ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
AL	Action limit
ANA	Antinuclear antibodies
APF	Assigned protection factor
AS	Artificial stone (equivalent to ‘engineered stone’ or ‘quartz conglomerate’)
CDPH	California Department of Public Health
CNC	Computer numerical control (router)
CT	Computed tomography
CXR	Chest x-ray
D_{LCO}	Diffusion capacity for carbon monoxide
EDS	Energy dispersive spectroscopy
FEV	Forced expiratory volume
FVC	Forced vital capacity
GC-MS	Gas chromatography-mass spectrometry
GM	Geometric mean
HR	Hazard ratio
ILO	International Labour Office
LDH	Lactate dehydrogenase
LEV	Local exhaust ventilation
NS	Natural stone
NSW	New South Wales
PAH	Polyaromatic hydrocarbon
PEL	Permissible exposure limit
PMF	Progressive massive fibrosis
PPE	Personal protective equipment
RCS	Respirable crystalline silica
RD	Respirable dust
ROS	Reactive oxygen species
RP	Respiratory protection
sACE	Serum angiotensin-converting enzyme
SDS	Safety data sheet
SEG	Similar exposure group
SEM	Scanning electron microscopy
TLV	Threshold limit value
TWA-8h	8-hour time-weighted average
UFP	Ultra-fine particles
VOC	Volatile organic compound
XRD	X-ray diffraction
XRF	X-ray fluorescence

ANNOTATED BIBLIOGRAPHY

00. Methods

We have searched Web of Science and PubMed using the query “engineered stone” OR “Artificial stone” OR “Quartz conglomerate.” Titles and abstracts of the search results (n = 763) were screened for relevance, of which 144 underwent full-text review. We additionally reviewed the bibliographies of these papers to identify additional relevant articles that may not have been found in the initial database searches. This secondary screening identified 16 additional papers.

01. Field exposure studies

DeVaughn, A., Go, Leonard H. T., Cohen, Robert A., & and Shao, Y. (2025). Investigation of occupational exposure to respirable crystalline silica (RCS) among engineered stone fabricators in Chicago—A pilot study. *Journal of Occupational and Environmental Hygiene*, 22(2), 101–109. https://doi.org/10.1080/15459624.2024.2421488

An exposure study of two AS shops in the Chicago area. Investigators characterized airborne RCS concentrations using personal and area sampling and conducted a worker questionnaire and documented worker activities. Study involved eight workers, from whom nine breathing zone samples were obtained. TWA-8h ranged from 11 to 203μg/m^3, with a median concentration of 90μg/m^3 and with seven samples exceeding the PEL for RCS. AS dust samples contained higher silica concentrations (56-95%) than NS samples (30%). >90% of particles emitted from hand polishing tools were <2.5μm in diameter. No respiratory protection was observed.

Phillips, M. L., Johnson,David L., & and Johnson, A. C. (2013). Determinants of Respirable Silica Exposure in Stone Countertop Fabrication: A Preliminary Study. *Journal of Occupational and Environmental Hygiene*, 10(7), 368–373. https://doi.org/10.1080/15459624.2013.789706

An exposure study conducted in four AS shops in Oklahoma City. Shops used a mix of dry and wet methods. TWA-8h exceeded the ACGIH-TLV for all workers who used dry methods, even for only a limited time (n = 15 person-days). The GM exposures for those using dry methods extensively was 1 mg/m^3 (n = 12 person-days). Workers using automated or remotely controlled tools had much lower exposures, with TWA-8h of 0.02 mg/m^3 (n = 3 person-days). Several shops still used dry methods to a limited degree, even when reporting using only wet methods. Investigators identified dry cutting, dry grinding, and dry sweeping as the highest exposure tasks. Tasks in the middle exposure tier included dry and wet polishing, wet sawing, use of compressed air, moving pieces of stone, and washing down surfaces. The authors conclude that even limited use of dry methods may expose workers to TWA-8h above the ACGIH-TLV and that shops reporting use of exclusively wet methods may still use dry methods for limited times.

Qi, C., & Echt, A. (2016). *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation* (Nos. 375–11a). National Institute of Occupational Safety and Health. https://www.cdc.gov/niosh/pubs/surveyreports/pdfs/375-11a.pdf?id=10.26613/NIOSHEPHB37511a

An exposure study evaluating personal breathing zone RCS levels among workers in a fabrication shop in Texas in 2015. Short term, task-based exposures to RD and RCS were measured in five workers using handheld tools to polish, grind, and laminate AS. Workers used wet methods throughout. Short-term RCS levels ranged from 27.1 to 142.6 μg/m^3 for polishers and 57.8 to 450.8 μg/m^3 for grinders. The exposure difference between polishers and grinders was statistically significant. The mean short-term RCS levels for polishers was 62.2 μg/m^3 and 159.4 μg/m^3 for grinders. The short-term RCS levels for laminators ranged from 48.0 to 119.0 μg/m^3, with a mean of 90.8 mg/m^3. Initial grinding and cleaning and drying stones with compressed air produced particularly high RCS exposures. The authors conclude that wet grinding and polishing of AS may still lead to overexposure.

Qi, C., & Echt, A. (2021). *Engineering Control of Silica Dust from Stone Countertop Fabrication and Installation—Evaluation of Wetting Methods for Grinding* (Nos. 2021-DFSE-710). National Institute for Occupational Safety and Health. https://stacks.cdc.gov/view/cdc/174847

An exposure study evaluating personal breathing zone RCS levels during AS fabrication. Workers used grinders equipped with either water spray from a nozzle on the grinder, a center water feed built into the grinder, or a combination of water spray and sheet-flow wetting. Average short-term and task-based RCS concentrations were 190±105.4 μg/m^3 with tools equipped with water spray, 195±168 μg/m^3 with center-fed water, and 33.2±11.4 μg/m^3 for water spray combined with sheet-flow wetting. The investigators concluded that both water spray and center-fed water performed equally poorly, as they did not adequately wet the grinding spot. The sampling strategies used for the sheet-flow method differed from those used for the other control strategies; therefore, the results cannot be directly compared. However, the authors note a previous experiment that showed sheet-flow significantly reduces exposures to RD ($p = 0.026$) and RCS ($p = 0.002$).

Qi, C. (2024). *Investigation of Ventilation Engineering Controls for Stone Countertop Fabrication* (Nos. 2024-DFSE-1618). National Institute for Occupational Safety and Health.

An exposure study conducted during three site visits to an AS fabrication shop in the US. Engineering controls were configured differently for each of the three visits: Settings 1 and 3 deployed four dust extractors in the final grinding/polishing areas, while Setting 2 deployed five. Settings 2 and 3 additionally had a designated dust extractor booth for grinding, while Setting 1 performed grinding in an area farther away from the dust extractors. The three settings also used wet floor cleaning at different frequencies. Breathing zone air samples of RD and RCS were obtained among workers using grinding and polishing tools, and area samples were also collected. Setting 2 showed significantly reduced RD ($p = 0.002$) and RCS ($p = 0.007$) concentrations in area samples and in RD ($p = 0.007$) and RCS ($p < 0.001$) exposures for grinding. Exposures for grinding were below the OSHA PEL; however, neither Setting 1 nor Setting 2 appeared to reduce exposures for polishing, with TWA-8h RCS exposures still near the OSHA PEL under both settings. Setting 3 had elevated RD concentrations in area samples relative to Setting 2, with comparable levels of RD generated during grinding; however, Setting 3 had significantly lower RD ($p < 0.001$) and RCS ($p = 0.031$) produced during polishing than Setting 2, and all RCS concentrations were under the OSHA AL. The authors suspect this was due to a combination of the engineering controls used and the low silica content in the products fabricated during the visit. The most effective combinations of engineering controls were: 1) designing dust extractors for grinding as evaluated in Settings 2 and 3; 2) training workers to position themselves and workbenches consistently within the dust extractor's hooded enclosure as evaluated in Setting 3. This combination of controls consistently maintained individual RCS exposures below the PEL for grinding and polishing tasks.

Salamon, F., Martinelli, Andrea, Vianello, Liviano, Bizzotto, Rosana, Gottardo, Ottorino, Guarnieri, Gabriella, Franceschi, Antonia, Porru, Stefano, Cena, Lorenzo, & and Carrieri, M. (2021). Occupational exposure to crystalline silica in artificial stone processing. *Journal of Occupational and Environmental Hygiene*, 18(12), 547–554. https://doi.org/10.1080/15459624.2021.1990303

A cross-sectional quantitative exposure study of four AS fabrication shops in Italy. Shops ranged in size from six to 65 employees. Investigators collected personal samples on 51 subjects for duration of 8-hour shift. Three of four shops worked primarily with AS, while the fourth worked with ceramics. Highest levels of RCS were found among workers doing manual processing, with dry processing exposures significantly higher than wet processing (water fed) exposure (0.352 mg/m^3 v. 0.082 mg/m^3; $p = 0.0216$). The shop using a combination of dry and wet processing for manual processing had lowest RCS levels (0.007 mg/m^3 compared to 0.021-0.046 mg/m^3 for other shops). 21.6% and 13.7% of samples were over AL and PEL, respectively. Authors note variable efficacy of extraction booths and aspirated benches. Both controls require workers to properly position themselves and equipment for optimal protection;

however, workers may instead work from a portion of the stone that is either far from the air duct or between the stone and the duct, limiting the protective effect.

Seneviratne, M., Shankar, K., Cantrell, P., & Nand, A. (2024). Respirable Silica Dust Exposure of Migrant Workers Informing Regulatory Intervention in Engineered Stone Fabrication. *Safety and Health at Work*, 15(1), 96–101. https://doi.org/10.1016/j.shaw.2024.01.003

A cross-sectional qualitative and quantitative exposure study of six randomly selected fabrication shops in Sydney, Australia conducted in 2017. 34 workers were surveyed for six hours over a single shift, with three SEGs identified among the workers: 1) wet cutting with bridge saw or CNC; 2) dry finishing with hand-held tools; 3) polishers using water-fed pneumatic tools. All shops used similar tools but varied in their use of wet methods. All measurements were taken in the shop, rather than on-site. 79% of workers were exposed above the Australian TWA-8h PEL (0.1 mg/m^3). Workers using wet methods who were exposed over PEL tended to work close to the water spray. LEVs were poorly designed and poorly maintained. Most workers who used wet cutting did not wear PPE.

Soo, J.-C., Houlroyd, J., Warren, H., Philpot, B. J., & Castillo, S. (2025). Respirable dust and respirable crystalline silica exposures among workers at stone countertop fabrication shops in Georgia from 2017 through 2023. *Annals of Work Exposures and Health,* wxaf014. https://doi.org/10.1093/annweh/wxaf014
A worker exposure study conducted at 11 stone fabrication shops in Georgia. Investigators used sampling data to identify SEGs for tasks involved in stone fabrication and used Bayesian decision analysis (BDA) and the AIHA Industrial Hygiene Data Analyst (AIHA-IHDA) tool to project the needs of different SEGS for APFs of RP equipment. Four SEGs were identified: 1) support; 2) automated tool operator; 3) small tool operator; 4) fabrication/lamination. Of 75 full-shift personal air samples, 53% exceeded the PEL. BDA and AIHA-IHDA analysis of exposure data found that all employees involved in AS fabrication processes, including workers in the support SEG, should wear a respirator with an APF of 10, regardless of the engineering controls in use. Fabrication/lamination workers should use respirators with APF between 50 and 1,000.

Surasi, K., Ballen, B., Weinberg, J. L., Materna, B. L., Harrison, R., Cummings, K. J., & Heinzerling, A. (2022). Elevated exposures to respirable crystalline silica among engineered stone fabrication workers in California, January 2019–February 2020. *American Journal of Industrial Medicine*, 65(9), 701–707. https://doi.org/10.1002/ajim.23416

An exposure study including 152 employees at 47 workplaces in California, which investigated RCS exposures and employer compliance with Cal/OSHA RCS and respiratory protection standards. 38 employees (25%) had exposures over the PEL (median exposure = 0.09µg/m^3). 17 employees (11%) had exposures between the AL and the PEL. 24 workplaces (51%) had at least one exposure over the PEL, and 34 workplaces (72%) were cited for at least one respiratory protection standard violation. The authors concluded that there is widespread overexposure to RCS among workers and numerous employer violations of Cal/OSHA standards.

Weller, M., Clemence, D., Lau, A., Rawlings, M., Robertson, A., & Sankaran, B. (2024). An assessment of worker exposure to respirable dust and crystalline silica in workshops fabricating engineered stone. *Annals of Work Exposures and Health*, 68(2), 170–179. https://doi.org/10.1093/annweh/wxad072

An exposure study of 27 workshops in Australia that characterized worker exposure to RD and RCS following a 5-year program of inspections and awareness building. All workshops in the study used wet methods for fabrication. The pooled GM TWA-8h for RD and RCS were 0.09

mg/m^3 and 0.034 mg/m^3, respectively. Workers using pneumatic hand tools for cutting or grinding/polishing experienced the highest TWA-8h (0.062 mg/m^3), while those experiencing the lowest TWA-8h operated semi-automated routers and edge polishers (0.022 mg/m^3 and 0.013 mg/m^3, respectively). The GM RCS/RD ratio ranged from 0.31 to 0.56, which is high relative to those found for several other construction materials (0.2 or less). The authors concluded that while these exposure levels are significantly lower than those observed with dry cutting methods, the levels remain above the PEL of 0.05 mg/m^3; therefore, additional control measures are needed to provide adequate worker protection.

Zwack, L. M., Victory, K. R., Brueck, S. E., & Qi, C. (2016). *Health Hazard Evaluation Report* (Nos. 2014-0215–3250). National Institute for Occupational Safety and Health.

A two-day exposure investigation conducted by NIOSH at a 38-employee fabrication plant in Texas that worked with both AS and NS. NIOSH obtained 36 full-shift personal air samples and 28 task-based air samples. All tools were equipped with controllable water flow. All employees used appropriate personal respiratory protection. Full-shift exposures of employees using pneumatic wet grinders with diamond cup wheels to polish finished slabs were at or above the OSHA PEL and ACGIH-TLV. None of the other employees for whom data were collected were above the PEL, even polishers using resin-bonded discs. Other employees did have exposures above the ACGIH-TLV. The authors concluded that wet grinding both AS and NS and wet polishing AS can lead to high task-based exposures.

02. Engineering control efficacy studies (controlled environments)

Cooper, J. H., Johnson, D. L., & Phillips, M. L. (2015). Respirable Silica Dust Suppression During Artificial Stone Countertop Cutting. The Annals of Occupational Hygiene, 59(1), 122–126. https://doi.org/10.1093/annhyg/meu083

A characterization of the relative efficacy of three controls strategies in reducing RCS exposure during AS cutting with a handheld circular saw. Tests were conducted in a 24m^3 unventilated tent. Investigators used a saw fitted with different dust controls to make 6-mm and 3-mm deep cuts in 85% quartz AS and compared dry cutting, normal water feed to the front edge of blade, water-fed blade plus a 'water curtain' that ran normal to the saw's path, and water-fed blade plus LEV. Dry cutting produced RD and RCS concentrations of 69.6 and 44.6 mg/m^3, respectively. Cutting with a water feed produced RD and RCS concentrations of 3.54-7.51 and 1.87-4.85 mg/m^3, respectively. Cutting with a water feed plus curtain produced RD and RCS concentrations of 1.81-5.97 and 0.92-3.41 mg/m^3, respectively. Cutting with water feed plus LEV produced RD and RCS concentrations of 0.20-0.69 and <0.12-0.2 mg/m^3, respectively. The authors conclude that sawing with a wetted blade plus LEV most effectively reduced RD and RCS exposures compared to other options, with a 10-fold improvement over the wet-feed only condition.

