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FALLOUT OF FEAR

AFTER THE FUKUSHIMA NUCLEAR DISASTER, JAPAN KEPT PEOPLE SAFE FROM THE PHYSICAL EFFECTS OF RADIATION — BUT NOT FROM THE PSYCHOLOGICAL IMPACTS.

BY GEOFF BRUMFIEL

The first thing Kenichi Togawa does when he comes home from work is switch on his video-game console. The 39-year-old father of three spends hours each evening playing video games and drinking *shochu*, a strong Japanese liquor. He often falls asleep in front of the television, then wakes up shivering and crawls into bed with his wife, Yuka.

For nearly two years, Kenichi and his family have been refugees from the worst nuclear disaster in 25 years. On 11 March 2011, a giant earthquake struck off the northeast coast of Japan, sending a 13-metre-high wall of water into the Fukushima Daiichi nuclear power station and triggering meltdowns in

three of the six reactors. The next day, just hours before the Unit 1 reactor exploded, the Togawa family fled their home 10 kilometres from the plant. Today, they live in a tiny flat outside the evacuation zone — one of dozens in a series of slate-grey temporary buildings in the northeast section of Fukushima prefecture. The five Togawas are bundled into three rooms totalling just 30 square metres, with windows poorly insulated against the winter winds.

The past 18 months have taken a mental toll on the family. Kenichi, who had worked at the nuclear plant, was once a keen judo fighter who went out often with friends, but the radioactivity has scattered his martial-arts club. These

days, he exercises less and rarely socializes. He drinks more and has put on weight.

Yuka is prone to public outbursts of anger, unusual among Japanese women in the relatively traditional Fukushima prefecture. She is happy when she thinks about day-to-day life, but when her mind turns to the long term, as it inevitably does, she feels depressed. “This is temporary,” she says. “We leave our house in the morning and we come home and it’s temporary. It’s like floating in the air.”

Other people they know are struggling even more. Many of their current neighbours are out of work and stay at home all day. Some of Kenichi’s former colleagues sent their wives and

A woman prepares lunch in her little partitioned unit at an evacuation centre, Miyako April 2011.

children away, from fear of radioactive contamination, while they stayed to work.

In the immediate aftermath of the nuclear accident, public-health experts worried about the possible risk from radiation. Subsequent analyses have shown that the prompt, if frantic, evacuation of areas around the reactors probably limited the public's exposure to a relatively safe level (see 'The evacuation zones'). But uncertainty, isolation and fears about radioactivity's invisible threat are jeopardizing the mental health of the 210,000 residents who fled from the nuclear disaster.

Researchers and clinicians are trying to assess and mitigate the problems, but it is unclear whether the Japanese government has the will, or the money, to provide the necessary support. Nor is it certain that the evacuees will accept any help, given their distrust of the government and their reluctance to discuss mental problems. This combination, researchers fear, could drive up rates of anxiety, substance abuse and depression.

The nuclear evacuees face a more difficult future than the survivors of the tsunami, which left nearly 20,000 dead or missing and caused billions of dollars in damage. "The tsunami-area people seem to be improving; they have more positive attitudes about the future," says Hirooki Yabe, a neuropsychiatrist at Fukushima Medical University, who has been working with both groups. Nuclear evacuees "are becoming more depressed day by day".

ESCAPE

Fukushima prefecture is a patchwork of orchards, rice paddies and fishing villages. In the 1970s and 80s, coastal residents welcomed nuclear power and two plants were built to supply electricity to Tokyo. Kenichi started working at Fukushima Daiichi in 1994, and at the time of the accident was a contract maintenance engineer. Yuka worked as a hospital nurse. The Togawas and their children, now aged 9, 12 and 15, lived in a four-room flat in Namie, a small, close-knit seaside town.

The family's life was upended at 14:46 on 11 March 2011. Kenichi was in the smoking room at the plant when he felt the ground shudder for several minutes. He ran back to his office, weaving around scattered desks and downed ceiling panels, and grabbed his driving licence and car keys. But he quickly found that traffic had clogged the routes out of the plant because the quake and tsunami had destroyed bridges and roads. Kenichi ditched his car and walked the remaining 8 kilometres home.

