

A Glance at the Errors of Some Studies on the Health Effects of High Background Natural Radiation Areas

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ABSTRACT

There is no place on the Earth, the planet we live on, where the natural background radiation level is zero. Since the birth and even in our fetal stage, we have been exposed to different sources of natural radiation. Life, in fact, evolved in a radiation environment that was much more harsh than today. Earth serves as a source of terrestrial radiation. Uranium, thorium, and radium are among the radioactive materials that naturally exist in soil and rock. Moreover, the air, we breathe, contains radon, a colorless, odorless, radioactive gas that is created naturally by the radioactive decay of uranium and radium. The crucial importance of the studies on the health effects of living in areas with high levels of background radiation for understanding the biological impact of exposure to low doses of ionizing radiation is well documented. Despite the undeniable need for accurate information about the health effects of exposure to high levels of background radiation, many published papers suffer from methodological and other common types of errors. In this paper, we review three articles published on high background radiation areas. The first paper has addressed the frequencies of unstable (dicentric & rings), stable (translocations & inversions), and other types of chromosome aberration in adult men from both high background radiation areas of Kerala and areas with normal background radiation. The second paper has addressed different aspects of the world's high background natural radiation areas. Finally, the third paper has tried to address the role of background radiation on males to females' ratio at birth. The author has mainly referred to the studies performed on the impact of radiation exposures from nuclear testing (worldwide) and Chernobyl fallout (in Europe). The major shortcomings of these three papers, especially methodological errors, which affected the accuracy of their findings and conclusions are discussed.

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Keywords

Background Radiation • Biology • Health

Introduction

Living organisms have responded to different magnitudes of natural radiation from the early days of life on Earth. Professor Jaworowski the former chairman of the United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) (1981-1982) believed that when the first living organisms appeared on the Earth more than 3.5 billion years ago, the background radiation level was much higher than its current level [1]. In this light, it seems that the current repair mechanism of mutations reflects the early life's response to the high level natural background radiation under which they evolved [2]. Earth, the planet we live on, serves as a source of terrestrial

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radiation. Uranium, thorium, and radium are among the radioactive materials that naturally exist in soil and rock. Moreover, the air, we breathe, contains radon, a colorless, odorless, radioactive gas that is created naturally by the radioactive decay of uranium and radium. Dobrzyński et al. have previously addressed the crucial importance of the studies on the health effects of populations living in areas with high levels of background radiation for understanding the biological impact of exposure to low doses of ionizing radiation [3]. The issue of the health effects of life-time exposure to high levels of background radiation in some areas such as Ramsar [4-9] and Kerala [10-16] is well documented. Although the need for accurate information about the health effects of background radiation is undeniable, many published papers suffer from methodological and other common types of errors. In this paper, we review three articles published on different aspects of the challenging issue of living in high background radiation areas.

Karuppasamy et al. in their paper entitled "*Frequency of chromosome aberrations among adult male individuals from high and normal level natural radiation areas of Kerala in the southwest coast of India*" [17] have studied the frequencies of unstable (dicentric & rings), stable (translocations & inversions), and other types of chromosome aberration in adult men from both high background radiation areas (HBRAs) of Kerala and areas with normal background radiation. Karuppasamy et al. in their study did not find any statistically significant difference between the frequencies of the chromosome aberrations in high background and normal background radiation areas. Despite the popularity of the theme of this study, the paper authored by Karuppasamy et al. has some major shortcomings.