Johnson, D. L., Phillips, M. L., Qi, C., Van, A. T., & Hawley, D. A. (2017). Experimental Evaluation of Respirable Dust and Crystalline Silica Controls During Simulated Performance of Stone Countertop Fabrication Tasks With Powered Hand Tools. *Annals of Work Exposures and Health*, 61(6), 711–723. https://doi.org/10.1093/annweh/wxx040

A laboratory study of the RD-suppression efficacy of wet methods and on-tool LEV during the use of powered hand tools on AS. Investigators tested handheld diamond and silicon carbide (SiC) grinders and polishers, with and without water suppression and LEV. Tested both feed wetting and sheet-flow wetting. The authors concluded that on-tool LEV and sheet-flow wetting effectively reduced exposures during edge grinding and cutting, both individually and in combination. Feed wetting was less effective, both with and without LEV.

Martínez-González, D., Carballo-Menéndez, M., Guzmán-Taveras, R., Quero-Martínez, A., & Fernández-Tena, A. (2024). Evaluating silicosis risk: Assessing dust constitution and influence of water as a primary prevention measure in cutting and polishing of silica agglomerates, granite and marble. *Environmental Research*, 251, 118773. https://doi.org/10.1016/j.envres.2024.118773

A laboratory study of the compositions of dust generated during different machining processes of granite, marble, and AS, with and without water injection. Investigators conducted 10 tests on granite and AS samples and two tests on marble samples, with 6- to 25-minute measurement durations. RD generated from dry-cutting granite, marble, and AS were 70.85, 32.50, and 35.78 mg/m^3, respectively. The concentration of RD generated from wet-cutting granite, marble, and AS were 6.50, 3.75, and 3.95 mg/m^3, respectively. Dry-polishing granite, marble, and AS generated RD concentrations of 21.35, 13.68, and 17.50 mg/m^3, respectively. During wet-cutting, the percentages of RCS in the RD were 22.77% and 59.49% for granite and AS, respectively. Similar percentages were observed for dry polishing. During dry cutting, the percentage of RCS in the RD was 23.70% and 73.03% for granite and AS, respectively. The authors conclude that dry procedures produce significantly higher RD concentrations, with AS producing higher concentrations of RCS particles, particularly with dry procedures. Small (<0.5µm) RCS particles were produced when both dry- and wet-cutting AS, suggesting that water injection alone provides insufficient protection.

03. Physico-chemical characterization studies

Carrieri, M., Guzzardo, C., Farcas, D., & Cena, L. G. (2020). Characterization of Silica Exposure during Manufacturing of Artificial Stone Countertops. *International Journal of Environmental Research and Public Health*, 17(12), Article 12. https://doi.org/10.3390/ijerph17124489

A characterization of dust produced while cutting and grinding three AS and one NS (granite) samples in a controlled environment. Investigators used gravimetric analysis, XRD, and SEM with EDS to determine silica concentrations and particle morphology of both bulk and respirable dust. The respirable fraction of crystalline silica in AS samples was 53-54%, while that of NS was 8%. The number-based particle size distribution for AS had a primary peak in the nanometer range (0.01-0.1μm) with a secondary peak between 0.15 and 0.4μm. The number-based particle size distribution for NS had a primary peak between 0.15 and 0.4μm with a secondary peak in the nanometer range. RD concentration was highest for NS, which was four times higher than those of the AS samples. In contrast, RCS concentrations were highest for AS samples compared to NS. The authors conclude that dust produced from cutting and grinding AS contains higher concentrations of RCS in the nanometer range compared to NS, and the particles produced are more irregular than those produced by NS.

Di Benedetto, F., Giaccherini, A., Montegrossi, G., Pardi, L. A., Zoleo, A., Capolupo, F., Innocenti, M., Lepore, G. O., d'Acapito, F., Capacci, F., Poli, C., Iaia, T. E., Buccianti, A., & Romanelli, M. (2019). Chemical variability of artificial stone powders in relation to their health effects. *Scientific Reports*, 9(1), 6531. https://doi.org/10.1038/s41598-019-42238-2

A physico-chemical comparison of AS parent materials and the dusts they generate during different AS production processes. Seven different samples were tested from three fabrication shops in Italy. Each sample was processed using dry and wet conditions. Materials were characterized using XRF, electron paramagnetic resonance (EPR), and x-ray absorption spectroscopy (XAS). The authors report highly variable compositions in the parent materials. They further identify the generation of specific trace transition metals and free radicals, depending on the use of dry or wet processing methods. They relate wet-processing contaminants to the ion content of the process water, while dry-processing contaminants are related to the tool composition. Redox-active transition metal contaminants may modulate hydroxyl radical production. The authors also report highly stable radical species, as well as the persistence of the resin in the dust after processing. They hypothesize that the resin serves a protective role for the radical species: resin-coated particles may better protect surface radicals, allowing for an extended interaction with lung tissue.

Hall, S., Stacey, P., Pengelly, I., Stagg, S., Saunders, J., & Hambling, S. (2022). Characterizing and Comparing Emissions of Dust, Respirable Crystalline Silica, and Volatile Organic Compounds from Natural and Artificial Stones. *Annals of Work Exposures and Health*, 66(2), 139–149. https://doi.org/10.1093/annweh/wxab055

A characterization of the emissions profiles of the dust generated while dry cutting and polishing AS and NS in a controlled laboratory setting. Authors investigated both particles and VOCs produced during cutting/polishing of two AS, one sintered stone, and two NS. A larger mass of dust was emitted during cutting than when polishing, regardless of stone type. The percentage of crystalline silica in the bulk stone correlates with that in the dust generated during cutting or polishing. Cutting produced larger particles than polishing, and a higher concentration of particles in the respirable range was produced when polishing compared to cutting (16-32% during polishing compared to 8-13% while cutting). Resin-based AS, NS, and sintered stone had similar particle size distributions. More agglomerates were observed from cutting resin-based AS than NS, with resin-based AS agglomerates containing many smaller particles and a

wider range of particle sizes. The resin-based AS generated VOCs in a temperature dependent manner.

Kumarasamy, C., Pisaniello, D., Gaskin, S., & Hall, T. (2022). What Do Safety Data Sheets for Artificial Stone Products Tell Us About Composition? A Comparative Analysis with Physicochemical Data. *Annals of Work Exposures and Health*, 66(7), 937–945. https://doi.org/10.1093/annweh/wxac020

A comparison of SDS data to empirically measured mineral, metallic, and organic resin content for 25 AS samples from six manufacturers. Authors report inconsistency in the accuracy and level of detail of the SDS data. Several toxicologically relevant metallic and mineral constituents were empirically observed but not reported on SDS. Manufacturer SDSs usually reported quartz, cristobalite, feldspar, and titanium dioxide. Most of the measured concentrations fell within the reported ranges; however, the reported ranges were quite wide, with little consistency between manufacturers. Nine samples from two manufacturers contained silica in concentrations that were higher than the reported ranges. Some suppliers combined quartz and cristobalite while others reported them separately. Only one of the six suppliers reported crystalline mineral content other than silica. Measured resin content was within reported ranges, but it was not reported by all manufacturers.

Ramkissoon, C., Gaskin, S., Hall, T., Pisaniello, D., & Zosky, G. (2023). Engineered Stone Fabrication Work Releases Volatile Organic Compounds Classified as Lung Irritants. *Annals of Work Exposures and Health*, 67(2), 288–293. https://doi.org/10.1093/annweh/wxac068

A laboratory exposure study of dry machining AS, which screened the VOC emissions from 12 AS products in a controlled environment using pyrolysis GC-MS. The RD generated during dry cutting contained 8.6-20% resin by weight. Phthalic anhydride (PA) was the most abundant VOC detected, comprising 26-85% of the total organic composition of the tested AS. Benzaldehyde and styrene were also found in all samples (4.0-22% and 2-6%, respectively). Investigators measured VOCs emitted during active cutting processes for one AS sample. In a 30-minute test period, styrene was the most abundant VOC detected (3.57 mg/m^3), with PA (0.32 mg/m^3), benzene (1.10 mg/m^3), ethylbenzene (0.13 mg/m^3), and toluene (1.70 mg/m^3) also detected. The PA exposure exceed the ACGIH short-term exposure limit of 0.005 mg/m^3.

Ramkissoon, C., Gaskin, S., Thredgold, L., Hall, T., Rowett, S., & Gun, R. (2022). Characterisation of dust emissions from machined engineered stones to understand the hazard for accelerated silicosis. *Scientific Reports*, 12(1), 4351. https://doi.org/10.1038/s41598-022-08378-8

A laboratory exposure study of dry-machining AS. Investigators tested twelve commercially available AS from five brands; additionally included three NS for comparison (black granite, white marble, and a high purity reference quartz). Dry-cutting AS produced high concentrations of <1µm particles containing >80% RCS (quartz and cristobalite). The three NS samples produced particles with similar size distributions to those of the AS. AS contained 8-20% (w/w) resin and 1-8% (w/w) elemental metals. In contrast, NS contained lower RCS (4-30%) and higher metal content (29-37%). NS produced particles with lower surface area and surface charge compared to AS, though both properties varied considerably within the group.

Rishi, K., Ku, B. K., Qi, C., Thompson, D., Wang, C., Dozier, A., Vogiazi, V., Zervaki, O., & Kulkarni, P. (2024). Release of Crystalline Silica Nanoparticles during Engineered Stone Fabrication. *ACS Omega*, 9(51), 50308–50317. https://doi.org/10.1021/acsomega.4c06437

An investigation of the size-resolved fractional silica content of nanocrystalline silica (NCS) and RCS released while dry grinding AS in a controlled environment. Investigators performed

quantitative analyses using XRD and Fourier-transformed-infrared (FT-IR) spectroscopy. Both alpha quartz (15-60%) and cristobalite (10-50%) forms were identified in both NCS and RCS, with the combination of the two forms found to comprise more than 70% of the total mass in the sub-100nm range. No resin binder was detected in this size range. Although the sub-100 nm fraction was ~1% of the aerosol mass, this fraction comprised 4-24% of the aerosol surface area of lung-deposited crystalline silica. The authors concluded that surface area may be the more relevant exposure metric, and engineering control systems using mass as the primary exposure metric may be inadequate. Performing XRD with size-fractionated calibration curves appeared to better estimate the crystalline silica content in the sub-micron range. FT-IR was less precise due to interference from other inorganic oxides that may be present in the stone.

Thompson, D., & Qi, C. (2023). Characterization of the Emissions and Crystalline Silica Content of Airborne Dust Generated from Grinding Natural and Engineered Stones. *Annals of Work Exposures and Health*, 67(2), 266–280. https://doi.org/10.1093/annweh/wxac070

A laboratory characterization of the RD and RCS generation rates, particle size distributions, and size-dependent crystalline silica concentrations of the dust produced from grinding AS and AS products. Investigators tested two crystalline silica-based AS, one recycled glass AS, and one granite. The lognormal number-weighted particle size distributions appeared similar across the tested stone types, with the most prominent mode of the trimodal distribution appearing at 2.0-2.3µm. Bulk dust from the recycled glass AS contained no crystalline silica, while the two AS and one NS contained 60, 23, and 30% (w/w) crystalline silica, respectively, with cristobalite as the dominant quartz from in the crystalline silica-based AS dust. Crystalline silica content in bulk dust appeared representative of that in RD. Granite generated more dust per unit volume of material removed than the engineered stones. The highest normalized generation rate of RCS consistently occurs at 3.2-5.6µm for all crystalline silica-containing stones. The authors conclude that engineering controls should prioritize particle removal in this size range.

04. Toxicological studies

Maharjan, P., Crea, J., Tkaczuk, M., Gaskin, S., & Pisaniello, D. (2021). Metal Ion Release from Engineered Stone Dust in Artificial Lysosomal Fluid—Variation with Time and Stone Type. *International Journal of Environmental Research and Public Health*, 18(12), Article 12. https://doi.org/10.3390/ijerph18126391

An *in vitro* study of the solubility of metal ions from AS dust in artificial lysosomal fluid (ALF). Ten AS products were dry-cut, ground, and milled to produce a dust with a median diameter of 10-18µm. Dust composition was assessed for twelve different metals. The authors proceeded to assess the solubility of only four (Fe, Mn, Al, and Ti), as the others were below the limit of detection. ALF (pH 4.5) was exposed to the generated dust at 37ºC. Metal ion concentrations in the ALF were measured at 1, 2, 4, and 8 weeks. Time trends for metal release varied with AS type and ion species. The majority of available material was solubilized for all four metals. The degree of solubilization, measured as the proportion of metal released versus the amount available, ranged from 39-96% across all samples and metals. The authors conclude that metal ions are highly bioavailable once engulfed by lung macrophages.

Pavan, C., Polimeni, M., Tomatis, M., Corazzari, I., Turci, F., Ghigo, D., & Fubini, B. (2016). Editor's Highlight: Abrasion of Artificial Stones as a New Cause of an Ancient Disease. *Physicochemical Features and Cellular Responses*. Toxicological Sciences, 153(1), 4–17. https://doi.org/10.1093/toxsci/kfw101

An *in vitro* study of the toxicological properties of AS dust generated during wet and dry sawing, grinding, and polishing. Authors characterized the ability of the AS dust to catalyze free radical generation in aqueous suspensions (a simulation of the cellular environment), the membranolytic potential on human erythrocytes, the cytotoxic activity (measured as LDH release) on murine alveolar macrophages and human bronchial epithelial cells, and the induction of epithelial-mesenchymal transition (EMT) in BEAS-2B cells. Reference quartz was used as a positive control, and a synthetic amorphous quartz was used as a negative control in EMT experiments. AS morphological features were comparable to those of reference quartz, but the AS dust contained more transition metal ions, which may contribute to its reactivity. AS dust showed strong potential to generate free radicals. Hydroxyl radical generation was comparable whether dust was produced with wet or dry cutting and largely exceeded that of the quartz reference. However, carboxyl radical generation and kinetics varied between the two production methods. Wet processing eliminated C-H bond reactivity. Reactivity also decreased as particles aged. AS dusts were neither hemolytic nor cytotoxic on murine MH-S macrophages. Low cytotoxicity was observed in BEAS-2B cells. Authors attribute attenuated cytotoxicity on resin residues on AS particle surfaces, as cytotoxicity increased and hemolytic activity appeared after thermal degradation of the resin. All dusts induced EMT, suggesting these dusts are strong activators of fibrotic markers.

