

Questionnaire reliability and validity for aluminum potroom workers

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KONGERUD J, VALE JR, AALEN OO. Questionnaire reliability and validity for aluminum potroom workers. *Scand J Work Environ Health* 1989;15:364–370. As a part of a study on the respiratory symptoms of aluminum potroom workers, the reliability of a self-administered questionnaire and an interview questionnaire was studied with the use of 261 and 49 employees, respectively. The validity of the self-administered questionnaire (134 persons examined) and the interview questionnaire (90 persons examined) was assessed in a comparison of the statements with the case histories. The reliability of the self-administered questionnaire was fairly high, the kappa coefficient ranging from 0.58 to 0.83, while the reliability of the interview questionnaire varied from -0.03 to 0.45. The same pattern was present with regard to validity, as the self-administered questionnaire showed the highest mean sensitivity, specificity, and agreement in a comparison with the case histories. The self-administered questionnaire seemed to discriminate well between symptomatic and asymptomatic individuals, whereas supplemental information about symptoms, as obtained by a standardized interview questionnaire, appeared to be less valid.

Key terms: case history, evaluation, occupational history, questionnaires, respiratory symptoms.

Standardized questionnaires on respiratory symptoms have been available since the 1960s (1). Such questionnaires are primarily aimed at recording manifestations of chronic bronchitis. While the standardized respiratory questionnaires prepared by the British Medical Research Council (BMRC) (1) and the American Thoracic Society (2) include questions about wheezing and asthma, none of the existing standard questionnaires can provide information on the possible association between asthmatic symptoms and work conditions. Using questions from the BMRC questionnaire as a model, we therefore constructed two questionnaires, one self-administered questionnaire and one interview questionnaire, to be used in a prospective survey of asthmatic symptoms among aluminum potroom workers.

Several methodological problems emerge with the use of questionnaires in epidemiologic work (3). Translating questionnaires to another language may change the individual interpretation of the questions and hence the outcome rates (4). Furthermore, in spite of a careful design of the questions and their order, there will always remain some doubt about the reliability and validity of the answers obtained.

The purpose of our study was, therefore, to examine the quality of answers to some questions with respect to their reliability and validity.

Subjects and methods

Sample and survey design

The 297 potroom workers, men and women, present in four Norwegian aluminum plants on a randomly selected date constituted the survey group (table 1). Only one man refused to participate. Of the respondents to the screening questionnaire, 35 did not take part in a second query because they had left the plant, were performing their military duty, were on sick leave, or were not present for other reasons. No one declined to participate in the second examination. A detailed flow chart of the study is presented in figure 1.

Of the 296 initial respondents, 101 reported cough or a combination of dyspnea and wheezing, and these responses qualified the persons for an interview with a standardized questionnaire. Ninety interviewed persons, mixed with 44 randomly selected persons denying all respiratory symptoms, were then examined by an experienced chest physician (JK) who did not know the responses to the questionnaire. The 11 persons who were interviewed but who did not attend the clinical examination were absent from the plant when the chest specialist visited it.

Questionnaires

Major respiratory symptoms (dyspnea, wheezing, and cough), possibly predisposing conditions in the case history (allergy, familial asthma, previous asthma), and exposure data, including smoking habits and former work exposure, were, as a first stage, recorded on a self-administered questionnaire. Workers with a pattern of respiratory complaints believed to be particularly relevant, ie, wheezing and dyspnea combined or cough, were then interviewed with a detailed question-

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Table 1. Characteristics of the aluminum potroom workers examined by a self-administered questionnaire on two occasions.

