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RESEARCH ARTICLE

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Quality of life in retired workers with past exposure to asbestos

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Abstract

Background: Asbestos causes cancer and non-cancerous lung and pleural diseases and can also have a negative psychological impact but little is known about its effect on health-related quality of life.

Objectives: The aim of this study is to describe the health-related quality of life (HRQoL) of retired men with a history of occupational exposure to asbestos and examine factors linked with low HRQoL.

Methods: Retired male workers of the French Asbestos-Related Disease Cohort (ARDCO) completed self-questionnaires that included SF-36v2 and HAD scales, questions about their perception of asbestos (perceived dangers and level of exposure, expectations to fall ill, or knowing someone who is) and their respiratory symptoms. Asbestos exposure was assessed by industrial hygienists. A perceived risk score was created using factorial analysis. Multivariable regressions were performed for all SF-36 subscales.

Results: A total of 1266 of 2075 questionnaires (61%) were returned complete and included in analysis. After adjustment for potential confounders, an increase in perceived risk score resulted in a decrease in physical component summary score (PCS), up to 10.7 points ($p = 0.048$) and in mental component summary score (MCS) ($p = 0.044$). Presence of respiratory symptoms was also associated with significantly decreased PCS and MCS ($p < 0.001$). Poor HRQoL was linked to higher perceived risk score with $p \leq 0.01$ for all SF-36 dimensions. Asbestos exposure assessed by an expert was not associated with any outcome.

Conclusions: All dimensions of HRQoL appear to be affected by the perceived risk of incurring asbestos-related disease and respiratory symptoms.

KEYWORDS

anxiety, asbestos, depression, occupational medicine, quality of life

1 | INTRODUCTION

Asbestos causes cancer and non-cancerous lung diseases.[1] Asbestos exposure can also have a negative psychological impact, not only on patients suffering from asbestos-related diseases and their caregivers, but also on exposed subjects.[2] According to Bonafede et al.[2] many asbestos-exposed subjects showed psychological distress, as well as anxious and depressive symptoms. In a previous study[3] we noted that a sizeable proportion of former asbestos workers in the French asbestos-related diseases cohort (ARDCO), showed symptoms of anxiety or depression (19.7% and 9.9%, respectively). In Germany, in asbestos exposed subjects attending a surveillance program, Lang et al.[4] found that the strongest predictor for anxiety and depression was obstructive functional impairment and not diagnosis of non malignant asbestos related diseases. Besides, in the ARDCO cohort, the risk of developing anxious and depressive symptoms appeared to be strongly associated with the self-assessment of the intensity of asbestos exposure and the perception of asbestos-related risk. We surmised this psychological distress could be caused by the "sword of Damocles" effect, hanging over their head (a symbol of an imminent and ever-present threat, taken from Ancient Greek mythology) as subjects are faced with uncertainties as to their fate, rooted in the long latency before the appearance of asbestos-related diseases and the difficulty in quantifying one's level of exposure. This is compounded by the stigma surrounding asbestos in many countries.

Health-related quality of life (HRQoL) can be defined as "the health aspects of quality of life, generally considered to reflect the impact of disease and treatment on disability and daily functioning" and it also reflects "the impact of perceived health on an individual's ability to live a fulfilling life."[5] This patient-reported outcome has strong links to more traditional health outcomes, such as mortality in general population[6] or survival in cancer patients,[7] and often precedes declines in objective health by years, especially in elderly patients.[8]

While HRQoL in subjects with current long-term environmental exposures to chemicals or pollution has been the focus of a few studies,[9,10] none investigated the aftermath of these exposures. Former asbestos-exposed workers live with the knowledge that they have been exposed to a dangerous substance and that they might someday fall ill, a situation that Leibovits[11] likened to that of healthy genetic cancer carriers. For example BReast CAncer (BRCA) gene mutation carriers, with high risk of ovarian and breast cancers, experience decreased HRQoL despite being objectively healthy.[12] And while there are a few studies of HRQoL on mesothelioma patients,[13–16] only one study, by Franklin et al.,[17] in Australia, has investigated the mental dimension of HRQoL, in asbestos exposed subjects, using SF-12 scale. In their study, conducted in former Wittenoom workers and residents, Franklin et al.[17] found no significant differences in mental health dimension of HRQoL with or without radiologic abnormalities, but dyspnea was associated with poorer mental dimension of HRQoL.

The objectives of the present study are to describe the health-related quality of life in former asbestos-exposed workers, to identify the factors associated with poor HRQoL and to determine whether asbestos-related perceived risk and respiratory symptoms were associated with poor HRQoL.

2 | METHODS

2.1 | Study participants

Complete description of the overall design of the ARDCO cohort (Asbestos Related Diseases Cohort) has been previously published.[18] Briefly, between 2003 and 2005, a large-scale screening program for asbestos-related diseases (SPP-A/APEXS) was organized in three French regions (Aquitaine, Rhône-Alpes, and Haute et Basse Normandie) to improve the medical surveillance of worker formerly exposed to asbestos. Recruitment procedures were based on mailing, television, newspapers, or systematic invitations at National health insurance centers in each region. A total of 16,885 unemployed or retired volunteers completed a questionnaire including their complete work history, and also answered questions about specific asbestos-exposing tasks. Questionnaires were analyzed by industrial hygienists who assessed their asbestos exposure. Subjects with a confirmed occupational asbestos exposure were invited to undergo a free medical check-up that included a clinical examination and pulmonary function tests as well as chest X-ray and a chest CT-scan performed by program-approved radiologists.

Between 2007 and 2009, the ARDCO cohort was constituted including all the SPP-A/APEXS subjects with confirmed asbestos exposure and whose identity could be confirmed in the National health insurance database. Among those 14,218 subjects, 6546 chest CT reports could be retrieved, with images for 5825 of those.

