

Children's Well-being 11 Years After the Chernobyl Catastrophe

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Background: The psychological effects of technological disasters have rarely been studied in children. This study assessed the aftermath of the 1986 Chernobyl disaster in children evacuated to Kyiv from the contaminated zone surrounding the nuclear power facility.

Methods: In 1997, we evaluated three hundred 10- to 12-year-old children in Kyiv who were in utero or infants at the time of the disaster and who had resided near Chernobyl (evacuees) and 300 sex-matched homeroom classmates who had never lived in a radiation-contaminated area. Response rates were 92% (evacuees) and 85% (classmates). Data were obtained from children, mothers, and teachers using standard measures of well-being and risk factors for childhood psychopathology. The children also received physical examinations and basic blood tests.

Results: The evacuees and classmates perceived their mental health similarly except for Chernobyl-related anxiety

symptoms and perceived scholastic competence. No differences were found on the Iowa Conners' Teacher Rating Scale. Although the physical examination and blood test results were normal, the evacuee mothers rated their children's well-being as significantly worse, especially with respect to somatic symptoms on the Children's Somatization Inventory and Child Behavior Checklist. The most important risk factors for these ratings were maternal somatization and Chernobyl-related stress.

Conclusions: Given the multiple stressful experiences to which evacuee families were exposed, the small differences in the children's self-reports suggest that there are protective factors in the lives of these children. The trauma experienced by the mothers was reflected in their perceptions of their children's well-being, particularly somatic symptoms, but was not transmitted to the children themselves.

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THE ACCIDENT at the Chernobyl nuclear power plant began on April 26, 1986, and resulted in the permanent evacuation of 120 000 people primarily from the 30-km zone around the plant.¹ The magnitude of the crisis was unprecedented. The secondary impacts included a sudden, disorderly evacuation, increased rate of abortions, difficulty obtaining official papers allowing evacuees to live in the relocation cities, conflicts over housing and benefits, being dismissed with labels such as "radiophobia," and inadequate medical care. Like other toxicological disasters, the Chernobyl accident created a subpopulation who live in a condition of threat.² The one established consequence is an increase in thyroid cancer in youth,³ particularly in children who were between the ages of in utero to 2 years at the time of exposure.⁴

This is the first epidemiologic study of the psychological well-being of chil-

dren caught up in the aftermath of the Chernobyl disaster. Our study represents a collaboration between independent scientists in Kyiv and an interdisciplinary US research team. We thus employ the original Ukrainian spelling for Chernobyl (Chernobyl) and Kyiv (Kiev).

Prior research on the psychological effects of radiation catastrophes focused primarily on adults.⁵ The evidence from studies of Hiroshima and Nagasaki indicates that generalized and health-focused anxiety, somatization, and depressive symptoms remained elevated 10 to 20 years later.⁶⁻⁸ Studies assessing the psychological aftermath of the 1979 accident at the Three Mile Island (TMI) nuclear power plant demonstrated similar acute,⁹⁻¹¹ medium (5-6 years),^{12,13} and long-term (10 years) effects.¹⁴ Mothers of young children constituted a high-risk group,¹⁵ although the effects were not transmitted to their children.¹⁶⁻¹⁹

Several recent studies have addressed the psychosocial impact of the Chernobyl

SUBJECTS AND METHODS

SAMPLE AND SETTING

Chornobyl is located in northeastern Ukraine, 90 km north of Kyiv. When the accident occurred in 1986, the contamination was spotty but widespread. The 30-km zone surrounding the plant was permanently evacuated, although the undamaged reactors still function. This zone included small villages and the city of Pripjat (population approximately 50000), built for the workers and their families. Many evacuees, including 20000 people from Pripjat, were given temporary housing in Kyiv, which in time became their new home.

Kyiv received less radioactive contamination than other areas.¹ Because residents of Kyiv were not informed about the magnitude of the accident, their children were outdoors for the May 1 celebrations. As news about Chornobyl spread, the Minister of Health appeared on television saying that the situation was under control, the accident was minor, and a little bit of radiation was "good for you." However, fear spread, and in the summer of 1986, many parents in Kyiv sent their children away.

Thus, while the parents of the evacuees and their classmates experienced a traumatic event in 1986, the evacuees underwent a series of traumas stemming from knowledge that they were exposed to high levels of radiation and to the tumultuous circumstances of the evacuation, relocation, and resettlement.

