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Physics and Its Contemporary Role in Health, Medical Sciences and its Connection to Digital Technologies and Artificial Intelligence

O.S. Ahmed

Department of Physics, College of Sciences, Qassim University, Saudi Arabia

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ABSTRACT

The present advancement of health and medical sciences has been greatly aided by the fundamental pillar of physics. It has supplied the scientific and practical underpinnings for comprehending biological events and precisely identifying and curing illnesses. Medical imaging technologies including computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, and X-rays have been made possible by the concepts of radiation and medical physics, allowing doctors to identify illnesses more quickly and accurately. By precisely controlling radiation doses and protecting healthy tissues, physics has also improved treatment techniques, especially in radiotherapy and cancer treatment. Additionally, biophysics has been essential in comprehending how organs and biological systems work, including respiratory mechanics, blood flow, and nerve signal transmission. In the current era, physics has been connected to digital technology and artificial intelligence, which has made it easier to create intelligent medical devices, physical simulation models for disease behavior prediction, and higher-quality healthcare. Therefore, physics plays a crucial role in attaining medical breakthroughs, improving the effectiveness of diagnosis and therapy, and fostering innovation in the modern health sciences.

Key words: - Health and Medical Sciences, digital technologies and artificial intelligence, Kingdom of Saudi Arabia

INTRODUCTION

The study of basic natural concepts like motion, energy, and matter is the focus of the science of physics. It has grown to be an essential component of health and medical sciences in recent decades. Physical ideas are widely used in the development of medical devices, the diagnosis and treatment of diseases, and the enhancement of healthcare quality. In the past, this integration started with the discovery of X-rays in 1895, which went on to become one of the most crucial instruments in medical diagnosis. Since then, the use of physics in medicine has developed steadily and quickly. One of the subfields of applied physics, medical physics, links physical principles and techniques to the medical domain, especially in radiation and sophisticated technology-based diagnosis and therapy. The use of physical concepts and methods in medicine to help doctors diagnose and cure illnesses as well as shield patients and healthcare personnel from radiation risks is known as medical physics. Radiation protection, nuclear medicine physics, diagnostic imaging physics, and radiotherapy physics are some of its subfields.

Research Topic: The relationship between physics, digital technologies, and artificial intelligence; how may physics be used in the health and medical sciences?

METHODOLOGY:

This study employs a review-based technique that looks at real-world applications and technology based on physical principles and assesses how physics may improve medical diagnosis and treatment.

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Research Axes:

- Medical Imaging Physics.

- Radiotherapy Physics.

- Nuclear Medicine Physics.

- Physics of Vision and the Eye.

- Physics of Hearing and the Ear.

- Radiation Protection and Health Physics.

- Applied Physics Initiatives in the Kingdom of Saudi Arabia.

-The Connection Between Physics, Digital Technologies, and Artificial Intelligence.

1- Physics of Medical Imaging:

One of the most significant uses of physics in medicine is medical imaging, which includes: •X-rays, which show the body's internal architecture.

• Three-dimensional images are produced by computed tomography (CT) scans.

• Magnetic resonance imaging (MRI), which images soft tissues using radio waves and magnets.

• Ultrasound, which creates images of the body's organs using non-ionizing sound waves.

All of these methods rely on basic physics to regulate radiation, how radiation interacts with tissues, and how signals are transformed into images that doctors may use.

The German researcher Rontgen made the discovery of X-rays in 1895. They are electromagnetic radiation with very short wavelengths and high frequencies, with wavelengths between 10−8 and 10−12 meters and corresponding frequencies between 1016 and 1020 hertz (Hz), as illustrated in fig. (1). Similar to light, radio waves, microwaves, ultraviolet, and X-rays, X-rays are electromagnetic waves.

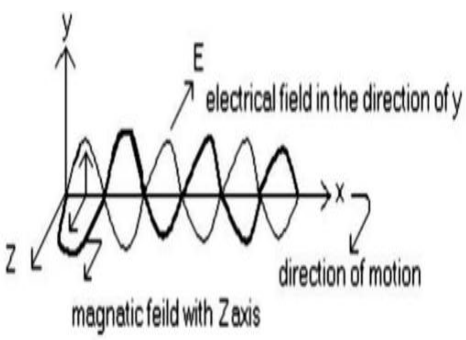

Fig. (1): electromagnetic waves

The amount of energy carried by each photon depends on the frequency of radiation:
$E = h\upsilon = h c / \lambda$
Where: h = Plank's constant = 6.6*10-34 (joule. sec), c = velocity of light= 3*108 m/sec ,

υ = frequency of radiation.

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How Do X-rays Operate? They are created when high-velocity electrons strike metal plates, absorbing the energy in the form of X-rays.

