peer reviewed **ORIGINAL ARTICLE**

Status of x-ray viewing boxes in Cross River State, Nigeria

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Abstract

Purpose: To determine the luminance and ambient lighting levels of x-ray film viewing boxes and viewing environments in X-ray facilities in the Cross River State of Nigeria in order to compare the results with existing international guidelines.

Materials and methods: Eighteen (n=18) viewing boxes in nine hospitals were studied. Luminance and ambient lighting levels were measured using a factory calibrated Model 615 BK precision light meter. Measurements were made from small openings made at the centre and four corners of a thick black sheet of cotton fibre overlying the respective boxes. Measurements were made of the 17 points on each box, and the box mean, highest and lowest luminance, as well as average uniformity values determined. Respective viewing room ambient light levels were determined 30 centimeters (cms) from the viewing boxes surfaces with the boxes turned off. Values obtained were compared with those published in the literature, following the European Commission (EU), American College of Radiology (ACR), British Institute of Radiology (BIR), National Institute of Radiation Hygiene (NIRH), South African Directorate of Radiation (SADR), and World Health Organisation (WHO) guidelines.

Results: Nine (50%) of the viewing boxes surveyed met the EU and WHO guidelines for uniformity and ambient light levels. All nine study centres met the ACR ambient light conditions, while 6% satisfied the SADR guidelines. Average brightness values of viewing boxes in the nine hospitals surveyed showed poor compliance with the published guidelines. Only one viewing box met the published minimum brightness value of 1500 cd m^{-2}.

Conclusion: The findings of this study highlight the need for quick intervention and adoption of quality control standards to improve radiographic viewing conditions in the state. This should facilitate optimal viewing conditions thereby enhancing accurate interpretation of conventional radiographic images.

Keywords
X-rays, radiographs, light meter, luminance, ambient lighting.

Introduction

X-ray film viewing boxes (VBs) are vital in the image viewing process as they affect the accuracy with which viewed radiographs are interpreted for diagnosis. When light intensity is low, the eye loses its resolving power or visual acuity and transfers from cone to the more sensitive rod vision. To achieve optimal visual acuity, it is recommended that the retinal cones receive an incident luminance (brightness) of 100 candela per square meter (cd m^{-2}) [1, 2].

X-ray VBs are easy to acquire and maintain but usually receive little attention in clinical practice. Hospitals spend huge sums of money acquiring other imaging equipment but tend to neglect the important need to maintain optimal viewing conditions of the less costly viewing boxes. It has been shown that suboptimal illumination levels, excessive pupil dilation, scattering of light within the film, view box glare, and improper ambient light levels, are factors which contribute to film reader performance [3, 4]. These parameters vary from place to place.

There are as yet no globally accepted VB standards for radiography. However, to ensure standardization, different institutions and regulatory bodies have developed guidelines suitable for their local applications. Some of these are the British Institute of Radiology [5] (BIR), The American College of Radiology (ACR) [6], The World Health Organisation (WHO) [7], The European Commission (EU) [8], National Institute of Radiation Hygiene (NIRH) [9], and South African Directorate of Radiation Control (SADRC) [10]. Similar guidelines are not found in Nigeria. The absence of these guidelines both for local and national application has not helped in the standardization of relevant practice in both personnel performance and equipment quality.

This study sought to determine the luminance and ambient lighting levels in x-ray viewing facilities in the Cross River State, Nigeria. It is important to maintain consistency in viewing conditions to achieve high level image reader performance and therefore reduce errors occasioned by poor viewing conditions which could adversely affect diagnosis. To the best of the authors' knowledge no work of this nature has been reported for any radiographic facility in Nigeria.

Materials and method

Eighteen (n=18) radiographic VBs in nine x-ray facilities in Cross River State were surveyed. Facilities included both state owned and private centres. The surveyed centres were coded for identification. A factory calibrated BK precision light meter was used to measure the viewing box brightness, VB brightness uniformity, and the ambient reading room light levels. These are three viewing condition parameters which have been reported in the literature [2, 4, 7, 8]. The meter gave luminance values in candela per square metre (cd m^{-2}) and ambient light values in lux.