Ramkissoon, C., Song, Y., Yen, S., Southam, K., Page, S., Pisaniello, D., Gaskin, S., & Zosky, G. R. (2024). Understanding the pathogenesis of engineered stone-associated silicosis: The effect of particle chemistry on the lung cell response. *Respirology*, 29(3), 217–227. https://doi.org/10.1111/resp.14625

An *in vitro* laboratory study of associations between physico-chemical properties of AS dust and lung cell response. Investigators analyzed the minerology, morphology, metal and resin content, particle size, and charge of RD particles from 50 resin-based AS (including three 'reduced-silica' AS), three NS, and 2 non-resin-based AS. The exposed human alveolar epithelial cells and macrophages to RD and measured cytotoxicity and inflammation. The observed near-significant differences in epithelial cell cytotoxicity ($p = 0.061$) between AS and NS samples. Differences in

inflammation in epithelial cells were near-significant (IL-6, $p = 0.084$) and significant (IL-8, $p<0.05$). While 15 AS samples showed higher cytotoxicity in epithelial cells than controls, no effect was observed from NS. Authors report a clear relationship between inflammatory response and quartz content among AS samples; however, this relationship was absent among NS samples. 'Reduced-silica' AS emitted very fine particles, including UFP. Authors report considerable inflammation from two 'reduced-silica' AS. Cobalt and aluminum accounted for 32% of observed variance in macrophage toxicity, while quartz explained only 11% of variance, which suggests that the relationship between quartz and macrophage inflammation is not the sole driver of observed cellular responses. The authors suggest that metal content, particle surface chemistry, and VOC generation may also play roles.

Ramkissoon, C., Pavan, C., Petriglieri, J. R., Fimiani, M., Pisaniello, D., Gaskin, S., & Turci, F. (2025). Physico-chemical features and membranolytic activity of dust from low or no crystalline silica engineered stone with implications for toxicological assessment. Scientific Reports, 15(1), 25451. https://doi.org/10.1038/s41598-025-10460-w

A study of physico-chemical properties and *in vitro* membranolytic activity of particles produced in the processing of five low- and reduced-silica AS slabs and one high-silica NS (quartzite). Physico-chemical analysis included particle size distribution, mineralogy, morphology, and zeta potential. A standard membranolysis assay assessed cytotoxicity. Particle dose was normalized to particle-specific surface area. Dusts were generated either by angle grinding or milling, with the milling protocol designed to produce dust with a comparable particle size distribution to that produced with grinding. The authors found that processing low-silica AS produced lower RCS compared to traditional AS; similarly, no-silica AS produced no RCS. Feldspar, mica, gibbsite, vitreous silica, and rutile were all identified in the dust as alternative fillers. AS samples produced a finer population of particles compared to the NS sample. Particle morphology varied among the AS samples, with the no-silica sample producing much smoother particles compared to the traditional AS particles, which were jagged. Raman spectroscopy showed resin coating many of the mineral particles, with no specific phase preferentially coated compared to another. Across each dust studied, the resin coating appeared to provide a blunting effect against the membranolytic activity of the particles, as the particles showed higher membranolytic activity after being exposed to a thermal treatment that removed the resin. Notably, the quartzite sample induced only very low membranolytic activity despite containing >80% crystalline silica and no resin. Traditional AS showed the highest membranolytic activity. The low- and no-silica dusts produced less (though still notable) membranolytic activity, even after thermal treatment. Authors note the limitations of the study, including the low number of samples and the use of two different processing methods.

Song, Y., Yen, S., Southam, K., Gaskin, S., Hoy, R. F., & Zosky, G. R. (2024). The aryl hydrocarbon receptor pathway is a marker of lung cell activation but does not play a central pathologic role in engineered stone-associated silicosis. *Journal of Applied Toxicology*, 44(10), 1518–1527. https://doi.org/10.1002/jat.4653

An *in vitro* investigation of the transcriptomic responses to AS and standard silica dust exposures in human alveolar epithelial cells (A549) and macrophages (THP-1 monocytes). Authors identified aryl hydrocarbon (AhR) pathway genes that showed unique expression under AS exposure (CYP1A1, CYP1B1, TIPARP). Expression was evident in both epithelial cells and macrophages. Expression of these genes correlated with IL-8 cytokine production in both epithelial cells and macrophages; however, the authors found only mild inhibition of inflammation in epithelial cells in the presence of AhR antagonist, with a small effect size that was inconsistent between AS samples. Authors conclude that AhR expression may be a useful

biomarker of cellular responses to AS dust exposure; however, this pathway is not expected to play a major pathogenic role in lung response.

Thredgold, L., Ramkissoon, C., Kumarasamy, C., Gun, R., Rowett, S., & Gaskin, S. (2022). Rapid Assessment of Oxidative Damage Potential: A Comparative Study of Engineered Stone Dusts Using a Deoxyguanosine Assay. *International Journal of Environmental Research and Public Health*, 19(10), Article 10. https://doi.org/10.3390/ijerph19106221

An *in vitro* study of the reactivity of lab-generated AS and NS dusts, as well as their potential to produce ROS and cause oxidative DNA damage using a cell-free deoxyguanosine hydroxylation (dG) assay. Study included 12 AS samples, 3 NS samples, one reference RCS sample, and one concrete sample. Investigators studied the effect of the age of the dust by running assays using portions of the settled fractions of dust on days 0, 1, 7, 14, and 21 after generation. RD fractions were found to be significantly more reactive than the settled fractions across all stone types/samples. The reduced reactivity of the settled dust did not appear to be related to its age but instead the mixture of larger particles that it contained. No significant change in RD reactivity of AS samples was observed over the 21-day period; however, a change in NS reactivity was observed over the same period.

05. Epidemiological studies: cohort + case-control studies

Hoy, R. F., Tomic, D., Gwini, S., Dimitriadis, C., Abramson, M., Collie, A., Barnes, H., Glass, D. C., Hore-Lacy, F., Kinsman, N., Sim, M. R., & Walker-Bone, K. (2025). The Rapid Rise of Silicosis in Victoria, Australia Associated With Artificial Stone Countertop Industry Work. *American Journal of Industrial Medicine*, 68(4), 358–367. https://doi.org/10.1002/ajim.23704

An epidemiological study of workers compensation claims for silicosis between 1991 and 2022 in Victoria, Australia, analyzed across 8-year time periods. Incidence rates (IRs) per 100,000 persons were calculated by period, age, and sex. Investigators identified 536 claims over the 32-year study period (98.9% male, with a median age of 40). 483 (89.9%) were received between 2015 and 2022, which represents a seven-fold increase from the preceding analysis period. The crude IR among adults increased from 0.12 per 100,000 between 1991 and 1998 to 2.38 per 100,000 between 2015 and 2022. Concurrently, 97% of the 210 cases reported to the Monash Silica-Associated Disease Registry between 2019 and 2022 had worked in the countertop industry and 95% worked with artificial stone.

Jiménez-Gómez, G., Campos-Caro, A., García-Núñez, A., Gallardo-García, A., Molina-Hidalgo, A., & León-Jiménez, A. (2024). Analysis of Immune Cell Subsets in Peripheral Blood from Patients with Engineered Stone Silica-Induced Lung Inflammation. *International Journal of Molecular Sciences*, 25(11), Article 11. https://doi.org/10.3390/ijms25115722

A case control study of AS workers in Spain (91 AS-silicosis patients compared to 22 healthy controls) that aimed to assess the proportions of lymphocyte subsets among AS-silicosis patients with simple silicosis versus PMF. 53 of the cases had simple silicosis (SS), while 38 had PMF. The total number of leukocytes did not differ among groups; however, both SS and PMF groups had significantly lower percentages of lymphocytes and significantly higher monocyte and neutrophil percentages relative to the control group. Both case groups had elevated neutrophil/lymphocyte ratios relative to the control group. Among cases, the proportions of memory B cells, naïve helper T cells, and the $CD4^+/CD8^+$ T cells' ratio in peripheral blood was significantly lower, while the percentages of plasma cells, memory helper T cells, and regulatory T cells were significantly increased. No significant differences were found in the natural killer cell regulatory and cytotoxic cells among the groups studied. The authors conclude that exposure to AS dust leads to several peripheral blood immunological alterations that may have a role in the pathogenesis of AS-related silicosis. These alterations are observed even after extended exposure cessation.

Kramer, M. R., Blanc, P. D., Fireman, E., Amital, A., Guber, A., Rhahman, N. A., & Shitrit, D. (2012). Artificial Stone Silicosis: Disease Resurgence Among Artificial Stone Workers. *Chest*, 142(2), 419–424. https://doi.org/10.1378/chest.11-1321

A retrospective cohort study of lung transplant candidates diagnosed with silicosis between 1997 and 2010 at the sole lung transplant referral site in Israel. Authors compared lung transplant incidence in this population to the International Society for Heart and Lung Transplantation (ISHLT) registry. 25 patients were diagnosed with silicosis over the study period. All patients reported dry-cutting Caesarstone for >90% of their work duties. 15 (60%) of patients were identified as candidates for lung transplant, and 10 (40%) underwent transplant. 0.2% of ISHLT registry patients underwent lung transplant for silicosis, compared to 3% in this center over the same period. The authors concluded that the 15-fold increase in lung transplant rates in this population relative to the ISHLT registry was related to occupational exposure to RCS from AS.

León-Jiménez, A., Hidalgo-Molina, A., Conde-Sánchez, M. Á., Pérez-Alonso, A., Morales-Morales, J. M., García-Gámez, E. M., & Córdoba-Doña, J. A. (2020). Artificial Stone Silicosis: Rapid Progression Following Exposure Cessation. *Chest*, 158(3), 1060–1068. https://doi.org/10.1016/j.chest.2020.03.026

An epidemiological study of the radiologic progression and lung function among AS-related silicosis patients (n = 106) following cessation of exposure. All patients were men with a mean age of 36.2 years and a mean exposure duration of 12 years at diagnosis. 99 patients were diagnosed with simple silicosis (93.4%), and seven had PMF. The mean follow-up period was four years. At the end of follow-up, 56% of patients had progressed two subcategories under the ILO scale, and 37.7% of patients had PMF. Average annual decreases in FVC and FEV1 were 86.8 and 83.8 mL/yr, respectively, with 25% of patients experiencing considerably more accelerated decline. Lower FVC at diagnosis and longer exposure durations were associated with progression to PMF. With each additional year of exposure, authors estimated a 9% increase in PMF hazard ratio (HR = 1.09, 95% CI 1.00-1.19), adjusted for age at exposure onset and cigarette consumption at diagnosis. Authors conclude that there is a rapid decline in lung function and progression to PMF in a short time following cessation of exposure among AS-related silicosis patients.

Quan, H., Wu, W., Yang, G., Wu, Y., Yang, W., Min, C., Shi, J., Qin, L., Huang, J., Wang, J., Huang, X., Mao, L., & Feng, Y. (2022). Risk Factors of Silicosis Progression: A Retrospective Cohort Study in China. *Frontiers in Medicine*, 9. https://doi.org/10.3389/fmed.2022.832052

A retrospective cohort study of 259 silicosis patients in China, of whom 80 previously worked with AS. Of 132 patients with median follow-up of two years, 66 patients showed silicosis progression. Of these 66 patients, 36 were from the AS group, while 30 were from the non-AS group. Only five patients from the AS group (12%) did not see progression over the two-year follow-up period, compared to 61 from the non-AS group (67%). Risk factors associated with progression included working with AS (HR = 5.67, 95%CI 3.05-10.55) and complicated silicosis in CT images (HR = 2.37, 95%CI = 1.38-4.08). The authors conclude that AS-silicosis patients have a five-fold risk in developing progression in disease with a significant decline in lung function during the 2-year follow-up period, compared to the non-AS patients.

06. Epidemiological studies: cross-sectional studies

Chen, C.-H., Tsai, P.-J., Chang, W.-W., Chen, C.-Y., Chen, C.-Y., Yates, D., & Guo, Y. L. (2024). Dose-response relationship between lung function and chest imaging response to silica exposures in artificial stone manufacturing workers. *Environmental Health: A Global Access Science Source*, 23(1), 1–13. https://doi.org/10.1186/s12940-024-01067-1

An epidemiological study of the impact of silica exposure on lung function and chest imaging among workers (n = 65) in two AS manufacturing plants in Taiwan. Exposure was estimated based on work tasks (time spent handling AS and time spent dry cutting), area concentration measurements, and time spent in specific areas. Areas included slab manufacturing processes (raw material handling, mixing, spreading, curing, cooling) and fabrication processes (cutting, grinding, polishing). 64% of workers wore N95 masks. The mean annual cumulative silica exposure was 3.61 mg/m^3/year (0.0001-44.4 mg/m^3/year). Based on linear and logistic regression models, each one mg/m^3/year increase in exposure was associated with a 0.46% reduction in FVC, a 0.45% reduction in FEV1, and a statistically significant increased risk of lung function abnormality (aOR = 1.27, 95%CI 1.03-1.56).

Glass, D., Dimitriadis, C., Hansen, J., Hore-Lacy, F., Sim, M. R., & Hoy, R. F. (2022). Changes to Silica Exposure Control Measures in the Artificial Stone Benchtop Industry in Victoria Australia. *Safety and Health at Work*, 13, S25. https://doi.org/10.1016/j.shaw.2021.12.786

An epidemiological study of AS workers (n = 324) participating in respiratory health screenings in Victoria, Australia between 2019 and 2024. Median age and work tenure were 36 and 6.8 years, respectively. 40% of participants worked at shops with fewer than 10 employees. Self-reported information about proportion of time using AS and doing dry work was used to derive exposure intensity scores. Relative scores were calculated for five jobs, and cumulative exposure was calculated as the work tenure times the exposure intensity score. Relative exposure intensity and cumulative exposure scores were associated with increased odds of adverse respiratory effects, suggesting this exposure estimation method is an accurate predictor of risk for workers in this industry.

Guarnieri, G., Salasnich, M., Lucernoni, P., Sbaraglia, M., Putzu, M. G., Zuliani, P., Rossi, F., Vio, S., Bianchi, L., Martinelli, A., Gottardo, O., Bizzotto, R., Maestrelli, P., Mason, P., & Carrieri, M. (2020). Silicosis in finishing workers in quartz conglomerates processing. *La Medicina Del Lavoro*, 111(2), 99–106. https://doi.org/10.23749/mdl.v111i2.9115

An epidemiological study of AS workers (n = 45) in Northern Italy. Workers were recruited through active search as part of health surveillance program. Authors reported the average cumulative silica exposure as a product of the average 8h-TWA and the years of exposure. Among workers in cohort with silicosis (n = 24), the average cumulative silica exposure was 4.3 mg/m^3/year compared to 2.2 mg/m^3/year for those without silicosis (n = 21) (p = 0.046). Accelerated silicosis was identified in 75% of cases. Inadequate prevention measures were reported among 75% of silicosis cases and among 33% of those without silicosis. 79% of silicosis cases did not use PPE compared to 45% of those without silicosis.

Heinzerling, A., Cummings, K. J., Flattery, J., Weinberg, J. L., Materna, B., & Harrison, R. (2021). Radiographic Screening Reveals High Burden of Silicosis among Workers at an Engineered Stone Countertop Fabrication Facility in California. *American Journal of Respiratory and Critical Care Medicine*, 203(6), 764–766. https://doi.org/10.1164/rccm.202008-3297LE

A report of the first estimate of silicosis prevalence among a cohort of AS workers in the US. Authors present results of an inspection and medical screening program at an AS fabrication

shop in California. Cal/OSHA performed an inspection of the facility in 2009 and measured RCS levels 22 times the PEL in effect at the time (0.1 mg/m^3). In early 2019, CDPH identified three cases of silicosis, including two fatalities, among former employees of this shop. CDPH subsequently provided silicosis screening to all current shop employees (n = 43). All employees were male with a median age of 37 (IQR 24-45yr). Five (12%) were diagnosed with silicosis, with the median age of those diagnosed of 40 (IQR 38-53yr). Among the 36 employees with available tenure data, the median AS exposure duration was 14.9 years (13.9-16.2, n = 4) among those with silicosis and 6.5 years (3.1-15.2, n = 32) among those without.

