

# Dosimetry During the Radiological Accident in Goiânia

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**CHALLENGES IN INITIATING AND CONDUCTING LONG-TERM  
HEALTH MONITORING OF POPULATIONS FOLLOWING  
NUCLEAR AND RADIOLOGICAL EMERGENCIES IN THE  
UNITED STATES  
A WORKSHOP**

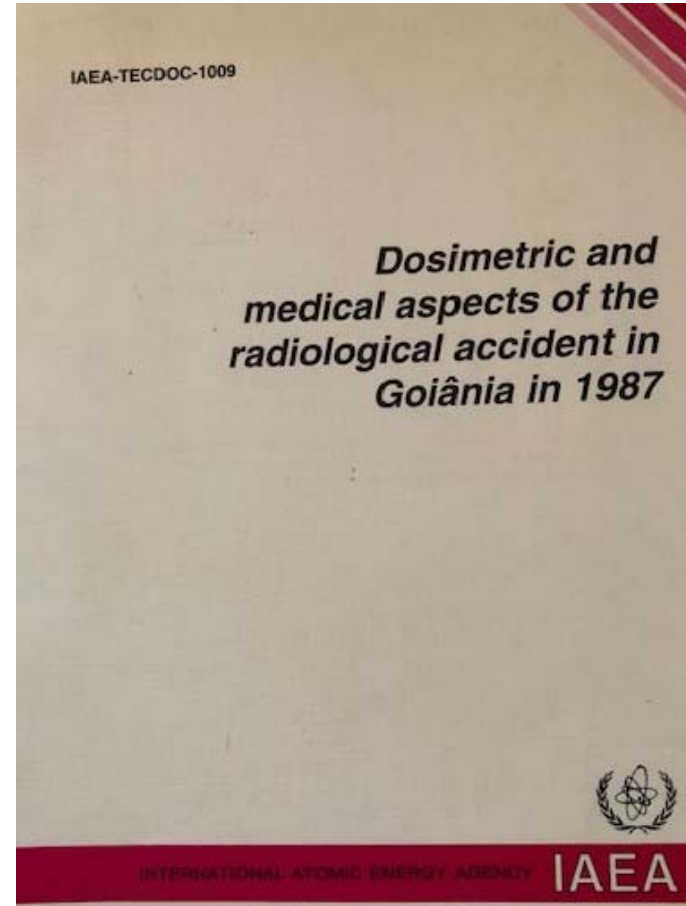
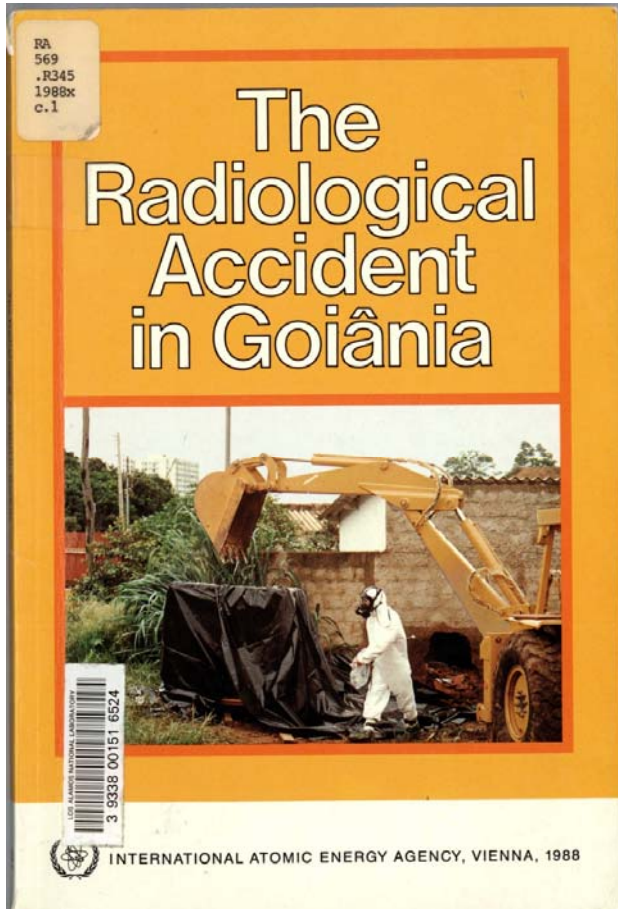
**March 12-13, 2019 - Washington, DC**