There he found that all his family members were safe, but he worried about the plant. In his job, he had overseen maintenance of the systems meant to cool the reactor in an emergency. If those had failed, he knew that a

meltdown would soon follow, spreading radiation to nearby towns. That night, as aftershocks rocked the house, his family slept fitfully with the lights and television on.

Kenichi was right to be alarmed. The tsunami had knocked out the generators that pumped cooling water into the reactor cores. As temperatures rose, the slender fuel rods full of uranium pellets began to warp. The meltdowns had begun.

Early the next morning, a siren wailed across Namie, signalling an evacuation. The Togawas were told to move to Tsushima, 30 kilometres to the northwest. After retrieving their car, the family set out, but the roads were choked with panicked residents and the Togawas ended up at a different evacuation centre. When Kenichi learned that the emergency diesel generators at the plant had also failed, he bundled the family into the car once more, hoping to reach Tsushima. "We have to run away," he remembers thinking in a panic.

On the way, Kenichi received a text message from a friend who worked at the power company's offices in Tokyo. Unit 1 had exploded, and radioactivity was spreading across Fukushima. The family drove from one full evacuation centre to the next, until they reached a dark, cramped gymnasium in Kawamata, around 40 kilometres northwest of the plant. There they were given a small patch of hardwood floor to call home. But they were still deeply worried about the radiation. "We didn't know much about radiation's effects, and we didn't know if Kawamata was safe or not," says Yuka.

Japan is used to natural disasters, and immediately after the tsunami hit, the country's

emergency services sprang into action. Groups of doctors and emergency workers from around the nation struck out for the northeast coast to begin search and rescue operations and to administer care. The medical university in Fukushima City became a hub. In the days and weeks after the accident, the university hospital took in seriously ill patients from the coast. It also found itself on the front line of the nuclear emergency: doctors used Geiger counters to screen evacuees' thyroid glands, which are particularly sensitive to radiation, and treated several workers from the nuclear plant, who had suffered high radiation exposures.

FIRST RESPONDERS

Mental-health experts were among the first responders, reflecting an ongoing change in Japan's attitudes towards mental health. For many years, Japan's modest but modern mental health services were geared to help only the most severely mentally ill. The society has traditionally paid little attention to more routine disorders such as depression. In recent years, however, the Japan Medical Association has started educating doctors about depression and suicide, and the national government has conducted public suicide-prevention campaigns.

Still, the quality of care remains patchy, and even before the accident, Fukushima prefecture was not a bright spot. Mental health was a not a priority for the rural, conservative region or its taciturn citizens. As a result, the tsunami and nuclear disaster strained the region's mental-health services to near breaking, says Yabe.

In the wake of the accident, most of the prefecture's resources were devoted to helping



EMPTY STREETS: In the aftermath of the nuclear disaster, 210,000 people had to evacuate Tomioka and other towns in Fukushima prefecture. Nearly 156,000 remain displaced from their homes.

those with established mental disorders. Yabe, for example, packed his car with antipsychotic and anticonvulsive medication and made runs to Soma City, where many evacuees had ended up. Mental-health professionals visited the cramped shelters elsewhere, but they tended to treat only the most severe cases of delirium and post-traumatic stress disorder.

The Togawas were among thousands of people left to their own devices by the overwhelmed doctors and counsellors. The family's first days in the cramped shelter are difficult to recall now, says Yuka, but what she can remember isn't pleasant: ill and elderly patients lying on the floor; ongoing fear about radiation; evacuees jumping queues and snatching food. "We were like dogs and cats without chains," she says.

With little guidance from the outside, the shelter's residents tried to organize themselves. Yuka volunteered her nursing skills, but after working for three days, she was filled with anger: why should she, a victim, have to spend all her time helping others, she wondered. Yuka locked herself in the family's car outside the shelter, "and just exploded and screamed and shouted and cried".

SUBTLE DAMAGE

As the evacuees struggled to adjust, so too did the doctors and psychologists at Fukushima Medical University. By May, the emergency response was mostly over and the hospital

had a new job — to assess the public's radiation dose. The task has proved tricky, says Shunichi Yamashita, a radiation health expert at Nagasaki University, who was brought in to head the Fukushima Health Management Survey. The radiation monitors around Daiichi were damaged or destroyed by the earthquake and tsunami, and the chaotic nature of the evacuation makes it difficult to assess how long and severely each person was exposed.