Our study focuses on children born between February 1, 1985, and January 31, 1987 (in utero to age 15 months when the accident occurred) now living in Kyiv. To identify these children, we merged the Ministry of Health's National Register of Persons Affected by Radiation as a Result of the Chornobyl Accident with lists of 2 large humanitarian organizations, Help for Families From Chornobyl, and Children of Chornobyl for Survival. We identified 721 children in the target age range, of whom 668 (92.6%) were on the National Register. In 1996 when our pilot work began, 693 of 721 were in Kyiv. Fifteen children were randomly selected for a pilot study. The remaining 678 names were randomized. Respondents were then selected sequentially until 300 interviews were completed.

The comparison group was composed of sex-matched, unexposed classmates from the same home-room (up to 3 per evacuee were selected initially in case of refusal). These children had similar life experiences growing up in Kyiv. Access to schools was facilitated by the Director of Education of Kyiv.

The response rates were 92% (300/326) for evacuees (80.7% were from Pripjat) and 85% (300/352) for classmates.

PROCEDURE

The study was conducted in 3 stages. Stage 1 entailed home interviews with the children and mothers during February through May 1997. The initial contact was made with mothers by telephone (or in person if the telephone was unavailable or shared). Written informed consent was obtained from mothers and children following a description of the study. The mothers were also informed that they would receive feedback about the findings when the study was completed.

The interviewers were employed by SOCIS-Gallup of Ukraine, an independent nongovernmental organization founded in 1992. Twenty interviewers conducted the assessments (10 for children and 10 for mothers). They had completed a general course on interviewing and worked on previous SOCIS projects. They were university graduates and were systematically trained for a period of 1 week.

Five checks were instituted to monitor the fieldwork: (1) completed interviews were immediately checked for missing data or inconsistencies; (2) a specially trained supervisor reviewed the response rate and interview content with each interviewer weekly; (3) a 10% random sample was recontacted and selected items verified; (4) mothers failing to participate in stage 2 were asked about potential problems during stage 1; and (5) the US investigators recontacted 20 randomly selected respondents. There was no evidence of field problems.

Stage 2 entailed basic physical examinations and blood tests and took place at the Center for the Rehabilitation of Victims of Torture and War approximately 2 to 4 weeks after the home interview. A total of 547 participants (91%) completed this stage, 275 evacuees and 272 classmates. Completers did not perceive their children's health differently from noncompleters. Three physicians were trained in the medical protocol by one of us (T.G.), who also confirmed the findings in 9 children. The blood samples were analyzed blindly at the Institute of Experimental Pathology, Oncology, and Radiobiology, Kyiv, and at the Veterans Affairs Medical Center in Northport, NY. The children were healthy except for minor seasonal problems (eg, swollen glands, inflamed tonsils). One evacuee girl had had her thyroid gland removed. The blood test results were in the normal range for both groups.

During stage 3, teacher ratings of child behavior and school record information were obtained in May (n = 599).

MEASURES

The major concern about the measures was their cultural and conceptual appropriateness. In addition, because psychiatric epidemiology was unknown in Ukraine and clinicians were unavailable as interviewers, the decision was made to incorporate as much structure as possible. Standard translation and back-translation procedures were

reported long-term psychological effects, but the scientific validity of these reports is difficult to evaluate.^{1,27-29}

Although exposed children have an elevated rate of thyroid cancer and are a major focus of humanitarian organizations, no systematic mental health data exist. Four sources of evidence suggest that exposed children constitute a high-risk group for psychological impairment. First, mothers of young children living in a contami-

accident. Four Western-based studies with clearly explained methodologies found that compared with controls, exposed adults, particularly women, had elevated somatization, anxiety, depressive, and posttraumatic stress symptoms during the first decade after the accident.²⁰⁻²⁵ In addition, a mortality study of Estonian liquidators (Chornobyl cleanup workers) found that suicide was the leading cause of death.²⁶ Many Russian-based studies also

followed for US and Ukrainian measures. Eighty percent of mothers and 72% of children were interviewed in Russian and the remainder in Ukrainian.

