



Oral presentation

**Submission from
Alexander Belyakov**

In the Matter of

Ontario Power Generation Inc.

Application to renew the Power
Reactor Operating licence for the
Darlington Nuclear Generating Station

Commission Public Hearing
Part 2

November 2-5, 2015

Exposé oral

**Mémoire de
Alexander Belyakov**

À l'égard de

Ontario Power Generation Inc.

Demande concernant le renouvellement
du permis d'exploitation pour la centrale
nucléaire de Darlington

Audience publique de la Commission
Partie 2

2-5 novembre 2015

c/o Louise Levert
Secretariat
Canadian Nuclear Safety Commission
280 Slater St., P.O. Box 1046
Ottawa, Ontario K1P 5S9

Via Email: interventions@cnscccsn.gc.ca

September 26, 2015

Re: November 2, 3, 4 and 5, 2015, a two-part public hearing on the application by Ontario Power Generation Inc. to renew, for a period of 13 years, its power reactor operating licence for the Darlington Nuclear Generating Station. Ref. 2015-H-04 (May 26, 2015).

Dear Sirs or Mesdames:

I am writing to alert you to the serious safety issues.

Ontario Power Generation Inc. (OPG) has requested the licence period, for 13 years, to cover life extension activities, including refurbishment of the four Darlington NGS reactors. **I would like to participate in the public hearing both in writing and verbally in person**, if no business travel will be scheduled for me the same day of your hearings.

Please reject the 13 years licence because it harms nuclear safety. As a resident of the Great Toronto Area, I am concern that a Darlington accident would dislocate at least 477,000 people. Although the nuclear industry is promoting itself as safe, some researchers speculate the likelihood of having a minimum of one major nuclear accident is 66.6% in 5 years. The tendency in a 30-year period is for about a minimum of one major accident (63.2 % likelihood), with a 25.8 % probability of having two (Ha-Duong and Journé 2014). In some cases, **high density of nuclear reactors can increase possible risks**. The 435 operable nuclear reactors worldwide, together with 71 under construction (World Nuclear 2015), are relatively close to many cities. But how close is close enough to compromise their safety?

“Following the nuclear disaster at Japan’s Fukushima power plant in March 2011, **the USA urged Americans to evacuate the area within 50 miles (80 km) of the power plant**, suggesting a disconnect between domestic emergency planning procedures and practice in the event of an accident” (Union of Concerned Scientists 2011). In general, potentially affected populations are not properly prepared to cope with the major effects of complex mega-disasters.

The Soviet authorities established the 30 km zone of mandatory resettlement in the Chernobyl area. The Japanese government gradually extended the evacuation zones within 3 km, 20 km and 30 km. There is a difference with the International Atomic Energy Agency's recommendations about "two sizes of zones in anticipation of qualitatively different radiation hazards: one with a radius of 10 miles (16.1 km) to address whole-body radiation exposure and another with a radius of 50 miles (80.5 km) aimed at preventing ingestion of radioactivity in food and water" (Geist 2014).

I propose **expanding the plume exposure pathway** and review the existing recommendations about emergency planning zones (based on accident analyses conducted in the 1960s and 1970s). One of the arguments is that **zoning around the Darlington Nuclear Generating Station and related (possible) resettlement pose the greatest threat for violating human rights in case of nuclear emergencies and lack of emergency preparedness.**

The majority of human rights violations and even deaths happen due to evacuation shortcomings. There were dangers associated with lack of preparations for the evacuation of vulnerable populations in Japan: "more than 50 patients died either during or soon after evacuation, probably owing to hypothermia, dehydration, and deterioration of underlying medical problems" (Tanigawa K et al. 2012, 890). There are cases of people who committed suicide due to depression over leaving their homes (including a 102-year-old resident of a village near Fukushima). Stress-related deaths reach 2,973 in Tohoku (The Asahi Shimbun, 2014). People are often not properly informed and provided with choices. Do you know **how lack of emergency preparedness may affect population in the Great Toronto Area?**

No life-extension should be permitted without the full disclosure of all potential risks.

Transparency is a strong democratic value. If approved, the Darlington Refurbishment would create **unnecessary environmental, health and food crises** for future generations and compromise sustainable development in Canada.

Attached please find submission of my peer-reviewed research "From Chernobyl to Fukushima: an **interdisciplinary framework for managing and communicating food security risks** after nuclear plant accidents" recently published in Journal of Environmental Studies and Sciences. Please consider my solutions as a part of my written comments.

I know that you will see that these issues are addressed. If I can be of any assistance, please call me. Thank you for your time and attention to these matters.

Yours very truly,

Alexander Belyakov

Alexander Belyakov, Ph.D.

From Chernobyl to Fukushima: an interdisciplinary framework for managing and communicating food security risks after nuclear plant accidents

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From Chernobyl to Fukushima: an interdisciplinary framework for managing and communicating food security risks after nuclear plant accidents

Alexander Belyakov¹ 

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Abstract This comparison of government disaster management and public communications after the Chernobyl and Fukushima nuclear accidents seeks to create a framework for disaster management that enhances food resilience (the ability of food systems to withstand perturbations that could cause disruption of food supply); and in the specific case of nuclear disasters, the avoidance of contaminated food and provision of alternative foods. This paper integrates food security, emergency management, and risk communications perspectives. Misinformation and incomplete information can bias decision-making and political actions. When risk communication is inadequate, the public reacts with fear, mistrust, panic and stress. People have difficulty deciding what they can safely eat and what they should not eat. Many choose to reject all food from affected regions, which can compromise food security. Lack of proper information may lead to such extremes in behavior as avoidance of dairy products and consumption of untested foods, which may in fact have high levels of radioactivity. The measures taken by the USSR after the Chernobyl disaster lacked consistency and clarity and were not effective in providing food security for the affected people. The government also demonstrated a lack of attention to social justice in its dealings with people who moved back to the contaminated area, ignoring government policy that they should stay out. Those people still suffer from food insecurity. In Japan, food that met government safety levels was available, but many consumers nonetheless questioned the safety

of food supplies and farmers often were confused about production and marketing. In both the Chernobyl and Fukushima cases, the evacuation of affected people was aimed at reducing exposure to radiation and did not sufficiently consider neither the psychological and physical health impacts of resettlement nor the security and safety of food supplies. Government responses would have been more effective in some regions if a timely distribution program of adequate, safe alternative foods (especially radioprotectors) from non-affected areas had been initiated.

