*International Journal of Basic and Applied Science 11 (4) (2023) 142-148*

Published by: IOCSCIENCE

International Journal of Basic and Applied Science

Journal homepage: www.ijobas.pelnus.ac.id

# Radiation levels of isolation rooms used by radio-iodine ablation patients during hospitalization

**Muhammad Waqar[1], Touqir Ahmad Afridi[2], Quratulain Soomro[3]**

[1,2]Medical Physics Division, Nuclear Medicine Oncology & Radiotherapy Institute Nawabshah (NORIN), Pakistan

[3]NM & Allied Division, Nuclear Medicine Oncology & Radiotherapy Institute Nawabshah (NORIN), Pakistan

**Article Info**

***Article history:***

Received Aug 27, 2022
Revised Dec 14, 2023
Accepted Mar 30, 2023

***Keywords:***

Background radiation;
Effective dose;
Isolation rooms;
Radiopharmaceuticals;
RAI-131.

**ABSTRACT**

The use of RAI-131 in thyroid carcinoma patients presents a special concern on the environmental radiation safety for those who come in contact with the patients especially after discharge from the facility because of excretion of I131 through perspiration, salivation, breathing and urination. Methods & Materials: The present study was conducted at Nuclear Medicine Oncology and Radiotherapy Institute Nawabshah (NORIN) Sindh from 2017 to 2021 with the objective to evaluate contamination hazards by Excretion made by thyroid cancer patients received iodine therapy stayed in isolation room with doses ranging from 80–200 mCi. The areas included corridor, sink, patient bed, and toilet bowl of isolation rooms before admission and after discharge using LAMSE RM-1001 survey meter. The minimum background radiation level measured before patient stay in isolation room was 0.07 µSv/h while the maximum was 0.40 µSv/h and the mean background reading was 0.18 ± 0.072 µSv/h. The maximum dose rate after discharge was observed at toilet bowl with mean of 9.69 ± 1.98 µSv/hr and minimum of 5.0 µSv/hr and maximum value 13.77 µSv/hr. The readings recorded for the sink were: 2.0 µSv/h minimum, 20.0 µSv/h maximum with a mean of 5.55 ± 1.57 µSv/h while those for the patient bed 0.41 µSv/h minimum, 6.92 µSv/h maximum and a mean of 2.83 µSv/h. the least dose rate was found in isolation room corridor (1.53 ± 0.78 µSv/h) with maximum and minimum values 0.28 & 3.20 µSv/h respectively. Radiation is harmful; safety measures must be ensured to minimize radiation exposure to the family members as well as community either during hospitalization or after discharge of RAI-131 patients. The radiation levels from toilet bowls, beds, sinks, and corridor of isolation rooms were well within the acceptable limits and hence, do not pose significant hazard to the public.



***Corresponding Author:***

Muhammad Waqar,
Medical Physics Division,
Nuclear Medicine Oncology & Radiotherapy Institute Nawabshah (NORIN),
Sakrand Road near PITE college, Dist SBA, Sindh, Pakistan.
Email: phy_waqar@yahoo.com

## 1. INTRODUCTION

The process of radioiodine ablation of thyroid cancers encompasses the administration of Iodine 131 labeled radiopharmaceutical. I-131 is a gamma emitter and is a relatively long-lived radionuclide with half-life of 8.04 days [1][2].

This shows that I-131 has gamma emissions of 636.9 keV (7.3%) and 364.5 keV (81.2%) and beta minus (β-) emission of 606.3 keV (89.3%)[3]. It is observed that in the patients with normal renal functions, the 24-hour retention of radiopharmaceutical is 40% to 50% of the injected dose [4]. These patients need special attention towards the evaluation of radiation dose and risk to the caregivers and relatives after hospitalization [5] and also to general public who interact with the patients [6].

The factor which required the most attention is the general public health: The International Commission on Radiological Protection (ICRP) and the Pakistan Nuclear Regulatory Authority (PNRA) has set the acceptable annual exposure dose for the general public to be 1mSv/yr [7]. On the other hand, the European Commission has categorized the dose limits to certain constraints e.g., age (for infants including fetus, 1 mSv/yr; adults to 60 years old individuals, 3 mSv/yr; beyond 60 years of age, 15 mSv/yr [6]. The International Atomic Energy Agency (IAEA) has set the limit at 5 mSv [8] and the Nuclear Regulatory Commission (NRC) of the US set a limit of less than 5 mSv [9].