• The X-ray beam creates an image on a metal film after passing through the air and coming into touch with bodily tissues. According to fig. (2)

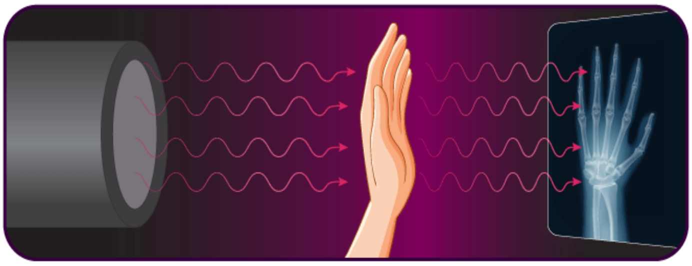

Fig. (2): X-Ray beam

Production of X-rays: When high-energy electrons collide with a heavy metal target, such as copper or tungsten, X-rays are produced. When electrons strike this substance, some of them will come close to the metal atoms' nuclei, where they will be repelled due to their opposing charges (because the nucleus is positive and electrons are negative, the electrons are drawn to the nucleus). An x-ray is created as a result of the electron's energy decreasing due to this deflection.as depicted in Figure 3

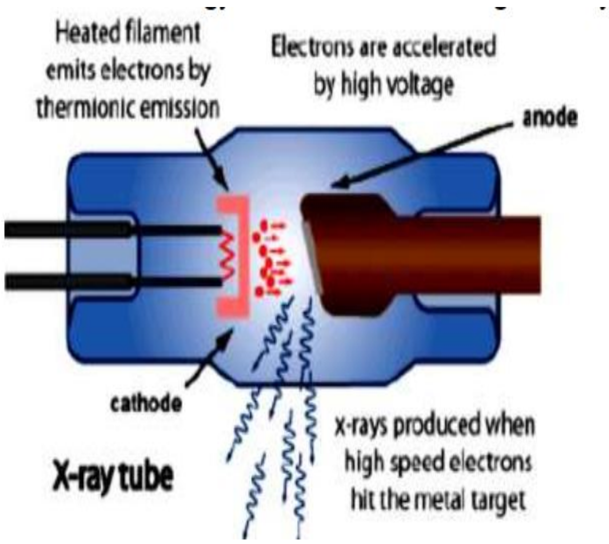

Fig. (3): X-ray production

Biological effect of an x-rays beam:-A amount of X-ray radiation that will be absorbed by biological material and has the potential to alter cells is known as the mass attenuation coefficient. According to Fig. (4)

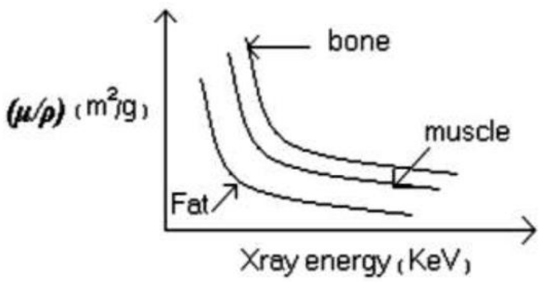

Fig.4 :X-ray energy absorbed by the biological material

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x-ray spectrum :- The range of photon energies generated in an x-ray tube as a result of the characteristics of Bremsstrahlung radiation is known as the continuous x-ray spectrum. as seen in Figure 5.

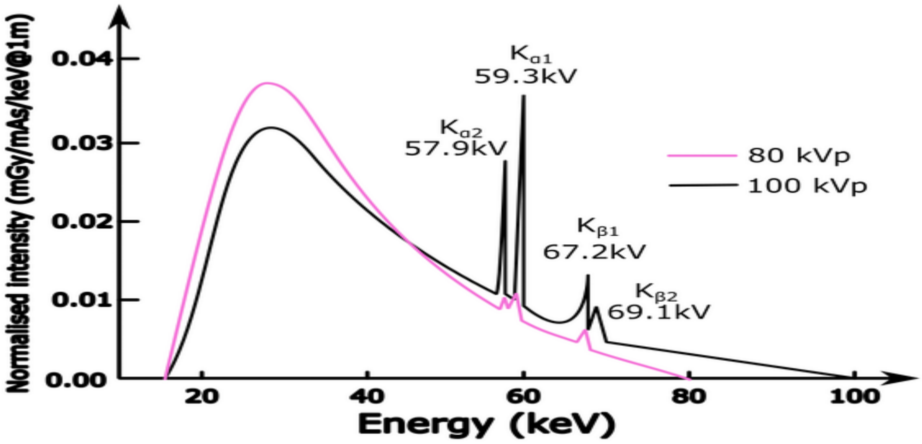

fig.5**:- x-ray spectrum**

Interaction of X-rays with matter: -

Photoelectric effect (P.E):-One of the bonded electrons is ejected from the K or L shells when a photon with energy E collides with an atom .The kinetic energy of the electron that is extracted from the atom, known as a photoelectron, is equal to the difference between the energy of the incident x-ray and the electron's binding energy. The third power of the absorbing material's atomic number (Z3) directly relates to the likelihood of the photoelectric effect and The third power of the x-ray energy (1/E)3 has an inverse relationship with the likelihood of the photoelectric effect. **as shown in fig (6)**