Children's Self-reports

Six measures were included: (1) the Children's Manifest Anxiety Scale,⁴⁰ the sum of 28 items rated 0=no and 1=yes (eg, I worry when I go to bed at night, I have trouble making up my mind) (α [Cronbach α] = .81); (2) the Depression Self-Rating Scale,⁴¹ the mean of 21 items rated 0=never to 3=all the time (eg, I look forward to things as much as I used to, I think life is not worth living) (α = .80); (3) the Fear Inventory, the mean of 47 current fears, adapted from the Fear Survey Schedule for Children,⁴² rated 0=not at all afraid to 4=very much (α = .94); (4) the Children's Somatization Inventory⁴³ (CSI), the sum of 37 items rated 0=absent to 4=experienced a whole lot, such as headaches, sore muscles, and stomachaches (α = .94); (5) the short form of the Perceived Competence Scale for Children,⁴⁴ the means for 6 subscales containing 4 items each, rated 1=low to 4=high level of competence (scholastic [α = .66]; social [α = .60]; athletic [α = .64]; physical [α = .57]; behavior [α = .64]; and self-worth [α = .50]); and (6) the Children's Chornobyl Anxiety Scale, the sum of 15 items modeled after Pynoos et al⁴⁵ indicating degree of concern about Chornobyl, rated 0=absent to 4=always present (α = .86) (eg, Do you get scared or upset when you think about the Chornobyl disaster? Do you have bad dreams about Chornobyl?).

Maternal Reports of Child's Well-being

Two measures were included: (1) the Russian adaptation⁴⁶ of the Child Behavior Checklist⁴⁷ (CBCL) administered during stage 2 (n=546), composed of 118 items, rated 0=not at all true to 2=completely true, comprising 8 subscales—withdrawn (α = .72), somatic complaints (α = .80), anxious/depressed (α = .79), social problems (α = .64), thought problems (α = .51), attention problems (α = .75), delinquent behavior (α = .60), and aggressive behavior (α = .86); and (2) mothers' ratings on the CSI (M-CSI) (α = .91). The correlation between the M-CSI and the CBCL somatic complaints scale was 0.58 ($P < .001$).

Teacher Reports

The Iowa Conners' Teachers Rating Scale⁴⁸ is the sum of 10 items, rated 0=not at all to 3=very much, covering behavioral symptoms, such as inattentive or uncooperative (α = .90).

Maternal Reports of Chornobyl-Related Stress

Three measures were analyzed: (1) the Chornobyl Health Stress Scale, an 8-item scale focused on the health effects

of the Chornobyl disaster on mother and child, effects on future generations, and worries about eating or drinking contaminated food or milk (α = .77); (2) child diagnosed with vascular dystony (the official Chornobyl diagnosis) reflecting headaches, dizziness, blood pressure changes, and gastrointestinal tract upset; and (3) the Impact of Events Scale-Revised⁴⁹ (mean score) focused on Chornobyl-induced distress, assessing 22 avoidance, intrusion, and hyperarousal symptoms (α = .94) on a scale of 0=not at all to 4=very much.

DATA ANALYSES

Thirteen risk factors were analyzed: (1) child's age and (2) sex; (3) school performance (1=mostly Cs to 5=mostly As); (4) maternal education (1=less than high school; 6=advanced degree); (5) perceived standard of living (Likert scale developed in Kyiv: 0=lowest and 10=highest); (6) mother's and (7) teacher's ratings of the child's physical health (1=very bad to 5=excellent); (8) paternal alcohol abuse (mother's report of whether husband drinks too much [0=no; 1=yes, but not during the last 12 months; 2=yes, during the last 12 months]); (9) maternal lifetime depression (having the requisite symptoms for DSM-IV major depressive disorder based on a modified version of the depression module⁵⁰ of the Structured Clinical Interview for DSM-III-R⁵¹); (10) mother's Symptom Checklist-90^{52,53} somatization score (α = .89); (11) the sum of 23 life strain items rated by mothers as present ("somewhat" or "very true"), such as problems with finances, employment, or leisure time⁵⁴ (α = .79); the child's perception of quality of communication with his or her mother (12) and father (13), based on the means of 10 items rated 1=never to 5=always (eg, How often do you talk things over with your mother/father? When you do something wrong, how long does your mother/father stay angry with you?)⁵⁵ (α = .64 and .87 for mothers and fathers, respectively).

