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Assessment of indoor cancer linked to accumulated radiation dose from different types of television sets in dwellings

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ABSTRACT: Exposure to radiation from different types of television sets was measured to ascertain the levels of hazards posed to the human biological system. Measurement of the annual radiation dose hazards was performed using a halogen-quenched GM tube with thin mica end window having a density of 1.5 mg/cm^2, effective window diameter of 0.360 inch and side wall of 0.012 inch thick. The GM tube was placed for 180 minutes and the sensor faced the screens of the various TV sets, one meter apart. The annual radiation dose ranged from 0.012 ± 0.006 mSv/yr for plasma-SONY to 0.13 ± 0.012 mSv/yr for SHARP and SAMSUNG 24 inch TV sets, containing cathode ray tubes. The annual doses from the 15 and 24 inch-LG TVs (manufactured with cathode ray tubes) were relatively low, with values of 0.031 ± 0.017 and 0.035 ± 0.005 mSv/yr, respectively. The 21 inch THERMOCOOL and PROTECH (with cathode ray tubes), produced annual doses of 0.110 ± 0.052 Sv/yr and 0.063 ± 0.002 mSv/yr, respectively. This provides an insight into the amount of radiation generated by different TV sets in households, on an annual basis. After some years of exposure to TV radiation, health complications such as carcinogenesis or other adverse cellular events may occur, due to cumulated (but does not always) doses which may result in DNA damage, to the human biological system.

Keywords: annual radiation dose, cathode ray tubes, health hazards, ionizing radiation.

INTRODUCTION

Liquid crystal display (LCD) televisions and computer monitors are easier on the eyes than televisions containing Cathode Ray Tubes (CRTs). LCD televisions refresh a pixel at a time instead of an entire line, which can cause eyestrain and flickering in a CRT television. The cathode ray tube (CRT) is a vacuum tube containing one or more electron guns and a fluorescent screen used to view images. It has a means of accelerating and deflecting electron beam(s) onto the screen to create images. The images may represent electrical waveforms (oscilloscope), pictures (television, computer monitor) radar targets or others (Kheifets et al., 2006). CRTs have also been used as memory devices, in which case the visible light emitted from the fluorescent material (if any) is not intended to have significant meaning to a visual observer (though the visible pattern on the tube face may cryptically represent the stored data).

The CRT uses an evacuated glass envelope which is large, deep (i.e. long from front screen face to rear end), fairly heavy, and relatively fragile. As a matter of safety, the face is typically made of thick lead glass, so as to be highly shatter-

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resistant and to block most x-ray emissions, particularly if the CRT is used in a consumer product. CRTs have largely been superseded by newer display technologies such as liquid crystal display, plasma display and light emitting diode (LED), which are more economical in terms of manufacturing costs, power consumption, weight and bulk.

In television sets and computer monitors, the entire front area of the tube is scanned repetitively and systematically in a fixed pattern called a raster. An image is produced by controlling the intensity of each of the three electron beams, one for each additive primary color (red, green, and blue) with a video signal serving as reference. In all modern CRT monitors and televisions, electron beams are bent by magnetic deflection, from a varying magnetic field generated by coils and driven by electronic circuits around the neck of the tube. Electrostatic deflection is also commonly used in oscilloscopes, a type of diagnostic instrument (Persson, 1994; Cember, 1996).

Health endpoints associated with the effects of low frequency electromagnetic field (LF-EMF) include childhood leukaemia, brain tumours, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, breast cancer, miscarriage and some cardiovascular conditions (Hardell et al., 2007). To study the effects of radiation emitted by CRT-TV screens, normal healthy volunteers were assumed not to react on exposure to CRT TV screen. The results might lay a foundation to understanding the underlying cause of the so-called ‘‘screen dermatitis’’, with special reference to mast cells.

In comparing the effects of various radiation types, we have to consider which radiation type deposits the most energy or causes the most damage, in a small volume of cells. In this regard, the most dangerous is alpha radiation followed by beta and lastly gamma. The most common effects of radiation are mutation and cancer induction (Ian, 2007). Radiation can cause damage to DNA, which may alter a gene or set of genes, and as such the resulting organism manifests biological defects (Zhou et al., 2002). Fertilized eggs fail to develop when significantly damaged and are sloughed off or aborted spontaneously. In fact, some estimates suggest that almost half the fertilized cells are lost by this natural process (Xu et al., 2010).

