Return to Work and Vocational Rehabilitation Support for Workers Suffering from Silicosis

Report produced in partnership with University of Illinois Chicago (UIC) and Monash University Centre for Occupational and Environmental Health

Executive summary

WorkCover Queensland engaged the University of Illinois Chicago (UIC) and Monash University Centre for Occupational and Environmental Health in a joint research literature review in 2019 to understand the current state of knowledge to inform return to work (RTW) and vocational rehabilitation support for workers diagnosed with work-related silicosis or other chronic work-related respiratory conditions and to establish a way that these findings can be effectively translated into policy and practice. The review was divided into two parts, each with different, but complementary, aims and objectives; one part being conducted by a research team led by Monash University and the other part being conducted by a research team led by the UIC.

The focus of UIC's review was to understand the current state of knowledge to inform return to work and vocational rehabilitation support for workers diagnosed with silicosis with specific emphasis on the roles of non-surgical treatments, pulmonary rehabilitation, chest imaging, lung function testing, and exercise testing.

The review confirmed that there are no non-surgical interventions that have been shown to improve functional capacity for work and that there is currently no curative treatment for silicosis, nor are there modalities that have been demonstrated to mitigate or partially reverse the pulmonary impairment. The efficacy of anti-fibrotic medications is an area of active research and pulmonary rehabilitation may provide some benefit, although data is sparse for those diagnosed with silicosis.

Lung function tests, exercise testing, and chest imaging are important tools in diagnosis and evaluation of impairment in individuals with silicosis. Results from these tests can inform return to work strategies. Functional impairment and disease severity cannot be fully described by any one of these tools alone, and therefore all three should be employed when evaluating an individual's capacity to work. Importantly, monitoring lung function impairment over time in silica-exposed populations is of critical importance to identify those who may deteriorate and require further intervention and changes to management strategies including return to work. It is likely that cardiopulmonary exercise testing (CPET) is helpful in revealing differences in functional limitations not observed through resting spirometry testing. CPET may be a more sensitive test of impairment in workers with the early stages of silicosis.

The authors concluded by recommending that workers with clinical, radiographic, or pathologic findings consistent with silicosis be removed from further exposure to silica dust. They supported further trials of anti-fibrotic medication, pulmonary rehabilitation and ongoing research into return to work outcomes.

Monash University investigated the issues arising for workers in the stonemason industry with silicosis and associated respiratory conditions returning to work compared with other workers. A key consideration was how to ensure workers with a diagnosis of silicosis are returning to a safe work environment, and what information is required to manage their return to work.

Their findings demonstrate the lack of information available to adequately inform best practice in return to work for these workers. What is clear is that there are many jobs outside of artificial stone workplaces which should be avoided, either because of exposure to respirable crystalline silica (RCS); exposure to other respiratory toxins; or the work environment or demands of the job are not compatible with reduced respiratory function, including the ability to wear respirators.

The authors conclude that retraining options and processes at an individual and system level need to follow established principles, such as those set out in Safe Work Australia's National Return to Work Strategy and the Health Benefits of Good Work Consensus Statement developed by the Australasian Faculty of Occupational and Environmental Medicine of the Royal Australasian College of Physicians, acknowledging that neither address specific issues relevant to a worker who has silicosis. Until there is evidence of safety at different levels of silica exposure, the Monash researchers recommend a default approach for those with silicosis or at high risk of developing silicosis is "prudent avoidance" and support of the informed choice of the affected worker.

The impacts of mental health are very important considerations with research highlighting high levels of anxiety and depression amongst affected workers, especially as the accelerated form of silicosis from work with artificial stone is occurring in young workers. Mental health impacts have been shown to be an important consideration in assess impairment and return to work options for workers with silicosis.

In order to manage a safe return to work, Monash recommends that Vocational Assessment methods for workers with silicosis need to take an holistic approach to return to work for these workers. An assessment of their respiratory capability is important, but this needs to be supplemented by physical restrictions related to any other associated conditions, such as autoimmune diseases and mental health conditions. A comprehensive assessment of the proposed jobs is also important to identify any potential sources of silica or other respiratory toxins and to ensure compatibility of the worker's abilities and the demands of the job.

It is important that any return to work program for workers at risk of, or diagnosed with, silicosis takes a multidisciplinary approach, with involvement of respiratory physicians, occupational physicians, case managers and a comprehensive occupational hygiene and safety evaluation. In this way any requirements for retraining and support programs, can be incorporated into the return to work plan for each individual worker.

Both UIC and Monash University support further research to better inform best practice in vocational rehabilitation and facilitating return to work for workers affected by silicosis.

Table of Contents

Silicosis Return to Work Review: Return to Work and Vocational Rehabilitation Support for Workers Suffering from Silicosis

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There are no conflicts of interest to declare for any members of the research team.

Glossary of abbreviations

6MWD: 6-minute walk distance

AS: Artificial stone

COPD: Chronic obstructive pulmonary disease

CPET: Cardiopulmonary exercise testing

CT: Computed tomography

CXR: Chest x-ray

DL_{CO}: Diffusion capacity of carbon monoxide

FEV_1: Forced expiratory volume in one second

FVC: Forced vital capacity

HRCT: High-resolution computer tomography

IL-6: Interleukin-6

ILO: International Labour Organisation

NIOSH: National Institute for Occupational Safety and Health

PMF: Progressive massive fibrosis

PR: Pulmonary rehabilitation

RANZCR: Royal Australian and New Zealand College of Radiologists

RTW: Return to work

SPIROLA: Spirometry Longitudinal Data Analysis

TL_{CO}: Transfer factor for carbon monoxide

TNF-α: Tumour necrosis factor-α

UIC: University of Illinois at Chicago

US: United States

$\dot{V}_{CO2}$: Carbon dioxide output

$\dot{V}_E$: Minute ventilation

$\dot{V}_{O2}$: Oxygen uptake

WLL: Whole lung lavage

Chapter 1: Introduction

Silicosis is an irreversible, progressive fibrotic lung disease caused by the inhalation of respirable crystalline silica dust. In addition to silicosis, inhalation of respirable crystalline silica may cause lung cancer, chronic obstructive pulmonary disease (COPD), kidney disease, infections such as tuberculosis, and autoimmune diseases.[1]

Workers from many industries are at risk of silica exposure, including agriculture, mining, construction, glass and ceramic fabrication, foundries, and fracking. Most recently, there has been considerable attention given to the recent global emergence of silicosis amongst artificial stone fabrication and processing workers. Since 2009, there have been over 500 cases of artificial stone (AS) silicosis reported from Australia, Belgium, Canada, China, Israel, Italy, Spain, and the U.S. In these cases, workers are fabricating and installing countertops from engineered stone which can contain >90% crystalline silica, compared to granite which contains <45% silica.[2]

Artificial stone silicosis was first described among artificial stone workers in Italy,[3] but was soon reported in other countries including Spain where 47 cases were found between 2009 and 2012.[4] Cases of AS silicosis were noted by a transplant center in Israel to which a large number of young workers had been referred.[5] Mao et. al. reported 98 cases from Shanghai where over 50% progressed on CXR imaging, and 89% progressed on CT scans.[6] All of these countries have reported poor implementation of dust controls, respiratory protection use, or education about the hazards of respirable crystalline silica. This is an emerging problem in Australia as well with recent reports of AS silicosis among countertop processors in New South Wales, Victoria, and Queensland.[7] Most recently, 18 cases of AS silicosis, including the first two reported fatalities, have been reported among stone countertop workers in the U.S. between 2017 and 2019.[8] There are striking commonalities among all of these reports. Chief among them are that these severe cases of AS silicosis are coming from relatively small businesses in which workers are performing dry cutting of artificial stone without respiratory protection or dust suppression measures. Tragically, this disease is occurring in relatively young workers. Consequently, these workers will require support and rehabilitation to facilitate a return to work where possible.

WorkCover, the principal agency responsible for workers' compensation in Queensland, has requested a review of the literature pertaining to return to work among workers with silicosis. This review will help in the formulation of appropriate return to work support for these workers.

Aims of the review

The principal aims of this review are to:

1) Identify the current state of knowledge to inform return to work (RTW) and vocational rehabilitation support for workers diagnosed with work-related silicosis or other chronic work-related respiratory conditions and to identify gaps in this knowledge.

2) To recommend ways that findings of this review can be effectively translated into policy and practice.

Specifically, the following questions were addressed:

1) What non-surgical treatments or rehabilitation options are available to improve workers' capacity to work, including pulmonary rehabilitation?

2) What information is required to manage return to work for those diagnosed with silicosis with specific regard to clinical functional respiratory measures relevant to return to work including lung function testing, exercise testing, and chest imaging?

Chapter 2: Methods

2.1 Literature review

In order to address the aims of the review and to access a broad range of information, we systematically searched sources of both published and grey literature.

2.1.1 Peer-reviewed literature

To complete the peer-reviewed literature search component of this review, we searched the following academic databases: EMBASE, MedLine, PubMed, and Cochrane database of systematic reviews. Our search strategy included a diverse set of search terms and statements which included either '*silicosis'* and any of the following search terms: '*return to work'; 'non-surgical treatments'; 'therapies'; 'lung function test'; 'chest radiograph or x-ray'; 'progression'; 'exercise testing'; and 'pulmonary rehabilitation'*. Studies were included in the review if they met the following inclusion criteria:

- Articles with a quantitative study design including cohort studies, case studies, case reports, clinical trials, case-control studies, systematic reviews, meta-analyses, and cross-sectional studies. Qualitative and simulation based studies were excluded.
- Studies of workers, aged ≥18, who have had mineral dust exposure in the course of their employment.
- Studies must include data on health and/or vocational rehabilitation or return-to-work efficacy in these populations
- Studies from any country and in any language, provided the text is available in the English language.
- Peer-reviewed articles addressing silicosis and any of the following: return to work, treatments, pulmonary rehabilitation, progression, chest radiography, lung function testing, and exercise testing.

Once the searches were completed, all resulting articles were subjected to successive rounds of screening for relevancy that included screening titles and abstracts to identify those articles for inclusion in the review.

2.1.2 Grey Literature

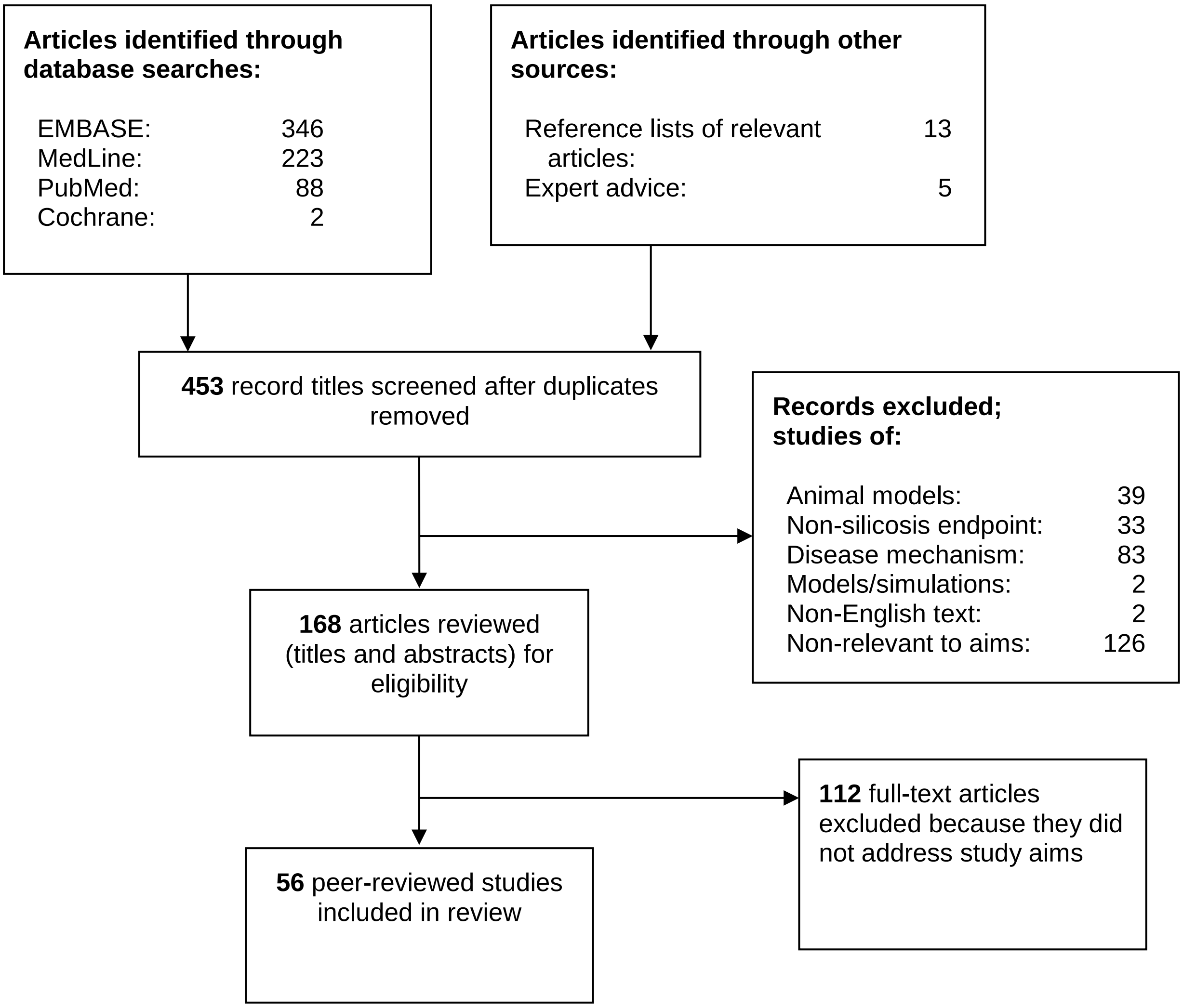
In addition to the databases mentioned above, we considered evidence beyond that found in formally published, peer-reviewed literature sources. Such evidence, collectively known as “grey” literature, includes conference proceedings and/or unpublished abstracts, technical briefs, theses and dissertations, government reports, guidelines from health or other professional bodies, and other types of online documents or reports. We searched the following databases and organizational websites for publications in the grey literature relevant to the study aims.

1) OpenGrey (http://www.opengrey.eu/)
2) Grey Literature Report (hhtp://greylit.org/)
3) American Thoracic Society (http://www.thoracic.org/)
4) American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR, https://www.aacvpr.org/)
5) European Respiratory Society (https://www.ersnet.org/)
6) National Coalition of Respiratory Disease and Black Lung Clinics (http://blacklungcoalition.org/)
7) International Labour Organization (www.ilo.org/)
8) United States National Institute for Occupational Safety and Health (NIOSH, https://www.cdc.gov/niosh/index.htm)
9) United States Occupational Health and Safety Administration (OSHA, https://www.osha.gov/)

3.1 Retrieved data

The database searches of peer-reviewed literature yielded 453 unique articles for consideration for inclusion in the study. After excluding those that did not meet study inclusion criteria or study aims, we performed in-depth reviews of 56 full-text peer-reviewed articles (Figure 1). A summary of the full-text articles included in the review can be found in Appendix 1. We identified 9 grey literature sources that contained relevant information pertaining to study aims. A summary of relevant materials from our search of the grey literature can be found in Appendix 2.

Figure 1. Summary of peer-reviewed literature selection process.



3.2 Main findings from literature review

3.2.1 Non-surgical treatments and rehabilitation options available to improve workers' capacity for RTW

Non-surgical medical treatments

Silicosis is an irreversible disease which may be progressive in a significant proportion of cases. There is no proven satisfactory treatment other than lung transplantation in advanced cases. This section reviews the literature regarding trials of therapies as well as modes of palliation to improve quality of life.

Crystalline silica, especially freshly fractured silica, has been shown to be extremely toxic in part due to the generation of surface free radicals.[9–11] Early investigations in preventing silicosis or slowing its progression examined the inhalation of aluminium citrate or polyvinyl-pyridine-N-oxide, under the hypothesis that coating the surface of inhaled silica particles with these compounds might interfere with their toxic effects. However, no benefits were demonstrated in objective measures of disease in humans such as radiographic improvements, exercise test tolerance, and lung function.[1,12]

Multiple clinical trials have been conducted in China investigating the therapeutic effects of tetrandrine or matrine, alkaloid herbal extracts, in conjunction with N-acetylcysteine, an anti-oxidant precursor of glutathione, in patients with silicosis. These trials suggest possible improvements in FEV_1, FVC, and exercise tolerance, as well as a reduction of inflammatory markers such as interleukin-6 (IL-6) and tumour necrosis factor-α (TNF-α).[13–15] However, there were significant limitations in these studies including small sample sizes, non-blinded study designs, and absence of long-term follow up. Treatment with tetrandrine is not currently a widely accepted therapy for silicosis.

Treatment with corticosteroids has also been attempted in patients with silicosis. A case report of one man with acute silicosis suggested dramatic initial improvement in FVC and FEV_1 after treatment with prednisone. However, these improvements were not sustained and follow up after three years revealed a deterioration of lung function with radiographic progression of disease to progressive massive fibrosis (PMF).[16] In a small case series of individuals with chronic silicosis treated initially with 30 mg of prednisolone daily for six weeks followed by tapering to a low maintenance dose of 0.25 mg/kg/day, the investigators observed improvement in FEV_1, FVC, and DLCO.[17] This study did not evaluate ther long-term benefits and adverse effects of corticosteroid use, including consideration of the potentially increased risk of mycobacterial disease and other infections due to both silicosis and chronic corticosteroid administration.

Whole-lung lavage (WLL) has been employed in an attempt to reduce the lung burden of inhaled dust and associated inflammatory cells in individuals with coal mine dust lung disease and silicosis. In case reports from individuals with these diseases undergoing WLL, the procedure was successful in removing large quantities of dust and inflammatory cells and providing immediate symptomatic relief.[18,19] However, it remains unclear whether WLL confers clinically relevant long-term improvements in lung function or slows progression of the disease. WLL is considered to be generally safe when performed at experienced centres; however, the procedure is not without potentially serious complications. It has been suggested by some that WLL be employed in individuals with acute silicosis with an ILO category 2 or higher on chest radiograph, as these individuals stand to benefit most from the procedure and are at highest risk of disease progression.[18,20] There is no published evidence showing significant long-term benefit of WLL in accelerated or chronic silicosis.

Improved understanding of the basic pathophysiology of silicosis and the availability of specific antagonists for several of the many cytokines, chemokines and other mediators involved in the pulmonary fibrotic response may allow the use of anti-fibrotic treatments for patients with silicosis in the future. For example, IL-1 blockade using anakinra,[21] or tyrosine kinase blockers such as nintedanib[22] may be effective in preventing progressive disease.

