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Social and Environmental Factors in Lung Cancer Mortality in Post-War Poland

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Poland and other Eastern European countries have undergone heavy industrial development with marked increases in air pollution and occupational exposure in the nearly 50 years since World War II. These countries have also experienced substantial increases in chronic disease mortality in the past three decades. While it is tempting to assume a direct association between these phenomena, more detailed analyses are called for. Poland offers a potentially rich opportunity for comparing geographical patterns of disease incidence and of industrial change. In this paper we 1) elucidate the prospects for attributing lung cancer mortality to industrial emissions in Poland, using an ecological approach based on the hitherto unaddressed geographic differences, and accounting for regional differences in cigarette consumption; 2) propose explanatory hypotheses for the observed geographic heterogeneity of lung cancer; 3) begin systematic testing of the widely accepted but not well-scrutinized notion that pollution in Poland is a major contributor to declining life expectancy. Regions with the highest fraction of cancer that cannot be explained by smoking appear to be highly urbanized, have high population exposure to occupational carcinogens, experience the highest rates of alcoholism and crime, and are associated with the post- World War II population resettlement. Although the analysis does not rule out pollution as a significant contributor to lung cancer mortality, it indicates that other factors such as occupational exposures and various social factors are of at least comparable importance. We conclude that the observed trends in life expectancy in Poland should not be attributed primarily to pollution without careful attention to other contributing causes and that social factors, such as the major population resettlement, may have produced living conditions adverse to good public health. We argue that research on pollution and public health should treat these topics in a broad context including both technological and social change.

Key words: geography of cancer, industrial development, Poland, public health, urban factors in cancer. *Environ Health Perspect* 103:64–70 (1995)

Since 1945 Poland has undergone a fundamental and irreversible transition from a primarily agricultural economy to one heavily dependent on industrial production and energy generation. Unrelenting pressure by the government to develop heavy industry led to rapid urbanization of the country (between 1950 and 1990 the proportion of urban population has grown from 37% to 62% of total), and to significant changes in the living and working conditions of much of the population. This growth was achieved at a substantial human price, which is reflected in a doubling of per capita consumption of animal fats and alcohol, an almost tripling of cigarette consumption, and exposure of a large number of Polish workers (approximately 7% of the workforce) to occupational hazards such as noise, dust, vibrations, noxious gases, lead, carcinogens, and others in excess of legally acceptable limits.

Industrialization has also left a grim legacy of pollution and destruction of natural resources, especially in the more industrialized southwestern parts of the country, which are richly endowed with minerals and coal deposits. As shown in Figure 1, ambient average annual concentration of sulfur dioxide ranges from 10 to 100 μg/m^3 of sulfur, with concentrations exceeding 30 μg/m^3 for large areas in southwestern Poland (*1–3*). For comparison, in regions of high acid rain in the United States, the concentrations range from 5 to 20 μg/m^3 of sulfur, and episodic concentrations in cities now rarely exceed 50 μg/m^3 of sulfur (*4*). In Poland approximately 75% of all fuel consumption is coal, 95% of which is used for residential heating and energy generation. Ambient concentration of sulfur serves as an indicator of the regional rate of coal burning and thus of air pollution due to industrialization and urbanization generally, including the respirable particles which are most commonly blamed for respiratory health effects, including lung cancer.

Also shown in Figure 1 are the worst 20 areas of ecological threat, of which 5 are designated as ecological disaster areas. The designation "ecologically threatened" is formally given to geographic regions exhibiting a combination of high gaseous and particulate air emissions, extensive accumulation of industrial wastes, and a high rate of generation of municipal and industrial effluents that require treatment [as of 1991 27 such areas have been designated in Poland, covering 11% of Poland's territory and affecting 35% of its population (*2*)].

The alarming reports of environmental devastation coming from Poland during the past several years have been accompanied by equally sobering health statistics: following a dramatic increase in the average life expectancy during the 1950s, 1960s, and early 1970s, the rate of progress markedly decreased, and by the late 1980s the life expectancy among middle-aged men actually began to decline (for example, life expectancy at 45 was one year shorter in 1987 than in 1970) (*5,6*). Circulatory disease and cancer, which in the late 1980s represented 46.3% (male), 50.1 (female), and 18.5% (male) and 19.2 (female) of the total age-standardized mortality rate (*7*), respectively, largely explain the life expectancy statistics: since the 1950s mortality rates among men from cancer and circulatory disease have been growing by more than 2% and 6% per year, respectively (*8–10*).

The environmental devastation and decreasing life expectancy observed in Poland have also been experienced by other formerly communist countries in Europe, especially former Czechoslovakia, former East Germany, and Hungary. There has been a general tendency, both in Poland and elsewhere, to attribute, either explicitly or implicitly, the steady deterioration of population health to environmental pollution. In relation to cancer in Poland, three lines of evidence are consistent with that proposition: 1) urban populations exhibit higher mortality rates than rural populations, by a ratio of approximately 1.2 and 1.3 for men and women, respectively (*9*); 2) voivodships (political districts) with the highest overall mortality and mortality from cancer (especially lung cancer) tend to be located in the more developed western part of the country (Fig. 2) (*11*); and 3) on the average, pollution is higher in the western half of Poland, as compared with the eastern half.

