### Supplementary Table 1: Enterprise specific cohort characteristics

| Location   | Years of operation | Number of workers with at least one job in location* | Total employment years | Proportion of employment-years professionally exposed |
|------------|--------------------|------------------------------------------------------|------------------------|-----------------------------------------------------|
| Factory 0  | 1896-1956          | 141                                                  | 311                    | 97%                                                 |
| Factory 1  | 1934-1955          | 281                                                  | 799                    | 98%                                                 |
| Factory 2  | 1930-1980          | 1,960                                                | 15,084                 | 93%                                                 |
| Factory 3  | 1936-1977          | 1,936                                                | 16,031                 | 94%                                                 |
| Factory 4  | 1956-2010          | 5,650                                                | 45,517                 | 94%                                                 |
| Factory 5  | 1955-1997          | 4,230                                                | 33,731                 | 92%                                                 |
| Factory 6  | 1969-present       | 10,196                                               | 83,275                 | 51%                                                 |
| Central Lab| 1926-present       | 695                                                  | 5,727                  | 97%                                                 |
| Mine       | 1896 to present    | 25,173                                               | 305,431                | 83%                                                 |
| External Rail| 1970-present     | 1,202                                                | 9,428                  | 98%                                                 |
| **Total**  |                    | **515,355**                                          | **515,355**            | **88%**                                              |

* note that eligible cohort members had to work for at least one year in an eligible enterprise of JSC Uralasbest between 1975-2010, explaining the decline in workers from recent factory 6 to the first factory (factory 0), and they could have worked in multiple locations over time.
**Supplementary Table 2: Key cohort characteristics and their exposure (based on geometric mean monthly concentration per sampling point)**

| Gender | Median cumulative dust exposure (mg/m³-years) | Median cumulative fibre exposure (fibre/cm³-years) | Median average dust intensity (mg/m³) | Median average fibre intensity (fibre/cm³) |
|--------|-----------------------------------------------|---------------------------------------------------|-------------------------------------|------------------------------------------|
| Men    | 26.3 (0.01-1454.6)                             | 18.3 (0.01-1438)                                 | 2.6 (0.4-97.7)                      | 1.8 (0.4-31.3)                           |
| Women  | 39.1 (0.01-1184.4)                             | 31 (0.01-399.8)                                  | 3.5 (0.1-100)                      | 2.9 (0.1-43.2)                           |

| Birth year category | Median cumulative dust exposure (mg/m³-years) | Median cumulative fibre exposure (fibre/cm³-years) | Median average dust intensity (mg/m³) | Median average fibre intensity (fibre/cm³) |
|---------------------|-----------------------------------------------|---------------------------------------------------|-------------------------------------|------------------------------------------|
| <1930               | 74.9 (0.01-1454.6)                             | 40.6 (0.01-1399.8)                                | 3.7 (1-100)                        | 1.7 (0.6-43.2)                           |
| 1930-39             | 77.4 (0.04-1019.4)                             | 48.6 (0.03-438)                                  | 3.6 (0.7-100)                      | 2.1 (0.6-32.3)                           |
| 1940-49             | 44.1 (0.02-648.5)                              | 32.7 (0.01-193.2)                                | 3 (0.5-24.9)                       | 2 (0.4-8.8)                              |
| 1950-59             | 23.6 (0.01-368.8)                              | 17 (0.01-172.1)                                  | 2.7 (0.2-23.6)                     | 1.9 (0.3-9.5)                            |
| 1960-69             | 15.3 (0.01-364)                                | 11.5 (0.01-161.7)                                | 2.4 (0.1-24.1)                     | 1.8 (0.1-9.1)                            |
| 1970 on             | 13.4 (0.01-163.3)                              | 8.1 (0.01-100.7)                                 | 2.4 (0.1-19)                       | 1.8 (0.1-7)                              |

| Year of first job period | Median cumulative dust exposure (mg/m³-years) | Median cumulative fibre exposure (fibre/cm³-years) | Median average dust intensity (mg/m³) | Median average fibre intensity (fibre/cm³) |
|-------------------------|-----------------------------------------------|---------------------------------------------------|-------------------------------------|------------------------------------------|
| 1930-1955              | 102 (0.1-1454.6)                               | 52.5 (0.01-1438)                                  | 4.4 (1.3-100)                      | 1.7 (1.0-43.2)                           |
| 1955-64                | 76.8 (0.07-846.8)                              | 47.5 (0.04-296.8)                                 | 3.6 (0.7-54.2)                     | 2 (0.6-16.1)                             |
| 1965-74                | 40 (0.01-366.2)                                | 30.3 (0.01-193.2)                                 | 2.9 (0.5-20.9)                     | 2 (0.4-8.1)                              |
| 1975-84                | 19.6 (0.01-368.8)                              | 14.2 (0.01-161.7)                                 | 2.7 (0.1-23.6)                     | 1.9 (0.2-9.5)                            |
| 1985-94                | 13.8 (0.01-344.2)                              | 10.5 (0.01-130.6)                                 | 2.5 (0.1-24.1)                     | 1.9 (0.2-9.1)                            |
| 1995 on                | 10.6 (0.02-139.6)                              | 7.8 (0.02-83.8)                                  | 2.3 (0.1-13.5)                     | 1.5 (0.1-6)                              |