Means, medians, and percentages for the evacuees and matched classmates were compared using the 2-tailed paired *t* test, Wilcoxon signed rank test, and the McNemar test, respectively. $P > .05$ was considered nonsignificant. The effect size (difference in means divided by the pooled within-group SD) was used to evaluate the magnitude of group differences in well-being. Correlations were used to summarize the bivariate associations between Chornobyl-related stress and well-being. A series of mixed-level regression analyses⁵⁶ was performed to estimate (1) the unique effects of the Chornobyl stress measures on well-being, controlling for the 13 putative epidemiologic risk factors, and (2) the group differences that remained after controlling for different sets of predictors. These analyses took account of the correlated residuals created by the matched design.

nated region of Belarus were at high risk for psychopathology.³⁰ Second, highly exposed children receive extensive annual checkups (some are hospitalized for up to 1 month for testing) and have a variety of diagnoses, including "vascular dystony" (also known as "vegetative dystonia"), that indicate symptoms such as headache, fatigue, dizziness, changes in blood pressure, and abdominal pain. This was the "official" diagnosis in

Ukraine for Chornobyl-related conditions, based on tests not used in Western medicine.³¹ Third, although the assessment methods were unclear, one study reported greater emotional problems in exposed children in Belarus compared with controls.³² Finally, children studied after other disasters, particularly unexpected, severe traumatic events, are at increased risk for internalizing and externalizing symptoms.³³⁻³⁸

Table 1. Descriptive Characteristics of Mothers and Children in Kyiv, Ukraine, Assessed in 1997*

Variable	Evacuees (n = 300)	Classmates (n = 300)	Test†	P
Child characteristics				
School performance	2.84 ± 1.21	2.98 ± 1.34	t = 1.44‡	>.05
Communication with mother	4.01 ± 0.50	4.00 ± 0.48	t = -0.32§	>.05
Communication with father	3.79 ± 0.98	3.70 ± 1.02	t = -1.03	>.05
Mother's rating of child's health	2.66 ± 0.60	3.05 ± 0.62	t = 7.90§	<.001
Teacher's rating of child's health	2.96 ± 0.75	3.28 ± 0.71	t = 6.24‡	<.001
Maternal characteristics				
Age, y	37.2 ± 4.4	38.0 ± 4.7	t = 2.31§	.021
Standard of living	3.9 ± 1.6	3.7 ± 1.6	t = -1.78§	>.05
University graduate, %	13.7	26.8	χ ² = 16.22	<.001
Works outside the home, %	70.0	83.4	χ ² = 25.09	<.001
No. of children, median	2	2	z = -1.41	>.05
Currently married, %	88.7	89.4	χ ² = 0.02	>.05
No. of rooms per person in home	0.65 ± 0.15	0.60 ± 0.21	t = -3.40§	<.001
Pregnant in April 1986, %	36.7	29.4	χ ² = 4.32	.05
Lifetime depression, %	46.7	33.0	χ ² = 10.60	<.001
Husband lifetime drinking problem, %¶	36.6	35.7	χ ² = 0.01	>.05
SCL-90 somatization	1.49 ± 0.71	1.10 ± 0.60	t = -7.37§	<.001
No. of life strains	10.72 ± 3.65	11.31 ± 3.80	t = 1.96§	.05

*Data are given as mean ± SD except where noted. A Likert-type scale was used for variables as indicated. School performance, communication with mother, communication with father, mother's rating of child health, and teacher's rating of child health are all rated 1-5, with 5 being the best. Standard of living was rated 1-10, with 10 being the highest. The Symptom Checklist-90 (SCL-90) score was rated 0-4, with 4 being the highest.

†Matched analyses were performed: paired t tests, McNemar χ², and Wilcoxon z (signed rank test).

‡df = 299.

§df = 298.

||df = 294.

¶N = 268 evacuee and 266 classmate mothers.

Our study examined whether, 11 years after the accident, the well-being of children evacuated to Kyiv was poorer than that of their classmates. We also considered the contributions of epidemiologic-based risk factors,³⁹ including demographic characteristics, physical health, parental psychopathology, school performance, and quality of communication with parents, as well as maternal perceptions of Chernobyl-related stress.