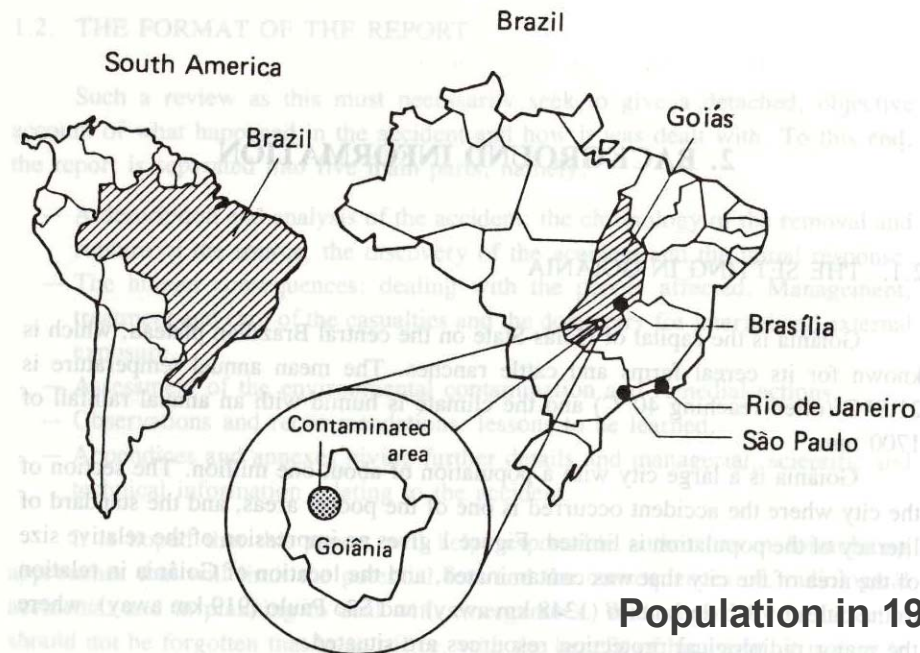
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**LA-UR-19-21929**