The first major shortcoming of this paper comes from its very poor sampling method and inclusion/exclusion criteria. While the population of HBRAs of Kerala is about 100,000 [18], the authors selected 70 and 25 individuals

from HBRAs and NBRAs, respectively. Interestingly, when they included only 0.07% of the residents of HBRAs in their study, they did not exclude smokers, people consumed alcohol or had tobacco-chewing habits (it is worth noting that 50% of the participants were smokers, 70% were alcohol consumers and 16% had tobacco-chewing habits). Moreover, the sampling method used in this study for selection of a small group of residents (70 individuals) for study from a very large group (a population of 100,000) is not clear. In this light if each resident of HBRAs had an equal chance of being included in the cases, the authors should explain the reason that the average annual dose received by the HBRA residents was only 5.36 times higher than the dose received by NBRA residents "*In the present study, the average annual dose received by the individuals from HLNRA was 7.02 ± 7.14 mGy/year (range: 1.53 to 34.92 mGy/year), whereas the average dose received by individuals from NLNRA was 1.31 ± 0.13 mGy/year (range: 0.88 to 1.50 mGy/year)*" while in another report the average dose for residents of HBRAs of Kerala was 7.5 times higher [18]. It's also not clear why they only selected 27 people from normal background radiation areas while they had 70 individuals from HBRAs.

Another shortcoming of this study is due to not measuring the indoor radon levels. A possible association between increased cytogenetic damage and indoor radon has been reported previously [19]. Interestingly, the authors reported that 50% of the participants were smokers. Therefore, considering the synergistic effects of radon and smoking, this prominent confounding factor cannot be ignored.

The selection of dosimetry locations is also another shortcoming of this study "*Measurements were made at a height of 1m inside (the main room having maximum occupancy) and outside (near the entrance) of each house. The mean of three readings was taken for each measurement*". Considering this point

that each person sleeps about 8 hours in his/her bedroom but normally does not spend any time at the house entrance. Therefore, the selection of these locations needs clarification.

In addition, the authors claimed that "*individuals from Ramsar, Iran reported significantly the higher frequency of unstable chromosome aberrations (mainly breaks) in HLNRA as compared to controls*". This claim is not true because only some of cytogenetic studies conducted in HBRAs of Ramsar have shown increased frequencies of unstable chromosome aberrations, and other studies did not find any statistically significant increases [20, 21]. In summary, these shortcomings cast doubt on the validity of the findings of this study.

Another article by AS Aliyu and AT Ramil entitled "*The world's high background natural radiation areas (HBNRAs) revisited: A broad overview of the dosimetric, epidemiological and radiobiological issues*", published in Radiation Measurements has also has some shortcomings. This paper has addressed the dosimetric, epidemiological and radiobiological aspects of the high background radiation areas around the world including Ramsar, Iran. Mortazavi and his colleagues have previously investigated the health effects of exposure to above-the-normal levels of natural ionizing radiation in HBNRAs of Ramsar [22-28]. They have also published the first reports on the induction of radio-adaptive response in the inhabitants of these areas [21]. Although the paper published by Aliyu and Ramil is very well-structured and deserves to be recognized as a remarkable contribution to the field of natural radiation studies, it has some shortcomings. First of all, the authors have stated that about eighty percent of our annual effective doses come from background natural radiation. It should be noted that due to the rapid increase in the number of diagnostic radiologic examinations, there has been the significant growth in the effective dose from medical sources. For example, the U.S. per-capita annual effective dose from medical procedures

has increased about six folds (0.5 mSv in 1980 to 3.0 mSv in 2006). In this light, new artificial sources of radiation account for about fifty percent of the radiation to which people in the United States are exposed. Artificial radiation is generated in medicine and dentistry, and is found in consumer and industrial products. Considering the NCRP value of 3.1 mSv as the average per-capita value for natural background in the United States, now medical uses and natural background have equal contributions in effective doses [29].

On the other hand, the authors have stated that "*An increased frequency of chromosome aberration was detected in some studies (Sohrabi, 1998 and Zakeri et al., 2011). Other studies (Ghiassi-nejad et al., 2002 and Masoomi et al., 2006) have linked the lack of differences between chromosomal aberrations in HBNRAs and NBRAs to adaptive response mechanism.*" As one of the authors of this paper (SMJM) is the corresponding author for one of the papers cited above [21], we should clearly mention that we only observed the adaptive response phenomena when we exposed the lymphocytes of residents of HBNRAs and NBRAs in vitro to a challenge dose of 1.5 Gy of gamma rays and observed a significantly reduced frequency of chromosome aberrations in HBNRA residents compared with those of the residents of the NBRAs. Adaptive response can be defined as the induction of repair by pre-exposure to low level chemical or physical stress. We have previously shown that when living organisms are pre-exposed to low levels of ionizing [22, 30-32] or non-ionizing radiation [33-37], and they receive a large dose (challenge dose) later, the detrimental biological effects can be less than if they were exposed to the large dose alone.

