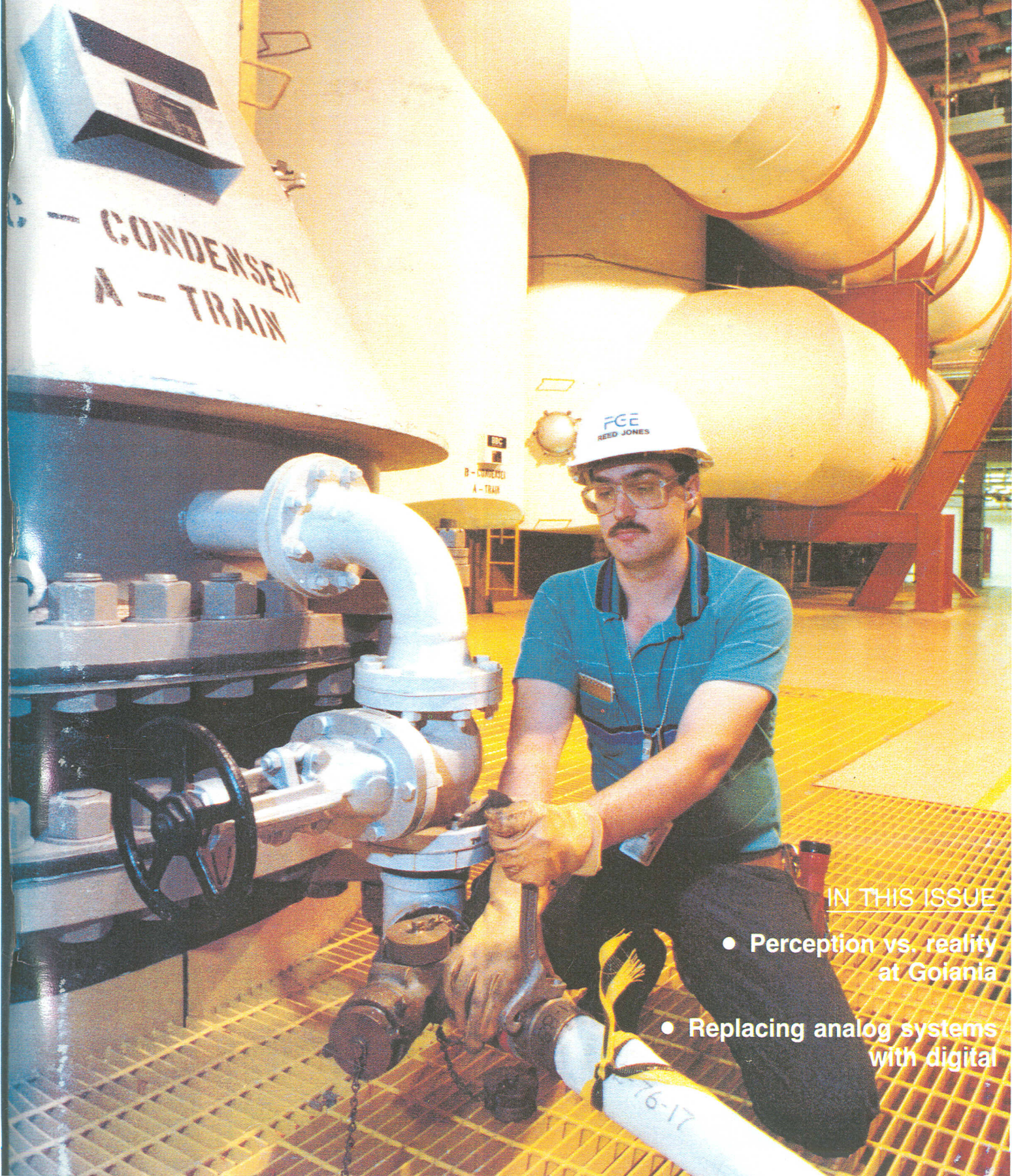


nuclear news

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COVER: Reed Jones, an auxiliary operator at Portland General Electric Company's Trojan nuclear power plant, is shown at the unit's condenser, tightening a temporary hose connected to the circulating water system. For a closer look at some other activities at the site, turn to page 42. (*Nuclear News* photo by Gregg M. Taylor)



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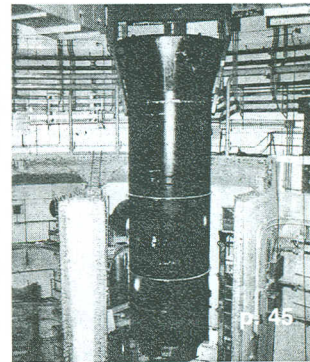
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Using the Goiania radiation accident as a model, John Petterson discusses the economic, political, and social consequences of the lack of understanding among the general population of radiation contamination risks.