The procedure adopted was as sug-

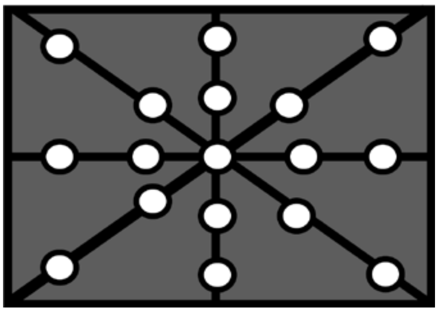

Figure 1: Designed test tool for measuring different points on the viewing box [12]

gested by the Electronic Industries Association Committee [11] and used by McCarthy and Brennan [12]. A thick black piece of cotton fibre material, designed as a test tool, was used to overlay the surface of each VB. Four x 2 cm diameter circles (holes) were cut into mid-points between the centre of the box and the four corners of the cloth; a fifth circle was positioned centrally. Figure 1 is a schematic representation of the method used. The size and position of holes were important to ensure that intensities that fell out the points of interest were excluded in the measurements. The black cotton fibre was attached to the front of each VB; the light meter was placed in contact with each hole on the viewing box. Each VB box was switched on and allowed to stay on for three minutes to ensure stability before readings were taken. The VB was switched off after all reading were taken. The procedure was repeated three times over each hole and averaged for each reading point. The mean values of each VB expressed in candela per square meter (cdm^{-2}) were also recorded. The luminance uniformity for each VB was determined with the below equation [2].

Where:

$$\text{Uniformity}(\%)=\frac{C_{max}-C_{min}}{C_{max}+C_{min}}x100$$

- C_{max} = the maximum luminance of the box
- C_{min} = the minimum luminance of the box

The ambient lighting levels for all rooms housing the VBs were measured with the photometer placed 30 cms from the VB with the box switched off. This distance is the usual clinical observation distance from a VB. The results obtained were compared with published guidelines (Table 1) of the EU, WHO, NIRH, SADRC, BIR and ACR to determine the level of compliance.

Results

Individual VB box and room light intensity values are summarized in Table 2 along with the percentage uniformity calculated for each VB. Figure 2 shows the relationship between the average luminance of the respective VBs and the minimum value recommended in published literature. Only one VB recorded an average luminance value above the minimum recommended value of 1500 cd m^{-2}. Three other VBs had average luminance values lower than the recommended minimum by between 0.5% and 9.0%. The rest of the VBs recorded values lower than the recommended minimum by over 20%.

Individual VB uniformity values ranged from 3.4% to 47.5%. A review of the uniformity of the luminance levels in respective hospitals shows that only GHA and NNH had acceptable uniformity values. The other facilities surveyed recorded average uniformity values in excess of 20%. All surveyed viewing rooms had ambient light readings less than 20 lux (Table 2).

The mean luminance values of central luminance and ambient lighting level of VBs recorded by each of the nine x-ray centre is presented in Table 3. Figure 3 shows the percentage uniformity recorded by VBs in each facility.

Discussion

Notwithstanding the advent and incorporation of digital processes in the medical imaging practice, over 90% of radiography centres in Nigeria still produce conventional radiographic images. There is currently no digital x-ray facility the Cross River State. In view of this it is most important that viewing conditions of conventional radiographs are maximized to ensure accurate radiographic image interpretation.

