

IMPACTS OF RADIATION FEARS ON JAPANESE NATIONALS FOLLOWING THE FUKUSHIMA NUCLEAR ACCIDENT

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ABSTRACT

Nuclear accidents pose a multitude of risks but one seldom prioritized is the mental impact that radiation fears impose. Following the disaster in Fukushima, the primary damage was psychological as perceived fears caused greater public health and economic costs than direct radiation exposure. Nuclear threats manifest as an ambiguous risk for laypeople that extends beyond acute dosage and warrants extensive consideration as possibly unfounded yet perceived dangers can nevertheless elicit substantial problems as exemplified by Fukushima. Acknowledging and understanding the mental effects of nuclear accidents is critical in mitigating human suffering in inevitable future disasters as glaring similarities exist with past events that are expected to recur. Japan continues to struggle with the psychological impacts imparted by radiation risks even today and in the foreseeable future due to inadequate preparedness and fear-driven actions based on current ineffective protocols implemented for recovery. No major proposed regulations nor efforts to tackle challenges stemming from radiation fears have arisen, but it is demonstrated that overcoming them is essential in constructing comprehensive responses following nuclear accidents.

1. INTRODUCTION

The Fukushima disaster imparted numerous costs on Japan, but infrequently discussed are the health consequences stemming from radiation fears. Following the accident, continuous developments regarding containment of the Fukushima Daiichi reactors were broadcasted, but as a feature published by *Nature* states ‘Japan kept people safe from the physical effects of radiation—but not from the psychological impacts’ [9]. Despite the Japanese government’s best intentions and arguably reasonable actions, psychological damage emanating from risk perception and misguided fears was the greatest harm caused by the nuclear accident in Fukushima. In particular, per-

ceived risks resulting from compromised resources, living spaces, and health outcomes caused the greatest distress. People naturally worry about air quality, food contamination, and personal radiation exposure if potentially harmful sources are identified. Whether these concerns are unfounded or not, they can have substantial repercussions. Broad yet basic components of life were impacted to varying degrees by Fukushima, and parallels are observed in past accidents. This warrants consideration of these primary risks and their effects on different peoples within Japan following the accident to help ensure pernicious panic does not propagate in future nuclear disasters. Radiation certainly poses legitimate risks and a level of fear was warranted after Fukushima, but

distinguishing actual threats from conjured hysterics is paramount for recovery after a nuclear disaster.

To preface the ensuing analysis, March 11, 2011 was undoubtedly a disruptive day on ordinary life in Japan due to an unprecedented sequence of events: a 9.0 magnitude undersea earthquake struck on the east coast of Japan precipitating tsunami waves that instigated a state of emergency since flooding caused failure of Fukushima Daiichi Nuclear Power Plant’s cooling system. The whole series of events—earthquake, tsunami, and nuclear accident—ultimately resulted in over 15,000 total deaths, displacing a quarter million citizens from their homes, and meltdowns of three nuclear reactors at Fukushima [25, 75, 1, 8]. The World Bank estimated this event as the costliest disaster in recorded history with economic expenses in excess of US\$235 billion [33]. After nuclear disasters, perception of nuclear energy can become a significant influence in shaping the country’s future. Nuclear power quickly became a delicate topic in a nation that utilized it for about a quarter of their electricity and proposed building 8 additional reactors in a decade [12, 69]. It is necessary to retain this context in consideration since the perceived risks and psychological impacts outlined are not due to the nuclear accident’s effects in isolation; instead they arise in a connected and complex world with other turbulent situations incontrovertibly affecting numerous aspects of life. While no members of the public received a dangerous dose of radiation [8], the residents nevertheless encountered a plethora of reasons to worry which ultimately became even more harmful than any radioisotopes.