Although substantial evidence has been accumulated suggesting that respiratory disease and various health problems among children can be traced in some regions to high levels of pollution, and health benefits are an important incentive for pollution

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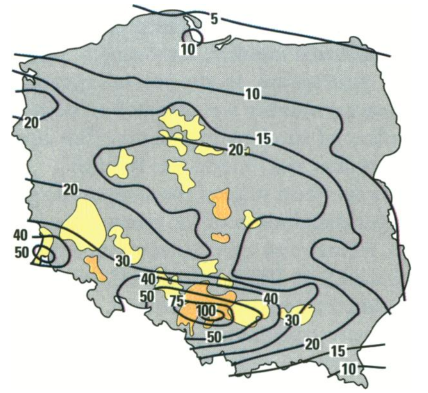

Figure 1. Average annual ambient concentrations of sulfur dioxide in Poland in 1985 (µg/m^3) and 20 worst areas of ecological threat. The areas designated as ecological disaster are shown in orange. From the National Bureau of Statistics (*2*).

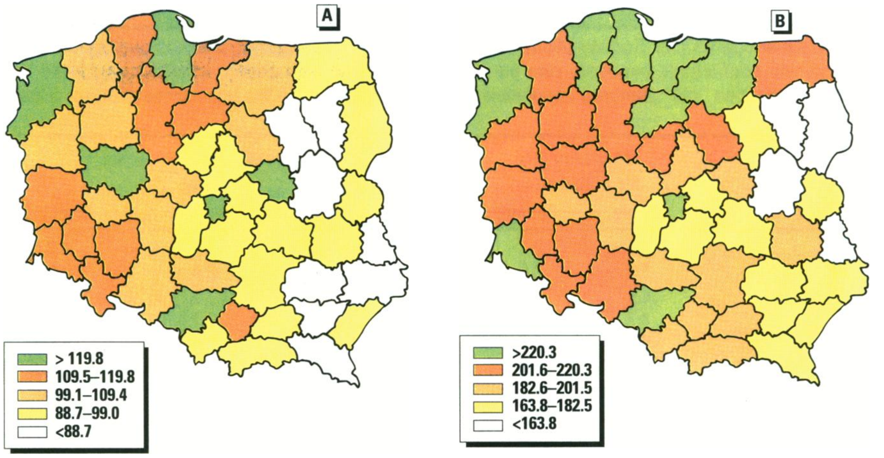

Figure 2. Geographic distribution of age-standardized cancer mortality rate per 100,000 in Poland, 1985–1988. From Tyczynski (*11*).

reduction, little evidence has been generated to date in support of the putative causal association between pollution and cancer mortality. It is unlikely that the gradient is an artifact of underreporting in the less developed and less affluent eastern territories (partly because the gradient has increased rather than decreased over time, and partly because it occurs for only some cancers, such as lung, kidney, pancreas, bladder, and breast, but not, for example, stomach). However, risk factors other than pollution, such as diet, tobacco use, alcohol consumption, hard living and working conditions, and various sociopolitical and economic factors, may, in fact, better describe the observed cancer statistics.

In both the emphasis on heavy industry, with attendant pollution and occupational exposures, and the recent increase in chronic disease mortality, Poland is representative of changes experienced by several former communist countries in Europe. However, the rate of change during the post-war years was more dramatic in Poland than, for example, in Czechoslovakia, East Germany, or Hungary, which were far more industrialized at the conclusion of the Second World War than Poland, making the latter an especially interesting case study. The objectives of this paper are 1) to elucidate the prospects for attributing lung cancer mortality to population exposure to industrial emissions in Poland, using ecological methods based on geographical differences and 2) by analyzing the relationship between lung cancer and industrial emissions, to initiate systematic testing of the widely accepted but not well-scrutinized notion that pollution in Poland is a major contributor to declining life expectancy. To the best of our knowledge, this is the first effort to address that question systematically using methods other than simple demographic analysis and accounting for geographical heterogeneities in cigarette smoking and its effects. No distinction is made between occupational and environmental hazards, which we collectively classify as industrial emissions, because the areas with the highest ambient air pollution are also characterized by high proportion of employment in hazardous industries known to be associated with lung cancer, such as coke ovens, smelters, steel mills, coal mines, and chemical plants.

Methods

Lung cancer is a suitable disease for detailed investigation of the effects of industrialization and pollution on the mortality rate in Poland because of its rapid changes over time, its geographical heterogeneity, and the substantial evidence that it is associated with inhalation of common occupational and environmental pollutants. However, any analysis of lung cancer incidence must take into account the fact that cigarette smoking is implicated in most cases, and in particular that cigarette consumption in Poland exhibits geographic heterogeneity similar to that for lung cancer (Fig. 3).

Starting with the premise that cigarette smoking is the major risk factor in lung cancer, the analysis proceeded in three stages. The procedure was designed to make maximum effective use of the extensive U.S. studies of the relationship between smoking and lung cancer, without assuming that U.S. numerical coefficients will hold unaltered for Poland. First, the expected voivodship-specific mortality rates from lung cancer for the 1985–88 period, age standardized to the "old" WHO world population (*7*), were estimated based on voivodship-specific cigarette consumption data from the period around 1975 and using the cancer rates found in the American Cancer Society (ACS)-sponsored Cancer Prevention Study II (CPS) (Heath C, American Cancer Society, personal communication). This calculation is summarized in the appendix, and the data are enumerated in Table 1. In the absence of statistics on cancer rates among smokers, nonsmokers, and former smokers in Poland, the ACS survey was chosen because it was by far the most ambitious of several such studies in the United States in terms of design (prospective), size (1.2 million participants in 25 states), and duration of follow-up [between 1959 and 1972 (CPS I), and from 1982 until present (CPS II)]. Because there are large differences in the prevalence of smoking between males and females, urban and rural populations, and in the average cigarette consumption by voivodship in Poland (Figs. 3 and 4), the mortality rate among smokers and former smokers was calculated as a weighted sum of the rates contributed by each group, where the population sizes for each group were taken from census data (*12*).