Due to the lack of specific treatments for silicosis, palliation of the disease and symptomatic treatment is important. Although use of bronchodilators has not been formally studied in individuals with silicosis with airflow obstruction, their favourable safety profile makes them a reasonable treatment option to alleviate respiratory symptoms, particularly in patients who also suffer from airflow obstruction. Additional symptomatic relief may be provided by treatment with cough suppressants and mucolytic agents that promote clearance of mucus from the upper and lower airways. Intercurrent bacterial infections should be treated with antibiotics.[1] Like others with chronic lung disease, silicotics should receive vaccinations for preventable infections, including influenza and pneumococcal disease. Oxygen therapy should be considered for silicotics with hypoxaemia and/or severe dyspnoea, as long-term oxygen therapy has been shown to prolong survival in patients with chronic obstructive pulmonary disease (COPD) and severe hypoxemia. However, more information is needed on whether long-term oxygen therapy improves survival in silicosis and which patients would benefit most.[1,23,24] The clinician should also consider other conditions associated with silica exposure, such as tuberculosis, COPD, renal disease, lung cancer, and autoimmune diseases.[1,25] Further discussion of treatments of these associated conditions is outside the scope of this review.

It is important to emphasize that there are currently no known curative therapies for silicosis, nor are there therapies demonstrated to mitigate or partially reverse the pulmonary impairment. However, removal from exposure is widely recommended for workers with silicosis in order to decrease the rate of disease progression.[1,26–28] Personal protective equipment and working in very low or no dust exposure is imperative for those who continue to work in jobs with continued exposure, although these measures may not prevent disease progression.

Pulmonary Rehabilitation

Pulmonary rehabilitation (PR) is defined by the American Thoracic Society and the European Respiratory Society as “a comprehensive intervention based on a thorough patient assessment followed by patient tailored therapies that include, but are not limited to, exercise training, education, and behaviour change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors.”[29] Exercise capacity is reduced in individuals with chronic lung diseases and this can lead to deconditioning and loss of functional capacity in life, which in turn, can lead to anxiety and depression. Exercise capacity is closely associated with quality of life and self-reported measures of well-being.[30] Therefore, PR may be a useful management tool for those with silicosis in terms of increasing exercise capacity and quality of life.

PR aims to improve exercise capacity, reduce pulmonary symptoms, reduce the number and frequency of exacerbations and hospitalizations, promote independent function in daily life, and improve measures of psychological well-being. Common outcome measures of the efficacy of PR include lung function (e.g., spirometry results), 6-minute walking distance (6MWD), maximum exercise capacity, skeletal muscle strength, respiratory symptoms, dyspnoea, exacerbations and hospitalizations, quality of life, and anxiety and depression scales. The educational component of PR is designed to teach participants about their lung disease; medication and treatment options; diet and nutrition; important of exercise; breathing retraining; strategies for managing breathing problems; use of oxygen therapy (if applicable).[31]

PR reduces dyspnoea, increases exercise capacity, and improves quality of life in individuals with COPD,[29] but its efficacy is less well understood for those with fibrotic lung diseases like silicosis. Several studies have compared the efficacy of PR for COPD and non-COPD patients. In one study, PR improved exercise capacity, as measured by the 6MWD, and quality of life in both COPD and interstitial lung disease groups.[32] More recently, a study comparing COPD patients to non-COPD patients including 28 with pulmonary fibrosis showed that an 8-week PR program significantly improved the 6MWD and quality of life measures in all participants without significant differences between disease groups.[33] Another study compared the effects of an identical 8-week PR program in individuals with idiopathic pulmonary fibrosis to those with COPD with PR resulting in improvements in dyspnoea, muscle force, 6MWD, and improved daily functioning in both groups. These improvements were of smaller magnitude in the fibrosis group and were not sustained after six months.[34]

There are few studies of the efficacy of PR specifically in individuals with silicosis. A study of 31 patients with pulmonary fibrosis undergoing a 6-week pulmonary rehabilitation program showed reductions in dyspnoea, increased quality of life, and increased performance on the 6-minue walk test. Only one of the subjects had silicosis, therefore it is unclear whether the results observed in this study are generalizable to others with silicosis.[35] A large study of individuals with occupational respiratory disease (n = 263) showed immediate improvements in the 6MWD and anxiety measures for those with silicosis (n=42) following a 4-week inpatient pulmonary rehabilitation program.[36] Silicotics showed immediate and sustained increases in maximum exercise capacity and skeletal muscle strength. This study found no acute or long-term improvements in lung function measures or respiratory muscle function in silicotics. Respiratory infections and health care utilization decreased significantly as a result of the PR program. Importantly, the study investigators did not observe improvements in quality of life, anxiety and depression. The mechanisms of exercise limitation are different in COPD versus pulmonary fibrosis, which may explain why pulmonary rehabilitation programs based on guidelines for subjects with COPD are less effective in producing sustained improvements in subjects with silicosis and other fibrotic lung diseases. It is possible that the underlying pathophysiology of silicosis may interfere with improvement in lung function as a result of pulmonary rehabilitation, but PR can optimize the use of remaining healthy lung tissue in individuals with silicosis.

Adverse effects of pulmonary rehabilitation are rarely reported. There are few contraindications to pulmonary rehabilitation, but these include conditions that may make physical training exceedingly difficult such as severe arthritis or neurological disorders or those that may put patients at risk such as uncontrolled cardiac disease.[29] Clinical trials assessing pulmonary rehabilitation are sparse. Consequently, training method and the contribution of disease severity have not been examined with respect to the benefits conferred by pulmonary rehabilitation.[37]

3.2.2 Ensuring workers with a silicosis diagnosis return to a safe work environment

When considering whether a worker can or should return to work after a diagnosis of silicosis or an associated condition, it is important to consider the specific diagnosis (e.g., acute, accelerated or chronic silicosis; COPD; lung cancer; etc.) and the natural history of the disease process as well as likelihood of further exposure. Assessment of impairment in those with silicosis must be performed by a specialist physician and includes not only the diagnosis of disease, but also the evaluation of disease severity and the potential impact on capacity to work.[38] Lung function tests, exercise testing, and chest imaging are important tools in diagnosis and quantifying impairment in individuals with silicosis.

Chest Imaging
Silicosis is most often diagnosed through chest radiograph (CXR) in the context of an appropriate silica exposure history. CXRs are typically classified according to the International Labour Office's guidelines for interpreting chest radiographs for pneumoconioses.[39] CXRs are relatively low-cost and deliver a lower dose of radiation compared to computed tomography (CT) scans, making them an ideal tool for screening large populations as well as for serial examinations of disease progression in silica-exposed workers. However, as the technology of CT scanning has improved with more detectors, and better resolution with lower doses of radiation, the radiation dose is approaching that of CXR but the costs remain high. CT scanning, particularly with high resolution views, significantly improves the detection of early abnormalities in silicosis.[40,41]

Epidemiologic studies show a strong relationship between cumulative exposure to silica dust and disease severity and risk of progression, as measured on serial CXRs, even after the worker has been removed from exposure. In a prospective cohort study of 141 granite workers with silicosis, Lee et al[42] found that 37% showed radiographic evidence of disease progression over a 2- to 17-year follow up period. Progression was strongly associated with duration of exposure and severity of disease status at the time of initial CXR. Workers were at increased risk of progression if they had evidence of large opacities on their initial CXR. Once a worker is diagnosed with silicosis, continued exposure to silica is associated with greater functional impairment and radiological severity of disease compared to those who cease exposure.[26,27] Silicosis can progress in the absence of further exposure, as demonstrated in a retrospective cohort study of Japanese tunnel workers. In this study, more than half of study subjects progressed in disease severity, some in under two years, despite leaving the workforce and being removed from further silica exposure.[43] A recent outbreak of hundreds of cases of silicosis in Turkish denim sandblasters also showed rapid disease progression in the absence of further silica exposure in as little as four years.[44] Based on the findings from these studies, and the potential for development of silicosis despite compliance with regulatory silica dust levels,[45] it is generally recommended that further silica exposure be avoided once silicosis is recognised, or even strongly suspected.

While plain CXR remains the most common chest imaging tool for pneumoconiosis surveillance and diagnosis, several studies have indicated that high-resolution CT has shown higher sensitivity in detecting coalescences of small opacities and progressive massive fibrosis in individuals with silicosis.[33,40,46,47] In the recent outbreak of silicosis in artificial stone workers, from Queensland, Australia, 43% of workers with positive CT findings had a normal ILO classification, suggesting plain CXR may have low sensitivity for silicosis in this population.[48] While the sensitivity of CXR increases as severity of disease increases,[1] the false negative CXR findings in the recent silicosis outbreak has led the Royal Australian and New Zealand College of Radiologists (RANZCR) to recommend that CT of the chest be the primary imaging modality for screening and diagnosis of exposed workers.[49]

Lung Function Testing

Complete lung function testing at rest includes spirometry, lung volume testing, and single breath carbon monoxide diffusion capacity (DL_{CO}), also known as transfer factor or TL_{CO}. Spirometry is used most commonly for surveillance and screening[50] since the equipment is low-cost and portable, but needs to be carefully performed according to recommended guidelines.[51] The most important variables from spirometric testing are the forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and their ratio (FEV_1/FVC). Severity of lung function impairment can be categorised based on the percent reference FEV_1 as mild to very severe (See Table 1).[52] DL_{CO} testing provides information on the functional integrity of gas exchange across the alveolar-capillary membrane.

Spirometry and diffusion capacity testing are useful in the longitudinal evaluation of workers to determine accelerated rates of decline that may indicate developing silicosis.[53] Lung function decline is a significant predictor of morbidity and mortality.[54–56] Therefore, monitoring lung function impairment over time in silica-exposed populations is important for monitoring deterioration in functional capacity and for informing management strategies including return to work. Lung function may be in the normal range in the early stages of silicosis. Where impairment exists, both restrictive and obstructive spirometric patterns of impairment have been observed.[1] Wang et al[57] demonstrated that lung function abnormality may exist in silica-exposed workers prior to radiographic evidence of silicosis.

Studies of artificial stone workers in Israel show that exposure to artificial stone dust from raw material containing >90% crystalline silica, and in particular ultrafine particles from these processes, is associated with significantly reduced lung function as measured by FEV_1, total lung capacity, and diffusion capacity compared to unexposed controls.[58,59] Importantly, the observed decreases in lung function were still within normal range, indicating that lung function testing alone may not be sufficiently sensitive to identify early disease. However, a study of 16 Turkish sandblasters with acute or accelerated silicosis found that only four individuals showed moderate to severe lung function impairment based on FEV_1 values.[60] Spirometric abnormalities may not always be present in those with silicosis, but there is evidence that there is a strong inverse relationship between increasing profusion of lung opacities and decreasing diffusion capacity of carbon monoxide (DL_{CO}) among silicotics.[46] In fact, Wang and Christiani[61] reported significant decreases in FEV_1, FVC, vital capacity, and DL_{CO} with increasing stage of silicosis in a group of silica-exposed workers. Declines in these measures of functional capacity were worse in silicotics compared to those with asbestosis or coal workers' pneumoconiosis. Thus, there are data which suggest that complex lung function testing in silicosis rather than just spirometry may be helpful for early diagnosis.

Longitudinal lung function monitoring requires maintaining acceptable data and test quality over time. Also, the calculation and monitoring of means for a group of participants is needed. Sensitive and specific strategies are needed to identify those at greatest risk of excessive lung function loss to allow targeted intervention. The U.S. National Institute for Occupational Safety and Health has developed the Spirometry Longitudinal Data Analysis (SPIROLA) software to address these issues and to assist medical professionals in longitudinal lung function surveillance.[62,63]

Table 1. Severity of spirometric abnormality based on the forced expiratory volume in one second (FEV_1), adapted from the American Thoracic Society/European Respiratory Society[52]

Degree of severity	**% of reference FEV_1**
Mild	>70
Moderate	60-69
Moderately severe	50-59
Severe	35-49
Very severe	<35

Exercise testing

Exercise testing provides an objective measure of work capacity and the cause of exercise limitation in patients with silicosis who complain of dyspnea. The sensation of breathlessness, especially upon exertion, is a common symptom of silica-exposed individuals. Patients with simple silicosis may have normal resting lung function and blood gas levels, but report breathlessness on exertion. Breathlessness is a subjective measure of impairment and often does not correlate with resting lung function results.[38] This becomes problematic when silica-exposed individuals seek workers' compensation or work reassignment.

Cardiopulmonary exercise testing (CPET) is useful for the objective determination of functional capacity and impairment,[64] among other uses. CPET allows for the measurement of pulmonary gas exchange - specifically oxygen uptake ($\dot{V}_{O2}$), carbon dioxide output ($\dot{V}_{CO2}$), and minute ventilation ($\dot{V}_E$) - typically during a symptom-limited progressive exercise test protocol. CPET is available in Australia in most respiratory laboratories and attracts a Medicare rebate.

Several studies have evaluated the usefulness of CPET to derive objective measures of functional impairment in individuals with silicosis. The first such study was conducted in China and included 215 individuals with occupational silica exposure or silicosis and mild to moderate reported dyspnoea. This study showed that a ventilatory limitation to exercise was significantly associated with self-reported levels of dyspnoea.[65] A study of sandblasters and stone carvers in Brazil showed significant differences in radiographic severity of disease, lung function impairment, and exercise capacity based on type of silica exposure, with sandblasters having significantly worse outcomes on all three metrics of disease severity.[66] The authors concluded that exercise testing revealed differences in functional limitations not observed through resting spirometry testing. CPET may be a more sensitive test of impairment un workers with the early stages of silicosis.[67]

Regular routine health monitoring is recommended for patients diagnosed with silicosis. This should include, at a minimum, a respiratory questionnaire, complete lung function testing with spirometry, lung volumes and diffusion capacity, and chest imaging with high quality plain chest radiography or low-dose HRCT.

4.1 Conclusions

The focus of this review was the current state of knowledge to inform return to work and vocational rehabilitation support for workers diagnosed with silicosis with specific emphasis on the roles of non-surgical treatments, pulmonary rehabilitation, chest imaging, lung function testing, and exercise testing. In general, there is a lack of research in the peer-reviewed and grey literature on these topics with regard to returning diagnosed individuals to work. There is sufficient evidence, however, that all of these tools are useful in ensuring that the health of workers with silicosis is monitored and maintained, which will maximise return to work options.

Currently, there are no curative non-surgical treatments for silicosis, nor are there established treatments that can reverse pulmonary impairment in those with the disease. The efficacy of anti-fibrotic medications is an area of active research and while WLL can reduce the dust burden in the lungs, it is an expensive and invasive procedure without clear long-term clinical benefits.

Pulmonary rehabilitation is a useful management tool for those with silicosis and associated conditions and increases exercise capacity and quality of life. The evidence supportive of PR relates mainly to those with COPD, for whom it has been shown to reduce dyspnoea, increase exercise capacity, and improve quality of life. By contrast, there are few studies of the efficacy of PR specifically in individuals with silicosis. This gap in our understanding highlights an opportunity for further research about the role of pulmonary rehabilitation programs for those with silicosis. The few existing studies of the efficacy of PR in silicotics suggest that it can reduce dyspnoea, anxiety, and the occurrence of respiratory infections and health care utilization. It has been shown to increase skeletal muscle strength, maximum exercise capacity, and quality of life in some individuals with silicosis. Sustained benefits from 4- to 8-week programs are not apparent, which would suggest long-term maintenance programs may be needed to maintain functional capacity in those with silicosis.

Lung function tests, exercise testing, and chest imaging are important tools in diagnosis and evaluation of impairment in individuals with silicosis. Results from these tests can inform return to work strategies. Functional impairment and disease severity cannot be fully described by any one of these tools alone, and therefore all three should be employed to when evaluating an individual's capacity to work. Importantly, sustained monitoring programs using chest imaging, lung function testing, and exercise testing should be implemented to track longitudinal changes in disease severity and functional capacity as a result of the progressive nature of the disease.

Silicosis is a preventable disease and the increasing number of AS silicosis cases globally is shedding a light on an industry that has failed to mitigate the risks posed to its workers by exposure to silica dust. Unfortunately, as silicosis is often a latent disease, the cases discovered in Australia recently represent potentially only a small fraction of those who may develop severe disease in the future as a result of their exposure in the industry over the last 20 years. In many cases, workers with this disease are relatively young (<50 years of age) with many potential working years ahead of them. Consequently, these workers will require substantial support in identifying and achieving return to work options.

While the aim of this review was to understand how to support return to work strategies for with AS silicosis, it is important to note that primary prevention of the disease continues to be of utmost importance. Disease surveillance efforts and enforcement of regulatory limits on silica dust exposure are necessary for understanding and stemming this epidemic of silicosis among artificial stone workers.

4.2 Recommendations

As a result of this review, we have formulated the following recommendations to help support return to work efforts for workers with a diagnosis of silicosis.

1) There are currently no known curative therapies for silicosis, nor are there therapies proven to mitigate or partially reverse the pulmonary impairment caused by silicosis. As the risk of

silicosis and its severity increases with increased cumulative exposure to respirable crystalline silica, it is recommended that workers with clinical, radiographic, or pathologic findings consistent with silicosis be removed from further exposure to silica dust. Clinical trials of potentially useful therapies such as tetrandrine and nintedanib should be organized and funded.

2) Pulmonary rehabilitation should be provided for affected workers to optimise the use of remaining healthy lung tissue in individuals with silicosis.

3) Annual health monitoring is recommended for those with silicosis and should, at a minimum, include:

a. Respiratory symptom questionnaire

b. Complete lung function test with spirometry, lung volumes, and DL_{CO}

c. Chest imaging with high quality plain chest radiograph and/or low-dose HRCT

4) An ongoing research program to provide an appropriate evidence base to assist workers in facilitating return to work

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Appendix 1.

