Eur Respir J
1992, 5, 12–20

Changes in chronic respiratory symptoms in two populations of adults studied longitudinally over 13 years

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ABSTRACT: Data from two longitudinal studies conducted in Cracow, Poland, and Tucson, Arizona, USA, were used to evaluate the differences in period prevalence, incidence and remission rates of respiratory symptoms between two populations, as well as to assess the between-cities similarities in the relationships of the symptoms to age and smoking habit. The analysis was based on data from 3,082 adult Cracow residents, interviewed twice 13 yrs apart, and from 1,452 Tucson adults, with mean period between initial and final survey of 12.2 yrs. Log-linear models were used to consider possible interactions of the symptoms, age, smoking, gender and city.

The relationship of the symptoms to smoking was similar in both cities, after adjustment for age and gender, with at least doubled incidence rates of most symptoms in continuous smokers compared to lifetime nonsmokers. The between-population differences in the symptoms were related to age, indicating onset of bronchitic symptoms occurring earlier in life in Cracow, and of asthmatic symptoms in Tucson. These differences were due to factors other than tobacco smoking *e.g.* various types of ambient air pollution.

Eur Respir J., 1992, 5, 12–20.

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Keywords: Epidemiology; respiratory tract diseases; smoking.

Received: December 4, 1990; accepted after revision August 5, 1991.

The Tucson study was supported by NHLBI SCOR grant No. HL14136, and the Cracow study was supported in part by grant P-05-109-N from NHLBI. M.K. was the recipient of International Fogarty Fellowship, grant No. 1-F05-TW03940.

Chronic respiratory symptoms are likely to be the subjective markers of chronic respiratory diseases. Wheeze and attacks of breathlessness are connected with rate of decline in pulmonary function [1, 2]. Chronic cough, chronic phlegm and breathlessness were reported to be predictors of disability from respiratory diseases, hospitalization due to respiratory diseases in general or to chronic obstructive pulmonary diseases, and of medication [3, 4]. The symptoms were also found to indicate groups with increased mortality [5–8]. This justifies the consideration of the symptoms, in spite of their subjectivity and qualitative nature, in studies on aetiology of chronic airways disease besides the objective measurements such as spirometry. Numerous studies have indicated that the prevalence of the symptoms is greater in cigarette smokers than nonsmokers and increases with age [9]. A few studies have directly addressed the long-term changes in symptoms, their incidence and remission rates [10–14], confirming that the dynamics of the disease are related to smoking and age.

The purpose of this work is to assess to what extent the relationships of the dynamic stages (incidence, prevalence, remission) of a number of respiratory symptoms to age and tobacco smoking are similar in two different populations studied in very different places by similar methods. A further objective is the comparison between the cities of the symptoms rates, taking into account possible confounding by age, smoking and gender. In this longitudinal analysis, the multivariate log-linear models are used to account for the differences in combined distributions of age, smoking and gender between the two populations.

Material and methods

The data used for this analysis were collected in the Cracow and Tucson longitudinal epidemiological studies of obstructive airways diseases. The methodologies of both studies were reported in detail previously [15–18]. Briefly, the Cracow study was based on a random sample of adults aged 19–70 yrs in 1968. Standard interviews were collected from 4,355 subjects. In 1981, 13 yrs (±3 months) after the initial survey, the interviews were repeated. An attempt was made to interview all survivors still living in Cracow, and 3,082 subjects (80.4% of the original group not known to die in the follow-up period) were reinterviewed. In the initial survey of the Tucson study, starting in 1972, a sample of 3,485

non-Mexican American residents of the town were studied, and 2,243 of them were 19–70 yrs of age. Until 1985, nine follow-up surveys were performed in this group. For the present analysis we utilized the data from the initial and final surveys (Survey 9 or, if not available, Survey 8) with the minimal period of 132 months between the surveys. There were 1,452 subjects initially aged 19–70 yrs: 465 with follow-up period 132–143 months, 921 with 144–155 months and 73 followed longer, for up to 164 months; mean follow-up period was 12 yrs and 2 months.