This equation is shown as follows:

$$Ei = Eb + EKE$$

where Ei is the energy of the incident x-ray, Eb is the electron-binding energy, and EKE is the kinetic energy of the electron.

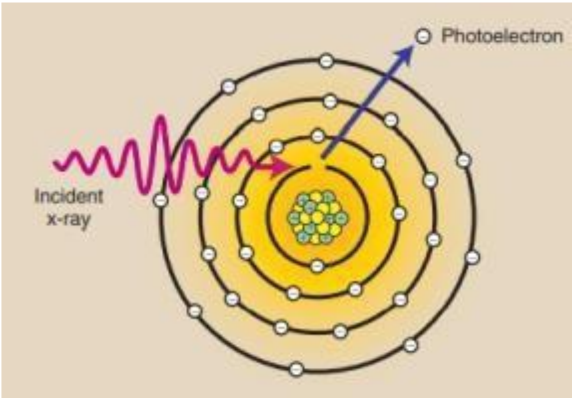

Fig (6) :- Photoelectric effect (P.E)

Compton effect (C.E) **:-** The incident x-ray interacts with an outer-shell electron in Compton scattering, ejecting it from the atom and ionizing it. A Compton electron is the term for the expelled electron. Compton scattering is a major interaction in the diagnostic energy range with soft tissue (100 keV-10 MeV), and the x-ray continues in a new direction with less energy. this energy transfer is represented as follows:

$$Ei = Es + (Eb + EKE)$$

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where Ei is energy of the incident x-ray, Es is energy of the scattered x-ray, Eb is electron binding energy, and EKE is kinetic energy of the electron. as shown in fig (7)

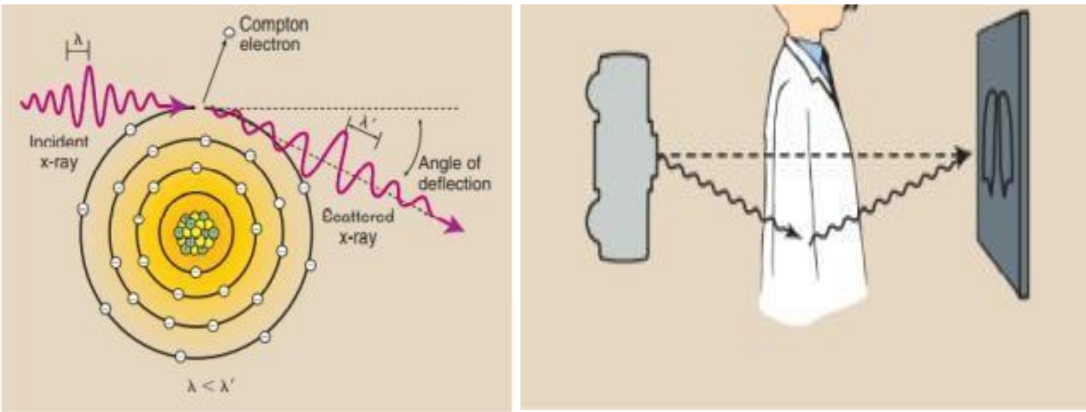

Fig (7) : Compton effect (C.E)

Pair Production :- A photon with an energy greater than 1.02 MeV may be able to avoid interacting with electrons and get close enough to the atom's nucleus to be affected by the strong nuclear field. Two electrons—one positively charged (positron) and one negatively charged—appear in lieu of the x-ray as a result of its interaction with the nuclear field. This method demonstrates how energy can be transformed into mass, as Einstein predicted. When a positron and a free electron combine, their combined mass is transformed into energy in the form of two photons, a process known as annihilation radiation. It is unimportant in x-ray imaging, but it is forms the basis for positron emission tomography imaging (PET Scan) in nuclear medicine. As shown in fig (8)