There is a strong phobia for radiation exposure in the public zones, which is quite valid, and has led to an increased concern of the procedures involving administration of radiation doses especially in medicine [10]. This study focuses on the effects of radiation on those individuals who interact with the patients after they have been discharged from hospital. It has been reported previously that the patients who have been administered radiopharmaceuticals, after hospitalization, impart very small amounts of radiation doses to the surrounding people [11]. These doses are much lower than the limits set by radiation protection regulations [12] which proves that there is no significant radiation risk to public and environment. As per database of National Council on Radiation Protection and Measurement (NCRP) United States, the nuclear medicine has a very little contribution of around 4% in the total average effective dose equivalent (0.14 mSv/yr of 3.60 mSv/yr) [13] this contribution is negligible when it is compared with medical x-rays 11% (0.39 mSv/yr of total 3.60 mSv/yr) [14]. This is due to the fact that a nuclear medicine patient eliminates almost all of the activity during hospitalization through physical as well as biological decay. In most cases, around 50-60% of activity is eliminated in the first 24 hours post-administration. Moreover, it has been reported that over 85% of activity is excreted after a stay of 4-5 days in the isolation room. This poses a significant hazard for contamination of isolation room [1]. Also, the excretion results in contamination of the patient's environment and of inadvertent ingestion of radionuclide by caregiving and surrounding persons [15][4]. Patients are instructed to drink water and other fluids as maximum as possible in order to excrete the radiopharmaceutical from body and reduce dose to bladder [16][17].

As the most of activity is excreted via urination, sweating, salivation, and breathing, the most critical spots in the isolation rooms are therefore the toilet bowl, patient bed, sink, and corridor. These areas ae selected for investigation before and after the stay of patient having oral ablative dose of I-131 [18][19]. Also, the contamination hazard to caregivers and attendants of patients via emitted rays and body fluids is an important problem that needs consideration [20].

The Nuclear Medicine Oncology and Radiotherapy Institute Nawabshah (NORIN) is a comprehensive healthcare institute for cancer diagnosis, treatment, and research [21]. It was established with the objective to implement the latest research methodologies for cancer management [22]. Special rooms with all necessary radiation protection measures have been designed for hospitalization of RAI-131 ablation patients as shown in Figure 2. The purpose of this study was to measure the level of contamination activity released by patients treated with radioiodine therapy during hospitalization and after discharge. This will enable us review the radiation safety rules in the specialized isolation room designed for used by RAI-131 patient's radiopharmaceuticals.

## 2. RESEARCH METHOD

NORIN cancer hospital Nawabshah is located in the remote rural area of Sindh, Pakistan. 103 thyroid carcinoma patients who received I131 ablation therapy have been chosen as subjects for this study. The patient population consisted of 27 males and 76 females with ages ranging from 25 to 65 years. Patients were orally administered therapeutic amounts (80-200 mCi) of I131-labelled sodium iodide NaI. After administration, the patients were hospitalized and isolated for 3-4 days until the dose rate from the

patient's body was not more than 30 µSv/hr at a distance of 1 meter [14]. Patient consent was taken before the procedure.

The dose rate was measured with RM1001-RD LAMSE survey meter calibrated from Secondary Standard Dosimetry Laboratory PINSTECH Islamabad as shown in Figure 3. The used model is specialized for measurement of radiation dose rates in radiation facilities including hospitals. The equivalent dose readings were measured in µSv/hr displayed on the screen of survey meter.


Figure 1. RM1001-RD LAMSE survey meter calibrated from SSDL Pakistan

In order to avoid radiation dose to patient attendants and caregivers, NORIN has its domestic patient discharge policy; patients are only discharged from the hospital when the exposure rate from the patient's body is between 20-30 µSv/hr. After the patient were discharged, the contamination levels in the selected spots were measured with survey meter at a distance of one meter from surface. All data were recorded manually and was further verified from hospital database system [22]. For the statistical analysis of the data, independent Z-test on SPSS 17 statistical software (SPSS Inc. USA) was used and values at a level of significance of 5% (P<0.05).

## 3. RESULTS AND DISCUSSIONS

The background radiation and post discharge dose levels in the selected spots of isolation room (Corridor, Patient bed, Sink, Toilet bowl) are assessed for the radiation risks associated with the RAI patients admitted in cancer Hospital Nawabshah, Pakistan. The results are summarized in Tables 1 with mean values (µSv/yr) and standard error with P values.