The age-specific quantitative relationship between smoking rate and cancer mortality rate derived from the CPS II study formed the basis for the calculations of the relative risk among continuing smokers (Table 1). We have also considered the possibility of using a different linear risk coefficient (see

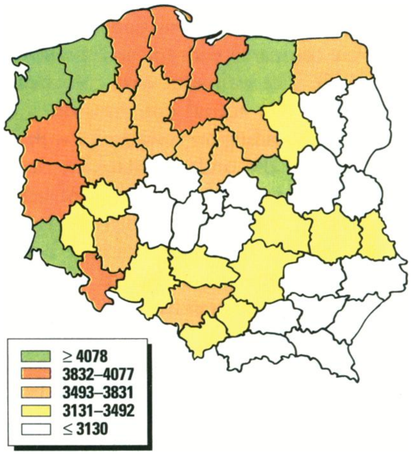

Figure 3. Geographic distribution of average annual per capita cigarette consumption among adults over 18 in Poland, 1975–1979. From Kocot (*15*).

Table 1. American Cancer Society (ACS)-based lung cancer rates for nonsmokers and the ACS-based smoking rate coefficients (mortality rate per cigarette-day) for men and women along with the World Health Organization "old" standard population (*7*) (per 100,000) used in the age standardization of cancer rates

	Mortality rate for nonsmokers		Rate coefficients per cigarette-day		
Age group	Male	Female	Male	Female	Population
35–39	5.1	2.3	0.2	0.7	6,000
40–44	5.0	2.0	0.4	0.4	6,000
45–49	6.4	2.6	1.0	1.5	6,000
50–54	4.2	6.6	5.6	2.7	5,000
55–59	5.6	6.2	10.1	5.6	4,000
60–64	11.4	13.8	11.1	6.0	4,000
65–69	17.6	17.1	21.1	13.9	3,000
70–74	32.6	30.2	51.9	13.1	2,000
75–79	44.9	34.0	55.7	18.2	1,000
80–84	83.4	60.4	68.4	16.2	500
85+	95.1	62.9	72.0	21.1	500

Results) to account for any differences in the smoking behavior and cigarette characteristics between the two countries and to account for a possible underestimation of the cigarette risks by the ACS study (which was skewed toward a middle-class U.S. white population). This adjustment is also described in the appendix. The relative risk among continuing smokers was calculated separately for men and women in urban and rural areas and for each voivodship based on their corresponding average smoking rates (number of cigarettes per person per day) and the corresponding percentages of smokers, former smokers, and nonsmokers. The relative risk among former smokers was assumed to be 0.4 of that of continuing smokers, as calculated by Brown and Chu (*13*), irrespective of the smoking rate and the number of years since cessation. Random, countrywide population surveys were the source of data on average smoking rates among urban and rural males and females in Poland and on the percentages of smokers, former smokers, and nonsmokers in each group (*14*). To test the reliability of these statistics, the voivodship-specific estimates of expected cigarette consumption, based on the survey data and population characteristics, were compared with the actual sales statistics (*15*). The estimates were consistently lower than the actual consumption, by 10–50%, depending on voivodship, with the magnitude of the underestimate increasing proportionally to the percentage of urban population (not shown). Until the recent several years, the sales statistics have been a fairly reliable indicator of cigarette consumption in Poland, owing to the uniform pricing of cigarettes and tight control exercised by the state on their manufacturing and distribution, and we gave these statistics more weight than the survey data. Accordingly, for each voivodship we adjusted the smoking rates proportionally for urban and rural males and females, until the survey-based estimates matched the sales data.

In the second stage, the calculated voivodship-specific cancer rates were compared with the corresponding observed rates. [Mortality statistics have been quite reliable in Poland since the mid-1960s, when mandatory confirmation of cause of death by physicians was introduced (*8*). Furthermore, traditionally low population mobility between voivodships, even in seeking advanced care at large medical centers, suggests that the place of potential exposure to carcinogenic agents and the place of death would be the same in most cases.] If the calculated rate accurately reflects the effect of cigarette consumption, then the portion of observed mortality that exceeded the calculated rate would show the effects of pollution and occupation, if such effects exist. Two approaches were taken in interpreting that excess cancer rate; in one the excess number was assumed to be proportional to the calculated number, thus using a "relative risk" assumption; in the second approach, the excess number was assumed to be independent of smoking experience, thus using an "absolute risk" model (see Results).

In the third stage of the analysis the geographic distribution of the excess rates, both as a relative risk comparison [(observed – calculated) × 100%/calculated], and as an absolute comparison (observed – predicted), were compared to the geographical distribution of indicators of pollution and other social phenomena.

The comparisons we present have been between the most recent voivodship-specific cancer mortality statistics, which are from the 1985–88 period, and the earliest reliable smoking statistics in Poland, which extend back to 1975. The effect is to presume a latency period of approximately 12.5 years. This may be too short, for in the traditional ecological observations of national trends in lung cancer mortality following trends in cigarette consumption, the observed lag time has been generally between 20 and 30 years. On the other hand, Kocot (*15*) has found that when a 10-year latency period is assumed, the per-capita annual consumption of cigarettes in Poland gives the best statistical correlation with mortality rates from lung cancer, for both men and women.