Between 2011 and 2012, during the first follow-up (ARDCO II), subjects for whom a chest CT report was available at inclusion were invited to undergo a second chest CT-scan and to complete a self-questionnaire that included questions about their knowledge of asbestos and their perception of it.

During the second follow-up, in 2015 (ARDCO III) subjects who had returned the self-questionnaire during ARDCO II were solicited to complete another self-questionnaire that included the same questions about asbestos as well as questions on their smoking status, somatic comorbidities, and the Hospital Anxiety and Depression (HAD) and SF-36v2 scales. This second follow-up was not associated with a CT-scan.

The project was approved by the Ethics Committees Paris-Cochin and Ile de France 3. All participants received information about the study and provided their written informed consent.

The present study included all male participants of the ARDCO cohort who answered all questions of the SF-36v2 scale.

2.2 | Data collection

2.2.1 | Outcomes

Health-related quality of life was measured using the French version of the SF-36v2 scale,[19–22] a commonly used HRQoL tool. This 36-items questionnaire consists of 8 dimensions (cf. Table 1) and two composite scores: the Physical Component Summary (PCS) calculated

TABLE 1 Description of the SF-36V2 subscales.

Dimension	Description	Number of items
Physical functioning (PF)	Participants' reported level of difficulty in carrying out a range of physical tasks from low exertion to high exertion.	10
Role-physical (RP)	Limitations in performance of regular daily activities due to physical problems	4
Bodily pain (BP)	Participants' experience of bodily pain and the extent to which pain interferes with their normal day	2
General health (GH)	Participants' perception of their current overall health status, how their health compares to others and expectations of future health	5
Vitality (VT)	Respondents' perceived levels of energy.	4
Social functioning (SF)	The extent to which physical or emotional problems impact on respondents' participation in social activities.	2
Role emotional (RE)	Limitations in performance of regular daily activities due to emotional problems	3
Mental health (MH)	The amount of time over the last 4 weeks a respondent felt happy, calm, down, depressed, and nervous.	5

Note: Adapted from Margreet Frieling.[22]

here as an unweighted mean of Physical Functioning (PF), Role-Physical (RP), Bodily pain (BP), and General health (GH), and the Mental Component Summary (MCS) based upon Vitality (VT), Social Functioning (SF), Role Functioning (RE) and Mental Health (MH). All scales and composites are scored on a scale from 0 to 100, with higher scores indicating higher HRQoL.

2.2.2 | Asbestos-related perceived risk

The questionnaires of ARDCO II and ARDCO III included following 5 questions about the participants' knowledge or perception of risks related to asbestos: Q1"*What do you consider to be your exposure level to asbestos?" (No exposure, Light exposure, Intermediate exposure, Heavy exposure), Q2 "Do you think you will become ill because of asbestos?" (Yes, Maybe, No, Does not know), Q3 "Do you know anyone with an asbestos-related disease?" (Yes, No), Q4"All people exposed to asbestos eventually become ill because of asbestos" (True, False, Does not know), Q5 "All asbestos related diseases can be cured" (True, False, Does not know)*. Using these variables, we created an asbestos-related perceived risk score.

2.2.3 | Other variables

Measures taken at inclusion: asbestosis and interstitial lung abnormalities were assessed by two independent trained radiologists. Cumulative asbestos exposure index (CEI) in fibers/mL was estimated by industrial hygienists based on the subjects reported work history using job-exposure matrices.[18] Patient were not informed of their CEI. Measures taken during the ARDCO III follow-up: anxious and depressive symptoms were measured using the French version of the Hospital Anxiety and Depression Scale (HADS).[23–25] HAD scales are each scored from 0 to 21: patients are considered asymptomatic if their score was between 0 and 7, a score between 8 and 10 means presence of a few symptoms of depression/anxiety, while scoring over 11 suggest the presence of depression/anxiety. History of serious chronic conditions was ascertained using data from the French national health insurance system, as patients must report all serious diseases to obtain full health coverage. The list of diseases (*affections longue durée ALD*) is defined by decree in France (e.g., cancer, coronary disease, diabetes, Alzheimer's, chronic kidney disease, multiple sclerosis, etc.) but also includes any disease or combination of diseases that is expected to require more than 6 months of care. Subjects were also asked to report any medical conditions, choosing from a list of broad categories of diseases. We chose to include in our analysis only the presence or absence of any self-reported somatic comorbidity. Self-rated health was measured by the first question of the SF-36 ("In general, would you say your health is") on a 5-item Likert scale from "Excellent" to "Poor."

2.2.4 | Statistical analysis

Creation of an asbestos perceived risk score: To measure perceived risk, we performed confirmatory factorial analysis (CFA), using the questions about the participant's knowledge or perception of risks related to asbestos. We compared several models: a single-factor model (perceived risk) and two two-factor models (perceived danger & perceived exposure; societal & personal risk).[26,27] If a participant did not answer one of the questions, their answer for the same question in phase II was used for CFA. If the answer in phase II was also missing, participant was excluded from the analysis Details of models can be found in Supporting Information S1. After selection of the model, confirmation of factorial invariance was obtained on data taken from ARDCO II. A perceived risk score was created as a weighted sum of the answers to the different questions, with the weights roughly proportional to the loadings found in the CFA.

We checked that the perceived risk as measured by this score was associated to anxious and depressive symptoms, measured by the HAD in linear regression, as had been described elsewhere.[3] We performed separate multivariable linear regressions for each scale, adjusting for age, region of recruitment, marital status, smoking status, asbestos exposure index, respiratory symptoms, the other HAD score, self-reported comorbidities, and history of chronic diseases. A Pearson correlation coefficient was computed to assess the linear relationship between the perceived risk score and cumulative asbestos exposure index (CEI).

