al. (2007)
	Wet grinding	61.7	0.11	98		
7	LEV	1.4	0.13	91	0.075	Carlo, et al. (2010)
	Water suppression	3	0.03	99	0.075	
8	Silica substitute	0.074	0.049	66	0.025	Radnoff and Kutz (2013)

However, in the study by Mashqoor et al. (2017), 78% of the workers had no PPE. Similarly, in Bedoya-Marrugo et al. (2017), 70% of respondents did not use PPE. Moreover, Shah and Tiwari (2010) found that 50% of the workers did not use PPE. This meant that the workers without PPE experienced high exposure to chemical irritants and were likely to develop symptoms of skin diseases (Tente and Mwanaumo, 2022). This would have been the reason for the construction industry's high rate of skin diseases.

Periods of exposure to chemical irritants have also been associated with symptoms of skin diseases. Shah and Tiwari (2010) found an association between increased exposure duration (8-10 hours) and skin conditions. The skin symptoms were work-related and were aggravated by work. The study by Bedoya-Marrugo et al. (2017) found that the period of exposure to cement was directly proportional to the likelihood of developing dermatitis. A prolonged duration of exposure was associated with more morbid skin conditions (Moshqoor et al., 2017).

3. Methods

The data was collected between May and November 2021 in a cross-sectional study. One road and one building project were used as two case studies. The two case studies were selected to get experience on roads and building projects to represent the construction industry accurately. Bricklayers, carpenters, butchers, tilers, demolition workers, painters, road construction workers and handymen were purposively sampled. The estimated study population for building and road project sites was 1,012 workers. The sample size was established at 10% of the estimated population. Moreover, the sample size was limited to 100 because the number of workers was reduced due to Covid-19 by the Ministry of Health. Therefore, the total sample size was 100 workers, 50 for each case study.

The qualitative data was collected using observation schedules and a camera. What was observed in the schedule were the dust levels in terms of plumes of dust, sources of dust, dusty environment, the methods of controls according to the hierarchy of controls and the types of PPE provided. In this study, the appearance of a plume of dust (a large quantity of dust that rises into the air in a column) was considered high exposure, and the absence of a plume was considered low exposure to dust. Overt and direct observations were used. Overt observation is when participants know they are being observed (Lugosi, 2006). The workers were consulted, and observations were only done after workers consented to take part in the study. The overt observation ensured ethical issues were adhered to according to the ethical clearance approval by the Natural and Applied Sciences Research Ethics Committee (NASREC). Moreover, observations revealed interactions between workers and management regarding control measures in silica dust and chemical irritants exposure reduction.

Observations were accompanied by the photographs, which were taken using Tecno Canon 17 phone camera (6.6 "-720x1600 pixels). According to Pain (2012), photographs are used in data collection to get appropriate tacit data for providing cues for understanding the topic. In this research, photographs were used to complement what was being observed. The plume of dust was captured to enhance the description of dust exposure levels. In this case, text from the observations and photographs enhanced the meaning of the data (Johnson, 2004).

It was deduced from the literature review that some skills or activities experienced high exposures to silica dust; therefore, using observation, silica dust was observed in the form of dust. Photographs were taken with the consent of the participants. In addition, the researcher gave the participants assurance that faces would be avoided and only capture the activity or interest of observation according to NASREC ethical approval. Data was collected during the eight hours - full-day shift. The data were qualitatively analysed using the constant comparative method. This method of data analysis involves constantly comparing data points to other data points to form categories and concepts (Anderson and Jack, 2015).

4. Results and Discussion

The findings revealed that the workers were exposed to dust as a plume of dust was observed. The exposure depended on the activities being performed and if there were any controls used. The findings of the dust exposures and controls observed are presented in Table 2.

Table 2: Summary of the Observed Key Concerns

Key Concerns	Description of observed
Dust exposure levels and sources	• Offloading of gravel • Loading of spoil • Dry concrete grinding • Quarry loading for batching • Dry sweeping during housekeeping • Cement bag opening during manual mixing • Demolition works
Dust controls	• Water spray to suppress dust (at intervals and whenever water was available) • Water on-tool/machine • Dust nets on road works • Few work-suits (building project) • Few dust masks • Covid-19 masks (mandatory) • Few proper gloves • No gloves • Torn gloves (not suited for the skill so easily torn) • Exchangeable gumboots depending on activity

All the activities observed had high exposure levels as the plume of dust was seen as shown in Figures 2, 3, 4, 5, 6, 7 and 8. Dust exposures were observed during the damping of gravel during road constructions, dry concrete grinding, quarry loading for batching, dry sweeping during housekeeping, and cement bag opening during manual concrete or mortar mixing and demolition works.