To use the U.S.-based statistics without adjustment for performing a risk assessment in Poland would implicitly make several assumptions about the two populations:

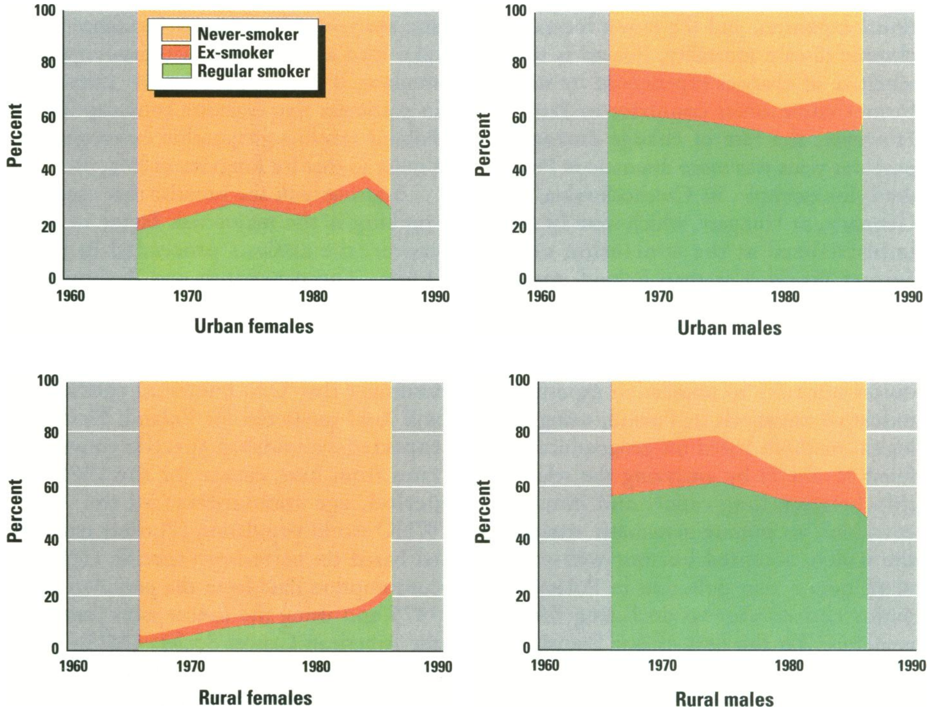

Figure 4. Temporal trends in prevalence of never-smokers, ex-smokers, and regular smokers among urban and rural males and females in Poland, 1960–1986. From Zantoski et al. (*14*).

1) that the nonsmokers in Poland and the U.S. have similar rates of lung cancer; 2) that the sex-specific average age at start of smoking and the average duration of the habit are similar in the two countries during the periods covered by the respective studies; 3) that the ex-smokers in the two countries resemble each other in the average time since cessation and the duration of the habit; and 4) that the relationship between smoking rate and cancer risk is the same for Polish and American cigarettes and for Polish and American smoking habits.

Support for the first assumption comes from the stability of the rate among nonsmokers in the U.S. over the past three decades (*16–18*). The surveys of the smoking habits of the population conducted in Poland during the 1970s and 1980s indicate that while the second assumption may be reasonable for men, it is not for women: the social acceptance of smoking among Polish women trails behind that in the U.S. by approximately two decades, as judged by statistics on the prevalence of smoking (*9,14,19–21*) (Fig. 4). It is therefore reasonable to assume that Polish women have been smoking fewer cigarettes and for a shorter period of time than their American counterparts, which would lead to an overestimation of calculated risks. For similar reasons, the third assumption is open to question. However, in the latter case the direction of the error in the estimates of the risks among ex-smokers is not known: while the shorter interval since cessation that is likely to exist in Poland, due to a more recent existence of smoking cessation programs and more recent uptake of the habit by many women, would lead to underestimation of risks, a lower smoking rate would have an opposite effect. The uncertainty contributed to the overall estimates of cancer mortality by ex-smokers is probably not large because of the lower proportion of that group and because of lower relative risks among ex-smokers, as compared to smokers. As described below, our results indicate that the fourth assumption may be incorrect.

Our approach to these ambiguities, which allows for adjustments in the ACS cancer coefficients and which considers both relative and absolute risk approaches, provides a flexible set of possible relationships between cancer rates and the voivodship-specific cigarette consumption data. The data analysis then provides information on the smoking-cancer relationship in Poland, and establishes a range of possible residuals for comparison with pollution and other potential health hazard indicators.

Results

The estimated mortality rates from lung cancer in Poland are significantly lower than the observed rates: 44% and 53% for males and females, respectively, when averaged over 49 voivodships. Because it is unlikely that cigarette smoking is not the major factor in lung cancer mortality in Poland, even in the presence of large effects of pollution and occupation, other explanations for the apparent underestimates are more plausible. We group them into two general categories: those related to the cigarettes themselves and consistent with the "absolute risk" model, and those related to the combination of cigarettes and other factors, and consistent with the "relative risk" model.

Among the first group of explanatory variables is the carcinogenic potency of Polish cigarettes, which have until recently been mostly unfiltered and which are made of high-tar black tobacco, as compared to the blond tobacco used in the United States; there may also be differences in the mode of cigarette use which affects the likelihood of cancer induction; the effects of smoking cessation on cancer rates are probably smaller among Polish women than in the United States because of their more recent start, and thus quitting, of the habit; we may also be underestimating the effects of environmental tobacco smoke, especially on rural women who are the most likely to be nonsmokers married to smokers, although the magnitude of that unaccounted effect would be relatively small. This first type of explanation implies that the slope of the dose–response relationship based on the U.S. experience is too shallow for the Polish situation and should be adjusted upward. We found that applying a proportionality constant of 2 to the slope does, in fact, bring the average calculated rate to the level of the average observed rate.