2.2.5 | Identification of factors associated with poor and intermediate HRQoL

Subjects with missing data for a given variable were excluded from multivariable regression featuring that variable. Multivariable linear regressions were performed for PCS and MCS, included as continuous variables. Relative importance of explanatory variables was assessed using LMG metric (R^2 contribution averaged over orderings among regressors).[28,29]

For the other SF-36 dimensions, as condition for linear regression were not met, we chose to perform multivariable multinomial regressions to explore factors associated with poor and intermediate HRQoL. Poor HRQoL was defined here as being in the first tertile, intermediate HRQoL as being in the second tertile, while subjects in the third tertile were considered to have a good HRQoL.

All multivariable analyzes were adjusted for age, region of recruitment, marital and smoking status. The significance level was set at $p = 0.05$.

All data analyzes were performed using statistical software R version 4.3.1.[30] Confirmatory factor analysis was performed using package *lavaan 0.6-15*[31] and estimator DWLS. Relative importance of factors in linear regression was assessed using *relaimpo 2.2-5* package.[32] Package *performance 0.10.4*[33] was used to check model assumptions for linear regressions. Multinomial regression was performed using package *nnet 7.3-19*.[34]

3 | RESULTS

The study population flowchart is shown in Figure 1. Of the 2167 ARDCO III questionnaires sent out, 1462 were returned by men, and 1266 could be included in statistical analysis. There was no difference in age, region of recruitment, smoking status at inclusion or estimated exposure to asbestos between respondents and non-respondents.

General characteristics of the included participants are shown in Table 2. The median (interquartile range) age was 73.0 (70–78), 30.9% were former smokers and only 30 (2.4%) current smokers. The median of cumulative asbestos exposure index (CEI) was 26 (4–42) fiber/mL.year/mL. Symptoms of depression and anxiety were present in 21% of subjects for anxiety and in 14% for depression. Almost all 1144 (92.6%) patients reported a somatic comorbidity, while only 42% had declared a chronic condition to their insurance. PCS and MCS median score were 59 (46–73) and 62 (47–75). Over two-third of patients (868, 68.6%) felt they were in good health and 20.5% in fair health.

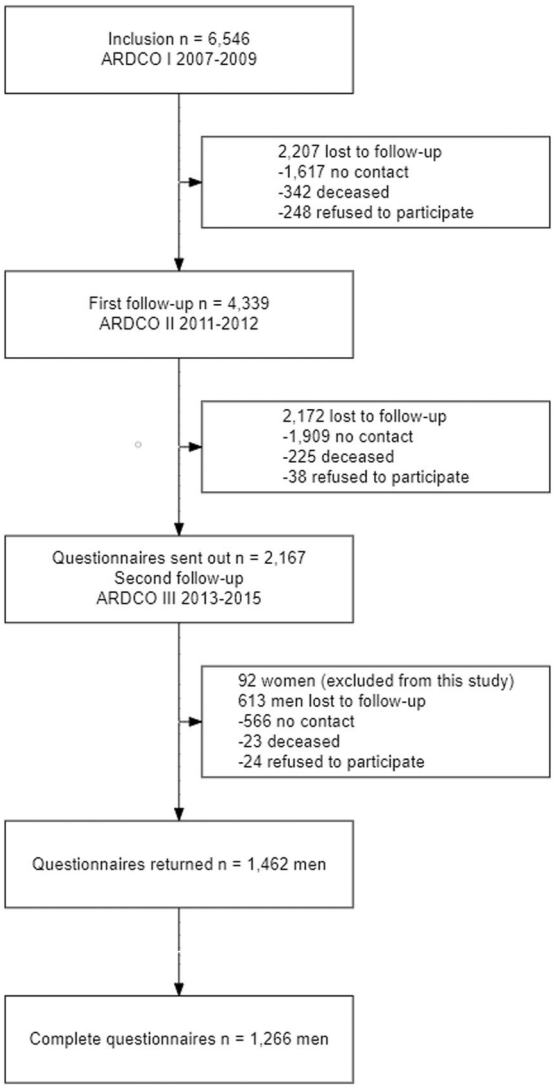

FIGURE 1 Flowchart for the asbestos-related diseases cohort and present study.

3.1 | Measure of perceived risk

Results of the different models tested: single-factor model (perceived risk) and two two-factor models (perceived danger & perceived exposure; societal & personal risk) can be found in Supporting Information S1. Description of the single chosen model and score construction is shown in Table 3. The best fit was for the single factor model and both fit and loadings remained similar with the phase II data. Applying weights roughly proportional to these loadings to the answers of the five asbestos-related questions, a perceived risk score was created with a total ranging from 0 to 126 (higher score meaning higher perceived risk).

TABLE 2 Socio-demographic characteristics of included subjects.

Variable	*N*	Description[a]
Age at reception of questionnaire	1266	73.0 (70.0, 76.0)
Marital status	1266	
Single		160 (12.6%)
Living with someone		1094 (86.4%)
Region	1266	
Normandie		415 (32.8%)
Aquitaine		313 (24.7%)
Rhône-Alpes		538 (42.5%)
Smoking status	1256	
Never smoker		838 (66.7%)
Former smoker		388 (30.9%)
Current smoker		30 (2.4%)
Asbestos cumulative exposure index (CEI)	1266	26 (4, 42)
Knowledge or perception of risks related to asbestos		
Self-assessed level of asbestos exposure (Q1)	1265	
Light or none		290 (22.9%)
Does not know		115 (9.1%)
Intermediate		516 (40.8%)
Heavy		344 (27.2%)
Do you think you will become ill because of asbestos? (Q2)	1263	
No		81 (6.4%)
Does not know		368 (29.1%)
Possible		612 (48.5%)
Yes		202 (16.0%)
Do you know anyone with an asbestos-related disease? (Q3)	1259	
No		358 (28.4%)
Yes		901 (71.6%)
All people exposed to asbestos eventually become ill because of asbestos (Q4)	1265	
False		575 (45.5%)
Does not know		443 (35.0%)
True		247 (19.5%)
All asbestos-related diseases can be cured (Q5)	1265	
True		395 (31.2%)
Does not know		771 (61.0%)
False		99 (7.8%)
Asbestos perceived risk score[b]	1256	78 (51, 93)