Keywords Food security · Nuclear safety · Chernobyl nuclear accident · Fukushima nuclear accident · Emergency management · Risk communication

Introduction

This paper shows how food security and risk communication issues significantly impact the management of nuclear disasters, some of which can have global environmental repercussions. The stresses nuclear accidents place on food systems can threaten human welfare and even survival nearby. Only the Chernobyl and Fukushima Daiichi nuclear power plant accidents have been rated 7, the highest level on the International Nuclear and Radiological Event Scale. Although “the consequences of the Chernobyl accident clearly exceeded those of the Fukushima accident” (Steinhauser et al. 2014, 800), both of these nuclear accidents caused disruptions in the food supply.

Two issues deserve special consideration in the analysis of food resilience after nuclear power plant accidents. The first involves communication to the general public. The potential for cognitive dissonance—the stress that arises when one’s behaviors do not match his beliefs—is high. In general, people tend to ignore or deny disaster data that contradicts their

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existing beliefs. If, for example, someone believes that radiation is much more dangerous than authorities claim, then that person may be reluctant about following authorities' recommendations on how to behave around it.

A second issue relates to how scientists adopt decisions and reach conclusions. If experts present uncertain statistics as final scientific findings, this action may ultimately affect the pollution prevention and cleanup decisions of the governments (Moore 2003). This paper explores these two topics—misinformation and incomplete information—that directly affect decision-making processes in all areas of political expertise, including food security policies.

Evidence from environmental policy, communications studies, and emergency management, the food industry is examined, emphasizing the following two questions:

1. How do nuclear disasters affect food security?
2. In such disasters, how does communication impact or alter governments' emergency management responses and food security policies?

The main objectives are to examine how nuclear disasters in Chernobyl and Fukushima affected food security and how the experience of having lived through them prompted governments to develop improved plans to deal with future nuclear disasters.

The methodology for the research includes a literature review, policy analysis, personal insights following on-site fieldwork at the Chernobyl exclusion zone in Ukraine and Belarus during the period 1993–2011 and content analysis of media publications in Ukraine. The author conducted the most recent field trips to the affected areas in Belarus with the help of the International Chernobyl Research and Information Network,

supported by UNDP, IAEA, UNICEF, and WHO (Fig. 1). The analysis is limited to Ukraine and Japan. The author carried out in-person interviews with 25 state officials in Ukraine between 1993 and 2011 and 12 officials in Belarus in 2011. Two scientists from Japan were interviewed in Toronto in 2013–2014 and an additional scientist was contacted by e-mail.

Nuclear disasters are complex and have repercussions for the disruption of the food system both in the short and the long term. Policy-making in response to nuclear issues has always been difficult. Development of new policies requires the active involvement of—and a clear understanding among—a wide array of stakeholders. Policy differences within the food security framework should be made explicit and ultimately resolved. The 1996 World Food Summit defined food security as being achieved when “all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 2003). Many governments subsequently reaffirmed the right to food in their national legislation, taking food security policy to a new level. Both the Soviet and Japanese governments failed, by the above definitions, to adequately protect their citizens' rights of access to at least basic levels of uncontaminated foods.

This similarity in government responses is alarming. Chernobyl happened in an authoritarian USSR in 1986, while Fukushima happened in a capitalist country, a democracy with a free press in 2011. Despite the fact that some Japanese media were reluctant to take an anti-government stance, the *Asahi* newspaper, one of the biggest dailies, was critical of the government. Moreover, social media were active in 2011, which enabled immediate information distribution on the internet. Japan's capitalist food system made it possible for consumers in Fukushima to purchase needed food and to rely on imports after the disaster. These differences in conditions played some role but did not account for the full range of problems with food supply post-Fukushima.

Challenges for food security after the Chernobyl nuclear disaster

The Chernobyl disaster on April 26, 1986 is one of the most famous and controversial tragedies of our time. It happened at the Lenin Chernobyl Nuclear Power Plant (which consisted of four reactors) in the Soviet Union. The Chernobyl plant is located only 93 km from Ukraine's capital Kyiv. A one-off test of whether the turbine generator could continue providing electricity after the reactor scrambled caused the tragedy. The resulting explosion and fire at the Chernobyl plant sent a radioactive cloud over a large part of Europe. Emergency staff reported traces of pollution in Asia and North America, including Canada (Parliament of Canada 1986; Kerr et al. 1992). In the Soviet Union, the accident affected mostly Ukraine and neighboring Belarus and Russia. “Application



Fig. 1 An inhabited house in the contaminated area in Belarus. Photo by the author

of remediation on a limited scale will remain necessary for at least several decades (up to 2045–2050)” (Fesenko et al. 2006, 357). Kuchinskaya (2014), Nesterenko et al. (2009) researched the Chernobyl aftermath in Belarus.

Soviet authorities failed to take some very simple preventive actions. One of the biggest threats from the disaster was radioiodine carried long distances by clouds. Potassium iodide tablets should block radioiodine uptake by the thyroid. But authorities did not give them even to residents of Prip'yat, a town near the Chernobyl nuclear plant. Face masks are also an inexpensive tool that can prevent inhalation of radioactive dust, but authorities did not distribute them. Officials even failed to warn people to stay inside. As a result, many children spent April 26, 1986 outdoors, unaware of the high radioactive pollution (Smith and Beresford 2005).

One of the major differences between nuclear and other types of disasters is that radiation is invisible and confusing. Thus, officials must warn people when high radiation levels exist. Soviet leaders did not. Twenty years later, Gorbachev (2006) disingenuously denied claims that the Soviet leaders from the governmental commission were engaged in concealment of information about the tragedy: “Its members all had dinner with regular food and water, and they walked around without respirators, like everybody else who worked there. If the local administration or the scientists knew the real impact of the disaster, they would not have risked doing this.” Such statements might alternatively mean that some authorities had a clear understanding that short-term exposure to external radiation sources and contaminated food during their brief visits to Chernobyl would not cause drastic health effects. Later, Japanese officials would eat Fukushima produce in front of the TV cameras to promote food safety (Kimura and Katano 2014).

Food safety is especially critical when the internal dose from contaminated food is high in affected areas. This is exactly the situation in the case of Chernobyl. According to Ukrainian physicians (Nyagu 2006), residents of the contaminated areas in Ukraine received radiological doses of 2 to 74 millisieverts (mSv) (Nyagu 2006, 76–77). Cumulative doses are expected to rise to 160 mSv during the 70 years after the disaster (1986–2056). One study indicates that about 80–95 % of radiological doses are expected to come from contaminated food (milk, meat, vegetables, forest products) (Nyagu 2006). Another study provides similar average estimates for most contaminated rural areas in Ukraine. Milk consumption provides 70 % of radiological doses, meat—7 %, vegetables—7 %, other foods—9 %, water—1–2 %, and air—1 % (Onishi et al. 2007).