The second type of explanation assigns great importance to factors not related to cigarette smoking but which serve to modify (in a multiplicative fashion) the cancer-inducing effects of tobacco. In this view, the underestimation of the effects of cigarettes in Poland is due to disregarding the apparently significant effects of these modifying factors in the calculation. As reviewed recently by Hertzman (*22*), support for that hypothesis comes from international comparisons of the slopes of dose–response relationship between the average per capita cigarette consumption and cardiovascular and lung cancer mortality, which show large differences among countries and regions. Although the Eastern European countries were not included in these comparisons, the relatively low slope in Japan and high slope in the United States and Great Britain were interpreted by the author as implicating the existence of such modifying factors (*23*). Notably, for both sexes the voivodship-specific magnitude of the underestimate of mortality rate increases proportionally to the per-capita cigarette consumption (not shown), which is consistent with both types of explanation.

Having no basis for favoring either type of explanation, we used both in the second and third stages of the analysis. Figure 5A shows the geographic distribution of the difference between the observed and calculated rates, normalized to the estimated rates for men and women, respectively, in accordance with the "relative risk" assumption [(observed − calculated) × 100%/calculated, the second type of explanation]. With this model the geographical pattern does not depend on normalization, so we have made no adjustment to the calculated dose–response. Figure 5B shows the geographic distribution of the difference between the observed and adjusted calculated mortality rates for men and women (with the dose–response adjustment factor of 2), in accordance with the absolute risk assumption (the first type) for the excess rates. Figure 5 shows that for both kinds of risk models, the voivodships with the highest unexplained proportion of cancer rates for men are primarily concentrated within the western half of Poland, although there is also a pronounced "tail" in the southern section, as well as several lower rate voivodships within the western territories. For women, the patterns are similar but less pronounced, with, however, a notable absence of the southern "tail." Many of the voivodships with a "high incidence of unexplained cancer," especially for men, also coincide with the territories that were annexed from Germany at the conclusion of the Second World War (Fig. 5), although here again there are important exceptions.

Regarding the question of the relationship between lung cancer mortality and exposure to industrial emissions, we observe that there appears to be little resemblance in the pattern of high unexplained cancer rates and the gradient of air pollution levels, as represented by SO_2 levels and the location of the ecological threat areas (Fig. 1). At least for men, the most polluted voivodships also seem to experience high cancer rates, even those outside of the post-German area.

To summarize, the poor spatial overlap of pollution levels and the unexplained cancer rates in Poland do not provide support for the hypothesis that air pollution and occupational exposures alone can explain the geographic distribution of the unexplained cancer rates in Poland, though the contribution of these factors is suggested among men. Furthermore, the systematic tendency of the high unexplained rate voivodships to be located in post-German territories suggests

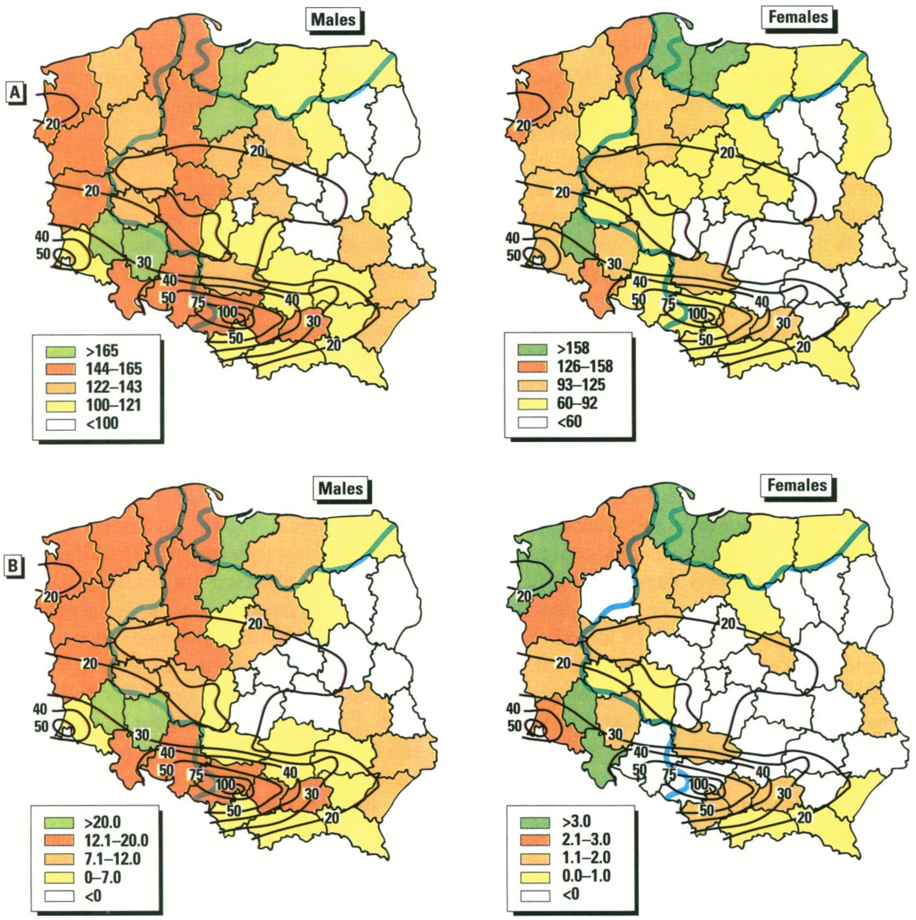

Figure 5. Geographic distribution of the "unexplained" lung cancer mortality rates in Poland. (A) (observed – calculated) × 100/calculated; (B) (observed – adjusted calculated) mortality rates. Adjusted rates were calculated by multiplying the slope of dose–response curve by a factor of 2; blue line demarcates the German territories in 1939; black line demarcates the areas of highest air pollution, as shown in Figure 1.

that other factors may be important to the story.

