Chapter 6
Emotional Consequences of Three Mile Island and Chernobyl: Lessons Learned for Fukushima

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Abstract The psychosocial consequences of the Three Mile Island (TMI) and Chernobyl nuclear power plant accidents are regarded as their biggest public health effect. This chapter reviews the specific evidence about the mental health impact of these enormous events and the unique role of damaging health risk perceptions stemming from perceived radiation exposure. The short- and long-term mental health consequences range from general distress in the form of anxiety and depressive symptoms to clinical depression and anxiety disorders, posttraumatic stress disorder (PTSD), and medically unexplained physical symptoms. The two most vulnerable groups after TMI and Chernobyl were mothers of very young children residing near the facilities and cleanup workers. The group of greatest concern, namely, children and adolescents raised in the shadows of these events, were not significantly impacted psychologically, socially, or cognitively. The mental health of older adults was not studied. Early findings from Fukushima suggest that anxiety and depression are major issues among the affected population. The elements needed for well-designed, inclusive, multidisciplinary studies of the psychological aftermath of Fukushima are discussed.

Keywords Three Mile Island • Chernobyl • Mental health • Cleanup workers • Mothers

6.1 Introduction

The TMI accident in 1979 and Chernobyl catastrophe in 1986 were vastly different events, with TMI classified by the International Atomic Energy Association as a level 5 accident (limited release of radioactive material) and the Chernobyl explosion classified as a level 7 (major) accident. Both occurred during the night, both involved human error, and both generated an intangible and frightening exposure

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(radiation). In addition, after these events, there was contradictory (TMI) or incomplete (Chernobyl) disclosure by authorities about what occurred, leading to a collapse of trust in official information and government officials, widespread rumors about adverse or bizarre effects on plants and animals, and claims that the accidents would cause hundreds (TMI) to many thousands (Chernobyl) of deaths. In both cases, the official consensus was that mental health was the biggest public health consequence of the accident [1, 2]. Yet, in contrast to this consensus, psychiatry researchers, radiation scientists, and mental health providers made little to no efforts to design interventions to mitigate the mental health consequences of these terrifying accidents. The costs of ignoring mental health after TMI and Chernobyl extend beyond mental health per se because psychiatric impairment is associated with mortality, morbidity, decreased productivity, and diminished quality of life [3].

6.2 Context of the Accidents

6.2.1 TMI

The accident at TMI began in the early morning of March 28, 1979, and evolved into a partial meltdown of the core and a small (0.4–1 terabecquerel) release of radioiodine primarily inside the reactor itself [4]. The average exposure dose to the two million people within 50 miles of the plant was estimated to be 0.015 mSv. Nevertheless, on March 30, the Governor of Pennsylvania issued an advisory for pregnant women and preschool children to evacuate the 5-mile area surrounding the plant, which was later extended out to 20 miles. In fact, 144,000 people, just under half the population, left. Most families returned to the area within 2 weeks [5]. Over the next several months, scientists and government officials publicly disagreed about the magnitude of the release and the potential for an increased incidence of cancer. The President's Commission report concluded that 1–2 excess cancers were possible (though unlikely), while antinuclear scientists claimed that the death toll would exceed 300 cases. In the long term, no increase in cancer morbidity or mortality attributable to the TMI accident was found [6], and the Commission's conclusion proved to be correct.

6.2.2 Chernobyl

The Chernobyl accident occurred 7 years later, in the early hours of April 26, 1986, and resulted in a massive explosion and complete meltdown, with extensive contamination in parts of Ukraine, Belarus, and Russia [2]. Potassium iodide prophylaxis was given to 5.4 million people. Approximately 135,000 people were permanently evacuated from the 30-km zone in the first months. Over time, that number grew to 350,000. The average exposure received by evacuees was 350 mSv. During the initial evacuation, pregnant women were urged to have abortions, although they were not told why, and most reportedly complied. By the end of the summer of 1986, 134 emergency personnel developed acute radiation syndrome, and 31 died. In all, more than 600,000 men and women were brought to Chernobyl to “liquidate” the consequences of the accident. The physical health aftermath of the accident included an increase in cataracts and suicide among liquidators and an increase in thyroid cancer among young children from drinking contaminated milk. To date, there have been 4,000 cases of thyroid cancer in children out of 18 million exposed, including 9 deaths. The highest-risk group for thyroid cancer is the age group in utero to 4 years [2, 7]. Responsibility for monitoring the long-term health consequences, particularly health problems among the liquidators, became complicated after the Soviet Union collapsed in 1991, when the economies of the independent republics were in shambles.