TABLE 2 (Continued)

Variable	*N*	Description[a]
Quality of life		
SF-36 - Physical Functioning (PF)	1266	80 (55, 90)
SF-36 - Role-Physical (RP)	1266	50 (44, 75)
SF-36 - Bodily Pain (BP)	1266	55 (45, 78)
SF-36 - General Health (GH)	1266	54 (42, 63)
SF-36 - Physical Component Summary (PCS)	1266	59 (46, 73)
SF-36 - Vitality (VT)	1266	50 (38, 63)
SF-36 - Social Functioning (SF)	1266	75 (50, 88)
SF-36 - Role Emotional (RE)	1266	58 (42, 75)
SF-36 - Mental Health (MH)	1266	65 (50, 80)
SF-36 - Mental Component Summary (MCS)	1266	62 (47, 75)
Self-rated health	1266	
Excellent		10 (0.8%)
Very good		93 (7.3%)
Good		868 (68.6%)
Fair		259 (20.5%)
Poor		36 (2.8%)
Mental health		
HADS Anxiety scale	1253	
Asymptomatic [0–7]		669 (53.4%)
Possible anxiety [8–10]		315 (25.1%)
Probable anxiety		269 (21.5%)
HADS Depression scale	1263	
Asymptomatic [0–7]		823 (65.2%)
		264 (20.9%)
Probable depression [11–21]		176 (13.9%)
Somatic health		
Self-reported somatic comorbidities	1235	
No		91 (7.4%)
Yes		1144 (92.6%)
Chronic disease (Insurance)	1266	
No		728 (57.5%)
Yes		538 (42.5%)
Respiratory symptoms	1266	
No		427 (33.7%)
Yes		839 (66.3%)
Pleural plaques	1266	
No		906 (71.6%)

TABLE 2 (Continued)

Variable	N	Description[a]
Yes		360 (28.4%)
Interstitial lung abnormalities	1266	
No		1039 (82.1%)
Yes		227 (17.9%)

Abbreviation: IQR, interquartile range.

[a]Quantitative variables: median (IQR), qualitative variables: *n* (%).

[b]Composite score based on the five asbestos-related questions (Q1–Q5).

The asbestos perceived risk score significantly predicted HAD score for both scales in multivariable linear regression (anxiety: $\beta = 0.01$, confidence interval [CI] = 0.01–0.02, $p < 0.001$, adjusted $R^2 = 0.453$, F (DF 13/1193) = 77.77, $p < 2.2e\text{-}16$; depression: 0.01, CI = 0.01–0.02, $p < 0.001$, adjusted $R^2 = 0.469$, F(DF 12/1193) = 83, $p < 2.2e\text{-}16$). There was a positive correlation between cumulative asbestos exposure index and perceived risk (Pearson d(1254) = 0.25 $p < 0.001$).

3.2 | Health-related quality of life: Physical and mental component summary of the SF-36

Main results of linear regressions for PCS and MCS are shown in Table 4 For both variables, the models explained a statistically significant and substantial proportion of the variance (adjusted $R^2 = 0.496$ and 0.631).

Higher asbestos perceived risk and respiratory symptoms were statistically associated with a decrease in the PCS score ($p < 0.001$), showing lower physical HRQoL. Similarly self-reported somatic comorbidities, chronic conditions, and both HAD scales were also significant and negative, while asbestos CEI, was not significant. Factors with the greatest contribution to our model were depression, anxiety, respiratory symptoms, and asbestos perceived risk (R^2 contributions: 0.176, 0.119, 0.064, and 0.048, respectively).

Higher asbestos perceived risk and respiratory symptoms were also statistically associated with a decrease in the MCS score ($p < 0.001$), showing lower mental HRQoL. Age, marital status, self-reported somatic comorbidities, chronic conditions, and both HAD scales were also significant and negative, while asbestos CEI, smoking status and region of origin were not significant. The variables which contributed the most to our model were depression and anxiety followed by respiratory symptoms and perceived risk (R^2 contributions: 0.264, 0.224, 0.050, and 0.044, respectively).

3.3 | Other dimensions of health-related quality of life

Main results for the multinomial regressions for the 8 SF-36 subscales can be found in Table 5 for physical dimensions and Table 6 for mental dimensions.

Higher asbestos perceived risk significantly increased the odds of having a poor score for all SF-36 dimensions. The odd ratios were all between 1.01 and 1.02, with all $p < 0.1$. The presence of respiratory symptoms also significantly increased the odds of having a poor HRQoL score in all dimensions, with ORs ranging from 1.96 to 3.75. Symptoms of depression or anxiety also a negative impact on all poor HRQoL dimensions, with a larger effect for patients with probable mood disorder [e.g., VT Depression OR(probable) 35.4 vs. OR (possible) 15.2]. Self-reported somatic comorbidities was only negatively associated with BP and GH, while the presence of chronic conditions negatively affected all dimensions except MH.

While higher perceived risk was significantly associated to intermediate level of HRQoL for 3 dimensions (GH, VT, and MH), it was very close to significance (p between 0.051 and 0.078 for 3 others [PF, RP, and BP]). For the rest of the factors, the associations remain, roughly speaking, similar, albeit with a smaller size effect.

4 | DISCUSSION

In workers with past exposure to asbestos, poor HRQoL in all its dimensions was significantly linked to higher perceived risk and presence of respiratory symptoms.

