Health Effects of the Chernobyl Disaster: Illness or Illness Behavior? A Comparative General Health Survey in Two Former Soviet Regions

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Results are described of a general health survey ($n = 3044$) that was conducted 6.5 years after the Chernobyl accident in 1986 in a seriously contaminated region in Belarus and a socioeconomically comparable, but unaffected, region in the Russian Federation. The purpose of the study was to investigate whether there are differences in the general health status of the inhabitants of the two regions that may be attributed to the Chernobyl disaster. A broad-based population sample from each of these regions was studied using a variety of self-report questionnaires. A subsample ($n = 449$) was further examined with a standardized physical and psychiatric examination. The results show significantly higher scores on the self-report questionnaires and higher medical service utilization in the exposed region. No significant differences were observed in global clinical indices of health. Although there were trends for some disorders to be more prevalent in the exposed region, none of these could be directly attributed to exposure to ionizing radiation. The results of this study suggest that the Chernobyl disaster had a significant long-term impact on psychological well-being, health-related quality of life, and illness behavior in the exposed population. — *Environ Health Perspect* 105(Suppl 6):1533–1537 (1997)

Key words: Chernobyl disaster, health survey, subjective health, illness behavior

Introduction

Ever since one of the four reactors of the nuclear power plant at Chernobyl exploded 26 April 1986 causing radioactive contamination of large parts of Europe, the extent of the health effects of the disaster have been a subject of debate. However, with the exception of a rise in malignant thyroid cancers in children, no major effects on the general health of the population through radiological mechanisms have been substantiated (*1–4*). Instead, the abundance of health problems in the exposed regions has been tentatively linked to psychological stress related to the disaster (*3*). Earlier disaster studies, e.g., on the aftermath of the incident with a nuclear reactor at Three Mile Island, Pennsylvania (1979), have demonstrated that signs and symptoms of psychological distress may be measured as long as 6 years after an event (*5*). Increased mortality from cardiovascular disease attributed to the effects of stress has been reported after the 1976 disaster with highly toxic dioxin at Seveso, Italy (*6*). In the case of the Chernobyl disaster the occurrence of psychological distress in the exposed population has been documented, but the clinical significance of this is as yet unknown (*7–9*).

This article reports on a comparative general health survey conducted in two former Soviet regions, investigating the psychological and physical health status of an exposed and a nonexposed population sample in the former Soviet Union. The first sample was recruited from the Gomel region (Belarus), one of the most seriously contaminated regions of the former Soviet Union. The Gomel region is a semirural area, about 50 miles northeast of Chernobyl with approximately 1.5 million inhabitants. The city of Gomel itself was only mildly contaminated (< 185 Bq $^{137}Cs/m^2$), but in the surrounding territories a number of villages and towns have been evacuated because of contamination with radionuclides (> 555 Bq $^{137}Cs/m^2$). The region is inhabited by thousands of evacuees and accident recovery workers. The majority of the population considers itself to be seriously affected by the disaster (*10*). The second sample was drawn from the Tver region (Russian Federation), which lies approximately 700 miles northeast of Chernobyl, well outside the range of significant fallout deposits. The city of Tver and its surrounding region have a comparable socioeconomical structure and population size. The two regions have shared the same state, culture, and health care system for many decades, making it unlikely that significant differences in health-related attitudes existed before the disaster. As in Gomel, a nuclear power plant is located about 50 miles away from the major city. The surveys were conducted in autumn 1992 and spring 1993, respectively.

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This study was conducted in the framework of a Byelorussian–Dutch humanitarian aid project to alleviate the consequences of the Chernobyl disaster. The project was sponsored by the Government of The Netherlands and executed by the National Institute of Public Health and Environmental Protection in cooperation with the University Hospital, Utrecht, The Netherlands. The authors thank T. Wohlfarth and M.W.J. Koeter for their valuable support in the analysis of our data.

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Abbreviations used: AOR, adjusted odds ratio (adjusted for sex, age, marital state, and education); CI, confidence interval; *DSM-III-R, Diagnostic Statistical Manual, third edition revised*; GHQ-12, General Health Questionnaire, 12-item version; *ICD-9-CM, International Classification of Diseases, 9th edition, Clinical Manual*; MDCL, Munich Diagnostic Checklist for *DSM-III-R*; MOS-SF, Medical Outcome Study, short form; OR, odds ratio.

The purpose of the study was to test the hypothesis that differences in general health status of the two samples, if present, would be related to psychological distress and changes in illness behavior among the inhabitants of the exposed regions, rather than to the effects of ionizing radiation.