# Basic References



# Goiânia, Goiás (state), Brazil



**Population in 1987: 1 million**

**Distance to Rio de Janeiro and Sao Paulo: 580 miles**

# Schematic Diagram of the Dispersal of Cs-137

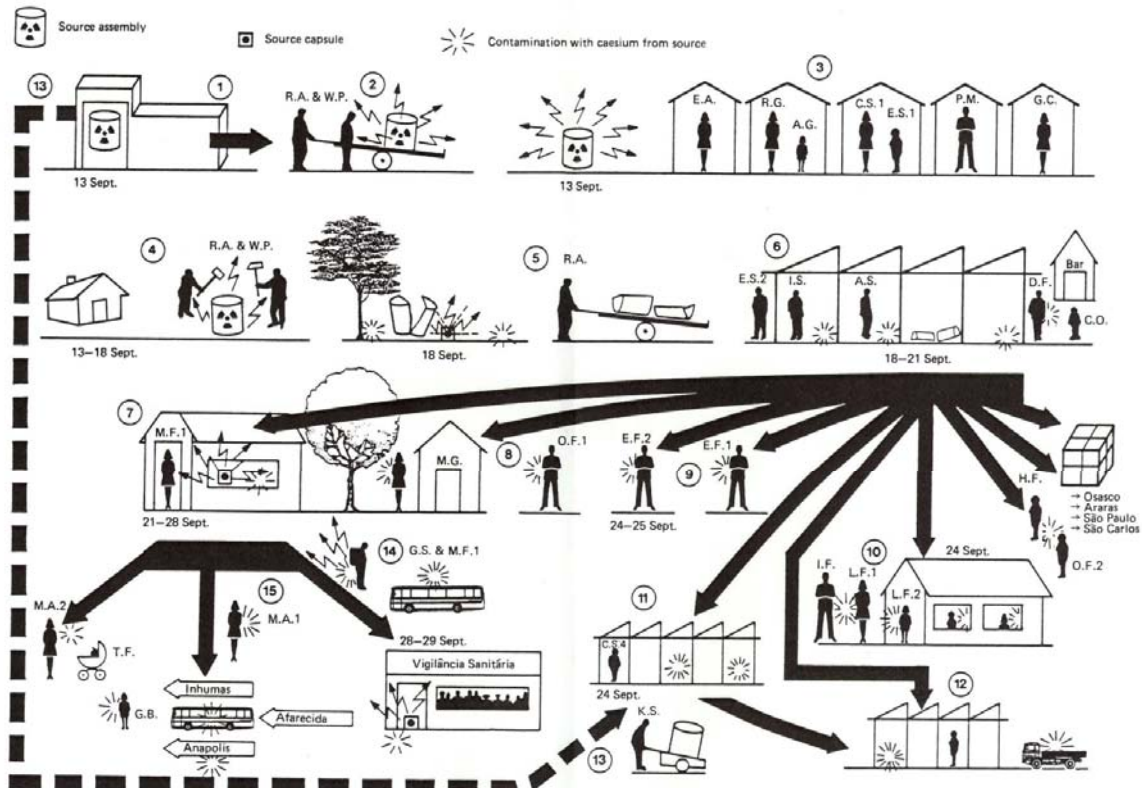
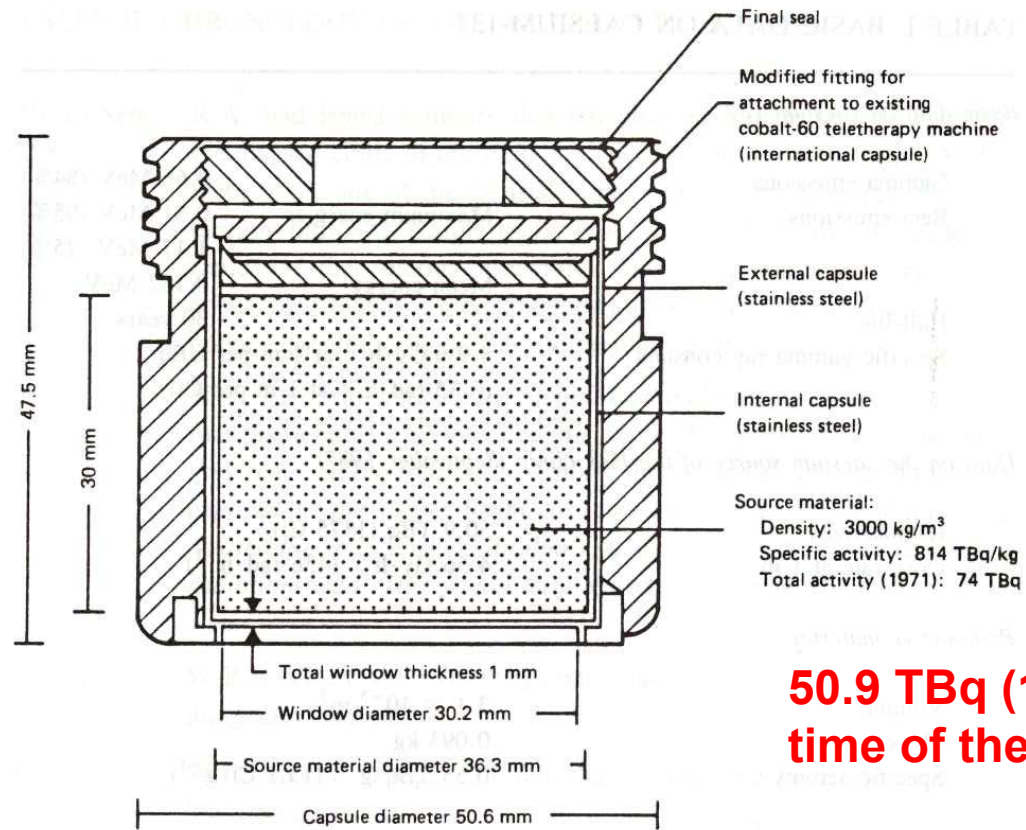


FIG. 8. Schematic diagram of the dispersal of caesium-137 in the accident in Goiânia. The diagram is based on a drawing made shortly after the discovery of the accident in attempting to reconstruct what had happened. It is reproduced in the format in which it was originally drawn even though it differs in minor details from what is now considered to be the best description of events (see the text of the report). Key: (1) the derelict clinic of the IGR; (2) removal of the rotating source assembly from an abandoned teletherapy machine by R.A. and W.P.; (3) source assembly placed in R.A.'s yard near houses rented out by R.A.'s mother E.A.; (4) R.A. and W.P. break up source wheel and puncture source capsule; (5) R.A. sells pieces of the source assembly to Junkyard I; (6) Junkyard I: the caesium

chloride is fragmented and dispersed by I.S. and A.S. via public places; (7) D.F.'s house: contamination is further dispersed; (8) visitors and neighbours, e.g. O.F.1, are contaminated; (9) E.F.1 and E.F.2 contaminated; (10) I.F.'s house; other arrows indicate dispersion via visitors and contaminated scrap paper sent to other towns; (11) contamination is spread to Junkyard II; (12) contamination is spread to Junkyard III; (13) K.S. returns to the IGR clinic to remove the rest of the teletherapy machine to Junkyard II; (14) M.F.1 and G.S. take the source remnants by city bus to the Vigilância Sanitária; (15) contamination transferred to other towns by M.A.1. (By courtesy of CNEN, Brazil.)

