

Mortality in the German Porcelain Industry 1985–2005: First Results of an Epidemiological Cohort Study

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OBJECTIVE

To evaluate mortality due to lung cancer, silicosis, renal cancer, renal disease and other causes among German porcelain production workers potentially exposed to crystalline silica.

METHODS

Seventeen thousand six hundred forty-four medical surveillance participants (1985–1987) were followed through 2005 for mortality. Cause-specific Standardized Mortality Ratios (SMR) and 95% confidence intervals were estimated.

RESULTS

Women (SMR=0.85; 95% CI=0.78 to 0.93), but not men, demonstrated a healthy worker effect. Lung and renal cancers, and renal disease (non-malignant renal disease) were not associated with employment or exposure surrogates. Mortality was increased from silicosis (SMR=7.20; 95% CI=2.32 to 16.8), liver (SMR=1.99; 95% CI=1.29 to 2.93) and pancreatic (SMR=1.71; 95% CI=1.18 to 2.41) cancers among men, and diabetes among women (SMR=1.74; 95% CI=1.07 to 2.65). A sub-cohort of Bavarian workers generated similar but generally higher SMRs.

CONCLUSION

Silicosis mortality was increased in this, among the largest studies to date. However, associations previously observed between crystalline silica exposure and renal or lung cancers or non-malignant renal disease were not supported.

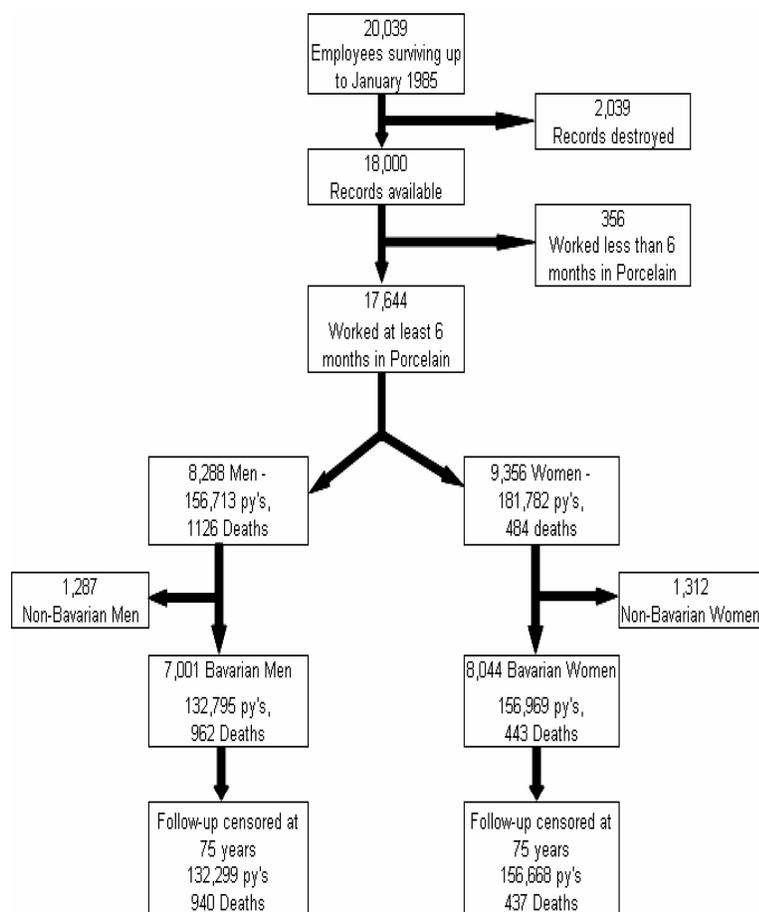


Fig. 1. Study population, Full Cohort and Bavarian Subcohort

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QUANTITATIVE CRYSTALLINE SILICA EXPOSURE ASSESSMENT FOR AN HISTORICAL COHORT EPIDEMIOLOGICAL STUDY

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OBJECTIVE

To conduct a time-dependent quantitative assessment of respirable crystalline silica exposure for an epidemiological study of 18,000 German porcelain workers. Results are used to quantify lung cancer mortality and silicosis morbidity risks.