Discussion

There is a considerable agreement, though by no means a consensus, that air pollution plays a role in the well-documented excess lung cancer mortality experienced by urban dwellers. Estimates of that contribution in the United States, based on different methodological and conceptual approaches and all saddled with considerable uncertainty, have ranged from 2% to more than 10% (*23–25*). A retrospective case–control study of lung cancer victims in highly polluted Krakow, Poland, was consistent with these estimates by placing the effects of urban air pollution on the rates of lung cancer at approximately 4.3% and 10.5% of total lung cancer for men and women, respectively (*26*). For occupational exposures, the estimated contributions to lung cancer mortality were 4% in the United States (*23*) and 21% and 8% for men and women in Krakow, respectively (*26*).

Our initial finding that environmental and occupational carcinogens alone cannot explain the observed patterns of "unexplained" cancer is not inconsistent with these earlier findings. This is largely due to the relatively low sensitivity of the indirect method applied here, where the variation between the residuals in similar voivodships is as great or greater than the expectation from the Krakow study. Although this ecological approach is useful for exploring the combined effects of multiple ill-defined factors on health and for comparing hypotheses, its applicability to quantitative risk estimation is limited by serious uncertainties such as pooling of different types of lung cancer not equally associated with cigarette smoking, pooling the exposed and nonexposed populations, averaging highly variable individual smoking histories over a large population on the basis of relatively crude national statistics, aggregation of data for regions defined by political districts rather than the intensity of hypothetical risk factors, inability to verify medical diagnosis or to account for population migration, and the lack of control over a host of confounding variables. The effect of these and other uncertainties can be surmised based on the observed fluctuations between voivodship statistics for the various rates of concern.

On the other hand, the indirect method has proved very useful in estimating the likely magnitude of the effects of urban residence on lung cancer (*27–30*), the effects of living in counties hosting various hazardous industries (*31*), and the effects of smoking on cancer and cardiovascular mortality in different countries (*32*). Our method for estimating the smoking-related proportion of cancer mortality using the (hitherto unpublished) data we collected on smoking cannot be accomplished in an unambiguous fashion on the basis of the available data. The ambiguities, however, do not invalidate the methodology. Our treatment, including the validation of estimated smoking rates against the actual (and quite reliable) sales statistics in each voivodship and the use of a range of normalizations for differences between observed and expected rates, was intended to establish boundaries on the uncertainties and the range of possible influences of smoking on the geographical distribution of cancer rates. The analysis thus sets limits on the magnitude of the influence of air pollution and in particular shows that its effects can be no greater than the effects of other causes that are generally included in ecological studies.

Our inability to explain, within that range, the high residual rate of cancer in the western and northern territories by the degree of air pollution alone, using the indirect method and using sulfur dioxide concentration as a pollution index, indicates that the magnitude of effects of these risk factors in those areas are not large relative to other risk factors and that other factors have as large or larger influence on mortality rates. This is not to say that air pollution has no effect. For instance, the relatively high residual cancer rates for males in the most industrialized and polluted southern voivodships, and their absence among women, may be indicative of a significant role played there by concurrent exposure to occupational and environmental carcinogens, possibly acting synergistically. High occupational exposures among men to chemical carcinogens and radon in this region, which is characterized by a high density of mines, smelters, coke ovens, and steel mills, have been well documented (*3,33*). The putative contribution of occupational factors to the observed distribution of residual cancer rates is also consistent with the high residual rates in some northern voivodships, which, though not characterized by the mining, smelting, or coal-processing industries, have been the center of the ship-building industry, with its attendant occupational asbestos exposures.

The tendency of high unexplained rates to manifest themselves in the post-German territories suggests that social factors may also play an important role. These territo-