Survey	N	Males (%)	Age (years)		Dyspnea (%)	Dyspnea and wheezing (%)	Cough (%)
			Mean	SD			
First	296	89.2	36.5	12.5	31	19	27
Second	261	90.4	36.9	12.3	30	20	23

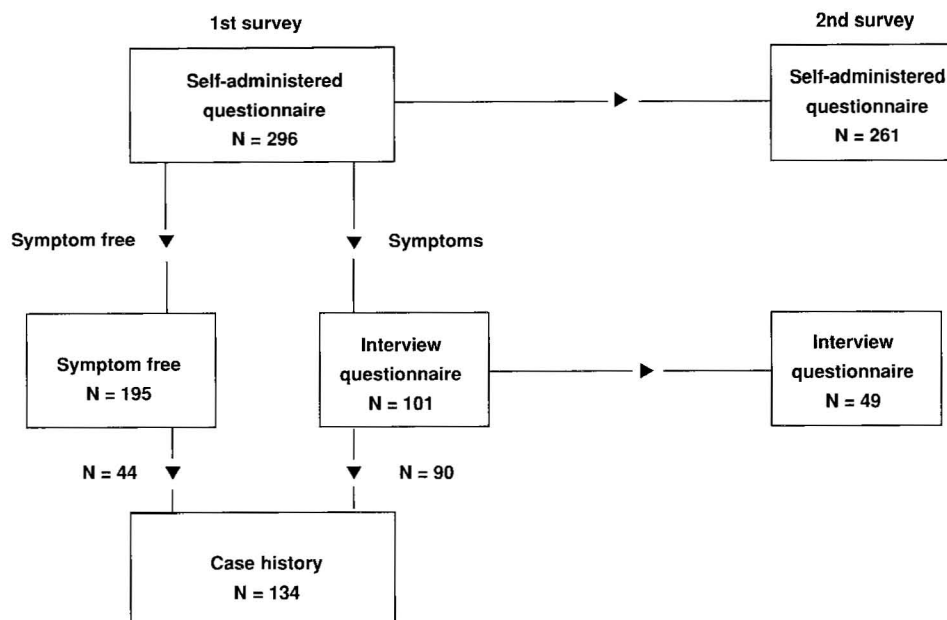


Figure 1. Schematic presentation of the administrations of the questionnaires. The numerals indicate the number of persons examined with the different questionnaires at different times.

naire that had been standardized. This questionnaire was designed to provide supplemental information on respiratory symptoms. Some of the questions in the questionnaire interview were translations from the BMRC questionnaire.

The interviewers were all experienced plant nurses who had worked with interview questionnaires for several years. They were trained by one of the authors (JK), using BMRC procedures for the training and educating of interviewers (5). It was emphasized that there should be no probing for responses and that unanswered questions should be dealt with in the same manner by all the interviewers. In the clinical, close-ended interview, we obtained information which was comparable to that obtained by the questionnaires. (The questionnaires are obtainable from the authors on request.)

Definitions and data analysis

Validity. Validity refers to the ability of a questionnaire to measure what it was intended to measure. It is generally expressed as sensitivity and specificity (table 2). Validity is usually assessed in a comparison of the results of a questionnaire with separate, independent

Table 2. Measurements of questionnaire reliability and validity.

Registration 1	+	+	-	-
Registration 2	+	-	+	-
Frequency	a	b	c	d

Sensitivity:	$a/(a+c)$	Specificity:	$d/(b+d)$
$n =$	$a+b+c+d$		
$p_o =$ observed agreement	$= (a+d)/n$		
$p_c =$ expected agreement	$= [(a+b)/n] \cdot [(a+c)/n] + [(c+d)/n] \cdot [(b+d)/n]$		
Kappa agreement	$= (p_o - p_c)/(1 - p_c)$		

Validity:	Registration 1 is questionnaire. Registration 2 is clinical history.
Reliability:	Registration 1 is first administration of the questionnaires. Registration 2 is second administration of the questionnaires.

criteria. For respiratory questionnaires appropriate criteria are generally unavailable. However, the questionnaire method attempts to elicit essential aspects of

those symptoms that would be found in an extensive clinical history (6, 7). Despite the disagreements that might exist between physicians in relation to diagnoses, Hampton et al (8) found that a correct clinical diagnosis was obtained by history taking alone in 85 % of the cases studied in a medical outpatient clinic. On the basis of this finding, we decided to test the validity of the questionnaires against clinical history taking. In addition to sensitivity and specificity we estimated the kappa agreement (table 2) between the questionnaires and the answers obtained by a chest physician (JK).