The electromagnetic fields (EMFs) of TVs constitute one of the biggest hazards in our homes because children often love to sit very close to the TV, thereby exposing themselves to a steady flow of harmful electromagnetic fields for hours. In a commentary published by Science Direct on the topic “Electromagnetic fields as cancer-causing agents”, Belpomme et al. (2007, 2008) stated that the classification of electromagnetic fields (EMFs) as mutagenic or cocarcinogenic agents is an ‘‘unfounded claim about the effect of EMFs’’ (Cedervall, 2008).

The argument is because EMF effects depend on energy and the energy level is not sufficient to cause direct breakage of macromolecules such as DNA; thus, genotoxicity cannot occur as a consequence of the non-thermal effects of EMFs. The recall is ‘‘the level of physics and chemistry are without exceptions consistent with those of biology’’. Indeed, in this type of scientific debate as in others, clinical and experimental data are more convincing than the theoretical point of view (Belpomme et al., 2008).

From the recent international consensus meeting (Bioinitiative Report, 2007), EMFs-related health endpoints include several types of biological responses such as genotoxicity, immune system deregulation and inflammation (Bioinitiative Report, 2007; Hardell and Sage, 2008) and several types of related diseases such as cancers, particularly childhood leukaemia, brain

tumours and breast carcinoma (Bioinitiative Report, 2007; Hardell and Sage, 2008; Hardell et al., 2007). Since biological responses are extremely complex and according to the second principle of thermodynamics, may depend on many factors relevant to entropy, i.e. on structural information instead of energy problems, and particularly here may depend on EMFs-related frequency, dose intensity, exposure duration and the number of exposure episodes, indirect or secondary biological effects of EMFs cannot be excluded (Belpomme et al., 2008). As reported (Bioinitiative Report, 2007), in addition to structural tissue disorganization and epigenetic disregulation, one other factor which may contribute to the mutagenic (clastogenic) effect of EMFs (Haider et al., 1994; Lai and Singh, 2004; Mairs et al., 2007) is its enhancement of free radicals formation inside cells, thereby damaging macromolecules through the Fenton reaction, which entails the conversion of hydrogen peroxides into hydroxyl free radicals (Belpomme et al., 2008). Moreover, as previously mentioned, other carcinogenic and cocarcinogenic effects of EMFs could include inflammation and immunoderegulation.

Although the precise biological mechanism by which EMFs act as mutagenic or cocarcinogenic agents needs to be further clarified, it therefore clearly appears that on the basis of present available clinical and experimental data, there is sufficient evidence to consider EMFs as cancer-causing agents (Belpomme et al., 2008). TV sets with larger screens tend to generate stronger fields because they contain larger EMF producing cathode-ray tubes. In general, the larger the TV screen, the stronger the EMFs generated. Blood being the main part of the human system was studied in relation to the harmful effects of electromagnetic waves emitted from CRT TV/PC screen (Jonai et al., 1996). TV sets have become such an integral part of homes, many homes, and 4 x 4 m^2 hotel rooms contain CRT-TVs of either LG 15 inch, LG 24 inch, SAMSUNG 24 inch, PROTECH 21 inch, SONY 21 inch, SONY (plasma) 29 inch, THERMOCOOL 21 inch and SHARP 24 inch. As a result of insufficient space in some living rooms, many people put TV sets on their head bed, beside sleeping beds, or beside the chair in their 4 x 4 m^2 sitting rooms.

In the modern world, it is hard to imagine life without television in the living apartment, since it provides entertainment to people of all ages. Since the invention of television in the beginning of the 1900s, history has seen many firsts in the area of television. The very first prototype for a plasma display monitor was invented in July 1964 at the University of Illinois by professors Donald Bitzer and Gene Slottow, and then graduate student Robert Willson. However, it was not until after the advent of digital and other technologies that successful plasma televisions became possible.

A plasma display is an emissive flat panel where light is generated by phosphors excited by a plasma discharge between two flat panels of glass. During the early sixties, the University of Illinois used regular televisions as computer monitors, for their in-house computer network (Abramson, 1995). Donald Bitzer, Gene Slottow, and Robert Willson (the inventors listed on the plasma display patent) researched plasma displays as an alternative to the cathode-ray tube-based television sets being used (Abramson, 1995). A cathode-ray display has to constantly refresh, which is okay for video and broadcasts but bad for displaying computer graphics. Donald Bitzer began the project and enlisted the help of Gene Slottow and Robert Willson. By July of 1964, the team had built the first plasma display panel consisting of a single cell.

Today's plasma televisions use millions of cells (Abramson, 1995).