Table A1. Summary[a] of peer-reviewed literature search.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Akgun, M	2015	Turkey	Prospective cohort study	Re-evaluate a cohort of denim sandblasters who had terminated employment to determine incident silicosis, progression, lung function loss, and mortality among the original cohort.	At the end of the 4 year follow up, nearly all 83 assessed sandblasters had silicosis (prevalence of 96%). Most workers showed radiographic progression (82%) and lung function loss (66%) within the 4 years, absent further exposure. Nine workers had died, at a mean age of 24 years.
Akgun, M	2006	Turkey	Case series	Describe first cases of silicosis among denim sandblasters in Turkey	Sixteen cases of silicosis among denim sandblasters are described. All cases were young (<30 with the exception of one case) with relatively short exposures. While all cases reported symptoms and had radiographic evidence of disease, only four individuals showed moderate to severe lung function impairment based on FEV1 values.
Antao, V	2005	Brazil	Case-control	Assess HRCT findings in silicosis and define role of HRCT in early detection of parenchymal abnormalities in workers exposed to silica	Demonstrated that HRCT was more sensitive than chest radiographs for detecting early changes in silica exposed workers. Inter-rater agreement was higher for HRCT than CXRs; and HRCT findings correlated with functional impairment.
Bang, KM	1993	USA	Cross-sectional	Investigate effect of percent predicted value of forced expiratory volume in one second (FEV1) and the ratio of FEV1 to FVC on all-cause mortality in a national cohort.	Lowered FEV1 is a significant predictor of all-cause mortality. The FEV1/FVC ratio was a significant predictor of mortality among men only.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Baughman, P	2011	USA	Prospective cohort study	Examine relationship between lung function decline and COPD morbidity; COPD and coronary heart disease (CHD) mortality; and all-cause mortality in a cohort of the general population.	Lung function decline was significantly associated with COPD morbidity as well as COPD and CHD mortality. Mortality risks were higher for women.
Begin, R	1991	Canada	Cross-sectional	Evaluate the ability of both conventional and high resolution computed tomography scans of the thorax to detect early silicosis in subjects exposed to silica dust; compare inter-rater reliability across modalities	Abnormal parenchymal findings increased across each modality - chest x-ray, conventional CT scan, and HRCT scan. HRCT was the most sensitive technique for detecting early changes associated with silicosis as well as best at detecting coalescences of small opacities. Inter-rater reliability was greatest for HRCT reads.
Carneiro, APS	2006	Brazil	Retrospective cross-sectional study	Describe effects of continued exposure to silica dust among a group of workers with a previous diagnosis of silicosis.	Among workers who had continued silica exposure after their diagnosis of silicosis, rates of severe silicosis, or PMF, were much higher than those without a previous silicosis diagnosis. Findings underscore removing workers from silica dust exposure as soon as evidence of silicosis is observed.
Dumavibhat	2013	Japan	Retrospective cohort study	Investigate natural course of silicosis, absent further exposure, among Japanese tunnel workers.	Progression of silicosis severity was observed in over half of the cohort (n=33, 51%); with most progressing to severe disease within the study time period.
Ferreira, AS	2006	Brazil	Retrospective cohort study	Compare results of outpatient pulmonary rehabilitation (PR) program among those with and without COPD.	This study compared results from PR among COPD patients and non-COPD patients, 28 of whom had pulmonary fibrosis. After an 8-week program, 6MWD and quality of life measures significantly improved in all participants without significant differences between disease groups.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Foster, S	1990	USA	Case series	Characterize effects of a 4-week pulmonary rehabilitation inpatient program among non-COPD patients and compare these to results from a similar trial in COPD patients	Pulmonary rehabilitation improved exercise capacity, as measured by the 6MWD, and quality of life in both COPD and interstitial lung disease (non-COPD) groups. Few silicosis patients included in this study.
Goodman, GB	1992	USA	Case report	Describe response of one foundry worker with silicosis to use of corticosteroid therapy.	Improvements observed in lung function in response to steroid treatment were transient and did not alter natural course of disease progression.
Han, B	2013	China	Case series	Characterize the association between functional capacity and measures of subjective well-being and quality of life among patients with silicosis (n=324)	Exercise capacity, as measured by the 6MWD, was significantly associated with measures of well-being and quality of life. Patients with silicosis scored low on measures of well-being and quality of life.
Hessel, PA	1988	South Africa	Retrospective cohort study	Describe progression of silicosis among South African gold miners (n=631); determine effect of silica dust exposure on progression; determine effect of continues silica dust exposure after disease onset; and compare exposures among those who progressed to PMF and those who did not.	Cumulative dust exposure was significantly associated with rate of progression, and those who progressed to PMF were more likely to have had increased exposure after disease onset than those who did not progress to PMF. Silicosis progressed among most miner, regardless of whether or not dust exposure continued after disease onset.
Hnizdo, E	2011	USA	Case report	Evaluate impact of intervention on spirometry quality on accuracy and prevision of lung function measurements and the estimated rate of lung function decline.	Spirometry and diffusion capacity testing are useful in the longitudinal evaluation of workers to determine accelerated rates of decline that may indicate developing silicosis. Particularly important is the monitoring of within-person variation on PFT measures to accurately predict rate of lung function decline. Investigators used SPIROLA software in this study.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Holland, A	2008	Australia	Meta-analysis	Assess effects of physical training on exercise capacity symptoms, QOL, and survival compared to no training in interstitial lung disease patients	The meta-analysis included data from two studies and found that physical training increased 6-minute walk distance and QOL in ILD patients. Physical training reduced dyspnea. No long-term effects were observed.
Hoy, R	2018	Australia	Case series	Report characteristics of Australian workers with artificial stone silicosis.	Seven male patients are described, all working in small artificial stone fabrication businesses. Median duration of exposure prior to symptoms was 7 years; 6/7 patients had PMF. These patients experienced rapid decline in lung function.
Jastrzebski, D	2006	Poland	Experimental intervention	Estimate level of dyspnea and quality of life in patents with pulmonary fibrosis after 6 weeks of respiratory rehabilitation.	Pulmonary rehabilitation improved dyspnea scores and some measures of quality of life. No evaluation of long-term, sustained improvements on these scales.
Kennedy, MC	1956	UK	Randomized control trial	Compare efficacy of two doses of aluminium powder inhalations in relieving symptoms, improving functional capacity, and slowing/halting progression of radiologic changes in silicosis patients	No evidence that inhalation of aluminium powder, at either dose, improved symptoms, functional capacity, or slowed progression in those with silicosis.
Kozu, R	2011	Japan	Prospective nonrandomized open trial	Evaluate the effects of pulmonary rehabilitation on dyspnea, exercise capacity and health status in subjects with idiopathic pulmonary fibrosis and compare changes in the IPF patients to those with COPD	PR improved dyspnea, muscle force, and exercise capacity in both IPF and COPD groups, but the magnitude of improvement was smaller for IPF patients. Sustained improvements were observed after 6 months for those with COPD, but not those with IPF.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Kramer, MR	2012	Israel	Retrospective cohort study	Characterize patients referred for evaluation for lung transplantation to the study hospital with silicosis over a 14 year period (n=25; 1997-2010)	All patients were exposed by dry cutting artificial stone. Patients had moderate-to-severe restrictive lung disease and two developed PMF. Based on registry data, 0.68 silica cases requiring transplantation would be expected during this time period, rather than the observed 10.
Lee, HS	2001	Singapore	Prospective cohort study	Investigate predictors of radiological progression in silicosis in a cohort of granite workers with silicosis	Nearly 37% of the cohort showed radiologic evidence of progression over the study period. Increasing length of follow up, presence of large opacities at the time of the initial CXR, tuberculosis, and recent silica exposures were associated with higher risk or progression.
Lopes, AJ	2008	Brazil	Correlation study	Estimate correlation between CT scan and chest x-ray findings in nonsmokers with silicosis (n=53)	High-resolution CT scans are superior to chest x-rays in detecting PMF as well as early changes associated with silicosis.
Lopes, AJ	2012	Brazil	Case series	Compare imaging findings, lung function variables and CPET results between shipyard sandblasters (n=25) and stone carvers (n=16) with silicosis	Findings from imaging and PFTs were must worse among sandblasters than stone carvers. Sandblasters were significantly more likely to have PMF than stone carvers. Authors conclude that type of silica dust exposure strongly influences the imaging and lung function findings in those with silicosis.
Mannino, DM	2006	USA	Prospective cohort study	Evaluate lung function decline as a predictor of morbidity and mortality in a population with and without COPD	Rapidity of lung function decline increased with increasing stage of disease (GOLD scale). Decline in lung function was associated with modest increase risk of COPD hospitalizations and deaths.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Mao, L	2019	China	Retrospective case series	Improve understanding of the severity of silicosis in the artificial stone countertop industry by analyzing the occupational exposures and clinical characteristics of patients with silicosis in this industry	Reported 98 silicosis cases from an artificial stone factory in Shanghai where over 50% progressed on CXR imaging, and 89% progressed on CT scans.
Martinez, C	2010	Spain	Case report	Describe three cases of artificial stone silicosis	All three cases were males in their 30s who had worked primarily in the artificial stone industry. Two men had simple chronic silicosis, while one had PMF.
Mason, GR	1982	USA	Case report	Describe results of whole lung lavage (WLL) in a patient with silicosis and dyspnea	WLL removed large quantities of dust, primarily composed of silica, silicates, and graphite. WLL provided immediate symptomatic relief, but did not produce improvements in pulmonary function.
Miao, R	2012	China	Randomized clinical trial	Evaluate clinical efficacy of tetrandrine and matrine treatment in patients with silicosis (n=63).	Compared to those receiving routine treatment (n=30), the treatment group (n=33) received tetrndrine (orally) and matrine (injection) at specific time intervals over the course of 16 months. Treatment group had significant improvements in chest pain, dyspnea and other respiratory symptoms. Improvements in FVC and FEV_1 were observed among the treatment group.
Miao, R	2013	China	Randomized clinical trial	Evaluate clinical efficacy of tetrandrine and acetylcysteine treatment in patients with silicosis (n=96).	Compared to those receiving routine treatment (n=47), the experimental group (n=49) received tetrandrine and acetylcysteine orally at specific time intervals over the course of 16 months. Treatment group had significant improvements in rates of cough, expectoration, chest pain, and dyspnea compared to controls. Investigators observed improvements in FVC and FEV_1 among the treatment group as well.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Newbigin, K	2019	Australia	Letter, case series	Share observations from treating initial cases of artificial stone silicosis from Australia	78 cases of AS silicosis were reviewed. Mean age was relatively young (34 years) with relatively short mean tenure (12 years). HRCT was more sensitive in diagnosing silicosis in this population of workers.
Ochmann, U	2012	Germany	Longitudinal prospective clinical trial	Evaluate the short- and long-term effects of a PR program in a population of workers with occupational respiratory diseases	A total of 263 subjects were included, but only 42 had silicosis. PR was associated with decreased hospitalizations and exacerbations across all disease groups. Among those with silicosis, there were improvements in exercise capacity and muscle strength, but no improvements in lung function values.
Ophir, N	2016	Israel	Retrospective cohort study	Screen a population of workers exposed to artificial stone dust (ASD) for inflammatory biomarkers and particulate deposition in airways and compare these findings to those from non-exposed workers.	Among workers exposed to ASD, pulmonary function was significantly reduced and markers of inflammation were significantly increased compared to non-exposed workers. Importantly, the observed decreases in lung function were still within normal range, indicating that lung function testing alone may not be sufficiently sensitive to identify early disease.
Ophir, N	2019	Israel	Retrospective cohort study	Aimed to demonstrate effect of ultrafine particles in the lungs of artificial stone dust (ASD)-exposed workers on functional inflammatory and imaging parameters	Demonstrated that exposure to ultrafine ASD particles is associated with significantly reduced lung function as measured by FEV_1, total lung capacity, and diffusion capacity compared to unexposed controls. ASD exposure is associated with worsening CT findings and elevated inflammatory markers.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Perez-Alonso, A	2014	Spain	Case series	Describe epidemiological and clinical characteristics of an outbreak of silicosis (n=46) among artificial stone workers in Spain	Median age of those with silicosis was 33, with a median tenure of 11 years in the stone fabrication industry. Just over a quarter of cases were under the age of 30. 91% of cases had simple chronic silicosis, 9% had PMF. Lack of employer compliance with safety and control measures widely reported.
Rose, C	2019	USA	Case series	Describe 18 cases of silicosis in the artificial stone industry in the US	18 cases of silicosis are detailed, including two fatalities. Most patients had severe, progressive disease. Additionally, most cases were Hispanic and worked in small businesses where safety and control measures were lacking.
Sharma, SK	1991	India	Case series	Evaluate effects of daily oral prednisolone therapy in individuals with chronic silicosis.	Individuals with chronic silicosis (n=34) treated initially with prednisolone 30 mg daily for six weeks followed by tapering to a low maintenance dose of 0.25 mg/kg/day, the investigators observed improvement in FEV1, FVC, and DLCO.
Sun, J	2019	China	Clinical non-randomized trial	Evaluate therapeutic effects of tetrandrine treatment and N-acetylcysteine in silicosis, specifically with regards to TNF-alpha and IL-6 levels	Improvements in FVC and FEV1 observed in the treatment group compared to controls. Treatment group had reduced levels of IL-6 and TNF-alpha.
Violante, B	1986	Italy	Clinical investigation	Aimed to investigate if 1) pulmonary function tests, symptoms, or chest x-ray findings are most predictive of exercise capacity; and 2) if exercise testing is a more sensitive assessments of pulmonary impairment than a resting PFT	Exercise testing is not more sensitive than a PFT for assessing pulmonary impairment; exercise capacity was not correlated with symptoms, PFT findings, or chest x-ray findings.

First Author	Year	Country	Type of Study	Study Aim(s)	Relevant Finding(s)
Wang, X	1997	China	Cross-sectional	Compare differences in pulmonary impairment between workers exposed to silica, asbestos, or coal mine dust based on radiographic presence of disease.	Compared to workers without radiographic evidence of pneumoconiosis, workers with pneumoconiosis showed significantly decreased lung function (FEV1/FVC and DLCO). DLCO and spirometry values were decreased in dust-exposed workers even without radiographic evidence of pneumoconiosis.
Wang, X	2000	China	Cross-sectional	Examine differences in respiratory impairment and symptoms among workers exposed to silica, asbestos, or coal dust; assess relationship between respiratory dysfunction and radiological abnormalities due to the dust exposures	Vital capacity and DLCO decreased across increasing stages of pneumoconiosis in each dust-exposed group, but was most pronounced among silica-exposed workers. Similarly, dyspnea and chronic cough increased with greater disease severity, but was highest among those with silica exposure.
Wang, X	1995	China	Cross-sectional	Examine the role of exercise testing in evaluating dyspnea among silica-expose workers and patients with silicosis to provide a more objective measure of exertional dyspnea.	Exercise tolerance and lung function was poorer in silicosis patients than the silica-exposed workers. The proportion of subjects with dyspnea from questionnaires was significantly higher than through the objective exercise testing measures, although exercise testing measures were strongly correlated with self-reported dyspnea.
Wilt, JL	1996	USA	Case series	Describe whole lung lavage (WLL) performed to reduce dust, inflammatory cells, and cytokine burden in two coal miners with pneumoconiosis.	Authors demonstrated that WLL can reduce dust and inflammatory cell burden in those with pneumoconiosis, but does not appear to alter the natural course of the disease.

[a] Summaries are not provided for review articles, editorials, letters to the editor, factual reports, or animal studies.

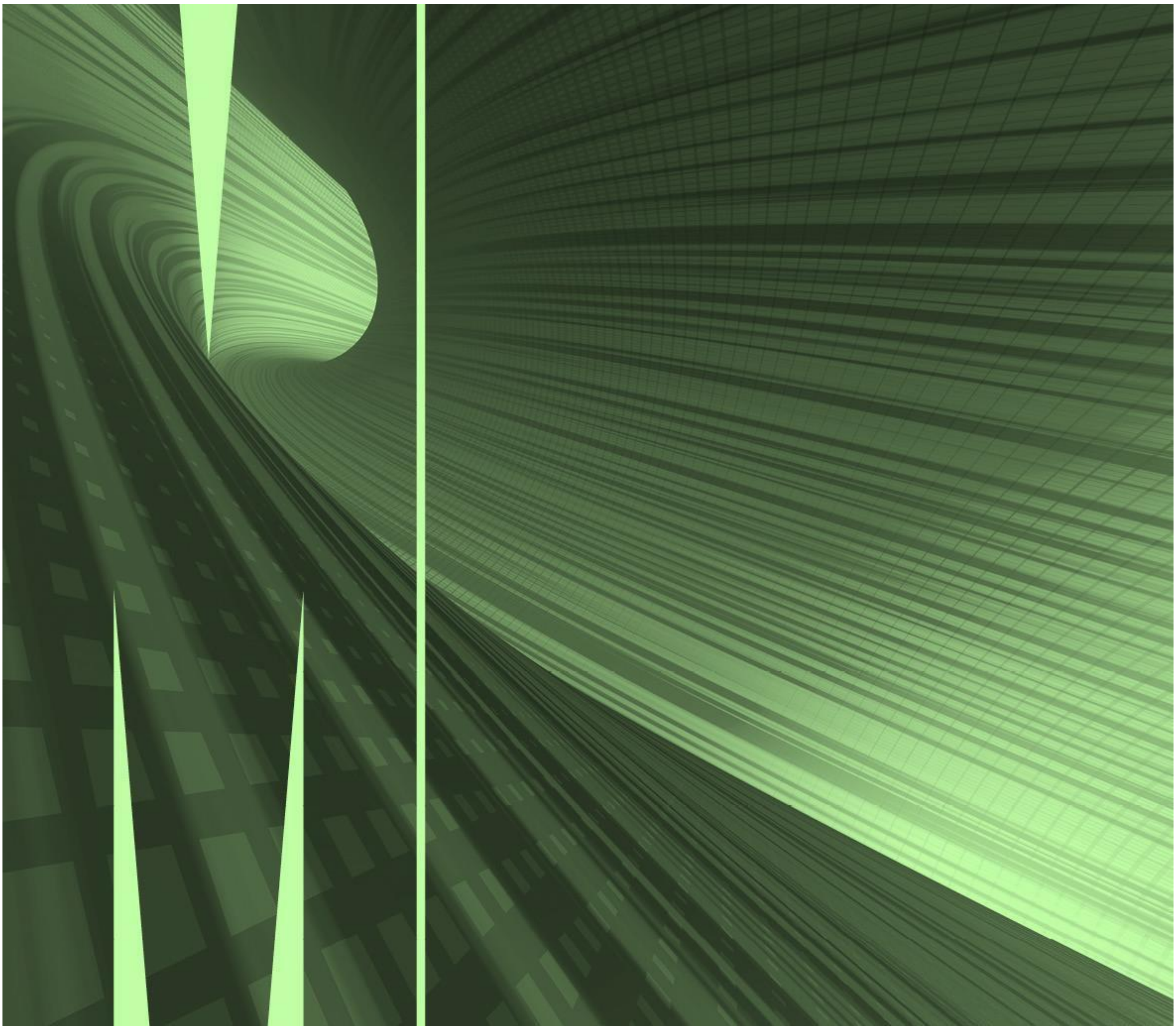
Appendix 2.

Table A2. Summary of grey literature search.