To explore this link between asbestos-related risk perception and HRQoL, in the absence of an existing suitable measuring instrument, a perceived risk score was built using 5 simple questions. The CFA found a one-factor structure that provided a good fit to the data.

The association between perceived risk and MCS, persisting even when taking into account anxious and depressive symptoms, was expected. The size of effect is small but clinically meaningful (maximum of 7 points) but the contribution of the variable to our model is modest (4.4%). This association also held true for all subscales for poor HRQoL. We surmise that the distress caused by the uncertainty surrounding their fate is at the root of this association. This direct link between risk perception and the psychological aspects of HRQoL comes in addition to the indirect path we mentioned previously: asbestos exposure has been shown to cause distress anxiety and depression[2] which in turn affect the subject's HRQoL. This is also visible in this study, where a high prevalence of anxiety (21%) and depression (14%) is combined with notable coefficients and R^2 contributions ($\beta = 16$ and 22, R^2 contribution: 22% and 26%).

An increase in perceived risk score resulted in a decrease in PCS, up to 10.7 points. While this association was expected, the fact that it is statistically significant for all subscales including Physical Functioning is more surprising. It is possible that subjects with high level of perceived risk, who are convinced they will become ill someday because of asbestos, may have their judgment colored by this "certainty" and be globally more pessimistic. Or that fundamentally more pessimistic subjects perceived more negatively both their asbestos-related risk and their HRQoL. Another eventuality is that the association could be due to bias. Lower physical functioning usually hints at somatic diseases. While we did take into account both

TABLE 3 Results of confirmatory factor analysis for asbestos perceived risk for chosen model and construction of asbestos-related perceived risk score.

	Confirmatory factor analysis— Standardized loadings latent variable "risk"		Construction of score			
	Phase 3	Phase 2	Type of answer	Unweighted range	Chosen weights	Weighted range
Self-assessed level of asbestos exposure (Q1)	0.742	0.760	4-item Likert scale	0–3	15	0–45
Do you think you will become ill because of asbestos? (Q2)	0.754	0.759	4-item Likert scale	0–3	15	0–45
Do you know anyone with an asbestos-related disease? (Q3)	0.622	0.576	Yes/No	0–1	12	0–12
All people exposed to asbestos eventually become ill because of asbestos (Q4)	0.304	0.244	Yes/does not know/no	0–2	6	0–12
All asbestos-related diseases can be cured (Q5)	0.366	0.279	No/does not know/curable	0–2	6	0–12
	Fit					
χ^2	0.089	0.224				
Comparative fit index	0.996	0.998				
Root mean square error of approximation (95% confidence interval)	0.029 (0.000–0.059)	0.019 (0.000–0.051)				
Standardized root mean square residual	0.022	0.021				

TABLE 4 Results of multiple linear regressions for SF-36 physical and mental component summary dimensions adjusted for age, region, marital, and smoking status.

	Physical component summary (PCS)[a]				Mental component summary (MCS)[a]			
	β	95% CI	*p*-value	R^2 cont.[b]	*β*	95% CI	*p*-value	R^2 cont.[b]
Asbestos perceived risk score	−0.09	−0.12, −0.06	**<0.001**	0.048	−0.06	−0.08, −0.03	**<0.001**	0.044
Cumulative asbestos exposure index	0	−0.01, 0.01	0.6	0.001	0	−0.01, 0.01	>0.9	0.002
Respiratory symptoms				0.064				0.050
No	–	–			–	–		
Yes	−6.9	−8.6, −5.2	**<0.001**		−5.3	−6.8, −3.8	**<0.001**	
HADS anxiety				0.119				0.224
Asymptomatic	—	–			–	–		
Possible anxiety	−6.2	−8.1, −4.2	**<0.001**		−10	−12, −8.3	**<0.001**	
Probable anxiety	−9	−11, −6.6	**<0.001**		−16	−18, −13	**<0.001**	
HADS depression				0.176				0.264
Asymptomatic	–	–			–	–		
Possible depression	−10	−12, −8.0	**<0.001**		−12	−14, −9.9	**<0.001**	
Probable depression	−17	−20, −15	**<0.001**		−22	−24, −20	**<0.001**	
Chronic disease (insurance)				0.032				0.019
No	–	–			–	–		
Yes	−5.2	−6.8, −3.7	**<0.001**		−3.5	−4.8, −2.1	**<0.001**	
Self-reported somatic comorbidities				0.030				0.016
No	–	–			–	–		
Yes	−7.2	−10, −4.2	**<0.001**		−3.4	−6.0, −0.80	**0.01**	
	R^2 = 0.503, adj. R^2 = 0.496 F = 75.3 (DF 16/1190) p < 2.2e-16	R^2 = 0.636, adj. R^2 = 0.631 F = 130 (DF 16/1190) p < 2.2e-16						

Note: Bold values are statistically significant $p < 0.05$.

[a]Higher score means better health-related quality of life.

[b]Relative importance of variable calculated as R^2 contribution averaged over orderings among regressors (LMG).

self-reported and insurance declared diseases, and adjusted for both in our models, it is still possible that we did not capture all comorbidities.

The absence of link between expert-evaluated asbestos exposure (CEI) and HRQoL was expected We included the cumulative asbestos exposure index in our analysis to address the eventuality that the effect we attributed to perceived risk was only an effect of increased exposure to asbestos, and, as such, of an increased frequency of asbestos-related diseases and especially cancers, that can reduce HRQoL.[13,14,35] In our study subjects were not informed of their asbestos CEI estimated by industrial hygienists. The association between HRQoL and perceived risk (including asbestos level of exposure assessed by subjects) but not with CEI, found in this study, highlighted the importance for previous asbestos workers to physicians to have reliable information delivered by their physician about their cumulative asbestos exposure level.