Radiation from TVs cannot be underestimated and are defined as the propagation of energy through matter or space. It can be in the form of electromagnetic waves or energy particles classified as ionizing and non-ionizing radiation. The ionizing types include; alpha particles, beta particles, neutrons, gamma rays, x-rays, and have the ability to knock an electron from an atom, that is, to ionize (UNSCEAR, 1982, 1988, 1993 and 2008).

However, it should be emphasized that most television sets emit measurable levels of radiation, resulting in biological consequences. This research focused on addressing and finding more clarification on the following issues; (1) to identify health effects resulting from exposure to different types of television sets; LG 15 inch, LG 24 inch, SAMSUNG 24 inch, PROTECH 21 inch, SONY 21 inch, SONY (plasma) 29 inch, THERMOCOOL 21 inch and SHARP 24 inch over a prolonged period of time, (2) to analyze biological dose produced by TV sets and specify safe television radiation-to-man distance. We also addressed the effect on adults and children when exposed to radiation from TV sets.

MATERIALS AND METHODS

The measurements of radiation dose were performed using the Alert Digilert 200 handheld digital radiation detector with LCD Display. The radiation detector is accurate, typically ±15% from factory and ±10% from NIST, in surveying levels of potentially harmful ionizing particles and rays in the environment. It uses a board memory to collect accumulated counts with free observer USB software, which allows data download from the internal memory, setting of computer alarms, and instrument calibration. The thin walled GM tube has a thin mica end window with density of 1.5 to 2.0 mg/cm^2 and effective window diameter of 0.360 inch with a 0.012 inch thick side wall, which provides an excellent sensitivity to low levels of alpha, beta, gamma, and x-rays; with USB for use with observer USB software for PCs. It comprises of a 9-volt alkaline battery with red flashing light and each ionizing radiation event is indicated by a beep. The battery life is approximately 2000 hours at normal background radiation levels.

The GM tube has an operating range of 0.001 (1µR) to 200 mR/hr, 1.0 to 2000 µSv/hr, 1.0 to 214,000 CPM, 0 to 3575 CPS and 1.0 to 9,999,000 total counts. The energy sensitivity of 1070 CPM/mR/hr is referenced to Cs-137 and detects alpha down to 2.5 MeV. It has typical detection efficiencies of 80, 35 and 75% to detect beta particles at 3.6 MeV, 50 keV, and 150 keV, respectively. It detects gamma and X-rays down to 10 KeV typically through the window, 40 KeV minimum through the case within the temperature range of 0 to 50°C.

The measurements of electromagnetic radiation from different types of TV sets; LG 15 inch, LG 24 inch, SAMSUNG 24 inch, PROTECH 21 inch, SONY 21 inch, SONY (plasma) 29 inch, THERMOCOOL 21 inch and SHARP 24 inch, in various homes of Lapai metropolis was performed. At first, this was done by obtaining radiation measurements in the absence of TV sets (taken out totally from the sitting rooms) in the living rooms, using the Alert Digilert-200 Handheld digital radiation detector with LCD Display for 180 minutes. The second aspects of the measurements were performed in the presence of TV sets and were on (operating normally and showing some entertainment programs) for 180 minutes at a distance of one meter between the TV screens and GM tube. The whole sets of experiments were repeated three times and the mean values recorded are shown in Table 1.

RESULTS AND DISCUSSION

The counts obtained were converted to different units according to the calibration

specified on the Alert Digilert-200 Handheld digital radiation detector. Table 1 below contains samples of TV sets used, period, duration and counts. Table 2 shows the different dose equivalent values and associated conversions.

Table 1. Results of activity from various TV sets

Samples of TV sets	Duration (min.)	Mean counts without TV sets	Mean counts with TV sets	Number of counts	Activity (cpm)
LG 15 inch	180	3266	3348	82	0.456
LG 24 inch	180	3105	2196	91	0.506
SAMSUNG 24 inch	180	2596	2896	333	1.85
PROTECH 21 inch	180	3470	3637	167	0.93
SONY 21 inch	180	3467	3600	133	0.74
SONY (plasma) 29 inch	180	2827	2857	30	0.17
THERMOCOOL 21 inch	180	2752	3041	289	1.606
SHARP 24 inch	180	2899	3250	351	1.95

