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## EMOTIONAL CONSEQUENCES OF NUCLEAR POWER PLANT DISASTERS

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### Abstract

The emotional consequences of nuclear power plant disasters include depression, anxiety, post-traumatic stress disorder, and medically unexplained somatic symptoms. These effects are often long term and associated with fears about developing cancer. Research on disasters involving radiation, particularly evidence from Chernobyl, indicates that mothers of young children and cleanup workers are the highest risk groups. The emotional consequences occur independently of the actual exposure received. In contrast, studies of children raised in the shadows of the Three Mile Island (TMI) and Chernobyl accidents suggest that although their self-rated health is less satisfactory than that of their peers, their emotional, academic, and psychosocial development is comparable. The importance of the psychological impact is underscored by its chronicity and by several studies showing that poor mental health is associated with physical health conditions, early mortality, disability, and over-utilization of medical services. Given the established increase in mental health problems following TMI and Chernobyl, it is likely that the same pattern will occur in residents and evacuees affected by the Fukushima meltdowns. Preliminary data from Fukushima indeed suggest that workers and mothers of young children are at risk of depression, anxiety, psychosomatic, and post-traumatic symptoms both as a direct result of their fears about radiation exposure and an indirect result of societal stigma. Thus, it is important that nonmental health providers learn to recognize and manage psychological symptoms and that medical programs be designed to reduce stigma and alleviate psychological suffering by integrating psychiatric and medical treatment within the walls of their clinics.

### Keywords

National Council on Radiation Protection and Measurements; Chernobyl; mental health; risk perception; Fukushima

### INTRODUCTION

In the past 35 y, three nuclear power plant accidents evolved into major disasters – Three Mile Island (TMI), Chernobyl, and Fukushima. Long-term follow-up studies of populations affected by TMI and Chernobyl show enduring impacts on emotional well-being, manifested in terms of depression, anxiety, post-traumatic stress disorder, poor self-rated health, and medically unexplained symptoms. Overall, the rates of psychological impairment range from 25–75%, depending on the population under study, the timing of the assessments, the perceived or actual magnitude of the exposure, and the degree of direct involvement with the accident. These rates far exceed population-based rates of common mental disorders. For

example, the lifetime prevalence of depression in women in Ukraine is 20.8% (Bromet et al. 2005), while the lifetime prevalence of depression in women 11 y after Chernobyl was 46.7%.

While natural and man-made disasters both impose a substantial burden on mental health, events involving radiation are particularly pernicious (Neria et al. 2008). The three major nuclear power plant accidents share common features that heighten vulnerability, including the intangible nature of radiation exposure; the inherent horror associated with radiation exposure (Slovic 1987); incomplete, conflicting, and unintelligible disclosures by authorities about radiation and about what occurred at and outside the nuclear plants; contradictory reports by the media as the events unfolded; widespread rumors about adverse health effects and bizarre effects on plants and animals; distrust of and hostility toward government authorities and the scientific community; the tendency to attribute almost all health problems to radiation exposure; fears about health effects in future generations; chaotic health monitoring by government agencies; ecological and socio-economic disruptions; and most importantly, lack of resolution about the actual amount of exposure received and potential risks to the population at large.

Notwithstanding these shared features, the events themselves were different in a number of respects. The 1979 accident at TMI in central Pennsylvania caused a partial meltdown of the core, a small (0.4–1 TBq) release of radioiodine primarily inside the reactor itself, and a temporary evacuation advisory for pregnant women and small children living within ~8 km of the plant. The average exposure dose to the two million people within ~80 km of the plant was estimated to be 0.015 mSv, and no increases in cancer morbidity or mortality were found (Hatch et al. 1990). The 1986 Chernobyl accident resulted in a meltdown and extensive contamination of regions of Ukraine, Belarus, and Russia; 31 deaths among emergency cleanup workers and firefighters; permanent evacuation of ~200,000 residents; and a marked increase in thyroid cancer among young children from drinking contaminated milk (Bard et al. 1997). The accident occurred to a population previously exposed to an artificial famine and gulags during the Stalin era, the programmatic extermination of the Jewish population during World War II, and the suffocating political controls that existed until Perestroika. The 2011 Fukushima meltdowns came on the heels of a magnitude 9.0 earthquake (and aftershocks) and devastating tsunami; 380,000 people were evacuated, and although no workers died, some elderly patients died in transit. In the latter two events, evacuees faced enormous stigma from the communities where they were relocated. Obviously, the cultural contexts of these three events are also strikingly different. Yet, as shown in this review, the mental health effects are remarkably similar.