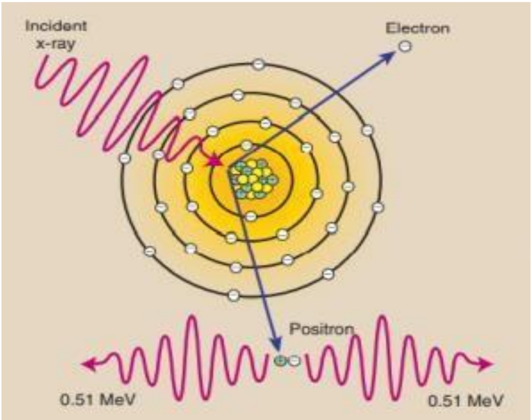

fig (8)**:-** show Pair Production

Applications:-

1. Tomography: - x-ray images of slices of the body, or body section radiography.

2. Axial tomography:- is an image of slice across the body and is taken by rotating the x-ray tube and film around the patient. useful in planning the treatment of cancer.

3. Computerized axial tomography (CAT) or Computerized tomography (CT): It`s use of a technique for analyzing data by computer. as shown in fig.9

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Fig (9)

2- Physics of Radiation Therapy

Initially, radiation therapy was employed to help in diagnosis. Radiation therapy started when high-energy radiation (megavolts) was attained. This resulted in the creation of the Betatron , which produces high-intensity X-rays that can reach deeper depths by accelerating electrons to high energies (42 MeV). As a result, malignant tumors were treated using these beams. Accurately determining the right dose is essential for radiation therapy for malignant tumors. It was discovered that doses below what is necessary do not entirely eradicate the tumor, but instead leave behind remains that allow it to proliferate and spread once more. In addition to killing the malignant tumor, excessive doses also damage nearby tissues in a healthy state. Radiation therapy's basic goal is to minimize radiation's impact on healthy tissue while maximizing its ability to kill malignancies. This is accomplished by concurrently delivering a high dose by aiming the radiation beam at the tumor from every angle. When creating the treatment strategy, it's crucial to remember that some normal tissues are more sensitive than others. X-rays and gamma rays are examples of ionizing radiation that functions by stripping atoms of their electrons, turning them into ions. Additionally, it disrupts the connections that hold molecules together, making it easier for their atoms to ionize. The sick cells whose atoms have been ionized are killed by these ions, which function as poisonous agents. The kind of radiation, the kind of cell, and the environment all have an impact on cell death. Understanding that the cell nucleus is more radiation-sensitive than the surrounding cytoplasm is also essential.

3- Nuclear Medicine Physics: Techniques that employ radioactive isotopes to diagnose and treat specific diseases, like visualizing the vital functioning of organs and utilizing radioactive tracers to pinpoint disease or tumors, rely on radiation physics. A thorough understanding of how radiation interacts with biological stuff is essential for these applications. Nuclear medicine mostly uses beta particles for treatment (since their energy is absorbed locally in tissues) and gamma rays for diagnosis (because they may enter the body).

The Use of Radioactive Isotopes in Medicine

The most popular method for diagnosis is technetium-99m (Tc-99m). Half-life: around six hours Thyroid disorders are diagnosed and treated with iodine-131 (I-131).

Positron emission tomography (PET) uses fluorine-18 (F-18).

Physical Devices in Nuclear Medicine

Gamma cameras use photomultiplier tubes (PMTs) and a scintillation crystal detector. In order to create an image, it transforms photons released by the body into electrical signals.

Three-dimensional images are produced via SPECT (Photon Emission Computed Tomography). It depends on the gamma camera rotating around the subject.

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PET (Positron Emission Tomography) uses the annihilation of an electron and a positron to produce two opposing photons with an energy of 511 keV. It is regarded as one of the most precise methods for tumor diagnosis.

Applications in Medicine: Diagnostic Uses heart function evaluation, thyroid illness diagnosis, early tumor detection, and kidney and liver function research. (Physical Advantage: Offers functional data prior to the appearance of anatomical alterations.)

Therapeutic Applications: I-131 treatment for thyroid cancer. Beta-emitting isotopes and targeted radionuclide treatment are used to treat some cancers.

4- Physics of the Eye and Vision: How lovely it is to see your road free of barriers so that you and others can go safely. This is how God uses the gift of sight to guide humanity, and it is based on three pillars: The optic nerve transmits information to the brain via millions of nerve fibers, and the visual cortex in the brain is where interpretation and actualization of the vision take place. The eye focuses images of its surroundings onto the retina. Vision loss occurs when any of these pillars are lost or when one of them malfunctions. By using glandular cleansing substances, blinking aids in eye cleanliness. We can see both close and distant objects because to the eye's accurate, quick focusing. From full daylight to total darkness at night, the eye operates with excellent efficiency in a broad range of light intensities ($10^{-}10$). The human eye has a system that controls internal pressure, keeping it at 20 mmHg to retain its form, and it opens automatically. The cornea lacks blood vessels to preserve its clarity, is translucent, and has its own cleansing agents. The eye is encased in a bony shell that serves as a shield and is supported by fatty bases that shield and absorb shocks. The brain corrects images that seem inverted on the retina so that we perceive objects upright. Stereoscopic vision is produced by the brain combining the images from each eye. We feel the same thing even if we are missing one eye. The eye may move in any direction thanks to its flexible muscles. The cornea, a transparent, clear portion in the front of the eye that is in charge of two-thirds of the focusing process, is one of the parts of the eye's focusing mechanism. Because light refracts, its focusing power remains constant.