Perception vs. reality of radiological impact: The Goiania model

by John S. Petterson

The subject of this article is a radiological accident that occurred in Goiania, Brazil, in the fall of 1987, involving the spread of radioactive contamination in a city having roughly the same population as San Diego, Calif.—around one million persons.

The reason for wanting to document this case and present the findings is simple. According to U.S. Department of Energy technical risk assessments (and our own as well), the likelihood of a major accident involving exposure to radioactive materials in the process of site characterization, construction, operation, and closure of a high-level waste (HLW) repository is extremely remote. All agree, however, that there is a high probability that a minor accident involving radiological contamination will occur sometime during the lifetime of the repository—for example, during transport, at a monitored retrievable storage site, or at the permanent site itself during repackaging and deposition. A large number of potential accident scenarios could be considered, for example: transport accidents involving agricultural production areas and affecting state, regional, or national markets; an important tourist attraction; on a bridge or the banks of a major waterway or impoundment; as well as a number of rather virulent terrorist scenarios. It soon becomes

clear that the more serious impacts of such events would result not from the accident itself (except in the case of terrorism or other intentional misuse), but from the public's reactions to information about the accident, i.e., to their perception of the risk involved.

We are all, no doubt, quite familiar with the issue of perceived risk—i.e., fears that are seemingly disproportionate to the actual technical or statistical likelihood of an event. For example, the public invariably estimates nuclear power as a greater risk to their health than driving a car, despite abundant evidence to the contrary. The problem, however, in assessing the potential impacts resulting from a small nuclear-related incident, is to establish the concrete links between perceptions of risk and behavioral responses.

The Goiania event provided a unique opportunity to examine how a relatively minor accident involving radioactive material could result in a chain of events affecting an entire state's economy, stigmatize an entire state's population, and disrupt social relations throughout a community and region. It also provided a classic example of the process by which the public's perception of risks, not the actual event or risk itself, can result in a wide array of painful and costly responses. Simply stated, it provided a unique opportunity to examine the consequences of perceived risk and stigma under actual conditions. Before one can understand the relationship between the event and its consequences, however, one must first understand the event.

The Goiania accident

On September 13, 1987, two adult male residents of the city of Goiania, in

the central Brazilian state of Goias (population 13 million) entered an abandoned clinic in search of scrap metal. They discovered a heavy machine that had been used to treat cancer with controlled doses of radiation. They dismantled the device and extracted a stainless-steel cylinder. They took this cylinder to a junkyard, broke it open with a sledgehammer, and removed a 1-in.³ platinum capsule. They then sawed open the capsule itself, revealing approximately 100 g of luminescent material, described by witnesses as "carnival glitter."

Children playing in the junkyard were attracted to this glowing, "magical" material and began to play with it—spreading it on their hands and bodies. The children and the workers, in turn, took it home with them, showed their friends, and spread it on clothing, paper, walls, floors, and, in one case, even consumed some of the material that had spread from hands to food. In this last case, the child began to vomit after just 10 minutes. Within a few days, many others would fall ill. It would be nearly two weeks, however, before their illnesses were diagnosed as radiation poisoning, and the source of the problem, cesium-137 exposure, was identified.*

Consequences of the accident

The consequences of this event have been varied and far-reaching. Beyond the obvious physical consequences, the

*When fabricated in 1971, the capsule contained 93 g of material consisting of 28 g of cesium chloride and 65 g of binding agent. This material represented approximately 2000 curies in 1971 and, assuming a 30-yr half-life, approximately 1000–1500 Ci today as the cesium continues to decay into barium.

John S. Petterson is president of Impact Assessment, Inc., of La Jolla, Calif. The author wishes to express his gratitude, in particular, to Halim Girade, Paula Curado, and Donald Binns, for their assistance in obtaining much of the data presented in this article. This article is adapted from a paper presented at Waste Management '88, held February 28–March 3, 1988, in Tucson, Ariz.