What was done in Ukraine after the Chernobyl disaster?

Edward Geist has reconstructed the events following the Chernobyl accident. He praised the culture of mass

mobilization, as well as individual heroism. He concluded: “in some respects, the Soviet response to Chernobyl compares favorably to the Japanese government’s handling of the Fukushima Daiichi accident a quarter century later” (Geist 2015, 126). Nevertheless, emergency management’s performance and the food security management measures taken after the Chernobyl disaster overall were less effective than those that followed the Fukushima crisis.

Officials ordered nearly one million people to move out of areas with contaminated soil to avoid exposure to low levels of radiation. “Starting on May 2, 1986, about 50,000 cattle, 13,000 pigs, 3300 sheep, and 700 horses were evacuated together with the people” (Fesenko et al. 2006, 353). Some experts insist that resettlement often was excessive (Filyushkin 1996). Because the IAEA’s rules require that radiation doses be as low as reasonably achievable, some IAEA and UN officials are motivated to downplay the potential harmful effects of actual radiation exposure.

The Soviet authorities established the 30-km zone of mandatory resettlement. There is a difference from the agencies’ recommendations about “two sizes of zones in anticipation of qualitatively different radiation hazards: one with a radius of 10 miles (16.1 km) to address whole-body radiation exposure and another with a radius of 50 miles (80.5 km) aimed at preventing ingestion of radioactivity in food and water” (Geist 2014).

The evacuation reduced the internal dose from contaminated food and water, including from agricultural food that could have been produced in the area from which people were relocated. However, the evacuation could have caused changes in people’s diets and decreased food availability overall (food was more available, for example, in Prip'yat compared to some villages to which people were moved). The evacuation might not have been the most appropriate way to ensure better food outcomes, but what the alternatives might have been and their implications for other issues such as health were unclear at that time (Belyakov 1996). Besides, the increased levels of radiation in Prip'yat would have contaminated available food. The government relocated children living in affected areas outside the 30-km zone to camps in recreational areas. However, this did not mean that children generally received high-quality, diverse food.

Officials needlessly overpaid some people but underpaid the majority and failed to provide support to displaced people who illegally returned to the affected zone. Residents in a few distant areas received regular benefits even though radiation levels there were low (e.g., Boyarka). Some experts claim that people sometimes were falsely or intentionally (due to corrupt practices) identified as major victims of the disaster (Filyushkin 1996; Davies and Polese 2015). Nonetheless, the paid benefits still could have allowed them to improve their nutritional practices immediately after the disaster. Later, the Ukrainian state harmed food security by

unofficially deciding “not to assert its role. For many marginalized individuals, despite a belief that Chernobyl has caused widespread sickness, the risk from invisible radiation is considered less of a health threat than the tangible reality of leaving behind social support networks after moving, and the ability to employ local informal economic tactics” (Davies and Polese 2015, 42).

Authorities did not store emergency food kits for the general population or for emergency workers. Many people were hungry and thirsty for a long period of time. It is critical to have nuclear emergency food rations with a long shelf life in stock in strategic locations, especially in countries that house many nuclear reactors. All emergency food kits should be able to withstand radiation exposure. Officials made almost no attempt to promote food processing (both industrial and home-cooked) that would decrease the contamination of food by radionuclides (Nesterenko and Nesterenko 2009).

Authorities identified milk, meat, wild berries, and mushrooms as high-risk foods. They instituted radiological controls on markets and retail chains. However, without an adequate educational campaign, the controls caused confusion and mistrust on the part of the public. In addition, adequate controls were not in place to prevent the return of disposed contaminated food to the market.

The sale of milk directly from milk tanks to people who used recyclable open jars to buy their milk was phased out. Although this improved the quality of milk consumed by decreasing the potential for bacterial contamination, highly radioactive air particles continued to contaminate milk after the disaster. “Application of the countermeasures was often delayed in rural settlements for privately produced milk, resulting in low countermeasure effectiveness in some areas. This led to a high intake of radioactive iodine through the milk food chain for a few weeks after the accident and, as a consequence, to high doses to the thyroid for a relatively large number of people living in affected areas” (Fesenko et al. 2006, 353).

Both the affected population and emergency workers did not acquire knowledge about radioprotectors (foods that protect against harmful effects of radiation). Scientists had already discovered apple polyphenols’ significant potential to protect human bodies from radiation-induced damage (Chaudhary 2006). Educational campaigns could have highlighted this useful grocery item through the easily recognizable expression: “An apple a day keeps the doctor away.” Through the state-owned enterprises, officials distributed some radioprotectors promoted as a kind of Soviet-style recognition of employees rather than radioprotection. Examples of such foods included fruit candies, marmalade, or marshmallows prepared from apple fruit puree.

Also, soy isoflavones can act as probable radioprotectors against gamma radiation (Dixit et al. 2012). Furthermore,

nuclear medicine has discovered many agents that limit damage from radionuclides. Soviet mainstream medicine officials did not mention any alternative food supplements such as acidic whole foods, wild chaga, spice oils, zeolite, bentonite—all of which have the potential to decontaminate radioactive ions (Ingram 2011a, 165–170). Access to radioprotective food was a major problem in Ukraine because “manufactured radioprotectors are still cost-prohibitive for many, and such products are not widely available. This means that citizens must develop their strategies to counter the ill effects of contaminated food” (Phillips 2002, 19–20).

Food security measures lacked consistency, a well-balanced approach, proper public awareness building, and effectiveness (defined for purposes of this paper as removal of contaminated products and provision of safe products to people rather than resettlement as its human costs may outweigh the benefits).

Risk communication regarding food safety after the Chernobyl disaster

What is important in terms of governmental decisions on food security and specifically food safety during nuclear accidents is that authorities immediately inform people in affected areas about:

- The nature of the emergency situation and its possible impacts, including impacts on food production (the disaster occurred during a significant period of the crop year), food contamination, and other aspects of the food system;
- Safe and effective food choices: which foods are safe and which are not, which have radioprotective abilities (preventing absorption of radionuclides);
- Governmental decisions concerning food security, what the government did to ensure food safety in the specific areas, and what it plans to do next and why;
- Food literacy: how to protect one’s family and decrease the risk of exposure through educated food choices among other things.

Other food security management measures are also important after any nuclear disaster:

- Preventing consumption of contaminated food;
- Ensuring proper and safe food storage;
- Handling safe disposal of contaminated food and agricultural products;
- Proposing alternative safe foods and making sure the affected population (especially people who relocated or are still living in affected areas) have access to safe, affordable food.