Hore-Lacy, F., Hansen, J., Dimitriadis, C., Hoy, R., Fisher, J., Glass, D., & Sim, M. R. (2022). Predictors of psychological stress in silica-exposed workers in the artificial stone benchtop industry. *Respirology*, 27(6), 455–461. https://doi.org/10.1111/resp.14257

An epidemiological study of mental health outcomes among AS workers at risk of silicosis (n = 547 with complete data). 92.5% of participants were male and 74.4% were under age 44. Researchers collected occupational, medical, and smoking histories, modified Medical Research Council dyspnoea scale, perceived stress scale (PSS-10) questionnaire, spirometry, and CXR. Each increase in dyspnoea score was associated with an increase in the PSS-10 score. Higher PSS-10 scores were also observed among those who attended screening early in the program, had left the AS fabrication industry, had a past or present diagnosis of anxiety and/or depression, and had exposure in the industry for 5-14 years (compared to those with exposures of 0-4 years). Clinical markers, including spirometry and CXR, were not predictors of stress.

Hoy, R. F., Glass, D. C., Dimitriadis, C., Hansen, J., Hore-Lacy, F., & Sim, M. R. (2021). Identification of early-stage silicosis through health screening of stone benchtop industry workers in Victoria, Australia. *Occupational and Environmental Medicine*, 78(4), 296–302. https://doi.org/10.1136/oemed-2020-106897

An epidemiological study reporting exposure and disease outcomes for AS workers participating in a silicosis screening program (V-SHARP) in Victoria, Australia. 587 workers completed primary evaluation out of the 826 workers registered with the program. 239 workers met criteria for secondary screening (based on estimated silica exposure, the presence of symptoms, and/or test results). Of the 239 workers referred for secondary evaluation, 97% indicated exposure to a work environment where dry processing of AS occurred. 86 of the 239 workers undergoing secondary screening tested positive for silicosis, of whom 22 had worked in the industry for less than 10 years at the time of diagnosis. Their median age was 42 years. Those with simple silicosis (n = 65) had been working in the industry for a median of 14 years, while those with complicated silicosis (n = 21) had been working for a median of 13 years. 72 were still employed in the AS industry at the time of diagnosis. ANAs were detected in 37% of workers with silicosis and 24% without.

Hoy, R. F., Dimitriadis, C., Abramson, M., Glass, D. C., Gwini, S., Hore-Lacy, F., Jimenez-Martin, J., Walker-Bone, K., & Sim, M. R. (2023). Prevalence and risk factors for silicosis among a large cohort of stone benchtop industry workers. *Occupational and Environmental Medicine*, 80(8), 439–446. https://doi.org/10.1136/oemed-2023-108892

An epidemiological study of 544 AS fabrication workers (94.5% male with a median age of 36.2 years). 493 (91%) reported working with both NS and AS, and 86.2% were exposed to dry processing of stone. 414 (76%) required secondary screening based on having ‘high’ or ‘very high’ estimated silica exposure. Of those requiring secondary screening, 117 (28.2%) were diagnosed with silicosis (median age at diagnosis was 42 years with a median exposure of 12

years). Silicosis diagnosis was associated with longer exposure duration, older age, lower BMI, and smoking. Among those diagnosed with silicosis, FVC and D_{LCO} were below normal in only 14% and 13% of subjects, respectively. As such, the authors discourage the use of respiratory symptoms such as coughing or shortness of breath as markers of possible disease. The authors further suggest the implementation of medical surveillance programs as a pathway to earlier disease detection and increased efforts to reduce workplace exposures.

Hua, J. T., Zell-Baran, L., Go, L. H. T., Kramer, M. R., Bree, J. B. V., Chambers, D., Deller, D., Newbigin, K., Matula, M., Fireman, E., Dahbash, M., Martinez-Gonzalez, C., León-Jimenez, A., Sack, C., Ferrer, J., Villar, A., Almberg, K. S., Cohen, R. A., & Rose, C. S. (2022). Demographic, exposure and clinical characteristics in a multinational registry of engineered stone workers with silicosis. *Occupational and Environmental Medicine*, 79(9), 586–593. https://doi.org/10.1136/oemed-2021-108190

A cross-sectional epidemiological evaluation of differences in demographic, occupational, radiologic, pulmonary function, and silica-related comorbidity among AS workers enrolled in a four-country silicosis registry. Mean age and work tenure of the 98.8% male cohort was 51.7 and 19.9 years, respectively; however, tenure depended on case ascertainment method. For example, Queensland, Australia has a state surveillance program, and cases are identified earlier and with shorter work tenure. 32.5% of cases had PMF, of whom 18.5% worked for 10 or fewer years with AS. Common silica-related comorbidities included lung function impairment and autoimmunity.

Requena-Mullor, M., Alarcón-Rodríguez, R., Parrón-Carreño, T., Martínez-López, J. J., Lozano-Paniagua, D., & Hernández, A. F. (2021). Association between Crystalline Silica Dust Exposure and Silicosis Development in Artificial Stone Workers. *International Journal of Environmental Research and Public Health*, 18(11), Article 11. https://doi.org/10.3390/ijerph18115625

A cross-sectional epidemiological study of 311 AS workers in Spain. 64 of these workers were previously diagnosed with silicosis, while 247 were at risk for the disease. Acute silicosis was the dominant clinical form (42%), while accelerated and chronic silicosis accounted for 32.8% and 25% of cases, respectively. Authors observed no significant differences in job tasks performed between the two groups. Workers installing AS on-site were at greater risk of silicosis than those working in the shop (79.7% of workers with silicosis performed work in shops, compared to 91.1% of workers without silicosis; $p < 0.01$). The authors attribute this increased risk to the workers either not using or not being provided PPE.

Tomic, D., Hoy, R. F., Sin, J., Martin, J. J., Gwini, S. M., Barnes, H., Nikpour, M., Morrisroe, K., Lim, Y. Z., & Walker-Bone, K. (2024). Autoimmune diseases, autoantibody status and silicosis in a cohort of 1238 workers from the artificial stone benchtop industry. *Occupational and Environmental Medicine*, 81(8), 388–394. https://doi.org/10.1136/oemed-2024-109526

An epidemiological study of stone workers (n = 1238) in Victoria, Australia, which aimed to estimate the prevalence of clinical autoimmune disease and common autoantibodies of exposed workers. Workers were invited to participate in a free screening, which involved questionnaire, physical exam, spirometry, CXR, and, for those referred, high-resolution CT scan and blood testing. After a median exposure tenure of 7 years, 0.9% of stone workers had clinical autoimmune disease. 25% had detectable ANAs, 5% had detectable extractable nuclear antigens (ENAs), and 3% were positive for rheumatoid factor (RF). ANAs were associated with age, smoking, very high silica exposures, and silicosis. The prevalence of detectable ANAs and ENAs was much higher than that in the general population (5-9%), and some of those detected have high sensitivity and specificity for systemic sclerosis.

Tustin, A. W., Kundu-Orwa, S., Lodwick, J., Cannon, D. L., & McCarthy, R. B. (2022). An outbreak of work-related asthma and silicosis at a US countertop manufacturing and fabrication facility. *American Journal of Industrial Medicine*, 65(1), 12–19. https://doi.org/10.1002/ajim.23304

A cross-sectional investigation of an outbreak of silicosis and work-related asthma (WRA) at an AS countertop fabrication facility in Texas. The investigation involved clinical examinations of workers, an industrial hygiene survey that included qualitative and quantitative exposure assessments, and a questionnaire. Sampling occurred on four separate dates. Silica sampling was performed on four workers in the fabrication department, while phthalic anhydride sampling occurred on six workers in the casting department. 16.7% of casting samples exceeded phthalic anhydride PEL, while 54.5% of fabrication samples exceeded silica PEL. 16 workers had confirmed or suspected WRA. 12 workers received medical surveillance for silicosis. Four of these workers (33.3%) were diagnosed with silicosis based on abnormal chest CT scans.

Wu, N., Xue, C., Yu, S., & Ye, Q. (2020). Artificial stone-associated silicosis in China: A prospective comparison with natural stone-associated silicosis. *Respirology*, *25*(5), 518–524. https://doi.org/10.1111/resp.13744

An epidemiological study including 18 patients in China with AS-related silicosis and 63 with NS-related silicosis. The median durations of exposure prior to the onset of silicosis symptoms were 6.4 and 29.3 years for AS-and NS-related exposures, respectively. Four of 18 patients with AS-related silicosis (22%) experienced lung function deterioration over just six to 12 months of follow-up. 38.9% of those with AS-related silicosis were lung transplant candidates, and 28% died. In contrast, 3.2% of those with NS-related silicosis required lung transplant, with no NS-related silicosis patients dying. The authors concluded that, compared to NS-associated silicosis, AS-associated silicosis was characterized by short latency, rapid radiological progression, accelerated decline in lung function, and high mortality.

07. Epidemiological studies: single case and case series

Chen, C. H., Tsai, P. J., Chang, W. W., Chen, C. Y., Chen, C. Y., & Guo, Y. L. (2024). Subpleural curvilinear lines as an early indicator of silicosis in artificial stone workers. Pulmonology, 30(2), 174–176. https://doi.org/10.1016/j.pulmoe.2023.08.006

A case series including AS workers (n = 19) in Taiwan. 12 subjects had abnormal high-resolution CT scans, and four of these subjects had subpleural curvilinear lines in their upper lobes. Three of these subjects were raw material operators making slabs while the fourth performed wet-cutting of manufactured slabs. Only two of the four subjects had abnormal CXRs. Lung function in all four subjects was mildly impaired. The authors suggest that the presence of subpleural curvilinear lines in high-resolution CT may be an early indicator of silicosis among AS workers.

Fazio, J. C., Gandhi, S. A., Flattery, J., Heinzerling, A., Kamangar, N., Afif, N., Cummings, K. J., & Harrison, R. J. (2023). Silicosis Among Immigrant Engineered Stone (Quartz) Countertop Fabrication Workers in California. *JAMA Internal Medicine*, 183(9), 991–998. https://doi.org/10.1001/jamainternmed.2023.3295

A case series reporting AS-related silicosis among workers in California. Cases were identified by CDPH surveillance between 2019 and 2022. 52 cases were identified, with diagnoses occurring between 2010 and 2022. 37 of these cases (70%) were identified in LA county. The median age and work tenure of identified cases was 45 (IQR 40-49) and 15 (IQR 10-20) years. Twenty patients (38%) presented with advanced disease, which was characterized by PMF. A delay in diagnosis occurred in 30 patients (58%). 23 (45%) reported the use of wet methods for fabrication, while 25 (48%) continued working with AS after diagnosis. 10 cases (19%) were fatal. 11 cases were referred for lung transplant. Of these, three underwent transplant with one fatality.

Feary, J., Devaraj, A., Burton, M., Chua, F., Coker, R. K., Datta, A., Hewitt, R. J., Kokosi, M., Kouranos, V., Reynolds, C. J., Ross, C. L., Smith, V., Ward, K., Wickremasinghe, M., & Szram, J. (2024). Artificial stone silicosis: A UK case series. *Thorax*, 79(10), 979–981. https://doi.org/10.1136/thorax-2024-221715

A case series including eight workers in the United Kingdom (all male; median age 34 years with a median of 12.5 years of exposure). One subject died, and two subjects were referred for lung transplant. All cases worked in small shops (<10 employees) that performed dry cutting of AS with inadequate ventilation. Subjects estimated that AS comprised 50-100% of materials they processed. 60% had positive ANA and 57% had elevated sACE. 25% had non-tuberculosis mycobacterium infection.

Friedman, G. K., Harrison, R., Bojes, H., Worthington, K., & Filios, M. (2015). Notes from the Field: Silicosis in a Countertop Fabricator—Texas, 2014. *MMWR. Morbidity and Mortality Weekly Report*, 64(5), 129–130.

A case report of an AS-related silicosis patient in Texas (age 37 years with work tenure of 10 years). His is the first reported AS-related silicosis case in North America. Case presented in 2010 with a two-year history of persistent cough and shortness of breath on exertion and had neither a smoking history nor a history of pulmonary disease. PFT, electrocardiogram, and CT scan showed abnormalities. At the time of publication, the case was oxygen-dependent and being monitored for possible lung transplant.

Gandhi, S. A., Heinzerling, A., Flattery, J., Fazio, J. C., Alam, A., Cummings, K. J., & Harrison, R. J. (2023). Active Surveillance of Engineered Stone Workers Facilitates Early Identification of Silicosis: A Discussion of Surveillance of Occupational Lung Diseases. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 33(2–3), 119–129. https://doi.org/10.1177/10482911231189503

A case series including 18 AS-related silicosis patients in California, who were diagnosed between 2006 and 2020. Median age at diagnosis was 20 years, while the median work tenure was 14.5 years. Eight cases (44%) were identified through employer surveillance following workplace investigation, and 3 cases (17%) from employer reporting. The remaining cases were identified passively through hospital records. Cases identified through active surveillance had significantly higher percent predicted lung function at time of diagnosis than those identified through passive surveillance (measured through FVC, FEV1, and DL_{CO}). More severe PFT and diffusion abnormalities were observed among cases identified through passive surveillance. At time of identification, 12 cases were alive, of whom two had undergone lung transplant.

Guarnieri, G., Bizzotto, R., Gottardo, O., Emanuela, V., Cassaro, M., Vio, S., Putzu, M. G., Rossi, F., Zuliani, P., Liviero, F., Mason, P., & Maestrelli, P. (2019). Multiorgan accelerated silicosis misdiagnosed as sarcoidosis in two workers exposed to quartz conglomerate dust. *Occupational and Environmental Medicine*, 76, 178–180. https://doi.org/10.1136/oemed-2018-105462

A case series of two Italian AS workers (male, ages 35 and 38 years with 8-13 years of exposure) with accelerated pulmonary and hepatic silicosis. Air sampling had been performed at the workplace of the second case, with TWA-8h RCS values of 0.260, 0.486, and 0.744 mg/m^3.

Hoy, R. F., Baird, T., Hammerschlag, G., Hart, D., Johnson, A. R., King, P., Putt, M., & Yates, D. H. (2018). Artificial stone-associated silicosis: A rapidly emerging occupational lung disease. *Occupational and Environmental Medicine*, 75(1), 3–5. https://doi.org/10.1136/oemed-2017-104428

A case series presenting the clinical characteristics of patients with AS-related silicosis in Australia. Cases were identified through voluntary reporting by practicing physicians, who provided occupational histories, respiratory function tests, and chest radiology and histopathology reports. Seven cases of AS-related silicosis were identified in Queensland, Victoria, and NSW between 2011 and 2016. All patients worked in small shops with an average of eight employees (2-20). All workers performed dry cutting, primarily with hand tools. Ventilation in workplaces was limited to ceiling fans or passive airflow. No patients had been trained on respirator use or enrolled in a surveillance program. The median exposure duration of these patients was 7 years (4-10 years). Six of the seven patients presented with severe lung function impairment and radiological features of PMF. Duration of symptoms was 0.5 to three years. Cases presented progressive disease consistent with accelerated silicosis.