| Work Location | Median cumulative dust exposure (mg/m³-years) | Median cumulative fibre exposure (fibre/cm³-years) | Median average dust intensity (mg/m³) | Median average fibre intensity (fibre/cm³) |
|---------------|-----------------------------------------------|---------------------------------------------------|-------------------------------------|------------------------------------------|
| Factories     | Total 39.7 (0.03-1055.8)                       | 34.8 (0.03-438)                                   | 3.8 (0.1-100)                      | 3.5 (0.1-43.2)                           |
|               | Men 36.7 (0.04-1055.8)                         | 31.7 (0.05-438)                                  | 3.9 (0.5-92.6)                     | 3.6 (0.4-21.5)                           |
|               | Women 41.3 (0.03-1011.2)                       | 36.5 (0.03-346.4)                                 | 3.8 (0.1-100)                      | 3.5 (0.1-43.2)                           |
| Mine/External Rail | Total 22.9 (0.01-1114.2)                      | 14.7 (0.01-95.3)                                 | 2.4 (0.4-47.6)                     | 1.6 (0.4-2.4)                            |
|               | Men 21.9 (0.01-1114.2)                         | 14.3 (0.01-95.3)                                  | 2.3 (0.4-47.6)                     | 1.6 (0.4-2.4)                            |
|               | Women 29.3 (0.02-767.6)                        | 17.7 (0.01-91)                                   | 2.7 (0.5-47.5)                     | 1.7 (0.4-2.4)                            |
| Both          | Total 32.6 (0.01-1454.6)                       | 24.2 (0.01-399.8)                                 | 3.4 (0.1-100)                      | 2.5 (0.2-38.4)                           |
|               | Men 29.3 (0.01-1454.6)                         | 21.4 (0.03-302.4)                                 | 3.2 (0.4-97.7)                     | 2.3 (0.5-31.3)                           |
|               | Women 40.4 (0.01-1184.4)                       | 31.8 (0.01-399.8)                                 | 3.7 (0.1-100)                      | 2 (0.2-38.4)                             |
|               | Total 30.2 (0.01-1454.6)                       | 22.1 (0.01-438)                                  | 2.9 (0.1-100)                      | 1.9 (0.1-43.2)                           |
### Supplementary table 3: Correlation matrix of a) cumulative exposure and b) exposure intensity

#### a) Cumulative exposure

|                  | Cumulative dust (AM) | Cumulative fibre (AM) | Cumulative dust (GM) |
|------------------|----------------------|-----------------------|----------------------|
| Cumulative dust (AM) | 1                    |                       | 0.77                 |
| Cumulative fibre (AM) | 0.77                | 1                     |                      |
| Cumulative dust (GM) | 0.99                 | 0.74                  | 1                    |
| Cumulative fibre (GM) | 0.76                | 1.00                  | 0.74                 |

#### b) Exposure Intensity

|                  | Dust exposure intensity (AM) | Fibre exposure intensity (AM) | Dust exposure intensity (GM) |
|------------------|------------------------------|-------------------------------|-----------------------------|
| Dust exposure intensity (AM) | 1                             |                              |                             |
| Fibre exposure intensity (AM) | 0.70                          |                              |                             |
| Dust exposure intensity (GM) | 0.97                          | 0.65                          | 1                           |
| Fibre exposure intensity (GM) | 0.68                          | 0.98                          | 0.68                        |

AM: arithmetic mean; GM: geometric mean

### Supplementary Figure 1: Process of exposure derivation

1. **Step 1:** Use the mean monthly dust concentrations by sampling point: flag sampling points that only have one concentration per year or only concentration in one season (i.e. minimum two concentrations per sampling point per year) or are missing concentrations for an entire year.

2. **Step 2:** Convert monthly dust concentrations (capped at 100 mg/m³) to estimated monthly fibre concentrations.

3. **Step 3:** By sampling point, calculate a seasonal and then derive the annual dust and estimated fibre concentrations.

4. **Step 4:** Derive the annual dust and estimated fibre for a Job Group by combining relevant sampling points (1951-2001 data).

5. **Step 5:** MODELLING
   - Use Step 4 data from 1951/64 to 2001 to model dust and estimated fibre concentrations by Job Group and year separately.
   - Derive modelled dust concentrations where data were flagged as either not systematically collected, missing or collected using an alternative method.
   - Derive estimated fibre where data were flagged in Steph 1 by applying conversion factors to annual modelled dust concentration.
   - Match the JEM to the Occupational History Database and assign exposure to individual workers by Job Group in the Mine and/or specific Factory by Year.

6. **Step 6:** Sampling Point Annual Dust Concentration: \( P_{D,year} = \frac{1}{2} \times W_{D,year} + S_{year} \) / 3
   - Sampling Point Annual Fibre Concentration: \( P_{F,year} = \frac{1}{2} \times W_{F,year} + S_{year} \) / 3
   - Job Group Annual Dust Concentration: \( \text{Job Group} = \frac{P_{D,year} + P_{D,year} + \ldots + P_{D,year}}{n} \)
   - Job Group Annual Fibre Concentration: \( \text{Job Group} = \frac{P_{F,year} + P_{F,year} + \ldots + P_{F,year}}{n} \)

7. **Step 7:** Missing Job Group Annual Dust Concentrations: Best Linear Unbiased Prediction from Linear Mixed Model (BLUP)
   - Missing Job Group Annual Fibre Concentrations: fibre/Dust-ratio x BLUP

8. **Step 8:** Individual Annual Dust and Fibre History:
   - Linking Occupational History to Annual Dust and Fibre Concentration

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Supplementary Figure 2: Illustrative example of exposure derivation

E-Y: employment-years; DC: dust concentration; FC: fibre concentration; JEM: job exposure matrices; ADC: annual dust concentration; AFC: annual fibre concentration

Supplementary Figure 2: Illustrative example of exposure derivation