Suppressing unnecessary radiation fears tactfully is vital for current countries with nuclear reactors located near metropolitan areas in the event of an accident. Bill Borchardt, the executive director of operations for the U.S. Nuclear Regulatory Commission (NRC), stated that if an event akin to Fukushima occurred in America’s 99 re-

actors, then the evacuation zone would extend out to 80 kilometers encompassing a total area with over 180 million residents. The NRC’s Patricia Milligan does not anticipate changes in planning zones following Fukushima [2], although undue complacency would be imprudent as the conditions necessitating evacuation are amiss. Certain necessary actions following Fukushima were undertaken by the NRC such as improving safety functions in power failure events, supplying additional monitoring equipment, installing filtered vents, and planning emergency reactor infrastructure (e.g. staffing) [94, 95], but a comprehensive post-accident psychological health strategy coordinated by organizations such as the NRC, Environmental Protection Agency (EPA), and Federal Emergency Management Agency (FEMA) is lacking [40, 42]. A leaked un-redacted version of the NRC’s analysis of dam failures and flooding risks following Fukushima discovered nearly one-third of U.S. nuclear reactors may encounter water hazards exceeding design limits [56, 90]. The NRC has been aware of this severe nuclear accident risk for over a decade and attempted concealing it from the public out of potential embarrassment, but preparedness for such events is vital. A future meltdown may be quite different from Fukushima, but even if it is not identical, the mental impact on humans can be considerable.

As outlined in this report, regulating governmental agencies should carefully address psychological damage following nuclear disasters. Forced evacuations and associated responses may be inadvisable since unintended effects could cause greater damage than directly from radiation. In 1979 when authorities advised residents within 30 kilometers of the Three Mile Island (TMI) nuclear reactor to evacuate voluntarily, a majority of them did not [2]. Thus emergency planning zones, effective communication, and consideration of evacuation procedures and the toll it has on people is crucial in coordinating disasters, especially with the unique challenges of radiation fears. Current efforts by Tokyo Electric Power Company

(TEPCO) is widely observed to be adversely impacting life in Japan as approximately 88% of Japanese citizens disapprove of TEPCO's handling of Fukushima and likewise consider the national government unhelpful [58]. Fukushima's mental health influences are multifaceted and essential to document as radiation fears and psychological damage are intrinsically tied. This report underlines the ineffectiveness of current measures and mental counselling implemented following nuclear accidents, and the risk perception of radiation that can be most damaging and poorly controlled as witnessed in Japan.

2. BUILDING WIDESPREAD MISTRUST

Pessimism apropos Japan's future became pervasive throughout the country following the nuclear accident at Fukushima [58]. In the first days after declaring a state of emergency, residents were beginning to learn of the situation's magnitude on the basic necessities of food and water: Local authorities reported traces (within safety limits) of iodine-131 and cesium-137 in drinking water in regions such as Maebashi for the first time in two decades that testing has been performed [47]. Samples of radioactive particles collected in surrounding agricultural land raised the possibility of replacing contaminated soil posing potential harm to Fukushima's farmers and final consumers [48]. Radioactive iodine was present in dairy milk above allowable ranges in certain cities and tainted spinach was discovered over 140 kilometers away from the Fukushima Daiichi plant, prompting Japanese authorities to provide iodine pills for evacuees. Officials such as Japan's chief cabinet secretary, Yukio Edano, tried to alleviate fears and claimed present radiation levels in foods posed no immediate health threats, but food safety inspectors were discovering otherwise [1]. Some other vegetation and goods (e.g. leaf greens, apricots, mushrooms) derived from neighbouring areas of Fukushima exceeded consumption standards and the Japanese government sought comprehensive agriculture testing to as-

suage widespread anxiety. Despite authorities providing reassurances and radiation-contaminated foods being largely exaggerated in the public [21], concern remained prevalent due to isolated occasions of official incompetence and mislabeling of contaminated supplies for public use [24]. Over three quarters of the Japanese population believed food from Fukushima was unsafe, and fears of radiation contaminating food were not solely possessed by the country's consumers [58]. Beef producers were slow to test cattle and feed because of fears of damaging their market, and countries were documented to be testing all food imports from Japan after the tsunami. With conflicting instructions and circulating reports, Japanese citizens were avoiding sources even deemed safe by the government [1]. Being unable to trust basic necessities without a faithful resolution in sight placed constant pressure on individuals and induced anxiety even when simply eating. Staying fearful transformed the relationship between authorities and the public.