RESULTS

DESCRIPTIVE CHARACTERISTICS

The children were matched for sex; 48% were male. The median age of both groups was 11 years, although evacuees were slightly younger (10.7 ± 0.60 years vs 10.8 ± 0.79 years). Close to 40% of both groups had a grade average of B or better, and the quality of communication with parents was rated as positive (**Table 1**). Although the physical examination and blood test results were unremarkable, the teachers rated 24.7% of evacuees vs 10.7% of classmates as having "bad" or "very bad" health, and 36.7% of evacuee mothers compared with 14.0% of the classmate mothers rated their children's health as "bad" or "very bad."

The median ages of the mothers were late 30s and, like the children, the evacuee mothers were younger. The perceived standard of living was low in both groups. Most mothers were currently married, and the average number of children per family was 2. The evacuee mothers were less often university graduates or working outside the home; similarly, fewer evacuee fathers were university graduates (17.3% [46/266] vs 34.3% [91/266];

P < .001). The apartments given to the evacuees were somewhat larger (more rooms per person) than those of the classmates. Consistent with the children's age, relatively more evacuee mothers were pregnant at the time of the accident. More evacuee mothers met criteria for lifetime depression, and evacuee mothers had significantly higher Symptom Checklist-90 somatization scores. However, the classmate mothers reported more life strain overall.

DIFFERENCES IN CHILD WELL-BEING AND CHORNOBYL STRESS

The groups were not significantly different on the Iowa Conners' Teachers Rating Scale or on 9 of the 11 children's self-report scales (**Table 2**). The 2 scales on which the evacuee children rated themselves more negatively (*P* ≤ .05) were scholastic competence and the Children's Chernobyl Anxiety Scale. Using the conventional criteria, these group differences were small to negligible (effect size approximately 0.2).

Both groups of mothers viewed their children similarly on several CBCL internalizing scales. However, the evacuee mothers perceived their children as substantially more symptomatic on the 2 somatization measures (effect size > .50), particularly the CSI. The evacuee mothers also reported higher CBCL thought problems scores, while the comparison mothers reported more problems on delinquent behavior, a difference that remained significant after controlling for age.

With respect to Chernobyl stress, the evacuee mothers had significantly higher scores on the Chernobyl Health Stress Scale (9.98 ± 2.23 vs 8.33 ± 2.65; paired

Table 2. Differences in Well-being Between Evacuees and Classmates*

Measure	Evacuees (n = 300)	Classmates (n = 300)	Paired <i>t</i> Test	<i>P</i>	Effect Size
Teacher reports					
Iowa Conners' Teachers Rating Scale ⁴⁸	5.93 ± 6.00	5.38 ± 5.42	-1.37†	>.05	.11
Children's self-reports					
Children's Manifest Anxiety Scale ⁴⁰	13.30 ± 5.39	12.68 ± 5.04	-1.54‡	>.05	.13
Depression Self-Rating Scale ⁴¹	0.80 ± 0.35	0.76 ± 0.33	-1.27‡	>.05	.10
Fear Inventory ⁴²	2.09 ± 0.59	2.03 ± 0.61	-1.16‡	>.05	.09
Children's Somatization Inventory ⁴³	17.57 ± 15.85	15.23 ± 16.31	-1.74‡	>.05	.14
Children's Chornobyl Anxiety Scale ⁴⁵	15.74 ± 9.88	13.88 ± 9.34	-2.36†	.02	.19
Perceived Competence Scale for Children ⁴⁴					
Scholastic competence	2.63 ± 0.72	2.78 ± 0.69	2.46‡	.02	.20
Social competence	2.89 ± 0.69	2.82 ± 0.76	-1.08‡	>.05	.09
Athletic competence	2.66 ± 0.69	2.76 ± 0.70	1.81‡	>.05	.15
Physical competence	2.82 ± 0.68	2.90 ± 0.66	1.54‡	>.05	.13
Behavioral competence	2.85 ± 0.60	2.84 ± 0.63	-0.39‡	>.05	.03
Self-worth	2.95 ± 0.58	2.99 ± 0.53	0.87‡	>.05	.07
Mothers' reports					
CBCL withdrawn	58.14 ± 7.61	57.18 ± 7.30	-1.32§	>.05	.14
CBCL somatic complaints	70.47 ± 9.42	65.14 ± 9.21	-6.55§	<.001	.57
CBCL anxiety depression	57.88 ± 7.11	56.58 ± 7.18	-1.82§	>.05	.18
CBCL social problems	55.77 ± 7.22	55.18 ± 6.75	-0.44§	>.05	.08
CBCL thought problems	54.67 ± 6.64	53.00 ± 5.15	-3.05§	.003	.29
CBCL attention problems	60.48 ± 7.78	59.03 ± 7.79	-1.39§	>.05	.19
CBCL delinquent behavior	53.71 ± 5.62	55.06 ± 6.39	2.99§	.003	.23
CBCL aggressive behavior	54.28 ± 5.46	54.53 ± 5.97	0.76§	>.05	.04
Children's Somatization Inventory ⁴³	22.92 ± 15.54	14.05 ± 11.27	-7.96‡	<.001	.65