6.3 Research Contexts of the Accidents

In the USA, prior to 1979, disaster studies were anecdotal, were based on convenience samples, such as litigants, and utilized nonstandard questionnaires. In general, disaster studies, like community mental health research done at the time, focused on psychiatric symptom severity. In 1979, only one American study had administered a diagnostic interview with a community sample [8]. For that study, conducted in New Haven, Connecticut, Weissman and colleagues trained social workers to administer the lifetime version of the Schedule for Affective Disorders and Schizophrenia (SADS-L) [9]; diagnosis was operationalized using the Research Diagnostic Criteria [10]. The New Haven study showed that diagnostic interviews were acceptable and could be administered reliably to non-patient samples. Then in 1980, the American Psychiatric Association published the third edition of the *Diagnostic and Statistical Manual for Mental Disorders* [11], which for the first time provided operational definitions of common psychiatric disorders like depressive and generalized anxiety disorders, as well as codifying posttraumatic stress disorder (PTSD). A structured interview to assess common DSM-III disorders in community samples was published the following year [12]. Thus, TMI occurred just before these major breakthroughs in nosology and assessment and at a time when disaster research was outside the purview of epidemiology.

When Chernobyl occurred, no foundation existed for conducting systematic research on mental health, let alone on the psychiatric and medical consequences of a disaster. Indeed, there was no tradition of population-based health studies in the former Soviet Union and no tradition of random sampling and personal interviews. DSM-III was unknown. There was no system of outpatient mental health or substance abuse care. People with schizophrenia were put in psychiatric hospitals, and alcoholics were managed by the prison system. To complicate matters, psychiatry was often used as a means of social control, and stigma against people with mental illness was rampant.

Thus, both situations required pushing the envelope in terms of research methods, and both proved to be catalysts for developing psychiatric epidemiologic studies of disasters more broadly. Currently, there are many epidemiologic studies of disaster survivors after both natural and environmental catastrophes [13, 14].

6.4 Mothers of Young Children in the Aftermath of TMI and Chernobyl

6.4.1 TMI

The Behavioral Health Task Force report to the President's Commission on the Accident at Three Mile Island indicated that in the immediate aftermath, there were acute psychological effects on mothers of young children and newborns [15]. There was also compelling evidence from non-disaster studies that women with small children in high threat stressful conditions had an elevated rate of depression [16]. Thus, in the summer of 1979, when the National Institute of Mental Health asked us to evaluate the psychological effects of the accident, we focused on mothers of young children living near TMI. Since the study was designed before DSM-III and its new PTSD diagnostic category, we tested whether TMI mothers had higher rates of major depression and generalized anxiety disorders as defined by the Research Diagnostic Criteria [10] as well as greater psychological symptom severity than controls.

The TMI sample included approximately 400 mothers living within 10 miles of TMI, almost all of whom had evacuated the area for about 2 weeks. We were not allowed to access vital statistics records, and thus the sample was identified from birth announcements in local newspapers, which was a universal practice at the time. In addition, we selected a comparison sample of approximately 180 mothers residing near a nuclear power plant in Western Pennsylvania. The mothers were interviewed with the SADS-L [9] by social workers and psychologists at 9, 12, 30, and 42 months post-TMI. At the 30- and 42-month points, we added a comparison group of 175 mothers living near a coal-fired plant. The undamaged reactor at TMI was restarted in 1986 after a long court battle. At that time, we mailed questionnaires on mental health and risk perceptions to the TMI sample. We also mailed similar questionnaires to the TMI sample at the 10th anniversary in 1989. The response rate to the mail-out questionnaires was about 50 %. (For details, see [17].)