Hua, J. T., Cool, C. D., Klein, E. F., Adir, Y., Lee, L. J., Zell-Baran, L. M., Cohen, R. A., Kraus, R. C., Brigitte Gottschall, E., Krefft, S. D., Van Hook, C., & Rose, C. S. (2025). Silicosarcoidosis: Histologic and Clinical Features of an Occupational Granulomatous Disease. American Journal of Industrial Medicine, 68(6), 491–507. https://doi.org/10.1002/ajim.23724

A multinational case series of workers with both sarcoidosis and occupational RCS exposure (n = 35), which reports clinical and histopathologic findings. The mean age and work tenure of the cases were 48 and 21 years, respectively. 86% (25/29) had granulomas and 94% (17/18) with evaluable lung tissue had lymphocytic inflammation and/or lymphoid aggregates. Of those with evaluable lung tissue, 39% (7/18) had silicotic nodules, 44% had mixed-dust macules/nodules,

and 50% had birefringent dust. Study also used a quantitative microscopy technique to measure birefringent dust density in lung specimens of silicosarcoidosis cases and compared these measurements to those measured from the specimens of healthy controls. Birefringent dust density was significantly greater ($p < 0.001$) in silicosarcoidosis cases compared to health controls (147±179 vs. 12±9 particles/mm^2) but lower than in coal miners with silica-related PMF (623±777). Authors also report significant differences in the frequency of histologic abnormalities

León-Jiménez, A., Mánuel, J. M., García-Rojo, M., Pintado-Herrera, M. G., López-López, J. A., Hidalgo-Molina, A., García, R., Muriel-Cueto, P., Maira-González, N., Del Castillo-Otero, D., & Morales, F. M. (2021). Compositional and structural analysis of engineered stones and inorganic particles in silicotic nodules of exposed workers. *Particle and Fibre Toxicology*, 18(1), 41. https://doi.org/10.1186/s12989-021-00434-x

A case series including seven cases of AS-related silicosis among Spanish workers. Report includes chemical characterization of AS materials commonly encountered by study subjects in the years prior to their diagnoses. The AS samples contained 88-99.6% silica, with variable quantities of quartz and cristobalite. Al, Na, Fe, Ca, and Ti were the most frequently detected metals, while styrene, toluene, m-xylene, and PAHs were among the most frequently detected VOCs. Patients were male, with average age of 36 years at diagnosis. At diagnosis, one patient had PMF after an average 8-year follow-up, four patients had PMF. Tissue samples showed high proportions of Al and Si at centers of nodules observed in lung biopsies, with high correlation between Si and Al ($r = 0.93$). The authors note that several identified VOCs, PAHs, and metals have been associated with lung inflammation and respiratory disease.

León-Jiménez, A., Rodríguez-Rubio Corona, J., Jiménez-Gómez, G., Piñero Fernández-Reyes, M. L., Hidalgo-Molina, A., Pajares-Vinardel, M., Conde-Sánchez, M. Á., Campos-Caro, A., & Sanchez-Morillo, D. (2025). High metabolic activity in positron emission tomography and systemic inflammation occurring years after exposure cessation in engineered stone silicosis. Scientific Reports, 15(1), 25364. https://doi.org/10.1038/s41598-025-10562-5

A case series including complicated silicosis patients ($n = 17$) with ≥5 years' work experience with AS fabrication and ≥7 years exposure cessation. Investigators conducted positron emission tomography/computed tomography and respiratory function tests and took blood samples. Subjects had a mean age of 44±5.4 years, a mean work tenure of 1.9±3.2 years, and a mean exposure cessation duration of 11.6±1.6 years. High-resolution CT scans showed five subjects with PMF category A, six with category B, and six with category C. All patients had mediastinal lymphadenopathy with high metabolic activity, and 88% of subjects also had hypermetabolic lymphadenopathy in other extrathoracic areas. No correlation was observed between SUV_{max} and exposure duration. A significant, positive correlation was observed between SUV_{max} and ICOERD classification ($\rho = 0.747$, $p = 0.001$) and between SUV_{max} and ICOERD classification ($\rho = 0.697$, $p = 0.002$). SUV_{max} was also significantly and inversely correlated with many bronchial obstruction indices, including FEV1 and FEV1/FVC ratio. Moderate-to-strong correlations were observed between SUV_{max} and lymphocyte subsets: Increased metabolic activity was associated with a decrease in cell populations. The authors note several limitations, including the small sample size, the limited quantitative exposure information, and the potential inaccuracy of correlating exposure load with exposure time.

Levin, K., McLean, C., & Hoy, R. (2019). Artificial stone-associated silicosis: Clinical-pathological-radiological correlates of disease. *Respirology Case Reports*, 7(7), e00470. https://doi.org/10.1002/rcr2.470

A case report of two AS-related silicosis patients who underwent lung transplantation in Australia. Patients were ages 36 and 47 at diagnosis, with nine and six years of work tenure. Both patients were exposed to similar working conditions and activities (dry cutting AS with inadequate ventilation and PPE). Authors report fibrotic/nodular silicosis and silicoproteinosis within the same lung parenchyma of both patients.

Manglani, R., Akbar, S., Beasley, M. B., & Epelbaum, O. (2023). A 44-year-old stone worker with progressive dyspnea: Lessons from a new twist on an old foe. *Monaldi Archives for Chest Disease*, 93(2), Article 2. https://doi.org/10.4081/monaldi.2022.2345

A single case report of AS-related acute silicosis in New York. Patient was 44 years-old and had worked in countertop fabrication for 20 years, with his work involving dry cutting without protection. Following an initial diagnosis of sarcoidosis and continued progression of disease despite steroid therapy, the patient was diagnosis with acute silicosis.

Martínez González, C., Prieto González, A., García Alfonso, L., Fernández Fernández, L., Moreda Bernardo, A., Fernández Álvarez, R., Rolle-Sóñora, V., Ruano Raviña, A., & Casan Clarà, P. (2019). Silicosis in Artificial Quartz Conglomerate Workers. *Archivos de Bronconeumología* (English Edition), 55(9), 459–464. https://doi.org/10.1016/j.arbr.2019.07.001

A retrospective case series of 96 silicosis cases diagnosed between 2010 and 2017 in Spain. Investigators analyzed clinical, radiological, pathological, and functional characteristics of cases. Mean age of cases was 45 years; however, the mean age of accelerated silicosis patients (n = 10) was 33 years. 55% of cases were diagnosed with simple silicosis. The mean exposure time to AS was 15 years, with 77% of cases not using protection measures. 50% of patients were asymptomatic with normal physical examinations.

Matar, E., Frankel, A., Blake, L. K. M., Silverstone, E. J., Johnson, A. R., & Yates, D. H. (2017). Complicated silicosis resulting from occupational exposure to engineered stone products. *Medical Journal of Australia*, 206(9), 385–386. https://doi.org/10.5694/mja16.00257

A single case report of an AS worker in Australia (age = 54). Patient dry cut AS for more than seven years without PPE and with inadequate ventilation. Exact work tenure was not specified. Patient was diagnosed with complex silicosis and PMF and is a candidate for lung transplant.

Newbigin, K., Parsons, R., Deller, D., Edwards, R., & McBean, R. (2019). Stonemasons with silicosis: Preliminary findings and a warning message from Australia. *Respirology*, 24(12), 1220–1221. https://doi.org/10.1111/resp.13672

A report of preliminary findings of a retrospective silicosis case series in Queensland, Australia. Study included 78 subjects (median age = 33 years; median tenure = 12 years). All subjects were diagnosed with either accelerated (n = 36) or chronic (n = 42) silicosis. 68% of subjects report working with AS for >50% of work tenure, using PPE for <50% of their tenure, and performing work using dry cutting for >50% of their tenure, with AS-related work and dry cutting the most common high-risk practices (90% and 87%, respectively). 68% of subjects did not use any hazard controls while working.

Ophir, N., Shai, A. B., Alkalay, Y., Israeli, S., Korenstein, R., Kramer, M. R., & Fireman, E. (2016). Artificial stone dust-induced functional and inflammatory abnormalities in exposed workers monitored quantitatively by biometrics. *ERJ Open Research*, 2(1). https://doi.org/10.1183/23120541.00086-2015

An epidemiological study of AS-exposed workers in Israel, including subjects with silicosis diagnosis and without previous diagnosis. Subjects completed an occupational questionnaire,

which included self-reported AS dust exposure, and underwent spirometry and sputum induction. There are several issues with the paper that make interpretation difficult. (These are summarized by Weiler Ravell and Bishara, 2016.)

Orriols, R., Torrente, A., Campà, M. T., Comas-Cufí, M., Tura-Ceide, O., Sabater, G., & Vendrell, M. (2023). Artificial Stone Silicosis. Progression and Laboral Impact After 3-years Follow-up. *Archivos de Bronconeumología*, 59(4), 267–269. https://doi.org/10.1016/j.arbres.2022.11.008

A case series of AS-related silicosis among workers in Spain, who were diagnosed between 2006 and 2021. Study reports clinical, functional, radiological, and occupational characteristics of the patients. Study includes 32 patients (all men, mean age = 44.9 years) who worked at 14 different companies. Reliable information was obtained from 9 of the 14 companies. Among these companies, 27 out of 61 workers who handled AS were diagnosed with silicosis (44.3% prevalence). After detecting an index case, 24 (88.9% of silicotic patients came together as clusters in the 9 companies studied. The mean duration of AS exposure was 21 years. 31.3% of patients reported using protective measures. 28.1% of patients were asymptomatic, with 31.2% of patients having normal respiratory symptoms. 56.3% of patients met criteria for simple silicosis, while the remainder met criteria for complicated silicosis. Patients were followed for a mean of 39.6 months, during which time 9.3% of patients progressed from simple to complicated silicosis and one patient presented an accelerated course. 31.3% of patients worsened clinically and 43.8% worsened functionally.

Paolucci, V., Romeo, R., Sisinni, A. G., Bartoli, D., Mazzei, M. A., & Sartorelli, P. (2015). Silicosis in Workers Exposed to Artificial Quartz Conglomerates: Does It Differ From Chronic Simple Silicosis? *Archivos de Bronconeumología (English Edition)*, 51(12), e57–e60. https://doi.org/10.1016/j.arbr.2015.06.003

A case series of three AS workers in Europe. All three cases performed similar cutting, polishing, and installing tasks. The three cases did not use wet methods or PPE during finishing or installation tasks. All cases used AS intensively for over a decade. Measurements obtained from the shop of two of the three cases show average RCS concentrations in the finishing area above the PEL and over 20 times higher than the ACGIH-TLV. RCS measurements were unavailable for the third case's workplace. All three cases were asymptomatic and had normal lung function but received abnormal chest x-ray results during routine medical screenings. All cases tested negative for tuberculosis.

Pascual del Pobil y Ferré, M. A., García Sevila, R., García Rodenas, M. d. M., Barroso Medel, E., Flores Reos, E., & Gil Carbonell, J. (2019). Silicosis: A former occupational disease with new occupational exposure scenarios. Revista Clínica Española (English Edition), 219(1), 26–29. https://doi.org/10.1016/j.rceng.2018.11.005

An epidemiological study of reported silicosis cases in Spain, which aimed to identify new sources of silica exposure and working conditions that promote the onset of disease. Cases were reported between 2009 and 2016 and identified through reviews of epidemiological-occupational surveys and medical records. 19 cases were identified, 69% of which were AS related. The mean age of AS-related silicosis cases was 47±13 years, and the mean exposure duration was 11±4 years. The mean of the rest of the group was 62±16 years with a mean exposure of 27±8 years, with a statistically significant difference in exposure duration between the two subgroups. Four cases presented with complicated forms of silicosis, of which three were AS related.

Pascual, S., Urrutia, I., Ballaz, A., Arrizubieta, I., Altube, L., & Salinas, C. (2011). Prevalence of silicosis in a marble factory after exposure to quartz conglomerates. Archivos de Bronconeumologia, 47(1), 50–51. https://doi.org/10.1016/j.arbres.2010.09.004

A prospective study on 11 AS workers in Spain. Four subjects worked in cutting while the remainder worked in assembly. None of the subjects reported use of controls or PPE. Six cases of silicosis were diagnosed (prevalence = 55%). 5 of the six cases are assemblers (83%). [Full text unavailable in English.]

Pérez-Alonso, A., Córdoba-Doña, J. A., Millares-Lorenzo, J. L., Figueroa-Murillo, E., García-Vadillo, C., & Romero-Morillo, J. (2014). Outbreak of silicosis in Spanish quartz conglomerate workers. *International Journal of Occupational and Environmental Health*, 20(1), 26–32. https://doi.org/10.1179/2049396713Y.0000000049

A case series of AS workers diagnosed with silicosis in Spain between 2009 and 2012. Silicosis was identified in 46 men, of whom 26% were under age 30 at time of diagnosis (median age = 33 years; median tenure working with AS = 11 years). Of these cases, 91.3% were diagnosed with simple chronic silicosis based on an abnormal CT scan. Other respiratory diseases were detected in 32.6% of patients, with allergic rhinitis being the most common. Patients frequently reported non-compliance with prevention and engineering control requirements. Water curtains were present in only 15 cases' (32.6%) workplaces. Only 11% of cases reported the use of properly functioning ventilation systems. No workers reported any employer monitoring. Only 33% of cases reported using PPE, and those that did were most commonly using inadequate protection.

Ronsmans, S., Decoster, L., Keirsbilck, S., Verbeken, E. K., & Nemery, B. (2019). Artificial stone-associated silicosis in Belgium. *Occupational and Environmental Medicine*, 76(2), 133–134. https://doi.org/10.1136/oemed-2018-105436

A report of two cases of AS-related silicosis in Belgium. Patients were employed at a two-man company that produced and installed AS countertops. The first patient made countertops by mixing epoxy resin, gravel, sand, pigment, and quartz flour, using approximately 200kg of quartz flour weekly. After curing, countertops were cut, ground, and polished with no dust protection and occasional use of dust masks. The first worker developed symptoms after <10 years (9.5 years) of making and processing AS. The second worker installed countertops on-site, which involved performing dry grinding in customers' homes. This patient had nearly 25 years of silica exposure. HRCT scans of both patients showed abnormal high-resolution CT scans. The first patient quit his job upon diagnosis with silicosis. His cough disappeared after two years without exposure, and his pulmonary function tests (PFTs) remained normal. The second patient continued to work with reduced exposures, and his PFTs also remained unchanged.