*Data are presented as mean ± SD unless otherwise indicated. CBCL indicates Child Behavior Checklist.⁴⁷

†df = 298.

‡df = 299.

§df = 247.

||N = 240 pairs for CBCL scales.

$t_{299} = -6.41$; $P < .001$; effect size = .48) and on the Impact of Events Scale (0.84 ± 0.67 vs 0.52 ± 0.55 ; paired $t_{299} = -8.38$; $P < .001$; effect size = .37). In addition, 48% of evacuee vs 14% of comparison mothers reported that their child was diagnosed with vascular dystony (McNemar $\chi^2 = 68.81$; $P < .001$).

BIVARIATE RELATIONSHIPS BETWEEN CHORNOBYL STRESS AND CHILD WELL-BEING

We next examined the relationships of the Chornobyl stress measures to child well-being in the evacuees and classmates. Given the number of correlations (3 stress variables × 22 measures × 2 groups), a Bonferroni-adjusted α of $P < .001$ was applied. The Chornobyl stress measures were only weakly related to the teacher rating scale and the child self-report scales. Among the latter, only 1 correlation coefficient approached statistical significance (that for the Chornobyl Health Stress Scale and the Children's Manifest Anxiety Scale [evacuees]; $r = 0.16$; $P = .007$).

In contrast, for both groups, the Chornobyl Health Stress scale was significantly related ($P < .001$) to the CBCL somatic complaints ($r = 0.27$ and 0.32 for evacuees and classmates, respectively) and the M-CSI ($r = 0.35$ in both groups). The Impact of Events Scale was also significantly correlated with the somatization scales in both groups, particularly with the CSI ($r = 0.38$ for evacuees and 0.25 for classmates; $P < .001$). Reports of vascular dystony were similarly correlated with the CSI ($r = 0.37$ for

evacuees and 0.26 for classmates; $P < .001$). In the evacuee (but not control) group, only 4 other correlations were significant ($P < .001$): Impact of Events Scale with the CBCL thought problems ($r = 0.22$), anxious/depressed ($r = 0.28$), and attention scales ($r = 0.21$), and vascular dystony with the anxious/depressed scale ($r = 0.24$).

MULTIVARIATE ANALYSIS

The final analysis considered the ability of the epidemiologic and Chornobyl risk factors to account for group differences in the measures of child well-being. Only the 5 variables on which the evacuee children were significantly more impaired than their classmates are presented.

A comparison of the unadjusted and adjusted group means (Table 3, rows 1 and 2) shows that the epidemiologic risk factors accounted for 50% to 75% of the observed group differences. For the 3 measures on which the unadjusted group differences were relatively small (effect size $< .30$), the group difference that remained after controlling for the risk factors was not statistically significant. However, the adjusted difference remained significant for the 2 somatization measures.

We note that in the epidemiologic multivariate models, the strongest predictors of (greater) scholastic competence ($P < .001$) were higher grades ($t_{223} = 9.38$), better quality of communication with mother ($t_{223} = 4.89$), and being male ($t_{296} = 3.64$). None of the variables was strongly associated ($P < .001$) with the Children's Chor-

Table 3. Accounting for Differences Between Evacuees and Classmates Before and After Adjusting for Epidemiologic Risk Factors and Chernobyl Stress*

Group Difference	Child Self-reports		Maternal Reports		
	Scholastic Competence	Chernobyl Anxiety	Thought Problems	Somatic Complaints	M-CSI
Unadjusted	-0.125†	1.907†	1.635‡	5.240§	8.038§
Adjusted for epidemiologic risk factors	-0.046	0.978	0.673	2.128‡	2.018†
Adjusted for Chernobyl stress factors	-0.115	0.965	0.938	1.350	1.432
Adjusted for both sets of factors	-0.047	0.640	0.718	0.584	-0.262

*Unstandardized regression coefficients. M-CSI indicates mothers' ratings on the Children's Somatization Inventory.⁴³

†P < .05.