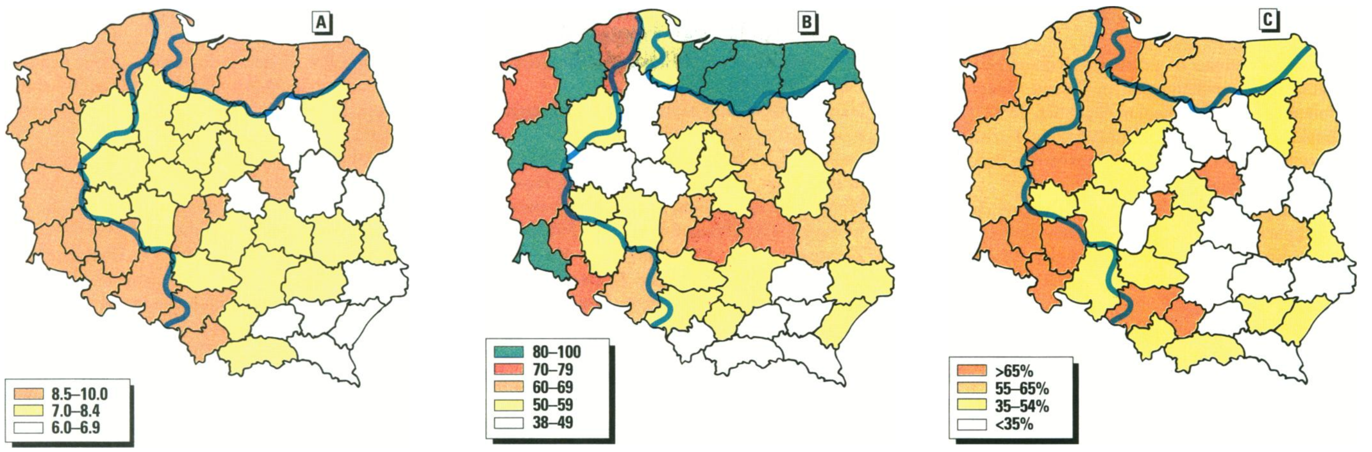

Figure 6. Geographic distribution of crime and alcoholism consumption rates and degree of urbanization in Poland. (A) Alcohol consumption rate, liters of 100% alcohol per person per year, 1990–1992; (B) crime rate, convictions per 10,000 per year, 1990–1992; (C) urbanization. From the National Bureau of Statistics (*12*) and Halik (Warsaw Medical Academy, personal communication).

ries also have higher crime and alcoholism rates than the rest of the country and are among the most urbanized in Poland (Fig. 6). In an attempt to explain the crime and alcoholism rates, Halik (Warsaw Medical Academy, personal communication) hypothesized that the population living in these areas—largely first- and second- generation migrants from the east who replaced most of the original German population during the brief post-war resettlement period—continues to experience the aftershock of that uprooting after several decades. Another line of reasoning can be derived from the recent work of Hertzman (*22*). Unable to explain a large fraction of the gap in the life expectancy between the Eastern and Western Europe with higher levels of pollution, lower access to health care services, smoking, diet, and other traditional determinants of health, this author suggested the socioeconomic environment in the east during the 1960s, 1970s, and 1980s—social isolation, perception of powerlessness and poor well-being, and decline in economy—as a major modifying factor of these other determinants of health status.

It is far too soon to tell whether these explanations will withstand further scrutiny, and if so, what is the nature of the relationship between cancer rates, urbanization, environmental and occupational pollution, social pathologies (as indicated by alcohol consumption and crime rate), socioeconomic environment, and historical developments in the post-German territories in Poland, although the idea of psychosocial stress as a factor in cancer development is not new (*34*). The most appropriate beginning hypothesis is that numerous social factors can function as amplifiers of the very real effects of smoking, pollution, and occupational exposures on lung cancer.

Clearly, the question of the effects of the political, social, and technological changes in the modern period of Poland's history merits further study, both in Poland and in the neighboring Germany, and the analysis of other cancers as well as cardiovascular diseases should be included. It would also be informative to include other formerly communist countries with similar mortality trends but much less environmental pollution than Poland, such as Latvia. For now, we see at least three immediate applications of the initial findings reported here: to encourage policy makers and analysts to view the problem of pollution and health in Poland and other formerly communist countries in a broader perspective of technological, social, and political changes in that region during the post-war decades; to develop realistic expectations about changes in population health that can be reasonably achieved from any future environmental improvements; and to provide guidance to the governments of Poland and its neighbors and to the international organizations on allocating scarce resources into pollution control technology, public education, and social programs aimed at social transformation.

Appendix

A summary of the calculations that generate age-standardized lung cancer mortality rates by voivodship using the American Cancer Society (ACS) cancer rates (Heath C, personal communication) and calculations that generate adjusted lung cancer mortality rates follows.

Calculation of age-specific, sex-specific lung cancer mortality rates for nonsmokers, smokers, and ex-smokers in each voivodship:

Rate for nonsmokers = ACS nonsmoking rate (by age group)
Rate for smokers = rate for nonsmokers + ACS smoking rate coefficient
× average smoking rate (by voivodship)
Rate for ex-smokers = 0.4 × rate for smokers

where, for the ACS cancer rates shown in Table 1, and the average smoking rates for each voivodship were estimated from cigarette sales as described in the text.

Calculation of average age-specific, sex-specific cancer rates for each voivodship:

Average rate = rate for smokers × % of smokers + rate for ex-smokers
× % of ex-smokers + rate for nonsmokers
× (1 – % smokers – % exsmokers)

where the % of smokers and % of ex-smokers were derived from the voivodship-specific % of urban population and the national surveys of smoking habits.

Calculation of age-standardized cancer rates for each voivodship:

Age-standardized rates (per 100,000) = (1/100,000) × $\Sigma_{\text{AGE GROUP}}$
{age-specific rates
× standard population for age group}

where the standard populations are shown in Table 1.