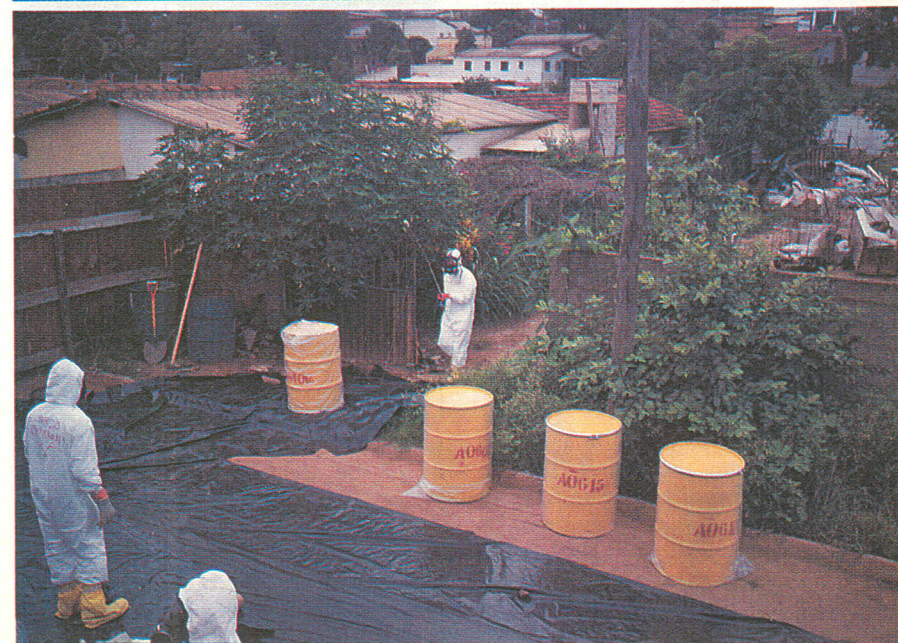
event has also had a significant impact on the economic stability and the social/political fabric of this Brazilian state. While the full extent of these impacts will not be known for some time, this article is intended to address some of the initial findings of importance to the U.S. nuclear waste program. The discussion that follows is based on data collected from economic agencies, tourist offices, and from formal and informal interviews with local residents, and local, state, and national officials conducted during October 1987, April–May 1988, and September 1988 at Goiania and in Rio de Janeiro, where the Comissao Nacional de Energia Nuclear (CNEN), Brazil's national nuclear energy commission, is located.

Physical consequences. There have been significant physical consequences of the event. As of April 18, 1988, there have been 249 suspected cases of contamination. Of these, 120 concerned shoes or other clothing only. The remaining 129 cases involved traces on skin, of which 79 individuals were decontaminated and sent home with less than 0.1 nanocurie/cm² readings and 50 individuals were hospitalized or placed in a temporary dispensary under medical care with greater than 0.1 nCi/cm² readings. Four people have died, one individual had an arm amputated, and several major grafting operations have been or remain to be performed.

Even with its small magnitude, when the absolute number of individuals involved is considered, the event has been characterized by many as one of the most serious nuclear-related accidents in history, second only to Chernobyl. It is the worst nuclear accident documented to have occurred in the Western Hemisphere. When measured in terms of fatalities and injuries alone, however, the event itself hardly seems to be of international significance—certainly no more so than any other industrial accident. On the other hand, the secondary consequences have been considerable. The course of these events, the channels through which the impacts have occurred, and the aggregate socioeconomic impacts have indeed been remarkable. These may be usefully broken down into economic, political, and social consequences.

Continued on next page

TOP: One of the principal sites of contamination and one of the first homes to be decontaminated and reconstructed. CENTER: The salvage yard, initial site of contamination, where the radiological device was dismantled and the cesium-137 removed. BOTTOM: Cleanup operations at a paper recycling yard, where one of the larger pieces of the cesium was carried. From this site, a shipment of paper bearing trace levels of contamination was sent to São Paulo.



Economic consequences. Economic impacts of the event fall into several broad categories: agricultural and textile products, treatment and research, property (land and housing), cleanup (materials, labor, site), and services (hotels, transportation, tourism).

