

Supplementary Table 1. Asbestos exposure assessment asbestos dust concentration

Author (year)	Exposure assessment methods	Unit for exposure assessment	Sample collection	Exposure time of participants	Level of dust concentration	Occupational Exceeding Limits (OELs)	Percentage of participants working in the area with exceeding limit of asbestos (%)
Lojananond (2004) ³²	Asbestos exposure was measured in break pad (friction materials), tile factory, and cement tube.	fibre/cc	Personal sampling and air sampling	Total n=117 by using self-reported questionnaire	Brake pad factory #1=9.95 fibre/cc; brake pad factory #2=9.32 fibre/cc and brake pad factory #3=6.22 fibre/cc	OSHA PEL for asbestos is 0.1 fibre/cc (cc) of air as an eight-hour time-weighted average (TWA). NIOSH recommended exposure limits is 100,000 fibres/cc (cc) of air (100,000 fibres/cc), or 0.1 fibre/cc (cc). The threshold limit values (TLVs) of the ACGIH is 0.1 fibre/cc.	100% (35 in 35 samples from 4 factories)
Siriwatananukul (2008) ²⁷	Ambient asbestos exposure in tile factory was measured by using NIOSH 7402.	fibre/cc	Personal sampling and air sampling	Average time exposure = 23.11± 4.19 years	Mean asbestos level in different locations were; 1. At the material line to mixing area (site 1)=0.0028 fibre/cc 2. At the material line to mixing area (site 1)=0.0068 fibre/cc 3. At the area of tile production (Machine 5)=0.0049 fibre/cc 4. At the area of tile production (Machine 5)=0.002 fibre/cc	NIOSH recommended exposure limits (RELs) is 100,000 fibres/cc (cc) of air, or 0.1 fibre/cc (cc).	Asbestos level was below the NIOSH OEL among all workers.

Supplementary Table 1. Asbestos exposure assessment asbestos dust concentration (cont.)

Author (year)	Exposure assessment methods	Unit for exposure assessment	Sample collection	Exposure time of participants	Level of dust concentration	Occupational Exceeding Limits (OELs)	Percentage of participants working in the area with exceeding limit of asbestos (%)
Tangtong and Phanprasit (2008) ²⁸	Ambient asbestos dust in contained material building was measured by NIOSH 7400.	fibre/cc	Personal sampling and air sampling	Unclear	1. Three personal samples from ceiling repairing ranged from 0-0.36. 2. Six personal samples from ceiling repairing and removing ranged from 0.04-0.11. 3. Twelve ambient air samples from building repairing ranged from 0-0.09. 4. Nine ambient air samples outside the building ranged were equal to 0.	NIOSH recommended exposure limits is 100,000 fibres/cc (cc) of air (100,000 fibres/cc), or 0.1 fibre/cc (cc).	13% (4 in 30 samples)
Phanprasit et al (2009) ²⁶	Asbestos level in cement roof factory was measured by NIOSH 7400 and counting rule A.	fibre/ml; Additional assessment: Cumulative exposure for each task was calculated based on the years of exposure. The unit of cumulative exposure measurement was fibre-years/cc.	Personal sampling and air sampling	Workers who had worked in the cement, from 1975 until 2005.	The ambient air samples in the four factories were 0.017, 0.001, 0.006 and 0.001 fibre/cc. The roof fitting polishers had the highest exposure to airborne asbestos fibre at 0.73 fibre/cc. The estimated cumulative exposure for the workers performed studied-tasks ranged between 90.13-115.65 fibre-years/cc. The relative risk among the asbestos cement roof tile manufacturing workers in different areas ranged from 5.37-5.69.	NIOSH recommended exposure limits (RELs) is 100,000 fibres/cc (cc) of air (100,000 fibres/cc), or 0.1 fibre/cc(cc).	5% (1 in 19 personal samples)

Note: Occupational safety and Health Administration (OSHA) defined permissible exposure limit (PEL) for asbestos is 0.1 fibre/cc (cc) of air as an eight-hour time-weighted average (TWA), with an excursion limit (EL) of 1.0 asbestos fibres/cc over a 30-minute period.³⁹ The National Institute of Occupational Safety and Health (NIOSH) recommended exposure limits (RELs) at 100,000 fibres per cubic meter (cc or cc) of air (100,000 fibres/m³), which is equal to 0.1 fibre per cubic centimeter of air (0.1 fibre/cc or cc), as determined by a 400-liter air sample collected over 100 minutes in accordance with NIOSH Analytical Method 7400.³⁹ The American Conference of Governmental Industrial Hygienists (ACGIH) suggested that the threshold limit values (TLVs) of asbestos is 0.1 fibre/cc (cc).³⁹ The ACGIH defined a respiratory fibre as a fibre longer than 5 microns and at least three times as long as their diameter as determined by the membrane filter method at 400-450 X magnification using phase contrast illumination. Thailand exposure limit for occupational exposure for asbestos (chrysotile form) is 0.1 fibre/cc.³⁸

Supplementary Table 2. Silica exposure assessment and level of silica dust concentration