Respiratory symptoms have a negative impact on all HRQoL subscales and summaries. This association has been documented in other populations (COPD,[36] general population[37]). Hints to the association had been observed in in other asbestos-exposed populations such as in the residents of Libby[38] for respiratory QoL, and also in workers and residents[17] from Wittenoom for mental health dimension of HRQoL.

As for the SF-36v2 in themselves, in the absence of French normative data for the second version of the SF-36 scale, we abstained from formal comparisons as using norms for V1 or another country would introduce bias.[22] Nevertheless, the absolute scores for all subscales appear to be low. In comparison to international data

TABLE 5 Results of multiple multivariable multinomial regression analysis for poor and intermediate score in each SF-36 dimension—Physical health dimensions.

	PF		RP		BP		GH	
	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]
Asbestos exposure index	1.001 (0.999–1.003) $p = 0.3$	1.000 (0.998–1.002) $p > 0.9$	1.000 (0.998–1.001) $p = 0.7$	1.000 (0.998–1.001) $p = 0.7$	1.000 (0.998–1.001) $p = 0.9$	0.999 (0.997–1.001) $p = 0.3$	0.999 (0.997–1.001) $p = 0.2$	0.999 (0.997–1.001) $p = 0.15$
Asbestos perceived risk score	1.006 (1.000–1.012) $p = 0.051$	**1.018 (1.011–1.025)** $\mathbf{p < 0.001}$	1.005 (0.999–1.011) $p = 0.078$	**1.011 (1.004–1.018)** $\mathbf{p = 0.002}$	1.005 (1.000–1.011) $p = 0.074$	**1.009 (1.002–1.015)** $\mathbf{p = 0.011}$	**1.009 (1.003–1.014)** $\mathbf{p = 0.003}$	**1.026 (1.019–1.034)** $\mathbf{p < 0.001}$
HADS anxiety								
Asymptomatic	–	–	–	–	–	–	–	–
Possible anxiety	**1.56 (1.08–2.27)** $\mathbf{p = 0.02}$	**2.02 (1.32–3.09)** $\mathbf{p = 0.001}$	**2.18 (1.50–3.18)** $\mathbf{p < 0.001}$	**2.68 (1.74–4.14)** $\mathbf{p < 0.001}$	**1.94 (1.33–2.81)** $\mathbf{p < 0.001}$	**3.77 (2.47–5.76)** $\mathbf{p < 0.001}$	**2.29 (1.58–3.34)** $\mathbf{p < 0.001}$	**4.89 (3.13–7.63)** $\mathbf{p < 0.001}$
Probable anxiety	1.65 (0.97–2.81) $p = 0.07$	2.64 (1.51–4.62) $\mathbf{p < 0.001}$	1.37 (0.80–2.34) $p = 0.3$	2.75 (1.59–4.76) $\mathbf{p < 0.001}$	2.55 (1.47–4.41) $\mathbf{p < 0.001}$	5.72 (3.22–10.2) $\mathbf{p < 0.001}$	3.18 (1.70–5.92) $\mathbf{p < 0.001}$	10.9 (5.71–20.8) $\mathbf{p < 0.001}$
HADS depression								
Asymptomatic	–	–	–	–	–	–	–	–
Possible depression	**2.32 (1.46–3.67)** $\mathbf{p < 0.001}$	**5.18 (3.19–8.39)** $\mathbf{p < 0.001}$	**2.69 (1.68–4.32)** $\mathbf{p < 0.001}$	**6.53 (4.00–10.7)** $\mathbf{p < 0.001}$	**2.12 (1.37–3.30)** $\mathbf{p < 0.001}$	**3.71 (2.31–5.94)** $\mathbf{p < 0.001}$	**1.92 (1.22–3.03)** $\mathbf{p = 0.005}$	**4.68 (2.86–7.66)** $\mathbf{p < 0.001}$
Probable depression	1.98 (0.98–3.99) $p = 0.06$	**7.51 (3.77–14.9)** $\mathbf{p < 0.001}$	2.18 (0.96–4.91) $p = 0.06$	**15.4 (7.15-33.0)** $\mathbf{p < 0.001}$	1.99 (0.98–4.06) $p = 0.06$	**6.75 (3.34–13.6)** $\mathbf{p < 0.001}$	2.00 (0.85–4.71) $p = 0.11$	**10.8 (4.70–24.6)** $\mathbf{p < 0.001}$
Chronic disease reported to health insurance								
No	–	–	–	–	–	–	–	–
Yes	**1.39 (1.01–1.91)** $\mathbf{p = 0.042}$	**2.71 (1.89–3.88)** $\mathbf{p < 0.001}$	**1.38 (1.00–1.90)** $\mathbf{p = 0.047}$	**2.61 (1.82–3.74)** $\mathbf{p < 0.001}$	**1.37 (1.01–1.86)** $\mathbf{p = 0.046}$	**1.57 (1.10–2.24)** $\mathbf{p = 0.01}$	**1.66 (1.21–2.28)** $\mathbf{p = 0.002}$	**3.73 (2.53–5.50)** $\mathbf{p < 0.001}$
Self-reported somatic comorbidities								
No	–	–	–	–	–	–	–	–
Yes	**2.58 (1.41–4.70)** $\mathbf{p = 0.002}$	2.26 (0.97–5.26) $p = 0.06$	**2.04 (1.15–3.59)** $\mathbf{p = 0.01}$	**2.51 (1.05–5.97)** $\mathbf{p = 0.04}$	**2.42 (1.38–4.25)** $\mathbf{p = 0.002}$	**4.69 (1.83–12.0)** $\mathbf{p = 0.001}$	**2.08 (1.19–3.61)** $\mathbf{p = 0.01}$	2.51 (0.99–6.39) $p = 0.05$

TABLE 5 (Continued)

	PF		RP		BP		GH	
	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Intermediate versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]
Respiratory symptoms								
No	–	–	–	–	–	–	–	–
Yes	**2.24 (1.64–3.06)** **$p < 0.001$**	**3.52 (2.38–5.20)** **$p < 0.001$**	**2.22 (1.62–3.04)** **$p < 0.001$**	**2.77 (1.88–4.07)** **$p < 0.001$**	1.34 (0.98–1.84) $p = 0.06$	**2.58 (1.75–3.80)** **$p < 0.001$**	**1.57 (1.15–2.13)** **$p = 0.004$**	**3.58 (2.33–5.48)** **$p < 0.001$**

Note: Bold values are statistically significant $p < 0.05$.