Precise aim is made possible by the eye's flexible lens, which is supported by elastic muscles. Because of its flexibility, it can alter both its power and focal length, which modifies the focal length of the complete optical system that includes the cornea and lens. The power of the lens utilized is determined by the following relationship:

$$1/f = 1/u + 1/v$$

where v is the distance of the image from the lens, u is the distance of the viewed object from the lens, and f is the focal length of the lens.

Eye Refraction Correction Device: Light enters the patient's eye and travels to the retina. The light source is the retina. Positive or negative lenses are used to correct the light returning from the retina to the examiner's eye until it converges at infinity, or emerges from the correction lens parallel to the eye. The lens that the eye requires for correction at this time is the proper one.

5- Physics of the Ear and Hearing: Speech and hearing are two ways to communicate. Because of its extreme sensitivity, the ear can detect even the weakest sound waves. The auditory cortex, which receives auditory impulses from the auditory nerve and interprets them by the brain, the sensors that produce an action potential in the auditory nerve, and the mechanical system that influences the hair cells in the cochlea all aid the ear in the process of hearing. Deafness is the result of losing any one of these components. Even the tiniest mechanical vibrations can be transformed into electrical impulses that travel along the auditory nerve because to the ear's incredibly precise architecture.

Physics of Hearing: The oval window membrane allows the fluid inside the cochlea to receive the oscillatory motion of the stapes. The hair cells attached to the brain or auditory nerve are then stimulated. The brain receives the electrical impulses produced in this process, which give rise to the perception of hearing. A rise in pressure occurs as sound waves are transferred from the outer ear to the cochlear fluid. The cochlear base lining, which

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is a thin membrane at the intersection with the oval window membrane and thickens farther from there, is then affected by this pressure. The hearing threshold curve, which shows the relationship between sound strength and the frequency that is barely audible, is shown in Figure (10).

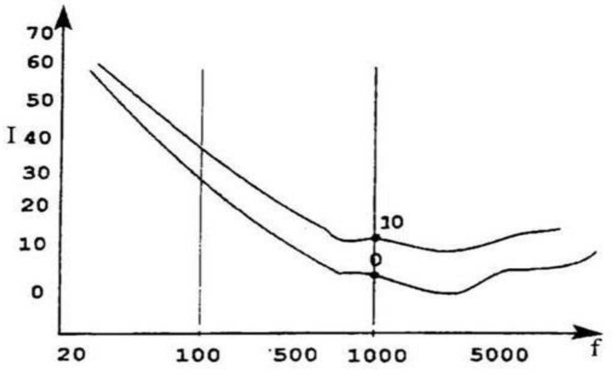

Figure (10) :- shows the relationship between sound intensity and frequency.

6- Radiation protection and health physics: intends to shield employees and patients from needless radiation exposure. It lowers hazards, encourages safety practices, and sets safe criteria for the use of radiation equipment. In order to determine dosages and guarantee adherence to international standards, this component depends on physical principles. from radiation has been present on Earth's surface from the beginning of time, all living things are destined to exist in environments that are high in radiation.Natural radiation, also known as background radiation, originates from a variety of sources, including some that are almost exclusively released by our bodies (like radioactive potassium) and a sizable portion that comes from the soil we live on and its byproducts, like structures and building materials. Geographical location on Earth's surface determines this; in regions like Brazil and India, it is higher than average. In addition to ultraviolet radiation, the Earth is shielded from a significant fraction of cosmic rays from space by the upper atmosphere. Because it contains radon gas, a member of the radioactive radium family with a half-life of 3.8 days, the air we breathe is a source of radiation. When air is inhaled, it enters the lungs and sticks to them. Because radon damages the alveolar lining, the lungs are more vulnerable to radiation than other body regions. The amount of radiation that reaches the lungs is nine times higher than what the body receives overall. The amount of radon in a building varies depending on its nature; wooden homes have half the concentration of natural homes, while concrete homes have a third. Tobacco leaves are known to cause cancer in smokers because radon particles stick to them when they dry. When X-rays and radioactive materials are used in diagnosis and treatment, medical personnel are exposed to radiation.