Ronsmans, S., Goeminne, P., Jerjir, N., Nowé, V., Vandebroek, E., Keirsbilck, S., Weynand, B., Hoet, P. H. M., Vanoirbeek, J. A. J., Wuyts, W. A., Yserbyt, J., & Nemery, B. (2022). Outbreak of Silicosis in Workers Producing Artificial Stone Skirting Boards: A Novel Application of Silica-Based Composites. *CHEST*, 162(2), 406–409. https://doi.org/10.1016/j.chest.2022.03.039

A case series of four AS workers with occupational lung disease (age 38-59 at diagnosis). Authors used past spirometry data to calculate individual yearly declines in FEV and FVC using smoking cessation-adjusted multivariable linear regression. RCS was measured in the workplace after the first case had been diagnosed. Respiratory symptoms started after working for 7-27 years at the same company, which produced polyester-silica composite panels. The workers' FEV1 had been declining 98-221 mL/year before diagnosis, which is three- to seven-fold faster than normal FEV1 decline in non-smokers. FVC had declined 17- 220 mL/year. High

RCS concentrations were measured when filling molds (0.167 mg/m^3), cleaning molds (0.329 mg/m^3) and dry finishing panels (1.080 mg/m^3). Styrene concentration was high while filling molds, but levels remained below the TLV (108 mg/m^3).

Rose, C. (2019). Severe Silicosis in Engineered Stone Fabrication Workers—California, Colorado, Texas, and Washington, 2017–2019. *MMWR. Morbidity and Mortality Weekly Report*, 68. https://doi.org/10.15585/mmwr.mm6838a1

A case report of 18 silicosis patients among AS fabrication workers in California, Colorado, Texas, and Washington. Study includes the first two reported fatalities in the U.S. 11 of the 18 cases were aged <50 years and had severe, progressive disease. Five of the 18 cases also had autoimmune diseases, while two also had latent tuberculosis infections. The authors note that many employees in the industry are Latino immigrants, who may be particularly vulnerable to workplace hazards because they have fewer employment options, diminished access to medical care, and face threat of retaliation if they report occupational hazards or file workers' compensation claims.

Shen, H.-S., Lai, Y.-T., Tsai, H.-C., & Chang, S.-C. (2021). Artificial stone-associated silicosis with concurrent Cryptococcus infection. *Respirology Case Reports*, 9(6). https://doi.org/10.1002/rcr2.765

A single case report of a 33 year-old AS worker with acute silicosis and concurrent cryptococcus infection. Case had been working in AS fabrication for eight years, including cutting, grinding, drilling, finishing, transporting, and installing AS without use of PPE. While his shop had ventilation, work areas were dusty. Several of his co-workers reported similar symptoms. Following progression of his disease, patient was ultimately referred for lung transplant.

Shtraichman, O., Blanc, P. D., Ollech, J. E., Fridel, L., Fuks, L., Fireman, E., & Kramer, M. R. (2015). Outbreak of autoimmune disease in silicosis linked to artificial stone. *Occupational Medicine*, 65(6), 444–450. https://doi.org/10.1093/occmed/kqv073

A case series including AS-related silicosis patients referred to the Israeli pulmonary institute for lung transplant assessment. The Institute is the national center for lung transplant referrals. Of the 40 silicosis patients in the dataset, all were male and had worked with AS for at least six years, with six subjects reporting exposure for 20 years or more. Of the 40 subjects, nine (23%) had autoimmune diseases and, among these nine, three had pulmonary alveolar proteinosis. The upper end of the expected prevalence of autoimmune disease (based on European data) is 3%; therefore, the prevalence among the Israeli AS-related silicosis patients is seven times that of the general population.

Turner, M. T., Samuel, S. R., Silverstone, E. J., & Yates, D. H. (2020). Silica Exposure and Connective Tissue Disease: An Underrecognized Association in Three Australian Artificial Stone Workers. *American Journal of Respiratory and Critical Care Medicine*, 201(3), 378–380. https://doi.org/10.1164/rccm.201905-1057LE

A case series of three AS workers from Australia that highlights the association between RCS exposure and the risk of development of connective tissue disorder (CTD), including predominantly systemic sclerosis (SSc). The three cases each tested positive for autoantibodies, which may be associated with CTDs. While SSc is the dominant form, additional CTDs associated with silica exposure include rheumatoid arthritis, systemic lupus erythematosus, dermatomyositis, polymyositis, and anticentromere antibody (ANCA)-positive vasculitis.

08. Epidemiological studies: biomarker identification, diagnosis methods, and treatments

Apte, S. H., Tan, M. E., Lutzky, V. P., De Silva, T. A., Fiene, A., Hundloe, J., Deller, D., Sullivan, C., Bell, P. T., & Chambers, D. C. (2022). Alveolar crystal burden in stone workers with artificial stone silicosis. *Respirology*, 27(6), 437–446. https://doi.org/10.1111/resp.14229

A report of the development and validation of novel microscopy methods to quantify alveolar crystal burden in bronchoalveolar lavage fluid (BALF) among patients with AS-related silicosis. The method was used to evaluate the alveolar crystal burden of 23 subjects with AS-related silicosis. All subjects were male with a median age of 38 years and a median exposure duration of 11 years. Results from the silicosis subjects were compared to a control group (n = 8), who had diagnoses of other lung diseases. BALF from silicosis patients showed higher alveolar crystal burden compared to non-silicosis patients (median = 0.44, range = 0.083-3.49 pg/cell compared to median = 0.057, range = 0.013-0.344 pg/cell, $p < 0.001$). The authors observed a significant positive correlation between the alveolar crystal burden and the years of full-time employment in the AS industry ($r = 0.49$, $p = 0.02$). The proportion of immune cells present in BALF was not significantly related to alveolar crystal burden. The authors conclude that alveolar crystal burden quantification can differentiate silicosis patients from patients with other respiratory disorders.

Barnes, H., Pilcher, D., Coull, J., Sin, J., Dabscheck, E., Siemienowicz, M., Pirakalathanan, J., Khoo, J., Sweeney, D., McLean, C., Pirakalathanan, P., Eikelis, N., Begka, C., Westall, G., & Hoy, R. (2024). Efficacy and safety of a whole lung lavage program for artificial stone silicosis. *Journal of Thoracic Disease*, 16(11). https://doi.org/10.21037/jtd-24-1050

A prospective case series that aimed to assess the feasibility, safety, and potential benefit of whole-lung lavage (WLL) as a treatment for patients with AS-related silicosis. Simple silicosis cases from a hospital in Australia were eligible if they were experiencing a decline in lung function and/or progression of symptoms despite a cessation of exposure. Eight cases underwent WLL (mean age of 38 years and mean exposure duration of 12 years at time of procedure). The procedure was deemed safe if administered in an expert center. Only small improvements in lung function were observed. Five of the eight cases experienced improved International Classification of High Resolution Computed Tomography for Occupational and Environmental Respiratory Diseases (ICOERD) score, although the effect was not significant. The authors conclude that WLL may be of limited benefit to some patients, but more research is needed to understand which patients would most benefit.

Campos-Caro, A., Jiménez-Gómez, G., García-Núñez, A., Hidalgo-Molina, A., & León-Jiménez, A. (2023). Plasma Cytokine Profiling Reveals Differences between Silicotic Patients with Simple Silicosis and Those with Progressive Massive Fibrosis Caused by Engineered Stone. International Journal of Molecular Sciences, 24(2), Article 2. https://doi.org/10.3390/ijms24021541

An epidemiological study comparing plasma cytokine profiles among AS-related simple silicosis patients (n = 53), AS-related PMF (n = 38), and healthy controls (n = 22). Investigators used multiplex assays to determine levels of 34 cytokines. Systemic cytokines were classified into five groups: pro-inflammatory, anti-inflammatory, TH1/TH2 cytokine profiles in silicosis patients, chemokines, and growth factors. Cytokine levels in the pro-inflammatory and anti-inflammatory groups were significantly elevated in the silicosis groups relative to the control group. The levels of certain cytokines were also elevated in the PMF group relative to the simple silicosis group. The levels of 11 of the tested cytokines did not significantly differ between any of the groups. The authors found that plasma cytokine levels remained high in patients even six years after

exposure cessation. The authors conclude that some cytokines may be useful biomarkers of disease severity for AS-related silicosis.

Chambers, D. C., Apte, S. H., Deller, D., Masel, P. J., Jones, C. M., Newbigin, K., Matula, M., & Rapchuk, I. L. (2021). Radiological outcomes of whole lung lavage for artificial stone-associated silicosis. *Respirology*, 26, 501–503.

A report of the use of whole lung lavage (WLL) in six AS-related silicosis patients in Australia. Patients were removed from occupational exposure for at least 12 months prior to procedure, and they had to have either worsening symptoms, worsening lung function, or both. Workers were targeted who had predominant ground-glass opacification. Workers with extensive fibrosis were excluded. All six patients were male with a median age of 37 years. All patients underwent bilateral lavage with a median lavage volume of 26.8 (15-30.8) L. The authors report a significant reduction in the International Classification of High Resolution Computed Tomography for Occupational and Environmental Respiratory Disease (ICOERD) score before and after WLL, from 7 (6.75-7.25) to 1.75 (1-2.5) ($p = 0.0135$).

Fireman, E., Mahamed, A. E., Rosengarten, D., Ophir, N. N., & Kramer, M. R. (2021). Quantitation of Silica Contents in Lung Explants of Transplanted Patients: Artificial Stone-Induced Silicosis vs. Idiopathic Pulmonary Fibrosis. *International Journal of Environmental Research and Public Health*, 18(14), Article 14. https://doi.org/10.3390/ijerph18147237

A study of silica content in biopsies of lung-transplanted silicosis patients (n = 17) using XRF spectrometry. Researchers also gathered occupational and clinical histories of patients. Lung biopsies of AS-related silicosis patients contained significantly higher levels of silica compared to idiopathic pulmonary fibrosis patients (7284±4694 ppm compared to 899±366 ppm, $p < 0.0001$). Titanium and aluminum levels were also significantly higher among AS-related silicosis patients than IPF patients. Authors identified a silica cut-off value of 1128 ppm, which has 100% sensitivity and 94% specificity for predicting AS-related silicosis.

García-Núñez, A., Jiménez-Gómez, G., Hidalgo-Molina, A., Córdoba-Doña, J. A., León-Jiménez, A., & Campos-Caro, A. (2022). Inflammatory indices obtained from routine blood tests show an inflammatory state associated with disease progression in engineered stone silicosis patients. *Scientific Reports*, 12(1), 8211. https://doi.org/10.1038/s41598-022-11926-x

An epidemiological investigation of circulating biomarker levels and systemic inflammatory indices among AS-related silicosis patients (n = 91) who are no longer exposed to AS dust. Study included 53 subjects diagnosed with simple silicosis (SS) and 38 with PMF, as well as 22 healthy, unexposed controls. Investigators measured LDH, sACE, protein C reactive (PCR), rheumatoid factor (RF), alkaline phosphatase, and fibrinogen. They observed significantly elevated levels of LDH, sACE, and fibrinogen among the SS and PMF patients, compared to the healthy controls, with significant sequential increase in LDH and fibrinogen levels observed from control to simple silicosis to PMF subjects. sACE levels were not significantly different between SS and PMF groups. Investigators also observed significant increases in all inflammation indices tested, with moderately high sensitivity and specificity for differentiating between patient and control groups.

Grubstein, A., Shtraichman, O., Fireman, E., Bachar, G. N., Noach-Ophir, N., & Kramer, M. R. (2016). Radiological Evaluation of Artificial Stone Silicosis Outbreak: Emphasizing Findings in Lung Transplant Recipients. *Journal of Computer Assisted Tomography*, 40(6), 923. https://doi.org/10.1097/RCT.0000000000000454

A report of high-resolution CT findings and their relationship to PFT results among AS-related silicosis patients (n = 82) in Israel. 13 of the subjects had undergone lung transplant. Authors observed a significant inverse relationship between chest CT scores and PFT, including FEV1 ($r = -0.54$, $p < 0.0001$), total lung capacity ($r = -0.4$, $p < 0.0001$), and D_{LCO} ($r = -0.6$, $p < 0.0001$). PMF patterns were observed in all patients who received lung transplant and in 51 (74%) of the patients who had not. PMF was diagnosed in 40% of patients without lung transplant compared to 85% of patients with lung transplant.

Hoy, R. F., Hansen, J., Glass, D. C., Dimitriadis, C., Hore-Lacy, F., & Sim, M. R. (2021). Serum angiotensin converting enzyme elevation in association with artificial stone silicosis. *Respiratory Medicine*, 177, 106289. https://doi.org/10.1016/j.rmed.2020.106289

An epidemiological study of male AS workers in Australia (n = 179, median age = 40 years), which assessed the relationship between sACE and AS-related silicosis. All enrolled subjects had worked in an environment where dry processing occurred. All subjects underwent PFT, high-resolution CT scans, and blood testing, including sACE. 60 workers with AS were identified, and these subjects had significantly higher median sACE levels (64.1 U/L, 95% CI 51.5-87.5) compared to the 119 subjects without silicosis (35.0 U/L, 95% CI 25.2-46.9). The difference was highest among subjects with complicated silicosis (70.0 U/L, 95% CI 51.5-88.5, n = 16). Subjects with lymphadenopathy alone had elevated median levels (43.0 U/L) compared to those with normal HRCT, but levels were lower than those with silicosis. No associations were observed between sACE and either exposure duration or spirometry. All reported values are unadjusted, and longitudinal studies are needed to further evaluate sACE as a biomarker for AS-related silicosis.

Hoy, R. F., Jones, C., Newbigin, K., Abramson, M. J., Barnes, H., Dimitriadis, C., Ellis, S., Glass, D. C., Gwini, S. M., Hore-Lacy, F., Jimenez-Martin, J., Pasricha, S. S., Pirakalathanan, J., Siemienowicz, M., Walker-Bone, K., & Sim, M. R. (2024). Chest x-ray has low sensitivity to detect silicosis in artificial stone benchtop industry workers. *Respirology*, 29(9), 785–794. https://doi.org/10.1111/resp.14755

A study comparing paired CXR and high-resolution CT images from 110 AS workers. Each pair was independently read by two radiologists from a panel of seven. Accuracy of screening positive (ILO major category 1, 2, or 3) and negative (ILO major category 0) CXRs were compared with identification of radiological features on high-resolution CT. CXR was positive for silicosis in only 27/110 (25%) of workers, while high-resolution CT was positive in 40/110 (36.4%). Of the 83 with negative CXR, 15 (18.1%) had silicosis on high-resolution CT. Among the 99 workers with ILO category 0 or 1 CXRs, the sensitivity of screening positive CXR compared to silicosis identified by HRCT was 48% (95% CI 29-68), and the specificity was 97% (95%CI 90-100%). The authors conclude that reliance on CXR alone for health monitoring would ‘provide false reassurance for many workers, delay management and underestimate the prevalence of silicosis in the artificial stone benchtop industry.’

Khan, S. N. S., Stirling, R. G., Mclean, C. A., Russell, P. A., & Hoy, R. F. (2022). GM-CSF antibodies in artificial stone associated silicoproteinosis: A case report and literature review. *Respirology Case Reports*, 10(9), e01021. https://doi.org/10.1002/rcr2.1021

A case report on a 26-year-old AS fabricator with silicoproteinosis and elevated serum granulocyte-macrophage colony-stimulating factor Ab (GM-CSF-Ab). GM-CSF-Ab is a key diagnostic feature of autoimmune (primary) pulmonary alveolar proteinosis (PAP). GM-CSF promotes differentiation of alveolar macrophages in the lung, which clear surfactant and debris from alveoli. GM-CSF-Ab neutralizes the effects of GM-CSF by interfering with macrophage

differentiation/maturation that occurs in the development of PAP. GM-CSF-Ab levels above 5.0 µg/mL have a sensitivity and specificity of 100% for autoimmune PAP; however, the presence of GM-CSF-Ab in lower levels may occur in healthy individuals or those with other lung diseases. GM-CSF-Ab levels do not correlate with disease duration or severity, pulmonary function, or serum biomarkers of PAP.