Methods

Subjects

Because no reliable records of the inhabitants of the regions were available, it was not possible to draw random samples of the population. As an alternative, we started by taking a sample of employed inhabitants of the exposed region, in order to get a broad sample in which all strata of the population would be represented. At the time, according to official statistics, more than 99% of the adult population was either employed, retired, or student. This sample was obtained by selecting a number of factories, collective farms, and schools throughout the region, corresponding to census data from 1989 relating distribution of occupations in the region. In addition, a number of people were sampled from waiting rooms of municipal counsels, where unemployed and retired people come to collect their benefits. The sampling sites were selected by a local agency specializing in social surveys that had the necessary insight and experience to ensure an optimal distribution of sampling sites. The interview sites in Tver were chosen to be comparable to the ones in Gomel (*11*). At each site people were randomly asked to participate until a fixed number of people between 18 and 65 years of age had been reached. Written information was provided, explaining the purpose and design of the study, and stating that participation was strictly voluntary and anonymous.

The study was conducted using a two-phase sampling design (*12*) (Table 1). During the first phase the population samples described above were examined using a self-report questionnaire. From these samples stratified subsamples were drawn for participation in the second phase of the study, which consisted of a standardized clinical examination. For the recruitment for this second phase, respondents from the population samples were divided into three strata according to their level of distress as measured using the General Health Questionnaire (GHQ, see below). Respondents with high or medium GHQ scores were given a higher selection rate for phase 2, in order to study respondents with intermediate and high levels of distress in sufficient numbers for statistical analysis. Because we expected to encounter lower levels of distress in Tver, and therefore fewer cases in the higher GHQ strata, we used slightly different sampling rates on the two study sites, in order to have sufficient clinical cases regardless of possibly lower case rates.

In Gomel, 1617 respondents took part in the first phase of the study (response rate 92%) and in Tver, 1427 people (response rate 88%). In Gomel, 265 people were examined during the second phase and in Tver, 184 (response rates 82 and 65%, respectively). Nonresponse in phase 2 was not related to sex, age, subjective health, or GHQ score.

Table 2 shows the sociodemographic characteristics of the study samples. Despite our efforts to obtain a comparable sample by using identical sampling procedures at both locations, the two phase 1 samples differed significantly on all sociodemographic characteristics except employment status. As may be observed in Table 2, the phase 1 sample in Tver contained more women, elderly, divorced, and widowed people, but fewer people with higher education. Phase 2 samples (unweighted) differed significantly for sex (43.4% men in Gomel vs 33.2% in Tver), but not for other sociodemographic characteristics.

Instruments

The phase 1 respondents were examined using a self-report questionnaire to assess subjective health, psychological well-being, and health-related behaviors. Subjective

Table 1. Schematic representation of study design and sampling fractions.

	Gomel	Tver
Phase 1. Screening of population sample using the GHQ-12		
Sampled for phase 1	1763	1620
Participated in phase 1	1617 (92%)	1427 (88%)
Stratified sampling for phase 2		
GHQ-12 score: 0,1	1:10 sampled	1:10 sampled
2–7	1:5 sampled	1:4 sampled
8–12	1:3 sampled	1:2 sampled
Phase 2. Standardized physical and laboratory examination. Standardized psychiatric interview, using MDCL		
Sampled for phase 2	322	284
Participated in phase 2	265 (82%)	184 (65%)

Table 2. Sociodemographic characteristics phase 1 samples Tver and Gomel.

	Phase 1				Phase 2		
Variable	Gome, % (*n*=1617)	Tver,% (*n*=1427)	df	Chi-square	Gomel, % (*n*=265)	Tver, % (*n*=184)	Chi-square
Sex							
Male	47.3	41.3	1	14.78*	43.4	33.2	4.78**
Female	52.7	58.7			56.6	66.8	
Age, years							
18–29	26.3	24.9	4	18.75*	23.0	23.9	6.10***
30–39	31.0	27.2			34.7	29.9	
40–49	22.2	24.3			23.0	22.8	
50–59	15.7	14.8			15.1	13.6	
60–65	4.8	8.8			4.2	9.8	
Marital status							
Married	75.2	68.6	3	13.57**	73.6	69.0	2.11***
Single	14.7	17.1			15.5	19.0	
Divorced	6.5	8.8			6.4	5.4	
Widowed	3.5	5.5			4.5	6.5	
Education							
Primary school	5.3	7.2		46.16*	3.0	5.4	5.03***
Continued education	62.4	71.2			59.6	66.3	
Higher education	32.3	21.6			37.4	28.3	
Employment status							
Employed or student	92.6	94.8	2	0.32***	94.5	95.4	2.90***
Retired	6.9	4.8			6.4	3.8	
Unemployed	0.5	0.5			0.1	0.8	

