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Transportation of Radiopharmaceuticals Produced in the "Instituto de Pesquisas Energéticas e Nucleares – IPEN".

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Abstract. The IPEN, under the rule of the National Commission of Nuclear Energy (CNEN), has been producing radioisotopes since 1959, making nuclear medicine viable and consolidated in Brazil. The IPEN is the largest shipper of radioactive materials in Brazil, and its radiopharmaceutical production facilities ship around 30,000 packages per year, in about 1,000 shipments. However, for routine shipments of radiopharmaceuticals, the IPEN depends on carriers, which have transport plans approved; this kind of plans issued, for the carriage of a range of radionuclides and activities, has no expiration date. In this paper, the weekly amount of radioisotopes produced and distributed in 2001/2002, considering the activity and de annual number of packages and consignments are shown. The percentages concerning transport means and distribution in the different regions of the country have also been presented, showing the consumption profile. The amounts per week would be about 9 TBq of total activity. Radionuclides transported under these plans are primarily IPEN-TEC ^{99m}Tc generator (Mo-99/Tc-99m), sodium iodine solution and capsules (I-131), thallium chloride (Tl-201) and gallium citrate (Ga-67), of which about 40% are shipped by road, and 60% by air. During the years 2001/2002, covering all the radiopharmaceutical material shipments in Brazil, only one transportation accident involving a radioactive carrying vehicle was reported. An annual growth of demand of 15% has occurred during this period, resulting in a better quality of life for the population, owing to the use of these radiopharmaceuticals for diagnosis and therapy. The highlights of this period were the efforts towards the nationalization of the radioisotope production, especially towards Mo-99, I-131, Ga-67 and Tl-201. Nowadays, the radiopharmaceutical production facilities have 30 products in their catalogue.

Topic: 5. Radiation Protection in the Workplace

1. *Introduction*

Among the numerous applications in diverse fields, those related to Medicine may be mentioned. In this area, the applications are made in a field generically designated radiology, which comprises radiotherapy, diagnostic radiology and nuclear medicine [1]. The nuclear medicine applies radioactive materials and nuclear physics techniques in the diagnosis, treatment and study of diseases.

The Radiopharmacy Center of the Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) produces several radioisotopes and radiopharceuticals used in nuclear medicine, such as technetium generator (99mTc), sodium iodine (131I or 123I), metaiodo-benzilguanidine (131I or 123I0, human serum albumin (125I or 51Cr), gallium citrate ((67Ga), thallium chloride (201Tl), sodium chromate (51Cr), sulphuric acid (^{32}P), sodium phosphate (^{32}P), fluoro-2-deoxi-d-gucose (^{18}F), sodium sulphate (^{35}S) and ethylenediamine-tetramethylene-phosphonic (^{153}F).

2. *Methodology*

The frequency of the production and distribution is weekly, specific radiopharmaceuticals are produced and distributed. Approximately 9 TBq of activity are processed and distributed every week.The transportation of these radiopharmaceuticals through the national territory complies with the transportation regulation for radioactive materials of the Comissão Nacional de Energia Nuclear [2].
The number of packages per year amounts to about 30,000 units in approximately 1,000 expeditions.The transportation is carried out by transporting firms authorized by the regulatory authorities and involves both air and road transportation.
In this paper, a statistic study of the distribution and means of transportation used are presented. The statistic study was done taking into account the more significant radioisotopes expedition, in terms of activity.

3. *Results and Conclusions*

In the data analysis, it was found that the transportation by air is used in more than 50% of the total expeditions. (FIG.1 to 4).

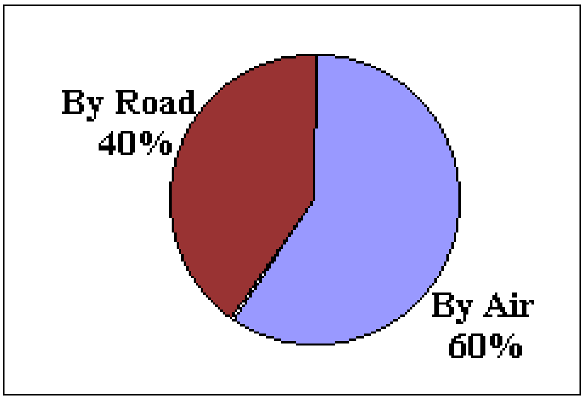

FIG. 1. *Means of transportation used in the distribution of the technetium generator (99mTc).*