The impact on agricultural products was dramatic. Within two weeks of the event (i.e., the announcement of the contamination), the wholesale value of the entire state's agricultural production fell by 50 percent. It is perhaps important to note that all of the major agricultural products of the region and state (including cattle, rice, and other grains) are produced outside of the community of Goiania and that none have been shown to be contaminated in any way. Manufactured goods, including textiles, clothing, and other finished products, were also affected. The sale prices for such items produced in and around Goiania (and to some extent throughout Goias) dropped by approximately 40 percent immediately following the announcement; however, none of these items was ever shown to have been contaminated. In fact, as far as we were able to determine, there was never even a published suggestion that they could have been contaminated. Prices continued to be depressed for a period of 30–45 days.

The average loss of 30 percent of official sales (i.e., on which taxes are paid) for October and November amounted to perhaps \$7 million (U.S.) the impact on the sub-rosa sales (i.e., those products that pass through the economy without official taxes—the vast majority of goods) would be several times greater. The aggregate losses to local farmers during this period, compared to the same period in 1986, have been estimated at 23 percent of total export value.¹

Treatment and care of victims, some for the rest of their lives, can be estimated at another \$750 000 (U.S.). Research costs, bureaucratic costs (federal police investigations, agencies filing legal suits against other agencies, defending themselves, and so on) will involve an as yet unknown economic cost.

Cleanup activities were basically concluded on December 21, 1987; however, the cost to remove the contaminated waste material has been significant. The material costs alone (metal containers, steel drums, and other products) for storing and transporting the nearly 40 tons of contaminated materials to a temporary repository have been significant. CNEN has undertaken to rebuild all of the homes destroyed in the process of decontamination—a far more costly approach than simply buying the homes. To this, one must add the direct labor costs of nearly 100 technical workers and staff involved in the monitoring and cleanup operation (estimated to have already cost in excess of \$7 million by December 1987), as well as the indirect costs of headquar-



Within Brazil, the state of Goias is shown in dark shading, and the city of Goiania is indicated by the black circle. The white square surrounded by Goias is not a part of the state; it is the district surrounding the national capital, Brasilia.

ters staff who have been preoccupied with the task of dealing with the legal, regulatory, and administrative impacts of the event.

During the first three months following the accident, there was a very definite impact on the number of homes sold, home sale prices, rental prices, and land prices. These impacts tended to increase with the geographic proximity to the contaminated areas. In the immediate vicinity of the accident itself, prices plummeted. While very few homes are being advertised in the immediate areas, there is a belief (vocalized by local residents) that home sale prices have remained below the preaccident levels, though they have clearly recovered considerably from

previous months. Substantive data remain to be analyzed to quantitatively support this belief. A newspaper content analysis and data from real estate organizations will be used for this purpose.

Hotel occupancy, normally near capacity this season of year, had vacancy levels hovering around 40 percent for the six weeks following the announcement (i.e., through November 16, 1987). The Hotel Castros (one of largest in Goiania) lost an estimated 1000 reservations as a direct consequence of perceived risk and stigma (a drop of nearly 60 percent in reservations for October). Conventions for General Motors, the Corrides Stock Car Association, Comansu Tractors, and the Regional Medical Association were all

canceled in response to the perceived risk and stigma associated with the accident. Representatives of the National Industrial Exposition officially "uninvited" the state of Goiás' exposition. This decision was later rescinded after forceful intervention by leading religious leaders.

An exception to the short-term negative impact on hotel occupancy was the Umuarama Hotel, in Goiânia, which was filled with more than 100 technicians from CNEN, out-of-town newspeople, political visitors and their entourage, and other visitors concerned with the accident.

The leading tourist attraction in the vicinity of Goiânia is the small community of Caldas Novas, approximately one hour's drive from the city. Caldas Novas is a community that owes its existence to the presence of what is perhaps the largest collection of hot springs in the world. Numerous hotels have been constructed to take advantage of these natural springs. Gigantic swimming pools, water falls, and streams are present throughout the area. Even though reservations and advanced payments are normally required, the occupancy rate dropped 30-40 percent immediately following the announcement of the accident. By the end of the second month following the accident, occupancy had rebounded to its prior rate. However, this case was of interest on two important grounds. First, Caldas Novas is located some distance from Goiânia and was only distantly associated with the accident. Second, many Caldas Novas hotels required a deposit to hold reservations, thus forcing reservation holders to make a hard choice between losing their deposit and assuming the perceived risk of going to the hot springs.