Abbreviations: BP, bodily pain; GH, general health; PF, physical functioning; RE, role emotional.

[a]Poor QoL (quality of life) = first tertile for SF-36 dimension, Medium QoL = second tertile, Good QoL = third tertile

[b]aOR = adjusted odds ratio (adjusted for age, region, marital and smoking status), CI = confidence interval.

(Supporting Information S2), the scores in our study are 10–30 points lower than those of the general population from the United States[19] and New Zealand[22] which can be at least partly explained by the old age (mean: 72.7 years *SD*: 5.1) and prevalence of chronic diseases in our population. Differences in language could also influence the score: Roser et al.[39] who included one quarter of French-speaking Swiss in his sample, noted the French-speaking subjects scored lower than the German-speaking ones for both PCS and MCS. Language and culture had a larger effect than gender or unemployment. The participants in our study scored lower than the Swiss on all subscales, even when considering only men or seniors (over 65) or subjects with a chronic condition, or retired workers. The results for the physical dimensions were comparable to those of Dutch rheumatoid arthritis patients[40] but our population scored lower on all four mental health subscales. French patients with inflammatory bowel diseases[41] had worse results for all dimensions, but the study included a majority of women who have a higher risk of poor HRQoL.

These differences in score between population are clinically significant. In many situations, a 5-point change in a summary score can be considered meaningful by both patients and clinicians.[42] By the same standards, the difference in score between workers with low perceived risk and high perceived risk would be considered clinically significant.

Our perceived risk score only measures one latent variable, as the fit for the two factors models was unsatisfactory. The selected model however seems to favor the personal risk side, given the vast difference in loadings between items 1-2-3 which are more personal risk oriented and 4–5 which focus on societal risk. Each side is influenced by different factors and communication types[27] and, while it appears plausible that low HRQoL is mostly linked to personal risk perception, it would be interesting to confirm this hypothesis to help improve medical communication.

One of the limitations of our study was that our measures of HRQoL, perceived risk and comorbidities could be perfected. We could not use norm-based scoring for HRQoL which prevented a more robust comparison. A perceived risk score had to be constructed, as at the time of the design of the ARDCO, there were no widely used questionnaire measuring risk perception. Finally, it is possible our double-pronged approach to comorbidities was still insufficient to capture all the nuances, as suggested by the low R^2 contribution of both variables.

Another limitation is the possible selective attrition of the cohort: participants with the strongest estimated exposure to asbestos were largely absent from our sample, despite being included in the ARDCO cohort at its inception. Greater mortality undoubtably explains part of the attrition, but one can also surmise that faced with the uncomfortable truth of their above average asbestos-related risk, these subjects chose to avoid further reminders and left the cohort. How this impacts this study is not clear.

All in all, the question of asbestos exposure and HRQoL is interesting from a research point of view both because the impact on mental health is not limited to the sole presence of anxious or depressive symptoms, and because physical health is also seemingly

TABLE 6 Results of multiple multivariable multinomial regression analysis for poor and intermediate score in each SF-36 dimension—Mental health dimensions.