We previously reviewed the mental health research following TMI (Bromet 1998) and Chernobyl (Bromet and Havenaar 2007; Bromet et al. 2011; Bromet 2012). As noted, general population studies show elevations in psychological symptom profiles and poorer subjective health among exposed compared to nonexposed cohorts though the majority of people in the general population do not manifest diagnosable psychiatric conditions (e.g., Havenaar et al. 1997). Similarly, although there have been some studies purporting to show cognitive impairments in babies born during the Chernobyl catastrophe, the evidence by and large suggests that children who grew up in the shadow of Chernobyl (Bromet et al. 2011) and TMI (Bromet et al. 1982) are emotionally, socially, and academically resilient. By far the largest effects have occurred among mothers of young children and nuclear power plant workers. This paper thus focuses on findings from these two high-risk groups.

## MOTHERS OF YOUNG CHILDREN

Our research group conducted similar epidemiologic studies of mothers of young children 10-11 y after the TMI and Chernobyl accidents. Both studies followed American Institutional Review Board procedures, and participants gave written informed consent. In both studies, similar questionnaires were administered on self-rated physical health, psychological symptomatology, and perceptions about the health effects of the accident. Specifically:

- The TMI sample included mothers who lived within ~16 km of the plant when the accident occurred (Bromet et al. 1982). Most evacuated the area when the Governor of Pennsylvania issued an advisory. The sample was identified from routine birth announcements in local newspapers appearing between January 1978 and March 1979. It is interesting to note that in 1979, mental health was stigmatized and marginalized, and the project, with its focus on mental health, was denied access to official birth certificates for sampling purposes. In 1989, at the 10 y anniversary of the accident,  $N = 156$  of the mothers completed a postal questionnaire (Dew and Bromet 1993).
- The Chernobyl sample included 300 mothers evacuated to Kiev from contaminated regions near the plant. Most (80.7%) were from Prip'yat, the city built near Chernobyl for employees and their families. They were selected from a sampling frame of evacuee families in Kiev with children born between February 1985 and February 1987. In 1997, 11 y after the accident, 300 evacuee mothers were interviewed face-to-face and completed many of the same self-report questionnaires as used in the TMI study (Bromet et al. 2002).

The average age of the TMI and Chernobyl mothers was 37 y at the time of data collection. Almost all of the mothers in the two groups were married, and the median number of children in both groups was two. More than half of the TMI (56.4%) and Chernobyl (60.3%) mothers had at least a high school education. Given the differences in the settings, 71.0% of the TMI mothers were Protestant, while 69.0% of the evacuees were Russian Orthodox.

In both studies, the mothers were asked to rate their overall health (Idler and Benyamini 1997). The TMI sample was given four response options: excellent, good, fair, or poor. The Chernobyl sample was given five response options: excellent, good, fair, poor, or very poor, reflecting cultural differences in the modal response to this question. Psychological health was measured with three subscales of the Symptom Checklist-90, a widely-used psychological symptom inventory (Derogatis 1982; Tarabrina et al. 1996). The three subscales were anxiety (10 items), depression (13 items), and hostility (6 items). The items were rated on a five-point distress scale from 0 = "not at all" to 4 = "extremely in the past 2 wk." The U.S. cut-point of one standard deviation was used to determine "high" vs "low" levels of symptom impairment. Lastly, both samples were asked if they believe that the accident affected their health. The response options for TMI mothers were "yes, unsure, and no," while for Chernobyl, they were "yes very, yes somewhat, and no."