The Biological Effects of Ionizing Radiation. Radioactive materials, including X-rays, have detrimental biological impacts. Many people have noticed that skin exposed to X-rays turns red and may develop ulcers if the exposure is increased. As is the case with extended direct contact to radioactive elements, an increased cumulative dose over time may cause skin cancer signs, which may spread to the subcutaneous tissue. There are two categories of radiation-induced biological effects: somatic and genetic. Individuals are directly impacted by somatic symptoms, such as skin redness, ulceration, and hair loss. These rely on the radiation dosage, the affected body part, and the patient's age. The somatic effect increases with patient age. Pregnancy is the most hazardous time for somatic impacts because radiation can cause prenatal deformities. When radiation is administered to cells during the radiation treatment procedure, genetic consequences have an impact on the genetic material and future generations. As a result, when receiving radiation therapy, it is advised to cover the reproductive organs with protective masks.

Skin redness, hair loss, ulceration, lung fibrosis, tissue perforation, low white blood cell count, and cataracts are among the most common somatic adverse effects of radiation therapy.

Radiation protection devices: We require To evaluate and reduce the dangers related to radiation, a variety of radiation measurement tools are employed. Personal monitors are those used by individuals, and their main purpose is radiation detection. Additionally, there are larger monitors known as area monitors and portable monitors. These devices' sensitivity to radiation—more especially, the ionization of the medium—is the basic

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idea underlying their construction. Certain devices function by altering the film's color, while others do so by rupturing molecular bonds or storing energy in a solid crystal that is then released as phosphorescence. Certain gadgets function by changing the electrical conductivity, Others measure how radiation alters the color of the device's screen or elevates the temperature of the medium it passes through. X-ray radiation is detected by an electrostatic detector. It is referred to as an ionization chamber since its two plates are separated. It is used to detect high-level radiation, specifically in the range of 0.0 to 1.5 Röntgen/hour, and is capable of detecting gamma, beta, and X-ray radiation. Radiation workers utilize signal counters because they are easy to use, reasonably priced, and offer a good record of the radiation doses they get. They are employed in the detection of X, beta, and gamma radiation. The fact that this gadget records lower dosages of X-rays (sensitive film) than stronger gamma rays is one of its drawbacks.

Radiation protection in diagnostic radiology: X-rays are the most common type of diagnostic radiology and are used to assist diagnose illness. By using materials that absorb weak radiation—which, if it reaches a patient's body, is absorbed and does not aid in diagnosis because of its weakness—the amount needed can be decreased without compromising the necessary information. The half value can be used to calculate these filters. Additionally, the exposure time is shortened by employing high-sensitivity, high-quality films. By modifying the ratio of the X-ray beam's cross-sectional area to the film's cross-sectional area so that it does not exceed one, X-ray exposure can be decreased. Similarly, the area of the patient's body exposed to X-rays should not be greater than the product of the retinoid dose and the cross-sectional area of the beam utilized (in centimeters squared). Using skilled professionals with a great deal of experience in operating, maintaining, and modifying the machine can also reduce the number of X-ray exposures under the same conditions (for imaging purposes), hence removing the need for repeat imaging. This is made easier by keeping an archive of each patient's films, which eliminates the need for reimaging in the event that a film is lost. Because of the sensitivity of the fetus and the possibility of deformity, it is especially crucial for pregnant women to utilize protective shielding to assist prevent unwanted radiation exposure, especially around and in the reproductive organs and eyes. Pregnant women should only have X-rays when absolutely required, utilizing all available shielding measures that provide the maximum level of safety. The 10-day rule, which permits imaging within 10 days of the latest menstrual cycle, can be adhered to if pregnancy is suspected. It has been discovered that using X-rays excessively and deviating from the previously specified rules results in higher radiation doses for the patient, which impairs image clarity and reduces diagnostic information. Increased radiation exposure and blurry images are the results of this image distortion. The intensity and intensity of modern X-ray machines are automatically adjusted, but any malfunction could expose the patient to too much radiation. The machine needs to be equipped with a dosimeter known as a rapmeter, and it is crucial to monitor, maintain, and overhaul it. Protection from radiation when receiving treatment: Since intense radiation is utilized in therapy, its sources are stored in totally isolated enclosures so that, when not in use, all of the radiation they emit is entirely absorbed.Additionally, every safety measure is taken during the procedure to guarantee that the precise patient receives the calculated and necessary dose at the specified place and that no one else does. During an operation, no one is allowed to enter the treatment room. The opening mechanism is made to stop the treatment machine right away if the room is opened to let people in. The sources themselves need to have adequate insulation. We use the absorption equation to determine the thickness of the shielding material needed for radiation protection:

$$I = I_0 e^{(-\mu x)}$$

where I is the radiation intensity exiting the shielding material of thickness X, I_0 is the initial radiation intensity, and μ is the linear absorption coefficient.