Table 1. Dose rates at different locations in isolation rooms at NORIN

| Isolation Room | Mean (µSv/hr) | Min (µSv/hr) | Max (µSv/hr) | Standard Error | P-Value (P < 0.05) |
|---|---|---|---|---|---|
| Background | 0.18 | 0.07 | 0.40 | 0.18 ± 0.072 | ----- |
| Corridor | 1.53 | 0.28 | 3.20 | 1.53 ± 0.78 | 0.045 |
| Patient Bed | 2.83 | 0.41 | 6.92 | 2.83 ± 1.71 | 0.026 |
| Sink | 5.55 | 2.00 | 10.0 | 5.55 ± 1.57 | 0.027 |
| Toilet Bowl | 9.69 | 5.00 | 13.77 | 9.69 ± 1.98 | 0.040 |

The mean background dose rate was observed 0.18 ± 0.072 µSv/hr in the range of 0.07 – 0.40 µSv/hr. Figure 04 represents the dose rate values at aforementioned locations and their mean values.

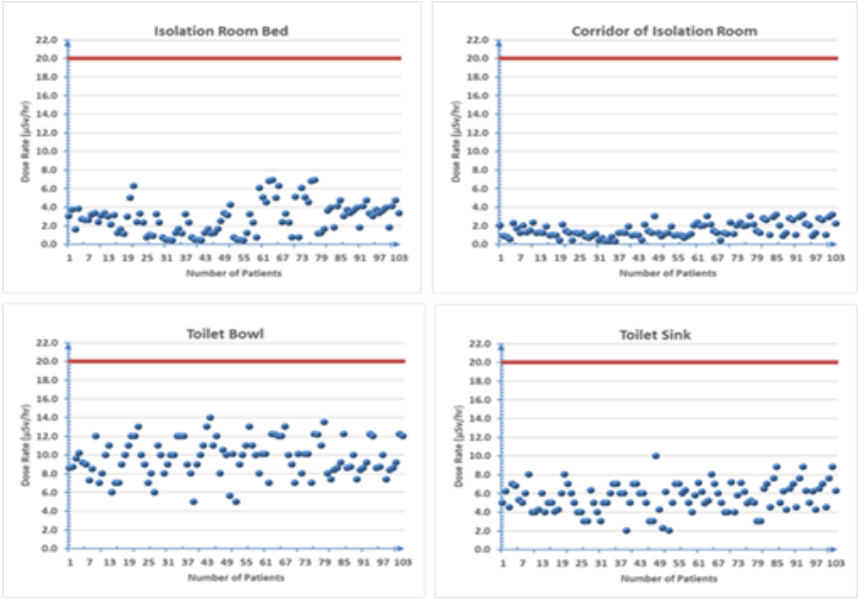


Figure 2. Post-discharge Radiation levels in Isolation rooms

The maximum dose rate after discharge was observed at toilet bowl with mean of 9.69 ± 1.98 µSv/hr and minimum of 5.0 µSv/hr and maximum value 13.77 µSv/hr. The second highest mean dose rate was observed at sink (5.55 ± 1.57 µSv/hr) with 2.0 µSv/hr and 10.0 µSv/hr the minimum and maximum respectively. The dose rate on the patient bed was recorded 2.83 ± 1.71 µSv/hr having upper bound at 6.92 µSv/hr and lower at 0.41 µSv/hr. The least dose rate was observed in isolation room corridor with the mean 1.53 ± 0.78 µSv/hr and upper limit of 0.40 µSv/hr and 0.07 µSv/hr on lower limit. Figure 5 represents the above statistics graphically.

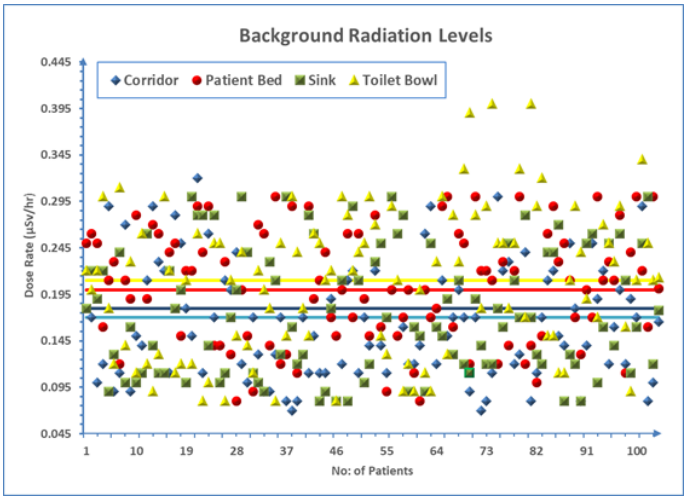


Figure 3. Background radiation levels with mean values at selected locations of Isolation rooms at NORIN.