Mistrust of politicians and government-funded researchers became rampant especially due to the confusion immediately following the meltdown and people not believing government health surveys which claimed only a few cases of evacuees received significant radiation dosage [9]. When under prolonged stress, residents near TMI similarly remained skeptical of personal exposure and forthcoming of results from regulating bodies and government members responsible for their welfare. Japanese authorities repeatedly raised radiation exposure safety limits (due to no preexisting provisions accounting for emergency scenarios) to avoid legally-required evacuations of all reactor personnel. This resultantly led to feelings of incompetence and neglect towards the Japanese government being fostered. In 1986 the Soviet Union implemented an information blackout following Chernobyl, but the situation in Fukushima developed diametrically differently as information was readily disseminated by the army, international moni-

tors, scientists, and educated citizens [8]. Children near Chernobyl continued playing outdoors after the accident and distribution of prophylactic potassium iodide was absent which unnecessarily compromised the safety of these individuals [55]. The Japanese government has corrected these past mistakes and attempted initiatives to gain credibility including extensive, albeit arguably needless, decontamination operations [37], although local communities and independent researchers have displayed an inclination to solve problems themselves without government influence [8].

Questions remained weeks after the original incident at Fukushima itself fueling further fears. Uncertainty regarding possible uncontrolled reactors overheating ballooned, and the public remained largely unaware of the situation's exact severity [1]. Discussions of radiation fears were becoming immune to scrutiny in certain places, too. Fictional heroes whose enemies complain about radioactivity surfaced and a clash arose: reducing negativity towards the current environment versus underplaying dangers [24]. This type of insensible silencing further marginalized certain populations and stunted needed conversations. Warranted and unwarranted hysteria surrounding the nuclear disasters subsequently migrated throughout the world rapidly: the European Union's Energy Commissioner described the event as an 'apocalypse' to the European Parliament [14] while the World Health Organization (WHO) reported people consuming iodine tablets without consulting a physician and being admitted to poison centers out of radiation fears [102]. Life was evidently altered for numerous Japanese nationals after Fukushima's meltdown and mistrust towards the government grew as these broadcasted warnings and public reassurances could not be duly trusted.

3. FALLOUT FROM EVACUATION

One of the most highly debated aspects of the Japanese government's response to Fukushima was the forced evacuations. A greater number of deaths occurred in the Fukushima Prefecture region due to nuclear evacuation alone than the preceding earthquake and tsunami combined [25, 75]. Hindsight yields clarity and risk management is a sensitive issue, but evacuation in Fukushima led to unnecessary deaths and was concluded to be an economically and medically inadvisable response largely driven by fear [98]. Using the K6 psychological distress scale which is based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), it was revealed that 14.6% of evacuees exhibited mental health issues after Fukushima compared to 3.0% across Japan during non-disaster periods with a strong correlation between environmental radiation levels and psychological distress as visualized in Figure 1 [38]. This was exacerbated by increased perception of risk which is dependent upon proximity to the radiation source.