*$p < 0.001$. **$p < 0.05$. ***$p > 0.05$.

health was assessed using a single item derived from the Medical Outcomes Study questionnaire, short form (MOS-SF) (*13*). This item asks the respondents to rate their own general health on a 5-point scale (1 = excellent; 2 = very good; 3 = good; 4 = fair; 5 = poor). This single item has been shown to be a valid measure for health-related quality of life. A score of 4 or 5 (health fair or poor) was taken to constitute a "case." Psychological well-being was studied using the General Health Questionnaire, 12 item version (GHQ-12) which is a widely used self-report questionnaire for psychological distress (*14*). Using the presence of a *Diagnostic Statistical Manual, third edition revised* (*DSM-III-R*) psychiatric disorder as a criterion, a score of 2 or higher has been found to have good sensitivity (84%), which makes the instrument useful as a screening device (*15*). The phase 1 self-report questionnaire further contained items concerning the number of visits to doctors and the use of prescription drugs during the previous month.

The clinical examination conducted during the second phase of the study consisted of a standardized examination by Dutch physicians specializing in internal medicine, who administered a standardized full medical history, evaluation of current complaints, and a physical and basic laboratory examination, including whole blood count, hepatic, renal, and thyroid function tests. In addition to establishing clinical diagnoses according to *International Classification of Diseases, 9th edition Clinical Manual*; (*ICD-9-CM*), the physicians rated the overall health of the respondents on the same 5-point scale (ranging from excellent to poor), that was administered to the respondents in phase 1. Using performance status as a guideline, patients with a score of 4 (fair health: good performance status, but with a disorder demanding medical attention) or a score of 5 (poor performance status and clinically ill) were counted as "clinical case."

A psychiatric examination was performed by specially trained Byelorussian and Russian psychiatrists, who administered a semistructured interview for diagnosing *DSM-III-R* disorders, the Munich Diagnostic Checklist (MDCL) for *DSM-III-R* (*16*). The instrument has been shown to have good reliability and validity in this study (kappa > 0.80) (*17*). For all assessments a time frame of 1 month (last 4 weeks) was used.

Statistical Analysis

All scores on the self-report questionnaires were recoded into a case/noncase format, using the cutoff values mentioned above. In order to balance the effects of oversampling cases with high GHQ scores, prevalence estimates for phase 2 parameters were estimated by weighting the results back to phase 1 proportions, using the observed sampling fractions as weights (i.e., corrected for nonresponse). For GHQ-12 score 0 to 1 (1:10 sampled), the observed sampling rate was 1:9.56. In this stratum, 48 cases were examined in phase 2, 11 of which were diagnosed as having a psychiatric disorder according to *DSM-III-R*. After weighting with a factor of 9.56, this resulted in 105 psychiatric cases among 495 phase 1 respondents from this GHQ stratum. Likewise, for respondents with a GHQ score of 2 to 7 (1:5 sampled), a weight of 5.82 was used, and for GHQ-12 score 8 to 12 (1:3 sampled) a weight of 3.95. In Tver these weights were 12.63, 5.30, and 2.75, respectively. Univariate odds ratios (OR) were calculated to estimate the relative risk associated with living near Chernobyl for the health indices measured in the study. Bonferroni-Holm correction was performed to rule out spuriously significant findings (type I errors), caused by the fact that each pairwise comparison has a 5% chance of a false positive statistically significant finding at 95% confidence level (*18*). Because the samples from both sites differed significantly on sociodemographic characteristics, multivariate logistic regression was performed for all outcome measures to calculate adjusted odds ratios (AOR), adjusting for sex, age, marital status, and education. As a result of the complex sample design and weighting specialized software (PCCARP) (*19*) was required to correct the effects of weighting on standard errors, based on the Taylor series linearization method (*20*).

Results

Table 3 shows the health indices in Gomel and Tver as they were found in both phases of our study. From these results it is clear that the general health status of both samples is rather poor. Fifty percent or more report unsatisfactory health or psychological distress. Similar proportions have visited a doctor and/or used medication during the previous month. More than a third of the sample suffers from a diagnosable medical or psychiatric condition that warrants medical attention.