As expected, given the magnitude of the two events and the different standard of living between the United States and Ukraine, especially when the studies were conducted, the Chernobyl mothers were much more likely to rate their health as fair or poor (38.5% of Chernobyl mothers vs 10% of TMI mothers), to score in the high impairment range on the psychological scales of depression (54% for Chernobyl mothers vs 24% for TMI mothers), anxiety (48% vs 31%), and hostility (51% vs 34%), and more likely to believe that their health was affected by the accident (96% of Chernobyl evacuees said "yes very" (48%) or "yes somewhat" (51%) vs 61% of TMI mothers said "yes" (43%) or "unsure" (17%).

The central question was the relationship between perceived risk and self-rated health and mental health. In both groups, those who believed that their health was affected by the accident (TMI: “yes” or “unsure” vs “no”; Kiev: “yes very” vs “yes somewhat” or “no”) had significantly higher anxiety, depression and hostility scores and rated their health more poorly than those who believed that their health was either “not affected” or “not affected very much.” Specifically, in both the TMI and Kiev samples, those who believed their health was affected by the accident were three times as likely to describe their health as “fair”/“poor.” These parallel findings for the association of risk perceptions with emotional well-being are striking given the differences in exposure, evacuation stress, stigma-associated stress, culture, and post-disaster socio-political environment.

Data are being collected in Japan that will ultimately show whether the same patterns exist among mothers of young children affected by Fukushima. Given the long-term psychological impact among atomic-bomb survivors (Lifton 1967; Ohta et al. 2000; Honda et al. 2002; Yamada and Izumi 2002; Kim et al. 2011), along with anecdotal news reports and studies of volunteer populations after Fukushima, there is reason to believe that the long-term psychological and subjective health aftermath for mothers of young children will follow a similar pattern. In Ukraine, doctors often indiscriminately attributed the health concerns reported by mothers to radiation exposure from Chernobyl. This too proved to be a significant risk factor for poor mental health and for poor subjective health ratings in the Chernobyl sample. In both Kiev and Japan, outpatient mental health services are uncommon, and the main source of support for emotional problems rests with nonpsychiatrist physicians, and in Japan, with public health nurses. Thus, in both settings, it is imperative that nonpsychiatrist physicians (family doctors, obstetricians, pediatricians) understand the actual health effects of radiation exposure and learn to recognize and manage anxiety and depression symptoms (Bromet 2011).

## NUCLEAR PLANT WORKERS

Studies of TMI workers conducted by the Behavioral Taskforce of the President’s Commission on TMI (Dohrenwend 1983) and by our research group (Parkinson and Bromet 1983) found little evidence of acute or chronic diagnosable mental health sequelae from the TMI accident. However, the Task Force reported that compared to other nuclear plant workers, TMI workers experienced greater job tension, anger, extreme worry, demoralization, and somatic complaints (Kasl et al. 1981). The findings for Chernobyl cleanup workers, referred to as liquidators, were more pronounced. Specifically, Rahu and colleagues found excess suicide in Estonian liquidators (Rahu et al. 2006, 2013), while a study of Ukrainian liquidators found elevated rates of mood and anxiety disorders, suicide ideation, and severe headaches relative to population controls (Loganovsky et al. 2008). Recent data from Tallinn also found that 24 y later, the rates of current depression, anxiety, alcoholism, and poor self-rated health were twice as high in liquidators compared to population controls (Laidra and Rahu 2013). Moreover, Loganovsky et al. also found that liquidators with mood disorders and post-traumatic stress disorder reported more loss work days than ill controls and unaffected liquidators and controls.