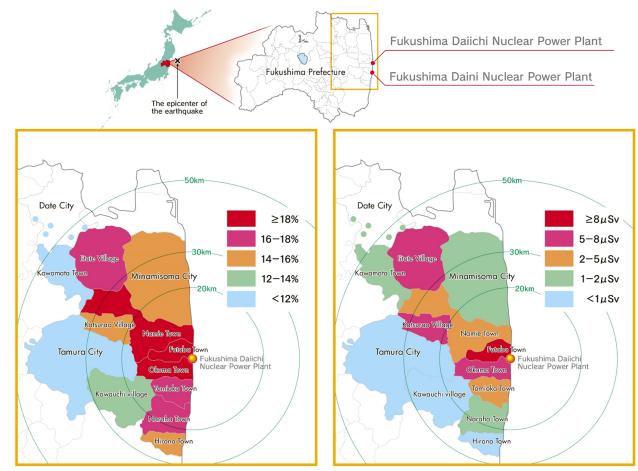


Figure 1 : Percentage of population reporting psychological distress one year after Fukushima (left); environmental radiation measured dose per hour (right) [38].

Even before complying with evacuation orders, incidents of suicide were reported for reasons such as elderly persons viewing themselves as a burden on their supporting

families during the progressing nuclear crisis [78]. The transpiring mass migration relocated 97% of the 76 000 people residing within 20 kilometers of the Fukushima Daiichi reactors within 4 days of the meltdown, with a majority of evacuees in the Fukushima prefecture doing so voluntarily. Unfortunately, this displacement process itself was poorly coordinated taking an extensive toll on mental health and splitting apart families. Inadequately organized evacuation procedures coupled with uncertainties in radiation levels caused unnecessary distress due to repeated expansion of evacuation areas, inadequate protection measures, and precarious resources (e.g. gas, water) slowing evacuation efforts [22]. Anxiety was high as a fifth of all evacuees were transferred to more than six separate destinations with some individual trips lasting for longer than 48 hours. Previous studies suggest more than two relocations after a disaster increases the risk for evacuees developing psychiatric problems due to restructuring lifestyles, familial separation, and losing familiar social support networks [26, 19], which are lessons learned redundantly through Fukushima. And temporary shelters were common endpoints for extended stays owing to implemented restricted zones [22], which are noted for promoting susceptibility to communicable illnesses, cardiovascular diseases, and mental stress [46, 89, 79]. Accompanying lifestyle changes became prominent as well as the percentage of overweight evacuees grew nearly 8% after the disaster while this was a 2% increase for non-evacuees [53]. Adjusting to temporary housing for long durations can be difficult as the future envisioned by some evacuees is no longer possible, and setting long-term goals can be difficult without permanence. Those who had a particular life ahead of them now feel trapped because of radiation dangers they largely do not fully comprehend [70]. Home was now transient and the wandering for permanence continued for a yet unspecified duration.

Adapting to new circumstances can be especially diffi-

cult for elderly people. Known to have an ageing population [21], Fukushima's medical and nursing care facilities were particularly vulnerable and over 50 elderly patients died during initial evacuations from nearby zones due to lacking medical support [83]. Following this loss of life, further hospital evacuations involved increased disaster medical assistance, transport vehicles, adjusted transportation routes, and better arrangement with admitting facilities which resulted in zero deaths during the evacuation of over 500 inpatients and elderly people [96, 105]. Thousands of healthcare personnel arrived in disaster-stricken areas by May 2011 to assist ongoing medical efforts, but poor communication of information on radiation curbed their utility [82, 84].

Preventing fear-driven responses in nuclear crises is an important task in public health [57], otherwise discrimination, stigmatization, and scapegoating arise [85, 17]. A survey administered by the Fukushima government discovered significant mental health issues and poor health perceptions in adult evacuees and emergency workers demonstrated a heightened risk for psychological trauma [103, 4, 61, 71]. Numerous additional factors influencing fear of the future arose from the evacuation due to familial discordance, unemployment, poor compensation, loss of community, and hyperarousal [45, 22]. In the years following Fukushima, when many evacuees were permitted to return home, 53% of total residents of Namie (4 kilometers away from the Fukushima nuclear plant) and over 75% of those below thirty-years-old decided against a return citing personal safety concerns [81], affecting the demographics and sustenance of the region. Many public facilities including schools remain closed within the formerly designated 20-kilometre restricted zone as well, signaling that the evacuation was no longer a temporary relocation for numerous victims.