Early on, as expected, the rates of depression/anxiety disorder and depressive and anxiety symptoms were significantly higher in the TMI mothers compared to the other groups. By the 30-month point, the symptom rates of the TMI mothers remained steady, but the rates in the comparison women increased as a consequence of the high unemployment that suddenly rocked the communities in Western Pennsylvania where the comparison groups lived [17, 18]. At the 10th anniversary, rather than symptom rates declining with time, as suggested by the few population-based studies conducted after TMI [15, 19–21], the symptom rates remained stable and higher than expected [22]. Moreover, risk perceptions, which were not significantly related to mental health early on, became important correlates of mental health at the later time points [22, 23].

6.4.2 Chernobyl

The Chernobyl study of maternal mental health was conducted in Kiev (Ukraine) 11 and 19 years after the accident. Prior to this, two methodologically rigorous studies had shown that mothers of young children were a high-risk group in areas contaminated by radiation in Russia [24] and Belarus [25]. Thus, we selected 300 evacuee mothers (80.7 % came from Pripyat, the city near Chernobyl built for employees and their families) and 300 mothers whose child was in the same homeroom as the evacuee children (comparison group) [26]. The evacuee mothers were randomly selected from a sampling frame of evacuee families in Kiev with children who were in utero to age 15 months at the time of the accident. The comparison families were in Kiev when the accident happened, though most sent their children to live with relatives in other parts of the Soviet Union in the summer of 1986. At the 19-year point, we added a population-based comparison group [27].

The measures and interviewer training materials were translated and back-translated into Russian and Ukrainian following the procedures outlined by the World Health Organization. All interviews were conducted face to face by trained interviewers. Demographically, the Chernobyl mothers were similar to the TMI mothers in age (average age of 37 at the 11-year point), marital status (most were currently married), and family size (average of two children). More of the Kiev women had education beyond high school [28].

Overall, the evacuee mothers were more symptomatic on every measure compared to Kiev mothers [26, 29, 30]. Specifically, they endorsed more symptoms of depression, anxiety, PTSD, and somatization than comparison women. The biggest factor that accounted for these differences was the negative risk perceptions of the evacuee mothers and being told by a doctor that their health problems were linked to Chernobyl [29, 30].

6.4.3 Comparison of TMI and Chernobyl Mothers

At year 10, the TMI mothers completed the anxiety, depression, and anger subscales of the Symptom Checklist-90 [31]; at year 11, the Kiev mothers completed the Russian version of the same measures [32]. Symptoms occurring in the past

2 weeks were rated on a 5-point scale (0 = not at all distressed, 4 = extremely distressed). The anxiety subscale contained ten items; in a US normative sample of women, one standard deviation above the mean was 0.74. The depression subscale contained 13 items (one standard deviation = 0.78), and the hostility subscale had 6 items (one standard deviation = 0.66). There were no normative data for the SCL-90 in Ukraine. Thus, the one standard deviation mark from the US normative data was used to create high- and low-symptom groups.

In both sites, mothers were asked to rate their health. In the TMI study, the scale was excellent, good, fair, or poor. In Kiev, after piloting, the scale was excellent, good, moderate, bad, and very bad, reflecting cultural differences in modal responses to this question.

Two risk perceptions were also assessed in both studies: do you believe that the accident affected your health? Do you believe that the accident affected your children's health? The response options for TMI mothers were "yes, unsure, no" (yes and unsure were compared to no), while for Chernobyl, the options were "yes very, yes somewhat, and no" (yes very was compared to somewhat or no; almost no one endorsed the "no" option).

Figure 6.1 shows that more evacuee mothers scored in the high range on the depression, anxiety, and hostility symptom scales compared to TMI mothers, and Kiev classmate comparison mothers were midway between the two groups. Similarly, while approximately 10 % of TMI mothers rated their health as fair or poor, 38.5 % of evacuees and 23.2 % of Kiev controls rated their health as poor/very poor. The same pattern was found for the two risk perception items, with fewer TMI mothers expressing concern compared to evacuees and Kiev controls being midway between the two.