‡P < .01.

§P < .001.

||Epidemiologic risk factors: child's age, sex, grade point average, child's perception of quality of communication with mother and father, maternal education level, perceived standard of living, mother's rating of child's health, teacher's rating of child's health, paternal lifetime drinking problem, maternal lifetime depression, mother's Symptom Checklist-90 somatization score, and degree of life strains.

nobyl Anxiety Scale. The only significant predictor ($P < .001$) of CBCL thought problems was Symptom Checklist-90 somatization ($t_{296} = 5.59$). Finally, for children's somatization, the Symptom Checklist-90 somatization and mother's rating of her child's health were significant (for CBCL somatic complaints, $t_{222} = 8.59$ for the Symptom Checklist-90 and $t_{222} = 4.94$ for the health rating; for the CSI, $t_{296} = 14.33$ for the Symptom Checklist-90 and $t_{296} = 7.16$ for the health rating).

When the multivariate analysis was repeated controlling for Chernobyl stress (Table 3, row 3), the adjusted group differences in each of the well-being measures except scholastic competence were reduced substantially. In fact, the Chernobyl stress measures accounted for as much of the observed group difference in the child Chernobyl Anxiety Scale and more of the observed group difference in the 2 mother-rated somatic symptom measures than the epidemiologic risk factors. None of the group differences was statistically significant after controlling for Chernobyl-related stress.

Together the epidemiologic risk factors and the Chernobyl stress measures accounted for more than half of the observed group differences in the child reports and CBCL thought problems, and nearly all of the difference in the 2 somatization scales (Table 3, row 4 vs row 1). Furthermore, the remaining group differences on the 5 well-being measures were not significant. It should be noted that each Chernobyl stress measure was significantly associated with the somatization scales in the final models.

COMMENT

Our central objective was to determine whether the well-being of children evacuated to Kyiv from the contaminated area around Chernobyl was poorer than that of non-evacuee children. We found that 11 years after the accident, children who were infants when the explosion occurred perceived their well-being as similar to that of their classmates. This finding is consistent with our previous report showing no differences in neuropsychological test performance.⁵⁷ The teachers and mothers perceived the children's behavior as similar in many respects.

However, although the physical examination and blood test findings were similar, the evacuee mothers reported significantly more somatic symptoms in their children. Chernobyl stress was significantly related to these perceptions, even after adjusting for other risk factors. The strongest relationships were between the mother's somatization level and her reports of somatic symptoms in her child.

The project was modeled on our research on mothers of infants following the nuclear power plant accident at TMI 20 years ago. There too we found little difference between TMI and comparison site children despite significant differences in the mothers' mental health and persistent concerns about their children's health.¹⁶⁻¹⁸ Ten years after the TMI accident, when the children were about the same age as the Chernobyl sample, 49% of TMI mothers were worried about the effects of the accident on their children's health. In the present study, almost all of the women were at least somewhat worried, and 58% of evacuee mothers thought that their children's health was "very" much affected. Given the difference in the magnitude of these events, this result is not surprising. There were many other important differences besides the level of radiation exposure, of course, including the fact that the TMI families did not leave home permanently or experience the severe strains that occurred with the resettlement and breakup of the former Soviet Union. Thus, the parallels in the findings are all the more striking.

Like our TMI study, we had to select a single comparison group because of budgetary constraints. We note that although the contamination in Kyiv was far lower than in the areas adjacent to Chernobyl, the classmate group provided a conservative comparison since many Kyiv mothers sent their children away from May through August 1986 and worried about the radiation exposure their children received.