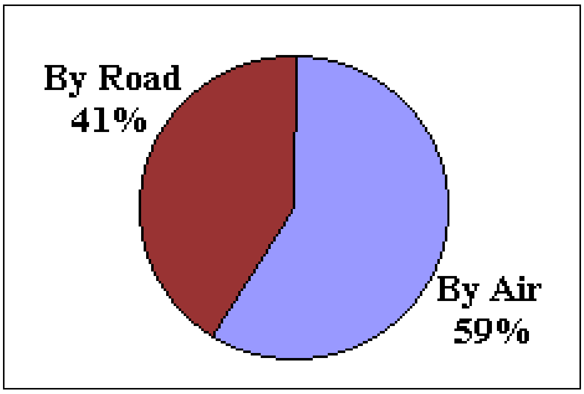

FIG. 2. *Means of transportation used in the distribution of the sodium iodine (^{131}I)*

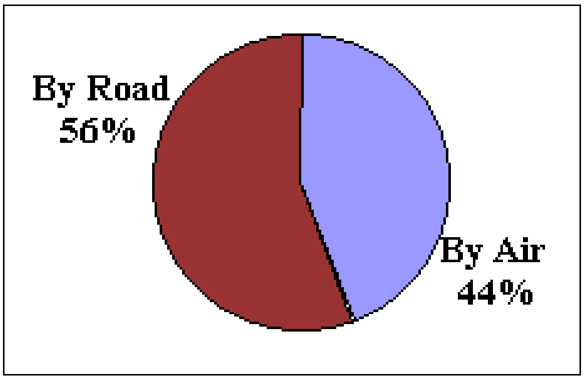

FIG. 3. *Means of transportation used in the distribution of gallium citrate (^{67}Ga)*

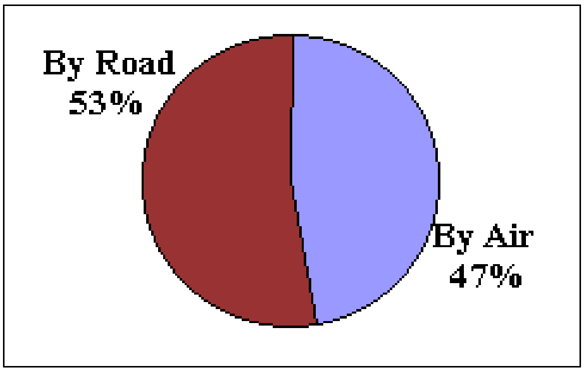

FIG. 4. *Means of transportation used in the distribution of thallium chloride (^{201}Tl).*

The distribution in the national territory meets the demand criteria in function of the development level of the macro-regions of the country (Table I). In this context, the south- eastern region registers over 50% of the national consumption, followed by the southern and north-eastern regions (Fig. 5 to 8). The increase of the demand is of about 15%, reflecting in the life quality improvement of the Brazilian population, owing to the use of these radiopharmaceuticals for diagnosis and therapy.

Table I : Macro-Regions of the Contry

Region	Area Km^2 (%)	Inhabitants (%)	*Density* Hab./Km^2	Comsuption 2003 GBq (%)
North	3,851,560 (45)	10,146,218 (7)	2,6	6,783,358(1)
Northeast	1,561,177 (18)	41,420,974 (28)	26,5	93,390,257(16)
Mid-west	1,604,852 (19)	9,419,896 (6)	5,9	38,711,213(7)
Southeast	927,286 (11)	64,610,100 (44)	69,7	342,930,208(61)
South	,	22,655,709 (15)	39,2	83,146,77(15)
Total	8,522.089(100)	148,252,897(100)	17,8	564,961,806(100)