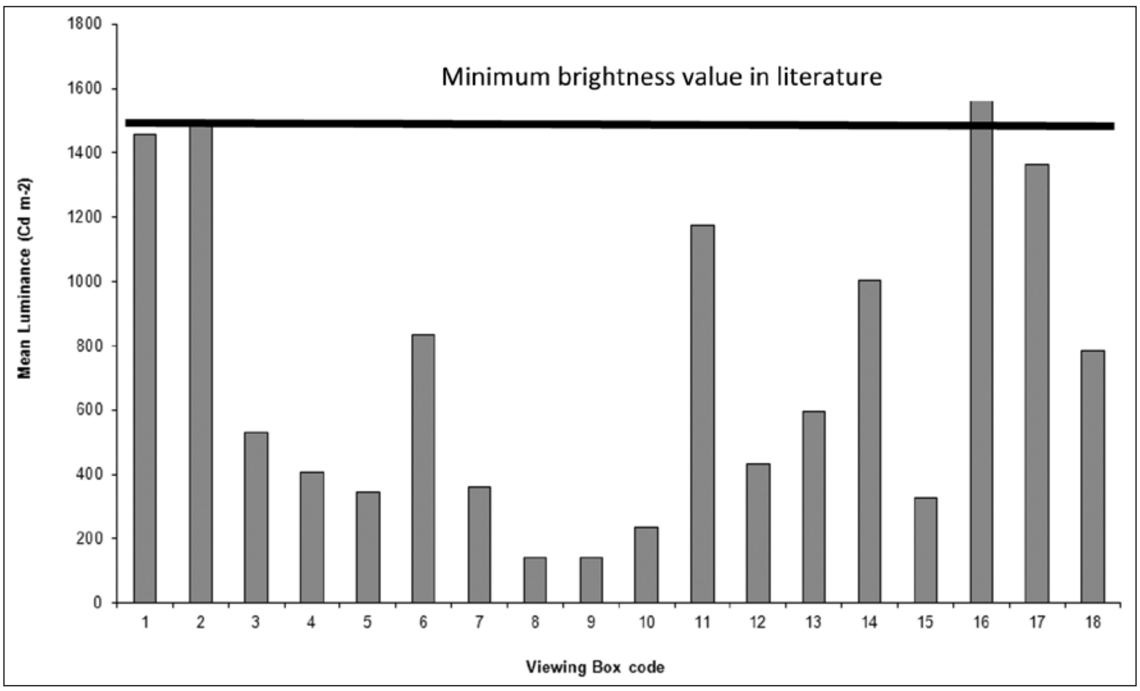

Figure 2: Comparison of individual viewing box brightness luminance with minimum recommended value in literature

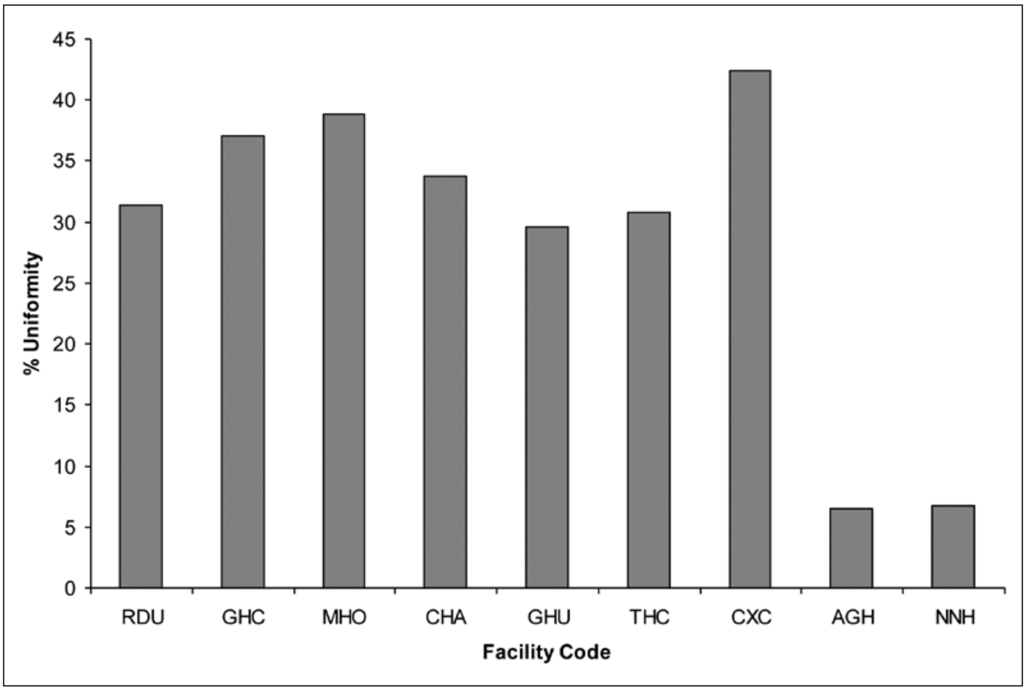

Figure 3: Mean % uniformity of viewing boxes in all nine facilities

Although visualisation of information is dependent on the quality of the radiograph, some information may be lost if radiographic viewing conditions are not ideal. It is therefore important for VB luminance and room ambient lighting to be optimal. Maintaining optimal radiographic viewing conditions is simple and cheap to achieve and would improve the accuracy and confidence of decision-making in the interpretation of radiographs.