Radiation safety in the field of nuclear medicine is of vital importance worldwide. Complete radiation safety instructions are given to patient as well as the attendants/caregivers before administration of RAI. An instruction leaflet is given at the time of discharge containing instructions about the safety measures at residence of the patient in order to ensure the safety of public and environment [23]. Despite the fact that due to physical and biological half-life of radiopharmaceutical, the dose rate falls below the safe limits within the stay period of 04 days in the hospital, special precautions are made for general safety and abide by ALARA principles. The upper bound for the radiation dose levels in the

unrestricted areas is 0.50 µSv/h with assumption of continuous occupation of facility. Background radiation levels of up to 20 µSv/h are considered safe, provided the fact that the 1 mSv/yr dose limit is not exceeded [24].

The Results of this study are lower compared with previous work. John E.E et al reported 21.72 µSv/hr in the toilet bowls used by radiopharmaceuticals injected patients in nuclear medicine facility of Ibadan [19]. Ferdoushi Begum et al. observed dose rate in toilet room was found high (22-110 µSv/hr), in the corridor, the dose rate was 3.4-18 µSv/hr and next to isolation room 0.3-16 µSv/hr for the thyroid carcinoma patients treated with high dose of RAI in Dhaka [25]. Another study conducted by Wirote Changmuang at Ramathibodiûs hospital for Admitted Thyroid Cancer Patient with High Dose I-131 Treatment in Related Hospitalized Area reported the exposure around the patient bed between 11.86-51.41 µSv/h [26]. Y. S. Abu-Khaled et al. (2009) also shows slightly higher values 25.8±0.6 µSv/hr at patient bed, 10.8±3.0 µSv/hr at bathroom environment and 0.14±0.05 µSv/hr at public corridor in the radio-iodine isolation room of king Hussain cancer center Jordan [26]. while the NRC Dose limit (10 CFR part 20) recommended dose rate of 20 µSv/hr. One of the studies found that the removable activity from the skin and room surfaces exceeded acceptable levels of removable contamination for restricted areas during hospitalization and at a time of discharge [27]. Results of current study are lower due to the strict following radiation protection protocols for RAI patients admitted in isolation rooms with PNRA & IAEA guidelines.

The level of contamination is independent of administered activity: this indicates that for the patients received same amount of RAI does not have necessarily same contamination level. Depending upon the renal clearance rates and other patient specific factors, the contamination level varies from patient to patient. The excretory channels for administered radionuclide in therapy are micturition, bowel, salivation, sweating, lachrymal fluid and lactation [28]. Other factors affecting the clearance levels in thyroid carcinoma patients are the variable amount of thyroid remnants, renal insufficiency and patients behaviour like following proper hygiene such as cleaning urine contamination in toilet, faulty urination style causing spillage of urine on flour, clothes changing frequency, bathing frequency, and water intake routine [14]. In our study Among the room surfaces, the toilet bowl surface showed the highest level of removable contamination and some is excreted by perspiration and saliva which are excreted in sink. That's why the sink has second highest contamination hazards

## 4. CONCLUSION

Radiation is harmful; safety measures must be ensured to minimize radiation exposure to the family members as well as community either during hospitalization or after discharge of RAI-131 patients. The radiation levels from toilet bowls, beds, sinks, and corridor of isolation rooms were well within the daily acceptable limits of 20 µSv/hr and hence, did not pose significant hazard to the public. It is also concluded that the contamination behavior is independent of the initial administered activity. There are other factors which affect the levels of contamination such that biological process, patient behavior, observance of radiation safety instructions given to the patient. Moreover, it is recommended that the toilet must be flushed twice at residence of patient after discharge due to highest radiation levels were found in toilet bowl. Isolation room corridor may be considered safe area for the patient attendants and workers at NORIN because the radiation protection protocols are duly followed. this also validates the quality assurance program of nuclear medicine in NORIN cancer hospital Nawabshah.

## ACKNOWLEDGEMENTS

The authors are wholeheartedly thankful to all radiation workers of NORIN Cancer Hospital Nawabshah for their assistance.