The various types of loss experienced after nuclear disasters is quite unique. Even within Japan, Fukushima's nuclear crisis impacts are more ambiguous than the preceding tsunami's effects. This can cause struggles in coping as prevalence of psychological illness was greater than double in Fukushima evacuees compared to strictly tsunami victims [38]. For example, nuclear evacuees were forced from homes that appeared perfectly normal, and many cannot return home due to uncertain employment opportunities and fears of insufficient decontamination, yet tsunami survivors are able to largely rebuild what was lost [44]. Certain significant risk factors for psychological distress are loss of life, destruction of property, personal vulnerability (e.g. history of mental illness), lacking medical attention, and contradictory information [4].

Inter- and intra-familial conflicts have grown, too. Knowledge of certain populations receiving greater financial compensation has developed resentment as people just outside the evacuation zone believe they are neglected victims of radiation exposure lacking governmental support. Frustrations from neighbouring regions accepting numerous evacuees are also present [44, 24]. Beliefs about radiation fears are held deeply and a trend known as 'atomic divorce' has emerged after Fukushima due to relationship straining and marriages melting down because of deeply conflicting views on radiation safety (e.g. relocating family, changing habits, pregnancy fears) [70, 24]. This is yet another cause of weakening social support and division arising within communities. Greater coordination between survivors and dispelling stigmas publicly is paramount to overcome barriers for victims.

Due to fears of radiation exposure and air contamination, parents and schools have largely prohibited outdoor activities for children in the Fukushima Prefecture. Follow-up studies revealed that the highest rates of obesity in

children aged 5- to 9-years-old are now in Fukushima compared to the rest of Japan after the meltdown possibly because of limited exercise (data may have been strongly influenced by health-conscious parents moving away from the area) [104, 87]. A majority of parents visiting a pediatric clinic in Fukushima City several months after the accident indicated that their children were distressed because of outdoor restrictions, and 85% of families hoped to move to less affected areas. The children were reportedly more irritable, obsessive, and generally apathetic, while parents exhibited greater anxiety [44, 36]. But there was no wholly correct decision: parents who stayed experienced guilt for exposing their children to possible radiation while those who relocated expressed sorrow for abandoning their neighbors.

Young women possibly exposed to harmful radiation levels were fearful of pregnancy complications and society's views towards them as some believe they should not be allowed to reproduce children [44, 18]. This resulted in former residents moving to unaffected areas and hiding their pasts (akin to atomic bomb survivors from Hiroshima and Nagasaki concealing their identity) [44, 70]. But struggles to marry and fostering resentment can lead to further mental anguish as victims were beginning to feel contaminated themselves. This can be especially troubling and mistargeted when no current evidence indicates an increased probability of miscarriages, stillbirths, or deformities in newborns exists yet these false ideas continue promulgating. Women have also traditionally been viewed responsible of nurturing their children's health, an extraordinarily difficult task to navigate when the ensuing consequences of radiation exposure in following years is unknown to you [70]. WHO stated that radiation exposure from Fukushima could increase cancer incidence in affected individuals [100], thus possibly raising feelings of guilt for caregivers. Generally, it was observed that psychological distress increased with age, lower education, proximity to the nuclear accident,

and higher in females on average than males, highlighting possible vulnerable demographics in future incidents [38].

Psychological illness is the principal source of disability, occupancy of medical services, and mortality, which underlines the importance of mental care in ‘silent disasters’ such as nuclear accidents [4]. Poor mental health outcomes are linked to physical morbidity, increased incidences of hypertension, diabetes mellitus, dyslipidaemia, polycythaemia, and atrial fibrillation in evacuees compared to the regular population [54, 67, 68, 65, 80]. Surveys also found that evacuees demonstrated less physical activity, greater difficulties sleeping, eating disturbances, increased alcohol consumption, and a growing prevalence of mental stress [103, 22, 20]. Fukushima residents also exhibited worries surrounding possible health effects due to radiation exposure despite low dose estimates [49, 100, 93, 92], revealing worry itself to be the most damaging aspect.