Limited data on high contamination of dairy products, mushrooms, and wild berries appeared in the local media about a month after the Chernobyl disaster. The government's failure to develop well-grounded educational programs to address the divergence of behaviors and beliefs as well as to answer all public questions created anxiety and distrust among people (Belyakov 2010). This failure is also due to cognitive dissonance inherent in government messages. While officials were not truthful about the radioactivity doses and acted as if nothing serious had happened during the first weeks after the disaster, the appearance of military personnel in protective clothing tended to alarm local residents. Individuals strive to have consistency in their lives. If beliefs and behaviors start to contradict each other, it causes discomfort or even serious stress. Governments can exacerbate this situation by prioritizing other non-food, disaster-related issues, thus neglecting communication with consumers of contaminated food.

In the Chernobyl case, the Soviet mass media in some instances erroneously reported about mutations in humans and cattle, increasing public fears and mistrust of both government and the mass media. For example, the newspaper "MIG" in Zaporizhya in 1991 published a report about mutations in humans and cattle. The agricultural workers refused to go to work and farmers tried selling their land and houses until journalists officially recognized their mistakes (Belyakov 2003, 69).

The population's perceptions about food safety are critical in emergency response. The most affected groups after the Chernobyl disaster were:

- People who were first resettled from the 30-km zone of mandatory resettlement but who later returned, even though this was not officially allowed in the early stages after the disaster;
- Professional fishermen;
- Local residents whose diet depends on fish, wild berries/mushrooms, or local dairy products and meat;
- Farmers dealing with irrigated agricultural products (or dairy) and consuming them themselves;
- Cleanup workers.

Although most of the affected population was evacuated and resettled elsewhere within Ukraine, some residents remained or illegally returned to the exclusion zone, ignoring health risks. Most of these people were elderly. Illegal residents of the 30-km zone who were protecting their right to return to their homes in the area faced severe problems. These people—variously called self-settlers, returned displaced people, or *samosely*—faced difficulties securing access to food and safe shelter.

Why did they come back? Eudokiya and Peter Degtyarenko from the village Kupovate in the exclusion zone explain: "There is no life. But in Markivsky District, where we were resettled,

there was no life either. There were two or three families together in one house. Rats and mice gave us no life. And also people..." (Belyakov 1994). The government failed to support these illegal residents. Only in 1993 did the government and local authorities informally recognize *samosely* in this zone. Once the government became aware of disruption of residents' food supplies, the meals-on-wheels delivery started to bring bread and some other limited food items to their area once a week. When local authorities recognized, in the mid-1990s, that *samosely* were starving, police began to provide hot meals for elderly people in the police cafeterias in these remote areas.

Most *samosely* have never been contacted by an expert in nutrition, and some were not even able to access a doctor. Due to welfare failure, food accessibility remains at almost survival level. Residents grow and process most of the food locally, collecting and consuming wild berries and mushrooms. Critics have pointed to the small state pensions, tiny food subsidies, and inadequate support: "The post-Chernobyl Ukrainian state offers only a 'Potemkin village' of welfare support—a complex web of de jure entitlements but a lived reality of de facto state abandonment" (Davies and Polese 2015, 36). Police ordered self-settlers' evacuations after a fire affected 400 ha of woodland in the 30-km zone in April 2015. The fire came as close as 5 km from the Chernobyl nuclear waste repository.

Although scientists (Onishi et al. 2007) estimated that professional fishermen would receive the highest radiation doses, mainly from radioactive sediments in the river system of which Kyiv reservoir is a part, officials did not properly inform fishermen and other vulnerable groups about the risks they faced. People's risk perceptions were quite varied—ranging from ignorance and dismissal to panic. In turn, people's responses to the disaster ranged widely—from ignorance to avoiding meat/dairy/berries/mushrooms to fleeing the affected area. Immediately after the disaster, rumors spread that drinking red wine helps decrease the absorbed radiation dose. This is true to a degree but only if the wine is consumed in small doses with the alcohol removed (Greenrod et al. 2005). As a consequence of misinformation about the beneficial effects of wine, there were cases where paramedics took children to hospitals drunk or even poisoned after parents had given them wine.

Another key group is cleanup workers. The Minister of Health remarked about the Chernobyl emergency workers, "No one has ever defined the value of human (life) here" (Petryna 2002, 3). Furthermore, many cleanup workers report being treated not as human employees, but as "biological resources to be used and thrown out. ... [S]lated for biorobotic death" (Petryna 2002, 30). Even after robots became available, they were often out of service, and cleanup workers frequently replaced them. Officials prohibited medical personnel from linking workers' cleanup-related illnesses with their stay in the zone. Moreover, this group was not properly

informed about risks and did not receive radioprotective food that might have decreased health risks.

The ways in which scientists communicate numerical risks are also crucial. In the case of Chernobyl, the same cancer risk could have been conveyed in the following ways: 131 additional cases of cancer expected in the lifetimes of the 24,000 people within 15 km of the plant; a 2.6 % increase in the cancer rate of exposed people; or an increase in cancer of only 0.0047 % of the population among 75 million people exposed in Ukraine and Belarus (Wilson and Crouch 1987; Suskind and Field 1996).

It would not be an exaggeration to say that nuclear disaster enormously influenced the Soviet economy, including food production. Some USSR regions experienced a deficit in many agricultural products, leading to the population's growing disappointment as their rights to food were compromised. As some scholars calculated, "Soviet agricultural losses are estimated to be from two to four percent of total production; radiation from Chernobyl tainted and made unusable up to 20 % of the milk, 10 % of the meat, 25 % of the potatoes, 10 % of the wheat, and 20 % of the sugar beets produced in the Soviet Union" (Dando and Schlichting 1988).

Just 5 years after Chernobyl, the fall of the USSR became a new factor that affected the food systems in Ukraine. The percentage of people that were food insecure increased, and food accessibility became a more critical issue than food safety for many people. They experienced dietary changes. Contaminated food that should have been discarded was sold on the market. According to Hostert et al. (2011), "the collapse of the Soviet Union resulted in land abandonment rates that were even slightly higher (36 % at the study region level) than those caused by the Chernobyl meltdown (33 %)." The area of agricultural land lost for use in Ukraine, Belarus, and Russia was 784,320 ha, destroying the main source of income and food supply for the rural population (IAEA 2006). Ukraine had also survived 10,000 % inflation and a deficit of basic food in 1990s. This may have contributed to dietary changes after the disaster and limited the ability of local agriculture to absorb losses.