Organization Name	First Author Name (where applicable)	Year	Country	Summary
American Association of Cardiovascular and Pulmonary Rehabilitation	N/A	2019	USA	Provides basic information about the goals and standard components of a pulmonary rehabilitation program.
American Thoracic Society	Redlich, CA	2014	USA	This document addresses specific aspects of the performance and interpretation of spirometry in an occupational setting, with specific attention paid to monitoring longitudinal changes over time.
American Thoracic Society/American College of Chest Physicians	N/A	2003	USA/Europe	Outlines the goals, components, and clinical applications of cardiopulmonary exercise testing, including potential risks.
American Thoracic Society/European Respiratory Society	Spruit, MA	2013	USA/Europe	Defines pulmonary rehabilitation (PR) as "a comprehensive intervention based on a thorough patient assessment followed by patient tailored therapies that include, but are not limited to, exercise training, education, and behaviour change, designed to improve the physical and psychological condition of people with chronic respiratory disease…" Expands the exercises deemed safe and effective as part of a PR program as well as expands the diagnoses that can be managed and treated with PR, which include interstitial lung diseases.

Organization Name	First Author Name (where applicable)	Year	Country	Summary
American Thoracic Society/European Respiratory Society	Graham, BL	2019	USA/Europe	Updated technical document detailing interpretive guidelines for spirometry.
European Society of Pneumology	Klech, H	1990	Europe	Outlines under which circumstances WLL may be appropriate treatment. Relevant to our review, WLL may be most appropriately employed in individuals with acute silicosis with an ILO category 2 or higher on chest radiograph, as these individuals stand to benefit most from the procedure and are at highest risk of disease progression.
Occupational Safety and Health Administration	N/A	2015	USA	This document outlines the hazards posed to workers in the artificial stone fabrication industry and includes overviews on silicosis cases, routes of exposure, and engineering controls.
Royal Australian and New Zealand College of Radiologists	N/A	2019	Australia/New Zealand	Relevant to our review, RANZCR recommends that CT of the chest be the primary imaging modality for screening and diagnosis of silica-exposed workers as a result of false negative CXR findings in the recent silicosis outbreak.
Spanish Society of Pulmonary and Thoracic Surgery	Martinez Gonzalez, C	2013	Spain	Outlines clinical guidelines for pulmonologists to assist patients in making a decision about return to work. Relevant to this review, the authors indicate that those with silicosis should not be returned to exposure.

Silicosis Literature Review - Return to Work and Vocational Rehabilitation Support for Workers Suffering from Silicosis



Monash University, November 2019

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Conflict of interest:

No conflict of interest to declare by any members of the research team.

Table

Table 1: Search strategy for peer-reviewed, published literature

Figure

Figure 1: Summary of peer-reviewed and grey literature selection, inclusion and exclusion.

Appendices

Appendix 1: Search strategy for database searches

Appendix 2: Summary of relevant findings in peer-reviewed literature. Appendix 3: Summary of relevant findings from Grey literature

Glossary of abbreviations

ACGIH: American Conference of Governmental Industrial Hygienists AFOEM: Australasian Faculty of Occupational and Environmental Medicine AS/NZS: Australia and New Zealand standard

AWES: Australian Work Exposure Study CT: Computed Tomography

CTD: Connective Tissue Disease

FEV_1: Forced Expiratory Volume in 1 second FVC: Forced Vital Capacity

HRCT: High-Resolution Computed Tomography IQR: Interquartile Range

LEV: Local Exhaust Ventilation MeSH: Medical Subject Headings

NIOSH: The National Institute of Occupational Safety and Health OSHA: Occupational Health and Safety Administration

PCBU: Person Conducting a Business or Undertaking PEL: Permitted Exposure Limit

PPE: Personal Protective Equipment QLD: Queensland

RACP: Royal Australasian College of Physicians RCS: Respirable Crystalline Silica

REL: Recommended Exposure Limit RPE: Respiratory Protective Equipment RTW: Return To Work

SSE: Site Senior Executive SWA: Safe Work Australia

SWORD: Surveillance of Work-related and Occupational Respiratory Disease TLV: Threshold Limit Value

TWA: Time weighted Average

UIC: University of Illinois at Chicago UK: United Kingdom

US: United States

WES: Workplace Exposure Standard

Executive summary

Background

Occupational silicosis is a severe respiratory condition caused by inhalation of very fine or respirable crystalline silica (RCS) particles. The disease leads to progressive irreversible scarring and stiffening of the lungs, and many sufferers may ultimately need a lung transplant in the absence of medical treatment options.

Recently, a number of cases of a severe form of silicosis, known as accelerated silicosis, have been reported in Queensland and other states of Australia and overseas among workers in the engineered stone benchtop industry. This engineered stone has a very high silica content of up to 96%. Accelerated silicosis has been reported in young men after just a few years of exposure to high levels of respirable silica dust, produced by cutting, grinding or polishing the engineered stone material. The young age of affected workers, many of whom will have young families to support, makes this disease particularly devastating. As most affected workers are young and still of working age, many will wish to return to work after a silicosis diagnosis.

Purpose

WorkCover Queensland has commissioned Monash University to conduct a literature review to find evidence to inform a best-practice, evidence-based approach to return to work and vocational rehabilitation specifically tailored to the needs of workers diagnosed with silicosis.

Approach

To address the review aims, a broad range of information was accessed through searches of both peer-reviewed literature and unpublished (grey) literature. Peer-reviewed literature was accessed using structured searches of library databases. The grey literature search focused on policies, guidance materials, and fact sheets produced by Australian Government agencies, Australian States and Territories, Australasian professional bodies, and by relevant international agencies, accessed through the organisation websites.

Key Findings

The key findings of the review are that:

1. A wide range of industries and jobs were identified as unsuitable for workers who had been advised to avoid all further exposure to respirable silica dust. These jobs all involve some type of processing, demolishing or disturbing of silica-containing materials, for example construction workers working with concrete or cement or mine and quarry workers.
2. Five published articles were located that focused on the mental health of workers with silicosis. Of these, all reported a high prevalence of anxiety and depression among this group. No regulations, guidance material or fact sheets were located in the grey literature that had focused on the mental health of workers exposed to RCS or diagnosed with silicosis.
3. Little literature was found to directly inform retraining options and processes at the individual or systems level specifically for workers who have been diagnosed with silicosis, or who have been exposed to high levels of respirable crystalline silica, although some jurisdictions do offer psychological support and other assistance. Therefore, there is a need to follow the general return to work principles outlined in the 2019 Safe Work Australia Return to Work Framework.
4. There is very little evidence available in the literature to inform return to work of workers diagnosed with silicosis, of workers with different stages of disease, or of asymptomatic workers who have been diagnosed with the early stages of disease.
5. Eight studies were located describing diseases that can arise concurrently with silicosis. These include renal disease, tuberculosis, respiratory infections, and lung

cancer, and autoimmune connective tissue diseases such as rheumatoid arthritis and scleroderma. These diseases may further limit the range of tasks and occupations suitable for workers who are seeking to return to the workforce.

6. For workers with no signs of disease, but who have been exposed to high levels of silica dust, it is important that their workplace complies with all legislated requirements regarding silica exposure limits, and exposure control measures.
7. No evidence or recommendations of modification of work duties based on previous silica exposure history was identified in the published or grey literature.
8. A large number of silicosis fact sheets and other guidance materials has been produced by federal and state agencies and professional bodies, involving a large amount of duplication, but the focus is not return to work guidance.
9. Little evidence is available to inform a RTW strategy for workers with silicosis. If their consent can be secured, the follow up of a cohort of Australian workers with silicosis and documentation of the course of their disease, including return to work outcomes, will produce valuable information with which to inform this evidence base in the future.
10. Given that there are many workers in Queensland who have been diagnosed with silicosis at an early stage, strategies for their RTW will need to be formulated, based on general principles and clinical experience, while waiting for the relevant research to be undertaken. It is important that any return to work program for workers at risk of, or diagnosed with silicosis, takes a multidisciplinary approach, with involvement of respiratory physicians, occupational physicians, and case managers with vocational expertise. In this way, assessment of medium term clinical prognosis, of worker expertise and capacity, and of any requirements for retraining and support programs, can be incorporated into the return to work plan for each individual worker.

Major conclusions

The major conclusions of this review are that:

1. There is little if any peer-reviewed or grey literature available to inform return to work policy or practice which is specifically tailored to the needs of the workers with silicosis, asymptomatic workers with signs of disease, or those with other silica-associated diseases.
2. More research is needed to inform many aspects of return to work and vocational rehabilitation for workers diagnosed with silicosis, including management of their mental health needs, and retraining options and processes at the individual and systems level. Follow up of the cohort of Queensland workers with silicosis will help to inform this evidence-base.
3. The severe, progressive and incurable nature of silicosis requires urgent reduction of exposure to respirable crystalline silica in the engineered stone benchtop industry. As there are workers currently being exposed to silica dust, strategies for their management and return to work must be developed now, based on general return to work principles, such as the Safe Work Australia 2019 Return to Work Strategy and the Health Benefits of Good Work Principles of the Australasian Faculty of Occupational and Environmental Medicine and clinical experience, while waiting for the results of return to work research to become available.

Chapter 1: Introduction

Silicosis is one of the oldest occupational diseases, with cases dating back to ancient times. During the latter part of the 20th century, effective controls were introduced and silicosis became an uncommon condition in most high income countries by the early 2000s, including Australia[1]. At that time, silicosis was mainly diagnosed in older workers who had been exposed to low or moderate levels of silica dust, usually over a long period of working in occupations such as mining or quarrying.

A recent resurgence of silicosis cases in Australia has revealed a rather different story. Recent cases have predominantly been young men developing the disease after a relatively short duration (usually less than 10 years) of high intensity exposure to respirable silica dust, particularly while working with engineered stone material in the installation of kitchen, bathroom and laundry benchtops[2, 3]. This particular form of the disease is referred to as accelerated silicosis.

Exposure to silica dust during the cutting and installation of engineered stone (also known as artificial, reconstituted, or manufactured stone, or quartz conglomerate) benchtops has emerged as having a high risk of silicosis because of the high concentration of silica this material contains. Engineered stone contains up to 96% silica compared to natural stone which contains 5 to 50% silica[4, 5]. The use of engineered stone for kitchen, bathroom and laundry benchtops has rapidly increased since it was introduced into Australia less than 20 years ago in parallel with the building boom[6].

The engineered stone industry does appear to result in significantly higher risk of silicosis[2, 7], and this is supported by reports from other countries. Two individuals making engineered stone benchtops have been diagnosed in Belgium and other cases are expected[8]. In a cohort study in Israel, all the cases of silicosis referred for lung transplantation had worked with engineered stone[9]. In contrast, of 161 cases of silicosis identified in the Surveillance of Work-related and Occupational Respiratory Disease (SWORD) registry, none were attributed to engineered stone in the UK[10].

Silicosis is a preventable lung disease caused by inhalation of very fine respirable crystalline silica dust and deposition in the lung alveoli, leading to irreversible scarring, stiffening of the lungs and impaired gas exchange[11]. Symptoms of disease include worsening breathlessness, cough and fatigue[12]. Currently there is no cure available and management of cases is confined to reducing exposure to silica dust. Silica dust exposure can also increase the risk of lung cancer, kidney disease, chronic obstructive pulmonary disease, and has been associated with tuberculosis and a number of autoimmune diseases[11, 13, 14].

The young age of the affected workers in the stone benchtop industry, often with young families to support, has highlighted the importance of vocational support for workers following a silicosis diagnosis. Return to work after an occupational illness or injury is well known to benefit the worker, their families and the economy[15]. However, workers with a diagnosis of silicosis are likely to have additional hurdles to cross to achieve a meaningful return to work. One requirement is to avoid further silica dust exposure in established cases, but there are many uncertainties about what other factors should be taken into account when vocationally assessing affected workers for return to work. These factors include:

- the common absence of respiratory symptoms in the presence of x-ray or CT scan changes,
- often normal (or near normal) lung function which is unlikely to restrict exercise tolerance,
- uncertainty about the likely rate of progression of fibrosis (even in the absence of further silica dust exposure),
- possible changes in work ability due to the presence of other silica-associated diseases, such as the autoimmune diseases, and
- the impact of associated psychological conditions, such as anxiety and/or depression, resulting from the potential to develop a fatal disease at such a young age.

To ensure Queensland workers at risk of silicosis receive the best possible support, including support for a meaningful return to work in light of the above uncertainties, WorkCover Queensland has decided to develop a best-practice, evidence-based approach to return to work and vocational rehabilitation in support of these workers.

A rapid review of peer-reviewed literature and unpublished (grey) literature has been conducted to provide a summary of recent evidence and other available information to inform this approach. The overall aim of the review is to identify factors, principles or limitations that need to be considered in designing tailored return to work plans for workers with silicosis to ensure they achieve a safe, meaningful and early return to work.

The rapid review has been divided into two parts, each with different, but complementary, aims and objectives; one part being conducted by a research team led by Monash University and the other part being conducted by a research team led by the University of Illinois Chicago (UIC). This report describes the aims, methods, results and conclusions of the part of the review conducted by Monash University from August – November 2019.

Aims of the return to work review

The overall aims of the two parts of the review are to:

1. Identify the current state of knowledge to inform return to work (RTW) and vocational rehabilitation support for workers diagnosed with work-related silicosis, and to identify gaps in this knowledge.
2. To recommend ways the findings of this review can be effectively translated into policy and practice.

In particular, the following questions are addressed:

What particular issues arise for workers in the stonemason industry with respiratory conditions returning to work compared with other workers?

How do we ensure workers with a diagnosis of silicosis are returning to a safe work environment, and what information is required to manage their return to work?

Aspects of the review undertaken by the Monash team

1) What particular issues arise for workers in the stonemason industry with respiratory conditions returning to work compared with other workers including:
   a. Roles/industries outside of the stonemason industry that should be avoided as they will likely accelerate the progression of the disease
   b. Mental health impact and measures
   c. Retraining options and processes at an individual and system level
   d. Managing return to work for asymptomatic workers who have been diagnosed with the early stages of disease taking into account the possible progression of their disease

2) How do we ensure workers with a diagnosis are returning to a safe work environment and what information is required to manage their return to work:
   a. Vocational assessment considerations and methods for respiratory disease
   b. Occupational hygiene and safety evaluation including air monitoring levels and effectiveness of control measures of engineered stone workplaces in consideration of decisions about return to work.

Chapter 2: Methods

2.1 Literature Review

In order to address the aims of the Monash part of the review and to access a broad range of information, sources of both peer-reviewed literature and grey literature were systematically searched, guided by the review questions allocated to Monash, as outlined in the previous section.

2.1.1 Peer-reviewed literature

In consultation with a senior and experienced librarian at Monash, key words addressing three main concepts of the study aims (return to work, work-related exposure to respirable silica dust and silicosis disease) were incorporated into a search strategy using a combination of Medical Subject Headings (MeSH) terms, text words and search statements. This was applied to several databases, including Medline, EMBASE, EMCARE, Scopus and Cochrane Database of Systematic reviews, using a combination of MeSH terms and text words. The search strategy used as the basis for the peer- reviewed literature searches is provided in Appendix 1. Other published articles were also identified through advice from the members of the research team, from reference lists of retrieved articles, and by searching Google Scholar. Selection of articles for inclusion was based on the inclusion criteria listed below. Eligible articles included in the review were tabulated and relevant information extracted and documented, as presented in Appendix 2.

Inclusion criteria for Peer-reviewed Literature

- Peer-reviewed publications based on Australian and international data addressing silicosis and other occupational lung disease work disability, return to work or other vocational outcomes.
- Occupational lung conditions including silicosis, progressive massive fibrosis, other pneumoconiosis and other chronic lung disease where workplace exposures have been a major contributor, such as chronic obstructive pulmonary disease.
- Original research papers (including intervention studies, cohort studies and other occupational studies), editorials, commentaries, reviews or other research-related articles in the peer-reviewed literature.
- The search was limited to publications in the English language and to publications from 2000 to capture papers of most relevance to accelerated silicosis and modern return to work principles and systems.

2.1.2 Grey Literature

A systematic search of the grey literature, defined as "Information produced on all levels of government, academia, business and industry in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity of the producing body”[16] was conducted. For this review, the focus of the search was Occupational Health and Safety policies, guidance material and factsheets produced by the Australian Commonwealth Government and affiliated organisations, Australian states and territories, Australasian professional bodies, and international organisations of countries with similar compensation and return to work frameworks as Australia. Selection of organisations for the search was based on advice from members of the research team and SWA staff and through in-text links and references contained in retrieved grey literature.

Search terms reflecting the main concepts of the study question, either singly or combined as appropriate, were used to construct search strategies of the selected organisations.

Documents were scrutinised for information that could inform the study aims, and relevant information along with document details was tabulated. This table is provided in Appendix 3.