The groups successfully followed differed slightly from all the groups interviewed in the initial surveys. The former were, on average, 2 yrs younger than all those interviewed (table 1). Among all Tucson subjects and Cracow men, a smaller proportion of smokers and ex-smokers were followed than found in the initial groups. These differences were in part due to higher mortality in older subjects and in smokers [18, 19]. The proportion of subjects with any respiratory symptom at the initial survey was greater among those followed (except Cracow men).

Table 1. – Initial characteristics of the analysed group and all interviewed in the initial surveys

	Cracow		Tucson	
	All interviewed+	Analysed	All interviewed+	Analysed
Males				
n	1925	1264	1003	613
%	100	65.7	100	61.1
Mean initial age yrs	41.1	39.4	43.5	41.1
% smokers	66.3	64.5	43.0	36.8
% ex-smokers	14.6	12.0	29.9	22.7
% with any respiratory symptom*	38.4	34.3	32.6	34.4
Females				
n	2430	1818	1244	839
%	100	74.8	100	67.4
Mean initial age yrs	41.7	40.4	46.3	44.4
% smokers	23.9	24.2	34.7	27.1
% ex-smokers	5.9	3.5	17.8	16.0
% with any respiratory symptom*	36.5	38.2	34.6	38.9

+: age 19–70 yrs; *: any of chronic cough, phlegm, wheeze, attacks of breathlessness or dyspnoea.

In both studies similar questions on symptoms were asked, based on standard questionnaires recommended by British Medical Research Council (BMRC) and National Heart & Lung Institute (NHLI) [20–21]. The following symptoms were considered in this study:

- Chronic cough: most days, ≥3 months a year, for ≥2 yrs;
- Chronic phlegm: most days, ≥3 months a year, for ≥2 yrs;
- Wheeze: apart from colds;
- Attacks of breathlessness (with wheezing; in Cracow: "not associated with chest pain");
- Exertional dyspnoea: "when walking with other people of the same age on the level ground" (Tucson); in Cracow: and/or "must rest after climbing one floor upstairs".

Moreover, subjects reporting to have bronchial asthma diagnosed by a doctor were considered to have asthma.

To analyse the dynamics of the symptoms, we considered their presence (absence) in the initial and final surveys, creating the following four categories for each symptom: Never (symptom absent in both surveys); Persistent (symptom present in both surveys); New cases (absent to present); and Remission (present to absent).

The relationship of these four category variables (each symptom separately) to age, smoking habit, gender and city was studied using log-linear models [22]. Age was considered in categories: 19–40, 41–55, 56–70 yrs of initial age, and smoking habit in the following groups never (lifetime nonsmokers) continuous (current smokers in the initial and final surveys); other (including ex-smokers and those who started or quit smoking during the follow-up). The combination of the analysed variables (symptom*age*smoking*gender*city) creates a multiway table (here 4 x 3 x 3 x 2 x 2 table). The log-linear models allow variations in cell frequency of this table to be attributed to univariate distributions of the variables ("1st order terms"), to their changes related to single variables ("2nd order terms"), to effects of the third variable on the two-variable relationships ("3rd order terms") *etc.* The log-likelihood ratios provide tests of significance of the model terms. The model selection procedure consists of hierarchical elimination of the nonsignificant ($p>0.05$) terms from the models as long as the overall fit of the model is good ($p>0.10$). The hierarchy principle ensures that the model with a higher order term contains all lower order terms. For example, if a model for a table created by combination of variables A, B, C and D contains significant 3rd order term A*B*C, the relationship between A and B is significantly different at various categories of C. Therefore, it is

necessary to specify level of C when the association of A with B is presented. However, if the 3rd order terms with D (as A*B*D) are not significant, the associations of A with D are similar in each category of B, allowing this relationship to be presented for a total group, summed (collapsed) over categories of B. In this analysis, the nonsignificance of a term A*B*City meant that the relationship between A and B was similar in both cities. Furthermore, a relationship A*City could be displayed with no stratification over B (because of its similarity in all categories of B) and B*City with no stratification over A. Therefore, the application of the log-linear models provides tests of the hypothesis concerning differences in relationships between the cities as well as indicates the simplest methods for presentation of the relationships.