In spite of these overall differences, the relationships of health risk perceptions to psychological symptom scores and subjective health ratings were remarkably

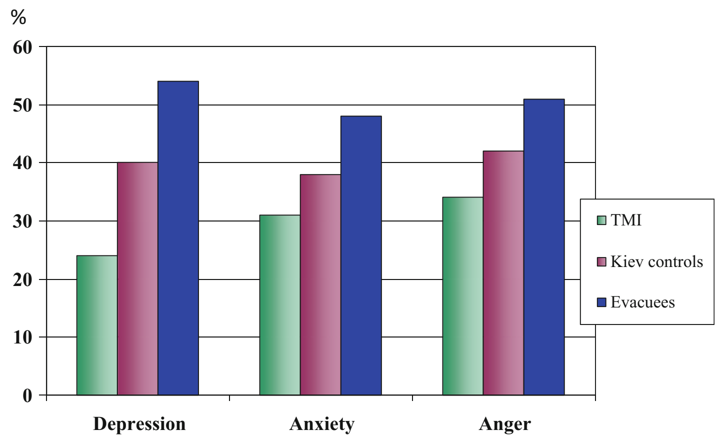

Fig. 6.1 Percent with high depression, anxiety, and anger symptoms in TMI, Chernobyl evacuee, and Kiev mothers 10–11 years after each accident

similar in the TMI, evacuee, and Kiev comparison groups. That is, mothers who believed that their health or their children's health was adversely affected by the accident had a two- to threefold increased odds of having high anxiety, depression, and anger and poor subjective health than those who were less concerned [28]. These parallel results were all the more striking because of the substantial differences between the TMI and Chernobyl mothers in exposure severity and socioeconomic circumstances.

The TMI and Chernobyl findings, combined with results of long-term assessments of A-bomb survivors [33–37], support the hypothesis that the mental health consequences of Fukushima will follow a similar pattern. Indeed, recent short-term evidence from the Fukushima Health Management Survey [38–40] is consistent with the TMI and Chernobyl reports.

6.5 TMI Workers and Chernobyl Liquidators

6.5.1 TMI

The President's Commission conducted an extensive analysis of the mental health of TMI employees [41]. Compared to workers at a nearby power plant in Eastern Pennsylvania, TMI workers showed increased demoralization, especially nonsupervisory workers. Following on this study, we assessed depression and anxiety in TMI workers during the first 4 years (9, 12, 30, and 42 months) following the accident. A total of 170 TMI workers and 160 workers at a nuclear plant in Western Pennsylvania were interviewed with the measures described above for TMI mothers [17]. At the 30- and 42-month points, we added a sample of 159 coal-fired plant workers from Western Pennsylvania. Although there were short-term differences in the expected direction, they were attributable to working conditions rather than to the TMI accident. Moreover, there were no long-term differences among the three groups of workers. The vast majority of TMI workers did not perceive the situation as dangerous.

6.5.2 Chernobyl

Chernobyl liquidators have been the subject of numerous local studies suggesting that highly exposed workers developed long-term cognitive impairments [42]. However, these findings have not been confirmed by international investigators. Moreover, the cohorts were convenience samples that do not provide generalizable data, the test conditions of liquidators and controls were not uniform, and, most importantly, the analyses did not consider alternative explanations for the deficits observed, such as alcoholism, extreme fatigue, and fatigability.

In contrast to the ambiguity of findings about cognitive functioning, the adverse mental health consequences of serving as a liquidator are compelling. The long-term emotional toll of working as a liquidator was first reported by Rahu and colleagues [43] who found a higher than expected rate of suicide in the 5,000 liquidators from Estonia relative to the general population for the period 1986–1993 (standardized mortality ratio = 1.52; 95 % confidence interval = 1.01–2.19). Rahu and colleagues later confirmed their finding in an extended period of follow-up [44].

