IMPACT OF IONIC AND NON-IONIC RADIATION ON HEALTH (CONTROVERSIONS AND SOLUTIONS)

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Abstract

This study aims to discuss controversial issues related to the effects of radiation on health, and propose possible solutions. This scientific study is a simple narrative review. The results of the review show that: 1) the controversy about the effects of radiation on health, is more dominant in non-ionizing radiation, rather than ionizing radiation; 2) solving problems regarding the effects of ionizing radiation is more aimed at managing contact time, distance, and the use of protective equipment, while solving the impact of non-ionizing radiation is more aimed at health education for the community. It is further suggested: 1) the need for organized research on the effects of radiation on health, with a more thorough and in-depth method, so that the resulting conclusions are minimal in controversy, 2) the government is expected to be more intense in carrying out overall and simultaneous prevention efforts, especially health promotion about radiation and its effects.

Keywords: ionizing radiation, non-ionizing radiation, health, health promotion

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1. Introduction

Today, the discourse on the effects of radiation is still a controversial issue. As an extreme example is the impact of radiation from cell phones, which has led to a lawsuit by Dr. Christopher Newman, a neurologist from Baltimore, against a cell phone manufacturing company to be responsible for a brain tumor he had suffered [1]. The ironic thing is that the results of these studies are inconsistent [2]. Under WHO coordination, developed countries have conducted research on the effects of radiation on health. Research centers and universities also do the same thing, but the results are still controversial [3].

Because this controversial discourse continues, the issue of the impact of radiation on health remains a very important discourse to be discussed scientifically. Thus, it is interesting to write a paper with the aim of: 1) analyzing controversial issues regarding the effects of ionizing and non-ionizing radiation on health, so that it can become one of the study materials for scientific discussion or further research, 2) propose solutions related to the impacts that occur as a result of radiation exposure.

2. Methods

This study was a literature review. The specific method applied was narrative review. Information was obtained from related previous literature, especially from journal articles and several other sources, which were selected based on the researcher's subjective considerations. Furthermore, a careful study and discussion was carried out, which refers to the stated study objectives. Furthermore, the results of the study were presented in a narrative manner.

3. Results and Discussion

Impact of Ionic and Non-ionic Radiation

Radiation is energy that is delivered, emitted and absorbed in the form of particles or waves [4]. Radiation can come from natural or artificial sources. Natural sources, for example, are radiation from the cosmic rays, radiation from elements in the layers of the earth's crust, radiation in the atmosphere due to shifts in the trajectory of the earth's rotation and so on. Meanwhile, sources of artificial radiation, for example, are radiation caused by X-rays, alpha rays, beta rays, and gamma rays [5]. There are two types of radiation, namely ionic radiation and non-ionic radiation. Ionic radiation can cause ionization and conversely non-ionic radiation cannot cause ionization. Classified as ionic radiation include alpha rays, beta rays, gamma rays, X rays, neutrons, and protons, while those included in the non-ionic radiation group include ultraviolet rays, infrared rays, ultrasonic waves, microwaves, visible rays, and laser light [6-8].

With advances in nuclear physics, especially radioisotopes, many benefits have been gained, including in the fields of medicine or health, agriculture, food technology, animal husbandry, industry, basic and applied research, and archeology. In the medical field, radiation is used for sterilization, diagnosis, and therapy of certain diseases [9]. In agriculture, radiation energy can be used in the manufacture of superior plant seeds, determining the right fertilization time, and pest control [10]. In the field of food technology, gamma radiation from the isotope Co-60 is used for the preservation of food ingredients. In the livestock sector, radioisotopes are used to manufacture chicken coccidiosis vaccines produced by oocyst radiation. Livestock vaccination systems are effective enough to prevent certain diseases and reduce livestock mortality [9]. In the industrial field, radiation has been used in the radiation polymerization industry, namely the industry for processing raw materials into semi-finished or finished materials [11]. In the field of research, radiation has been used for atomic spectroscopy and NMR (nuclear magnetic resonance) techniques. The isotopes used are produced in nuclear reactors [9]. In the field of archeology, radioisotopes are used to determine the age of fossils such as bones, rocks, trees, and minerals [11].