To display the trends in the significant relationships, the coefficients of the selected models were estimated. This enabled the calculation of odds ratio (OR) for the symptoms in various categories of the covariables, adjusted for confounding effects of the remain factors. The confidence intervals of particular estimated OR were not shown: the significance of the corresponding 3rd order terms in the log-linear model idicates significant differentiation between OR in particular categories of the stratifying factor. In fact, an OR greater than 2 (or less than 0.5) can be regarded as significantly different from 1 (with significance level 0.05 and power 0.85), given the size of the compared groups [23]. The computations leading to the models selection and the estimation of the models' coefficients was performed using HILOGLINEAR procedure of the SPSS/PC+ V2.0 system [24] and the program 4F of the BMDP package [25]. In the presentation, only the highest order terms are shown: due to a hierarchy principle, all lower order effects contained by these terms are included in the model (*e.g.* the presence of the term CP*Age*Smoking in the model implies that all 2nd order terms, CP*Age, CP*Smoking and Age*Smoking, were also present).

Results

The subjects studied in Tucson were older than those in Cracow (table 2). This was partly due to age stratification in the Tucson study design. Smoking habits differed markedly between populations; twice as many men smoked throughout the follow-up period in Cracow as in Tucson. In women, the proportion of continuous smokers was similar in both cities but the proportion of ex-smokers (giving up smoking anytime before the final survey) was greater in Tucson.

These differences in distributions of age and smoking habit should have an impact on the patterns of longitudinal symptoms. Before adjustment for these possible confounders, the overall period prevalence rates of wheeze, attacks of breathlessness and asthma were greater in Tucson (table 3), and the incidence rates of most of the symptoms were greater in Cracow. This pattern was similar in both genders. For most symptoms in both cities, over 40% of the subjects reporting the symptoms in the first survey did not report them 13 yrs later.

Table 2. – Distributions of age and smoking in the analysed groups (in %)

	Cracow		Tucson	
	Males	Females	Males	Females
All	100	100	100	100
n	1264	1818	613	839
Age (initial survey)				
19–40 yrs	56.6	54.2	51.7	41.8
41–55 yrs	31.3	29.2	24.5	24.7
56–70 yrs	12.0	16.6	23.8	33.5
Smoking habit (initial - final survey)				
Never - Never	16.7	62.2	31.3	48.5
Smoker - Smoker	51.3	19.3	24.8	19.0
Smoker - Ex-smoker	13.2	4.9	12.1	8.1
Exsmoker - Ex-smoker	11.9	3.5	22.7	16.0
Others	6.9	10.2	9.1	8.5

As shown, the 3rd order terms of log-linear models (listed in the legend of table 4), age, smoking, gender and city were intercorrelated in a quite complex way ($p<0.01$ for all). Adjusted for these intercorrelations, the significant relationships of the symptoms to age, smoking, gender and city are shown in table 4. The relationships of all symptoms to smoking were similar in both cities: for all symptoms the terms Symptom*Smoking*City were not significant.

The relationships of chronic cough and of attacks of breathlessness to smoking were homogeneous across categories of age, in both genders and cities. The relationship of wheeze and dyspnoea to smoking differed by gender. The effects of smoking on chronic phlegm differed by age. The relationship of asthma to smoking was different in various combinations of age and gender (4th order term), and that was similar in both cities.

The relationship of the dynamic pattern of almost all symptoms to age was different in Tucson and in Cracow. This was indicated by the 3rd order terms Symptom*Age*City. The exception was chronic phlegm. To describe more closely the relationships of the symptoms of age, adjusted for smoking and gender, we calculated the city-specific odds ratios (with age 19–40 yrs as a reference category) for persistence, incidence and remission of the symptoms using the effects estimated in the log-linear models (table 5). Also, the age-specific Tucson *vs* Cracow odds ratios, adjusted for gender and smoking, were estimated and presented in table 5.