METHODS

Over 8,000 historical industrial hygiene (IH) measurements from 1954-2006 were obtained from the German statutory accident insurance and prevention institution for the glass and ceramics industry (BGGK). Early IH values from different measurement devices were converted to modern gravimetric equivalent values. Conversion factors were derived from experiments obtaining measurements using both the historical and modern sampling



METHODS (Cont)

devices side-by-side in both controlled laboratory dust tunnels and in representative active workplaces. Exposure values were summarized and smoothed using LOESS regression; estimates for early years with no measurement data were derived using backward extrapolation. Annual estimates were obtained for six similar exposure groups (SEGs) for each year between 1938 and 2005. Employee work histories were merged with these job exposure matrix (JEM) values to determine individual cumulative crystalline silica exposures for each cohort member.

RESULTS

Over 40% of the cohort accumulated less than 0.5 mg/m³-years, and a third accumulated >1 mg/m³-years respirable crystalline silica. Nearly 5000 workers had cumulative respirable crystalline silica estimates over 1.5 mg/m³-years, with similar numbers of men and women in each, except for the highest category with 1113 women and 1567 men. Over half of those hired through 1960, but only 4.9% of those hired after 1960, accumulated > 3 mg/m³-years of respirable crystalline silica exposure. Similarly, half of those ever working in materials preparation accumulated >3 mg/m³-years, compared with 12% of those never working in this area.

CONCLUSION

Quantitative cumulative respirable crystalline silica exposures were estimated for each cohort member, allowing comprehensive estimation of quantitative exposure-response relationships for silicosis and lung cancer mortality risks. This represents the largest quantitative silica exposure assessment conducted to date in the porcelain industry in Europe.

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QUANTITATIVE CRYSTALLINE SILICA EXPOSURE AND SILICOSIS RISK IN THE GERMAN PORCELAIN INDUSTRY

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OBJECTIVE

To quantitatively evaluate the exposure-response relationship between estimated respirable crystalline silica exposure and silicosis morbidity risk among German porcelain workers. Previous analyses of this cohort demonstrated no increased risk of lung cancer mortality.

METHODS

Nearly 18,000 porcelain workers were followed for silicosis morbidity as determined from routine x-ray surveillance. Respirable crystalline silica exposure was determined by combining detailed individual employment histories with a job exposure matrix based on 8,000 historical industrial hygiene measurements. Cox proportional hazards regression with age as the time variable was used to evaluate silicosis morbidity by cumulative crystalline silica exposure, controlling for sex, smoking status and duration of employment as a time-dependent factor.

RESULTS

The exposure-response analysis for lung cancer mortality and silicosis morbidity is near to completion but not finalised as of May 2010.



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VALIDATING ROUTINE CHEST RADIOGRAPHS FOR A QUANTITATIVE EPIDEMIOLOGICAL STUDY OF CRYSTALLINE SILICA EXPOSURE AND SILICOSIS RISK

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BACKGROUND

Chest radiograph (x-ray) evidence of small rounded opacities with an International Labor Organization (ILO) profusion score $\geq 1/1$ often defines silicosis cases in epidemiological studies.

However, x-ray technologies and associated quality of films have changed over time, as well as criteria for reading and interpreting radiographs. Even using the same standards, high levels of inter- and intra-reader variability have been documented.

Therefore, archival readings of chest radiographs may not be of adequate validity for rigorous epidemiological investigations.

Original radiograph evaluation form

METHODS

Phase 1: A representative stratified sample of 1600 chest x-rays was drawn for blinded re-reading by two groups of specially trained independent re-readers.

Exact agreement between re-readers was around 90% of all readings. Discrepancies were adjudicated by consensus reading.

Consensus re-readings were compared with original interpretations by occupational physicians from the German Statutory Accident Insurance and Prevention Institution for the glass and ceramics industry (BGGK).