There were, however, also some important differences between the two samples. All self-reported health indices showed substantially higher rates in the exposed population, especially the variable MOS-SF, our measure of subjective health (74.5 vs 56.5%; OR 2.25, AOR 2.86). Psychological distress as assessed with the GHQ was also considerably higher in the Gomel region (64.8 vs 48.1%; OR 1.93, AOR 2.03). Both these differences were highly significant ($p < 0.001$). The parameters that indicate medical service utilization and use of medication also differed significantly ($p < 0.001$), although the observed magnitude was less dramatic.

For the parameters of clinical health collected in the second phase of the study, differences did not reach statistical significance at a 5% level. There was a trend toward more physical illness in the Gomel sample. The percentage of respondents with an *ICD-9-CM* diagnosis was 63.7% in Gomel versus 55.1% in Tver (OR 1.43, AOR 1.57). Because not all of these conditions demand medical attention, as in varices or unexplained abnormalities on laboratory tests, the percentage of clinical cases was lower, but showed the same trend (43.5% in Gomel vs 36.5% in Tver; OR 1.34, AOR 1.58). Corresponding differences were seen in the rates of a number of specific medical illnesses, notably for angina

Table 3. Self-reported and clinical health indices in Gomel and Tver.

	Prevalence		Univariate OR		Adjusted OR	
Self-reported health	Gomel	Tver	OR	95% CI	AOR	95% CI
Health fair or poor (MOS-SF)	74.5	56.5	2.25[a]	1.96–2.58	2.80[a]	2.35–3.34
Psychological distress (GHQ-12)	64.8	48.1	1.93[a]	1.69–2.22	2.03[a]	1.75–2.37
Visited doctor last 4 weeks	47.7	41.1	1.31[a]	1.14–1.50	1.38[a]	1.18–1.61
Used medication last 4 weeks	69.9	60.4	1.52[a]	1.30–1.78	1.55[a]	1.33–1.84
Clinical status						
Any *ICD-9-CM* physical diagnosis	63.7	55.1	1.43	0.94–2.17	1.57	0.99–2.49
Medical case	43.5	36.5	1.34	0.85–2.10	1.58	0.95–2.64
Any *DSM-III-R* psychiatric diagnosis	35.8	37.1	0.95	0.64–1.41	1.08	0.70–1.67

[a]Statistically significant.

pectoris, obesity, hypertension, anemia, nonmalignant thyroid abnormalities, and peptic disease (*11*). In all instances, except for peptic disease, prevalence was higher in the Gomel area. However, none of these differences reached statistical significance after Bonferroni-Holm correction.

Contrary to our expectations, no important differences could be demonstrated in the prevalence of psychiatric disorders (35.8% in Gomel vs 37.1% in Tver; OR 0.95, AOR 1.08), although a trend could be observed that distress-related disorders such as minor depression, posttraumatic stress disorder, and hypochondriasis were more common in the exposed sample, as could be expected from the disaster literature (*21*). These differences were, however, entirely balanced by a higher level of anxiety disorders in Tver. None of the differences was statistically significant.

The apparent discrepancy between the highly significant differences in self-reported health on the one hand, and nonsignificant differences in global clinical morbidity on the other is further illustrated in Figure 1. It shows the extreme end of the scales rating health: poor health (a score of 5 on the MOS-SF) as assessed by the phase 2 respondents, and the same rating according to the physician (a score of 5 on the same item). In Gomel, 28.1% of the respondents considered their health to be poor, whereas in Tver this figure was 10.4% (OR 3.34, AOR 4.18, $p < 0.001$); for a clinical rating of poor health these figures were 1.3% in Gomel and 0.7% in Tver (OR 1.97, AOR 2.77, $p > 0.05$).

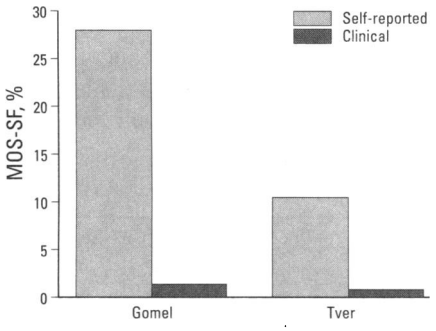

Figure 1. Clinical and self-reported assessment of general health in Gomel and Tver. Self-reported assessment of health: percentage of subjects who rated their health as poor on a 5-point scale (MOS-SF). Clinical assessment of health: percentage of subjects whose health was rated as poor by a clinician, using the same 5-point scale.