The persistence of chronic cough increased with age in both cities, and this increase started from a lower level and was more distinct in Tucson. In both cities the prevalence rates of chronic cough in subjects

Table 3. – Frequencies and Rates* of symptoms in Cracow⁺ and Tucson** (per 100 at risk)

	Cracow				Tucson			
	Males n=1264		Females n=1818		Males n=613		Females n=839	
Symptoms	n	Rate	n	Rate	n	Rate	n	Rate
Chronic cough								
Never	770	60.9	1414	77.8	463	75.5	675	80.5
Persistent	135	10.7	84	4.6	43	7.0	44	5.2
New	255	11.9	236	5.6	48	9.4	57	7.8
Remission	104	70.8	84	73.8	59	57.8	63	58.9
Chronic phlegm								
Never	693	54.8	1379	75.9	466	76.0	700	83.4
Persistent	192	15.2	96	5.3	43	7.0	34	4.1
New	271	28.1	255	15.6	42	8.3	44	5.9
Remission	108	36.0	88	47.8	62	59.1	61	64.2
Dyspnoea								
Never	1019	80.6	1011	55.6	551	89.9	664	79.1
Persistent	48	3.8	297	16.3	20	3.3	44	5.2
New	167	14.1	377	27.2	22	3.8	71	9.7
Remission	30	38.5	133	30.9	20	50.0	60	57.7
Wheeze								
Never	994	78.6	1480	81.4	423	69.0	607	72.3
Persistent	66	5.2	57	3.1	65	10.6	93	11.1
New	149	13.0	219	12.7	58	12.1	60	9.0
Remission	55	45.5	62	52.1	67	50.7	79	45.9
Attacks of breathlessness								
Never	1080	85.4	1566	86.1	466	76.0	590	70.3
Persistent	30	2.4	43	2.4	42	6.9	70	8.3
New	95	8.1	138	8.1	38	7.5	51	8.0
Remission	59	66.3	71	62.3	67	61.5	128	64.7
Asthma medically diagnosed								
Never	1193	94.4	1707	93.9	550	89.7	725	86.4
Persistent	15	1.2	23	1.3	12	2.0	31	3.7
New	43	3.5	60	3.4	7	1.3	23	3.1
Remission	13	46.4	28	54.9	44	78.6	60	65.9

*: Rates: Never =# never/total × 100, Persistent = # persistent/total × 100, New = # new/(never + new) × 100, Remission = # remission/(persietent + remission) × 100; ⁺: two surveys 13 yrs apart; **: surveys 1 and (9 or 8) 12.2 yrs apart.

Table 4. – The highest order of log-linear models involving effects of symptoms*

	Fit of the model	Terms		
	p	4th order	3rd order	2nd order
Chronic cough	> 0.19	-	CC*Age*City CC*Smok.	
Chronic phlegm	> 0.36	-	CP*Age*Smok.	CC*Sex CP*City CP*Sex
Dyspnoea	>0.74	-	D*Age*City D*Sex*City D*Sex*Age D*Sex*Smok.	-
Wheeze	>0.64	-	W*Age*City W*Sex*City⁺ W*Sex*Smok⁺	-
Attacks of breatthlessness	>0.14	-	At*Age*City	At*Smok. At*Sex
Asthma, medically diagnosed	>0.16	Amd*Age*Smok.*Sex	Amd*Age*City	-

*: all models include terms Age*Sex*City, Age*Sex*Smok., Age*Smok.*City and Smok.*Sex*City; ⁺: 0.05 > p>0.01; for all other terms p<0.01. CC: chronic cough; CP: chronic phlegm; D: dyspnoea; W: wheeze; At: atttacks of breathlessness; Amd: asthma medically diagnosed.

Table 5. – Odds ratios for symptoms persistence (Pers), incidence (Inc) and remission (Rem) estimated from log-linear models by age groups and city

