Cancer risks from chest radiography of young adults: A pilot study at a health facility in South West Nigeria

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Abstract
The recommendation of chest radiography for school admission and employment purposes should be discouraged due to the risks of radiation especially cancer induction. It is therefore imperative to keep diagnostic radiation doses as low as possible. This dataset presents the entrance surface dose, effective dose, bone marrow dose, breast dose, lung dose and the incidence cancer risks from chest radiography of 40 young adult females. The mean incidence cancer risk to participants is 1:20,000 for solid cancers. The data revealed the significant factors influencing the entrance surface dose and incidence cancer risks.

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How data was acquired | Thermoluminescent dosimeters (TLD-100; RadPro, Poland), PCXMC Software (20Rotation), Quality Control Kits (MagicMax, Germany)
---|---
Data format | Raw, Analyzed
Experimental factors | The aforementioned parameters in the abstracts were analyzed according to International Atomic Energy Agency (IAEA) standards for radiation protection of patients
Experimental features | Determination of entrance surface dose, effective dose and bone marrow dose, breast dose and lung dose in order to estimate the risk of radiation induced cancer from chest radiography
Data source location | Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Osun State, Nigeria
Data accessibility | All the data are in this data article

Value of the data

- The data can be used to assess incidence cancer risk from chest radiography in the State.
- The data will help to curtail the demand for chest radiography for school admission and employment purposes.
- The data will enhance the optimization of radiographic procedures in the State to be as low as reasonably achievable.
- The data is useful in radiation protection training and epidemiology studies.
- Cancer risks assessment can be extended to other irradiated organs arising from chest radiography not covered in this study.
- The study can be extended to multi-centre studies.
- The data can be helpful to radiation regulatory authorities and policy makers.

1. Data

The data contains radiation doses and incidence of cancer risks among young adult females who underwent chest radiography for school admission purposes. Radiation protection of patients in diagnostic radiology is a subject of global concern. Concerted effort to minimizing patient’s dose has led to generation of datasets [1–5]. Justification of radiographic examinations and optimization of the procedures have been the emphasis for the protection of patients [2,5,6]. Data on some experiences leading to the discouragement of requests for chest radiography used for school admission and employment purposes can be found in [7–9]. Data on the risks of cancer induction from low dose ionizing radiation can be found in [10–14]. Beyond cancer induction other radiation risks have been reported [15–17].

1.1. Description of data

The patient parameters, technical factors, radiation doses and incidence cancer risks are presented in Tables 1, 2 and 7. Descriptive analysis of patient parameters and technical factors are presented in Table 2 and the descriptive analysis of radiation doses and cancer risks is reported in Table 7. The influence of patient parameters and technical factors on entrance surface dose (ESD) is reported in Tables 3–6 and Fig. 2. Fig. 1 compares the entrance surface dose (ESD) with world data (Table 7). The cancer risks ratio is presented in Table 7.
### Table 1
Descriptive statistics of patient parameters and technical factors.

|       | Age   | BMI     | FFD     | FSD     | kVp    | mAs    |
|-------|-------|---------|---------|---------|--------|--------|
| N     | Valid | 40      | 40      | 40      | 40     | 40     |
|       | Missing | 0       | 0       | 0       | 0      | 0      |
| Mean  |       | 20.25   | 22.8815 | 147.23  | 121.58 | 74.13  | 23.50  |
| Median|       | 20.00   | 22.2700 | 153.00  | 124.00 | 74.00  | 25.00  |
| Std. Deviation |       | 2.295   | 3.82241 | 8.710   | 7.828  | 2.633  | 4.591  |
| Variance |       | 5.269   | 14.611  | 75.871  | 61.276 | 6.933  | 21.077 |
| Skewness |       | 0.360   | 0.321   | -1.143  | -0.267 | 0.115  | 0.510  |
| Std. Error of Skewness |       | 0.374   | 0.374   | 0.374   | 0.374  | 0.374  | 0.374  |
| Kurtosis |       | -1.016  | -0.622  | -0.467  | -1.311 | -0.794 | -0.341 |
| Std. Error of Kurtosis |       | 0.733   | 0.733   | 0.733   | 0.733  | 0.733  |
| Range |       | 8       | 14.84   | 22      | 26     | 9      | 16     |
| Minimum |       | 17      | 15.63   | 131     | 109    | 70     | 16     |
| Maximum |       | 25      | 30.47   | 153     | 135    | 79     | 32     |

ESD = entrance surface dose; BD = breast dose; ICR = incidence cancer risks; FFD = focus film distance; FSD = focus skin distance; kVp = kilovoltage peak; mAs = current time product.