While a majority of Japanese citizens believe either they or a family member were exposed to radiation a year after the meltdown [58], Dr. Thomas McKone, Deputy for Research Programs in the Environmental Impacts Division at Lawrence Berkeley National Laboratory, commented that nuclear meltdown fears from Fukushima were overblown. With expected fatalities minimal, the largest damage was the psychological stress of relocation and oblivion. Public health experts generally agree that predicted deaths in Japan from radiation exposure are less important than indirect effects such as depression [21]. Despite low radiation risks, stress derived from displacement, unseen toxicants, and uncertainty of the future are linked to unhealthy behavioural changes such as dietary choices, sleep deprivation, and reduced activity which can bolster negative cognitive effects [76]. Perceived exposure to harmful radiation was the most significant risk factor in the general population for men-

tal illness, which is consistent with observations of TMI and atomic bomb survivors [4]. These compounding factors can increase individuals’ susceptibility to developing both physical and mental health problems.

Even indeliberate cues can cause unnecessary fear with subtler ramifications. For example, the Fukushima disaster was classified as a level 7 (maximum) event on the International Nuclear and Radiological Event Scale, Chernobyl being the only other incident considered level 7. But such labels can be detrimental to the public’s awareness of real risks posed to their livelihood and are worth reconsideration. Also, enacting an appropriate response can be difficult and unclear even once psychiatrists identify issues as numerous evacuees are suffering from sub-clinical problems such as elevated stress and anxiety that do not warrant hospitalization nor extensive therapy based on current guidelines [9]. Prevention is the goal, but large-scale effective mental intervention for affected peoples requires significant input from the medical community. FEMA, in coordination with the U.S. Department of Homeland Security and Lawrence Livermore National Laboratory, has developed a National Disaster Recovery Framework to assist in radiological incidents with consideration of nuclear terrorism [40]. Their work outlines recovery activities (e.g. rescue operations, communication plans) and guidelines to help survivors with various ongoing issues such as risk perception following attacks involving radiation. Long-term efforts are concomitant with short-term phase activities as visually outlined in Figure 2 since revitalizing contaminated areas should not simply begin abruptly—it requires integration within the community from the beginning to assist risk perception since it is typically learned over time following the disaster. But the framework’s focus on psychological trauma remains vague and a cohesive public mental health framework absent to provide effective psychiatric support to victims of nuclear accidents. An exhaustive focus on radiation fears is a crucial supplement in recov-

ering from general radiological incidents.

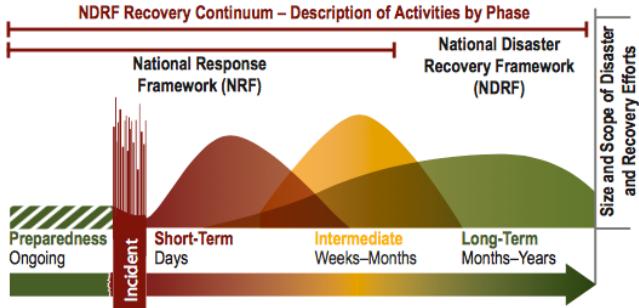


Figure 2 : Overlapping of recovery phases based on FEMA's National Disaster Recovery Framework to effectively help survivors of nuclear accidents [40].

5. PARALLELS WITH PAST AND FUTURE DISASTERS

Despite Fukushima's uniqueness, numerous commonalities exist with past nuclear accidents that will inevitably recur in future disasters. At risk of repeating bromides, they should be studied instead of learning the same tough lessons again. While reports of acute radiation syndrome are considerably lower in Japan, Chernobyl evacuees were relocated for significant periods of time and endured similar mental distress as witnessed after Fukushima. TMI also involved indecisive responses from public officials, poor evacuation planning, and ambiguous situations took a psychological toll on victims [22]. Studies on exposed infants' cognitive functions after Chernobyl have been inconsistent, but numerous evacuee mothers contend their offspring had memory problems despite no conclusive evidence [44, 5, 86]. General population studies have perhaps predictably found high rates of depression and stress in Chernobyl and TMI evacuees, especially mothers with young children which can lead to a vicious cycle of negative intra-familial interactions [44, 86, 13, 63].