Age yrs	Cracow			Tucson			Tucson/Cracow^{++}		
	Pers*	Inc*	Rem^{+}	Pers*	Inc*	Rem^{+}	Pers*	Inc	Rem^{+}
Chronic cough									
19–40	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.4	1.7
41–55	1.9	1.0	0.8	2.7	1.6	0.8	1.1	0.6	1.7
56–70	2.8	0.8	0.8	2.8	1.2	0.5	0.7	0.6	1.1
Chronic phlegm†									
All ages	NS	NS	NS	NS	NS	NS	0.5	0.3	2.4
Dyspnoea									
19–40	1.0	1.0	1.0	1.0	1.0	1.0	0.4	0.3	2.7
41–55	4.1	1.9	0.6	4.1	1.8	0.4	0.4	0.3	2.1
56–70	13.8	3.1	0.4	7.1	2.9	0.3	0.2	0.2	1.8
Wheeze									
19–40	1.0	1.0	1.0	1.0	1.0	1.0	5.6	1.0	1.2
41–55	2.2	1.2	0.7	1.3	0.7	0.6	3.3	0.8	0.8
56–70	3.2	1.4	1.0	0.9	0.9	0.8	1.5	0.8	0.7
Attacks of breathlessness									
19–40	1.0	1.0	1.0	1.0	1.0	1.0	5.4	1.5	1.2
41–55	1.6	1.9	1.4	1.2	1.7	1.0	4.1	1.2	0.9
56–70	3.3	1.0	1.1	1.4	1.1	0.8	2.3	1.6	0.8
Asthma, medically diagnosed									
19–40	1.0	1.0	1.0	1.0	1.0	1.0	5.8	0.7	2.5
41–55	2.8	2.0	1.2	0.9	1.7	0.5	1.9	0.5	1.0
56–70	4.5	2.3	0.5	1.2	1.4	0.7	1.0	0.4	3.2

*: odds in relation to "no symptoms" category; $^{+}$ odds in relation to "persistent symptoms" category; $^{++}$: Tucson *vs* Cracow odds ratios; †: CP*Age*City - not significant (NS) (p>0.25).

aged over 55 yrs were 2.8 times greater than in the youngest groups. The incidence rates did not change significantly with age. However, in Cracow there was a tendency for the highest incidence rates in the youngest people, while in Tucson more new symptoms appeared in subjects 41–55 yrs of age. The odds for remission decreased faster with age in Tucson. These results suggest that the onset of the persistent chronic cough occurs in younger people in Cracow than in Tucson but the symptoms occurring at younger age in Tucson have a higher remission rate. The age-specific persistence rates of chronic cough did differ significantly between the cities.

The between-city differences of dynamics of chronic phlegm were similar in all age groups. The incidence of new cases in Tucson was 29% of that in Cracow and the remissions were 2.4 times more likely in Tucson. As a result, persistent chronic phlegm was two times less common in Tucson than in Cracow.

In both cities, the persistence and incidence rates of dyspnoea clearly increased with age and chances of remission decreased with age. In all age groups the odds for persistent or new symptoms were markedly smaller, and chances for remission greater, in Tucson than in Cracow.

The patterns of wheeze and attacks of breathlessness were similar. The persistence rates of both symptoms significantly increased with age in Cracow and were similar in all age groups in Tucson. The rates were markedly higher in Tucson than in Cracow, especially in the youngest subjects. The incidence rates of wheeze slightly increased with age in Cracow, and decreased in Tucson. These differences suggest that, in most cases, wheeze and attacks of breathlessness appear at a young age in Tucson while in Cracow the chance of these symptoms appearing increases gradually with age.

Similarly to the excess of wheeze and attacks of breathlessness in Tucson, the persistence rates of asthma diagnosed by a doctor was over five times greater in Tucson than in Cracow among subjects under 40 yrs of age. However, in Cracow the odds for reporting new asthma were greater in all age groups considered and increased with age faster than in Tucson. Remission rates were smaller in the older than in the youngest subjects in both cities, and the prevalence of persistent asthma in the oldest subjects was as high in Cracow as in Tucson.

As mentioned before, the effects of tobacco smoking were quite consistent in both cities. Table 6 shows the odds ratios of the symptoms for continuous smokers *vs* lifetime nonsmokers, estimated from the models shown in the table 4. The models indicated the stratification necessary (and sufficient) for the presentation and allowed calculation of the odds ratio adjusted for the factors not used for the stratification.