Table 2. Annual dose in Rem/hr, Rem/yr, mSv/yr

Samples of TV sets	Rem/hr	Dose (Sv/hr)	Annual Dose (Rem/yr)	Annual Dose (Sv/yr)	Annual Dose (mRem/yr)	Annual Dose (mSv/yr)
LG 15 inch	27.36	0.2736	0.0031	3.1×10^{-4}	3.1	0.031
LG 24 inch	30.36	0.3036	0.0035	3.5×10^{-5}	3.5	0.035
SAMSUNG 24 inch	111	1.11	0.0126	1.2×10^{-4}	12.6	0.126
PROTECH 21 inch	55.6	0.556	0.0063	6.3×10^{-5}	6.3	0.063
SONY 21 inch	44.4	0.444	0.0051	5.1×10^{-5}	5.1	0.051
SONY (plasma) 29 inch	10.2	0.102	0.0012	1.2×10^{-5}	1.2	0.012
THERMOCOOL 21 inch	96.36	0.9636	0.011	1.1×10^{-4}	11	0.114
SHARP 24 inch	117	1.17	0.0133	1.3×10^{-4}	13.3	0.134

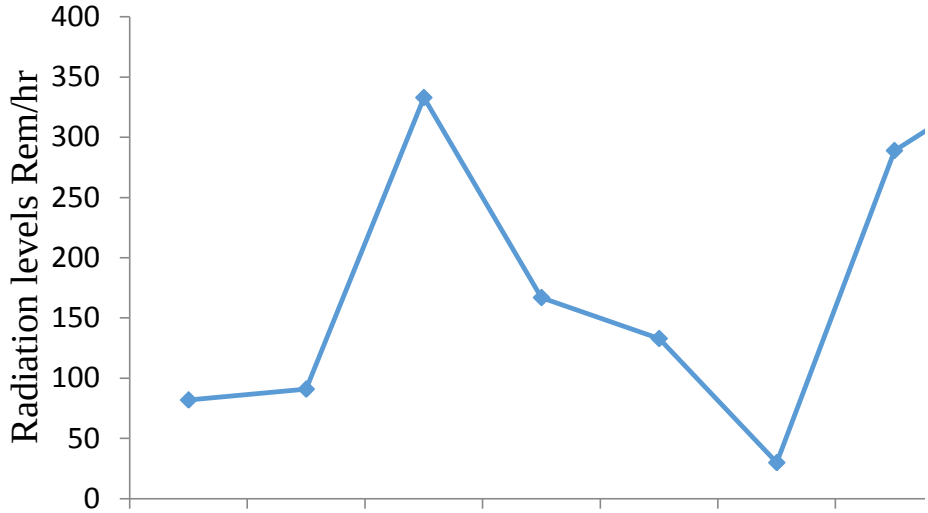

Fig. 1. Radiation emitted by eight different Television sets

The variation in Figure 1 shows that different TV sets emit varying levels of radiation. It was observed that the sizes of TV sets with CRTs influenced radiation emission. This can be seen in Figure 1, where the larger screens emitted more radiation, as is the case with Samsung 24 inch, Thermocool 21 inch and highest with Sharp 24 inch. The question is: do TV Sets Give Off x-rays, gamma rays, beta and alpha particles? From our observation, based on the high values of 111 rem/hr for Samsung 24 inch, 96.36 rem/hr for Thermocool 21 inch and 117 rem/hr for Sharp 24 inch, x-rays may be produced when electrons, accelerated by high voltage, strike an obstacle while traveling in a vacuum, as obtainable in a CRT TV. Since many TV components operate at thousands of volts, there is the potential for x-ray generation. These components may produce x-rays capable of escaping from the television receiver or CRT. This unintentional emission of x-radiation poses a potential hazard and must be controlled.

This indicates that there are some risks associated with watching CRT-TVs, as indicated in Figure 1 and Table 2 with an annual dose of 0.114, 0.134, and 0.126 mSv/yr for THERMOCOOL 21 inch, SHARP 24 inch and SAMSUNG 24 inch, respectively. This annual dose level may lead to cancer related diseases, even though cells of the human body can withstand certain radiation effects. Consistent exposure can be harmful, especially to young children, as was observed in the case of flat screen LCD SONY (plasma) of 29 inch, emitting very low radiations (0.012 mSv/yr). This brings us to another question; how safe are TV sets today? As seen in this work, emissions of x-radiation from properly operated TV sets and computer CRT monitors, are well controlled and do not present a public health hazard, due to the fact that the annual radiation dose from large or small CRT-TVs were far less than 0.3 mSv/yr, the annual effective dose established by UNSCEAR (2000). Based on the results of flat screen LCD SONY (plasma) of 29 inch (0.012 mSv/yr), it is important to note also that flat panel TVs incorporating Liquid Crystal Displays (LCD) or Plasma displays are not capable of emitting x-radiation. As such these products do not pose a public health hazard.