Therefore, when there is no challenge dose, adaptive responses cannot be observed. In this light, the lack of difference between chromosomal aberrations in the residents of HBNRAs and NBRAs cannot be due to the induction of adaptive response; however, hormetic effects

(radiation hormesis) might be responsible for such an effect.

The third problem in this paper comes from the size of the population of HBNRAs “in general, residents of Ramsar receive annual absorbed dose of about 260 mSv y^{-1} from background radiation, which is 20 and 200 times the permitted limit for radiation and non-radiation workers, respectively”. The authors should note that Ramsar is a big city and only a small area of this city with 1000-2000 population has high levels of natural radiation. In this light, the mean dose for the residents of HBNRAs of Ramsar is only 10 mSv y^{-1} [21] and exclusively a very small proportion of the residents receive doses as large as 260 mSv y^{-1} . It is worth noting that a recent study revealed that the monthly average background gamma dose in Ramsar is about 57 μ Sv (annual dose of 686 μ Sv). The authors of this paper even claimed that the dose equivalent measured for high level natural radiation areas of Ramsar was the same as high elevation cities. Although we believe that this paper has also some shortcomings, it simply shows that the annual dose in the whole city of Ramsar is not that high.

The 3rd paper that needs to be reviewed here is authored by Jargin “Male to Female Ratio at Birth: the Role of Background Radiation vs. Other Factors. *J Environ Stud.* 2018;4[1]:4” [38]. Jargin in this paper has referred to the studies performed by Grech on the impact of radiation exposure from nuclear testing (worldwide) and Chernobyl fallout (in Europe) [39, 40]. He criticized the validity of the conclusion of Grech “elevated levels of man-made ambient radiation may have reduced total births, affecting pregnancies carrying female pregnancies more than those carrying male pregnancies, thereby skewing M/T (male live births divided by total live births) toward a higher male proportion” and “birth rates are greatly reduced and the M/T ratio is skewed upward significantly with population exposure to ionizing radiation, even at great

distances from major nuclear events” and stated that in low dose radiation exposure, the dose-response relationships can only be studied in large-scale animal model experiments. Jargin also mentions that these studies should be conducted on different mammal species and confirms the importance of comparable doses and dose rates, as well as the necessity of paying attention to potential biases and conflicts of interest. This paper has some major shortcomings. Interestingly while the author is aware of the importance of high background radiation areas around the world “There are many places in the world where the dose rate from NRB is 10-100 times higher than the average e.g. 260 mGy/a in Ramsar, Iran [6], or 70 mGy/a at certain locations in Kerala, India [7], yet there are no reliable data on shifts of sex ratios at birth in such areas. For example, a study based on $\geq 150,000$ consecutive live singleton newborns in Kerala did not indicate any impacts of elevated NRB on the sex ratio [8]”, he mainly focuses on Grech studies. Jargin does not pay attention to this key point that the findings of areas with low or high levels of radioactive contamination cannot be used for evaluation of the health effects of high background radiation areas and vice versa. This is due to the key point that in high background radiation areas, people have lived in these areas for many generations and adaptive responses are frequently reported in the residents. It’s worth noting that the adaptive response is controlled by some genetic factors [41].

Conclusion

Despite the key importance of the studies on the health effects of chronic exposure of populations living in HBRA to high levels of natural radiation and its role in better understanding of the challenging issue of biological impact of exposure to low doses of ionizing radiation, some of published reports have major shortcomings which significantly affects the accuracy of their findings and conclusions.

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Conflict of Interest

None

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