Table 6. – Odds ratios for symptoms persistence, incidence and remission in continuous smokers *vs* lifetime nonsmokers estimated from log-linear models

Smoking	Persistence* Never	Persistence* Cont.	Incidence* Never	Incidence* Cont.	Remission+ Never	Remission+ Cont.
Chronic cough						
All	1.0	2.9	1.0	3.4	1.0	0.5
Chronic phlrgm						
Age yrs						
19–40++	1.0	3.4	1.0	3.0	1.0	1.4
41–55	0.8	7.7	1.0	2.9	3.2	1.1
56–70	1.6	10.5	1.3	3.8	2.0	0.8
Dyspnoea						
Males	1.0	8.2	1.0	2.3	1.0	0.3
Females	1.0	1.1	1.0	0.9	1.0	1.6
Wheeze						
Males	1.0	3.6	1.0	3.3	1.0	2.7
Females	1.0	2.7	1.0	2.7	1.0	1.4
Attacks of breathlessness						
All	1.0	1.4	1.0	2.5	1.0	1.3
Asthma, medically diagnosed						
Males						
Age yrs						
19–40++	1.0	0.4	1.0	0.8	1.0	2.7
41–55	0.9	1.7	0.5	2.2	2.1	0.9
56–70	0.2	5.9	0.4	5.4	6.4	0.6
Females						
Age yrs						
19–40++	1.0	0.6	1.0	0.6	1.0	2.8
41–55	1.1	1.1	1.1	1.9	0.9	1.7
56–70	3.3	4.7	0.9	2.1	0.5	1.1

*: odds in relation to "no symptoms" category; +: odds in relation to "persistent symptoms" category; ++: reference age category; Never: lifetime nonsmoker; Cont: continuous smoker.

Continuous smokers had three times greater persistence and incidence, and half of the remission rates of chronic cough in relation to lifetime nonsmokers, and the effects were similar in all age groups, in both genders and cities.

The persistence and incidence rates of chronic phlegm were three times greater in continuous smokers than in lifetime nonsmokers. The prevalence rates increased rapidly with age in smokers, much faster than in nonsmokers. The incidence rates were three times greater in smokers than in nonsmokers in all age groups, and no significant increase of incidence rates with age was found in nonsmokers. The remission rates decreased with age in smokers, whilst they increased in nonsmokers.

The dynamics of exertional dyspnoea was clearly related to smoking, but only in males. Among smoking men, new dyspnoea cases were over two times more common, the remission of the symptom 70% less frequent, and the persistence eight times greater than in lifetime nonsmokers.

The persistence and incidence rates of wheeze were three times higher in continuous smokers than in lifetime nonsmokers. The remission rates were also greater in smokers than in lifetime nonsmokers, especially in males. Similar effects of smoking were seen for attacks of breathlessness, though they were smaller (but independent of all other considered factors).

The relationship of asthma diagnosed by a doctor to smoking was dependent on age. Under 40 yrs of age the persistence and incidence rates of asthma were smaller, and remission rates greater, in smokers than nonsmokers. In ages over 40 yrs, the persistence and incidence rates were markedly higher in smokers than in nonsmokers.

Discussion

This analysis indicates that there are no between-cities differences in the effects of smoking on the symptoms. This indicates that the harmful effects of smoking are similar despite differences in the populations, types of cigarettes smoked or other possible confounders. There are significant between-cities differences in the relationship of symptoms to age, and for dyspnoea and wheeze - in the relationship to gender. The onset of bronchitic symptoms occurs earlier in life in Cracow, and of asthmatic symptoms in Tucson. This is not due to differences in smoking prevalence, so other factors than tobacco smoking are responsible for differences in the rate of

development of the symptoms in both populations. The patterns of this association were estimated based on the data accumulated from both studies. This provides good insight into the natural pattern of changes in symptoms, and to the factors affecting this pattern.

The analysed groups were followed for a relatively long period and mortality as well as losses to follow-up could change some characteristics of these groups in relation to the underlying populations. As could be expected, the groups followed were younger and smoked less. As shown previously [18, 19, 26], subjects with poorer ventilatory function were more likely to die over the follow-up period, although there was no difference in the lung function between those followed and those still living but lost to follow-up. The selection was not related to the respiratory symptoms and was similar in both compared populations. Therefore, we can assume that the selection has not biased the analysed associations.