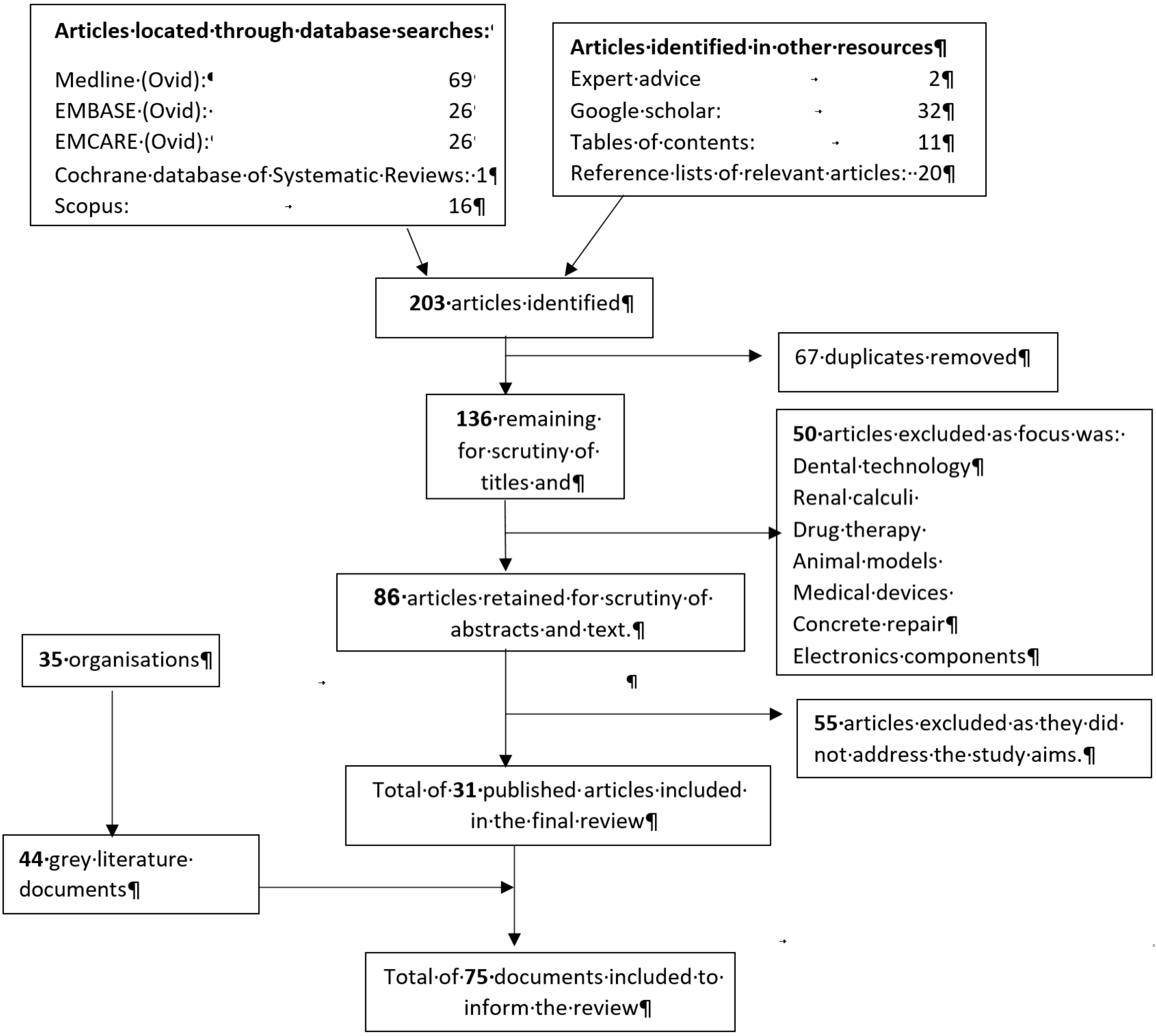
Chapter 3 Main Findings

3.1 Retrieved Data

3.1.1 Peer-reviewed and Grey Literature

As shown in Figure 1, a total of 203 articles were retrieved through database searches. Of these, 67 were duplicates, and a further 105 were excluded as they did not address the aims of the review, leaving a total of 31 articles for inclusion in the final review (See Appendix 2). In addition, a total of 44 grey literature documents were retrieved from the websites of 35 organisations. Relevant information from these documents can be found in Appendix 3. A number of overseas items of grey literature were identified explaining what silica is, dealing with silicosis prevention and exposure standards. None of these considered return to work, but for completeness they are also listed in Appendix 3.

Figure 1: Summary of peer-reviewed and grey literature selection, inclusion and exclusion.



3.2 Peer-reviewed and Grey Literature Review

Key findings from the review of peer-reviewed and grey literature, with regard to the study aims, are summarised below:

3.2.1 Issues that Arise for Stonemason Industry Workers with Respiratory Conditions on Return to Work Compared with Other Workers

Roles and Industries outside the stonemason industry that should be avoided as they may accelerate disease progression

Many jobs have been identified as unsuitable for a worker where it has been decided that there should be no further exposure to silica-containing dust for that worker. SafeWork Australia has identified the following jobs as having exposure to RCS[17]:

- excavation, earth moving and drilling plant operations
- clay and stone processing machine operations
- paving and surfacing
- mining, quarrying and mineral ore treating processes
- tunnelling
- construction labouring activities
- brick, concrete or stone cutting; especially using dry methods
- abrasive blasting (blasting agent must not contain greater than 1 per cent of crystalline silica)
- foundry casting
- angle grinding, jack hammering and chiselling of concrete or masonry
- hydraulic fracturing of gas and oil wells
- pottery making.

This is consistent with some international research into jobs where silica related diseases occurred. A study that used data from the SWORD occupational lung disease registry found that silicosis cases in the UK came from the following industry sectors: mining, quarrying, ceramics, brickworks, foundry, construction, stonemasonry, and tunnelling[18]. Cases of silicosis have also been reported in dental workers and jewellery workers[19, 20]. In 2013, Esswein et al. reported that workers in the hydraulic fracturing ('fracking') industry are exposed to RCS[21]. A silicosis case has been reported in a farmer working with sandy soil[22]. An outbreak of silicosis was associated with sand blasting in Turkey, however, as noted above, in Australia, the blasting agent must not contain greater than 1% crystalline silica, so this exposure is unlikely to occur here[23, 24].

There has been some recent research into how common silica exposure is in Australian jobs, which can inform which jobs are unlikely to be unsuitable for those with silicosis to return to. A cross sectional survey of 4,993 Australian workers aged 18 - 65 years in 2012, the Australian Work Exposures Study (AWES), estimated that 6.6% of Australian workers were exposed to RCS, and 3.7% were exposed to high levels of RCS in their workplaces[25]. The most commonly exposed jobs were those performed by miners and construction workers and the most exposed tasks were working with concrete or cement, and being near rock crushing devices[25]. Therefore such silica exposed jobs in these industries are likely to be unsuitable for workers with silicosis and silica-exposed workers, if it has been decided they should not return to a job involving silica exposure. Another factor to consider about suitability for returning to a silica exposed job is likelihood of compliance with control measures. A qualitative study in Israel found that despite awareness of the dangers of unprotected exposure to respirable dust, some workers did not comply with safety guidelines due a perception that others should take responsibility for their safety[26].

Importantly, these findings suggest that more than 90% of jobs don't have silica exposure and could be considered for workers with silica-related conditions, taking into account other relevant factors, such as age, education level, transferable skills, mental health and respiratory and other physical functioning. It is important to remember that many other jobs can involve exposure to other respiratory toxins, such as coal dust, metal dust, welding fume, wood dust and many others. These other possible exposures also need to be taken into account when assessing suitability of a worker with accelerated silicosis returning to work in a different type of job.

In addition, for many jobs which don't involve silica exposure, there is often a requirement for good respiratory function. This may relate to a high degree of physical exertion required for the tasks, working in an unusual environment, such as at altitude or underwater or a requirement for wearing extensive personal protective equipment. These types of jobs place additional demands on a worker's respiratory system, so a worker with accelerated silicosis is less likely to be able to cope with these higher demands. Therefore, this is another important factor to take into account when assessing other jobs for their suitability for returning to work of the worker with accelerated silicosis.

Mental health impacts and measures

No Australian papers and very few international peer-reviewed literature articles were located that focused on the mental health of workers diagnosed with silicosis, however of those few, all reported the prevalence of depression and anxiety to be greater in people with silicosis than in those without. Wang et al. reported in 2008 that 27.3% of silicosis patients identified though an industry based registry in China showed evidence of depressive symptoms (measured using the Beck Depression Inventory) compared to 7.3% of controls[27]. Depressive symptoms were positively associated with severe respiratory symptoms and poor physical function, (defined as Forced Expiratory Volume in 1 second (FEV$_1$) <50% predicted and Forced Vital Capacity (FVC) % less than the mean predicted value based on age and height.

Yildiz et al. evaluated quality of life, depression and anxiety among 50 young men who had worked in the denim sand blasting industry in Turkey and had been diagnosed with silicosis[28]. This group had pulmonary function test results within normal limits, but had more severe depressive and anxiety symptoms (measured using the Beck Depression Inventory and Beck Anxiety Inventory respectively) than controls. The authors concluded that depression and anxiety among silicosis patients contributes to a decreased quality of life.

Perceptions of social support (from family, friends and significant others), measured by face-to face interview and structured questionnaire, were found to be low among a group of 324 inpatients (mean age 74.1 years, range 36-91years) with silicosis in China[29]. Of this group, 99% showed symptoms of anxiety, and 86% displayed symptoms of depression. The authors suggest that symptoms of depression in silicosis patients might be alleviated with improved social support.

Treatments can also be an important factor in mental health of those with serious respiratory diseases. One study from Italy found that a better quality of life and better mental health were independent predictors of return to work in a group of thoracic organ transplant patients in Italy having their transplant for a variety of lung conditions[30].

Therefore, despite the absence of any published peer-reviewed literature from Australia, these findings suggests that mental health of such workers and their mental health support, including after major treatment such as a lung transplant, are likely to be important factors to take into account when considering suitable return to work options.

Retraining options and processes at an individual and system level

This was not a focus of attention of the peer-reviewed articles or grey literature documents identified through the searches. Findings from Spain suggests that workers may not come forward for screening, because a silicosis diagnosis may require them to leave work with little compensation and if they obtain another job this diagnosis would jeopardise their pension[31]. The relevance of this finding to the Australian situation is not clear, as pension systems are quite different between Spain and

Australia. Still, this potential barrier of keeping a diagnosis hidden when retraining or moving to a new job due to concern about a potentially reduced income, is something to be considered during vocational assessment of silica exposed workers and identifying suitable return to work options for them.

Managing RTW for workers at different stages of disease progression

Workers who develop silicosis from artificial stone exposure, often have very rapid disease progression, often much faster than occurs in the more traditional form of chronic silicosis. Therefore, this needs to be taken into account when considering new jobs to be performed in the medium to longer term. This is an area which has not been a prime focus of the identified peer-reviewed and grey literature. However, Vooijs et al (2015) carried out a systematic review of nine effective interventions to enhance work participation for people with chronic diseases[32]. They identified some weak evidence that interventions focusing on the workplace, for example changes in work organisation or conditions were the most effective strategies and called for more studies to be undertaken to improve the evidence base. However, none of the studies in the systematic review specifically mentioned silicosis.

In particular, none of the identified documents obtained during our search took into account the more rapid rate of progression of accelerated silicosis compared with chronic silicosis and the implications of that for return to work options. This is likely to have important implications for sustained return to work, as the rapid progression of the disease may mean that their suitability for work is likely to change over a short period of time, therefore requiring regular monitoring of their fitness for work. None of the identified literature addressed the question of the significance of progressive massive fibrosis or other disease sequelae in vocational assessment.

As many cases are likely to require lung transplant, this would require a major reassessment of work capability, but none of the identified published or grey literature addressed the likely return to work implications of transplantation[9]. Lung transplant teams comprise multidisciplinary staff who address a range of life aspects in the rehabilitation phase following transplantation, including return to work. In addition to the requirement for silicosis lung transplantation cases to not return to dust exposed jobs post-transplantation, there would be the additional restrictions related to immunosuppression and higher risk of infection.

3.2.2 Ensuring Workers with a Silicosis Diagnosis Return to a Safe Work Environment

Vocational considerations for respiratory disease

The Australasian Faculty of Occupational and Environmental Medicine (AFOEM) of the Royal Australasian College of Physicians has developed a Consensus Statement on the Health Benefits of Good Work (HBGW)[15]. This statement has over 250 Australian and Aotearoa New Zealand signatories representing a variety of employer organisations and statutory bodies. The HBGW program emphasises the beneficial effects on mental and physical health and wellbeing of people being in healthy and safe work[15]. This also applies to workers who develop disease or injury at work, including the benefits of an early return to safe work[15]. The Principles laid out in the HBGW Consensus Statement do not address silicosis or other forms of chronic lung disease specifically. These principles relate to the need to take into account any form of chronic illness in ensuring that any work that a worker is to return to can be done safely and with no further impact on any respiratory or other condition.

Safe Work Australia has recently released the Australian National Return to Work Strategy 2020 – 2030, which provides a broad evidence based framework which aims to minimise the impact of work-related injury and illness, and enable a timely, safe and durable return to work[33]. The guiding principles of the Strategy emphasise that the return to work process should not exacerbate existing conditions or create new ones, and acknowledge that psychological factors may affect the process. Therefore, this strategy and its associated RTW framework is very relevant to returning a worker with silicosis and any associated psychological health issues to suitable work.

Both the HBGW program and RTW Strategy highlight important guiding principles which apply to workers with silica-related disease or those with high previous silica exposure who are at risk of developing disease in the future, even in the absence of further silica exposure[15, 33]. Although the return to work strategy contains no specific information or guidance about return to work for those workers with silicosis, such as the need to avoid future exposures, unsuitable occupations, retraining options, mental health issues, or frequency of on-going health monitoring, it does contain several important principles to guide all relevant stakeholders in decisions about suitable return to work for workers, with chronic diseases, such as silicosis. These include (i) supporting workers to be actively involved in their recovery and return to work, (ii) supporting workplaces to reduce stigma and promote positive relationships and behaviours, (iii) helping employers and other stakeholders, including health practitioners, workplace rehabilitation services, insurers and claims managers, to support workers in their recovery and return to work[33]. HBGW also promotes the benefits of early RTW, especially for improved mental health outcomes. Therefore this has particular relevance to workers with silicosis where associated mental health issues are common.

The adverse effects of silica are not confined to the respiratory system. There is evidence to show that silicosis is associated with an increased risk of autoimmune disease (particularly rheumatoid arthritis and scleroderma),[34-37]renal disease[13, 36], tuberculosis[34, 36, 38], respiratory infections[36], and lung cancer[39, 40]. Those workers exposed to RCS from engineered stone can have raised inflammatory cytokines as well as reduced lung function[41]. These conditions may limit the range of jobs a worker with silicosis is able to transition to. It could be expected, for example, that rheumatoid arthritis or scleroderma may limit dexterity, or ability to assume a standing or crouching position. In addition, the non-respiratory features of the disease may be debilitating and limit physical activities, such as pain from inflamed joints, thickening of skin or eye involvement. The National Return to Work Strategy does not address specific considerations relevant to a worker with silicosis who develops associated conditions which may further affect vocational abilities[33]. These considerations include the chronic pain from autoimmune diseases, changes in hand function through joint and/or skin involvement, affects on vision and the long term medications that people with autoimmune conditions need to take.

More specific considerations for those with silicosis include:

- Transitioning from manual semi-skilled work to non-manual work for those with limited respiratory capacity,
- The impact of other functional limitations such as arthritis,
- Avoidance of further exposure,
- The changing course of the condition, with the potential for reducing lung function over time and the need for further treatment that may limit work activities eg lung transplant followed by use of immunosuppressants),
- Uncertainty about the future and anxiety / depression.

Principles to address these issues are include case management that offers:

- A holistic range of assistance initiatives ranging from practical support to retraining and financial advice to mental health support,
- Identified work options are considered in light of the individuals respiratory capacity,
- Vocation planning takes into account their likely clinical course and prognosis,
- The opportunity for the individual to shape their own vocational direction,
- Reflecting the important role of consultation, efforts to aid workers in retraining are sensitive and committed,
- Recognising return to the workforce is more likely when the person is engaged and motivated, and the challenges faced by those with silicosis, the individual's work choices and / or retraining should be supported where practical,
- Case manager experience and expertise in retraining and redeployment for those with long term health problems,
- Coordinated interactions with the person's treating specialist team which will likely be required over the long term,
- A flexible approach, recognising that people have differing beliefs, expectations and readiness

for return to work

- A buddy or support group may help individuals identify suitable work options and assist in providing connection and support during retraining and return to work.

Queensland Regulations relating to exposure to silica at work

Respirable crystalline silica (RCS) is a statutory defined 'hazardous substance' under the provisions of the Work Health and Safety Regulation 2011 (Qld): Chapter 3 General risk and workplace management: Division 5 Control of risk; Division 6 Health monitoring; Division 7 Managing risks from airborne contaminants[42]. Under these regulations an employer has a duty to reduce exposure by implementing appropriate exposure control measures and also to implement health monitoring. In Queensland, and since the commissioning of this literature review, a new Code of Practice for the Industry sector has been enacted and formally commenced on 31 October 2019[43]. This code is generally applicable for all workers exposed to RCS, but has some particular implications for those workers with established silicosis. This is because of the concern about further progression of disease in these worker from any further RCS exposure.

While it is reasoned that the Code will create a safe workplace for a person without a significant cumulative silica exposure, no evidence currently exists that it will create a safe workplace for either (i) workers with established disease or (ii) workers with significant past exposure but without detectable manifestations of disease as yet. The exposure to RCS should be reduced as far as is reasonably practical below the SafeWork Australia (SWA) Workplace Exposure Standard (WES) for all workers, regardless of whether they have silicosis or not. At the time of the start of this review, the WES was 0.1mg/m^3 as an 8 hour time weighted average exposure (TWA). However, this WES was reviewed in late 2019 and a new limit of 0.05mg/m^3 has been proposed. This lower WES reinforces the need to implement exposure control measures for all RCS exposed workers and is likely to make it more difficult to ensure a safe working environment for those workers with silicosis who want to return to work with artificial stone. Therefore, this is likely to further reduce the range of employment opportunities for workers diagnosed with silicosis. Roles not currently considered to present a RCS risk may be reclassified as presenting a risk due to the reduced WES, further restricting the range of silica exposure jobs that workers could return to.

In Queensland, air monitoring is now mandated by the Code of Practice, as is the ongoing health monitoring of the potentially exposed worker[43]. The code does not address return to work options for workers with silicosis. It requires the health monitoring report to identify, whether there are signs of disease and make recommendations as to whether the worker can continue in their current employment. The Code identifies the nature of health monitoring for all workers who remain in the employ of the PCBU, it is silent on future health monitoring of the worker who is diagnosed with silica-related disease but who leave the employer, for example due to deciding to change careers or for older workers at retirement.

Occupational hygiene and safety evaluation, effectiveness of control measures of engineered stone workplaces in consideration of decisions about return to work.

Many workers who have been screened for silicosis have had RCS exposure but are not (as yet) showing signs of disease. The more rapid progression of silicosis from artificial stone than from other sources of silica means that it is especially important that RCS control be closely monitored during RTW for those workers with established disease and those with a high previous RCS exposure, but who are likely to develop disease. In such cases, it is very important that the return to work setting for a worker with silicosis complies with the new Code of Practice to ensure that as far as reasonably practical, no further significant silica exposure adds to their cumulative lung burden[43]. Guidelines developed by the Australasian Faculty of Occupational and Environmental Medicine (AFOEM) provide a consensus of the medical opinion that a worker with a confirmed diagnosis of silicosis should not have any further predictable exposure to silica dust[12].

In addition, if silicosis is identified in a specific workforce the other workers who were also exposed during the critical period, may also be at continuing increased risk. Therefore this can have a material impact on the future work options for many workers in the one workplace. If workers with high previous exposure and/or early changes on x-ray without symptoms are to return to their workplace, exposure should be optimised by compliance with the Code of Practice for the bench top industry sector, being applied across any industry sector that needs to manage the risk associated with the relevant silica exposure limit. Below are some findings from our review showing how this can be done and potential barriers for creating safe workplaces for workers with silicosis.