Author (year)	Exposure assessment methods	Unit for exposure assessment	Sample collection	Exposure time of participants	Level of dust concentration	Occupational Exceeding Limits (OELs)	Percentage of participants working in the area with exceeding limit of silica (%)
Aungkasuvapala et al (1995) ²⁴	Personal pump with 5-micron polyvinyl-chloride - (PVC). Pore filter was used to collect air for area and personal sampling.	mg/m ³	Personal sampling and air sampling	Mean±S.D. =4.0 ± 4.8 years	The average amount of total dust was 24.3±34.6 mg/m ³ (n=28, range 0.6-178.5 mg/m ³) and that of respirable dust was 2.4±1.6 (n=53, range 0.4-13.1).	The updated silica OSHA PEL is 0.05 mg/m ³ or 50 µg/m ³ . The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³). The ACGIH TLV for respirable fraction, α-quartz and cristobalite is 0.025 mg/m ³ . The dust level of cristobalite, respirable dust by Thailand OELs is 0.025 mg/m ³ . The dust level of α-quartz, respirable dust by Thailand OELs is 0.025 mg/m ³ .	NA
Yingratanasuk et al (2002) ²⁹	Personal dust sampling: a subset of the dust samples was analysed for crystalline silica content by IR spectrophotometry.	mg/m ³ ; Three exposure metrics were constructed: 1. Years in Trade 2. Exposure-years that a subject has worked in any stone-working jobs (months per year). 3. Jahr's cumulative quartz exposure	Personal sampling	4 months to 30 years	Site 1 Carvers=0.22 mg/m ³ Pestle makers=0.05 mg/m ³ Site 2 Mortar makers=0.05 mg/m ³ Site 3 Mortar makers=0.88 mg/m ³ Exposure metrics 1. Years in trade=13.32 (8.2) years 2. Exposure-year=10.87 (7.71) years 3. Jahr's Quartz Exposure=19.64 (26.19) mg/m ³ -year	The updated silica OSHA PEL is 0.05 mg/m ³ or 50 µg/m ³ . The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³). The ACGIH TLV for respirable fraction, α-quartz and cristobalite is 0.025 mg/m ³ . The dust level of cristobalite, respirable dust by Thailand OELs is 0.025 mg/m ³ . The dust level of α-quartz, respirable dust by Thailand OELs is 0.025 mg/m ³ .	NA

Supplementary Table 2. Silica exposure assessment and level of silica dust concentration (cont.)

Author (year)	Exposure assessment methods	Unit for exposure assessment	Sample collection	Exposure time of participants	Level of dust concentration	Occupational Exceeding Limits (OELs)	Percentage of participants working in the area with exceeding limit of silica (%)
Danphaiboon et al. (2012) ²⁵	Ambient silica dust in stone mill factory was measured by NIOSH method 7601 issue 3 + spectrophotometry	mg/m ³	Air sampling	NA	The silica levels in 9 stone mill factories were 1.30, 1.99, 6.34, 1.10, 15.08, 15.91, 6.31, 11.25 and 1.67 mg/m ³ respectively.	The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³).	100% (9 in 9 factories)
Danphaiboon (2012) ³⁰	NIOSH 7500	mg/m ³	Air sampling	NA	Ambient silica mean was 9.24 ± 6.14 mg/m ³ (ranging from 1.10-15.91 mg/m ³)	The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³).	100% (7 in 7 provinces in the northern region of Thailand)
Danphaiboon et al (2012) ³³	NIOSH 7601 spectrophotometry	mg/cc	Air sampling	NA	Mean=12.11 mg/m ³ (SD=4.85) (max=20.41 mg/m ³) (stone mortar factory in Phayao)	The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³).	100% (117 in 117 participants)
Oopara (2013) ³¹	Personal air sampling with portable device attached to the workers' collar	mg/m ³	Personal sampling and air sampling	Workers in working zone before kiln: average= 14.7 years; Workers in working zone after kiln: average= 14.2 years	4.25-4.75 mg/m ³	The updated silica OSHA PEL is 0.05 mg/m ³ or 50 µg/m ³ . The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³). The ACGIH TLV for respirable fraction, α-quartz and cristobalite is 0.025 mg/m ³ . The dust level of cristobalite, respirable dust by Thailand OELs is 0.025 mg/m ³ . The dust level of α-quartz, respirable dust by Thailand OELs is 0.025 mg/m ³ .	NA

Supplementary Table 2. Silica exposure assessment and level of silica dust concentration (cont.)

Author (year)	Exposure assessment methods	Unit for exposure assessment	Sample collection	Exposure time of participants	Level of dust concentration	Occupational Exceeding Limits (OELs)	Percentage of participants working in the area with exceeding limit of silica (%)
Thongtip et al (2019) ¹⁹	NIOSH 7601 with a visible absorption spectrophotometer.	mg/m ³	Personal sampling	Stone cutter Mean=23 (17) years Stone grinder Mean=21 (17) years	Stone cutter Mean=0.096±0.094 Stone grinder Mean=0.130±0.106 Agricultural workers Mean=0.004±0.005	The NIOSH REL for respirable crystalline silica is 0.05 mg/m ³ (50 µg/m ³).	75% (stone cutters (n=29) + stone grinder (n=28) =57 in 77 participants)

Note: The updated silica OSHA PEL is 0.05 mg/m³ or 50 µg/m³ as an 8-hour TWA. The NIOSH REL for respirable crystalline silica is 0.05 mg/m³ (50 µg/m³) as a TWA for up to 10 hours/day during a 40-hour workweek. ACGIH TLV for respirable fraction, α-quartz and cristobalite is 0.025 mg/m³.³³⁹ The dust level of cristobalite, respirable dust by Thailand OELs is 0.025 mg/m³. The dust level of α-quartz, respirable dust by Thailand OELs is 0.025 mg/m³.³⁸