Results demonstrated that significantly more films were read as "positive" by the BGGK readers, and no films originally read as "negative" were considered $\geq 1/1$ by the re-readers, i.e. there were no false negatives.

Phase 2: All x-rays were re-read for all cohort members whose most recent x-ray had been classified originally as $\geq 1/0$. Additionally, a random sample of 60 negative x-rays (0/0 and 0/1) were included to verify low false negative rate seen in Phase 1.

All 4,774 x-rays for these 522 cohort members were provided to re-readers to more closely approximate the normal conditions under which all sequential x-rays for an individual would be evaluated simultaneously.

Table: Re-reading vs. Original BG reading by individual (n= 547)*

Re-reading	Original BG Reading									Total
	$\leq 0/1$	1/0	1/1	1/2	2/1	2/2	2/3	3/2	3/3	
$\leq 0/1$	49	182	113	29	8	4	0	0	0	385
1/0	5	37	37	21	8	2	0	0	0	110
1/1	1**	5	4	2	5	2	0	1	0	20
1/2	0	2***	4	1	5	1	1	1	0	15
2/1	0	0	1	3	3	0	1	1	0	9
2/2	0	0	0	0	0	4	0	1	0	5
2/3	0	0	0	0	0	0	0	0	0	-
3/2	0	0	0	0	0	1	0	2	0	3
3/3	0	0	0	0	0	0	0	0	0	-
Total	55	226	159	56	29	14	2	6		547

* Excluding 5 persons for whom no joint x-ray assessment of the original and re-reading was available
 ** Only delay in classification; classified by BG $\geq 1/1$ one year later (but no film for re-reading available)
 *** Both x-rays in consensus reading (difference 1/1 vs. 1/2)

RESULTS

The TABLE above compares the results of our consensus re-reading scores with the original scores from the historical BGGK records:

- Compared to original BGGK readings, re-readers had exact agreement only 58% of the time (diagonal gray cells in table).
- More than 90% of all individuals selected for re-reading were classified as $< 1/1$, or "without silicosis" for purposes of the epidemiological study.
- 52 cohort members (10%) were classified as 1/1 or higher by re-readers (blue cells at right of table) and considered as having silicosis.
- In contrast, 266 cohort members (49%) would have been considered as having silicosis based on the original BGGK classification (blue cells at bottom of table).
- Compared to the original readings, re-readers scored higher 3% and scored lower scoring 39% of the time.
- Among x-rays with disagreement, 57% of the readings differed by only one ILO category, but for 43% the difference was ≥ 2 categories.

CONCLUSIONS

The original compensation insurance readers substantially over-diagnosed silicosis using the ILO category of 1/1 or higher.

While compensation or other administrative systems may intentionally interpret x-rays conservatively, such classification could bias etiological research. Further evaluation is needed to determine the impact different classification of radiographs might have on epidemiological research results.

X-ray re-reading exercises using multiple blinded expert re-readers, following a standard reading and classification protocol, are recommended wherever possible for epidemiological studies relying on historical x-rays for the determination of silicosis.

AUTHORS' AFFILIATIONS

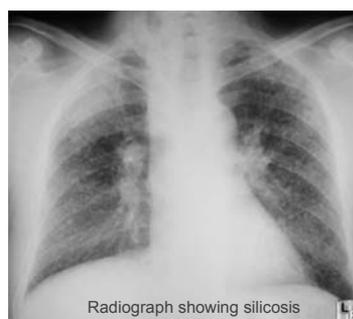
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QUESTIONS?

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Radiograph showing silicosis



Preparing molds for casting



Mobile x-ray unit from the 1950s

OBJECTIVES

To improve the validity of routine x-ray evidence of silicosis for an epidemiological historical cohort study of nearly 18,000 German porcelain workers, using a re-reading exercise in two phases.

The two phases allowed an efficient alternative to re-reading all 120,000 available radiographs, the vast majority of which are negative.