Radiation Protection in Nuclear Medicine: The following guidelines must be followed by nuclear medicine practitioners:

1. Take medication with the recommended radiation dosage.

2. Make use of the proper dosages of radiopharmaceuticals. Calibration is crucial for a 99m -Tc source.

3. Giving the right radiopharmaceutical dosage to the right patient while preventing mistakes.

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4. Using standard tests using gamma cameras or line scanners to make sure radiation measurement equipment is operating flawlessly. Radiation shielding is particular to gamma rays with strong penetrating strength because the majority of radioactive materials employed release gamma rays. In contrast, beta-emitting sources are absorbed within a few millimeters of the targeted region. Investigating radioactive mishaps and attempting to mitigate their effects are other aspects of radiation protection. [1-10]

7- Applied Physics Initiatives in Medical and Health Sciences in the Kingdom of Saudi Arabia: [11-13]

Through direct applications in diagnosis, treatment, and scientific innovation, physics plays a crucial role in the development of healthcare and medical research in Saudi Arabia. This is in line with the Kingdom's Vision 2030, which aims to promote science and technology and raise the standard of healthcare services.
1. The Saudi Society for Medical Physics (SMPS) was founded in 2006 under the umbrella of the Saudi Commission for Health Specialties with the intention of advancing professional practices and strengthening the role of physics in healthcare.

• The "Saudi Board" program in medical physics has been accredited in the areas of diagnostic and therapeutic radiography, improving the professional credentials and academic standing of experts in this sector.

• The planning of professional seminars, workshops, and conferences, such the Annual Medical Physics Conference in Jeddah , First seminars about medical physics careers.

2. University education and awareness programs. World Medical Physics Day Events

A. Jazan University hosted a celebration of World Medical Physics Day at the University College in Darb. In addition to an interactive display on gadgets like MRIs and diagnostic tools, the event featured basic lectures on radiation safety and the application of medical physics to treat illnesses. In order to emphasize the relationship between medical physics and clinical applications, such as nuclear medicine physics and radiation protection equipment requirements, the Jazan University Physics Department staged similar festivities.

B. Lectures and Training Workshops:To connect physical ideas to contemporary medical applications, Umm Al-Qura University's College of Applied Sciences hosted lectures and awareness workshops on medical physics and radiography.

3- Research and Development in Universities

Advanced Research Groups: The Department of Physics and Astronomy at King Saud University has a Physics and Biomedical Technology Group. In order to create better healthcare technology, this group carries out applied research in radiation biophysics, biosensors, and medical imaging.

4. Clinical Applications in Major Hospitals:-King Faisal Specialist Hospital's Biomedical Physics Department: The hospital's Biomedical Physics Department was founded in 1985 and focuses on advanced clinical applications, such as monitoring the quality of radiological imaging and radiotherapy systems, training medical professionals and technicians, and ensuring the safe and efficient use of radiation in diagnosis and treatment.

5. Collaboration and Innovation (Advanced Medical Technology)

Workshops on Regulation and Technology: King Abdullah University of Science and Technology (KAUST) and the Saudi Food and Drug Authority organized a workshop to talk about the future of medical technology, including the regulation of AI-enabled devices and the creation of cutting-edge diagnostic tools like wearable biosensors and PCR technologies. - Local radioisotope discovery and production: The King Faisal Specialist Hospital & Research Centre is a major producer of radiopharmaceuticals used in diagnosis and therapy, including significant varieties like iodine-123, gallium-67, and lutetium-177. Creating national guidelines for dose and protection: The Saudi Food and Drug Authority (SFDA) has added nuclear medicine to the list of National Reference Dose Levels (NDRLs).

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8- The Connection Between Physics, Digital Technologies, and Artificial Intelligence :- [14-15]

Modern physics has advanced significantly as a result of advances in digital technologies and artificial intelligence (AI). Many scientific, medical, and engineering domains are undergoing revolutionary change as a result of the integration of physical principles with sophisticated software. A deeper comprehension of intricate natural phenomena, better medical diagnosis and treatment, and the creation of cutting-edge technologies in engineering, the environment, and energy are all made possible by the convergence of physics, digital technologies, and artificial intelligence. This link implies that physics will be merged with digital analysis and intelligent computers in the future rather than being restricted to conventional theories and experiments.

1. Digital Physics

Digital physics is the use of computers and digital models to accurately replicate physical processes, such as the movement of molecules, the study of energy and heat, and the analysis of waves and light.