Political and legal consequences. The political aftermath of the accident was also dramatic. Ramifications of the accident concerned such issues as legal liability, criminal culpability, and regulatory responsibility. In addition to the three doctors who owned the abandoned clinic and radiation device, leading figures in the State Department of Health and the CNEN were also indicted under criminal charges.

In addition to the obvious flaws of regulatory policy and the regulatory implementation process, and the negligence of those in charge of overseeing and carrying out policy, a number of other fundamental questions remain unanswered. Who is responsible for reimbursement? Mitigation? Compensation? What about accountability? There appeared to be none. The state agencies place responsibility on the CNEN; however, CNEN identifies the State Department of Health as the responsible agency. The State Department of Health asserts that it cannot be held responsible, as it has no specialists trained to inspect radioactive isotopes, and asserts that nuclear waste is

the exclusive province of CNEN. For its part, the Federal Health Ministry claims that its unit for inspecting radiotherapy facilities had been disbanded, and that a new unit had not been set up for that kind of work; thus, the Ministry claimed that CNEN should be responsible.

This event has had a profound effect on the organization of the CNEN agency itself. As a product of the blame leveled at CNEN in Brazil, for example, efforts were made to reassign their responsibility for other activities (because they were "overworked" in government parlance), and bills have been submitted to the Brazilian congress to split the agency into several distinct divisions (licensing, monitoring, enforcement, research, etc.).

Internal operations of the agencies involved have been seriously affected. The accident has focused attention primarily on this single issue and has diminished all other legitimate missions, some of them critically important. Agency directors have been totally dominated by the issue; some worry that they too may be subject to criminal charges, and concentrate their time on defending their agencies or themselves. In any case, their attention is focused on this particular issue to the detriment of the agency's overall mission.

The event has also provided another forum for political dissent, in effect giving a public forum to more or less distantly related opponents. A member of the Brazilian Green Party, for example, has managed to have a nuclear physicist from the German Green Party come to Goiânia to exaggerate dangers in order to glean political points for his own efforts at reelection. This caused untold damage when his so-called "scientific" findings (which grossly exaggerated radiation readings) were reported in the press.

The Goiânia accident has also had significant effects on the Brazilian nuclear energy program, nuclear weapons-grade plutonium production, and the search for an HLW repository. Articles dealing with the cesium accident almost invariably discuss the issue of disposal of tons of contaminated waste; this in turn leads to the issue of nuclear waste disposal in the larger sense. Nuclear waste disposal leads to the Brazilian nuclear energy facility construction and its problems, which, finally, leads to a discussion of the problem of siting an HLW repository in Brazil. All of these programs and issues have been the subject of intense scrutiny as a direct result of the cesium accident.

Political hostilities between the city of Goiânia and other cities, between Goiânia and the state of Goiás, between Goiás and other states, between Goiás and the federal government, and between other states and the federal government, were all fomented as a direct result of the incident. The efforts of cities

surrounding Goiânia to prevent the accident from affecting their economies had serious impacts on Goianian exports and intercommunity travel and social relations. Similar efforts by state authorities to isolate the economic impacts in Goiânia had an even more detrimental consequence. The incident also initiated a rash of political actions by other states to prevent nuclear waste from being buried within their borders—creating a major problem for the national government's efforts to locate and construct an HLW repository for anticipated commercial and military wastes. The state of Rio de Janeiro, for example, passed a law prohibiting burial of nuclear waste within its boundaries. Other states have begun similar movements, and tribal groups in areas slated for future national burial sites (who had not even known they were near a potential site) held protests in the capital. According to the members of the Goiânia Chamber of Commerce, concerted actions by other states to take advantage of Goiás' predicament have exacerbated existing rifts between Goiás and neighboring states, and have tended overall to weaken significantly Goiás' relative political and economic position.

Social consequences. The social consequences of the incident were also extensive. The social stigma attached to the immediate vicinity of the accident (57th St.), the local neighborhood (Setor Areopuerto), the residents of the city of Goiânia, and the state of Goiás has been marked. The expanding, concentric zones of stigma have tended to follow geopolitical boundaries, not the physical pathways of radiation transfer.

The impact of perceived risks and stigma was almost immediately apparent. Once the source of the problem had been identified in the media, a virtual panic ensued. Concern very quickly reached the point where the CNEN had to establish monitoring stations to check people for contamination. By late April 1988, more than 12.5 percent of the city's population (125 800 individuals) had, of their own volition, lined up to be checked with Geiger counters for signs of external radiation.