Adjustment of age-specific, sex-specific lung cancer mortality rates for nonsmokers, smokers, and ex-smokers in each voivodship:

Rate for nonsmokers = ACS nonsmoking rate (by age group)
Adjusted rate for smokers = rate for nonsmokers + 2
× ACS smoking rate coefficient
× average smoking rate (by age and voivodship)

REFERENCES

1. National Bureau of Statistics. Report on the state of the environment [in Polish]. Warsaw, Poland:National Bureau of Statistics, 1992.
2. National Bureau of Statistics. Annual statistical reports, section on the environment [in Polish]. Warsaw, Poland, 1990–1992.
3. Academy of Social Sciences. Polish workers. Occupational hazards in industry and excess mortality among men [in Polish]. Warsaw, Poland:Institute for Studies on the Working Class, 1987.
4. U.S. EPA. The acidic deposition phenomenon and its effects: critical assessment document. EPA/600/8-85/001 Washington, DC: Environmental Protection Agency, 1985; 81–82.
5. Malczewski J. Spatial differentiation of male life expectancy in Poland as a function of social and economic conditions [in Polish]. In: Spatial problems in public health. Warsaw, Poland:Polish Academy of Sciences, 1990.
6. Baldwin G. Mortality trends for young and middle-aged adults in Eastern Europe. Washington, DC:U.S. Bureau of the Census, 1989.
7. WHO. 1993 World health statistics annual. Geneva:World Health Organization, 1993.
8. Kopczynski J. Mortality from selected causes in Poland in 1960–1985 vis-a-vis the goals of the World Health Organization [in Polish]. In: Poland 2000. Warsaw, Poland: Polish Academy of Sciences, 1987.
9. Zatonski W, Tyczynski J. Cancer in Poland. Epidemiological situation. In: Cancer prevention. Vital statistics to intervention. Proceedings of the international conference, 12–14 October 1988 (Zatonski W, Boyle P, Tyczynski J, eds). Warsaw, Poland:PA Interpress, 1990;48–84.
10. Kupsc W, Jasinski B. Epidemiology of circulatory disease in Poland. Part I. Mortality from circulatory disease from 1976 to 1988 [in Polish]. Warsaw, Poland:Institute of Cardiology, 1991.
11. Tyczynski J. Geography of selected malignant neoplasms in Poland. Temporal trends [in Polish] (doctoral dissertation). Warsaw, Poland:The Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology, 1990.
12. National Bureau of Statistics. Annual statistical reports [in Polish]. Warsaw, Poland.
13. Brown CC, Chu K. Use of multistage models in infer stage affected by carcinogenic exposure: example of lung cancer and cigarette smoking. J Chronic Dis 40(suppl 2):171S–179S (1987).
14. Zatonski W, Okolski M, Kocot K, Przewozniak K, Tyczynski J. Demographical consequences of smoking in Poland: tobacco smoking and malignant neoplasms [in Polish]. Warsaw, Poland:The Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology, 1990.
15. Kocot K. Effect of tobacco smoking on lung cancer mortality by voivodship [in Polish]. Demographic Studies 103:43–53 (1991).
16. Garfinkel L. Cancer mortality in nonsmokers: Prospective study of the American Cancer Society. J Natl Cancer Inst 65:1169–1173 (1990).
17. Garfinkel L, Silverberg E. Lung cancer and smoking trends in the United States Over the past 25 years. Ann NY Acad Sci 609:58–73 (1990).
18. Garfinkel L, Stellman S D. Smoking and lung cancer in women: findings in a prospective study. Cancer Res 48:6951–6955(1988).
19. U.S. DHHS. Smoking and health. A national status report. Rockville, MD:U.S.Department of Health and Human Services, 1986.
20. Pierce JP, Fiore MC, Novotny TE, Hatziandreu E J, Davis R M. Trends in cigarette smoking in the United States: projections to the year 2000. J Am Med Assoc 261:61–65(1989).
21. Stellman SD, Garfinkel L. Smoking habits and tar levels in a new American Cancer Society prospective study. J Natl Cancer Inst 76:1057–63(1986).
22. Hertzman C. Environment and Health in Central and Eastern Europe. Vancouver, BC:University of British Columbia, 1993.
23. Doll R, Peto R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. J Natl Cancer Institute 66:1193–1308(1981).
24. U.S. EPA. Cancer risks from outdoor exposure to air toxics. EPA-450/1-90-004a. Washington, DC:Environmental Protection Agency, 1990.
25. Pershagen G, Simonato L. Epidemiological evidence on air pollution and cancer. In: Air pollution and human cancer (Tomatis L, ed). New York:Springer-Verlag, 1990;63–74.
26. Jedrychowski W, Becher H, Wahrendorf J, Basa-Cierpialek Z. Case-control study of lung cancer with special reference to the effect of air pollution in Poland. J Epidemiol Comm Health 44:114–120 (1990).
27. Haenszel W, Taeber K E. Lung cancer mortality as related to residence and smoking histories. J Natl Cancer Inst 32:803–838 (1964).
28. Hammond EC. Smoking habits and air pollution in relation to lung cancer. In: Environmental factors in respiratory disease. New York:Academic Press, 1972;47–56.
29. Goldsmith J. The urban factor in lung cancer: smoking, industrial exposures, and air pollution as possible explanations. J Environ Pathol Toxicol 3:205–217 (1980).
30. Clement Associates, Inc. Review and evaluation of the evidence for cancer associated with air pollution. EPA 450/5-83-006; NTIS PB84-164078. Springfield, VA:National Technical Information Service, 1983.
31. Blott WJ, Fraumeni JF. Geographic patterns of lung cancer: industrial correlation. Am J Epidemiol 103:539–550 (1976).
32. Peto R, Lopez AD, Boreham J, Thun M, Heath C Jr. Mortality from tobacco in developed countries: indirect estimates from national vital statistics. Lancet 339:1268–1278 (1990).
33. Domanski T, Chruscielewski W, Kluszczynski D, Olszewski J. Radiological classification of Polish underground mines and recommendations for surveillance. Research report. Lodz, Poland: Department of Radioactive Contaminations, Institute of Occupational Medicine, 1990.
34. Cooper CL. Psychosocial stress and cancer. Chichester:John Wiley and Sons, 1984.