# $^{137}\text{Cs}$ Source



**50.9 TBq (1375 Ci) at the time of the accident**



**100 g of CsCl → 3500 m<sup>3</sup> Waste**



***3800 metal drums (200 L), 1400 metal boxes (5 tons), 10 shipping containers (32 m<sup>3</sup>) and 6 sets of concrete packaging. It took 275 truck loads.***

# Individual Monitoring

# Monitoring at the Olympic Stadium



5. *Monitoring people for contamination at the Olympic stadium.*



# First Medical Care at the Olympic Stadium



# Flow chart for medical care

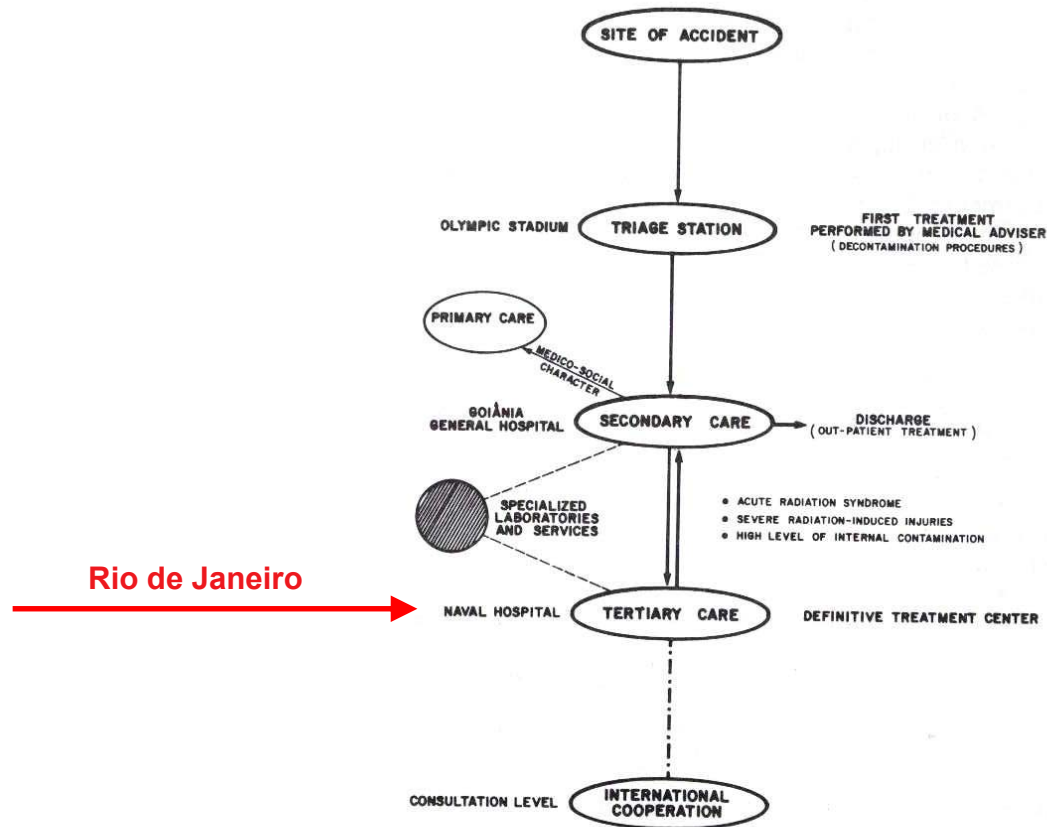


Fig. 1. Flow chart representing the different medical care levels.

# Individual Monitoring

- **In vitro:** urine and fecal samples sent to Institute of Radiation Protection and Dosimetry (IRD) in Rio de Janeiro for analysis (more appropriate bioassay method during the first days because of external contamination).
- **Cytogenetic dosimetry:** Blood samples also sent to IRD.
- **In vivo:** improvised whole body counter installed at the Goiânia General Hospital.
- Long-term in vivo and in vitro monitoring needed in order to evaluate the efficacy of PB in reducing the radiation dose.

