LOST & FOUND DANGERS
ORPHAN RADIATION SOURCES RAISE GLOBAL CONCERNS

BY PEDRO ORTIZ, VILMOS FRIEDRICH, JOHN WHEATLEY, & MODUPE ORESEGUN

Global awareness is growing of problems associated with commercial radiation sources whose whereabouts are largely unknown. For one reason or another, they have fallen outside of regulatory control. With radiation sources being transported across borders, the implications stretch beyond the State where the sources were originally used.

These uncontrolled radiation sources are commonly called "orphan sources". The term typically is taken to include: sources that were never subject to regulatory control; sources that were subject to regulatory control but since have been abandoned, lost or misplaced; and sources that were stolen or removed without proper authorization.

Exactly how many orphan sources there are in the world is not known, but the numbers are thought to be substantial. Sealed sources or their containers can be attractive because of their appearance or their apparent value as scrap. The subsequent recovery of such sources by workers and unsuspecting members of the public who are not aware of the inherent hazards could give rise to external irradiation or, if the sources are tampered with, the possibility of internal exposure. Such cases already have led to serious injury and in some cases death. Sources incorporated into scrap metal for subsequent recycling can lead to the contamination of industrial plants and the environment, possibly with serious economic consequences. Patterns of international trade in scrap metal mean that such material could be transferred from one country to another.

Photo: Junk and scrapyards are among the places where orphan radiation sources could turn up. *(Credit: Carnemark/World Bank)*

Many orphan sources originated from use in medicine and industry. Some, however, derive from defense activities (used for civil defense exercises and other applications) about which knowledge may not have been available to the civilian authorities.

TYPES OF SOURCES

Teletherapy Sources. Some radiation sources, purchased in the 1950s and 1960s, or later, were imported before regulatory control was enforced and no provisions for return or disposal were made. Sources in their irradiation head have been buried in hospital gardens or yards and it is not unlikely that many of these sources are still in similar condition around the world. Although five to eight half-lives of cobalt-60 have passed, the sources still

Mr. Ortiz, Mr. Wheatley and Ms. Oresegun are staff members in the IAEA Division of Radiation and Waste Safety. Mr. Friedrich is a staff member in the IAEA Division of Nuclear Fuel Cycle and Waste Technology.

may have an activity of the order of around 20 to 100 Ci. Fatal doses can be received in a relatively short time.

As noted earlier, abandoned teletherapy sources in their irradiation heads have caused catastrophic consequences in Ciudad Juarez, Mexico and Goiania, Brazil. Other abandoned transport container sources have been involved in severe irradiation cases (Turkey) and even fatalities (Georgia).

Another problem is the issue of donated and second-hand equipment. As cobalt-60 teletherapy units are being replaced by accelerators in most developed countries, there is a straightforward temptation to donate them to developing countries, without any arrangement for return of sources to manufacturers. This approach may become another increasing source of orphan sources if import/export information is not exchanged among regulatory authorities of the countries involved and proper regulatory control from both sides is not exercised.

The fact that a missing teletherapy source (24 TBq) in Turkey could not be traced back -- and it is not known whether the source was returned to the country of origin or remained in Turkey -- adds an international dimension to the problem. The total number of teletherapy sources in the world can be estimated in several thousands. If proper regulatory control is not exercised, the problem of teletherapy orphan sources is likely to increase.

Radium Sources from Brachytherapy. Before 1950 radium was the only radionuclide source in common use, especially for brachytherapy. It was used in the form of needles, for interstitial brachytherapy and tubes for intracavitary brachythearpy. For reference, a brachytherapy source placed in its applicator in contact with tissue delivers a dose of the order of 40 Gy at one centimeter distance from the source in about two to three days of continuous exposure. Accidents with severe injuries involving a lost brachytherapy source, if found by someone not knowledgeable about radiation sources and placed into a pocket, close to tissue, cannot be excluded.

A brachytherapy set in a single hospital may have had several tens of individual, very small sources. As other radionuclides became available, radium-226 was progressively replaced, but many radium sources were donated to other hospitals or even to other countries. Other sources were disposed in an uncontrolled manner.

Today radium sources constitute a special problem. They were imported into many countries before the 1950s, long before any regulatory control and any regulatory requirement of accountability; consequently, traceability is very uncertain. Most of the original owners are dead, and family members retained these sources as tubes and needles because of the platinum capsule or radiation filters made of gold. Many of the old premises (hospitals, clinics) used for such treatment have been abandoned, closed or relocated.

As opposed to common practice today (when radiotherapy is performed only under the responsibility of radiation oncologists), radium was used by various other professionals: ophthalmologists, dermatologists, gynecologists; radiologists; and even by non-physicians. Sources were often loaned or borrowed and

Photo: Radiation sources are used throughout the world, for medical care and other purposes. In Colombia, the IAEA has helped set up safe storage conditions for sources used in radiotherapy.
(Credit: Perez/IAEA)

transported from clinic to clinic in private cars with no security precautions. Thus, sources were often lost. Places where radium-226 has been found include jewelry boxes of family descendants of original owners, in private safes, and in private garages.

Industrial Radiography. Portable devices can be transported in ordinary cars and can be exported and moved to other countries rather easily. It is thought that a radiography device that led to an accident in Peru was illegally imported. Cars are a common target for theft, and a car with a radiography source inside is no exception.

Industrial radiography sources have activities that can cause severe injuries in minutes or a few hours when placed in contact with someone, for instance through a pocket. There are a number of examples when people placed radiography sources inside their pockets that caused serious injury, including amputation of a limb.