Figure 2 shows a tipper truck offloading gravel during the road construction works. A plume of dust was seen escaping in the open air. Road workers, passers-by pedestrians, cyclists and traffic were exposed to the dust, thereby posing a health risk to the exposed. There was no dust control observed during these activities. Therefore, the road workers, passers-by pedestrians, cyclists and traffic were exposed to the same amount of dust emanating from offloading the gravel. The excavator was loading a tipper truck with spoil to transport it to the damping site. A plume of dust was seen from loading the spoil during the road construction in Figure 3. Road workers and road users were exposed to the dust in the process, posing a health hazard. The dust exposure in Figure 3 extended to the nearby truck business premises.

Figure 2: Picture showing dust exposure during offloading of gravel

Figure 3: Picture depicting dust exposure during loading of spoil

This is similar to Normohammadi et al. (2016), who found that cutting and breaking concrete produce hazardous dust for workers. The worker performed dry grinding during concrete drain shaping, and the plume of dust was seen during the activity in Figure 4. The worker was seen without the recommended PPE, such as a dust mask, gloves, work suits, safety boots and a hard hat. This is similar to Kirkeskov et al. (2016) 's finding that few workers wear RPE even when performing activities that produce high dust levels in the construction industry.

Figure 4: Picture showing dust exposure during dry concrete grinding

In Figure 5, the workers were loading quarry dust for batching. The dust was seen as a result of loading. The loading worker was seen without a dust mask, and the other was wearing a Covid-19 facemask. The workers were likely to be exposed to dust which is harmful to their health. Dry sweeping was another activity seen as a source of construction dust, as shown in Figure 6. Dust came from the concrete and mortar remains as they were swept during housekeeping. Other controls like water should be used with the recommended PPE to reduce dust exposure, especially dust masks. The worker was seen in the PPE but had a facemask instead of the recommended dust mask. The Covid-19 face mask was inadequate in reducing exposure to dust as it was specifically made for Covid-19 prevention.

Figure 5: Picture showing workers loading quarry dust for batching

Figure 6: Picture showing dust exposure during dry sweeping

There was cement dust escaping into the open air as the worker in Figure 7 opened a bag of cement while manually mixing plaster and mortar at a building site. The worker was noticed wearing a black cloth face mask which was recommended for Covid-19 prevention. Face masks are not recommended for silica dust reduction as their particles are so tiny that they penetrate surgical and cloth face masks designed for Covid-19 prevention.

Figure 7: Picture showing cement dust exposure during dry mixing

Workers in Figure 8 were performing demolition works. One worker broke the wall using a hammer, and the other manually loaded the rubble. Dust was produced from both activities, especially when manually loading the rubble. The workers were wearing Covid-19 recommended face masks.

Figure 8: Picture showing dust exposure during demolition and loading of rubble

The results in Figure 4 are similar to the findings of Flanagan et al., 2003 and HSE (2012), who found that grinding concrete produces high exposure to silica dust. Also, the findings on demolition workers being exposed to silica dust are similar to Lumens and Spee (2001), Normahammadi et al. (2016) and Kirkeskov et al. (2016) 's findings. The difference was that in this research, silica dust exposure was qualitatively considered in terms of observed dust, and it was established from the literature that similar activities in construction recorded high levels of silica dust, which was above the permissible limits. In Lumens and Spee (2001), Normahammadi et al. (2016) and Kirkeskov et al. (2016), silica dust concentrations were quantitatively measured using air sampling methods.

The controls that were observed in the two case studies were spraying of water to suppress dust, water on-tool/machine, dust nets on road works, few dust masks, mandatory Covid-19 face masks, few work suits, few gloves, torn gloves and changeable gumboots depending on the activities being performed. The findings on the controls are shown in Figures 9, 10, 11 and 12. The combination of water and face masks/dust masks was similar to the findings by Tente et al. (2022). The common use of facemasks on both road and building projects was mandatory for Covid-19 prevention during the pandemic by the Ministry of Health.

During data collection, Covid-19 was prevalent, and as a preventive measure, all workers were mandated to wear face masks during COVID-19. The face masks were surgical masks and cloth face masks, as evidenced in Figures 4, 5 and 7. Nevertheless, despite the facemasks being worn constantly, they did not reduce silica dust exposure adequately. This is because face masks were designed to reduce exposure to Covid-19 and not silica dust RPE. Other masks recommended for silica dust exposure reduction, such as disposable dust masks, industrial dust masks and N95, were rarely used on sites. This can be seen in Figure 11, where only a worker operating the concrete mixer was spotted wearing the recommended dust mask.

The worker in Figure 9 removed some wetted gravel back on the road base during base processing. The worker sprayed water to suppress dust, thereby reducing dust exposure for himself and the traffic, as shown in Figure 9.

Figure 9: Picture showing dust control using water for base processing

Despite the water suppression control, the worker did not wear the recommended full PPE to reduce dust and chemical exposure.