Radiation can cause various effects which include: damage due to ionic and non-ionic radiation, effects of radiation on cells, as well as side effects as a result of radiation exposure.

1. Damage due to ionic and non-ionic radiation
   Negative effects on living tissue that occur due to radiation exposure are related to the type of radiation. In general, ionic radiation has a heavier impact than non-ionic radiation. Ionization can cause damage to our body's cells, and can even cause cell death directly. This happens because ionization can damage cell membranes and cause intracellular swelling, so that cells experience lysis. When cells are injured or die, an inflammatory response is stimulated that results in capillary leak, interstitial edema, accumulation of white blood cells, and scarring. Ionic radiation also indirectly damages the bonds between Nitrogen base pairs in DNA molecules, resulting in errors in DNA replication or transcription [8].
2. Effects of radiation on cells
   Ion production can cause unpredictable chemical reactions, for example water irradiation can produce H+ and OH-; some ions are very strong oxidizing and reducing agents which can lead to further chemical interactions; some ions will interact with each other, with oxygen, with organic molecules and so on. Cell toxins or abnormal products can be produced from these

chemical reactions. The effects of these abnormal reactions and products can include: changes in organic compounds that result in changes in cell structure and behavior, cells become sterile due to premature aging so they do not try to divide, and cell death occurs directly or as a result of the two previous processes [12].

3. Side effects of radiation
   Cree & Rischmiller [12] explained that the side effects of radiation can be acute, subacute, or slow. Acute effects occur while the action is given and 6 months afterward, subacute effects occur 6 months after the action is stopped, whereas late effects will appear clearly within 1 year or more after the action is stopped. Acute side effects are associated with very rapid cell division, eg cells of the intestine, bone marrow, and esophagus. Subacute and delayed effects are associated with kidney, bone, liver, and nerve tissue. The side effects above are grouped into genetic effects, changes in general health, and skin reactions.

In general, there are several factors that affect the degree of tissue damage caused by radiation, namely: the amount of radiation absorbed by the body, the type of radiation, the chemical nature of the radiation, the concentration of oxygen, and radiosensitivity [12].

1. The amount of radiation absorbed by the body
   Even small doses of ionizing radiation can have serious effects when exposed to the body repeatedly, for example many people working on projects involving radioactivity research end up developing cancer, sometimes 40 years after the initial exposure to the radiation. Marie Curie the atomic nucleus researcher and her daughter died of leukemia due to exposure to radiation. Likewise, the incidence of leukemia among those who survived the bombings of Hiroshima and Nagasaki was very high [12].
2. Type of radiation
   Alpha rays have the largest size so they are blocked by the skin, beta rays can penetrate the skin as thick as one centimeter, but gamma rays can penetrate the way X-rays penetrate [12]. The biggest radiation disaster was the atomic bombings in Hiroshima and Nagasaki, each of which had a different radiation impact, due to the different types of radiation that dominated. In Hiroshima, the effect of neutron radiation dominates, while in Nagasaki it is dominated by the effect of gamma rays. Because of this difference, the impact of radiation on the two cities that were hit by the atomic bomb almost simultaneously has different characteristics [13].
3. Chemical properties of radiation
   The chemical nature of the isotopes involved is very important. As an example is the comparison between Krypton-85 and Strontium-90. Krypton-85 is generated during nuclear reactions and released into the atmosphere during the reprocessing of nuclear fuel. However, this element is very unreactive and chemically classified as a noble element. Once in the atmosphere, it can affect the skin and lungs, but, because it is chemically unreactive, it cannot pass through other parts of the body, nor does it accumulate in the body. On the other hand, although Strontium-90 is also formed in nuclear reactions, it has similar properties to calcium, so Strontium-90 tends to enter the bones, then accumulates, and where its radiation will cause bone cancer and leukemia. Another example is iodine isotopes that enter the thyroid gland [12].
4. Oxygen concentration
   Oxygen in very large concentrations at the time of irradiation (irradiation) can magnify the damage that occurs [12].
5. Radiosensitivity
   Cells with high sensitivity to radiation include self-renewal systems such as glands in the intestine, which can divide rapidly and in an orderly manner, and non-specialized cells in the ovaries, testes, bone marrow, lymph and so on can respond rapidly to low-dose therapy. Liver, kidney, mature bone, etc. cells have an intermediate level of sensitivity that takes longer to respond and requires higher radiation doses. Cells with a low level of sensitivity, including brain cells, muscle cells, and spinal cord, only respond to very high doses of radiation [12].