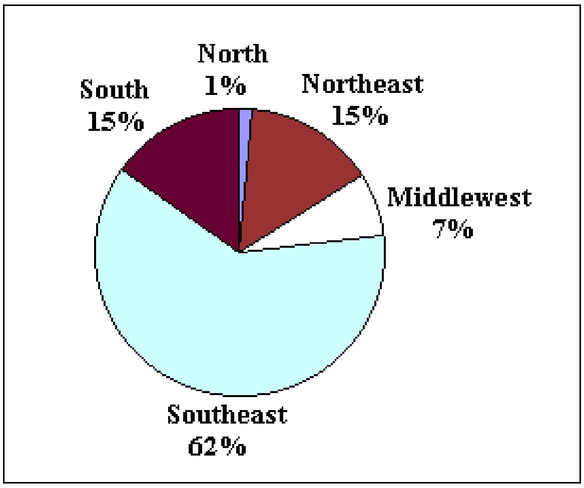

FIG. 5. Distribution of technetium generator (99mTc) in activity, per region.

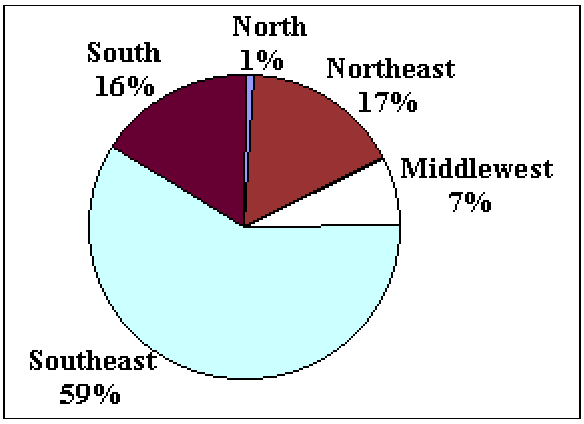

FIG. 6. Distribution of sodium iodine (^{131}I) in activity, per region..

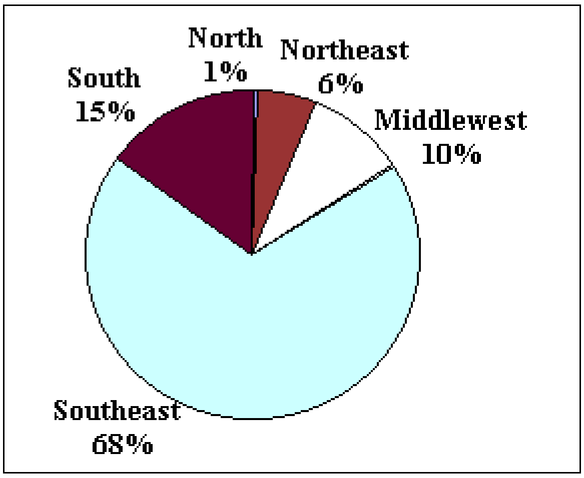

FIG. 7. Distribution of gallium citrate (^{67}Ga) in activity, per region.

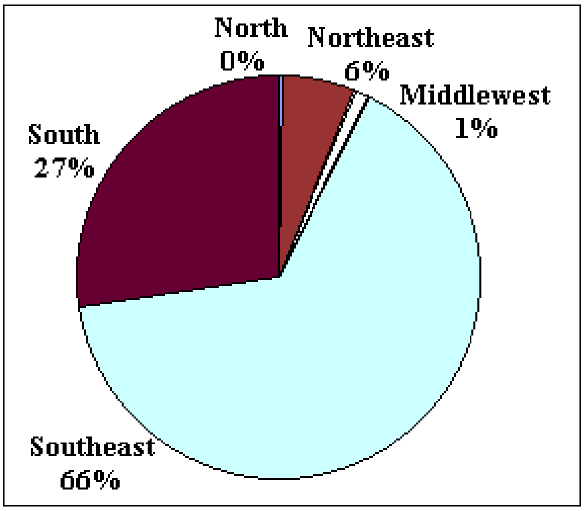

FIG. 8. Distribution of thallium chloride (^{201}Tl) in activity, per region.

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1. Okuno, E., Caldas, I.L. e Chow, C, **Física para ciências biológicas e biomédicas**, Harper & Row do Brasil, (1982).
2. Comissão Nacional de Energia Nuclear, **Transporte de Materiais Radioativos,** Norma CNEN NE 5.01, Resolução CNEN 13/88, Diário Oficial da.União, Brasil (01/08/1988).