### Table 2
Model Summary for entrance surface dose, patient parameters and technical factors.

| Model | R     | R square | Adjusted R square | Std. error of the estimate |
|-------|-------|----------|-------------------|---------------------------|
|       | 0.775 | 0.601    | 0.528             | 0.16941                   |

### Table 3
Analysis of variance for entrance surface dose, patient parameters and technical factors.

| Model | Sum of squares | df | Mean square | F     | Sig.  |
|-------|----------------|----|-------------|-------|-------|
| 1     | Regression     | 1.425 | 6 | 0.237 | 8.275 | 0.000 |
|       | Residual       | 0.947 | 33 | 0.029 | 0.065 | 0.794 |
| Total |                | 2.372 | 39 |       |       |       |

### Table 4
Coefficients of variables.

| Model | Unstandardized coefficients | Standardized coefficients | t    | Sig.  |
|-------|-----------------------------|---------------------------|------|-------|
|       | B                          | Std. error                | Beta |       |
| 1     | (Constant)                 | 1.739                     | 2.033| 0.855 | 0.399 |
|       | Age                        | 0.024                     | 0.020| 0.225 | 1.225 | 0.229 |
|       | BMI                        | 0.024                     | 0.017| 0.371 | 1.427 | 0.163 |
|       | FFD                        | -0.019                    | 0.006| -0.666| -3.284| 0.002 |
|       | FSD                        | 0.013                     | 0.007| 0.428 | 1.908 | 0.065 |
|       | kVp                        | 0.002                     | 0.033| 0.022 | 0.063 | 0.950 |
|       | mAs                        | -0.030                    | 0.012| -0.563| -2.565| 0.015 |
### Table 5
Correlation matrix of entrance surface dose, patient parameters and technical factors.

| Correlations | ESD | Age | BMI | FFD | FSD | kVp | mAs |
|--------------|-----|-----|-----|-----|-----|-----|-----|
| Pearson      | ESD | 1   | 0.539 | 0.234 | −0.620 | −0.129 | 0.379 | −0.046 |
|              | Age | 1   | 0.568 | 0.568 | 0.380 | 0.163 | 0.741 | 0.418 |
|              | BMI | 1   | 0.039 | 0.442 | 0.607 | 0.039 | 0.859 | 0.793 |
|              | FFD | 1   | 0.039 | 0.607 | 1     | 1     | 1     | 1     |
|              | FSD | 1   | 0.039 | 1     | 0.607 | 1     | 1     | 1     |
|              | kVp | 1   | 0.039 | 1     | 0.607 | 1     | 1     | 1     |
|              | mAs | 1   | 0.039 | 1     | 0.607 | 1     | 1     | 1     |
| Kendall’s    | ESD | 1   | 0.450 | 0.221 | −0.544 | −0.011 | 0.368 | 0.037 |
|              | Age | 1   | 0.355 | 0.355 | 0.384 | 0.190 | 0.596 | 0.301 |
|              | BMI | 1   | 0.095 | 0.095 | 0.263 | 0.409 | 0.641 | 0.627 |
|              | FFD | 1   | 0.190 | 0.409 | 1     | 0.641 | 1     | 1     |
|              | FSD | 1   | 0.409 | 1     | 0.641 | 1     | 1     | 1     |
|              | kVp | 1   | 0.409 | 1     | 0.641 | 1     | 1     | 1     |
|              | mAs | 1   | 0.409 | 1     | 0.641 | 1     | 1     | 1     |
| Spearman’s   | ESD | 1   | 0.620 | 0.314 | −0.685 | −0.050 | 0.506 | 0.028 |
|              | Age | 1   | 0.491 | 0.491 | 0.479 | 0.242 | 0.753 | 0.375 |
|              | BMI | 1   | 0.098 | 0.098 | 0.263 | 0.395 | 0.777 | 0.734 |
|              | FFD | 1   | 0.242 | 0.395 | 1     | 0.777 | 1     | 1     |
|              | FSD | 1   | 0.395 | 1     | 0.777 | 1     | 1     | 1     |
|              | kVp | 1   | 0.395 | 1     | 0.777 | 1     | 1     | 1     |
|              | mAs | 1   | 0.395 | 1     | 0.777 | 1     | 1     | 1     |