## REFERENCES

[1] Y. Zhang, S. Wang, H. Xia, and J. Ge, "A novel SVPWM modulation scheme," in *2009 Twenty-Fourth Annual IEEE Applied Power Electronics Conference and Exposition*, 2009, vol. 10545245, pp. 128–131, doi:

10.1109/APEC.2009.4802644.
[2] R. N. Ambade *et al.*, "Development of a dry distillation technology for the production of 131 I using medium flux reactor for radiopharmaceutical applications," *J. Radioanal. Nucl. Chem.*, vol. 303, no. 1, pp. 451–467, 2015, doi: https://doi.org/10.1007/s10967-014-3423-4.
[3] P. Shackett, *Nuclear medicine technology: Procedures and quick reference*. Philadelphia, Pennsylvania, Amerika: Lippincott Williams & Wilkins, 2019.
[4] H. A. Ziessman, J. P. O'Malley, and J. H. Thrall, *Nuclear medicine: the requisites e-book*, 4th ed. China: Elsevier Health Sciences, 2013.
[5] M. G. Stabin, "Health concerns related to radiation exposure of the female nuclear medicine patient.," *Environ. Health Perspect.*, vol. 105, no. 6, pp. 1403–1409, 1997, doi: https://doi.org/10.1289/ehp.97105s61403.
[6] G. S. Pant, "Dosimetric and radiation safety considerations in radioiodine therapy," *Ind J Nucl Med.*, vol. 20, no. 20, pp. 1–3, 2005, [Online]. Available: https://cir.nii.ac.jp/crid/1570854175815553920.
[7] M. Ahmad, "Scope of nuclear power in Pakistan," *J. Nucl. Energy Sci. Power Gener. Technol.*, vol. 0, no. 1, pp. 1–11, 2013, doi: http://dx.doi.org/10.4172/2325-9809.S1-001.
[8] M. R. Blevins and R. L. Andersen, "Radiation protection at US nuclear power plants—today and tomorrow," *Health Phys.*, vol. 100, no. 1, pp. 35–38, 2011, doi: 10.1097/HP.0b013e3181f6590d.
[9] L. R. Coover, E. B. Silberstein, P. J. Kuhn, and M. W. Graves, "Therapeutic 131I in outpatients: a simplified method conforming to the Code of Federal Regulations, title 10, part 35.75," *J. Nucl. Med.*, vol. 41, no. 11, pp. 1868–1875, 2000, [Online]. Available: https://jnm.snmjournals.org/content/jnumed/41/11/1868.full.pdf.
[10] G. G. Bural, C. M. Laymon, and J. M. Mountz, "Nuclear imaging of a pregnant patient: should we perform nuclear medicine procedures during pregnancy?," *Mol. Imaging Radionucl. Ther.*, vol. 21, no. 1, pp. 1–5, 2012, doi: 10.4274/Mirt.123.
[11] L. K. Harding, A. Bossuyt, S. Pellet, C. Reiners, J. Talbot, and E. T. G. E. Risks, "Radiation doses to those accompanying nuclear medicine department patients: a waiting room survey," *Eur. J. Nucl. Med.*, vol. 21, no. 21, pp. 1223–1226, 1994, doi: https://doi.org/10.1007/BF00182357.
[12] W. H. Thomson, N. J. Harding, A. Mills, H. Warren, and L. K. Harding, "Two waiting rooms or one," *Eur J Nucl Med*, vol. 15, no. 15, pp. 1–570, 1989.
[13] J. T. Bushberg, J. anthony Seibert, J. Edwin M. Leidholdt, and J. M. Boone, *The essential physics of medical imaging*, 3rd ed. Philadelphia, Pennsylvania, Amerika: Lippincott Williams & Wilkins, 2011.
[14] G. B. Saha, *Physics and radiobiology of nuclear medicine*, 4th ed. New York City, USA: Springer Science & Business Media, 2012.
[15] C. Wanke, J. Pinkert, B. Szermerski, and L. Geworski, "Assessment of the radiation exposure of relatives and caregivers of patients treated with Ra-223–Results of a German multicenter study," *Z. Med. Phys.*, vol. 31, no. 1, pp. 58–64, 2021, doi: https://doi.org/10.1016/j.zemedi.2020.09.002.
[16] D. S. Cooper *et al.*, "Management guidelines for patients with thyroid nodules and differentiated thyroid cancer: The American Thyroid Association Guidelines Taskforce," *Thyroid*, vol. 16, no. 2, pp. 109–142, 2006, doi: https://doi.org/10.1089/thy.2006.16.109.
[17] S. Mathur *et al.*, "Emergency imaging in pregnancy and lactation," *Can. Assoc. Radiol. J.*, vol. 71, no. 3, pp. 396–402, 2020.
[18] M. Blum, S. Tiu, M. Chu, S. Goel, and K. Friedman, "I-131 SPECT/CT elucidates cryptic findings on planar whole-body scans and can reduce needless therapy with I-131 in post-thyroidectomy thyroid cancer patients," *Thyroid Radiol. Nucl. Med.*, vol. 21, no. 11, pp. 1235–1247, 2011, doi: https://doi.org/10.1089/thy.2011.0010.
[19] O. Kupik *et al.*, "The Effect of Thyroid Hormone Withdrawal, Performed to Evaluate the Success of I-131 Ablation, On Quality of Life in Female Patients With Low-Risk Differentiated Thyroid Cancer," *Res. Sq.*, vol. 1, no. 23, pp. 1–21, 2021, doi: https://doi.org/10.21203/rs.3.rs-684400/v1.
[20] M. Mulazimoglu, N. Edis, M. O. Tamam, E. Uyanik, and T. Ozpacaci, "The evaluation of the external dose measurement of the patients treated with radioiodine therapy," *Radiat. Prot. Dosimetry*, vol. 141, no. 3, pp. 233–238, 2010, doi: https://doi.org/10.1093/rpd/ncq179.
[21] M. Waqar, M. Shahban, Q. Soomro, and M. N. Abro, "Institution-based assessment of cancer patients treated by external beam radiotherapy in the rural area of Sindh, Pakistan: Five years of data analysis," *Middle East J. Cancer*, vol. 9, no. 3, pp. 217–222, 2018, doi: https://doi.org/10.30476/mejc.2018.42126.
[22] M. Waqar, M. Shahban, Q. Soomro, and T. A. Afridi, "Assessment of residual activities of Technetium-99m radiopharmaceuticals to plastic syringes in nuclear medicine scans: 1-year experience at NORIN Nawabshah, Pakistan.," *Pakistan J. Nucl. Med.*, vol. 12, no. 1, pp. 31–36, 2022, doi: https://doi.org/10.24911/PJNMed.175-1636355717 OPEN.