Research on food safety in Ukraine after the Chernobyl disaster

One of the pre-conditions of effective food security policies and transparent risk communication is availability of extensive research, monitoring programs, and access for researchers to relevant information. In the USSR, no large-scale government-supported research on food safety was conducted immediately after the Chernobyl disaster. Ukrainian scientists working in state-owned research institutions report that research on radiological protection had not been supported by state funding. Authorities restricted access of some Ukrainian

scientists, including the world-known radiobiologist Dmytro Grodzinsky, to their own laboratory equipment. The Communist Party did not approve any independent investigation. For about 2 years, officials treated people as criminals if they possessed their own dosimeters (Medvedev 1990). Even the regularly collected data regarding milk contamination was neither properly analyzed within a large-scale spatial or broad temporal frame nor communicated or even classified. The Soviet administration did not prioritize food safety, instead devoting state funding to other concerns.

The government introduced obligatory control of food contamination (first of all milk and meat) on farms (all of which were state-owned at the time), on retailers, and on markets. Wild berries and mushrooms were also subject to control. Only farmers and middlemen whose products passed control were allowed to sell. Contaminated products were required to be disposed under state control. Experts warned that "with regard to the disposal of contaminated foods, veterinarians need to ensure that unscrupulous dealers do not take advantage of the disaster situation to obtain bargain meats and surreptitiously work them back into the food system" (Waltner-Toews 1990, 365). It was a difficult task because "in the 30-km zone, more than 20,000 remaining agricultural and domestic animals, including cats and dogs, were killed and buried. Due to a lack of forage for the evacuated animals, and difficulties in managing large numbers of animals in the territories to which they were moved, many of them were subsequently slaughtered (95,500 cattle and 23,000 pigs) in May–July 1986. Many slaughtered animals were buried, but some were stored in refrigerators causing great hygienic and economic difficulties and resulting in large quantities of radioactive waste" (Fesenko et al. 2006, 353).

Food from the 30-km zone was and is still traded in the neighboring cities (Davies and Polese 2015, 37). There are no studies on how much contaminated food was sold outside of the state-controlled markets. Since radioactivity measures were not accompanied by an adequate educational campaign among consumers and dealers, some poor people tried to avoid the official distribution channels and sell contaminated food illegally.

Since 1991, the Ukrainian Institute of Agricultural Radiology (UIAR) was able to establish various programs and started to share its research with the general public. Currently, UIAR executes the agricultural radiology part of the Ukrainian state program on elimination of consequences of the Chernobyl accident. UIAR Director Valery Kashparov explained that major difficulties in the successful implementation of many UIAR recommendations are underfunding, and government is more concerned with political consequences of decisions than health and safety. "Application of Prussian blue to cows, which provide an effective alternative to the more expensive radical improvement, was only implemented more than 6 years after the accident. Earlier application would have

substantially reduced internal doses to the population” (Fesenko et al. 2006, 358). UIAR has a program to prevent the transfer of radioactive cesium from soil to plants, but the government’s tendency was to spend money on social benefits for affected groups rather than on contamination prevention steps (Belyakov 2011). Unfortunately, the military conflict in Eastern Ukraine in 2014–2015 has resulted in even greater state funding reductions.

Ukraine should implement changes in its agricultural practices by promoting countermeasures—ploughing, liming, application of mineral and organic fertilizers, mulching, phytoremediation of land, radical improvement, and removal of soil are also effective countermeasures (Fesenko et al. 2006, 354). There are also some crops that do not accumulate radiocesium (White et al. 2003). Their use should minimize the entry of radionuclides into the human food chain. A supplement that has the ability to reduce cesium transfer from fodder to milk can be added to ferrocyn, which is administered to livestock (Fig. 2).

Belarus has developed agricultural countermeasures and other strategies whereby peasant farmers have improved the radiological quality of privately produced milk in the affected territories (Lepicard and Hériard Dubreuil 2001). “The provision of uncontaminated (or less contaminated) feed or pasture to previously contaminated animals for an appropriate period before slaughter effectively reduces contamination in meat” (Fesenko et al. 2006, 354).

Challenges for food security after the Fukushima disaster

On March, 11, 2011, a tsunami, triggered by the Tohoku earthquake, hit the Fukushima Daiichi nuclear plant. It caused a meltdown of three of the plant’s six nuclear reactors. As with Chernobyl, there was much secrecy around the Fukushima

disaster—likely an attempt on the part of the plant’s owner and operator, TEPCO (Tokyo Electric Power Company) and state officials, to prevent local hysteria and negative media coverage nationally and internationally. Scientists report “the lack of ‘full’ information and models of analysis; the overall impacts of Fukushima disaster on Japanese agrarian and food sector are far from being completely evaluated” (Bachev and Ito 2013).

The Japanese government advised limited groups of affected people not to eat the contaminated food: “restrictions on consumption of food (excluding water) were enforced only in Fukushima Prefecture. Distribution restrictions were enforced in Fukushima, Ibaraki, Tochigi, Gunma, Chiba and Kanagawa Prefectures” (Hamada and Ogino 2012, 89).

Effective communication is important in all disasters but even more so in nuclear disasters, which are characterized by a high dread-to-risk ratio: “Small quantities of radioactivity are being detected in food. Unless a large dread-to-risk ratio is assigned to choices such as whether to eat or not to eat, the experts’ models of risk will not match the choices” (Socolow 2011). As a result, public misunderstanding about these choices caused “considerable anxiety about low-dose radiation from the environment and food intake” (Tateno and Yokoyama 2013, 2).

There were dangers associated with lack of preparations for the evacuation of vulnerable populations: “more than 50 patients died either during or soon after evacuation, probably owing to hypothermia, dehydration, and deterioration of underlying medical problems” (Tanigawa K et al. 2012, 890). Food insecurity increased at the evacuation centers, where lack of nutritious food and clean water left many people hungry and thirsty. Support workers distributed rice balls and bread, the only food available to many for weeks. Canadian scientist Victor G. Snell observes that “One area which is starting (slowly) to change is the recognition of a trade-off between minimizing radiation dose and the real damage caused by unnecessary evacuation and/or food supply restriction” (personal communication).

There were also difficulties in transferring food to survivors staying at their homes. At the same time, places where food was still available for purchase experienced chaos. People bought food and water in large volumes due to distrust of the government and fear that soon these commodities would not be available (Bacon and Hobson 2014). The convenience stores became “a critical piece of social infrastructure” (Bestor 2013, 775).