Reliability. The agreement of response between two administrations of a questionnaire is an appropriate measure of reliability (table 2) (3). However, this approach assumes that the symptoms do not change in the interval between examinations; otherwise the results will be influenced by real variation in symptom status. On the other hand, if the interval is too short, the subjects may recall their former answers and hence bias

the results. The period between the test and retest was chosen to minimize both of these effects, but we were also forced to pay attention to shift schedules and vacations. Consequently, reliability was measured as the agreement between the statements obtained by two administrations of the self-administered and the interview questionnaires with an interval of three to five months. The reliability of the amount of smoking, estimated as pack-years, was expressed by the correlation coefficient (Spearman rank).

Kappa coefficient. The agreement between discrete variables in questionnaires and case histories, as well as agreement between the two administrations of a questionnaire (reliability), was estimated by the kappa coefficient (9). A kappa value of 0 corresponds to a chance expectation, while a kappa value of 1 indicates perfect agreement. Kappas ranging from 0.4 to 0.7 are considered satisfactory, while a value above 0.7 is regarded as excellent (10).

Data analysis of interview questionnaires versus self-administered questionnaires. Since only persons who reported symptoms were interviewed, false negative reports from the self-administered questionnaire were not discovered with the interview questionnaire. Therefore, the sensitivity and specificity of the main symptoms (dyspnea, wheezing, and cough) of the interview questionnaire could not be estimated.

Table 3. Reliability of some of the questions included in the self-administered respiratory questionnaire.^a

Variable	Reliability (kappa)	Standard error
Dyspnea	0.63	0.05
Wheezing	0.66	0.06
Dyspnea and wheezing	0.61	0.06
Cough	0.58	0.06
Allergy	0.70	0.09
History of asthma	0.66	0.16
Familial asthma	0.83	0.05
Smoking habits	0.86	0.03
Previous work exposure	0.76	0.05

^a The results are based on the data in table A1 of appendix I.

Table 4. Reliability of some of the questions included in the interview questionnaire on respiratory symptoms.^a

Variable	Reliability (kappa)	Standard error
Dyspnea	0.41	0.16
Dyspnea and wheezing	0.50	0.14
Cough	0.56	0.14
Cough more than three months a year ^b	0.42	0.15
Attacks of cough	0.45	0.15
Breathlessness when walking on level ground ^b	0.44	0.12
Attacks of breathlessness ^b	0.30	0.16
Symptoms at work	0.22	0.14
Symptoms at night, after work	-0.03	0.12
Symptoms with a duration of less than 1 h	0.34	0.14
Symptoms on vacation	0.13	0.17

^a The results are based on the data in table A2 of appendix I.

^b The questions were translated from the questionnaire of the British Medical Research Council.

Results

Reliability of the self-administered questionnaire

The comparison of the first and second administration of the self-administered questionnaire is shown in table A1 in appendix I. The reliability of the questions varied from 0.58 to 0.86 (table 3). The major respiratory questions (dyspnea, wheezing, cough, and a combination of dyspnea and wheezing) had very acceptable values, ie, kappa = 0.63, kappa = 0.66, kappa = 0.58, and kappa = 0.61, respectively. The reliability was higher for the reporting of childhood allergy (kappa = 0.70) and familial asthma (kappa = 0.83). The overall prevalence of symptoms from the two surveys did not differ significantly (table 1).

The question on smoking habits with the crude classification of smokers versus ex-smokers and never smokers had a high reliability (kappa = 0.86). The correlation coefficient for the amount of smoking was 0.88 (Spearman rank).

Reliability of the interview questionnaire

Table A2 in appendix I gives the comparison of the two sets of responses to the interview questionnaire. The reliability of the answers to the interview questionnaire (table 4) was generally lower than for the self-

administered questionnaire, the mean kappa being 0.67 and 0.26. However, for the main symptom questions, the reliability was fairly high (0.41 to 0.56). Questions translated from the BMRC questionnaire had a reliability within the acceptable lower limit, except for the question about "attacks of breathlessness" (kappa = 0.30). More-detailed questions, in particular those that were supposed to reveal a relationship between symptoms and work, had a low reliability, with the kappa coefficient in the range of -0.03 to 0.22.

Validity of the self-administered questionnaire

Table B1 in appendix II gives the comparison between the responses to the self-administered questionnaire and the case histories.