# In Vivo Measurements

## First Measurement System (Nov/1987)

- Improvised at the General Hospital of Goiânia.
- 20cm x 10cm NaI(Tl) detector, 5 cm Pb shielding.
- Detector positioned at 2 m from the floor.
- System proved adequate:  
MDA = 9 kBq (243 nCi) for 2 min counting



32. *The improvised whole body counter used in Goiânia.*

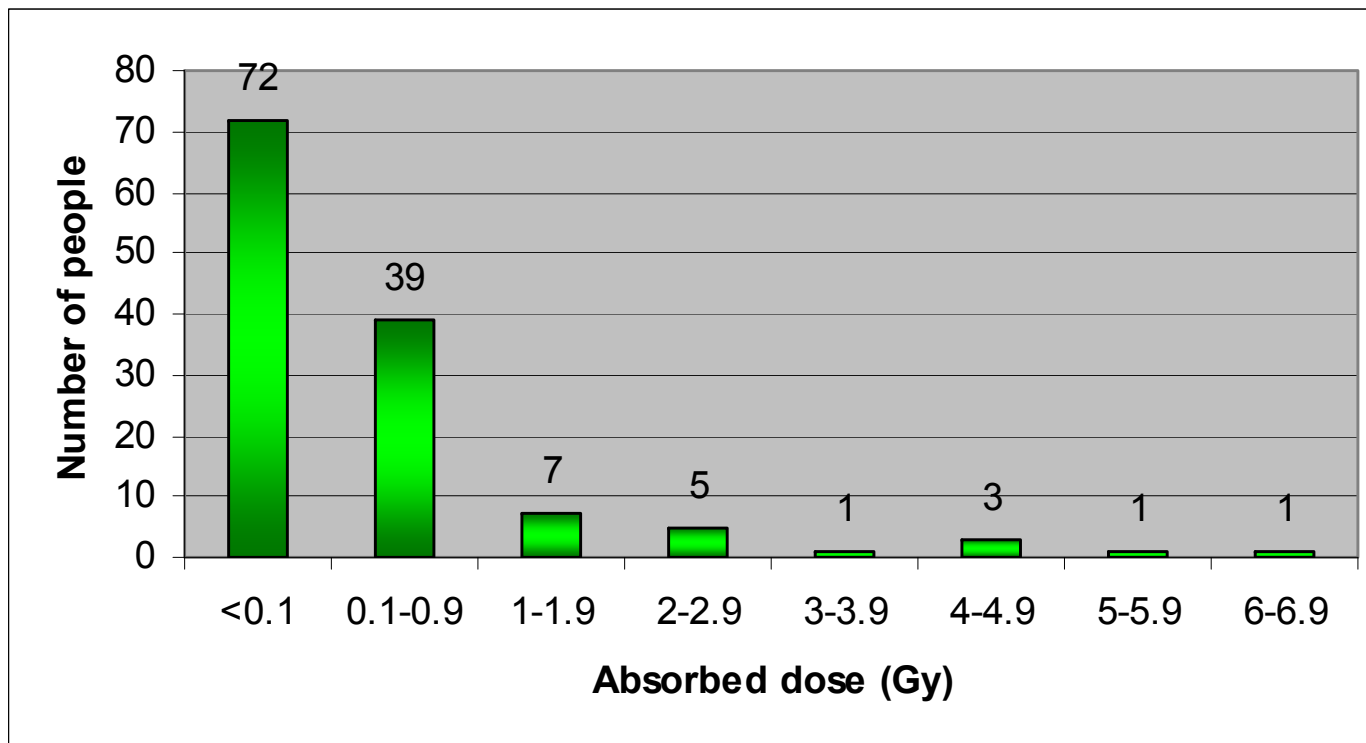


## Individual Monitoring

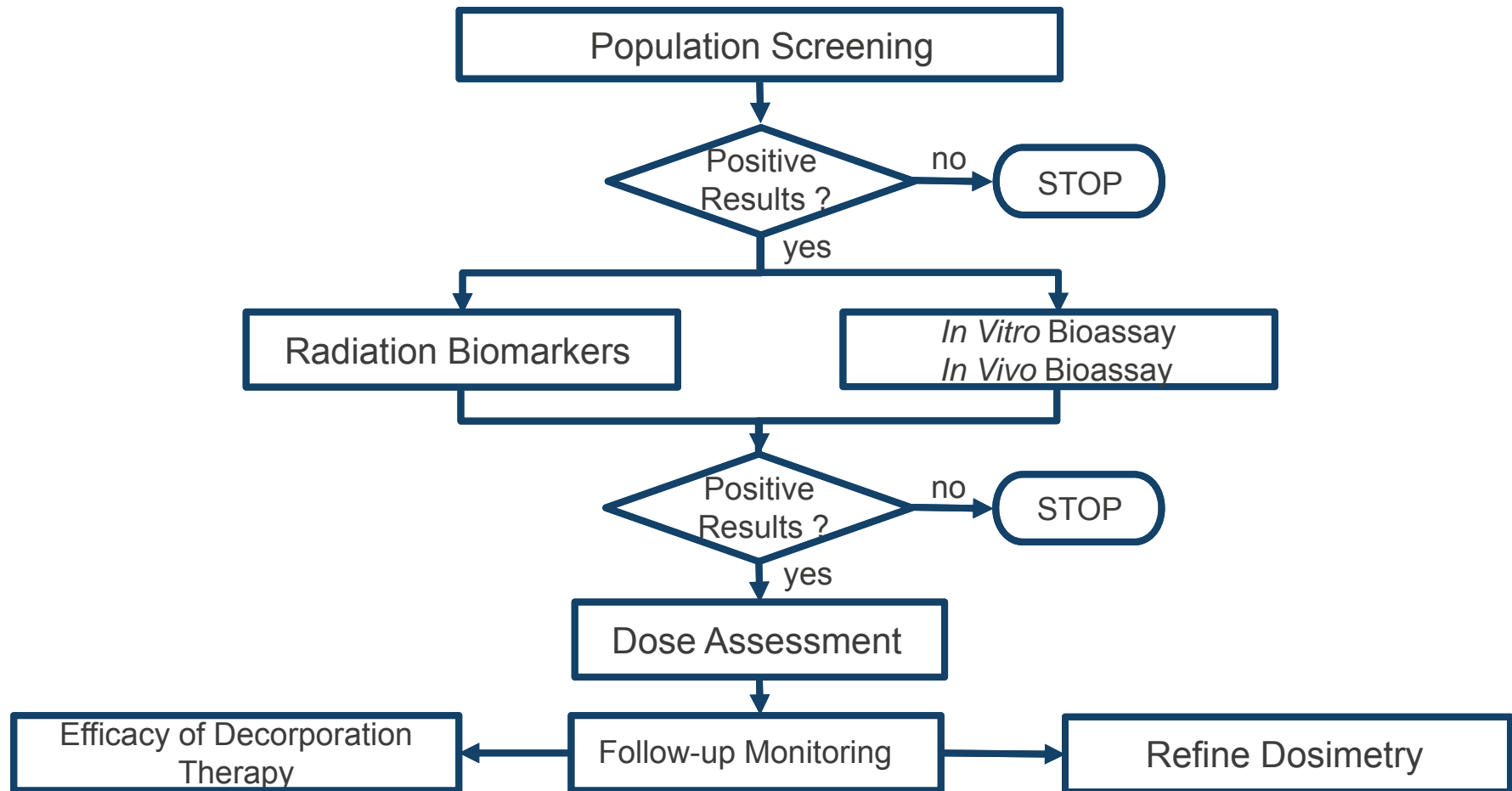
Category	Number of People
Monitored	112,000
External and Internal Doses Indicative	249
External and Internal Doses Conclusive	129
Admitted to Hospitals	49
Intensive Medical Care	22
Decorporation therapy (Prussian Blue - Radiogardase)	46
Deaths	4
Forearm Amputated	1