The results of this study show that the VBs monitored in this survey had brightness values below those recommended both by international bodies and the literature. Only VB #16 came close to these recommendations (see Table 2). However, it barely scaled the minimum recommended luminance value since it recorded the highest average luminance value of 1568.9 cd m^{-2}. The lowest recorded luminance (141.1) in the study was found in VB #8. The wide variation between VBs in the same facility and between VBs in different facilities is similar to the observation made elsewhere [12]. Poor brightness of VBs was reported in a Malaysian study [4].

Average luminance, rather than central luminance, is said to be a better indicator of VB brightness [2, 12]. This was found to vary from the central brightness by between 2% and 65%. Four VBs had percentage differences between the average and central brightness values less or equal to 10; four of the other VBs recorded differences of ≤ 20%. This wide variation is further observed in the percent uniformity values (Figure 2). Smaller uniformity values indicate better uniformity.

Table 1 shows that the guidelines from the EU and WHO recommend a percent uniformity of under or equal to 30% and viewing room brightness of less or equal to 50 lux. Nine (50%) of the VBs in this study met the EU and WHO uniformity and room ambient lighting guidelines respectively. All the viewing rooms met the ACR ambient brightness recommendation of 20 lux. Six VBs (33%) satisfied the South African Directorate of Radiation Control value for percentage uniformity. Only four VBs (11, 16, 17 and 18 in Table 2) recorded uniformity values complying with the NIRH guidelines.

Overall, it is clear that while VBs in this study largely show very poor compliance for luminance or brightness, the parameters of uniformity and ambient room brightness are largely satisfied. The poor compliance for luminance may not be unconnected with the lack of a defined quality assurance and control programme in all the hospitals surveyed.

X-ray VBs are easy and cheap to maintain. Regular cleaning of the front and back surfaces of the perspex cover

Table 1: Guidelines for viewing box luminance and ambient light levels in the Literature

Source of guidelines	Luminance of viewing box (cdm^{-2})	Uniformity of viewing box (%)	Ambient light level (lux)
European commission [8]	<1700-4000	≤30	≤50
American College of Radiology [6]	1500	15	20
British Institute of Radiology [5]	1500-3000	15	50-100
National Institute of Radiation Hygiene [9]	1500-300	≤15	≤100
South African Directorate of Radiation Control [10]	1500	20	100
WHO [7]	1500-3000	≤30	≤50

Table 2: Mean luminance, uniformity and ambient light intensity values for individual boxes and viewing rooms surveyed

View Box	Mean luminance (cdm^{-2})	Central luminance values (cdm^{-2})	Highest luminance value (cdm^{-2})	Lowest luminance value (cdm^{-2})	Uniformity %	Room Ambient light level (lux)
1	1457.1	1827.0	1827.0	1092.3	25.2	19.3
2	1492.4	1411.0	1702.7	1245.3	15.5	15.3
3	529.4	820.0	820.0	334.7	42.0	18.2
4	405.5	639.0	639.0	254.7	43.0	18.0
5	344.2	283.3	490.7	225.0	37.1	16.7
6	834.2	1118.7	1118.7	599.0	30.3	18.9
7	359.5	673.0	673.0	239.3	47.5	19.7
8	141.1	159.0	199.0	98.7	33.7	13.3
9	141.7	184.7	184.7	100.3	29.6	15.3
10	237.3	301.0	317.0	154.3	34.5	18.3
11	1175.8	1387	1387.0	1029.3	14.8	15.3
12	431.1	299.6	528.3	225.0	34.9	15.3
13	596.6	739.7	739.7	530.3	16.3	18.3
14	1003.8	1479.3	1479.3	797.3	30.0	18.0
15	326.8	197.7	489.3	197.7	42.4	19.3
16	1568.9	1602.3	1602.3	1498.2	3.4	15.3
17	1365.3	1497.7	1497.7	1238.3	9.5	18.0
18	783.5	874.3	894.3	763.0	6.8	18.0

N/B: The smaller uniformity values indicate better uniformity.