The validity of the symptom questions is shown in table 5. The question about cough had the lowest overall validity of the main symptom questions with a sensitivity of 73 %, a specificity of 67 %, and a kappa of 0.39. The questions about history of asthma and childhood allergy had the lowest sensitivity of the screening questions, 50 and 53 %, respectively.

The crude classification of smoking habits had an optimal specificity, sensitivity, and agreement (98 % 100 % and 0.97, respectively). High kappa agreement

(0.61) was also found for the question about former work exposure.

Validity of the interview questionnaire

Table B2 in appendix II gives the comparison between the responses to the interview questionnaire and the case histories.

The validity of some of the questions of the interview is shown in table 6. The mean sensitivity and specificity was 58 and 77 %, respectively. The kappa agreement ranged from 0.08 for symptoms at work to very acceptable values, as for instance for the question about respiratory symptoms at night (kappa = 0.63). The questions translated from the BMRC questionnaire had an agreement of 0.57, 0.54, and 0.20. The mean kappa agreement of the questions validated was 0.34.

Comparison of the self-administered and interview questionnaires

Table B3 in appendix II shows how symptoms reported in the self-administered questionnaire were reported in the interview.

Table 5. Validity of some of the questions included in the self-administrated respiratory questionnaire as compared with data in a clinical history.^a

Variable	Sensitivity (%)	Specificity (%)	Agreement (kappa)	Standard error ^b
Dyspnea	83	79	0.61	0.07
Wheezing	83	73	0.57	0.10
Dyspnea and wheezing	80	83	0.60	0.07
Cough	73	67	0.39	0.08
Allergy	53	98	0.60	0.11
History of asthma	50	98	0.32	0.25
Familial asthma	80	97	0.80	0.06
Smoking habits	98	100	0.97	0.02
Previous work exposure	66	93	0.61	0.09

^a The results are based on the data in table B1 of appendix II.

^b Standard error of the kappa.

Table 6. Validity of some of the questions obtained in the interview questionnaire on respiratory symptoms as compared with data in a clinical history.^a

Variable	Sensitivity (%)	Specificity (%)	Agreement (kappa)	Standard error ^b
Cough more than three months a year ^c	64	93	0.57	0.11
Attacks of cough	28	86	0.15	0.12
Breathlessness when walking on level ground ^c	69	52	0.20	0.13
Attacks of breathlessness ^c	67	89	0.54	0.14
Symptoms at work	44	68	0.08	0.08
Symptoms at night, after work	78	84	0.63	0.09
Symptoms with a duration of less than 1 h	87	49	0.34	0.09
Symptoms on vacation	25	91	0.18	0.09

^a The results are based on the data in table B2 of appendix II.

^b Standard error of the kappa.

^c The questions were translated from the questionnaire of the British Medical Research Council.

With regard to the question on dyspnea and the one on the combination of dyspnea and wheezing, only 2.7 and 3.5 %, respectively, gave negative statements in the interview. However, as many as 15.4 % of those reporting cough in the self-administered questionnaire denied such symptoms in the interview.

Discussion

Reliability

Agreement between the responses to the same questionnaire on two occasions is the usual measure of the reliability of a questionnaire (3). Simple observed agreement (see table 2) has, in most other studies, been used as the parameter of reliability, and it is not directly comparable with the kappa coefficient. Since the kappa index relates the observed agreement to the agreement that occurs by chance, we have found this parameter more valuable.

The self-administered screening questionnaire had an acceptable reliability (mean kappa = 0.70). The reliability of the main symptom questions compared favorably with others calculated from published data (11, 12, 13). In a study of cotton textile workers the reliability was 0.62 for a question on chest tightness and 0.31 for a question on grades of dyspnea (11). In another study of respiratory symptoms among coal miners, the reliability for questions on symptoms of phlegm and wheezing was 0.50 and 0.54, respectively (13). For a group of 30 medical patients, the reliability for questions on cough and dyspnea was 0.43 and 0.59, respectively (12). However, the reliability of our self-administered questionnaire was somewhat lower than what Mitchell & Miles found in a study of Queensland schoolchildren (14). The reliability of wheezing was found to be as high as 0.86, while the reliability of the statement on productive cough was 0.81. The increased reliability in the latter study might be due to the interval between the two administrations of the questionnaire. In the latter there were nine weeks between the studies, while in our study the interval ranged from three to five months — and this time interval might give a real change in symptoms. For example, alterations in environmental exposure, which is more likely to occur for industrial workers than for schoolchildren, might give rise to real changes in symptoms.