Similar stigmatization of arriving from contaminated regions was observed following both Fukushima and Chernobyl where evacuees struggled with their dislocation and association with the event. Acceptance into new homes was challenging as they absorbed the characteristic of being contaminated into their identity [8, 21]. Spikes in abortions due to fears of pregnancy complications and birth defects can also be devastating on individuals. Indications of long-term misperceptions presented themselves after Chernobyl, too, as children evacuated after the 1986 disaster reported greater physical ailments than peers despite no observable differences in health, academic progress, or psychosocial development, often attributing any symptoms of poor health to the accident [55, 3]. Some of these markers are yet to be seen after Fukushima, but they are certainly possible now and in future nuclear accidents if inaccurate radiation risk perceptions remain ubiquitous.

The general resilience exhibited by communities becoming more cohesive after natural disasters (e.g. earthquake, tsunami) which can reduce psychological impacts is generally weakened in human-caused incidents (e.g. vehicle accidents, sexual assault) [44] which can lead to stronger feelings of isolation. In large scale disasters such as nuclear accidents, this sense of communal resilience can be vital but absent. Reviews of disaster mental health outcomes found that very severe psychological impairment affects 20.4% of victims following technological accidents versus 12.5% of victims after natural events [51]. This can be dire in nuclear disasters where familiar support structures are fractured. Chernobyl victims suffered from severe headaches and depression, and groups such as factions of cleanup workers were 50% more likely to commit suicide than the average population [9, 23, 62, 44, 43]. Fukushima's nuclear power plant workers were especially vulnerable, too, as they lived close to the reactors (Figure 1) and faced risks of persecution. A cross-sectional study reported that 29.5% of Fukushima Daiichi and 19.2% of Fukushima Daini (which did not contribute significant radioactive

emissions) workers experienced post-traumatic stress responses, and targeted discrimination was the largest correlate [85, 71]. Workers at TMI in Pennsylvania also personally reported recurring periods of anger, extreme anxiety, and various psychophysiological symptoms after the accident along with increased rates of demoralization months afterwards, signaling general susceptibility to mental trauma following nuclear accidents [44, 31, 32]. Overall, 96% of Fukushima's nuclear plant workers received doses below 50 mSv and there were no observed acute radiation effects [22, 30] indicating the greatest immediate damage was psychological.

The outcomes of evacuees display certain contrasts and parallels with victims of other disasters, too. For example, symptoms of extreme stress and mental trauma were five times more prevalent in evacuees than normally observed throughout Japan. This is akin to rates for first responders assisting in the September 11, 2001 attacks in America. Evacuated children near Fukushima similarly exhibited stress levels doubling the national average [9]. After Hurricane Katrina caused evacuations in the United States in 2005, property loss and health concerns were found to be the primary stressors for displaced individuals as well [16]. Ronald Kessler, a professor of healthcare policy at Harvard Medical School, stated hopelessness following major tragedies is a common recurrence; that tsunami survivors' grief will subside as they return to normalcy and rebuild their homes but that Fukushima's evacuees may experience persistent growing anxiety due to larger uncertainties surrounding their future livelihood and radiation exposure [9]. Japan is especially unique being a nation that previously endured atomic bomb attacks and the fallout afterwards. Fortunately, there has been a spontaneous outpouring of assistance throughout Japan following the disaster, but in a country noted for traditional values such as stoicism, persons suffering from mental distress are less inclined to pursue appropriate medical attention [9, 21].