The percentage of silica in the stone being cut is an important determinant of RCS exposure. The US Occupational Health and Safety Administration (OSHA) reviewed exposure data for stone sawyers in marble (usually 2% RCS or less) and granite (10-45% silica) shops. RCS exposure when dry cutting granite without local exhaust ventilation (LEV), ranged from 0.089 to 0.460 mg/m^3 but for marble the exposure was between 0.039 and 0.045 mg/m^3 [44]. Cutting engineered stone (≥93% silica) without control measures for 30 minutes results in 44.6 mg/m^3 of RCS[45].

Exposure also varies with the specific job in stone countertop fabrication and installation. Exposures for polishers ranged from 0.027 to 0.143 mg/m^3 (short term exposure 62.2 mg/m^3), and for grinders it ranged from 0.058 to 0.451 mg/m^3 for (short term exposure 159.4 mg/m^3) when workers were handling both engineered stone and granite. Higher exposures were experienced by workers using compressed air to clean and dry the stone[46].

A variety of exposure control measures are available but wetting the materials to prevent airborne dust has been shown to be most effective but must be performed following specific protocols to be reliable (discussed below). In a study comparing wet and dry processes in companies manufacturing granite bench tops, the 8-hr TWA during dry processes (grinding, cutting, and polishing) ranged from <0.04-0.77 mg/m^3. During similar activities at companies that used wet processes, the exposures were an order of magnitude lower. They ranged up to 0.09 mg/m$^{3.}$ Such exposures are likely to be above the new SWA WES[47].

Consequently, more than one control measure e.g. wet cutting and LEV is likely to be needed to reduce exposure adequately in the engineered stone industry, especially for previously silica- exposed workers, with no or minimal clinical signs of disease, are to be able to continue in return to this form of work[48].

The US National Institute of Occupational Safety and Health (NIOSH) carried out a survey of a benchtop making facility, where approximately half of their materials were engineered stone and half were natural stone, mainly granite. The full-shift TWA respirable crystalline silica exposures ranged from Not Detected to 0.140 mg/m^3. The full-shift exposures when using the pneumatic wet grinders with diamond cup wheels during the final polishing stage of production were all at or above the NIOSH Recommended Exposure Limit (REL) TWA of 0.05 mg/m^3. NIOSH recommended the use of LEV in combination with wet methods for cutting, grinding, and polishing, and very high exposure tasks such grinding with diamond cup wheels (even wet grinding), should be carried out inside a negative pressure enclosure with high-efficiency air filtration[49].

Another study also showed that more than one control measure was necessary when cutting engineered stone. Investigators measured 44.6 mg/m^3 of RCS when during uncontrolled dry cutting of engineered stone for 30 minutes. The mean quartz content of the respirable dust was 58.5%. When various control measures were applied, the range of respirable quartz exposures were as follows, wet blade alone: 1.87-4.85 mg/m^3; wet blade plus water curtain: 0.92-3.41 mg/m^3; and wet blade plus LEV: <0.12-0.20 mg/m^3. The wet methods reduced exposure by an order of magnitude but additional controls were needed to reduce exposure to below the current WES[45].

Other studies, discussed below, show that wet methods result in reductions in silica exposure in the construction industry, but these studies did not include handling engineered stone.

In 2001 NIOSH measured airborne respirable dust at a construction site. The personal samples had a mean exposure of 53 mg/m³ (27 to 125 mg/m³) (n=5). During wet cutting, 15 of the 17 area respirable dust concentrations were non-detectable, and two samples had a concentration of 0.3 mg/m³. Personal air samples were 0.3 mg/m³ and 0.7 mg/m³. The report states "It is clear from the results presented above that dry cutting should be avoided because of the risk it poses to both the operator and nearby workers. At dry cutting dust levels, it takes only minutes to exceed the OSHA crystalline silica (quartz) Permitted Exposure Limit (PEL). In contrast, wet cutting results in a considerable reduction in exposures to dust."[50].

Silica exposure of construction industry labourers was reduced to one third when wet dust suppression was used [51], and when wet compared to dry cutting of sandstone with an angle grinder[52]. Dry hand sawing of a concrete floor resulted in exposures of between 3.2 and 14 mg/m^3 respirable quartz, whereas using a walk-behind saw which incorporated water resulted in largely undetectable levels of silica[53].

Attention must be paid to the type of wet controls. In brick cutting, low-misting nozzles reduced the respirable mass fraction of dust by about 63%, medium-misting nozzles by about 67%, high-misting nozzles by about 79% and freely flowing water by about 93%[54].

Some studies have also looked at the use of ventilation to control exposure in addition to wet methods. A study in the construction industry grinding concrete with hand held grinders stated that "to reduce silica exposure to acceptable levels" control measures (LEV and respirators) should be combined with "sound work practices such as working up wind and wet methods" [55].

Data were reported in 1999 from a lab and field study of dust suppression systems for cut-off saws in the construction industry. Over 15 minutes of cutting a paving slab with a silica content of 20%, respirable silica dust concentrations were a mean of 2.4 and 1.3 mg/m^3 respirable silica (2 different blades) in dry cutting to <0.6 mg/m^3 and <0.3 mg/m^3 when using wet methods. Respirable dust levels were reduced by at least 90 percent. The use of LEV also reduced exposure significantly [56].

A 2006 NIOSH report investigated dry cutting of cement tiles. Sixteen full-shift personal breathing zone air samples for respirable dust and silica were collected. The respirable crystalline silica exposure results showed that 88% (14 of 16) of the employees' levels exceeded the NIOSH REL TWA of 0.05 mg/m^3 and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 0.025 mg/m^3 8-hour TWA and 75% (12 of 16) exceeded the OSHA PEL for respirable silica. The total dust exposures ranged from 0.68 mg/m^3 to 13 mg/m^3. The respirable dust exposures ranged from 0.23 mg/m^3 to 2.3 mg/m^3. The company being investigated were advised to use dust control measures including wet cutting, LEV and respiratory protective equipment (RPE) [57].

These findings demonstrate that current control measures in many different industries using several types of silica containing materials (not just engineered stone), often don't keep RCS exposures below the previous WES of 0.1 mg/m^3 and would have great difficulty in consistently complying with the reduced WES to 0.5 or 02 mg/m^3. Therefore, it would be unsuitable for workers with a medium to long past history of exposure, especially involving dry cutting, or early x-ray findings in asymptomatic workers to be able to return to such workplaces.

In conclusion, the demonstrated difficulties with control of RCS exposure in workplaces using artificial stone and the halving of the WES for RCS will make it challenging for workers to RTW in their usual workplace. Therefore, it is very likely that the only option available will be to RTW in another type of workplace which is compatible with their respiratory function and other considerations, such as mental health status.

The situation where exposure has been high, so workers are at increased risk, yet not showing any abnormalities currently.

No evidence or recommendations of modification of work duties based on previous silica exposure history was identified in the published or grey literature identified in our search. For this group, workplace exposure controls should be the same as for other workers and in keeping with relevant regulations. Those that have been identified with high level previous exposure will require a higher level of prospective respiratory health screening for workers not yet diagnosed with silicosis than those with low level exposure, especially given the often rapid rate of progression which will very likely impact on their vocational options.

Fact sheets and other guidance from Sate Government and other bodies

The identified silicosis grey literature contains a large number of fact sheets, guidance material, including for health surveillance, Safety Alerts, checklists, bulletins and other similar documents produced by each Australian State and territory jurisdiction. Similar documents were identified from a number of Australian health and medical organisations (Lung Foundation Australia, Cancer Council of Australia, Thoracic Society of Australia and New Zealand (TSANZ), Royal Australasian College of Physicians (RACP) and the Australasian Faculty of Occupational and Environmental Medicine (AFOEM). Similar guidelines and fact sheets have also been identified from international organisations. All these guidelines etc are listed in Appendix 3. These resources inform employers and workers about risks of exposure to RCS, mitigation strategies and health monitoring. There is a lot of duplication in the documents, which mainly focus on risk factors for the disease, control measures, air sampling and medical assessment, but there is almost no guidance on vocational assessment and RTW outcomes for workers at risk of, or diagnosed with, silicosis. In some jurisdictions where English is more commonly not the first language of silica exposed workers, this information is available in languages other than English.

Chapter 4: Discussion, Conclusions and Implications

4.1 Discussion

This review sought to find information in recent published and grey literature to inform a return to work strategy, policy and practice that will provide the best possible support for Queensland workers at risk of silicosis, or diagnosed with silicosis, to return to the workforce.

Addressing the study aims, we found both national and international information about activities, occupations and industries outside the stone mason industry that were likely to be associated with the generation of RCS. There was information on exposure and controls in the engineered stone industry and about medical assessment for RCS-exposed workers.

While there is some research documenting mental health issues in workers with silicosis, there is a clear gap in evidence about the best strategies and programs to support the mental health of workers with silicosis and this can potentially be a barrier to return to work. This is an important gap as these workers face the stresses of uncertain disease progression and potential unemployment. Of the few articles available that addressed mental health in these workers, all reported an elevated prevalence of anxiety and depression. These articles did not have a focus on the best strategies to address mental health problems in silicosis workers.

There is almost no guidance on vocational assessment and RTW outcomes for workers at risk of, or diagnosed with, silicosis, either in the peer-reviewed literature or in the grey literature. The management of return to work in such workers was not explicitly discussed in any articles identified in this review. The main focus of virtually all of the literature included in the review was screening, diagnosis and exposure levels.

Neither retraining options and processes, nor managing return to work of workers with different stages of disease progression were the focus of any published or grey literature identified through searches, highlighting a current lack of useful evidence to inform strategies to address these important issues. Several articles provided details of diseases that are frequently found in conjunction with silicosis, illustrating the importance of consideration of occupational history, particularly of men, who present with renal disease, autoimmune disease or other diseases associated with silicosis. The presence of any of these conditions is potentially a further barrier to return to work.

The overwhelming conclusion of this review is that there is a paucity of both published and grey literature available to inform return to work policy or practice specifically tailored to the needs of:

- the worker with silicosis,
- asymptomatic workers with a previous history of silica exposure or
- those with associated disease.

Workers with accelerated silicosis are often considerably younger than those who developed chronic silicosis from silica exposure in other industries, so vocational assessment and considerations of return to work outcomes are more important in this group of workers, as they have a much longer time from diagnosis to usual retirement age.

While research output and policy and guidance development regarding the nature and prevention of silicosis is available from a variety of sources, very few articles discuss the patient's future management and care, including vocational assessment and return to work options. The recently released National Return to Work Strategy[33] provides a general framework, but does not address specific issues relevant to a worker who has silicosis. Until there is evidence of safety at different levels of silica exposure, the default approach for those with silicosis or at high risk of developing silicosis is "prudent avoidance"[12] and support of the informed choice of the worker. An informed choice would include information relevant to the risks of returning to the worker's previous silica exposed job or other jobs where silica exposure is known to occur.

What is clear from the available occupational hygiene data is that it will be challenging for workplaces using engineered stone to achieve safe air levels for workers diagnosed with silicosis and therefore return to work in their previous job is not likely to be a safe option. Because of the likelihood of rapid progression, prudent avoidance is the best option for people already diagnosed. Health workers coordinating with the worker their return to work options need to follow the RTW principles outlined in the HBGW Statement and the National RTW Strategy.

This may be particularly problematic for those workers who have more than a few years of exposure and are asymptomatic but who have very minor x-ray changes. There is some evidence to suggest that there may be a tendency to keep this information hidden for fear of losing wages, when looking for alternative work[31]. It has been suggested that workers who may have some early changes on x-ray may be reluctant to participate in further health monitoring due to anxiety about potentially adverse findings and the impact of these on future employment[43]. This anxiety could be alleviated through effective communication, easier access to monitoring and assurance that the purpose of further monitoring is to protect their health[43].

The young age of those affected by accelerated silicosis and the fast rate of progression are likely to result in more years of life lost due to early death, more years of living with a disability, greater psychosocial effects, greater impact on young families, and a greater economic cost to the worker and to the community compared to the typical chronic silicosis patient who are older and mostly retired[2,3]. Therefore, RTW is particularly challenging for these workers and in the absence of specific evidence-based guidance on vocational assessment for workers with silicosis, the health benefits of returning to good work need to be a prime focus.

4.2 Conclusions

The major conclusions of this study are that:

1. There is little if any peer-reviewed or grey literature available to inform return to work policy or practice which is specifically tailored to the needs of the workers with silicosis, asymptomatic workers with signs of disease, or those with other silica-associated diseases.

2. More research is needed to inform many aspects of return to work and vocational rehabilitation for workers diagnosed with silicosis, including management of their mental health needs, and retraining options and processes at the individual and systems level. Follow up of the cohort of Queensland workers with silicosis will help to inform this evidence-base.

3. Based on published findings prior to introduction of the Code, the severe, progressive and incurable nature of silicosis requires urgent reduction of exposure to respirable crystalline silica in the engineered stone benchtop industry to comply with the Code and the reduced WES for RCS and ensure the workplace is safe for workers with silicosis. Strategies for the management and return to work of workers with silicosis need to be developed now, based on general return to work principles and clinical experience, while waiting for the results of return to work research for workers with silicosis to become available.

To summarise, this review has found the following to address the two main questions and

1) What particular issues arise for workers in the stonemason industry with respiratory conditions returning to work compared with other workers including?

There are many jobs outside of artificial stone workplaces which should be avoided, either because of RCS exposure, exposure to other respiratory toxins or the work environment or demands of the job are not compatible with reduced respiratory function.

The mental health impacts has been shown to be an important consideration in RTW of workers with silicosis and it is important that this aspect of an affected worker's health is appropriately assessed in the RTW process.

While not specifically addressed in the body of literature relating to workers with silicosis, retraining options and processes at an individual and system level need to follow established principles, such as those set out in the Return to Work Strategy and the Health Benefits of Good Work.

A particularly difficult group to manage regarding RTW comprises those workers with a history of some years of exposure, but who are asymptomatic and are yet to develop clear cut changes consistent with a diagnosis of silicosis. Given the likelihood of rapid progression to established disease, a prudent course of action should be taken with these workers.

2) How do we ensure workers with a diagnosis are returning to a safe work environment and what information is required to manage their return to work?

Vocational assessment methods for workers with silicosis need to take a holistic approach to RTW for these workers. An assessment of their respiratory capability is important, but needs to be supplemented by physical restrictions related to any other associated conditions, such as autoimmune diseases and mental health conditions. A comprehensive assessment of the proposed jobs is also important to ensure compatibility of the worker's abilities and the demands of the job.

For workplaces being considered in a RTW process for a worker with silicosis, a comprehensive occupational hygiene and safety evaluation is required. This should include air monitoring if there is RCS or other respiratory toxins present to ensure that are levels are at acceptable levels and the effectiveness of control measures.

4.3 Implications

System level considerations are also important, to ensure that all relevant stakeholders understand the specific needs of workers with silicosis, including factors relevant to a meaningful and sustainable return to work. These stakeholders include the insurers who process claims and co-ordinate RTW programs, employers, doctors and other treating health practitioners caring for these workers and vocational assessment services.

There is little evidence about what constitutes an appropriate strategy in the RTW process to support the mental health of workers diagnosed with silicosis. Anxiety and depression are likely to be a significant problem for these individuals and RTW strategies will need to take the need for mental health support into account and to ensure that such workers are able to return to sustainable and safe work, and to access the benefits of good work[15, 33].

There is a lack of evidence available to inform retraining options for workers with, or at risk of, developing silicosis. There is an urgent need for future research in this area. The likelihood is that some of these workers may have restricted vocational opportunities because of their low level of English language capability, although this is not the case with most workers with silicosis in Queensland. Information about retraining and RTW options may need to be developed in other languages to assist any workers in the sector where English is not their first language.

Little evidence is available to inform a RTW strategy for workers with silicosis, including those in the engineered stone benchtop industry.   If their consent can be secured, the follow up of a cohort of Australian workers with silicosis and documentation of the course of their disease, including return to work outcomes, is very likely to produce valuable information with which to inform this evidence base in the future.

Given that there are many workers in Queensland who have been diagnosed with silicosis at an early stage, strategies for their RTW will need to be formulated, based on general principles and clinical experience, while waiting for the relevant research (which would allow evidence-based strategies to be developed) to be carried out. In the absence of evidence, general principles of return to work, such as those described in the Safe Work Australia National Return to Work Strategy and the Health Benefits of Good Work, should inform this process[33].

It is important that any return to work program for workers at risk of, or diagnosed with, silicosis takes a multidisciplinary approach, with involvement of respiratory physicians, occupational physicians, and case managers with vocational expertise. In this way, assessment of medium term clinical prognosis, of worker expertise and capacity, and of any requirements for retraining and support programs, can be incorporated into the return to work plan for each individual worker.

Appendix 1: Search strategy for database searches

Search Number	Search statement
1	Return to Work/
2	(resum* adj3 (work* or employment)).mp.
3	Rehabilitation, Vocational/
4	(back adj2 (work* or employment)).mp.
5	(return* adj3 (work* or employment)).mp.
6	(vocational adj (rehab* or assess*)).mp.
7	disability evaluation/ or work capacity evaluation/
8	(work adj (abilit* or disabilit* or capacit* or incapacit*)).mp.
9	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10	silicosis/ or anthracosilicosis/
11	(silicosis or pulmonary fibrosis).mp.
12	10 or 11
13	9 and 12
14	silicon dioxide/ or quartz/
15	(silica or silicon dioxide or crystalline silica).mp.
16	14 or 15
17	9 and 16
18	(stone benchtop or artificial stone or engineered stone or quartz conglomerate).mp.
19	9 and 18
20	13 or 17 or 18
21	limit 20 to (english language and yr="2000 -Current")

/ = MeSH subject heading
.mp. = text words

Appendix 2: Summary of relevant findings in peer-reviewed literature

First author (year), country	Type of study/paper	Aim of the paper	Relevant findings
Reviews			
Leso, V (2019)[7] Italy	Systematic review (n=8 studies)	To verify an association between artificial stone derived silica and silicosis, to characterise the disease, and to identify research gaps	Most studies were observational, but circumstantial evidence suggests a cause-effect relationship between exposure to artificial stone derived silica and silicosis. A general lack of suitable strategies for assessing or managing silica risks in the artificial stone industry is apparent. Further research is needed to assess characteristics of silica dust, levels of exposure and effectiveness of protective equipment to inform preventive strategies.
Edwards, G (2019)[3] Australia	Comment and Case series (n=99)	To comment on Leso, V etal[23] 2019, and to present details of a series of cases of silicosis identified in Queensland.	Comment: The review of Leso et al[23] highlights the lack of data required to inform both occupational health risk management and clinical management of workers exposed to respirable silica dust. Brief outline of current program to screen for cases of silicosis among workers in the engineered stone bench-top fabrication industry in Queensland was described. A total of 99 cases of silicosis associated with engineered stone work have been identified to February 2019, nearly all of whom were asymptomatic. Pooled data from these cases will be used to develop an index of exposure to trigger health monitoring using low-dose chest high-resolution CT.
Epidemiological studies			
Ophir, N (2016)[41] Israel	Case-control study (n= 68 exposed 48 non-exposed)	To assess the effect of ultrafine particles (<1µm) in the lungs of artificial stone workers on functional, inflammatory and imaging parameters.	An association between exposure to artificial stone dust ultrafine particles and reduced pulmonary function, worsening CT results, and elevated inflammatory cytokines was demonstrated. This data will contribute to the development of a biological marker for the ultrafine particle concentrations in the airways of artificial stone workers that will serve as an index of risk of lung disease among silica exposed workers.