The reliability of some major questions from the interview questionnaire (dyspnea, dyspnea and wheezing, cough, and cough more than three months a year) was above the acceptable lower limit (kappa = 0.40) (table 4). The lower reliability of these questions than with the same questions of the self-administered questionnaire could be explained by response bias introduced by the interviewer.

Smoking status has been reported with higher reliability than respiratory symptoms (13, 15). This was also the case in our study. The crude classification of former work exposure status showed the same reli-

bility as smoking status. The estimation of lifetime cigarette consumption (pack-years) also had a high reliability ($r=0.88$) and was fairly comparable to that reported by Samet et al ($r=0.81$) in a study of asbestos-exposed workers (16).

If we accept a kappa coefficient of 0.40 as the lower limit for approvable values, only the interview questionnaire had questions that were less reliable. These were detailed questions about symptoms and their relation to work, vacations, etc. A possible explanation for this variation could have been the influence of variations in the work environment exposure and the fact that a three-week summer vacation fell between the two examinations. However, there were no differences between the prevalence of work-related complaints and vacation disabilities on the two occasions. Furthermore, the constant prevalence of symptoms suggests that possible under- or overreporting occurred with equal frequency and should not have influenced subsequent results in either direction.

The respiratory questions in our study reviewed the preceding year. This interval may possibly introduce recall bias and could account for the lower reliability of the detailed questions of the interview questionnaire. The optimal recall period for dramatic occurrences such as motor vehicle accidents can be as short as three months (17). Large intraindividual variation in symptoms is another possible explanation for the low reliability of the interview questionnaire. This finding is in accordance with the findings of longitudinal studies by Ferris et al (18) and Sharp et al (19) suggesting that respiratory symptoms are not static; they both develop and remit, even in individuals who maintain the same smoking status. Samet et al (16), who studied a group of shipyard workers twice one year apart, also found that workers with unchanged smoking habits replied to the symptom questions with an average, observed agreement of only 70 % (implying an even lower value for kappa). Holland et al (7) measured an average observed agreement of 85 % when either the BMRC questionnaire or the National Coal Board's Pneumoconiosis Field Research Questionnaire was readministered after six months, and even in this study, using thoroughly validated questionnaires, certain questions had reliabilities as low as 66 % (implying an even lower value for kappa). Preliminary results (unpublished) from a prospective study on bronchial hyperreactivity in potroom workers indicate that symptoms show considerable intraindividual variability during an interval as short as three months, and these results support the theory that the low reliability is partly due to a real change in symptoms and is not entirely related to the quality of the questions.

Validity

The self-administered screening questionnaire had, except for childhood allergy, questions that correlated well with the physician's assessment. An underestima-

tion of allergy on the basis of the statement of childhood allergy seems likely, as allergy in the general population is estimated to be twice as high. However, allergy has been regarded for a long time as a risk factor for the development of "potroom asthma" and the selection of nonallergic persons to such employment has been practiced.

The question on a history of asthma had low validity. But only two of the 134 clinically examined persons gave an affirmative answer to this question, and the estimation of both validity and reliability is dubious.

The questions on smoking status and on previous work exposure showed excellent validity, well comparable with that of other questionnaires (20, 21).

The standardized interview questionnaire aimed at a more-detailed characterization of the respiratory symptoms. However, the quality of the information collected in the interview seemed to vary. There was close agreement between the self-administered and interview questionnaires regarding the positive answers to the questions on dyspnea and wheezing, while the question on cough showed less stability. We have no explanation why so many denied cough in the interview, while giving a positive answer in the self-administered questionnaire. Supplementary information on the character of complaints like the relation to work and duration of symptoms had generally a low validity in addition to the already mentioned low agreement of the interview questionnaire in the two administrations. Therefore, the interpretation of some of the supplemental questions is difficult and has to be done with care. Even questions translated from the BMRC questionnaire did not achieve better validity than the questions of the self-administered questionnaire.