Nuclear Gauges. Some types of nuclear gauges for controlling devices in manufacturing processes are usually intrinsically safe. Their use does not need significant training or maintenance, so they tend to be forgotten over the years and eventually become orphans. Although safe in design, such sources, once they become orphans, hold the large possibility of being dismantled or publicly accessible.

Sources Outside Civilian Control. The accident in Georgia -- in which sources used by military troops for civil defense exercises were found -- brought a new dimension to the problem of orphan sources, namely that some sources have never been under the control of civilian regulatory authorities. Twelve sealed caesium-137 sources and about 200 radium-226 sources had been abandoned by a previous military owner at a site without following set regulatory safety procedures. Instead, they were transferred to a new owner, and treated as disused sources for later conditioning as a waste. As a consequence of this abandonment, eleven individuals at the facility were exposed for a long period of time to high doses of radiation. This resulted, among other things, in severe radiation-induced skin injuries.

TRANSBOUNDARY MOVEMENT OF ORPHAN SOURCES

In a number of reported cases, the transboundary dimensions are evident.

- In an accident in Estonia, the source assembly was found with scrap metal, thought to have belonged to an old type of irradiator. In its report of the accident, the IAEA states that no gamma irradiators have ever been operated in Estonia and hence it is possible that the source and metal container were brought into Estonia from the Russian Federation with miscellaneous scrap metal for export to western Europe. The report concludes that there is a significant potential for other sources to reach the public domain by similar pathways. In fact, a second source was found on a highway during a search several weeks after the accident.
- In an accident in Ciudad Juarez, the teletherapy head was imported into Mexico from the United States and was purchased without authorization; contaminated rods were also also exported to the USA. The teletherapy source that caused the accident in Turkey was expected to be re-exported to the supplier in the USA. At the time, one transport container was found empty and the fate of the teletherapy radiation source remains unknown. Neighboring countries were alerted that the source possibly could have left Turkey.
- In an accident in Spain, the source entered the country with scrap metal, coming through other countries. The route of scrap is very difficult to trace and virtually can lead to any country.

INTERNATIONAL APPROACHES

Given the dimensions, it is clear that a comprehensive international approach, rather than isolated national actions, is needed to cope with the problem of orphan sources. One country's efforts against orphan sources can be jeopardized if neighboring countries do not regain and maintain control of their own sources at the same time. Moreover, the unauthorized transfer and export to other countries, as well as sources mixed with scrap metals, may well be very difficult to eliminate with isolated national initiatives.

An international approach needs to address three aspects of the problem:

- *Maintaining accountability of sources, through national*

FURTHER READING

The IAEA has published a range of reports on lessons learned from accidents involving radiation sources and radioactive materials, and on ways to prevent them. They include:

- *Diagnosis and Treatment of Radiation Injuries*, Safety Reports Series No. 2 (1998)
- *Planning the Medical Response to Radiological Accidents*, Safety Reports Series No. 4 (1998)
- *Methods to Identify and Locate Spent Radiation Sources*, Technical Document, TECDOC-804 (1995)
- *Lessons Learned from Accidents in Industrial Irradiation Facilities* (1996)
- *Lessons Learned from Accidents in Industrial Radiography* (1996)

Visit the IAEA's *WorldAtom* Internet services at www.iaea.org for a full listing of the Agency's publications on these and other subjects.

regulations and enforcement of compliance. This requires that control not be relinquished at any time during the source's lifetime.

- *Regaining control of existing orphan sources, through national search campaigns.*
- *Storing and properly disposing of orphan sources, located in search campaigns or found otherwise, or returning sources to the suppliers.*

Based on what's known about the problems, it can be inferred that virtually every country is likely to have a number of undiscovered orphan sources. Without an active search programme, they may remain undiscovered for years. They may only be detected if an accident occurs. A search campaign is therefore an unquestionable need to raise the chances of finding orphan sources.

After the accident in Goiania, some countries initiated search actions. In one of them, eleven teletherapy units were found in old irradiation rooms partially demolished and in hospital courtyards; in one case, the premises were demolished and a major road was under construction and about to be pass through the old irradiation room, in which the source in its irradiation head was still stored.

In a 1995 technical document (TECDOC-804, see box above), the IAEA provided guidance on how to maximize results of search campaigns. Before starting a physical search, it is indispensable to collect documentary information.

For medical sources, the information can be found in records of existing or former inventories of sources centrally kept (e.g. ministries of health or organizations responsible for procuring radiation sources, locally or from abroad), custom records, suppliers, records from cooperative programmes involving donations, discussions with older staff members or physicians, especially but not only, radiation oncologists, and papers published in journals.

For industrial sources, information also can be found at operating sites, as well as those no longer in operation; constructions projects, where companies from abroad often carried out work using radiography sources; industrial plants in which nuclear gauges may have been used; scrap dealers; and interviews with former staff of these industries.

Once documentary information has been collected and analyzed, planning the physical search can start. The plan covers administrative clearances and authorizations, the organization and procedures for the search team, and required equipment, training and safety measures.

Search campaigns can even be more productive if international programmes are operated in many countries simultaneously in a synchronized manner and information is exchanged at regional workshops or other means. Exchanging information about, for example, radiation source and device characteristics, suppliers, and import/export records can render significant benefits. Sharing information about lost and found sources would help provide confidence that the number of missing sources is being reduced.

As importantly, the work of providing assistance and expert teams in support of search campaigns would be facilitated through greater international cooperation. ❑