It is important to recognize that the entire "monitoring" effort (i.e., being checked from head to foot for contamination) was a response to perceived risk. The state and federal government did nothing to encourage people to come in for monitoring. They worked hard, in fact, to calm fears and to discourage people from coming in to be monitored. The fact that 100 000 people were personally afraid that they might inadvertently have been contaminated is a significant statistic. Approximately one of every 10 residents of a city of more than one million felt sufficiently at risk to take time off work, or use weekend hours, to travel across town and wait in line to have someone scan his or her body with a

Geiger counter for potential contamination. This is a significant behavioral response to a perceived risk!

In addition, more than 8000 residents requested and received official certification that they were not contaminated. These certificates were requested as an effort to counter the stigma attached to the area—stigma as evidenced by: 1) hotels in other parts of the country refusing to allow Goiania residents to register (e.g., in São Paulo, Cuiyaban, Manaus); 2) airline pilots refusing to fly with Goiania residents aboard; 3) bus drivers refusing to allow Goiania residents on their buses; 4) stoning of automobiles with Goiania license plates; and 5) virtually all conventions originally scheduled for hotels in Goiania during this period being canceled or rescheduled for other communities.

Perhaps the most important finding in examining the Goiania event, however, was the fact that of the first 60 000 individuals to be monitored, approximately 5000 individuals (8.3 percent) presented acute stress or allergic symptoms (i.e., rash around neck and upper body, vomiting, diarrhea, etc.).²

Curiously, the majority of these individuals claimed that these symptoms had begun after the capsule was broken but before the announcement in the news media. Not a single one of these individuals was contaminated! This has profound implications for the study of perceived risk in general and “special” nuclear-related impacts in particular.

The effort to bury the first victims of radiation exposure in the local cemetery brought about a major reaction. The construction of the massive lead-lined casket itself was followed very closely by the media for several days. The hearse carrying the first fatality, a six-year-old girl (who was to be “. . . buried along with her radioactive dolls”), to the Goiania cemetery was blockaded and then stoned—forcing the driver to flee. The police were able to scatter the protesters, and the burial was completed. The presence of this casket in the cemetery, however, remains an enduring source of concern to many.

The role of the media in agitating and exaggerating the level of anxiety and fear was indeed profound. Once established, however, it was self-perpetuating. For example, a local health official, quoted in a local newspaper, when asked who was at most risk of exposure and what could be done to minimize personal exposure, advised that “pregnant women and small children should remain at home and that domestic animals should be kept inside.” While this would, under normal conditions, be a relatively innocuous suggestion, under prevailing conditions the population of Goiania was predisposed to interpret this information as a threat—with the result that anxious pregnant women surged to the monitoring station,

school absences skyrocketed, and stray animals were routinely and systematically shot.

In evaluating the effects of the media, there are two salient points to be stressed—points that were key in understanding the role of the media in the Goiania radiation event. The first point, and one that is really directed to those charged with the management of a similar crisis, is that a healthy respect for the power of the media is required, as well as an understanding of the business of reporting the news. The media are not a single entity—rather, they comprise an array of businesses in competition with each other. Their stock in trade, in times of crisis, is the sensational nature of that crisis. The business of the newspaper is the sale of newspapers; the business of television or radio news is increasing their audience at the expense of other news entities (increase market share). In the atmosphere of trying to “scoop” other news entities, subtleties of the event may be enhanced or the public’s fears may be heightened out of proportion to the nature of the event itself. Scientists and bureaucrats not used to dealing with the media who end up as spokespersons for institutions or government agencies often make matters worse, which brings up the second point learned from the Goiania incident: The governmental institutions responsible for the management of a nuclear crisis must be cognizant of the needs of the news media in times of crisis, and they must be organizationally prepared to meet those needs.