The few attempts made so far, however, have generally shown minimal risk. The health survey's latest assessment suggests that the dose for nearly all the evacuees was very low, with a maximum of only 25 millisieverts (mSv), well below the 100-mSv exposure that has been linked to an increased risk of cancer in survivors of the atomic bombs dropped on Hiroshima and Nagasaki in 1945. The World Health Organization also issued a reassuring report in May, saying that most evacuees from places like Namie received estimated doses between 10 and 50 mSv. It did note, however, that infants might have received a dose that could increase the risk of cancer in their still-developing thyroids.

Radiation specialists say that it is difficult to predict the health effects from such low doses. "I think it's likely that there will be increased cancer risks, but they will be very, very small," says Dale Preston, an independent statistician who has studied atomic-bomb survivors. "If you did a large study, I think your chance of

observing a statistically significant radiation-associated risk would be pretty low."

With that in mind, the health survey decided against following a fixed cohort to study the incidence of disease. Instead, it provides thyroid screening and other health checks to any evacuees who desire them. The hope is that the screenings themselves, along with the data collected, will help to reassure the public that the risks are low, says Yamashita.

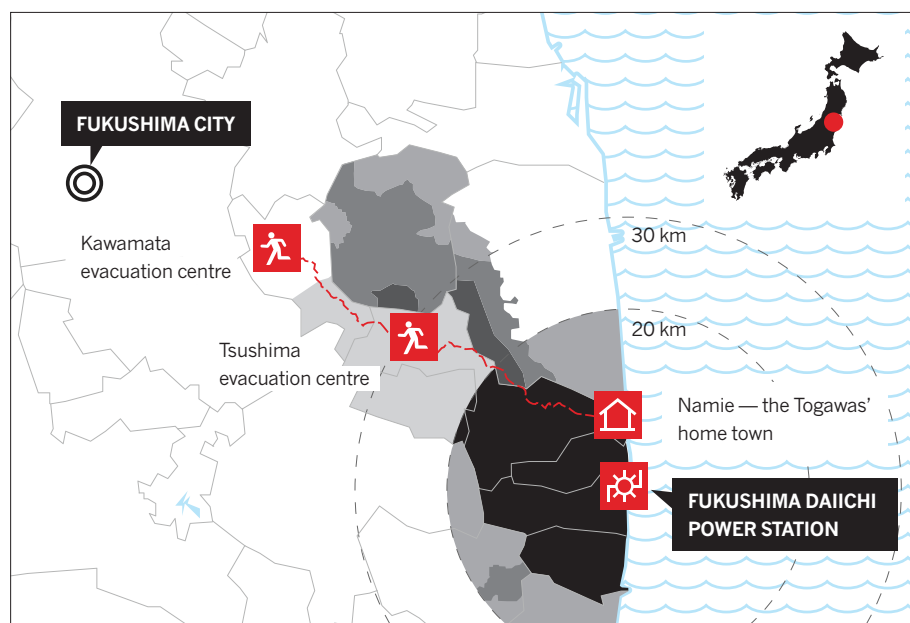
Mental health has been a major component of the survey. In January 2012, researchers sent out questionnaires to all 210,000 evacuees to assess their stress and anxiety. The levels tabulated among the more than 91,000 respondents were "quite high", says Yuriko Suzuki, a psychiatrist at the National Institute of Mental Health in Tokyo. Roughly 15% of adults showed signs of extreme stress, five times the normal rate, and one in five showed signs of mental trauma — a rate similar to that in first responders to the attacks of 11 September 2001 in the United States. A survey of children, filled out by their parents, showed stress levels about double the Japanese average.

The stress has pushed some evacuees to breaking point. On a crisp day last November, Kenji Ookubo wandered through Iitate, a village 40 kilometres northwest of the plant, practising his golf swings in the empty streets. The town had been evacuated after the accident because it lay in the path of the plume of radiation blowing away from the plant. But Ookubo couldn't stand the temporary housing, where he had started drinking and suffered from stomach aches. After renting a room in Kawamata, he began squatting in his parents' abandoned home. "I came back just to run away from the stress," he says. With no job, and no prospects, "I can't see the future," he says.