The changes to the food systems in Japan included new complex behavioral patterns of producers (especially small producers) and consumers. Sociologists reported about complex challenges in ongoing research related to behavioral changes:

- People now have to be more responsible in their own private decision-making regarding foods purchased, and this is problematic for several reasons, including lack of



Fig. 2 Cattle in the contaminated area in Belarus. Photo by the author

trust and actual and perceived lack of reliable information. “The Japanese public has experienced an increasing diminishment of trust in the government’s ability to ensure the safety of the food supply. Consumers are not convinced that ‘the experts’ (e.g., government officials) are providing sufficient information to enable them to avoid the threat” (Tomiko Yamaguchi, International Christian University, Tokyo);

- Increasing distrust of the Japanese food industry in general and damage to the reputation of organic agriculture in the affected region in particular; there is conflict among farmers wishing to continue their operations close to the contaminated areas in Fukushima and antinuclear activists encouraging them to relocate (Yoshimitsu Taniguchi, Akita Prefectural University);
- Organic farmers and *teikei* (direct co-partnerships between farmers and consumers) experienced restrictions on sales of their products (Keiko Yoshino, Hosei University; Hiroko Kubota, Kokugakuin University);
- Lack of governmental data provoked establishment of citizen groups, which test their own food in “citizen labs” (Aya Kimura, University of Hawaii). As of June 2013, these 110 groups were contributing to alternative food networks, with the number of measurements matching those done by the government (Megumi Nakagawa, Tohoku University) (International Sociological 2014).

Aya Kimura and Yohei Katano are researching the disaster’s impact on food justice in Japan and particularly impacts on organic farmers in Fukushima. The Food Sanitation Act does not include standards for radiation contamination of local food. Consumer skepticism that farmers would support governmental actions to downplay the radiation risks led to the Shinagawa Declaration 2011 by concerned communities, which labeled the farmers as “wrongdoers.” Some affected farmers were confused about the uncertainty and lack of guidance from the government and questioned: “With radiation, what’s the point in organic farming?” (Kimura and Katano 2014).

Sociological surveys report that 20 % of consumers still hesitate to purchase food produced in Fukushima prefecture (Consumer Affairs Agency of Japan 2014; Hongo 2014). Furthermore, activists’ and consumers’ concerns are connected to a recent state secrecy law that potentially could permit greater concealment of information regarding nuclear contamination, among other things (The Act on the Protection of State Designated Secrets, No. 108 of December 13, 2013).

More transparency and further research are needed. Otherwise, government decisions regarding food security and related concerns may be ineffective in protecting the public and possibly unreliable in future emergencies. Despite the limitations described here, a review of the literature on food security policies and responses following the Fukushima disaster still provides some valuable information.

Communication regarding food security issues after the Fukushima disaster

Some Japanese mass media outlets that have traditionally taken an accommodationist approach toward government agencies sought to convince the public that eating radioactive food is good for health. They employed an entire spectrum of arguments, ranging from general statements about the overall health benefits of food to appeals to national values. For example, the country’s largest circulation daily newspaper, *The Daily Yomiuri*, compared risks of not eating vegetables to risks of eating radioactive vegetables, where both risks were expressed in millisieverts, even though calculating the risk of not eating vegetables in millisieverts is methodologically rather questionable. The newspaper’s editors were trying to convince the public that eating radioactively contaminated food is better for health than avoiding such foods altogether.

The *Yomiuri* was also making the case to breastfeeding mothers that traces of radiation in breast milk are expected and should be ignored, given the general benefits of breast milk and that, in any case, human bodies are expected to have traces of radiation. One more argument aimed at convincing the public of the relative safety of radioactive food involved the obligatory school lunch program. When some parents wanted to opt their children out of the program due to fear that the food was radioactively contaminated, they were characterized as egoists acting against the national “sense of bonds and solidarity” which the lunch program was building (Tollefson 2014, 306–310). The government initiated the “Eat to Cheer Up” campaign, motivating citizens to proudly consume foodstuffs from the affected regions (Kimura and Katano 2014).

One of the lessons learned in disaster communications is about trust: “Transparency is vital, but having a singular message is paramount to maintaining trust” (Spencer 2013, 78). Lack of trust affects the speed and rhythm of responses in many areas, including food systems. Experts who were directly involved in information technology support for emergency response report: “we were asked to produce an information system for goods and food distribution in 3 days. That was impossible” (Murayama et al. 2013, 340). Trust affects all involved parties: emergency workers as well as people who rely on their support and information. As other experts report from their fieldwork, local residents’ fears of radiation related to food were high several months after the accident (Figueroa 2013).

According to Oda, who calls for expanded application of systems thinking within Japanese businesses, trust is missing in food systems: “For consumers, it is not only just about safety from a scientific point of view but also about trust. We need to rebuild a trustworthy food system, as the government did a poor job of communicating the risk of radiation in the early months of the crisis” (Oda and Sweeney 2012, 16).

Food that met government safety standards was available, but not all consumers considered it safe. Anthropologically speaking: “In Japanese, the word for safety is *anzen*, but when describing food safety, it is often used together with *anshin* (peace of mind). *Anzen* connotes measurable and technical ways of assessing risk, while *anshin* refers to emotionality and to individual perception. The ideal is that foods will be safe (*anzen*), and therefore people will eat them with confidence and peace of mind (*anshin*). The relationship between *anzen* and *anshin* is not easy to sustain in the post-Fukushima world” (Cisterna 2014, 74–75).

Many Japanese investigators mentioned serious communication issues related to health and food safety. The Independent Investigation Commission provided the following recommendations: “The government must communicate in ways that are clearly helpful to the public identifying: what is edible, what is the tolerable intake level, which foods continue to be safe, and whether tests are reliable” (Kurokawa et al. 2012, 9). This did not happen. According to scientist Jun Shigemura: “a combination of poor public communication by the authorities and TEPCO over radiation levels and the dangers they present to health, coupled with widespread uncertainty over the future, had created a ‘mental health crisis’ among Fukushima residents” (McCurry 2013, 791). Experts stress that two-way communications are critical in such situations. Trust is also essential. It has implications for subjective well-being; in Hommerich’s (2012, 58) words, “The fear of health implications of radioactive contamination of food strongly reduces happiness and—thereby—individual resilience.”

Some scientists were optimistic about their findings and radioactivity measurements performed by local government. Only 3 % of the agricultural products’ “samples investigated contained >500 Bq/kg, whereas the remaining 97 % contained less than the provisional regulation level of 500 Bq/kg in 2011” (Nihei 2013, 73). Other studies also confirm that the food contamination levels were well below relevant international standards (Itthipoonthanakorn et al. 2013; Chiu et al. 2013; Fisher et al. 2013).