Following the accident, health agencies strained to diffuse the stigma effects and spent enormous amounts of time and

Long-term care

At the First International Symposium on the Cesium-137 Radioactive Accident in Goiania, held September 28–30, 1988, in Goiania, Brazil, Henrique Santillo, governor of the state of Goias, stated that he had initiated legislative action that would provide lifetime pensions for the 104 individuals identified as victims of the accident. Brazil’s Secretary of Health announced that his agency would provide roughly 50 percent of the costs of the Leide des Neves Ferreira Foundation, a quasi-state agency established to care for the accident victims and to study the possibilities that similar accidents can happen in the future. In addition, Brazil’s Director of Public Works formally presented the working plans for construction of the permanent headquarters for the Foundation.

energy to help individual citizens overcome the effects of stigma. Health authorities worked hard to counter citizen concern that hospitals, clinics, and other medical facilities may remain contaminated. Local business and community leaders initiated a “cultural program” designed specifically to counter the stigma and, as they call them, “discrimination” impacts. As they put it, the information campaign has been initiated “to show that Goiania is not a Hiroshima or a Nagasaki or a Chernobyl.”

It must be emphasized that this situation was not simply a case of “ignorant peasants” flopping around in confusion, or of pervasive cultural or information-base differences. For example, doctors and dentists, trained in the United States, routinely refused to treat patients without certificates; unlike other emergencies, nurses refused to return from strike to treat contaminated individuals; and politically and economically well-placed individuals sought preferential treatment (certificates) for special surveys of homes they wanted to buy or sell, as well as for special “in-house” monitoring. Dealers and wholesalers of every imaginable product sought and received certificates of non-contamination. When questioned about the “facts” of contamination, the director of the Goiania Chamber of Commerce noted: “The facts are irrelevant. It is in the way they are being manipulated to serve economic and political objectives that has brought about these disastrous consequences.”

Simply stated, the members of the Executive Board of this Chamber of Commerce were uniformly of the opinion that the incident had been used by other Brazilian states to secure an unfair commercial advantage over Goias products. While it is true that other states did, in fact, profit at the expense of Goias’ situation, it is less likely a product of conspiracy than it is of individuals collectively taking advantage of a competitive “window of opportunity.” The consequences, however, are the same.

Summary

First, it is important to emphasize the danger in assuming that these impacts are somehow “culture-specific” phenomena. The incident started and flourished in a well-educated, urban, sophisticated population in a cosmopolitan city of one million residents. Some of the factors that promoted the spread of the problem, such as the unchecked manipulation and sensationalization by the media, the “outside experts” problem, and so on, apply more to Brazil than to the United States. However, it is important to understand that in many other ways, the risks are greater in the United States—information travels faster, has a greater impact on a larger number of people, and can affect national commodity markets in

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goiania

a matter of minutes. Moreover, as a population, we can hardly claim a much greater understanding of radioactive contamination. Finally, we must recognize that in the United States, a technical risk assessment can be absolutely accurate and yet fail to anticipate, or protect against, the potentially devastating impacts of social interpretations of an accident event.

This event demonstrates the importance of perceived risks in predicting potential socioeconomic impacts from a nuclear-related accident, and demonstrates that the social channels, political institutions, and economic mechanisms through which socioeconomic impacts are distributed are of profound importance to the control and containment of potential nuclear-related socioeconomic impacts in the United States.

The lessons to be learned from the Goiania event apply to both low- and high-level radioactive waste siting decisions, to reactor siting decisions, to radioactive materials transport, to medical and technical uses of radioactive substances, and, in fact, to accidents involving any number of other materials that can injure or kill through what to the public are mysterious processes.

A large number of potential accident scenarios have been under consideration in this research (such as a transportation or other surface accidents that result in a significant decline in tourism, the number of conventions, and the selection of a place as a retirement residence). The results of the work in Goiania make it clear, however, that such a significant shift in established social patterns and trends is not likely to occur as a direct outcome of a single nuclear-related accident (even, perhaps, a relatively major one); rather, they are likely to occur as a result of the enduring social interpretations of such an accident—that is, as a result of the process of understanding, communicating, and socially sustaining a particular set of associations with respect to the initial incident.

Any scenario that postulates the release (or the potential release) of a relatively small amount of radiation to the environment will entail a wide array of consequences. In any such scenario, the radiation exposure itself will be an obvious problem both in terms of physical risk and in terms of the socioeconomic impacts on the exposed persons and communities. As the Brazilian case illustrates, however, the aggregate impacts of the exposure itself will likely be minor when compared with the consequences of people's perceptions of the risks involved, and their reactions to those perceptions.

References

1. "Autos de Goiania," *Ciencia Hoje*, March 1988.
2. Personal communication, Donald Binns (CNEN).