The self-administered questionnaire seems to be a valuable tool for screening for respiratory symptoms among aluminum potroom workers, while the use of an interview questionnaire as a substitute for history taking by a physician seems less advisable.

Acknowledgments

The interviews were carried out by the plant nurses at the Karmøy, Sørø, Årdal, and Mosjøen aluminum works and their assistance is gratefully acknowledged. We also wish to thank our colleagues at the Department of Epidemiology, National Institute of Public Health, Oslo, for their valuable comments on this manuscript.

This study was supported by grants from the Nordic Aluminum Industry's Secretariat for Health, Environment and Safety (AMS).

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Appendix I

Comparisons between the same survey method

Table A1. Comparison of data from the first and second administration of the self-administered questionnaire.

	Administration 1	+	+	-	-
	Administration 2	+	-	+	-
Frequency		a	b	c	d
Variable		a	b	c	d
Dyspnea		59	23	18	161
Wheezing		44	14	17	186
Dyspnea and wheezing		35	16	16	194
Cough		44	26	15	176
Allergy		14	5	6	236
Previous history of asthma		4	3	1	253
Familial asthma		36	5	7	213
Smoking habits		163	11	6	81
Previous work exposure		47	9	13	192

Table A2. Comparison of data from the first and second administration of the interview questionnaire.^a

	Administration 1	+	+	-	-
	Administration 2	+	-	+	-
Frequency		a	b	c	d
Variable		a	b	c	d
Dyspnea		35	5	4	5
Dyspnea and wheezing		30	6	4	9
Cough		33	5	3	8
Cough more than three months a year		6	2	7	23
Attacks of cough		7	2	7	22
Breathlessness when walking on level ground		14	11	1	14
Attacks of breathlessness		5	3	8	24
Symptoms at work		16	10	9	14
Symptoms at night, after work		5	6	19	19
Symptoms with a duration of less than 1 h		24	10	5	10
Symptoms on vacation		2	5	6	36

^a The number of subjects in each row differs because the answering of some questions was dependent on a positive answer in the preceding question.

Appendix II

Comparisons between different survey methods

Table B1. Comparison of data from the self-administered questionnaire and the clinical history.

	Self-administered questionnaire	+	+	-	-
	Clinical history	+	-	+	-
Frequency		a	b	c	d
Variable		a	b	c	d
Dyspnea		58	13	13	50
Wheezing		34	8	7	22
Dyspnea and wheezing		33	16	8	77
Cough		50	21	20	43
Allergy ^a		10	2	9	113
History of asthma		1	3	1	129
Familial asthma ^a		24	3	6	96
Smoking habits ^b		91	—	2	41
Previous work exposure		19	7	10	98

^a The "no" and "don't know" statements were coded together.

^b Past smokers and never smokers were coded together.

Table B2. Comparison of data from the interview questionnaire and the clinical history.^a

	Interview questionnaire	+	+	-	-
	Clinical history	+	-	+	-
Frequency		a	b	c	d
Variable		a	b	c	d
Cough more than three months a year		16	2	9	25
Attacks of cough		7	6	18	36
Breathlessness when walking on level ground		18	15	8	16
Attacks of breathlessness		8	5	4	40
Symptoms at work		30	7	38	15
Symptoms at night, after work ^b		18	10	3	54
Symptoms with duration less than 1 h		34	26	5	25
Symptoms on vacation		9	5	27	49

^a The number of subjects in each row differs because the answering of some questions was dependent on a positive answer in the preceding question.

^b The "no" and "don't know" statements were coded together.

Table B3. Comparison of positive statements in the self-administered questionnaire versus the statements in the interview questionnaire.

	Self-administered questionnaire	+	+	-	-
	Interview questionnaire	+	-	+	-
Frequency		a	b	c	d
Variable		a	b	c	d
Dyspnea		71	2	.	.
Dyspnea and wheezing		55	2	.	.
Cough		66	12	.	.