Robinson, R., Hua, J. T., Lee, B., Villegas, K., Gaboyan, S., Rose, C. S., Lin, C. M., Golts, E., Yung, G., Akins, T., Gaissert, C., Malles, C., Gloria, A. M., & Afshar, K. (2025). One-year lung transplantation outcomes for engineered stone countertop workers with silicosis at a single center in Southern California, 2019 to 2023. *JHLT Open*, 9, 100280. https://doi.org/10.1016/j.jhlto.2025.100280

An epidemiological study of outcomes among lung transplant recipients at a single center in California. Compared pretransplant, perioperative, and 1-year post-transplant outcomes for silicosis (n = 7) and non-silicosis interstitial lung disease (ILD) (n = 69) patients. All silicosis patients had worked in AS fabrication. Occupational histories were unavailable for non-silicosis patients. Silicosis patients were younger than non-silicosis patients (median ages 43.1 and 59.3 years, respectively). Silicosis patients had significantly more lung function deterioration than non-silicosis patients ($p < 0.001$ for percent predicted FEV). Perioperative complication rates were similar between the two groups, as were 1-year post-transplant survival, allograft rejection rates, and pulmonary function tests.

Rosengarten, D., Fox, B. D., Fireman, E., Blanc, P. D., Rusanov, V., Fruchter, O., Raviv, Y., Shtraichman, O., Saute, M., & Kramer, M. R. (2017). Survival following lung transplantation for artificial stone silicosis relative to idiopathic pulmonary fibrosis. *American Journal of Industrial Medicine*, 60(3), 248–254. https://doi.org/10.1002/ajim.22687

An epidemiological study of survival following lung transplantation among silicosis and idiopathic pulmonary fibrosis (IPF) patients at a medical center in Israel. Followed 17 silicosis patients among 342 lung transplantations between 2006 and 2013. Survival was followed through 2015. Authors observed a non-significant survival improvement among lung transplant patients with silicosis compared to those with IPF during the same period (HR = 0.6; 95% CI 0.24-1.55). The authors conclude that survival among silicosis patients following lung transplantation is not reduced compared to IPF; however, they acknowledge the limitations of the small sample size and single center.

Wang, H., Zhou, S., Liu, Y., Yu, Y., Xu, S., Peng, L., & Ni, C. (2022). Exploration study on serum metabolic profiles of Chinese male patients with artificial stone silicosis, silicosis, and coal worker's pneumoconiosis. *Toxicology Letters*, 356, 132–142. https://doi.org/10.1016/j.toxlet.2021.11.011

A case-control study that characterizes serum metabolic profiles of pneumoconiosis and AS-related silicosis patients in China. Study included 46 male patients with pneumoconiosis, including silicosis (19, 41.3%), AS-related silicosis (15, 32.6%), coal worker's pneumoconiosis (12, 26.1%), and 46 dust-exposed healthy workers (controls). Subjects were divided into pilot and validation studies. The pilot study identified potential biomarkers associated with pneumoconiosis, which were validated in the validation study. Serum metabolites of 15 AS-related silicosis cases showed very different profiles for five biomarkers compared to the 31 other pneumoconiosis patients. Among these, kynurenine, a tryptophan metabolite, showed elevated expression in AS-related silicosis compared to other pneumoconiosis patients. Previous studies have shown that kynurenine affects both cell death and migration and shows immunomodulatory effects (mainly anti-inflammatory). The authors hypothesize that activated

tryptophan metabolism may be associated with the fast progression of silicosis observed in AS cases.

09. Qualitative studies of worker experience

Fazio, J. C., Garcia, S. R., Torres, I. R., Gandhi, S. A., Cummings, K. J., Buhr, R. G., Riley, K., Ponce, N., Bustamante, A. V., & Glenn, B. (2025). Silica Hazards in Engineered Stone Countertop Production: Worker Experiences and Challenges in Los Angeles. American Journal of Industrial Medicine, n/a(n/a). https://doi.org/10.1002/ajim.70010

A qualitative study that assessed workers' (n = 20) knowledge, attitudes and practices regarding silica hazards. Investigators worked with LA County DPH and community partners to conduct purposive sampling from worker centers or fabrication shops in LA; eligible subjects were limited to those with English or Spanish proficiency. All participants were Latino men, 90% of whom were foreign-born. Researchers conducted semi-structured interviews, which were informed by the socio-ecological model. Two researchers analyzed the transcripts using thematic and content analysis. 68% of respondents regularly engaged in dry cutting, with half saying that their employers did not provide respirators. 90% of respondents had basic knowledge about the respiratory hazards of dusts, but much of this was learned through word-of-mouth or social media. Workers feared being fired for raising safety concerns, and they felt trapped in their jobs, due to limitations around immigration status, skills, or presumed pay from other work. Participants identified wet cutting, workplace training, and regulation of AS, including elimination, as potential solutions.

Hore-Lacy, F., Gwini, S. M., Dimitriadis, C., Jimenez-Martin, J., Hoy, R. F., Fisher, J., Sim, M. R., Walker-Bone, K., & Glass, D. C. (2025). Measuring improvements in occupational health and safety in the artificial stone benchtop industry. *Annals of Work Exposures and Health*, 69(1), 5–16. https://doi.org/10.1093/annweh/wxae084

An evaluation of Australia's response to the engineered stone-related silicosis epidemic using longitudinal inspection data obtained in Victoria, Australia between 2018 and 2024. Data were available for 869 workers prior to the 2019 ban on dry cutting and for 557 workers after the ban. Researchers observed statistically significant improvements in safety measures after the ban. From the self-reported screening data, the proportion of workers reporting never dry cutting in a specific job increased from 17.3% before the ban to 67.2% after. Similarly, jobs without recommended ventilation and with dry cutting >10% of the time decreased from 31.1% before ban to 1.1% after. While investigators report improvements, they note that some jobs continue to involve dry processing without adequate engineering controls.

Pérez-Alonso, A., González-Domínguez, M. E., Novalbos-Ruiz, J. P., León-Jiménez, A., & Córdoba-Doña, J. A. (2021). Artificial Stone Silicosis: Accumulation of errors in the resurgence of an occupational disease: A qualitative study. WORK, 70(2), 433–442. https://doi.org/10.3233/WOR-213582

A qualitative, interview-based study of the lived experiences of AS-related silicosis patients. Subjects ages and work tenures ranged from 32-45 and 3-20 years, respectively. Interviews revealed three themes: 1) coincident labor deregulation and high demand for AS; 2) poor working conditions involving dry cutting of AS without proper protection and greater exposures during on-site installations; 3) deficient health surveillance and AS-related silicosis prevention efforts.

Spiegel, A., Cummings, K. J., Flattery, J., Harrison, R., & Heinzerling, A. (2022). Self-reported silica exposures and workplace protections among engineered stone fabrication workers in California. *American Journal of Industrial Medicine*, 65(12), 1022–1024. https://doi.org/10.1002/ajim.23432

An analysis of worker interview data collected during 2019-2020 Cal/OSHA inspections. Inspectors administered an English/Spanish questionnaire to workers at 106 shops, which assessed worker tasks, perceived exposures to silica dust, workplace protections, and use of medial surveillance. Complete questionnaires were available for 92 workers at 33 inspected facilities (31%). The median age of participants was 39 years, with a median work tenure of 3.8 years. 84 workers (91%) reported performing RCS-generating tasks including cutting, grinding, laminating, or polishing stone, with 25% of these workers reporting sometimes using dry methods while performing those tasks. Only 5% reported that they or their co-workers had been sent for medical exams.

10. Policy studies: recommendations, reflections, and resources

Carey, R., & Fritschi, L. (2022). *The future burden of lung cancer and silicosis from occupational silica exposure in Australia: A preliminary analysis.* Australian Council of Trade Unions. https://www.curtin.edu.au/about/wp-content/uploads/sites/5/2022/07/FEFreport_formatted.pdf

A risk assessment that evaluates the future burden of lung cancer and silicosis due to current occupational exposure to RCS. Researchers estimated future lung cancer cases using the future excess fraction approach, which is based on the lifetime risk approach. They then extrapolated the estimated case counts to future silicosis cases, and they estimated the number of future lung cancer and silicosis cases that may be avoided under different policy intervention scenarios. The study includes estimates for AS workers; however, limited data availability required the researchers to use a less detailed approach for these estimates. The models show that elimination of AS exposure is the most effective intervention, with 770-960 silicosis cases avoided). Implemented together, engineering controls and appropriate PPE avoided roughly half the number of cases avoided with an elimination intervention.

Cavalin, C., Menéndez-Navarro, A., León-Jiménez, A., Lecureur, V., & Lescoat, A. (2024). The ban on engineered stone in Australia: A milestone in the fight against emerging silica hazards. *European Respiratory Journal*, 63(6). https://doi.org/10.1183/13993003.00138-2024

A review of the factors contributing to the Australian ban on AS in 2024, including a discussion of the global lessons learned from the ban, with particular focus on Europe.

Cavalin, C., Menéndez-Navarro, A., & Lescoat, A. (2025). The Banning of Engineered Stone in Australia: An Evidence-Based and Precautionary Policy. *International Journal of Social Determinants of Health and Health Services*, 27551938251314656. https://doi.org/10.1177/27551938251314656

A review of the factors contributing to the Australian ban on AS in 2024, including a discussion of the global lessons learned from the ban.

Cole, K., Glass, D., Bence, T., Pisaniello, D., Knott, P., Rowett, S., & Johnson, S. (2023). Prevention of the Occupational Silicosis Epidemic in Australia: What Do Those Who Assess Workplace Health Risk Think Should Be Done Now? *Annals of Work Exposures and Health*, 67(2), 281–287. https://doi.org/10.1093/annweh/wxac064

A report of the results of an anonymous survey given to members of the Australian Institute of Occupational Hygienists (AIOH) about their practical experiences and perspectives on RCS exposure and regulation. The survey addressed individual characteristics, experience, perceived employer awareness, effectiveness of current regulation, and recommendations for improvement across three industries (mining/quarrying, construction/tunneling, and AS). 105 responses (20% of AIOH membership) were received, mostly representing senior members. 49% had experience with AS, compared to 65% and 84% in construction/tunneling and mining/quarrying, respectively. Of the responses, 71% were concerned about over-exposure to RCS. 43% of responses indicated that personal monitoring was taking place only sporadically (‘seldom’ or ‘never’) in AS industry. Respondents identified lack of financial resources and commitment from management as barriers to exposure control. Thematic analysis identified a common desire for a broader prevention strategy, including a federally coordinated response, which focuses on compliance and improves regulations, eliminating the source of exposure, performing respiratory disease monitoring, and improving training, awareness, and technology.

Hore-Lacy, F., Dimitriadis, C., Hoy, R. F., Jimenez-Martin, J., Sim, M. R., Fisher, J., Glass, D. C., & Walker-Bone, K. (2025). Screening Workers for Occupational Exposure to Respirable Crystalline Silica: Development and Usability of an Electronic Data Capture Tool. *JMIR Human Factors*, 12(1), e64111. https://doi.org/10.2196/64111

A report of an electronic data capture tool designed for the collection of occupational silica exposure assessment data for clinical and research use. While the tool was developed for AS workers in Australia, it is adaptable to other countries and industries.

11. Literature reviews

Barnes, H., Lam, M., Tate, M. D., & Hoy, R. (2024). Toward targeted treatments for silicosis. *Current Opinion in Pulmonary Medicine*, 30(2), 185–194.

A review of pharmacological therapies for silicosis, including currently available drugs, repurposed drugs, and treatments under development. The authors evaluate the plausibility of success of these treatments, given disease pathogenesis. The review does not include nonpharmacological treatments, such as whole-lung lavage or lung transplant. The authors conclude that there is no 'silver bullet' pharmacological therapy for silicosis and that a multimodal approach may be required. For example, the authors speculate that an ideal approach may involve down-regulation of the immune system coupled with a silica clearance treatment such as whole-lung lavage.

Fazio, J. C., Viragh, K., Houlroyd, J., & Gandhi, S. A. (2025). A review of silicosis and other silica-related diseases in the engineered stone countertop processing industry. *Journal of Occupational Medicine and Toxicology*, 20(1), 9. https://doi.org/10.1186/s12995-025-00455-8

A literature review of the epidemiology, occupational risks, regulatory gaps, diagnostic evaluation, and clinical challenges associated with AS dust exposure.

Fireman, E. M., & Fireman Klein, E. (2024). Association between silicosis and autoimmune disease. *Current Opinion in Allergy and Clinical Immunology*, 24(2), 45. https://doi.org/10.1097/ACI.0000000000000966

An overview of the mechanistic evidence, including epidemiological and animal studies, that supports the association between RCS exposure and autoimmune disease. The review focuses on new RCS exposure sources, such as AS, and discusses prevention, early detection, and treatment approaches.

Hoy, R. F., & Brims, F. (2017). Occupational lung diseases in Australia. *Medical Journal of Australia*, 207(10), 443–448. https://doi.org/10.5694/mja17.00601

A review of occupational lung diseases in Australia, which includes a brief discussion of lung disease among AS workers.

Hoy, R. F., & Chambers, D. C. (2019). Silica-related diseases in the modern world. *Allergy*, 75, 2805–2817.

A review of the minerology, epidemiology, and the radiological and clinical features of silicosis and other silica-related diseases. The review discusses recent studies of silicosis pathogenesis, clinical challenges, and the importance of obtaining occupational histories in a clinical setting.

Hoy, R. F. (2021). Artificial stone silicosis. *Current Opinion in Allergy & Clinical Immunology*, 21(2), 114–120. https://doi.org/10.1097/ACI.0000000000000715

A literature review of the health effects of occupational AS dust exposure and the global increase in AS-related silicosis. The review summarizes recent findings related to AS dust characteristics, AS-related silicosis and its pathological and radiological features, and emerging treatment options.

Hoy, R. F., Jeebhay, M. F., Cavalin, C., Chen, W., Cohen, R. A., Fireman, E., Go, L. H. T., León-Jiménez, A., Menéndez-Navarro, A., Ribeiro, M., & Rosental, P.-A. (2022). Current global perspectives on silicosis—Convergence of old and newly emergent hazards. *Respirology*, 27(6), 387–398. https://doi.org/10.1111/resp.14242

A literature review summarizing the global landscape of silicosis prevalence, including discussions of both historic and emergent contributors like AS. The review is structured largely by continent. The discussion of AS-related silicosis in North America, and specifically in the US, is limited by lack of data.

Jacobs, N. F. B., E. Zisook ,Rachel, & and Tarpey, T. A. (2024). Reported exposures to respirable crystalline silica during construction tasks and guidance for harmonizing future research. *Journal of Occupational and Environmental Hygiene*, 21(8), 602–622. https://doi.org/10.1080/15459624.2024.2357715

A literature review of occupational exposures studies of RCS during common construction tasks, including AS fabrication. After pooling exposure results for AS workers, which were collected for varying durations, the authors report an exposure range of 90 to 44,370 μg/m^3.