We subsequently conducted structured diagnostic interviews with 295 Ukrainian liquidators 18 years after the accident [45]. They had been assigned to work at Chernobyl between 1986 and 1990. None had a history of acute radiation syndrome. Their mental health was compared to 397 geographic matched men who had not served as liquidators. The control group lived in the same region as the liquidators and had participated in a national survey of mental health using the same structured interview. The diagnostic interview was a Russian and Ukrainian translation of the WHO Composite International Diagnostic Interview (CIDI) developed for use by the World Mental Health Survey Consortium [46]. Compared to controls, significantly more cleanup workers had major depression (18.0 % vs 13.1 %), suicide ideation (9.2 % vs 4.1 %), and severe headaches (69.2 % vs 12.4 %). Their odds of PTSD in the past year were 3.5 times higher than that of the controls. Most importantly, liquidators with depression and PTSD had substantially more work loss days compared to controls with these disorders and men in both groups without these disorders [45].

Liquidators also completed an exposure and symptom questionnaire. Those in the highest exposure category (working on the roof or in the industrial site during April–October 1986) had significantly greater somatization and PTSD symptom severity than liquidators with moderate (other workers on site in 1986–1987) and low (workers first sent to Chernobyl from 1988 to 1990) levels of exposure.

The Fukushima workers' experiences are more similar to those of the Chernobyl liquidators than TMI workers. The findings by Shigemura et al. [47, 48] indicate that TEPCO workers at the stricken Daiichi plant report significantly more psychological impairment on multiple measures than similar workers at an unaffected nuclear power plant in the same region. These kinds of symptoms, particularly PTSD symptoms, often become chronic and persistent. The workers also reported substantial stigma and slurs directed toward them, and these reports were significantly correlated with distress and PTSD symptom severity [47].

6.6 Children After TMI and Chernobyl

Our research after TMI and Chernobyl found no psychiatric, social, academic, or cognitive differences between exposed children and controls as toddlers (TMI) [49], at age 11 (TMI and Chernobyl) [26, 50] and at age 19 (Chernobyl) [51]. Other international studies of Chernobyl-affected groups who immigrated to other countries also found no relationship of radiation exposure and neuropsychiatric functioning [42]. On the other hand, local studies have produced findings showing impairments in highly exposed children, and northern European studies without direct data on radiation exposure have also suggested that Chernobyl had a neuropsychological impact (for review, see [42]). Since the highest exposure of Chernobyl children was lower than the lowest exposure of young A-bomb survivors who developed cognitive impairments, it seems unlikely that meaningful decrements associated with radiation exposure would exist. The discussion, however, remains open.

6.7 Lessons for Fukushima

Risk perception research has shown that exposure to radiation accidents and events, whether actual or perceived, is among the most feared and pernicious of risk perceptions. As noted earlier, at the 20th anniversary of the Chernobyl accident, the Chernobyl Forum concluded that the mental health impact was the biggest public health effect of the accident [2]. Previously, after the TMI accident, the President's Commission on the Accident at Three Mile Island had come to the same conclusion [1]. It is already becoming evident that mental health is a major component of the public health impact of Fukushima as well [52]. It is also likely that the effects will be long lasting given the devastation of the triple disaster. The evacuation zone covered 50,000 people living within 20 km of the facility and other communities found to have high levels of contamination. Thus, the relative and absolute magnitude of the psychological impact of the Fukushima nuclear plant accident cannot be overstated.

The World Health Organization (WHO) defined health as *a state of complete physical*, *mental and social well-being and not merely the absence of disease or infirmity*. The WHO estimates that disorders like depression, anxiety, and PTSD, which occurred after these nuclear power plant accidents, will be the second leading cause of disability in the industrialized world in the year 2020 [3]. After World War II, when epidemiology shifted its focus from infectious diseases to chronic physical and mental disorders, a large number of population-based studies were conducted that consistently showed that poor mental health leads to increased mortality, medical morbidity, and impaired quality of life [3]. The implications for the design of effective intervention and prevention programs are obvious. Health-care providers need to be knowledgeable about both medical and psychiatric conditions, and integrated treatment programs are critical. It is noteworthy that each event – TMI, Chernobyl, and Fukushima – occurred in regions where integrated care was not the norm and mental health was barely acknowledged as a co-occurring diagnostic condition worthy of treatment.