ESD = entrance surface dose; BD = breast dose; ICR = incidence cancer risks; FFD = focus film distance; FSD = focus skin distance; kVp = kilovoltage peak; mAs = current time product.

### Table 6
Descriptive statistics of radiation doses and cancer risks incidence.

| N   | Valid | Missing | ESD   | E    | BMD   | BD    | LD    | ICR_{BM} | ICR_{B} | ICR_{L} | ICR_{S} |
|-----|-------|---------|-------|------|-------|-------|-------|----------|---------|---------|---------|
|     | 40    | 0       | 0.016 | 0.18 | 0.19  | 0.19  | 0.66  | 0.78     | 0.81    | 2.81    | 4.56    |
|     | 40    | 0       | 0.015 | 0.17 | 0.18  | 0.18  | 0.61  | 0.73     | 0.81    | 2.82    | 4.35    |
| Mean|       |         |       |      |       |       |       |          |         |         |         |
| Median|     |         |       |      |       |       |       |          |         |         |         |
| Std. Deviation | 0.247 | 0.043 | 0.043 | 0.067 | 0.184 | 0.162 | 0.299 | 0.799 | 0.879 |
| Variance | 0.061 | 0.002 | 0.002 | 0.004 | 0.034 | 0.026 | 0.089 | 0.638 | 0.772 |
| Skewness | 0.959 | 1.628 | 1.334 | 1.174 | 1.558 | 1.559 | 0.799 | 1.169 | 1.255 |
| Std. Error of Skewness | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 |
| Kurtosis | 0.154 | 2.773 | 1.058 | 1.942 | 2.615 | 2.601 | 1.346 | 2.339 | 1.405 |
| Std. Error of Kurtosis | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 | 0.733 |
| Range | 1.01  | 0.20   | 0.18  | 0.32  | 0.86  | 0.65  | 0.35  | 1.30    | 1.50    | 9.01    | 2.32    |
| Minimum| 0.68  | 0.11   | 0.13  | 0.09  | 0.43  | 0.45  | 0.35  | 1.00    | 1.50    | 4.01    | 2.32    |
| Maximum| 1.69  | 0.31   | 0.31  | 0.41  | 1.29  | 1.34  | 1.75  | 5.53    | 7.25    | 5.53    | 7.25    |
| Percentiles | 0.25  | 0.89   | 0.14  | 0.16  | 0.14  | 0.54  | 0.67  | 0.54    | 2.17    | 3.94    | 3.94    |
| 50  | 1.00  | 0.15   | 0.17  | 0.18  | 0.61  | 0.72  | 0.81  | 2.82    | 4.35    | 4.35    | 4.35    |
| 75  | 1.18  | 0.17   | 0.20  | 0.22  | 0.70  | 0.85  | 0.97  | 3.26    | 4.93    | 4.93    | 4.93    |

ESD = entrance surface dose; E = effective dose; BMD = bone marrow dose; BD = breast dose; LD = lung dose; ICR_{BM} = incidence cancer risks for bone marrow; ICR_{B} = incidence cancer risks for breast; ICR_{L} = incidence cancer risks for lung; ICR_{S} = incidence cancer risks for solid cancers.
Table 7
Incidence cancer risks ratio for chest radiography.