It is a pattern seen frequently after major catastrophes, says Ronald Kessler, a professor of health-care policy at Harvard Medical School in Boston, Massachusetts. "In the short term, people get energized," he says. But when extensive damage or health problems prevent them from getting back to their old lives, depression and anxiety set in. "When something this big happens, it's just ridiculously daunting," he says. "At a certain point you just get worn down."

His own surveys of people evacuated after Hurricane Katrina, which struck the United States in 2005, show¹ that property loss and health concerns were the main causes of anxiety. Whereas many survivors of the Japanese tsunami have seen their homes rebuilt and lives restored, nuclear refugees are still dealing with both of those problems. Above all, the fear of radioactivity takes a unique toll. "It's something you don't feel; you don't notice what happened, and yet you understand that there are these long-term risks," says Preston. "It's scary."

Little is known about the long-term effects of



THE EVACUATION ZONES: During the first stages of the nuclear crisis at the Fukushima Daiichi power station, Japan evacuated a 20-kilometre radius around the plant, forcing the Togawa family to flee. They stopped at several centres before reaching Kawamata, where they currently reside. Japan later updated and expanded the evacuation zones.

- Fully evacuated zone.
- Dose rate of 20–50 millisieverts per year. Entry is restricted.
- Dose rate >20 millisieverts per year. Some access allowed. No protective equipment required.
- Residents may move freely but not stay over night.
- Planned evacuation area.

that fear, in part because nuclear accidents are so rare. But the 1986 disaster at the Chernobyl nuclear power plant in Ukraine suggests that fear of radiation can cause lasting psychological harm. Two decades after the accident, those who had evacuated as children complained of physical ailments more often than their peers, even though there was no difference in health². And the mothers of those children suffered from post-traumatic stress disorder at about twice the rate of the general population, says Evelyn Bromet, a psychiatrist at the State University of New York in Stony Brook. Other studies of Chernobyl's aftermath found that evacuees had elevated rates of depression³ and that a subset of clean-up workers committed suicide at a rate about 1.5 times that of the general population⁴.

For Fukushima evacuees, says Bromet, "There's going to be a tremendous amount of health-related anxiety and it's not going to go away easily."