Controversy Surrounding the Impact of Radiation on Health

Radiation is of great benefit to human civilization, but it can also have a negative impact on health. The impacts arising from large radiation such as the atomic bombs on Hiroshima and Nagasaki, as well as the Chernobyl tragedy, of course it is easier to believe that the source of the radiation really has an impact on public health. Likewise, radiation received by patients who undergo repeated radiation therapy, of course it will also be easy to believe that radiation has a clear negative impact on health. Empirically, the community can see for themselves that in fact many patients undergoing radiotherapy experience redness of the skin, hair loss and so on.

Research to prove the impact of radiation on the above cases would certainly be easier to do. For example, of course, it will be easier for research to prove that these various side effects (erythema, hair loss, desquamation etc.) are really the result of exposure to radiation. Of course, this cannot be separated from the type of radiation that plays a role in severe cases, namely the ionic radiation group or ionizing radiation, as discussed above, ionic radiation has a more severe impact compared to non-ionic radiation. Because the negative effects that arise are more severe, signs and symptoms will be easier to observe, so research will be easier to do.

Thus, the validity of the research results is also easier to realize.

However, apart from ionic radiation with a more severe effect, there is also non-ionic radiation with a milder effect, which may not even be felt or ignored by the public. If we examine the theoretical studies above, it appears that the controversial radiation cases are more towards non-ionic radiation sources. For example, extra-high voltage overhead was protested by the public because it was suspected of being a source of radiation in the form of the electromagnetic waves it generated. The extra-high voltage overhead protest is not a recent event. Since 1991 there have been people protesting. In 1995 the residents of Singosari, Gresik sued the Minister of Mines and Energy of Indonesia, the Governor of East Java, as well as the Director of PLN. Furthermore, residents under extra-high voltage overhead in Sumedang Regency, Indonesia also sued PLN to the District Court and the State Administrative Court [2]. It is clear that this condition must be taken seriously.

Claims about the impact of extra-high voltage overhead are also quite interesting. There are 22 children who are claimed to suffer from radiation-related disabilities because they live 5-10 meters from the tower, with a lifespan of approximately 20 years. There are also those who complain of itching, as well as the appearance of lumps all over the body. In other situations, many also complain of dizziness, palpitations, difficulty sleeping and other complaints [2]. Is it true that what the community was complaining about was really a result of extra-high voltage overhead? Couldn't that be due to other factors, such as conditions at work?

Another example is the use of cell phones. It seems that in the last decade there has been a very rapid increase. For example, when the author finished his education in 2002, at that time only a few students were using cell phones, even though this was a community college. Let's compare it with the current conditions. Not only modern society, but almost all levels of society have used sophisticated cell phone technology. Almost all of the simple people in rural areas (need to be proven by research) have used this technology in their daily lives.

What is interesting in our country is that it is rarely heard (or maybe almost never?) of public protests about the impacts arising from the use of cell phone technology. Even though in the western world, there have been quite interesting claims that radiation from cell phones has an impact on the emergence of brain cancer in a neurologist [1].

Does the radiation from cell phones also have a significant impact on public health? This is still a controversial discourse, as is the impact caused by extra-high voltage overhead radiation. The two examples above are only a small part of the controversial radiation issues. Of course there are many other problems that are identical to the two examples above, for example the Bhopal case in India, as well as other problems in this part of the world.