Several limitations should be noted. Because of difficulties in reconstructing radiation dose estimates,⁵⁸ we could not determine the risk conferred by actual exposure level. On the other hand, the evacuees came from the 30-km zone, and 81% were from Pripjat. Second, the study design was cross-sectional, and the data were obtained 11 years after the explosion. We therefore do not know whether differences existed before the Chernobyl

disaster happened or whether delayed effects will emerge as the children age. Third, families resettled in Kyiv are not representative of all residents of the 30-km zone. While we developed a reasonably complete enumeration of evacuees in Kyiv, it is impossible to specify the representativeness of our population. Fourth, the Chernobyl disaster unleashed a cascade of stressors, including harrowing experiences during the evacuation, arduous battles for residency permits in Kyiv and for government benefits, social stigma, and an irreversible loss of home, belongings, and lifestyle. The fact that there were multiple stressors is not unique to Chernobyl. As Azarian et al⁵⁹ noted regarding the 1988 earthquake in Armenia: "The most distinctive characteristic of the children . . . is the multiplicity of stressors to which they were exposed as a result of the traumatization." However, it is difficult to disentangle the web of stress and pinpoint specific experiences that increased the vulnerability of the population. Finally, our study was a pioneering effort in Kyiv. Without prior experience doing epidemiologic research there, we attempted to impose as much structure as possible. Our measures appeared to have excellent internal consistency and concurrent validity. The CBCL scores were similar to those reported for a sample near Moscow, Russia.⁴⁶ However, normative data for Ukraine are unavailable.

Based on previous disaster studies of children,^{33,38,60,61} we evaluated internalizing and behavioral symptoms. Unlike children exposed to acute disasters, the evacuee children seemed relatively unaffected by circumstances 11 years after Chernobyl. In some ways, the findings are consistent with studies of the offspring of trauma survivors that show very little effect on the next generation.^{62,63} However, while these children have no memory of witnessing the event, they are regularly exposed to the Chernobyl disaster by their parents and other circumstances (eg, being hospitalized every year for testing, being sent abroad in the summer for recuperation, and getting special lunches in school). It is common knowledge in Kyiv as to who the evacuee families are. The typical scene that occurred during our visits to families as we conducted the study was as follows: the child raced around the apartment while the parents made us comfortable; we discussed many topics amicably and with smiles; the subject of Chernobyl was brought up, and, in the child's presence, the mother related her worries about her child's health and showed us the child's medical record; the child witnessed the mother's sobbing about what the Chernobyl disaster had done. Thus, the children are keenly aware of their parents' reactions.

Carter et al⁴⁶ showed that somatization was the one CBCL subscale that was elevated in a Russian sample relative to American norms. Somatic complaints are a sign of distress in Russia and Ukraine.²⁸ Thus, it is not surprising that somatization symptoms were increased in the evacuee mothers and bore a strong relationship to perceptions of the children's well-being. In addition, the relationship between maternal somatization and mothers' reports of somatic symptoms in the children are consistent with other studies showing associations between maternal depression and mothers' reports of depressive symptoms in their children.⁶⁴ An increase in perceived

risk to health was reported after other technological disasters.⁶⁵ While conceivably the mothers identified real symptoms that went undetected by our study physicians, it is also conceivable that they projected their own feelings on their reports about their children.

How do we account for the fact that the children were so resilient and that the differences in their self-ratings were so small? These children have grown up with consistent, loving parents. Indeed, the data on parent-child communication showed no significant differences between evacuees and classmates and, more importantly, showed scores indicating positive relationships with parents. Moreover, the correlation between the mothers' and children's perceptions of communication was moderately strong ($r=0.30$; $P<.001$). The trauma of Chernobyl was inflicted primarily on the parents and only secondarily on the children even though the children are the focus of their parents' anxiety. The way the trauma is handled in many households is by open discussion and grieving, as opposed to the "conspiracy of silence" that frequently occurred in families of Holocaust survivors.⁶⁶ Conceivably, the open expression of emotion is a protective factor for these children. Finally, the children's reports of internalizing symptoms are subject to unreliability, and thus measurement error may have obscured real difficulties experienced by them.⁶⁷ When the cohort enters adolescence, the evacuee children may indeed begin to be at greater risk for anxiety and depression, disorders whose rates increase with teenage years.

To conclude, while we enumerated the limitations of our study, the results should also be viewed against its strengths. These include a sample of evacuee families with no known bias, the classmate comparison group living in similar conditions, an excellent response rate, standard approaches to assessing risk factors and well-being, mental health data from the children, mothers, and teachers, and physical examinations and blood tests performed by experienced and knowledgeable physicians. Although radiation and nuclear power evoke deeply rooted fear and anxiety in adults,⁶⁸ our study found that 11 years after the explosion, the trauma was not transmitted to children who were unborn or infants when their families were resettled in Kyiv.

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