TMI families moved back to their homes. Chernobyl families were resettled in other cities. The early adjustment period was fraught with difficulties stemming from stigma toward the evacuees, fear by local residents and local medical providers that the evacuees were contaminated, resentment by local residents who had waited for years to move into the new apartments given to the evacuees, and special benefits accorded to evacuees. Eventually, however, the evacuees, especially their children, became integrated into their new communities. The situation in Japan is more complex, given the stigma expressed toward A-bomb survivors that became redirected toward evacuees [53] and Fukushima plant workers [47]. The triple catastrophe occurred during a difficult economic period in Japan. Some evacuees wish to return to Fukushima after their villages are decontaminated, but jobs in these communities are scarce. Some evacuee families are separated because husbands' jobs are far from home. Still other evacuees prefer not to return to their villages and towns, particularly younger people who more easily found jobs in their new communities. Others fear moving back because of lingering concerns about radiation and distrust of official safety reports [54].

Many elderly people in nursing homes died during the evacuation and in the first 9 months after the disaster started [55]. The rates of alcoholism and suicide in older residents of Fukushima are higher than in other parts of Japan [52], though the suicide rate was higher even before March 2011. Unfortunately, after TMI and Chernobyl, there were no English-language publications on the psychological and alcohol sequelae among older people. There are anecdotal reports that some older people have moved back into the exclusion zone around Chernobyl, but no hard data about this population. Thus, there is little guidance about what to expect in the longer term after Fukushima.

Consistent with TMI and Chernobyl, mothers of young children are emerging as one of the most vulnerable populations [56]. It is important that obstetrician/gynecologists and pediatricians be aware of the signs of psychological distress in mothers and given basic tools for managing these symptoms and referral sources if the problems persist. Since many women do not spontaneously talk about mental health concerns, it is important for their medical physicians to ask about mental health directly. Even a short symptom questionnaire administered in the waiting area would alert the physician to co-occurring psychological issues that need to be addressed during the visit. In our Chernobyl sample, the association between distress severity and number of diagnoses (anemia, cataracts, thyroid, immune system problems, arthritis) among mothers was .42 ($p < 0.001$). Together, mental and physical health problems are also more strongly associated with disability than either one alone.

Mental health literacy extends beyond physicians, however. Raising awareness about and destigmatizing mental health problems need to be done at the level of the general population and community leaders and officials. Shortly after the

Fukushima accident, Japanese psychiatrists asked organizations like the World Psychiatric Association to provide information about psycho-education and treatment for the psychological sequelae of traumatic events [57]. To the extent that medical professionals, particularly non-psychiatrist physicians and nurses, interact with local community leaders and residents around these issues, rather than doing so through mental health specialists, the messages will be more readily received. At the conclusion of our Chernobyl research, we held a "town hall meeting" with all of the participants where we presented the findings and addressed their questions. It was striking that the highlight of the event was the report by the hematologist in our research group. Even though the findings were contrary to local rumor, the community perceived him as "on their side" and trusted that he was not engaging in more of the misinformation that had been gone on for years. Physicians have little to no experience in these kinds of settings. It is therefore important that they learn the skills they need to make such presentations and handle questions and answers and communicate more effectively to large groups. Communication is a dialogue. Physicians are trained to deliver information. Learning to handle challenging questions from informed, and sometimes misinformed, community members and journalists, is a critical skill in the twenty-first century and in post-disaster circumstances. Indeed, communication has become a pivotal issue for physicians and scientists as a result of Fukushima [58].

Long-term mental health research can provide critical information for identifying high-risk populations and for targeting interventions. Suggestions for developing and implementing such studies include:

1. *Multidisciplinary teams of medical and mental health specialists in equal partnership with members of the community*. This enables the acquisition of data that reflect issues of local concern. In addition, it facilitates the success of the study in all respects, including conceptualization, design, field work, analysis, and appropriate and timely communications of the findings to the study participants. Creating teams allows for the development of trust and the sharing of experiences that will be reflected in every aspect of the study. It is also important to be aware of personal biases and resentments among team members who were affected by the disaster so that the study and analysis are systematic and balanced. Consensus-driven research, according to Raphael and Ma [59], is an important element to understanding the complexity of the risk perceptions, responses, and other sociocultural risk and protective factors.
2. *Ongoing stakeholder dialogue meetings in open forums to discuss research and general mental health issues*. These meetings are critical to maintaining trust and can facilitate the success of the next generation of studies designed to investigate longer-term health and mental health issues. From a participant's perspective, how one study treats respondents reflects on scientists in general, not just on the specific study. Moreover, no matter how well conceived and designed the study, if the results are primarily published in scientific journals, rather than shared with local communities, eventually people begin to feel like "guinea pigs." It becomes a delicate balance not to bias respondents' information for future