Figure 2 shows the annual dose in mSv/yr. This entails that individuals who watch TV are exposed to a certain level of radiation. Although none of the TV sets exceeded the radiation dose limit (0.5 to 5.0 Sv/yr, including external sources) set by different organizations such as the World Health Organization (WHO), International Commission on Radiological Protection (ICRP, 2005), and the National Council on Radiation Protection (NCRP).

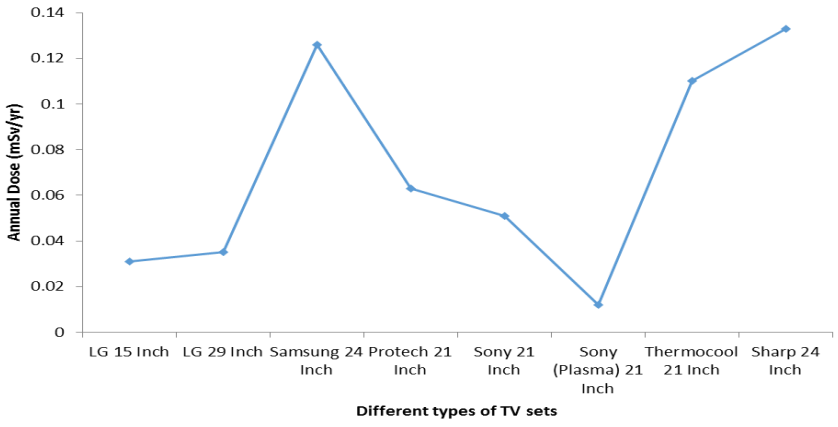

Fig. 2. Annual dose in mSv/yr by the different types TV Sets

However, watching too much television is bad for the eyes, even though most experts agreed that staring at the television (or computer monitors) will not cause permanent damage to a person's eyes (Majewska et al., 2007). However, focusing too long on an object can cause eyestrain, and temporary eye irritation. The American Academy of Ophthalmology stated that excessive TV watching can surely cause eye strain and fatigue, particularly for those sitting very close or watching from odd angles.

Around 1967, General Electric Company (GEC) disclosed that many of their color televisions were emitting excessive electromagnetic radiations due to a factory error. Over-exposure to electromagnetic radiation can be dangerous, and Public Health Service officials estimated radiation from the tube to be between 10 to 100,000 times the rate considered safe. GE corrected the problem by shielding the tubes inside the television with leaded glass. At the time, health officials stated that excessive levels of radiation would not harm most viewers. However, they did warn against children sitting close to the television for more than an hour, because of electromagnetic radiations, shooting through the vents on the bottom of the set. Even though GE recalled and repaired the faulty television sets, the threat of physically damaging electromagnetic radiation remained in people's minds. Therefore, a routine investigation like this, serves as a guide to our health. Man cannot be completely free from exposure to radiation, in the sense that it is an inescapable particle (natural radiation). Although electronics, especially television has been found to emit low levels of radiation, the fact is that, frequent exposure can result in health challenges.

CONCLUSION

The annual radiation dose hazards analysis was performed using the halogen-quenched GM tube with a thin mica end window of density 1.5 mg/cm^2, effective window diameter of 0.360 inch and side wall of 0.012 inch thick, for various types of TVs placed one meter apart. The annual radiation dose ranged from 0.012 ± 0.006 mSv/yr for plasma-SONY to 0.13 ± 0.012 mSv/yr for SHARP and SAMSUNG 24 inch CRT-TV sets. The annual dose from the 15 and 24 inch-LG CRT-TV sets were relatively low 0.031±0.017 and 0.035±0.005 mSv/yr. The 21 inch THERMOCOOL and PROTECH CRT-TV sets produced annual doses of 0.110±0.052 Sv/yr and 0.063±0.002 mSv/yr, respectively. However, the dose levels of all the TV sets did not exceed the recommended dose limit (0.5 to 5.0 Sv/yr including external sources) given by different organizations such as the World Health Organization (WHO), International Commission on Radiological Protection (ICRP, 2005), and the National Council on Radiation Protection (NCRP). This provides an insight into the amount of radiation generated by different TV sets in households, on an annual basis. After some years of exposure to TV radiation, health complications such as carcinogenesis or other adverse cellular events may occur, due to cumulated (but does not always) doses which may result in DNA damage, of the human biological system.

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