The controversy about the impact of non-ionic radiation sources is of course an ironic thing. For example, there are research results on extra-high voltage overhead which show that extra-high voltage overhead is harmful to health, but there are also those that state that extra-high voltage overhead is relatively safe. According to one reference, this controversy arose due to the inconsistent selection of research methods, as well as due to problems with the publication of research results. The results of research on extra-high voltage overhead, for example, seem to contain conflicting interests. Sometimes information is only conveyed piecemeal for the benefit of certain parties. It is ironic if scientific studies are only used as legitimacy tools for short-term interests [2]. Even though we know that we must pay attention to the safety of mankind far into the future, because potential replacements for us will appear in those future times.

Our next generation can be threatened by scientific studies that are used inappropriately. Since 1972 health problems due to electromagnetic field radiation have been known when Soviet researchers reported that those working under high voltage electrical transmissions had suffered from illness with nervous system related symptoms such as headaches, fatigue, changes in sleep patterns. Research related to the above did not succeed in drawing conclusions that there had been an impact in the form of such health problems. Precisely consistent results as the impact of electromagnetic fields are cancer, leukemia, brain tumors, and melanoma. The results of experimental research on the impact of electromagnetic fields are also very varied and controversial [14].

In dealing with a controversial issue like this, the author is of the opinion that opportunities to guarantee public safety should be prioritized. Even though the negative effects of non-ionic radiation are still confusing, at least there are statements issued by competent institutions in this field that can be used as a reference for making decisions in favor of public safety. For example, the INIRC (International Non Ionizing Radiation Committee) from the IRPA (International Radiation Protection Association), states that the electric and magnetic field values that characterize uninterrupted exposure conditions are fields that if all objects are removed, because electric fields in general will be disturbed. if it is close to the surface of an object. Biological effects are associated with field exposure on the body surface [14]. The statement shows that electromagnetic radiation needs to be watched out for, so that this can be used as a basis for implementing implementations aimed at ensuring public safety.

Meanwhile, it is absolutely necessary to conduct

research with a more consistent method and be properly organized by the government, so that it will produce conclusions with high validity, so that they can really become the basis for making the right decision.

The Solution to Reduce the Impact of Radiation on Public Health

The previous section has described the impact of radiation energy on health, both from ionic and non-ionic radiation sources. From this explanation, we can see that ionic radiation sources are capable of producing ionization reactions against chemical structures, including the structure of biomolecules in our bodies. The result is changes in biomolecules in our biological system, in various locations such as skin, cell membranes, as well as components contained in the cell nucleus, namely chromosomes which contain DNA as genetic material.

Due to the great effect of ionic radiation on biological systems, signs and symptoms due to this type of radiation are more easily recognized, for example erythema, hair loss, thrombocytopenia, anemia and so on. So we can say that the impact of ionic radiation is clearer or more obvious. The sources of the cause are also easier to ascertain, because they are not incidents in everyday life, but exposures that are specifically obtained, for example patients receiving radiotherapy in the form of radioisotopes, reactor workers exposed to radiation from nuclear reactor leaks, and so on.

With clear causes, as well as clear impacts, the solutions to deal with them also tend to be clear. Prevention is the main solution to create safer conditions, namely by paying attention to time, distance and protection.

To create the safest possible situation, the time in the radiation field must be as short as possible, so that the exposure becomes lower. Careful planning will create the shortest possible exposure time [12]. This can be applied in a variety of situations, whether in hospitals, nuclear power plants, nuclear reactors in research centers and so on.

Distance also determines the level of security. The farther the distance from the radiation source, the safer the condition. Cree & Rischmiller [12] explained that exposure distance adheres to the inverse square law. This relationship indicates that the intensity of radiation received from the source will decrease according to the square of the distance. If the intensity of radiation received within 1 meter from the source is R, then: the intensity of radiation received from a distance of 2 m is R/22 = R/4, the intensity of radiation received from a distance of 3 m is R/32 = R/9, the intensity of radiation received from a distance of 4 m is R/42 = R/16, and so on. Thus, the radiation level will decrease very quickly if the distance is increased.