Workers in Figure 10 were cutting asphalt roads using concrete cutters. The concrete cutter had a water tank mounted on its back. As the concrete cutter was cutting asphalt, water was dripping on the cutting blade, suppressing the dust which was being produced. Therefore, less dust escaped into the open air during the cutting activity. This meant that water control was able to reduce dust, similar to the findings of Carlo et al. (2010), who found that water control was able to reduce dust control by up to 99%.

Figure 10: Picture showing the use of a cutter with water on the road project

The lesser the dust emanating from the source, the lesser the dust exposure and the lesser the likelihood of workers developing respiratory diseases.
The worker in Figure 11 was seen in a surgical face mask, yet he was working on a dusty activity. The worker was loading quarry dust in a wheelbarrow for batching. The loading activity produced dust, as seen in Figure 11.

Figure 11: Picture showing a worker wearing a face mask while working

The other worker in Figure 12 was seen wearing a recommended dust mask. He was seen opening the bag of cement to load in the concrete mixer to make concrete. Since the dust mask was one of recommended RPE, it meant that it could protect the work from inhaling all the dust around the breathing zone. What was not known was whether the dust mask was good quality or well-fitted, as advised by Flanagan et al., (2003); Ahmed and Abdullah, (2012). The effectiveness of the dust mask in terms of quality could not be done by observation method as some practice tests are carried out to establish the quality.

Figure 12: Picture showing a worker wearing a dust mask while working

The findings on the use of the facemasks are contrary to some researchers who advised from their findings that to reduce exposure to silica dust, a suitable and well-fitted RPE is required (Flanagan et al., 2003; Ahmed and Abdullah, 2012). However, from the literature review, it can be concluded that despite using RPE as a control to reduce exposure to silica dust, it does not reduce silica exposure levels to below PEL (Tente et al., 2022). This is why it is recommended that the use of RPE and PPE should be the last in the hierarchy of controls (Flanagan et al., 2003).

Despite the recommendation that RPE and PPE should be used in combination with other control methods, findings of this study revealed that in some instances, no or inadequate PPE was being used, as shown in Figures 13 and 14. The worker in Figure 13 had no PPE and was fully exposed from head to toe to silica dust and chemical irritants. The worker is likely to develop skin disease symptoms, as shown in Figure 13.

The worker in Figure 14 has no gloves or dust masks, exposing him to silica dust and chemical irritants. The worker performs plastering without gloves, exposing his hands to wet cement, which burns the skin.

Figure 13: Picture showing a worker without any PPE

Figure 14: Picture showing a worker without gloves and a dust mask

Despite water being a commonly used control type, it had its challenges. According to the workers, the use of water as dust control in the building project had its challenges of messing the place and making an activity difficult to perform, similar to findings of Carlo et al. (2010). The challenge of using water made workers avoid it to ease their work activity. On the road project, the challenge of using water for dust control or suppression was that workers had to keep spraying every hour or more depending on the weather condition. This was a serious challenge as spraying water was not done as often because they preferred to use water for road works such as base processing rather than dust control. In addition, water was fetched far from the road sites and transported in the heavy traffic of Lusaka city, making water erratic on sites. This led to inadequate dust controls on the road sites on the road project.

5. Conclusion

The study assessed the dust levels, sources and controls for silica dust in the construction industry in Zambia. This was done using overt observation, an observation schedule, and a camera to capture the photographs. The observations showed that the dust levels were high as all the activities which were observed produced a plume of dust. The sources of dust, in terms of activities, on the road project, were offloading, loading of spoil and dry concrete grinding. The dust sources on the building project were; the loading of quarry dust for batching, dry sweeping, and opening of cement during dry mixing for concrete. The common controls were water and dust or face masks. Another control which was rarely used was dust nets that were also used as holding for the two sites. However, from the dust plume observed, the methods of control and the improper PPE suggest that the controls were inadequate. This may mean that the sampled skilled workers and their labourers were likely to be exposed to high levels of silica dust and chemical irritants in the construction industry in Zambia. Findings indicate that workers are at risk of health problems brought about by inhaling dust.

6. Recommendations and Limitations

Findings showed that only engineering control and PPE were utilised from the hierarchy of controls. A combination of controls should be implemented for effective silica dust reduction and reduced risk of ill health. Therefore, there is a need for improved ways that incorporate all controls in the hierarchy of controls and the participation of all construction stakeholders in reducing silica dust to safeguard workers' health and the possible effects on the projects. The study serves as an awareness to construction stakeholders of the health concern of high dust exposure levels and inadequate controls. Therefore, government and construction stakeholders must ensure that the controls are improved to mitigate dust and protect the workers.

The study was limited to observations. There is a need to measure the actual dust concentrations with and without controls using dust sampling to establish to what extent the workers are exposed to dust. This would help in policy formulation regarding exposure limits and adequate ways of dust control.

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