Table 3: Mean values of luminance, central luminance and ambient lighting levels viewing boxes per surveyed centre

Facility code	No. of viewing boxes	Mean luminance (cdm^{-2})	Mean central luminance (cdm^{-2})	Mean ambient lighting level (lux)
RDU	3	972.4	1169.9	17.7
GHC	2	344.2	283.3	16.7
MHO	1	596.9	895.9	19.3
CHA	2	141.1	159.0	13.3
GHU	2	141.7	184.7	15.3
THC	3	688.9	841.3	17.1
CXC	1	326.8	197.3	19.3
AGH	2	1467.1	1550.0	16.7
NNH	2	783.5	874.3	18.0

is recommended. This has been found to improve brightness [12-14]. The American College of Radiology [6] highlights that fluorescent tubes decrease in brightness by about 10% every 2000 hours. Replacement of tubes in a VB is therefore recommended every 18 to 24 months; tubes of the same type and colour should be used. However, in terms of the findings of this study it was observed replacements were only done when a tube malfunctioned.

It is suggested that the ACR recommendation should be implemented as part of quality assurance (QA) programmes. QA should include periodic checks of the VBs to maintain optimal conditions for viewing of radiographs. To maintain ambient lighting levels, shielding of the room is vital and the radiologists' viewing (reporting) rooms should be located away from direct sunlight. For purposes of standardization, the ministry of health in Nigeria should adopt one of the above cited recommendations for use by the hospitals. Monitoring of quality control practices by the said ministry would ensure compliance.

Conclusion

Most of the surveyed VBs in the Cross River State are in dire need of replacement as average box brightness and percentage uniformity fall short of the published guidelines. Ambient lighting was within acceptable level in all the centres surveyed in this study, satisfying the recommendations outlined in Table 3. The results of this study suggest an urgent need for implementation of quality assurance and control for radiographic VBs in the Cross River State.

References

1. Rill LN, Huda W, Gkanatsios NA. View box luminance measurements and their effect on reader performance. *Acad Radiol.* 1999, 6(9): 521-9.
2. Nyathi T., Mwale AN, Segone P, Mhlanga SH, Pule ML. Radiographic viewing condition of Johannesburg Hospital. *Biomed Imaging Interv J* 2008; 4(2): e17. URL: http://www.biij.org/2008/2/e17/
3. Alter, A J.; Kargas, GA.; Kargas, SA.; Cameron, JR.; McDermott, JC. The influence of ambient and view box light upon visual detection of low contrast targets in a radiograph. *Investigative Radiology*, 1982, 17(4): 402-405.
4. Lau S, Ng KH, Abdullah BJJ. Viewing conditions in diagnostic imaging: a survey of selected Malaysian hospitals. *J HK Coll Radiol.* 2001, 4: 264-267.
5. Harmann, E. And Stieve, F.E. 1999. Quality control of radiographic illuminators and associated viewing equipment. *British Institute of Radiology Report 18* London: BIR, 1999: 135-7.
6. American College of Radiology. *Acceptance testing protocols: a systematic approach to evaluating radiologic equipment.* 1983, Chicago, Il,: ACR,
7. *WHO quality assurance in diagnostic radiology.* 1982. Geneva: WHO.
8. European guidelines quality criteria for diagnostic radiographic images. 1996. *EU 16260* EU Brussels, Belgium, CEC.
9. National Institute of Radiation Hygiene. *Report on Nordic radiation protection co-operation. A quality control programme for radio diagnostic equipment: acceptance tests; Report No. 7*, 1999.
10. National Department of Health: Directorate: Radiation Control. *Inspection and verification scope for diagnostic X-ray imaging systems: Annexure A.* Cape Town, 2007.
11. Electronic Industries Association Committee. *Display monitor measurement – methods under discussion by EIA Committee JT-20-Part 1: Monochrome CRT Monitor Performance*, 1995.
12. McCarthy E., Brennan, PC. Viewing condition for diagnostic imaging in three major Dublin hospitals, a comparison with WHO and CEC recommendations. *BJR*, 2003, 76 (902): 94-7.
13. Cooney P, Davis C, Chua JBY W. van der Pullen, Malone JF. Survey of image viewing conditions for x-ray film. *Radiat Prot Dosim*, 1995, 57 (1-4): 305-308.
14. Wade, C., Brennan, P.C. Assessment of monitor conditions for the display of radiological diagnostic images and ambient lighting. *Br. J. Radiol.* 2004, Vol. 77: 467-71.