	VT		SF		RE		MH	
	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]
Asbestos exposure index	1.001 (0.999–1.002) $p = 0.5$	0.999 (0.997–1.001) $p = 0.3$	1.001 (1.000–1.003) $p = 0.089$	1.000 (0.998–1.002) $p > 0.9$	1.000 (0.999–1.002) $p = 0.7$	1.000 (0.98–1.002) $p = 0.8$	1.001 (0.999–1.003) $p = 0.4$	1.000 (0.999–1.002) $p = 0.6$
Asbestos perceived risk score	**1.006 (1.000–1.012)** **$p = 0.044$**	**1.012 (1.005–1.019)** **$p = 0.001$**	1.002 (0.996–1.008) $p = 0.5$	**1.015 (1.007–1.022)** **$p < 0.001$**	1.005 (0.999–1.011) $p = 0.10$	**1.010 (1.030–1.017)** **$p = 0.004$**	**1.007 (1.001–1.013)** **$p = 0.0118$**	**1.017 (1.009–1.026)** **$p < 0.001$**
HADS anxiety								
Asymptomatic	–	–	–	–	–	–	–	–
Possible anxiety	**2.4 (1.65–3.50)** **$p < 0.001$**	**2.4 (1.53–3.76)** **$p < 0.001$**	**2.74 (1.88–4.00)** **$p < 0.001$**	**6.68 (4.23–10.6)** **$p < 0.001$**	**3.25 (2.21–4.77)** **$p < 0.001$**	**3.62 (2.32–5.64)** **$p < 0.001$**	**5.62 (3.73–8.49)** **$p < 0.001$**	**14.9 (8.82–25.1)** **$p < 0.001$**
Probable anxiety	**3.07 (1.66–5.68)** **$p < 0.001$**	**4.77 (2.50–9.11)** **$p < 0.001$**	**9.22 (3.81–22.3)** **$p < 0.001$**	**44.3 (18.0–109)** **$p < 0.001$**	**2.9 (1.63–5.18)** **$p < 0.001$**	**5.76 (3.18–10.4)** **$p < 0.001$**	**7.65 (2.87–20.4)** **$p < 0.001$**	**107 (39.7–286)** **$p < 0.001$**
HADS depression								
Asymptomatic	–	–	–	–	–	–	–	–
Possible depression	**4.84 (2.75–8.51)** **$p < 0.001$**	**15.2 (8.49–27.3)** **$p < 0.001$**	**2.6 (1.61–4.23)** **$p < 0.001$**	**7.27 (4.31–12.3)** **$p < 0.001$**	**1.94 (1.22–3.11)** **$p = 0.005$**	**5.81 (3.59–9.40)** **$p < 0.001$**	**3.89 (2.28–6.65)** **$p < 0.001$**	**14.0 (7.77–25.4)** **$p < 0.001$**
Probable depression	2.41 (0.85–6.85) $p = 0.1$	**35.4 (13.2–94.6)** **$p < 0.001$**	4.09 (1.35–12.4) $p = 0.01$	24.1 (8.07–71.8) $p < 0.001$	2.5 (1.00–6.26) $p = 0.05$	**19.7 (8.19–47.4)** **$p < 0.001$**	2.76 (0.87–8.72) $p = 0.08$	**30.7 (10.1–93.6)** **$p < 0.001$**
Chronic disease reported to health insurance								
No	–	–	–	–	–	–	–	–
Yes	1.32 (0.96–1.82) $p = 0.09$	**2.28 (1.56–3.34)** **$p < 0.001$**	**1.42 (1.03–1.94)** **$p = 0.03$**	**1.73 (1.17–2.56)** **$p = 0.006$**	**1.74 (1.26–2.39)** **$p < 0.001$**	**2.06 (1.42–2.98)** **$p < 0.001$**	1.02 (0.74–1.42) $p = 0.9$	1.28 (0.83–1.99) $p = 0.3$
Self-reported somatic comorbidities								
No	–	–	–	–	–	–	–	–
Yes	1.94 (1.07–3.51) $p = 0.03$	1.02 (0.48–2.17) $p > 0.9$	1.62 (0.94–2.79) $p = 0.08$	1.34 (0.59–3.03) $p = 0.5$	1.23 (0.71–2.11) $p = 0.5$	**2.62 (1.00–6.84)** **$p = 0.049$**	0.82 (0.49–1.37) $p = 0.04$	1.88 (0.64–5.50) $p = 0.2$

TABLE 6 (Continued)

	VT		SF		RE		MH	
	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]	Medium versus Good QoL[a] aOR (95% CI)[b]	Poor versus Good QoL[a] aOR (95% CI)[b]
Respiratory symptoms								
No	–	–	–	–	–	–	–	–
Yes	**2.03 (1.48–2.80)** *p* < 0.001	**3.75 (2.48–5.68)** *p* < 0.001	**1.55 (1.13–2.13)** *p* = 0.006	**2.29 (1.49–3.50)** *p* < 0.001	**1.76 (1.28–2.43)** *p* < 0.001	**2.69 (1.80–4.00)** *p* < 0.001	**1.39 (1.00–1.91)** *p* = 0.047	**1.96 (1.21–3.15)** *p* = 0.006

Note: Bold values are statistically significant $p < 0.05$.

[a]Poor QoL (quality of life) = first tertile for SF-36 dimension, Medium QoL = second tertile, Good QoL = third tertile

[b]aOR = adjusted odds ratio (adjusted for age, region, marital and smoking status), CI = confidence interval.

affected by a mere perception. The impact of past occupational or environmental exposures on HRQoL should also be investigated in other settings, as asbestos exposure is unlikely to be isolated in its effect.

HRQoL is not as frequently used in occupational heath settings as it is in other medical fields, but we think it could be a valuable tool as it assesses the worker's health as a whole and not just as a sum of parts. HRQoL is also an important marker of present health and strong predictors of future health. As such it is important to address any changeable factors that could lower them. Perceived risk appears to be one of those factors.

Asbestos is sometimes seen as a problem from the past as it has been banned in many countries, but millions of workers are still exposed: in countries which still allow use of asbestos, or through random contacts with the asbestos still present in many buildings and machine, or as one of the numerous asbestos removal workers.

From the clinician's point of view, anytime objective exposure to asbestos is discussed with retired and currently exposed workers, be it during routine occupational health consultations, health education, end-of career visits, or post-exposure CT screenings, perceived exposure should also be discussed. Distortions in perceived risk[43] should specially be addressed, in particular when workers have false beliefs about asbestos related diseases or significant overestimations of their exposure level or their risk to develop asbestos related diseases. Psychological counseling should be offer to the most impacted workers.

5 | CONCLUSION

Our study is original as it is the first to consider the effects of past occupational exposure to asbestos (or to any carcinogen, for that matter) on HRQoL. We also highlighted perceived risk as a possible factor for low HRQoL which had never been noted before. The impact of past occupational or environmental exposures on HRQoL should be investigated in other settings.

In clinical practice, objective risk and health are obviously at the center of most, if not all, occupational health endeavours, but perception of risk or health should also be addressed as they can be linked to very concrete fallouts.

AUTHOR CONTRIBUTIONS

Conception and design of the work: Christophe Paris, Jean-Claude Pairon, Isabelle Thaon, Fleur Delva, and Emmanuelle Siefert. Acquisition and interpretation of data: Christophe Paris, Jean-Claude Pairon, Isabelle Thaon, Fleur Delva. Emmanuelle Siefert performed literature review, all statistical analysis and drafted the first version of this manuscript. Isabelle Thaon supervised all aspects of this manuscript. All authors participated in the drafting, revision, and correction of the final text.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

The project was approved by the Ethics Committee of Paris-Cochin (no. 1946/11-02-02 on 2002-02-11) and by the Ethics Comité Ile de France 3 (no. Am4541-1-1946 on 2010-06-08 & no. Am6498-2-1946 on 2015-06-06). All subjects received information about the study and provided their written informed consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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