At the same time, Morris-Suzuki (2014) criticizes the methodological approaches of Japanese government scientists. The National Institute of Radiological Science uses a model whose accuracy is quite limited: “It looks only at external radiation, entirely excluding the crucial question of internal radiation caused by inhaling irradiated particles or eating irradiated food, and it only considers radiation exposure up to 11 July 2011, excluding the high continuing levels of exposure which many local people have experienced ever since. The Institute also lacked accurate radiation figures for the first 3 days after the accident (when the highest doses are likely to have been received), so their figures for these days are based on computer simulations” (Morris-Suzuki 2014, 344).

Post-Chernobyl monitoring in North America shows that “concentrations of I-131 and Cs-134+Cs-137 would serve as the main indicators of the need for protective actions for imported and local food. However, concentrations of Ru-106 were consistently in excess or at a significant fraction of the derived intervention level, which suggests that Ru-106 should also serve as an indicator, i.e., be included as a principal radionuclide for nuclear reactor incidents” (FDA 1998, 26).

There are disparities between real, measured levels of radioactive contamination of food and perceptions of contamination by the population. Canadian scientist Victor G. Snell points to two major issues: “how one translates science-based risk to public policy and how one maintains public credibility while doing so” (personal communication). If the governments of the affected countries predominantly rely on nuclear industry experts who failed to communicate effectively with affected people, then damage to food systems may occur not because of the increased radioactivity levels but mostly due to miscommunication and panic.

The American geographer Peter Gould made interesting observations following the Chernobyl disaster. After governments heeded the advice of the nuclear industry, Gould found manipulation and suppression of information usually took place. The tactics deployed include the following: “suppression or covering up, defining the problem away, authoritative belittling, arithmetic obfuscation, public relations, creative deception, and information reduction” (Gould 1990, 113). Gould believes that the inadequate “reactions are not confined to the Soviet bureaucracy; they are the natural reaction of any bureaucracy to smother unfortunate news.” The suppression of information is the arrogant and endemic curse of all modern bureaucracies, a curse that is constituted of what they are” (Gould 1990, 22).

According to Robert Mason (2014, 55), “Japan’s “nuclear village,” a formidable force over the years, has been weakened, but not vanquished by the 3.11 disaster.” It made considerable efforts to cover up information about the disaster and its impacts. “The nuclear village consists of the “LDP ... Ministry of Economy, Trade, and Industry (METI, known as MITI until 2000), the ten nuclear power companies (the largest of which was Tokyo Electric Power Company: TEPCO), and Keidanren and Doyukai (two leading business institutions representing the interests of major corporations)” (Claremont 2014, p. 82).

A critical difference in the population’s literacy regarding nuclear radiation is evident between the USSR and Japan. USSR farmers often denied that there was a tragedy at all, ignoring the real threat of radioactive contamination of their dwellings. Unfortunately, this devaluation was supported by the Soviet government, which tried to downplay the catastrophe by characterizing it as merely a fire. Lack of awareness, underestimation of risks, and over-reliance on technology were the typical responses to this disaster (Auf der Heide

1989). As a result, many people continued to consume contaminated food, especially when confronted with increased food insecurity, poverty, and lack of alternative food supply.

The US photojournalist Michael F. Rothbart spent 2 years in Chernobyl on a Fulbright Fellowship and observed “that there is disinterest among residents in thinking about food safety issues—a fatigue or norming of dangers so that after decades most consumers pay little or no attention to information or regulation about bioaccumulation of radionuclides in food. It would be interesting to observe how long it takes the same sort of fatigue to begin in Fukushima” (personal communication).

People in the affected areas of Japan had better opportunities to access portable equipment and measure radiation on their own than was the post-Chernobyl case. In the USSR, many restrictions had been introduced; these limited the ability of citizens to understand and monitor the situation. Western scientists had even less access to the Chernobyl zone for many years, and only the USSR collapse opened borders. Despite the greater ability to gather data in Japan, it is clear that extensive efforts to recover and communicate additional data are still needed. And some topics, including food security, remain under-researched. Scientists mentioned “official figure of damages to agriculture, forestry, and fisheries alone in 20 prefectures amounts to 2384.1 billion yen” (Bachev and Ito 2013).

If iodine-131 is released into the environment, most current protocols call for the affected population to avoid or at least reduce consumption of locally grown food ingredients and groundwater for a minimum of 8 days (the half-life of iodine-131), up to 2 to 3 months (Christodouleas et al. 2011); they also are advised to take potassium iodide tablets. “In the most affected regions, the external dose from groundshine is important, but with increasing distance from the site, the ingestion of food becomes the main contributor” (World Health World Health 2012, 64). Unfortunately, the Soviet authorities failed to inform the population about these emergency responses during the first 8 days following the Chernobyl disaster. The Japanese government was also slow to react: “Government officials issue the first directive for the public to take potassium iodide and restrictions on consumption of food and water on March 21 [10 days after the accident began and 6 days after the largest releases of radioiodine]” (Bricker 2014, 206–207).

Challenges for policymakers

According to Geist (2014), policymakers in all major cases—at the Fukushima Daiichi, Chernobyl, and Three Mile Island Plants—have done guesswork due to “uncertainty about *source terms*—the quantities and characteristics of the radioactive isotopes released in a nuclear event.” What

governments can do to overcome this obstacle to emergency planning? A good example is joint radiation emergency management plan of the international organizations (EPR-JPLAN 2013).

The USA has programs for pre- and post-incident distribution. In 2013, the US government rewrote its plans for responding to radiation contamination, focusing more on long-term cleanup than emergency response. The Protective Action Guide from the US Food and Drug Administration contains guidance on radioactive contamination in food, new higher permissible radioactive levels in drinking water, and soil in a case of radiological incidents (EPA 2013).

Despite the fact that the industry is promoting itself as safe, some researchers have concluded that the likelihood of having a minimum of one major nuclear accident is 66.6 % in 5 years. The tendency in a 30-year period is for about a minimum of one major accident (63.2 % likelihood), with a 25.8 % likelihood of having two (Ha-Duong and Journé 2014). In some cases, high density of nuclear reactors can increase possible risks. The 435 operable nuclear reactors worldwide, together with 71 under construction (World Nuclear 2015), are relatively close to many cities. But how close is close enough to compromise their safety?

One hundred twenty million US residents live within 50 miles of a nuclear reactor, whereas the primary concern “is the contamination of water supplies, food crops, and livestock where evacuation is at the discretion of local authorities (...). Following the nuclear disaster at Japan’s Fukushima power plant in March 2011, the USA urged Americans to evacuate the area within 50 miles of the power plant, suggesting a disconnect between domestic emergency planning procedures and practice in the event of an accident” (Union of Concerned Scientists 2011).