Discussion

Perhaps the most striking finding of this study is the fact that more than 50% of a sample of presumably healthy and active adults living in the former Soviet Union perceive their health to be less than satisfactory. The percentage of respondents with a high GHQ score (64.8 and 48.1%) has only been matched under extreme conditions, such as in the immediate aftermath of a natural disaster (*22*). Prevalence figures of more than 50% of the population having a medical condition in terms of *ICD-9-CM*, and more than 35% suffering from diagnosable psychiatric illness, are exceptionally high. Apparently, a majority of the respondents in both regions is ill or feels ill. The high percentages of persons who visited a doctor during the past 4 weeks and/or used prescription medicine reflect these findings.

Because response in phase 1 of the study was high, and because nonresponse in phase 2 was not related to subjective health (MOS-SF) or to GHQ score, it seems unlikely that selection bias can explain these results. Although cultural factors may have colored the response pattern to the self-report questionnaires (*15*), the findings on both self-report and clinical health parameters seem to reflect poor health conditions in both regions. These alarming results are consistent with the health statistics published by the World Health Organization, showing high levels of morbidity and diminishing life expectancy over the past 15 years in all former Soviet republics (*23*).

As far as the health effects of the Chernobyl disaster are concerned, the most robust finding in our study is a substantial difference in all self-reported health indices, especially for the variables "subjective health" (MOS-SF) and "psychological distress" (GHQ-12). This finding is in agreement with other health perception surveys in the affected countries (*24*). We also observed a trend toward a difference in global levels of physical illness, but this difference was not of the same magnitude as observed for the self-report measures and lacked statistical significance after Bonferroni correction. The use of this statistical test is not without controversy, because it may lead to a false rejection of statistical significance (type II error) (*25*). Because differences for some individual disorders would have been statistically significant without this correction, it cannot be ruled out that there was significantly more angina pectoris, hypertension, obesity, benign thyroid disorder, and anemia in Gomel and more peptic disease in Tver. It is important to note, however, that none of these disorders can be attributed to exposure to ionizing radiation from the Chernobyl disaster, which would lead primarily to an increase in malignancies, especially leukemias and thyroid cancers, and cataracts. Our findings are therefore in agreement with the now emerging literature on the radiological consequences of the Chernobyl disaster, which indicate that, with the exception of thyroid cancer in children, no direct radiological health damage among the general population has thus far been established (*1–4*). Instead, the difference in morbidity pattern between the two regions is more likely to be related to differences in lifestyle, food pattern, or psychological stress between the two regions.

This conclusion, however, should be treated with caution. The size of our phase 2 sample was too small to detect anything but a major difference in prevalence. Furthermore, our samples consisted primarily of working adults, with the exclusion of those hospitalized or on sick leave. Importantly, we did not investigate the health of children or other risk groups. As was pointed out above, a rise in the incidence of thyroid cancers in children has been firmly established. Careful follow-up of health statistics at regional and national levels for a long period of time is needed to give a definite answer to the question of long-term effects of the exposure to radiation from Chernobyl.

The fact that, in contrast to the self-report scales, the differences in clinical health indices failed to reach levels of statistical significance may be partly explained by sample size and by differences in sample composition (fewer women, divorced, and widowed people in the exposed sample). This may have led to an underestimation of the effects of clinical health, as illustrated by the fact that all AORs, adjusting for these variables, are consistently higher than the univariate ORs. We therefore cannot rule out that more powerful studies would be able to demonstrate significant differences in clinical health parameters. Despite these restrictions, this study confidently shows that people in the exposed region experience their health as substantially worse in comparison to people from a nonexposed area, and that this finding cannot be

sufficiently explained by a higher prevalence of radiation-induced or other diseases.

Our data show that the Chernobyl disaster has caused longstanding loss of health-related quality of life, psychological well-being, and changes in illness behavior. These findings are consistent with the general stress literature, which indicates that many of the manifestations of stress in health are mediated by an influence of stress on illness behavior, e.g., on the awareness of physical sensations, on labeling these as symptoms of disease, and on changes in the use of healthcare facilities (*26*).

In case of the Chernobyl disaster such mechanisms may also occur. In this respect the role of the local health professionals is a crucial one. An earlier study in the Gomel region demonstrated that both doctors and patients perceive Chernobyl as the most important threat to health (*8*). Nuclear disasters, with their ominous implications for future health, appear to tax the whole healthcare system—patients, doctors, health administrators—as well as the belief systems that guide their decisions. In this light, the most important finding of this study is that the psychological impact of disasters such as Chernobyl does not primarily affect the field of mental health, but rather influences illness behavior, with direct relevance to the domain of public health. This area seems to have received little attention in prior reports on major industrial disasters and deserves further study.

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