# Dose Distribution for Exposed People

*Patients and Their Families: 129 People*

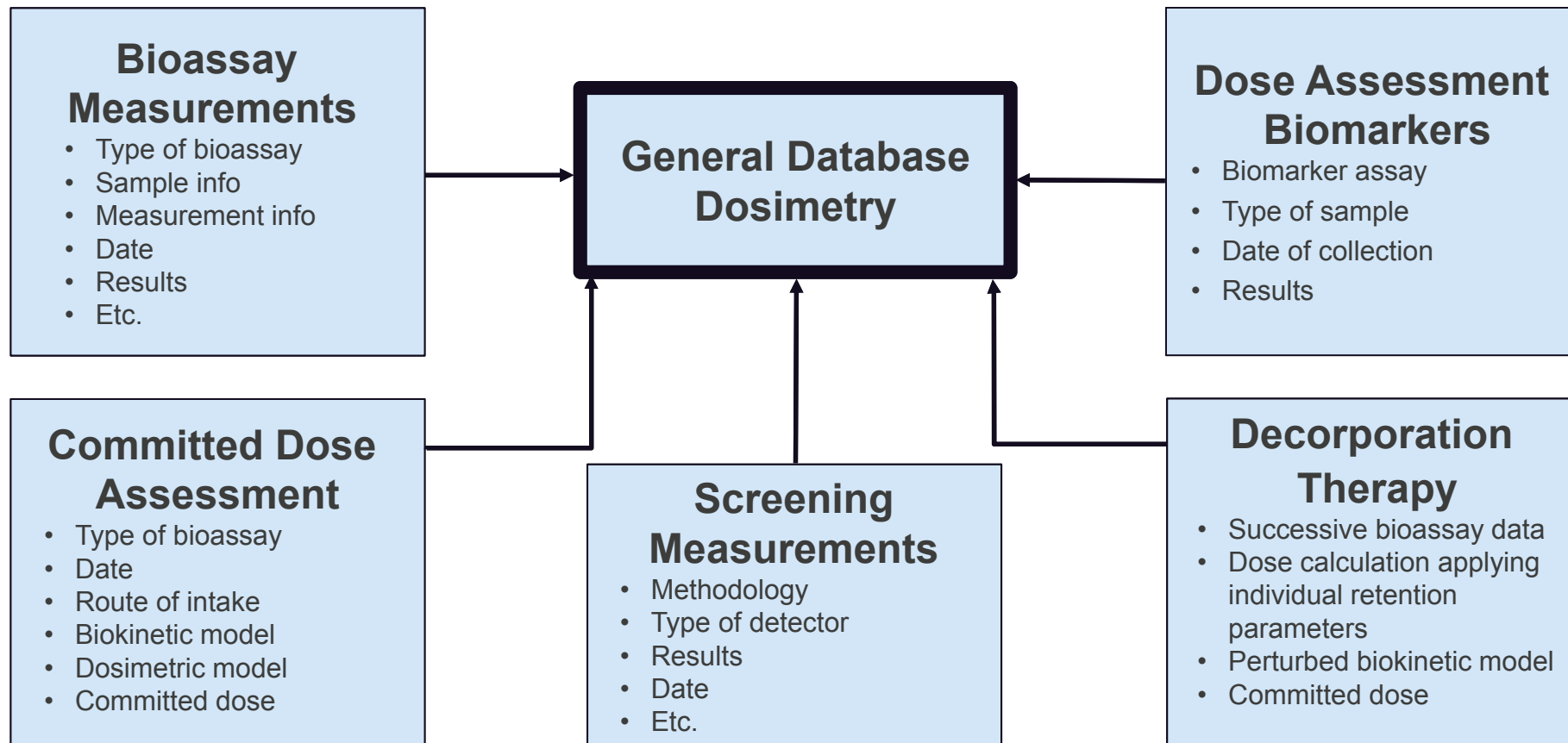


# Individual Monitoring for Emergency Response



# Database

(Screening, Medical, Legal and Epidemiological Purposes)





## Some difficulties with registry, dosimetry and follow-up

- Some persons didn't have a numbered ID, like SSN.
- Similar names with different levels of contamination caused confusion.
- Non-adults presented much smaller anatomical characteristics than those specified in the corresponding reference phantoms used in dose calculations.
- Long-term monitoring to evaluate the efficacy of PB was needed.

# Conclusions and Observations

Regarding

## MODELING THE OPTIMUM PRUSSIAN BLUE TREATMENT FOR ACUTE RADIATION SYNDROME FOLLOWING $^{137}\text{Cs}$ INGESTION

Tim G. Adams and Rocco Casagrande, Health Phys. 116(1):88–95; 2019

“Modeling found that **treatment is most effective if begun within 15 d of ingestion, and the course length should be at least 75 d to mitigate cancer risk and 290 d to mitigate fatalities due to acute radiation syndrome.** Extending the treatment time for contaminated individuals would increase demand for Prussian blue following an accident or attack and in turn, would require a larger stockpile of Prussian blue to meet demand. Not enough data is available to determine if this longer treatment time would lead to adverse medical outcomes due to the toxicity of the treatment itself.”