|                | ICRBM | Ratio  | ICRB  | Ratio  | ICRL  | Ratio  | ICRS  | Ratio  |
|----------------|-------|--------|-------|--------|-------|--------|-------|--------|
| Mean           | 0.78  | 1:100000 | 0.81  | 1:100000 | 2.81  | 3:100000 | 4.56  | 5:100000 |
| Minimum        | 0.58  | 0:35   | 0.35  | 0:35   | 1.61  | 2:100000 | 3.24  | 3:100000 |
| Maximum        | 1.34  | 1:100000 | 1.75  | 2:100000 | 5.53  | 6:100000 | 7.25  | 7:100000 |
| Percentiles    |       |        |       |        |       |        |       |        |
| 25             | 0.67  | 0:67   | 0.54  | 0:54   | 2.17  | 2:100000 | 3.94  | 4:100000 |
| 50             | 0.73  | 0:73   | 0.81  | 0:81   | 2.82  | 3:100000 | 4.35  | 4:100000 |
| 75             | 0.85  | 0:85   | 0.97  | 0:97   | 3.26  | 3:100000 | 4.93  | 5:100000 |

**Level of Risk:**
1: 1,000,000–1: 100,000: Minimal risk
1: 100,000–1: 10,000: very low risk

ICRBM = incidence cancer risks for bone marrow; ICRB = incidence cancer risks for breast; ICRL = incidence cancer risks for lung; ICRs = incidence cancer risks for solid cancers.

Fig. 1. Comparison of entrance surface dose [3,18–20].

Fig. 2. Scatter line plot for entrance surface dose (ESD), focus to film distance (FFD) and current time product (mAs).
2. Experimental design, materials and methods

2.1. Data collection

Data was collected during chest radiography of young adult females (aged 17–25 year) at the x-ray unit of Radiology Departments of Obafemi Awolowo University Teaching Hospital Complex Ile-Ife, Osun State, Nigeria. The participants were students admitted into one of the Schools of the University Teaching Hospital for the year 2017. Consent was obtained from each participant before the commencement of the examination. Entrance surface dose (ESD) were determined using thermoluminescent dosimeters (TLD-100: LiF: Mg, Ti) from RadPro International GmbH, Poland. Each of the TLD chip was enclosed in labelled black polythene pack. A total of three coded chips were used to measure the entrance surface dose (ESD) during the procedure in order to obtain the mean and enhance precision. The chips were attached to an elastic tape and placed in the centre of x-rays field where the beam intercepted with the irradiated part of the patient. Patient’s clinical information and exposure parameters were noted and recorded using self-structured form. The x-ray machine output parameters were determined using MagicMax quality control kits (IBA Dosimetry, Germany).

2.2. Data collection tool

The TLD chips were oven-annealed using Carbolite oven made in England. Irradiation of TLD chips for calibration (for TLD chips and Reader) was conducted at the Secondary Standard Dosimetry Laboratory (SSDL) of the National Institute of Radiation Protection and Research (NIRPR), Ibadan. TLD chips were read using Harshaw Reader (Model 3500) at the Department of Physics, Obafemi Awolowo University Ile-Ife.

2.3. Data analysis

The bone marrow dose, breast dose, lung dose and effective doses were evaluated from the measured entrance surface dose (ESD) using PCXMC software (version 20Rotation). Thereafter, BEIR VII model software was used to estimate the incidence cancer risk.

2.4. The study centre

The hospital is the only federal tertiary healthcare institution in the State with a population of about 4.7 million [21]. It provides tertiary, secondary and primary healthcare services to all the neighbouring States. The hospital serves as the teaching hospital of the Medical School of Obafemi Awolowo University Ile-Ife and has other six schools under its jurisdiction.