Si, S (2016)[25] Australia	Cross sectional survey of Australian workers aged 18 – 65 years.	To describe current occupational exposure to respirable crystalline silica, and the characteristics of those exposed, in Australia.	For 2012, it was estimated that 6.6% of Australian workers were exposed to respirable crystalline silica dust, and 3.7% were exposed to high levels of this dust in their workplaces. The most exposed occupations were miners and construction workers. The tasks that exposed these workers to the most dust were working with concrete or cement, and being near rock crushing devices.
Kramer, MR (2012)[9] Israel	Retrospective cohort study (n=25)	To describe all cases of silicosis referred to a lung transplantation centre over 14 years.	Of 25 patients, referred to a lung transplant centre from 1997 to 2010, all had worked with engineered stone used for kitchens and bathrooms. All had worked without dust suppression or PPE for an average of 10-12 hours daily. The authors conclude that strict enforcement of OHS regulation could have prevented the silicosis seen in these workers.
Case reports/case series			
Hoy, RF (2018)[2] Australia	Case series (n=7)	To describe the characteristics of the first cases of artificial stone associated silicosis in Australian workers.	All cases had worked in small businesses where their work included dry cutting artificial stone without adequate ventilation or personal respiratory personal protection. All cases were male, median 44 years (range: 26-61), median exposure 7.3 years (range: 4-10). All presented with cough and worsening dyspnoea.
Barber, CM (2018)[10] UK	Letter	Letter to Hoy, RF et al 2018,	While artificial stone benchtops, similar to those used in Australia have also been commercially available in the UK since approximately 2000, of 161 cases of silicosis identified in the Surveillance of Work-related and Occupational Respiratory Disease (SWORD) registry, none were attributed to engineered stone in the UK.
Ronsmans, S (2019)[8] Belgium	Letter and Case reports (n=2)	Letter to Hoy, RF et al 2018, and Barber 2018, and description of 2 cases of silicosis reported in Belgium.	Both workers, were employed in a small company making and installing artificial stone benchtops. Dust levels in the workplace were not measured, benchtop stone was cut dry and dust mask use was rare. At diagnosis they were aged 41 and 46 years. No other cases have been identified for workers in Belgium or surrounding countries. The authors expect more cases will be diagnosed in the future.

Perez-Alonzo, A (2014)[31] Spain	Case series (n=46)	To describe the characteristics, and environmental circumstances of men working in the artificial stone benchtop industry in Spain, who had been diagnosed with silicosis.	All cases were male. The median age at diagnosis was 33 years (IQR: 29-37 years), with 26% of cases aged <30 years at diagnosis. Median length of employment was 11 years (IQR: 9-17 years). Most had worked in circumstance of inadequate protection from silica dust, minimal monitoring of dust levels and inadequate medical monitoring. The author suggests meagre compensation may deter workers from being screened, as a silicosis diagnosis may require them to leave their current jobs. Furthermore, few would seek other employment, as this would jeopardise the pension they do receive.
Occupations that can potentially expose workers to respirable crystalline silica			
Barber CM (2019)[18] UK	Epidemiology of registry cases (n=216)	To describe the demographic characteristics of silicosis cases reported to the SWORD registry, 1996-2017.	Of 216 cases, the mean age at diagnosis was 61 years, (range 23-89 years). 1 in six cases were aged <46 years. Cases had worked in a number of industries including mining, quarrying, ceramics, brickworks, foundry, construction, stonemasonary, and tunnelling. Two cases of silicosis each were reported of dental workers and jewellery workers. No cases of silicosis were identified in workers who had worked with artificial-stone.
Akgun, M (2015)[23] Turkey	Cohort study (n= 83)	To reassess the demographic and pulmonary function characteristics of a cohort of former denim sandblasters, initially identified in 2007.	Of the 145 sandblasters assessed in 2007, 83 were reassessed in 2011. Of these, 9 had died at a mean age of 24 (range: 18-29) years. Prevalence of silicosis in the remaining group had increased from 60.2% to 95.9% over the 4-year period, despite no further exposure to silica. Only one worker had no evidence of pulmonary disease. Author's conclusion: silicosis continues to progress without continuing exposure to silica dust, and that almost all former denim sand blasters will develop silicosis.
Esswein, EJ (2013)[21] US	Systematic study of workplace exposures	To assess exposures to respirable crystalline silica dust of workers at hydraulic fracturing worksites	Based on assessments for PBZ crystalline silica exposure of workers at hydraulic fracturing sites, it was concluded that respirable crystalline silica presents an occupational exposure hazard for workers in the hydraulic fracturing ('fracking') industry.

Patel, A (2017)[22] Mexico	Case report (n=1)	Silicosis in a pepper farmer.	Male, 67 years old farmer, diagnosed with silicosis, had grown pepper plants for over 30 years. Pepper plants are grown in loose, sandy soil, which may have exposed him to silica dust, leading to the silicosis. Author's conclusion: exposure to sandy soil should be considered when investigating occupational pulmonary disease.
Murgia, N (2007)[20] Italy	Cross sectional study (n= 100)	To describe the characteristics of jewellery workers exposed to silica while using chalk molds.	Of 100 jewellery workers, 23 showed signs of silicosis on examination with HRCT. Jewellery workers exposed to silica in chalk dust when using chalk molds for casting, are at risk of developing silicosis.
Rosenman, KD (2004)[19] US	Case series (n=3)	To describe the characteristics of cases of silicosis in dental laboratory technicians	Dental technicians might be at risk of silicosis during procedures that generate respirable crystalline silica dust.
Mental Health of Individuals with Silicosis			
Mishali M, (2017)[26] Israel	Qualitative, interview-based study (n=25)	To understand psychological factors underlying non-compliance with safety regulations despite knowledge of dangers, in the stone and marble fabrication industry.	A range of psychological factors was found to underlie non-compliance to safety requirements despite appreciation of risk. Achieving a sustainable change in safety culture in stone-processing plants requires more than improving worker awareness. Rather, regulators and employers must demonstrate the importance of safety compliance through actions impacting on employment, freedom to operate and responsibility. No information was found that addressed the RTW focus of our study.
Han, B (2014)[29] China	Descriptive study (n=324 inpatients)	To investigate the influence of perceived social support on mental health and quality of life of silicosis patients, April to September 2011.	Over all, patients' perceptions of social support (from friends, family and significant others) were found to be low. Symptoms of anxiety and depression were present in 99.1% and 86.1% of patients respectively, higher than for other chronic diseases such as diabetes. It is suggested that improved social support may alleviate anxiety and depression in silicosis patients.

Yildiz, T (2011)[28] Turkey	Cross-sectional study. (n=50 patients with silicosis, n=30 controls)	To estimate quality of life, depression and anxiety in workers with silicosis due to denim sandblasting.	Psychiatric symptoms, including depression and anxiety, may contribute to a reduced quality of life for silicosis patients.
Wang, C (2008)[27] China	Cross-sectional study. (n=121 with silicosis, n=101 controls)	To compare the prevalence of depressive symptoms in patients with and without silicosis.	The authors report that 27.3% of silicosis patients (former miners, aged ≥60 years) identified though an industry based registry in China showed evidence of depressive symptoms (measured using the Beck Depression Inventory) compared to 7.3% of controls[27]. Depressive symptoms were positively associated with severe respiratory symptoms and poor physical function, (defined as Forced Expiratory Volume in 1 second (FEV_1) <50% predicted and Forced Vital Capacity (FVC)% <mean predicted, based on age and height).
Petrucci, L (2007)[30] Italy	Descriptive study (n=151 thoracic organ transplant patients)	To evaluate the rate of return to work after transplantation and its determinants in patients at a single facility in Italy	Of 151 thoracic organ transplant patients, 131 (87%), had worked previously. Of these patients, 51 patients (39%) went back to work and 3 more started working. It was determined that younger age, a better quality of life and mental health, having had an occupation, and having been off work for less than 24months, were independent predictors of return to work.
Conditions associated with silicosis			
Rose, C (2019)[34] USA	Case series (n=18)	MMWR report Surveillance of Silicosis among engineered stone workers	Of 18 confirmed cases of silicosis, 16 had worked with engineered stone and 2 had participated in workplace housekeeping activities. Two were diagnosed with tuberculosis and 5 had a concurrent autoimmune disease (1 x scleroderma, 4 x rheumatoid arthritis). It is important that an occupational history is taken for patients diagnosed with an autoimmune disease.

Shtraichman O (2015)[35] Israel	Clinical series of cases of advanced silica-related lung disease (n=40)	To determine the extent and range of autoimmune comorbidities in a population with advanced silica-related lung disease.	Of 40 cases, 9 (23%) were found to have signs and symptoms consistent with various autoimmune diseases, representing a 7-fold excess of that expected when compared with European data. All cases were male, and had been exposed to silica while working with artificial stone. This study highlights the importance of considering autoimmune disease as a possible co-morbidity in patients with silicosis, and of considering the occupational history of patients with autoimmune disease.
Millerick-May, ML (2015)[13] Michigan, USA	Cross-sectional study of cases of silicosis, (n=1072)	To determine the prevalence of kidney disease in individuals with confirmed silicosis, 1987 – 2009.	Of the study cohort, 24% had an indication of renal disease in their medical records. The prevalence of renal disease of individuals with a confirmed diagnosis of silicosis was higher than that of the general US population. The authors concluded that adverse effects of silica are not confined to the respiratory system.

Djebbar, A (2015)[36] Algeria	Case series (n=71) (Conference abstract)	To describe clinical characteristics of stonecutters in Eastern Algeria diagnosed with silicosis.	Silicosis of young male stonecutters, was characterised by a high rate of complications including tuberculosis, pneumothorax, respiratory infection, chronic pulmonary health disease, renal disease, and autoimmune disease. Multidrug-resistant tuberculosis occurred in 11 cases, 5 of whom subsequently died of this condition. Autoimmune diseases were reported to have progressed rapidly.
Makol, A (2011)[37] Michigan, USA	Cross-sectional study of silicosis cases, (n=790)	To determine the prevalence of Connective Tissue Disease (CTD) among people with confirmed silicosis, 1995-2006.	When compared with the general population, people with confirmed silicosis had an increased risk of developing rheumatoid arthritis (two to seven fold), scleroderma (28 fold), and anti-neutrophil syndrome associated vasculitis (25 fold). Rheumatoid arthritis was the most common CTD, followed by scleroderma. A vast majority of the cohort (98%) were men. Silica exposure should be considered as a possible risk factor for men presenting with a CTD.

Cowie, RL (1994)[38] South Africa	Cohort study over 7 years (n=1,153 gold miners)	To quantify the elevated risk of tuberculosis in subjects with silicosis	Over the seven year period, a routine mine tuberculosis surveillance program for tuberculosis found the annual incidence of tuberculosis to be 981/100,000 in the 335 men without silicosis and 2,707/100,000 in the 818 men with silicosis. The relative risk for tuberculosis was 2.8 (95% CI, 1.9 to 4.1) for men with silicosis compared with that of men without silicosis. This study has confirmed the high risk of tuberculosis in men with silicosis.
Poinen-Rughooputh S, (2018)[39] China	Metanalysis	To review the epidemiologic evidence of a relationship between occupational silica exposure and risk of lung cancer	The meta-analysis found evidence to support a carcinogenic role of silica in the lungs, which was more pronounced at higher levels of exposure.
Silica dust control methods			
Cooper, JH (2015)[45]	Experiment al investigatio n	To compare respirable silica dust exposures during simulated stone countertop cutting with stone saws equipped with three different types of dust suppressing attachments.	Sawing with a wetted blade in combination with local exhaust ventilation was 10 times more effective than a wetted blade alone for reducing mean respirable dust and quartz exposures. Use of a water curtain in the dust ejection path did not show a statistically significant benefit.
Akbar-Khanzadeh, F (2010)[55] USA	Experiment al investigatio n	To examine major factors influencing exposure of concrete grinding workers to silica dust and effectiveness of existing dust control methods.	No combination of factors or control methods were found to reduce an 8- hr exposure level to below the recommended criterion of 0.025 mg/m 3 for crystalline silica, indicating a need for further refinement of engineering controls, administrative controls, and the use of respirators. Concrete grinding exposes workers to high levels of crystalline dust.
Johnson, DL (2017)[48]	Experiment al investigatio n	To examine effectiveness of simple engineering controls to reduce crystalline silica exposure during cutting of engineered stone with hand tools.	On-tool local exhaust ventilation (LEV) in combination with sheet-flow wetting was found to be the most effective approach to reducing exposures to respirable dust; with this combination being more effective than each method alone.

Return to work after diagnosis of silicosis			
Vooijs, M (2015)[32] The Netherlands	Systematic review (n=9)	Review of effective interventions to enhance work participation for people with chronic diseases	More studies required to provide adequate evidence to inform a generic approach to retaining work or RTW for people with chronic disease. Weak evidence that interventions focusing on the workplace were the most effective strategies.

Appendix 3. Summary of relevant findings from Grey literature

Organisation	Selected Grey Literature	Information relevant to Silicosis Return to Work Review
AUSTRALIAN GOVERNMENT		
Federal Register of Legislation	Work Health and Safety (Abrasive Blasting) Code of Practice 2015. (accessed 19 Sept 2019) https://www.legislation.gov.au/Details/F2016L00417	According to Regulation 381, a person conducting a business or undertaking (PCBU) must not use, handle or store, or direct or allow a worker to handle or store, any substance containing more than 1% free silica (crystalline silicon dioxide) for the purpose of abrasive blasting.
Safe Work Australia	**Guidance:** Working with silica and silica containing products: National guidance material. (Sept 2019) (accessed 19 Sept 2019) https://www.safeworkaustralia.gov.au/system/files/documents/1909/national_guide_for_working_with_silica_and_silica_containing_products_0.pd f **Topic Overview:** Crystalline silica and silicosis (July 2019) (accessed 19 Sept 2019) **https://www.safeworkaustralia.gov.au/silica#overview**	The Australian workplace exposure standard for respirable crystalline silica, which must not be exceeded is 0.1mg/m^3 (eight hour time weighted average (TWA)). This exposure standard is currently under review. Building materials containing silica include: manufactured solid stone products such as stone benchtops, asphalt, cement, mortar and grout, concrete, concrete blocks, fibre cement products, bricks, drywall and some plasterboards, pavers and tiles including roof tiles. Silica dust can be produced when crushing, cutting, drilling, grinding, sanding or polishing these products. Under WHS regulations, a person conducting a business or undertaking (PCBU) has a duty to ensure the workplace standard for crystalline silica exposure is not exceeded, and to provide health monitoring to workers. The minimum health monitoring requirements for workers exposed to crystalline silica include: demographic, medical and occupational history; records of personal exposure; standardised respiratory questionnaire, standardised respiratory

		function tests, such as FEV1, FVC and FEV1/FVC; chest X-Ray full PA view (baseline and high risk workers only).
	Guidance: Health Monitoring for Exposure to Hazardous Chemicals: Guide for persons conducting a business or undertaking (2013) [**https://www.safeworkaustralia.gov.au/doc/health-monitoring- exposure-hazardous-chemicals-guide-persons-conducting-business-or-undertaking**](https://www.safeworkaustralia.gov.au/doc/health-monitoring-exposure-hazardous-chemicals-guide-persons-conducting-business-or-undertaking)	A person conducting a business or undertaking (PCBU) must ensure health monitoring is provided to a worker if their ongoing work involves handling or using hazardous chemicals, including crystalline silica. This monitoring should start before commencing work to provide a baseline for comparison with subsequent assessments, during the period of work and when the work terminates. The PCBU who engages the worker must pay all expenses associated with health monitoring. Workers must be told of any health monitoring requirements before commencing work, and must be consulted regarding the selection of the registered medical practitioner who will conduct the health monitoring. They must receive a copy of any health monitoring results. If ongoing monitoring reveals an illness, the health monitoring report will include advice about continuing work with that particular chemical, any need for reassigning a worker to a different work area with no exposure, and any need for counselling. Return to work may require assignment to a different work area where there is no exposure to the chemical. Health monitoring records for all workers must be kept for at least 30 years.