The Chernobyl liquidators are being monitored for the development of cancer. Given the striking findings about their mental health, the monitoring should also address suicide ideation and thoughts of death as well as signs and symptoms of mood and anxiety disorders and of post-traumatic stress disorder.

Suggestive evidence has already appeared from Japan indicating that Fukushima Daiichi cleanup workers have higher levels of distress and symptoms of post-traumatic stress disorder compared to workers at the nearby Daini Nuclear Plant (Shigemura et al. 2012). In

both groups, discrimination and slurs from the general population were associated with increased distress.

## COMMENT AND CONCLUSION

After TMI, the President's Commission concluded that the biggest public health problem was mental health. Twenty years after Chernobyl, the Chernobyl Forum similarly concluded that the biggest public health problem from Chernobyl was mental health (UN 2006). Poor mental health is a leading cause of disability world-wide and is associated with poor physical health, earlier mortality, complications in recovery from medical conditions, increased cost of medical services, absenteeism, and decreased quality of life. Yet, there were no expansions in mental health care for victims of either of these disasters.

The situation after Fukushima appears to be somewhat different. There is widespread recognition that the emotional consequences of the Great East Japan Disaster require immediate attention and intervention. There is also improved understanding that mental health is often expressed through somatic symptoms (Yevelson et al. 1997) and that, having been exposed to multiple hazards, the health and mental health needs of the population affected by the triple disaster are inextricably intertwined. Anecdotally, the socioeconomic decline of the area has also taken its toll on humans, and there is concern that the rate of alcoholism is rising among the unemployed in Fukushima prefecture.

A mental health needs assessment is being conducted by Fukushima Medical University, and as questionnaires are received, trained public health nurses are calling respondents and offering reassurance or referring them to care providers (Yasumura et al. 2012). In addition, the Japanese Society of Neurology and Psychiatry and the Japanese Society for Traumatic Stress Studies have provided information and treatment guidelines so that post-disaster mental health care can be carried out optimally (Suzuki and Kim 2012). Ultimately, nonpsychiatrist physicians will also need to learn to recognize the signs and symptoms of mental health problems, including psychosomatic manifestations, and will need to know how to differentiate between genuine radiation-health effects and psychologically-driven or mediated concerns. It is very likely that for individuals directly impacted by Fukushima, as occurred among physically healthy survivors decades after the atomic-bomb explosion in Nagasaki (Kim et al. 2011), the psychological distress occurring in the immediate aftermath of Fukushima will become chronic. Thus, long-term management will be required by both mental health professionals and nonmental health medical providers.

Along with TMI, Chernobyl, and Fukushima, the world has witnessed many tragic events involving mass casualties. The victims of tragedies like Fukushima justifiably worry that their plight will be overshadowed by new horrors occurring on the world stage. One benefit of continued monitoring and research on the mental and physical health of these three catastrophes is that the work itself symbolizes the long-term compassion and caring of investigators, including for future generations. Although longitudinal cohort studies with appropriate comparison groups will ultimately produce the most useful data on incident health consequences (Svendsen et al. 2012), volunteer studies and convenience sampling designs (e.g., Ben-Ezra et al. 2012, 2013; Kyutoku et al. 2012; Palgi et al. 2012) may also have a favorable effect on morale and provide clues for epidemiologic research to pursue.

The lessons learned from research on TMI and Chernobyl that will hopefully be transferred to research after Fukushima include the importance of studying physical and mental health together in an integrated fashion, the need for long-term research and for appropriate unexposed comparison groups, the value of incorporating input from and sustaining community advisory groups, and lastly, the importance of presenting a balanced picture of

the impact of the event. The measurement of exposure, albeit frustratingly imprecise, needs to be clearly articulated to the study population. Lastly, the mental health measures should include the disorders described in this paper as well as strengths and resilience so that communities can engage in proactive, positive growth in spite of the unwanted stressors imposed on them directly and indirectly by these disasters.

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