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Transparency document. Supplementary material

Transparency data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.05.123.
Appendix A. Supplementary material

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References

[1] B.F. Wall, R. Haylock, J.T.M. Jansen, M.C. Hillier, D. Hart, P.C. Shrimpton, Radiation risks from medical x-ray examinations as a function of the age and sex of the patient, Health Prot. Agency (2011) 1–70.
[2] International Commission on Radiological Protection, The 2007 Recommendation of International Commission on Radiological Protection Publication 103, Ann of the ICRP, UK, 2007.
[3] United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation. Report to the General Assembly with Scientific Annexes, UNSCEAR, New York, 2008.
[4] National Health Service, Diagnostic Imaging Datasets. Annual Statistical Release 2014/2015, NHS, England, 2015.
[5] International Atomic Energy Agency, Radiological Protection for Medical Exposure to Ionizing Radiation. Safety Standards Series No. RSG-1.5, IAEA, Vienna, 2002.
[6] F. Mohd, A. Aisyahton, Z.H. Ahmad, A comparison of two indirect methods for skin dose in chest radiography, Health Environ. J. 4 (2013) 103–114.
[7] International Atomic Energy Agency, Optimization of the Radiological Protection of Patients Undergoing Radiography, Fluoroscopy and Computed Tomography. Final Report of a Coordinated Research Project in Africa, Asia and Eastern Europe (IAEA-TECDOC-1423), IAEA, Vienna, 2004.
[8] R.A. Akinola, A.O. Akhigbe, A.S. Mohammed, M.A. Jaiyesimi, O.O. Omotayo, F.O. Jinadu, K.O. Wright, Evaluation of routine chest x-rays performed in a tertiary institution in Nigeria, Int. J. Cardiovasc. Res. 3 (2014) 1000178.
[9] A. Kumar, U. Srivastava, Role of routine laboratory investigations in preoperative evaluation, J. Anaesthesiol. Clin. Pharmcol. 27 (2011) 174–179.
[10] I. Izamin, A.M. Rizal, Chest x-ray as an essential part of routine medical examination: is it necessary? Med. J. Malay. 67 (2012) 606–609.
[11] BEIR VII Health risks from exposure to low level of ionizing radiation, Estimating cancer risks, National Research Council BEIR VII Phase, National Academies, Washington D.C., 2006, vol. 12, pp. 268–312.
[12] United States Environmental Protection Agency, Modifying EPA radiation risk models based on BEIR VII, Draft white paper, 2006.
[13] E. Cardis, M. Vrijheid, M. Blettner, E. Gilbert, M. Hakama, C. Hill, G. Howe, J. Kaldor, C.R. Muirhead, M. Schubauer-Berigan, T. Yoshimura, Risk of cancer after low doses of ionizing radiation: retrospective cohort study in 15 countries, Br. Med. J. 331 (2005) 77–80.
[14] J. Zhu, W. Hu, N. Ding, C. Ye, M. Usikuai, S. Li, B. Hu, B.M. Sutherland, G. Zhou, An optimized colony forming assay for low dose radiation cell survival measurement, Int. Res. J. Biotechnol. 2 (2011) 164–172.
[15] M.R. Usikalu, M.A. Aveda, E.B. Batabunde, F.O. Awojobi, Low level microwave exposure decreases the number of male germ cells and affect vital organs of Sprague Dawley rats, Am. J. Sci. Ind. Res. 1 (2010) 410–420.
[16] M.R. Usikalu, O.O. Obembe, M.L. Akinyemi, J. Zhu, Short duration to 2.45 GHz microwave radiation induces DNA damage in Sprague Dawley rat’s reproductive systems, Afr. J. Biotechnol. 12 (2013) 115–122.
[17] F. Umansky, Y. Shoshan, G. Rosenthal, S. Fraifeld, S. Spektor, Radiation induced meningioma, Neurosurg. Foc. 24 (2008) E7.
[18] International Atomic Energy Agency, Applying Radiation Safety Standards in Diagnostic Radiology and Interventional Procedures Using X-Rays. Safety Standards Series No. 39, IAEA, Vienna, 2006.
[19] R.A. Parry, S.A. Glaze, B.R. Archer, The AAPM/RSNA physics tutorials for residents, RadioGrap 19 (1999) 1289–1302.
[20] European Commission, Diagnostic Reference Levels in Thirty Six European Countries, Radiation Protection No. 180, 2014.
[21] Nigeria: States and Cities. (http://www.citypopulation.de/Nigeria-Cities.html), (Accessed 15 April 2018).