Another source of bias could be the measurement error of the outcome variables, *i.e.* the symptoms. The BMRC and NHLI questionnaires [20, 21] are thoroughly validated, and the new European Community for Coal and Steel (ECCS) respiratory questionnaire [27] includes questions on the symptoms with wording the same or very similar to that used in the analysed studies. The Polish version of the questionnaire was validated in the pilot study where good consistency of symptoms reporting was found [28]. Still, there are some possibilities of between-population differences in the answering of questions on symptoms due to dissimilarities in perception of the symptoms as well as due to the difficulty in expressing the same meaning in different languages. This demonstrates recent comparison of the French and English version of the questionnaire performed in a bilingual population [29]. The real changes in the symptoms over the follow-up period are represented well using two surveys only. This indicated previous analysis of Tucson data, where such definitions were confirmed with responses obtained in all eight surveys conducted in the follow-up period [2]. In the present analysis, the consistency of the bronchitic symptoms should be even better, as the definitions of cough and phlegm were the same in initial and final surveys, without a slight modification present in survey eight, the final one of the previous analysis. Definition of smoking habit categories, based on two surveys, is also adequate for definition of groups of lifetime non-smokers and continuous smokers. This confirms the data from the Cracow survey performed in 1973. The distribution of smoking habit based on all three surveys was very close to the one used in this analysis [30].

The analysis indicates that the frequency of chronic cough or phlegm was higher, especially in young people, in Cracow and of "asthmatic" type symptoms (wheeze, attacks of breathlessness) in Tucson, even after adjustment for differences in age and smoking structures. High prevalence rates of the asthma-like symptoms in Tucson population were noted in previous analyses [15, 31]. The between-city differences in prevalence of the symptoms as well as in relationship of the symptoms dynamics to age may be related to differences in environmental conditions of both studied populations. Besides significant differences in climate (temperature, humidity), this relates to the composition of ambient air pollution. In Cracow, the main pollutants are the products of coal combustion, with high contents of sulphur, and particulates, and with high acidity [32]. In Tucson, ambient air is polluted mainly by products of gasoline combustion and of photochemical reactions in the air (ozone), and by aeroallergens of desert origin [33, 34]. The latter substances might be more irritant and provoke more symptoms of an asthmatic type.

The differences in the structure of chronic respiratory diseases between Polish and American populations seem to be more general: hospital admissions due to asthma are more frequent in the USA (1.8 per 1,000 popn.) than in Poland (0.7), especially in the youngest people (2.4 *vs* 0.5 in the 1–14 yrs age group) [35]. In contrast, hospitalizations due to bronchitis and emphysema are more common in Poland (2.8 per 1,000 popn.) than in USA (1.4), with the difference decreasing with age.

The homogeneity of the effects of smoking in both cities shows that the effect of this factor is independent of the differences in environmental conditions of the compared populations. In both cities the frequency of chronic cough or phlegm, wheeze and attacks of breathlessness was higher in smokers than in nonsmokers.

Exertional dyspnoea was related to smoking only in men. Among women, where dyspnoea was much more frequent, other factors seem to induce the symptom. A similar relationship to smoking was seen in cross-sectional studies conducted in other populations [36, 37]. The increased prevalence of dyspnoea was seen in both male and female heavy smokers [38] but no effect of smoking on dyspnoea was found in a group of Danish males [39].

The results concerning asthma diagnosed by a doctor show a slightly different pattern to the symptoms. In young people, the disease rates are decreased in smokers, indicating a relationship of the disease to other factors than smoking, or the probable tendency not to smoke in young asthmatics. These factors must be much more common in Tucson, especially in the youngest people where the prevalence of asthma was five times higher than in Cracow. With advancing age, smoking increases its role as a risk factor, though the clinical picture of the disease also changes with age, as noted previously [31]. However, no increase in asthma incidence due to smoking was found in Finland [40].

A substantial part of the followed groups gave up smoking during the follow-up period. The effects of discontinuation of the habit on the course of the symptoms is a subject of separate analysis taking into account more data on smoking.

Although there were a number of similarities in relationships of particular symptoms to age, smoking and gender, these relationships were not identical for any pair of the symptoms. This indicates that each of the symptoms is connected to different physiopathological changes in the respiratory system. Therefore, the analysis presented here treated each of the symptoms separately; it is possible that only their combinations have clinical significance. Such an approach enabled between-population comparisons: the similarities and differences in the elementary symptoms are easier to interpret than those of complex syndromes.

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