	Strategy: National Return to Work Strategy 2020 - 2030 https://www.safeworkaustralia.gov.au/national-return-to-work-strategy- 2020-2030 (accessed 20 Oct 2019)	Provides a broad evidence based frame work that can be used to optimise worker recovery and capacity. Guiding Principles of the framework acknowledge that return to work process should not exacerbate existing conditions or create new ones, and that psychological factors may affect the process. No specific information about return to work and silicosis.
AUSTRALIAN STATE AND TERRITORY GOVERNMENTS		
Australian Capital Territory		
WorkSafe ACT	**Guidance Note:** Crystalline silica dust (March 2019) (accessed 19 Sept) https://www.accesscanberra.act.gov.au/app/answers/detail/a_id/4646/k w/silica	Provides guidance on the nature and health impacts of inhaling silica dust, health monitoring, exposure standards, activities that increase risk, and how to manage the hazard. Workers are advised to ensure they have received training and have the correct equipment. They should wear appropriate respiratory protection which requires them to be clean- shaven, and not smoke. No information about return to work and silicosis.
New South Wales		
SafeWork NSW	**Technical fact sheet:** Crystalline silica (2019) (accessed 19 Sept 2019) https://www.safework.nsw.gov.au/resource-library/hazardous-chemicals/crystalline-silica-technical-fact-sheet	Multi-lingual resource provides information about crystalline silica, sources of exposure, health effects, control methods, health monitoring regulation. No information about return to work and silicosis.

icare	**Fact sheet:** Crystalline silica – Frequently asked questions (2019) (accessed 7 Oct 2019) https://www.icare.nsw.gov.au/news-and-stories/reducing-worker-risks- for-silica/	Outlines work activities involving silica that require health monitoring, including: 1. Signs and symptoms of silicosis: could include cough, breathlessness, and tiredness. A worker may have no symptoms despite early changes evident on x-ray. Ceasing exposure to silica dust decreases risk of developing progressive disease. 2. What happens if a worker develops a work-related silica disease: Will be guided by the examining doctor. Actions that can be taken include deciding if the worker needs to be reassigned to a different area where exposure to silica will not occur. Any concerns about ongoing health can be discussed with the examining doctor.
State Insurance Regulatory Authority	Guidelines for workplace return to work programs, 2019 (accessed 16 Dec 2019) https://www.sira.nsw.gov.au/__data/assets/pdf_file/0008/574397/Guidelines-for-workplace-RTW-programs-Nov-19.pdf	Provides guidelines for return to work programs for employers, workers and other stakeholders, in accordance with NSW Workers Compensation legislation. The guidelines acknowledge the need for an individual plan developed in consultation with the worker, and that some workers may not be able to return to their pre-illness/injury workplace. The document includes a return to work program checklist, and a sample standard return to work program.
Northern Territory		
NT WorkSafe	**Bulletin:** Silica dust in the workplace - Information for business owners and managers (2019). https://worksafe.nt.gov.au/forms-and-resources/bulletins/silica-dust-in- the-workplace-information-for-business-owners-and-managers	Under the Northern Territory's no fault compensation scheme, a worker who acquires a silica-related disease during the course of employment, may be eligible to claim for entitlements including: payment of medical and associated expenses weekly payments of income maintenance while unable to work rehabilitation services assistance to return to work
Queensland		
Workplace Health and Safety Queensland	**Code of practice:** Managing respirable crystalline silica dust exposure in the stone benchtop industry. Code of Practice 2019 (accessed 15 Oct 2019) (To commence on 31 October 2019)	Provides practical guidance including controlling respirable silica dust risks, installing stone benchtops, training and health monitoring: Uncontrolled dry cutting or processing of engineered

	https://www.worksafe.qld.gov.au/ data/assets/pdf_file/0005/181940/M anaging-respirable-crystalline-silica-dust-exposure-in-the-stone-benchtop-industry-Code-of-Practice-2019.pdf	stone or natural stone is prohibited. A PCBU that fabricates stone benchtops must undertake air monitoring; details of timing, methods, and worker groups to be tested are described A PCBU must ensure health monitoring is available for workers engaged in fabrication, processing and installation of stone benchtops, and for those who are regularly exposed to RCS. Some workers may be reluctant about being screened, as they are anxious about ramifications of a positive diagnosis. They should be encouraged to participate to ensure an early diagnosis. If test results indicate disease, the health monitoring report should include recommendations about whether or not the worker can continue employment where they are.
	Website: Can I keep working as a stonemason? 2019 (accessed 21 Oct 2019) **https://www.worksafe.qld.gov.au/silicosis/diagnosis-and-support/can-i-keep-working-as-a-stonemason**	If a medical practitioner decides it is unsafe for a worker to continue working as a stonemason, WorkCover will provide assistance to help the worker find a new career, or training opportunities that they can be happy with.
Department of Natural Resources, Mines and Energy, Queensland	**Guidelines**: QGL02. Guideline for Management of Respirable Crystalline Silica in Queensland Mineral Mines and Quarries Mining and Quarrying Safety and Health Act 1999 May 2018, Version 2.0 (accessed 20 Oct 2019) **https://www.dnrme.qld.gov.au/ data/assets/pdf_file/0006/1263669/q gl02-guideline-**	Managing workers with a silica related disease: The Site Senior Executive (SSE) must ensure that a worker diagnosed with a silica related disease is protected from further exposure to RCS. In consultation with the worker and appropriate doctor, the SSE shall develop a RCS management plan which may require modifications to workplace, use of PPE or the removal of the worker from certain roles or tasks. The worker should consider alternative occupations that

	mines-quarries.pdf	do not involve exposure to substances hazardous to the lungs
South Australia		
SafeWork SA	**Fact sheet**: Support for people diagnosed with silicosis (2019) (accessed 20 Oct 2019) https://www.rtwsa.com/claims/silica-exposure-risk-for-engineered-stone- benchtop-workers	Includes information about making a work injury compensation claim, support available if the claim is accepted, and returning to work after a silicosis diagnosis: In consultation with workers, employer and medical experts, it may be decided that some people can return to their current role, others may need to seek alternative employment to avoid all exposure to silica dust. If the worker has the capacity to return to work, the Claims officer will assist identifying suitable work. This may involve referral to a job placement service.
Tasmania		
WorkSafe Tasmania	**Safety Alert:** Preventing exposure to silica from engineered stone benchtops (2019) (accessed 19 Sept 2019) https://worksafe.tas.gov.au/topics/Health-and-Safety/safety-alerts/preventing-exposure-to-silica-from-engineered-stone-benchtops	Provides information about silica, silicosis, risk controls and health monitoring. A PCBU must provide health monitoring for workers whose health may be compromised because of exposure to RCS. The PCBU must provide a copy of the health report to WorkSafe Tasmania if illness or disease is detected, or if remedial workplace measures are required. No information about return to work provided.
Victoria		
WorkSafe Victoria	**Amendment to regulations:** Occupational Health and Safety Amendment (Crystalline Silica) Regulations 2019. (In effect from 20 August 2019). **Advice:** Changes to protect Victorians working with engineered stone (August 2019).	Uncontrolled cutting, grinding and abrasive polishing of engineered stone with power tools is prohibited across the State of Victoria from 20 August 2019. A power tool must not be used to cut, grind or abrasively polish engineered stone, unless the tool has an on-tool water

	https://content.api.worksafe.vic.gov.au/sites/default/files/2019-08/ISBN-Changes-to-protect-victorians-working-with-engineered-stone-2019-08.pdf **Web site:** Crystalline silica health assessments. https://www.worksafe.vic.gov.au/resources/crystalline-silica-health- assessments	suppression device, or is fitted with on-tool dust extraction attached to a HEPA filtered dust class H vacuum cleaner (or similar system that captures the dust generated). Workers cutting, grinding or polishing engineered stone with a power tool must be provided with respiratory protective equipment that complies with AS/NZS 1716 – Respiratory protective devices. Employers must provide health monitoring if exposure to crystalline silica is likely to affect worker health. This requirement applies to all stone benchtop fabrication workplaces, unless air monitoring data shows that exposure is less than 0.02 mg/m3 TWA. Health monitoring should occur prior to employment or a new process commencing, to provide a baseline measure.
	Advice sheet: The prohibition on crystalline silica for abrasive blasting. https://content.api.worksafe.vic.gov.au/sites/default/files/2018-06/ISBN- Prohibition-on-crystalline-silica-for-abrasive-blasting-2017-06.pdf **Information sheet:** Working with engineered stone. https://content.api.worksafe.vic.gov.au/sites/default/files/2019-08/ISBN- Working-with-engineered-stone-2019-08.pdf	Materials with >1% silica must not be used for abrasive blasting in Victoria. Other materials for this are suggested. The Australian exposure standard for respirable crystalline silica dust is 0.1 mg/m3 as a TWA (time-weighted average) airborne concentration over 8 hours. This standard is currently being reviewed. WorkSafe Victoria recommends that employees are not exposed to levels above 0.02 mg/m3 as a TWA.

	Website: Dust containing crystalline silica in construction work. (2019) (accessed 23 Sept 2019) https://www.worksafe.vic.gov.au/dust-containing-crystalline-silica- construction-work	Provides guidance about composition of various types of stone, how to reduce risk during working with stone and cleaning up, maximum exposure standards and health monitoring. Health monitoring is required for employees who are exposed to silica dust at levels likely to exceed the Australian exposure standard. Where health monitoring is required, it should be completed before job placement, and at least every 2 years.
Western Australia		
WorkSafe WA	**Guidance Note:** Safe stone product fabrication and installation. 2018 **http://www.commerce.wa.gov.au/sites/default/files/atoms/files/gn_sto ne_product_fabrication.pdf** **Guidelines for appointed medical practitioners AMP):** Health Surveillance – Silica Dust (respirable crystalline) **http://www.commerce.wa.gov.au/sites/default/files/atoms/files/silica_ guidelines_hs.pdf**	Health surveillance is required for all workers exposed to respirable silica dust. This should occur at commencement of work, during employment and when leaving employment. This is to be paid for by the employer. No additional information to inform the 'return to work' review was identified. In the case of abnormal health surveillance findings, the Appointed Medical Practitioner (AMP) determines whether further exposure to silica dust should cease pending the outcome of referral to a respiratory physician. Respiratory physician advice and workplace environmental controls should be taken into careful consideration by the AMP before determining whether the worker may safely resume work in an environment which potentially exposes them to respirable silica dust and/or other hazardous dust.
Department of Mines, Industry Regulation and Safety	**Checklist:** Stone benchtop fabrication and installation – Checklist https://www.commerce.wa.gov.au/publications/stone-benchtop- fabrication-and-installation-checklist	Provides checklist for risk assessments, risk management, housekeeping and health surveillance. No additional information to inform the 'return to work' review was identified.

AUSTRALASIAN PROFESSIONAL BODIES		
Australian Institute of Occupational Hygienists (AIOH)	**AIOH Position Paper:** Respirable crystalline silica (RCS). December 2018 https://www.aioh.org.au/resources/publications1/epublications/aioh- position-paper-respirable-crystalline-silica-rcs-published-december-2018	The AIOH supports the 8-hour TWA of 0.1mg/m^3 for respirable crystalline silica, as long as worker exposures are at all times limited to as low as reasonably practicable (ALARP) below this limit.
Breathe Freely Australia. (A program of AIOH)	Controlling exposures to prevent occupational lung disease with engineered stone. (2019) (accessed 19 Sept 2019)https://www.breathefreelyaustralia.org.au/wp-content/uploads/2019/08/BFA-Silica-Dust-—Engineered-Stone-Health- Monitoring-August-2019.pdf	In jurisdictions where health monitoring is not regulated, it is recommended that health monitoring is performed when exposures are not controlled to below 50% Safe Work Australia Exposure Standard for respirable crystalline silica (8-hour TWA of 0.1mg/m^3) .
Lung Foundation Australia https://lungfoundation.com.au/	**Fact Sheet:** What is Silica? (Updated 2017) (accessed 19 Oct 2019) https://lungfoundation.com.au/wp-content/uploads/2018/09/Factsheet- Silica-May2017.pdf	Workers performing the following tasks with silica containing materials are at risk of inhaling crystalline silica dust: abrasive blasting, cutting, sawing, demolishing or disturbing, drilling, grinding, jackhammering, milling, mixing, polishing, roofing sacking or patching, sanding, scabbling, scarifying, scraping, sweeping and cleaning up, when using the following materials: Artificial (engineered)stone, asphalt, brick, cement, concrete, drywall, fibre cement products, grout, mortar, paints containing silica, plaster, refractory mortar and castables, rock, roofing tiles & pavers, soil (fill dirt and top soil), stone (including: granite, limestone, quartzite, sandstone, shale, slate), stucco and EIFS, terrazzo.
Cancer Council of Australia	**Occupational cancer risk series:** Silica dust. April 2019 (accessed 19 Oct 2019) **https://www.cancer.org.au/preventing-cancer/workplace-cancer/silica- dust.html**	Working with silica containing materials can increase the risk of lung cancer.Those at greatest risk are miners, construction workers, farmers and engineers. It is important to reduce or eliminate exposure to silica dust using the Hierarchy of Risk Controls. Smoking reduces the lung's ability to clear dust and increases the risk of lung cancer. Potentially exposed

		workers should stop smoking.
Thoracic Society of Australia and New Zealand (TSANZ)	See joint recommendations with AFOEM below	
Royal Australasian College of Physicians (RACP)	See joint recommendations with AFOEM below	
Australasian Faculty of Occupational and Environmental Medicine (AFOEM) (of the Royal Australasian College of Physicians)	**Frequently asked questions:** Accelerated silicosis (Oct 2018) (accessed 18 Oct 2019)**https://www.racp.edu.au/advocacy/division-faculty-and-chapter- priorities/faculty-of-occupational-environmental-medicine/accelerated-silicosis/faqs** **Consensus Statement on the Health Benefits of Good Work**. 2017 https://www.racp.edu.au/advocacy/division-faculty-and-chapter- priorities/faculty-of-occupational-environmental-medicine/health-benefits-of-good-work	The AFOEM of the RACP, along with the TSANZ recommend that the Australian workplace exposure standard (WES) for respirable crystalline silica be reduced from the current 0.1mg/m3 TWA to 0.025mg/m^3 TWA. This is the same as that recommended by the American Conference of Industrial Hygienists. Short term excursions over this limit must not exceed 0.25mg/m^3 over 15 minutes. All workers in the artificial stone industry must receive long term regular health surveillance. Regarding return to work of workers who have been diagnosed with accelerated silicosis, the AFOEM advice is to avoid further exposure to silica dust; and that suitability for future work is best discussed with an occupational and environmental physician. Clinical guidelines for engineered stone workers at risk of silica exposure are currently being developed. “The provision of good work is a key determinant of the health and wellbeing of employees, their families and broader society.”

INTERNATIONAL AGENCIES		
WHO: The Global Occupational Health Network (Gohnet). (accessed 20 Oct 2019)	**Newsletter:** Elimination of silicosis (2007) Gohnet Newsletter, Issue 12, 2007 https://www.who.int/occupational_health/publications/newsletter/gohnet12e.pdf	Included a series of articles focused on the elimination of silicosis. No additional information to inform the 'return to work' review was identified
International Labour Organisation (ILO) (accesses 20 Oct 2019)	**Website:** Occupational health: Silicosis (2019) **https://www.ilo.org/safework/areasofwork/occupational-health/WCMS_108566/lang--en/index.htm** **Program Outline:** Outline for a National Programme for the Elimination of Silicosis (2006). **https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_110415.pdf** (accessed 4 Oct 2019)	Main focus is elimination of silicosis. Outlines the joint ILO/WHO Global Programme for the Elimination of Silicosis (GPES), which aims to eliminate silicosis from the world. No additional information to inform the 'return to work' review was identified
European Agency for Safety and Health at Work	**Guidelines:** Agreement on Workers Health Protection through the Good Handling and Use of Crystalline Silica and Products containing it. (2019) (accessed 20 Oct 2019) https://osha.europa.eu/en/legislation/guidelines/agreement-on-workers-health-protection-through-the-good-handling-and-use-of-crystalline-silica-and-products-containing-it	This Agreement between a range of industry sectors across the EU aims to protect the health of workers exposed to respirable crystalline silica (RCS) in the workplace, minimise exposures to RCS in the workplace and increase knowledge about the health effects of RCS. No additional information to inform the 'return to work' review was identified
The European Network on Silica (NEPSI)	Workplace exposure to crystalline silica (updated May 2019) https://www.nepsi.eu/workplace-exposure-crystalline-silica	Occupational Exposure Limits in mg/m^3 8 hours TWA – Respirable dust (quartz), across 28 countries of the EU, ranged from 0.025 mg to 0.15 mg/m3 8 hours TWA.
American Conference of Government Industrial Hygienists (ACGIH)	**Press release:** Oil and Gas Extraction Workers Exposed to Respirable Crystalline Silica, July 31, 2013. (accessed 20 Oct) https://www.acgih.org/news/press-releases/press-release/oil-and-gas-extraction-workers-exposed-to-	A recent study[19] has found that respirable crystalline silica is an occupational exposure hazard for oil and gas extraction workers, particularly during directional drilling and hydraulic fracturing, (known as fracking).

	respirable-crystalline-silica	
Occupational Safety and Health Administration (OSHA) **U.S. Department of Labor**	Small Entity Compliance Guide for the Respirable Crystalline Silica Standard for Construction. (2017) https://www.osha.gov/Publications/OSHA3902.pdf	The Occupational Safety and Health Administration's (OSHA) Respirable Crystalline Silica standard for Construction (Permissible Exposure Level) is 50 micrograms per cubic meter of air (50 µg/m3) as an 8-hour time- weighted average (TWA).
American College of Occupational and Environmental Medicine (ACOEM)	No resources located	
American Lung Association	Diagnosing and Treating Silicosis (2019) https://www.lung.org/lung-health-and-diseases/lung-disease-lookup/silicosis/diagnosing-treating-silicosis.html Living with silicosis (2019) https://www.lung.org/lung-health-and-diseases/lung-disease- lookup/silicosis/living-with-silicosis.html	To keep the disease from getting worse, it is important to stay away from any additional sources of silica and other lung irritants, such as indoor and outdoor air pollution, allergens and smoke. The patient may consider counselling to discuss changing occupations. Patients with silicosis need to maintain their health by leading an active lifestyle and avoiding further exposure to silica. Tips to manage silicosis include: Avoid further exposure to silica Stop smoking Have yearly vaccinations for pneumococcal disease and influenza Be vigilant for the development of TB or other infections
Centres for Disease Control and Prevention (CDC) USA	Preventing Silicosis (2017) (accessed 25 Sept 2019) https://www.cdc.gov/features/preventing-silicosis/index.html	Provides information about crystalline silica exposure limits, and the hierarchy of controls, as applied to crystalline silica, for eliminating exposure in the workplace.
The National Institute for Occupational Safety and Health (NIOSH)	Silica, Crystalline (2013) https://www.cdc.gov/niosh/topics/silica/	Provides information about the nature of the silica hazard, exposures and health effects. Includes links to other documents discussing epidemiology of silicosis, prevention and exposure limits

California Division of Occupational Safety and Health (Cal/OSH)	**Important Update:** Respirable Crystalline Silica Standards, April2019 https://www.dir.ca.gov/dosh/respiratory-silica-FAQ.html **Hazard alert :** Employees and employers in the granite counter top fabrication industry (revised 2017) https://www.osha.gov/Publications/OSHA3768.pdf	
Canadian Centre for Occupational Health and Safety (CCOHS)	**Fact sheet**: Silicosis (2017) https://www.ccohs.ca/oshanswers/diseases/silicosis.html (accessed 1 Oct 2019)	No additional information to inform the 'return to work' review was identified
Health and Safety Executive (UK)	**Guidance:** Health surveillance for those exposed to respirable crystalline silica (RCS) (2011) http://www.hse.gov.uk/pubns/guidance/g404.pdf	Provides an outline of silicosis the disease, occupations and activities that expose workers to RCS, and details of health surveillance requirements. Regarding return to work, the article urges the employer to "Plan what you are going to do if a worker shows signs of lung disease. Make sure your employees are aware of your plans." No additional information to inform the 'return to work' review was identified
British Occupational Hygiene Society (BOHS)	No relevant resources located	

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