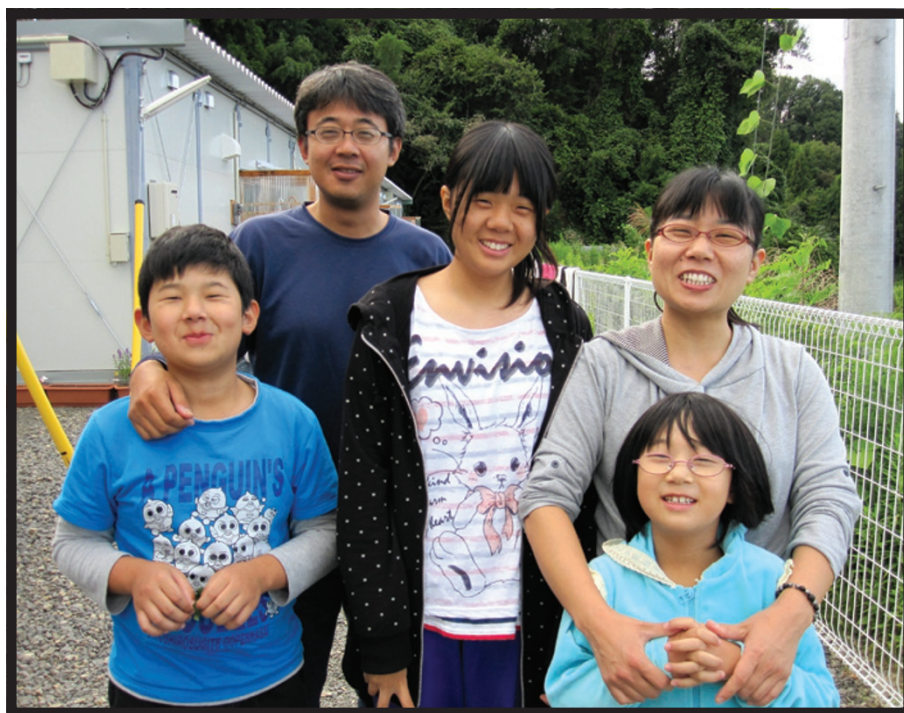
FEAR FACTOR

Yabe says that "radiophobia" remains a major problem among the Japanese refugees. A poll published last year by the Pew Research Center in Washington DC, for example, found that 76% of Japanese people believed that food from Fukushima was not safe, despite government and scientific assurances to the contrary. And many do not trust the government health surveys that found very few cases of significant radiation exposure among evacuees.

Yuka shares some of those concerns. She and Kenichi have educated themselves, and they have gained some reassurance from regular health checks and thyroid screenings. The children carry dosimeters provided by the health survey to collect radiation data and to calm public concerns. But Yuka wonders whether they will one day develop cancer.

At the moment, however, the family is pre-occupied with practical concerns. The government has said that the Togawas can remain in their small flat until August 2014, but after that, Yuka says, they don't know what will happen. "The government officials say that they are working on it and that they are trying to construct public housing for those people who had to evacuate. But where? Nothing is clear." Whenever she and Kenichi think about the long term, they start to feel depressed.

The scientists involved with the Fukushima Health Management Survey have assigned a team of psychiatrists and nurses to make follow-up phone calls to individuals who had high scores for distress on the mental-health questionnaire. But only about 40% of adults responded to the questionnaires, and the researchers suspect that the most severely affected people did not participate. Even when the psychiatrists can connect, the evacuees usually don't stay on the phone for more than five to ten minutes. "Northern people are a very closed people, they



THE TOGAWAS: After nearly two years in temporary housing, the family worries about the future but is happy to be together. From left, Shoichiro, Kenichi, Rina, Yuka (back) and Kae (front).

don't really talk about their personal things, especially to somebody they've never met before," says Yabe.

Even when the psychiatrists identify problems, it is unclear what to do about them. Most evacuees, like the Togawas, are suffering from sub-clinical problems — mental anxiety and stress that affects their everyday life but does not require hospitalization or extensive therapy. There is no established treatment regime for such survivors from large disasters, says Suzuki.

Yabe suggests that walk-in clinics specializing in mental health could be set up throughout Fukushima prefecture to engage communities and help families. Suzuki says that involving large segments of the population in group-therapy sessions might be the way forward. Many say that it would help for evacuees to develop a sense of community — but the government has not fostered that. Temporary houses are "strung out like a railroad", says Bromet. The government could have built them "in a circle with a playground in the middle, or some obvious place for people to meet, but they didn't", she says.

Kessler says that unlike the tsunami survivors, whose grief will lessen over time, the nuclear evacuees could experience growing anxiety, particularly about radiation. "When everything has settled down, that will be a huge, life issue," he predicts. Now is the best time to try to get ahead of these problems, he says. "There's a window of opportunity."

But the health survey lacks the funding for a more ambitious programme. The national government has given it just ¥3 billion (US\$34 million) a year, but it is currently consuming about twice that amount, so the survey is under enormous financial pressure, says Seiji Yasumura, one of its leaders and an epidemiologist at Fukushima Medical University. So far, only 100 of the 210,000 evacuees have been interviewed face-to-face by mental-health experts.

Little by little, things are getting better for the Togawas. The children seem happy in their new school, and in September 2011 Kenichi found a job with the local government, clearing contaminated soil from the homes of neighbours. "He's worked so much overtime that his company is saying he has to have a break," boasts Yuka. She has found part-time work as a nurse in a local clinic. Her occasional outbursts sometimes cause tension with co-workers, but she enjoys speaking her mind: "I say what I want to say."

After filling out one of the health-survey questionnaires last year, Yuka got a flyer in the post inviting her to talk to someone over the phone. She thought about it but decided not to. "I don't feel like phoning. It's been nearly two years," she says. "I don't know what to say." ■ **SEE**

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For an interactive graphic and to hear from evacuees, see: go.nature.com/te49b