studies while sharing the purpose and findings of current studies. But it is the balance that is critical to think through. The verbal and nonverbal communication and language at these meetings are also important elements of successful communication and maintenance of trust.

3. *Community education*. Most investigators focus on the questions to be asked and the response options of the measures. In fact, field studies are opportunities for one-on-one active listening, responding to concerns, and education about radiation and about mental health. This means that interviewers and raters need a tool kit and proper training to handle questions knowledgeably. Studies that rely on mail-out questionnaires can include boxes for respondent questions and concerns. The Fukushima Medical University surveys included such boxes, and a public health nurse was trained to call respondents and discuss their concerns on the phone [38].
4. *Use of social media*. Younger populations are engaged in social media activities. Investigators should also have an active presence on social media sites in order to promote the importance of their research and to communicate results more broadly [58]. To the extent that social media attracts opinionated and angry constituents, it is all the more important to engage this population using a medium with which they are comfortable. These interactions can also be used to educate people about what constitutes "good" versus "bad" science.
5. *Improving participation rates*. Response rates in disaster studies are often very low, and this means that the results are not generalizable to the original target population [60]. Response rates of comparison groups are often lower than affected groups. In Fukushima, as a consequence of the decaying level of trust in scientists and other authority figures, it has been especially challenging to obtain reasonable response rates (60 % or more). It is thus important to build trust before launching a study. It is also reasonable to consider including incentives for participation. One incentive is a free physical examination, thyroid test, and blood tests along with timely feedback of the results. Another incentive is financial rumination or a meaningful gift. If the study is being conducted face to face, then the other critical element is the training of the interview staff on the importance of a high response rate and on motivational interviewing. The interviewers should also learn how best to handle resistance and convert reluctant individuals. This is important to monitor so that interviewers who do not obtain an adequate response rate are retrained or reassigned.
6. *Communication*. As noted in many reports, the disaster at the Fukushima Daiichi facility was followed by misinformation, untruths, half-truths, and contradictory information by the scientific community. All of this was updated minute by minute on television, in social media, in newspapers, and on the radio. It was often the case that scientists with the best communication skills were those passing along erroneous, alarmist information, while scientists with the best understanding of radiation communicated primarily with one another, talked to the public using incomprehensible jargon, or were dismissive of the public's concerns. Communicating science is a skill. It requires understandable language, knowing one's audience, anticipating questions, and showing sincere respect for

people's concerns. Before the presentation to the respondents after the Chernobyl study, the American and Kiev investigators met for an entire week to discuss our presentations. The Kiev investigators were reluctant to present the comparisons of evacuee and control children because the absence of significant differences was contrary to official dogma reported in the media. In the end, the hematologist, who was the most concerned, gave out his phone number so that parents who wanted further testing could receive it free of charge. When the meeting concluded, the hematologist, who was surrounded by parents who wanted further tests, was smiling with the audience, and the atmosphere was exceptionally congenial.

6.8 Conclusion

Solid epidemiologic data on mental and physical health and risk perceptions are needed after toxic disasters, and especially after Fukushima, a triple catastrophe, and ongoing nuclear power plant disaster. The studies must be unbiased and built on a foundation of trust with the affected community. The information can then be used to develop and locate needed interventions. It is thus important that multidisciplinary studies be designed and conducted in collaboration with community leaders and that the concerns of the affected population are incorporated. If research is to have translational value, the data must be inherently reliable, valid, and generalizable. Research gives a voice to affected populations, and that voice is heard at local, regional, and international levels. Nuclear power plant disasters have long-term consequences and thus require long-term investments in research to understand the evolving needs of populations who found themselves in the wrong place at the wrong time.

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