In general, potentially affected populations are not properly prepared to cope with the major effects of complex megadisasters. Marsden et al. (2010, 257) argue that “in modernity, risks are incalculable and uncontrollable. If this is the case, then the structures adopted cannot ensure in the face of uncertainty that the risk assessment has addressed the appropriate risks and has generated an effective precautionary response” (Marsden et al. 2010, 257).

Furthermore, Marsden et al. (2010, 130) stress that “in the food sector specifically traditional risk communication strategies, which focus solely on public education, are bound to fail.” In fact, the general public is capable of greater understanding of post-disaster uncertainties than is typically realized. Therefore, governments should ensure full risk disclosure and adherence to recommendations of relevant international organizations on disaster management and resilience.

Food systems experience long-lasting consequences following disruptions, especially in the aftermath of anthropogenic disasters. The activities that constitute food systems include producing, processing, packaging, distributing,

retailing, and, finally, consuming food. All these activities produce a variety of outcomes, which contribute to food security in terms of availability, access, and utilization. Access to food also is dependent upon affordability, allocation, and preference. Food utilization includes nutritional and social values, as well as food safety (Ingram 2011b). A first attempt to assess the Fukushima disaster's consequences on agriculture and food chains is still in process (Bachev and Ito 2013).

It is imperative that scientists conduct research from the disturbed food systems perspective and demonstrate how to restore former, pre-disturbance functioning. In particular, it is essential for researchers to analyze activities and outcomes related to food systems disturbances caused by nuclear accidents.

Conclusion

Food systems are vulnerable to nuclear disasters regardless of policy measures. Disaster responses, therefore, must focus on how governments can protect citizens from contaminated food/land and provide them with alternative food sources or sources of livelihood. This paper's literature review and collection of additional data related to the Chernobyl and Fukushima nuclear disasters confirm that many food products were contaminated (meat, dairy, mushrooms, berries, vegetables) and that contamination significantly contributed to internal radiation doses. Farmers sometimes failed to produce food in areas deemed safe by the government for food production. People who moved back to the Chernobyl exclusion zone faced marginalization and related nutrition problems.

Immediately after the disasters, food insecurity increased among evacuated or relocated people. The national governments in both the USSR and Japan downplayed the consequences of the nuclear disasters, encouraging people to ignore much of the international mass media coverage, while at the same time failing to promote such emergency measures as the distribution of potassium iodide immediately after the accidents. The disasters contributed to failure of the USSR President Gorbachev's reforms and have shaken the Japanese government.

General public literacy regarding emergency preparedness and nuclear disasters in particular needs to be improved. Experts from different fields should be properly trained in responding to nuclear emergencies. This training should include explanations of how radionuclides behave in food systems and how human factors affect all processes. These actions will help in dealing with the difficulties of communicating complex scientific ideas. Developing dose models based not only on soil contamination but also on other sources of exposure (food, water) as well will benefit all parties. Methodological approaches require unification and transparency.

Adequate, transparent, and timely risk communication is critical to restoring food security after nuclear disasters. The stigma of nuclear disasters influences consumers' choices. People often reject all food from affected regions, which can compromise food security. Lack of proper information may lead to such extremes in behavior as total avoidance of dairy products, providing wine to children, and consumption of untested foods that may in fact have high levels of radioactivity. Comparing the Fukushima and Chernobyl nuclear disasters, we see that the Japanese authorities mostly succeeded in enforcing their restrictions on consumption of contaminated foods, while the Soviet administration failed to react immediately, resulting in negative health effects for the population that could have been avoided.

Loss of agricultural lands affects food systems and compromises food security. Officials need to utilize preventative measures to minimize the risks presented by production and consumption of radioactively contaminated food; these measures should include clear guidelines for the agricultural industry. While some such actions seem quite obvious and clearly should be included in disaster response planning, the authorities in many cases fail to implement them.

In the case of the Chernobyl disaster, policies and management steps taken by the USSR government were not very efficient in terms of food security of affected people. These steps lacked consistency and clarity. The mass resettlement of people was expensive and at the same time partially ineffective in reducing the overall radiation doses and risk factors. The government's response would have been more effective if it had initiated a timely distribution program for adequate, safe alternative foods (especially radioprotectors) from non-affected areas. Further research is needed into properties of foods that cause them to accumulate radionuclides as well as act as radioprotectors. Lack of social justice was mostly demonstrated in governmental dealings with self-settlers in Ukraine, who still suffer from food insecurity (limited food access, consumption of primarily self-produced contaminated food, nickel-and-dime benefits). All affected groups need detailed evacuation plans and radiation detectors.

Fukushima's more recent lessons on food security are still under-researched. Nevertheless, governmental responses were similar to those of the Soviet bureaucracy. Although Japan's government succeeded in limiting access to contaminated food, both the Japanese and Soviet governments failed to adequately protect citizens' rights to safe, adequate food. That right should be integrated into both preventative and post-disaster decision-making processes.

Another prerequisite of effective food security policies after nuclear disasters is availability of short-term, quick response research and longer-term monitoring programs, as well as access to research data for scientists, public health experts, and other decision makers. In both the Chernobyl and Fukushima cases, access to research data was limited. These

limitations created distrust that will impede future research, given the lingering mistrust between citizens and governments and mistrust within the food system itself.

It is hardly possible to separate out food security issues from other disaster response issues, given the current highly generalized approach that emergency management demands. Some countries do not appoint special multi-disciplinary teams to deal with nuclear disasters, let alone assign responsibilities to re-establish food security afterwards. Inadequate food literacy is a significant threat to food security. Specific educational campaigns for all possible affected groups should emphasize food with radioprotective abilities. Practitioners also need to develop separate food security resilience strategies and related communication strategies for nuclear disasters with special attention to three high-risk groups:

- People who frequently come into direct contact with contaminated food (e.g., agricultural workers)
- People experiencing high health risks (pregnant women, children, etc.)
- Food-insecure people.

Nuclear disasters have challenged many assumptions and caught some states by surprise in the past. It is time to learn from these experiences and use that knowledge to help prevent further humanitarian catastrophes. To date, few international studies have been conducted to compare the consequences of the Chernobyl and Fukushima nuclear disasters from a food security's point of view. Until additional vulnerability analyses of food-insecure households after disasters are undertaken, and their findings put into planning and practice, people in contaminated regions will remain uncertain about how seriously they are affected and what they can do to minimize risks for themselves and their families.

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