**We agree that a long-term health monitoring of some individuals can be performed. However we don't believe that this can be done to a huge number of people. THEY SIMPLY WON'T TAKE IT! Unless they are under constant supervision like in a hospital.**

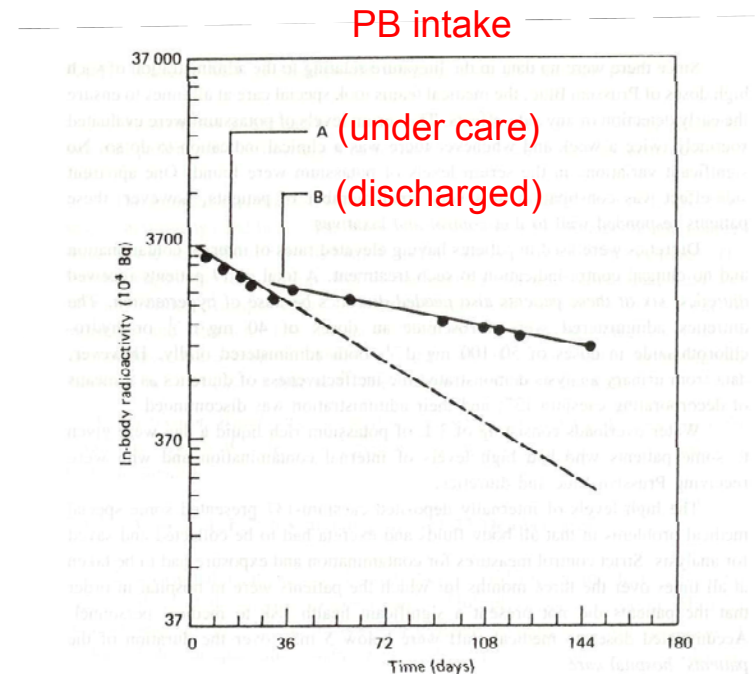


FIG. 11. The effect of the administration of Prussian Blue: plot of content of radioactive material in the body versus time. A: administration of 10 g of Prussian Blue per day. B: after cessation of administration of Prussian Blue.



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# Additional Info



## Accident Cause and Discovery:

- 1985: A private radiotherapy institute moved to new premises leaving the Cs-137 teletherapy unit in the old building, which was partly demolished, without notifying the licensing authority as required by law.
- September 13<sup>th</sup> 1987: two people entered, found some scrap value, removed the source assembly from the radiation head, took home and tried to dismantle.
- They partly dismantled the equipment → external gamma radiation with localized burns to their bodies. One had to have an arm amputated.
- The equipment was sold to a junkyard, source was ruptured (CsCl, highly soluble, readily dispersible) → environmental contamination + external and internal exposure of several persons.
- The source glowed blue in the dark and was passed from hand to hand.

## Accident Cause and Discovery:

- Remnants of the source, housing and the assembly, were sold to a second junkyard → more persons exposed.
- This proceeded for five days → people were showing gastrointestinal symptoms arising from their exposure to radiation from the source.
- Some look for hospitals and were treated as carriers of infectious-contagious diseases. → No improvements.
- The symptoms were initially not recognized as being due to ionizing radiation.
- Sept. 28<sup>th</sup>: one of the victims (wife of first junkyard owner) connected the illness with the source and took part of it to the public health department in a public bus. She told that “it is killing my family”. She had an estimated whole body dose of 5.7 Gy and an estimated intake of 100 MBq. She died on Oct 23<sup>rd</sup> at 38 years old.

## Initial Response Steps

- Sept. 28: A local physicist was the first to assess the source at the health department by monitoring it. He took actions on his own initiative to evacuate the area. At the same time he informed the authorities.
- The speed and the scale of the response were impressive.
- Population was instructed to go to the triage center which was the Olympic Stadium (soccer stadium). Supposed contaminated victims were separated.
- More severely irradiated/contaminated patients were transferred to Marcilio Dias Naval Hospital in Rio de Janeiro.
- Several other sites of significant contamination were quickly identified and residents evacuated.

# Levels of Patient Care

- Primary care level: The dispensary of the Institute for Protection of Minors (IPM). Patients presenting external contamination and slight internal contamination, warranting decontamination measures impossible to implement elsewhere. Also those who had their homes and properties interdicted, which added a medico-social character to this level.
- Secondary care level: Goiania General Hospital. Patients with first- and second-degree local radiation injuries, or those who had received doses capable of causing a slight-to-moderate impairment (1 to 2 Gy) of the hematopoietic system but who would not require special isolation measures or replacement therapy (platelet transfusions, for example). Also those with moderate-to-severe internal contamination. They could benefit from  $^{137}\text{Cs}$  removal procedures.
- Tertiary care level: Naval Hospital, Rio de Janeiro. Patients with severe impairment of the hematopoietic system, as well as those presenting third-degree local skin radiation injuries.