[23] P. J. Mountford, "Risk assessment of the nuclear medicine patient.," *Br. J. Radiol.*, vol. 70, no. 835, pp. 671–684, 1997, doi: https://doi.org/10.1259/bjr.70.835.9245878.

[24] J. E. Ejeh, T. H. Abiodun, K. S. Adedapo, Y. A. Onimode, and O. A. Ayeni, "Radiation levels from toilets used by patients injected with 99mTc-based radiopharmaceuticals in Ibadan," *Mol. Imaging Radionucl. Ther.*, vol. 23, no. 2, p. 60, 2014, doi: 10.4274/mirt.82905.

[25] F. Begum *et al.*, "Radiation exposure levels in close proximity to therapeutic patients treated for thyroid carcinoma with high dose I-131," *Bangladesh J. Nucl. Med.*, vol. 17, no. 1, pp. 50–54, 2014, doi: https://doi.org/10.3329/bjnm.v17i1.22491.

[26] W. Changmuang *et al.*, "Radiation from an admitted thyroid cancer patient with high dose I-131 treatment in related hospitalized area and exposure to associated personnel in Ramathibodi's new inpatient unit," *Asean J Radiol*, vol. 18, no. 2, pp. 118–122, 2012, [Online]. Available: https://www.researchgate.net/publication/236979011.

[27] E. Ibis, C. R. Wilson, B. D. Collier, G. Akansel, A. T. Isitman, and R. G. Yoss, "Iodine-131 contamination from thyroid cancer patients," *J. Nucl. Med.*, vol. 33, no. 12, pp. 2110–2115, 1992, [Online]. Available: https://jnm.snmjournals.org/content/jnumed/33/12/2110.full.pdf.

[28] N. H. Mohd Zainudin, J. Mohd Radzi, W. AI, and I. SNI, "Surface contamination in skin and room during hospitalization of thyroid cancer patient receiving radioiodine ablation," *IOSR J. Dent. Med. Sci.*, vol. 2, no. 1, pp. 27–33, 2012, [Online]. Available: https://core.ac.uk/download/pdf/222964081.pdf.