This could similarly be problematic for insular communities in other countries. In a study comparing similar demographics under distinct large-scale stressors—TMI and layoffs causing widespread unemployment—dissimilar short-term mental health outcomes yet comparable long-term symptomatology signaled of a possible cumulative or latent effect common to stressful events [6].

Further disparities will certainly arise in future nuclear disasters, but anticipating these notable prodromes manifesting in victims is crucial for recovery. A report by the United Nations detailed that life expectancy for Chernobyl evacuees decreased from 65 years to 58 years predominantly because of psychological illnesses, alcoholism, and suicide [35, 64], and these are constructive lessons for mitigating these inevitable challenges in the future. Community-based mental healthcare focusing on inadequate social support and radiation risk perception could serve as a key in reducing the severity of psychological distress following nuclear accidents [52]. Chronic stress can be profoundly harmful to humans, and in Chernobyl evacuees it was associated with a greater probability of severe clinical depression, infertility, and long-term memory effects [64, 66]. Fukushima was unique in its preceding sequence of events (i.e. tsunami and earthquake) and resultant compounding factors overwhelming victims [70], but these common vulnerabilities in mental health outcomes require consideration for future prevention of the same mistakes. The psychological distress imparted and ensuing radiophobia is recognized as the event's largest public health burden, and demonstrated that fear itself should be feared after nuclear accidents [35, 64].

6. CONCLUSION AND OVERVIEW

Mistrust from governmental actions over contamination of basic necessities, volatility during displacement, and ambiguous fears all coupled together to yield the great-

est damage by the Fukushima nuclear disaster. But this all essentially originated from perceived radiation risks. It poses important questions for developing comprehensive responses in future nuclear accidents as parallels exist in past disasters and inevitably unseen ones, too. Fear-driven responses following Fukushima led to an onslaught of poor mental outcomes, reduced average life expectancy, and was unjustified from a public health standpoint. It created the greatest tangible loss from the nuclear accident. The psychological reverberations from radiation perception is necessary for consideration in future events, otherwise comparable outcomes will emerge as observed in Japan.

Governmental agencies should be cognizant of radiation fears and associated psychological damage in Fukushima to institute effective recovery procedures following nuclear disasters as actions such as evacuations should only be executed if absolutely necessary based on dosage estimates and confidence limits. Correspondence with medical professionals in constructing a unified mental health framework following nuclear accidents is vital to supplement current protocols following radiation disasters as developed by FEMA. Despite these recommendations, adherence and coordination between experts and the public is essential as fear-driven responses still linger in Japan. Even relatively minor issues supported by scientific consensus such as slowly releasing treated tritium-contaminated water from Fukushima into the ocean has not been approved by Japanese politicians. The government is deciding against this recommendation by scientists due to unsubstantiated fears and public opinion despite the water posing a greater risk when concentrated in the tanks on land and associated unnecessary storage expenses [11]. Also, expanded testing programs (e.g. thyroid screening) are finding abnormalities at increased rates but these results are not being interpreted appropriately by the public nor even physicians [50, 77]. This can result in

escalating cancer diagnosis rates despite constant cancer mortality rates, and lead to unnecessary surgeries (e.g. thyroid removal) having drastic effects on quality of life. Thus basing decisions after nuclear disasters on fear-driven actions as opposed to careful evidence-based reasoning can amount to significant additional economic and public health losses. Therefore, focusing on effective situational remedies (e.g. agricultural countermeasures, urban decontamination, realistic information campaigns) [99] instead of instinctive responses is necessary when recovering after nuclear accidents since radiation risks are not instinctive to humans.

This report observes that the greatest long-term sequela of the Fukushima nuclear accident is not directly the radiation exposure but rather the emanating fears and associated psychological harm. Preparedness only extends so far and no two situations are identical, but these prominent radiation fears can similarly raise major consequences in future nuclear accidents if unaddressed because treating victims instead of solely studying them is vital.

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