Protector is a tool that should not be neglected to ensure safety. Reducing radiation exposure can be achieved by placing radiation reducing materials between the radiation source and the individuals involved. In this case, lead material is widely used as a gamma emitter because of its high density and its effectiveness against gamma radiation. But keep in mind that the shield only reduces the gamma radiation that penetrates it, so the thickness of the shield must be an important consideration [12].

Meanwhile, specifically for non-ionic radiation, it has also been discussed in the initial section that the effects may be much milder than the effects of ionic radiation. The result is that the effects of this radiation are difficult to recognize, especially for relatively short periods of use. Therefore it is very possible if the effects of radiation are ignored or even the public may not realize that they are exposed to harmful radiation. This condition causes unclear safety conditions for people who get exposure to non-ionic radiation. So there is controversy about whether or not exposure is safe to various kinds of non-ionic radiation sources, such as cell phones, extra-high voltage overhead electric fields, microwave ovens, laser beams, radio waves and so on.

The solutions offered are not necessarily easily accepted by society. However, the authors argue that strict prevention solutions must still be provided, particularly in the form of health education about non-ionic radiation and its impact on health. Light and practical tips should color this health education effort, so that it is easier to remember, understand, interest in, and apply. A simple example is propaganda to limit holding cell phones to the ear, for example by activating the speaker so that the sound of cell phones can be heard from some distance away. Examples of other tips can be arranged according to other potential radiation sources such as computers or laptops.

Security solutions against the effects of ionic and non-ionic radiation, all of which must be properly organised. In this case, the government must be able to bring together all parties related to radiation issues, such as research institutes, hospitals, nuclear-based industries and other related institutions, so that efforts can be carried out comprehensively and simultaneously.

4. Conclusion

Based on the above study, the following conclusions can be drawn: 1) controversy about the impact of radiation on health, generally leads to the impact caused by non-ionic radiation; 2) solutions for preventing ionic radiation are more directed at short times, long distances, and the use of protective equipment. Meanwhile, the solution to prevent non-ionic radiation is more directed at health education for the community.

It is further recommended that: 1) researchers conduct research on the effects of radiation on health

in an organized manner with consistent methods, so that results are obtained with minimum controversy; 2) the government organizes simultaneous and comprehensive prevention efforts, especially health education about radiation.

5. References

Pathak RK, Sinha AK, Banerjee BG, Vasishat RN, Edwin CJ. Biosocial Issues in Health. New Delhi: Northern Book Centre; 2008.

Anies. SUTET: Potensi Gangguan Kesehatan Akibat Radiasi Elektromagnetik SUTET. Jakarta: PT Elex Media Komputindo; 2006.

Anies. Cepat Tua akibat Radiasi? Jakarta: PT Elex Media Komputindo; 2009.

Harrington JM, Gill FS. Pocket Consultant Occupational Health. Oxford: Blackwell Science Ltd.; 1992.

Boel T. Dental Radiografi; Prinsip dan Teknik. Medan: USU Press; 2009.

Gabriel JF. Fisika Kedokteran. Jakarta: Penerbit Buku Kedokteran EGC; 1996.

Jeyaratnam J, Koh A. Texbook of Occupational Medicine Practice. World Scientific Publishing Co. Pte. Ltd.; 1996.

Corwin EJ. Handbook of Pathophysiology. USA: Lippincot Williams & Wilkins; 2008.

Ruwanto B. Azas-Azas Fisika. Jakarta: Yudhistira; 2007.

Rahayu I. Praktis Belajar Kimia. Jakarta: Pusat Perbukuan Departemen Pendidikan Nasional; 2009.

Kamajaya. Cerdas Belajar Fisika. Bandung: Grafindo Media Pratama; 2007.

Cree L, Rischmiller S. Science in Nursing. Australia: Elsevier Australia; 2001.

Peterson LE, Seymour A. Effect of Ionizing Radiation. Washington DC: Joseph Henry Press; 1998.

Anies. Electrical Sensitivity. Jakarta: Elex Media Komputindo; 2005.