Jones, C. M., Pasricha, S. S., Heinze, S. B., & MacDonald, S. (2020). Silicosis in artificial stone workers: Spectrum of radiological high-resolution CT chest findings. Journal of Medical Imaging and Radiation Oncology, 64(2), 241–249. https://doi.org/10.1111/1754-9485.13015

A review of the radiological features of the various forms of silicosis observed on high-resolution CT among AS-related silicosis patients in Australia.

Leso, V., Fontana, L., Romano, R., Gervetti, P., & Iavicoli, I. (2019). Artificial Stone Associated Silicosis: A Systematic Review. *International Journal of Environmental Research and Public Health*, 16(4), Article 4. https://doi.org/10.3390/ijerph16040568

A systematic review that aims to verify the association between AS-related silica exposure and the development of silicosis and to identify pathological characteristics of AS-related silicosis related to preventive and protective measures in the workplace.

Mandler, W. K., Qi, Chaolong, & and Qian, Y. (2023). Hazardous dusts from the fabrication of countertop: A review. *Archives of Environmental & Occupational Health*, 78(2), 118–126. https://doi.org/10.1080/19338244.2022.2105287

A narrative review of the literature for both solid surface composites (SSCs) and AS, including the composition, particle emission characteristics, workplace exposure data, particle constituent toxicity, and exposure reduction methods. Both AS and SSCs are artificial countertop materials that are composed of a mineral filler bound in a polymer matrix. While AS may use up to 95% crystalline silica (w/w) as a filler, SSC typically uses ~70% aluminum trihydrate. Additionally, AS typically uses a polyester resin binder, while SSC typically uses poly(methyl methacrylate).

Nikpour, M., Morrisroe, K., Calderone, A., Yates, D., & Silman, A. (2025). Occupational dust and chemical exposures and the development of autoimmune rheumatic diseases. *Nature Reviews Rheumatology*, 21(3), 137–156. https://doi.org/10.1038/s41584-024-01216-3

A review of the epidemiological evidence of the associations between occupational exposures to dust and organic solvents and the development of systemic autoimmune rheumatic diseases (SARDs). While the evidence of association between these exposures and SARDs are most compelling, the authors additionally include a brief discussion of several other exposures. Review includes discussion of many silica- and solvent-related SARDs, including systemic sclerosis, rheumatoid arthritis, systemic lupus erythematosus, small-vessel vasculitis, and sarcoidosis.

Ramkissoon, C., Gaskin, S., Song, Y., Pisaniello, D., & Zosky, G. R. (2024). From Engineered Stone Slab to Silicosis: A Synthesis of Exposure Science and Medical Evidence. *International Journal*

of Environmental Research and Public Health, 21(6), Article 6. https://doi.org/10.3390/ijerph21060683

A narrative review of literature that includes: 1) AS material characterization, including chemistry, particle size and shape, and particle mass; 2) occupational exposure pathways, including product characteristics, fabrication techniques, and engineering controls; and 3) host factors, including PPE, genetic predisposition, and other risk factors. Discussion includes both crystalline silica content of AS, as well as other components including resins and metals.

12. Editorials

Akgün, M., & Kar Kurt, Ö. (2025). A New Global Epidemic of Silicosis Due to Artificial Stone: Is Türkiye Next? *Thoracic Research and Practice*.

An editorial summarizing the global context of AS-related silicosis.

Barber, C. M., Fishwick, D., Seed, M. J., Carder, M., & Tongeren, M. van. (2018). Artificial stone-associated silicosis in the UK. *Occupational and Environmental Medicine*, 75(7), 541–541. https://doi.org/10.1136/oemed-2018-105028

A response to Hoy, et al. 2018. After reviewing cases reported to a UK registry, consulting with a group of occupational respiratory disease specialists, and reviewing the published literature, the authors report that there are, to date, no known cases of AS-related silicosis in the UK.

Barber, C. (2024). Artificial stone silicosis arrives in the UK: a tragic case of history repeating. *Thorax*, 79(10), 895–896.

An editorial that summarizes the key issues around the AS-related silicosis epidemic for clinicians in the United Kingdom.

Barnes, H., & Chambers, D. C. (2024). Silicosis—Where to from here? *Respirology*, 29(12), 1020–1022. https://doi.org/10.1111/resp.14853

An editorial that identifies next steps in Australia following the country's ban on AS in 2024. The authors highlight the need to evaluate the safety of new, low-silica materials.

Brampton, K. (2024). Why is BOHS not calling for engineered stone to be banned? Exposure, 1. https://www.bohs.org/app/uploads/2024/04/Exposure-Magazine-2024-Issue-1.pdf

An editorial explaining why the British Occupational Hygiene Society (BOHS) does not support an AS ban in the UK. The author argues that bans have not historically delivered their desired outcomes and argues that the risks can be adequately managed with engineering controls. The author additionally points to the ubiquity of automation and other engineering controls currently used in UK shops. Furthermore, he argues that the primary risk lies in AS that has already been installed, and that a ban would not mitigate this risk.

Cohen, R. A., & Go, L. H. T. (2020). Artificial Stone Silicosis: Removal From Exposure Is Not Enough. *CHEST*, 158(3), 862–863. https://doi.org/10.1016/j.chest.2019.11.029

An editorial discussing the findings reported by León-Jiménez, et al. 2020. The original article describes rapid progression of disease among AS workers with silicosis, despite exposure cessation. The editorial authors draw comparisons between the AS-related silicosis epidemic and the Hawk's Nest disaster.

Currow, D. C., Cole, K. F., Aranda, S. K., & Sim, M. R. (2025). We'll Look Back and Say, "Why Didn't We Act Sooner on Engineered Stone?" *American Journal of Respiratory and Critical Care Medicine*, 211(7), 1310–1310. https://doi.org/10.1164/rccm.202501-0282LE

A response to the editorial by Heinzerling, et al. 2025 that emphasizes the urgency of the issue and challenges the suggestion of a national inquiry that was made in the original article. The authors of this editorial argue that a national inquiry is inadequate and will only delay implementation of known protective measures.

Edwards, G. (2019). Accelerated Silicosis—An Emerging Epidemic Associated with Engineered Stone. Comment on Leso, V. et al. Artificial Stone Associated Silicosis: A Systematic Review. Int. J. Environ. Res. Public Health 2019, 16 (4), 568, doi:10.3390/ijerph16040568. International *Journal of Environmental Research and Public Health*, 16(7), Article 7. https://doi.org/10.3390/ijerph16071179

A response to the 2019 literature review by Leso, et al. The response highlights a government-funded case finding program in Queensland, Australia, which, at the time of publication (February 2019), had identified 99 confirmed silicosis cases among the roughly 400 AS workers screened. Nearly all identified cases were asymptomatic. 15 silicosis cases had PMF. The response also highlights the inadequacy of chest x-ray as a diagnostic method for AS-related silicosis, given the high false negative rate the author has observed (>10%).

Freckelton, I. (2024). Banning Engineered Stone: A Landmark Australian Public Health Law Reform. *Journal of Law & Medicine*, 31(1).

A chronology of the events that contributed to the AS ban in Australia, written from a legal perspective, with detailed policy descriptions.

Glass, D. C., & Hoy, R. F. (2025). The leadup to the artificial stone ban in Australia. *Annals of Work Exposures and Health*, 69(1), 1–4. https://doi.org/10.1093/annweh/wxae085

A chronology of the events that contributed to the AS ban in Australia, including discussions of critical advances in epidemiological and exposure research, the roles of community organizations and the Australian media, and the strategy and actions of the National Dust Disease Taskforce, which the Australian government established in 2019 and which ultimately recommended a conditional ban.

Heinzerling, A., Harrison, R., Flattery, J., Fazio, J. C., Gandhi, S., & Cummings, K. J. (2025). Deadly Countertops: An Urgent Need to Eliminate Silicosis among Engineered Stone Workers. *American Journal of Respiratory and Critical Care Medicine*, 211(4), 557–559. https://doi.org/10.1164/rccm.202410-2008VP

An editorial that summarizes the key issues around the AS-related silicosis epidemic, both in the US and globally. Authors call for the establishment of a national taskforce, similar to what was established in Australia prior to its ban.

Heinzerling, A., Harrison, R., Flattery, J., Fazio, J. C., Gandhi, S., & Cummings, K. J. (2025). Reply to Currow et al. and to Akgün. *American Journal of Respiratory and Critical Care Medicine*, 211(7), 1312–1313. https://doi.org/10.1164/rccm.202502-0405LE

Response to Currow, et al. 2025 and Akgün, et al. 2025.

Hoy, R. F., & Yates, D. H. (2018). Response to: 'Artificial stone-associated silicosis in the UK' by Barber et al. *Occupational and Environmental Medicine*, 75(7), 541–542. https://doi.org/10.1136/oemed-2018-105092

A response to Barber, et al. 2018.

Hoy, R., & Yates, D. H. (2019). Artificial stone-associated silicosis in Belgium: Response. *Occupational and Environmental Medicine*, 76(2), 134–134. https://doi.org/10.1136/oemed-2018-105563

A response to Ronsmans, et al. 2019.

Hoy, R. F., & Sim, M. R. (2022). Correspondence on 'Demographic, exposure and clinical characteristics in a multinational registry of engineered stone workers with silicosis' by Hua et al. *Occupational and Environmental Medicine*, 79(9), 647–648. https://doi.org/10.1136/oemed-2022-108496

A response to Hua, et al. 2022 that reports the extent to which previously reported AS-related silicosis case counts are underestimated. After reviewing all publicly available data published by Australian work, health, and safety agencies, Hoy and Sim identified 579 cases of AS-related silicosis, which is vastly higher than the 14 reported in their previously published paper. Since the time their paper was published, Australia has greatly improved its surveillance programs. As of March 2022, the program has assessed 1,053 workers and identified 238 with silicosis, translating to a prevalence of 23%.

Hua, J. T., Zell-Baran, L., Go, L. H. T., Kramer, M. R., Bree, J. B. V., Chambers, D., Newbigin, K., Deller, D., Matula, M., Fireman, E., Dahbash, M., Martinez-Gonzalez, C., León-Jimenez, A., Sack, C., Sancho, J. F., Villar, A., Almberg, K. S., Cohen, R. A., & Rose, C. S. (2022). Response to: Correspondence on 'Demographic, exposure and clinical characteristics in a multinational registry of engineered stone workers with silicosis' by Hoy et al. *Occupational and Environmental Medicine*, 79(12), 849–850. https://doi.org/10.1136/oemed-2022-108512

A response to Hoy and Sim, 2022.

Hua, J. T., Rose, C. S., & Redlich, C. A. (2023). Engineered Stone–Associated Silicosis—A Lethal Variant of an Ancient Disease. *JAMA Internal Medicine*, 183(9), 908–910. https://doi.org/10.1001/jamainternmed.2023.3260

An editorial describing the state of the AS-related silicosis pandemic, both in the US and globally.

Jones, R. M. (2022). Artificial Stone Silicosis: Need for Improved Controls. Annals of Work Exposures and Health, 66(2), 137–138. https://doi.org/10.1093/annweh/wxab118

An editorial that summarizes the key issues around the AS-related silicosis epidemic for industrial hygienists and calls for the development of improved controls.

Kirby, T. (2024). Australia bans engineered stone to prevent silicosis. *The Lancet Respiratory Medicine*, 12(4), e18. https://doi.org/10.1016/S2213-2600(24)00007-9

An editorial discussing the 2024 ban on engineered stone in Australia.

Kromhout, H., Tongeren, M. van, & Cherrie, J. W. (2024). Should engineered stone products be banned? Occupational and Environmental Medicine, 81(7), 329–330. https://doi.org/10.1136/oemed-2024-109708

An editorial response to the Australian AS ban. The editorial cites (and disagrees with) a recent editorial by Brampton, which explained why the British Occupational Hygiene Society (BOHS) is against a similar ban in the UK. Brampton argues that the risks posed by AS can be adequately controlled. The authors of this editorial disagree and express support for a ban in Europe.

Leso, V., Fontana, L., Romano, R., Gervetti, P., & Iavicoli, I. (2019). Reply to Accelerated Silicosis—An Emerging Epidemic Associated with Engineered Stone. Comment on Leso, V. et al. Artificial Stone-Associated Silicosis: A Systematic Review. Int. J. Environ. Res. Public Health 2019,

16(4), 568, doi:10.3390/ijerph16040568. *International Journal of Environmental Research and Public Health*, 16(7), Article 7. https://doi.org/10.3390/ijerph16071201

An editorial response to a comment by Edwards, et al. on the Leso, et al. 2019 literature review listed above.

Perret, J. L., Miles, S., Brims, F., Newbigin, K., Davidson, M., Jersmann, H., Edwards, A., Zosky, G., Frankel, A., Johnson, A. R., Hoy, R., Reid, D. W., Musk, A. W., Abramson, M. J., Edwards, B., Cohen, R., & Yates, D. H. (2020). Respiratory surveillance for coal mine dust and artificial stone exposed workers in Australia and New Zealand: A position statement from the Thoracic Society of Australia and New Zealand*. Respirology, 25(11), 1193–1202. https://doi.org/10.1111/resp.13952

A statement by the Thoracic Society of Australia and New Zealand, which discusses Australia's approach to respiratory periodic health surveillance and proposes a medical framework for improvements to respiratory surveillance to detect coal mine lung dust disease (CMDLD) and AS silicosis. The proposed framework includes appropriate referral, improved data collection/interpretation, enhanced surveillance, and the establishment of a national registry and an independent advisory group.

Weiler Ravell, D., & Bishara, H. (2016). Biometric monitoring in silicosis to detect early disease and monitor lung injury: Not quite there. *ERJ Open Research*, 2(4), 00086–02016. https://doi.org/10.1183/23120541.00086-2016

An editorial that raises several questions about the clinical and epidemiological inferences of Ophir, et al. 2016.

Wise, J. (2024). Doctors call for ban on cutting artificial stone after reporting first UK cases of silicosis. BMJ, 386, q1755. https://doi.org/10.1136/bmj.q1755

An editorial highlighting a recent case series (Feary, et al. 2024) that reported eight men in London with AS-related silicosis. The editorial echoes the authors of that report, who called for a concerted effort to advocate for more stringent regulations in the UK.

Yates, D., Brislane, K., Coles, J., Hosseini-Beheshti, E., & Linton, A. (2025). Comment on the Paper by Cavalin et al. The Banning of Engineered Stone in Australia: An Evidence-based and Precautionary Policy. International Journal of Social Determinants of Health and Health Services, 27551938251344405. https://doi.org/10.1177/27551938251344405

An editorial by members of the Asbestos & Dust Research Institute, which responds to Cavalin, et al. 2025. The editorial highlights lessons learned from the re-emergence of coal workers' pneumoconiosis in Queensland, which, the authors argue, set the stage for Australia's AS ban. They argue that the response to the coal mining situation provided political will for the AS ban. They also call for improved communication among different sectors. In discussing preventive approaches to managing dust-related disease in Australia, they highlight a unique quality of Australia's work safety laws, which is that they apply to 'workers' rather than 'employees' and 'employers,' which enables broader legislation than most countries are capable of.