• One example in medicine is the simulation of blood flow in arteries to forecast the effects of medications or surgical procedures before they are actually administered.

2. Physics and Artificial Intelligence

Artificial intelligence uses artificial neural networks and machine learning to assess vast amounts of physical data and make decisions far more quickly than conventional techniques. • Medical example: Using AI algorithms to more accurately identify cancers or anomalies in medical pictures (CT, MRI, X-rays).

• Engineering example: Using AI-based models to improve device design or forecast the behavior of novel materials.

3. Advantages of Integration

• Improved experimental accuracy: Errors can be decreased by simulating physical experiments before they are carried out.

• Accelerated scientific research: It is possible to process large amounts of data rapidly and effectively.

• Innovation in new technology, such as environmental monitoring tools, surgical robots, and intelligent medical imaging gadgets.

4. Useful Applications

• Modern medicine: AI accurately locates tumor regions and enhances radiography image quality.

• Nuclear physics and energy: creating safer and more effective energy sources by simulating nuclear reactions.

• Environmental fields: Using AI-powered physical models to forecast the spread of radioactive or airborne pollutants.

Scientific studies and research:[16-20]

The establishment of national diagnostic reference levels for adult pectct in saudi arabia :- this study aims to introduce national diagnostic reference levels (ndrls) for adult hybrid single photon emission computed tomography in nuclear medicine (nm) departments in the kingdom of saudi arabia. the administered activity (aa) of radiopharmaceuticals, volume-weighted computed tomography dose index (ctdivol) and dose length product (dlp) for ten hybrid spect/ct examinations were collected and analysed for one year. the median of aa, ctdivoland dlp for each dose quantity was derived and the suggested national drls were determined based on the 75thpercentile for all identified spect-ct examinations. a comparison of the defined adult ndrls in saudi arabia with the published data of other countries was performed. although there are no significant variations of the

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proposed ndrl of aa between countries, the proposed ndrls of the integrated ct metrics exceed the published data in most procedures. nm departments are urged to consider optimisation for both image quality and radiation protection.

occupational dose assessment for nuclear medicine technologists in saudi arabia: this study estimated the occupational radiation dose received by nuclear medicine and radiotherapy technologists in saudi arabia. a retrospective analysis of personal dosemetry data of 1243 nuclear medicine and radiotherapy technologists from 28 medical centers across saudi arabia from 2015 to 2019 was conducted. thermoluminescent dosemeters were employed to monitor the occupational radiation dose. for the study period, the average annual values for nuclear medicine and radiotherapy technologists were found to be 1.22 msv (sd = 1.00 msv) and 0.73 msv (sd = 0.40 msv) for hp(10) and 1.23 msv (sd = 1.07 msv) and 0.72 msv (sd = 0.41 msv) for hp(0.07), respectively. the work routines of nuclear medicine technologists cause them to be exposed to higher radiation doses than radiotherapy technologists. the occupational doses for all technologists were found to be below the annual dose limits, which indicates satisfactory working conditions in terms of radiation protection.

3- **Assessment of external occupational dose of phosphate mine workers in saudi arabia** using thermoluminescent dosemeters" workers in the mining industry face the problem of radiation exposure from naturally occurring radioactive materials. thus, this study aimed to estimate a hp (10) doses for mine workers in the phosphate mining industry in saudi arabia. the personal dose equivalent [hp (10)] of 606 mine workers in the phosphate mining industry in saudi arabia were obtained from 2016 to 2019 using thermoluminescent dosemeters (TLDS). the results showed that the annual mean hp (10) of all mine workers averaged over the study period was 0.66 msv (sd = 0.45), which is within the range of occupational doses reported worldwide. most of the hp (10) were <0.49 msv, and the maximum hp (10) was 3.55 msv. nonetheless, internal exposure should be evaluated along with external exposure to estimate a comprehensive baseline occupational dose for mine workers in the phosphate mining industry in saudi arabia.

4- **a 5-year retrospective analysis of ionizing radiation dose to hybrid operating room personnel in saudi arabia**"the annual average effective dose (ed) for operating room personnel (orp) in saudi arabia was estimated from the period of 2015-2019 using thermoluminescent dosemeters. a retrospective analysis was conducted on annual eds for 7530 orp working across 52 hospitals. these workers were only exposed to radiation in the operating room. the annual average ed over the period of 5 years was found to be 0.59 msv with no incidence of a dose above the annual dose limit of 20 msv. the maximum annual ed reported was 15 msv for an operating room worker in 2019. more than 88% of the workers received an annual ed of <1 msv. the study concluded that the work environment in hybrid operating rooms across saudi arabia is safe. however, it is always recommended that workers take every protective measure when dealing with ionization radiation.

5-**The role of artificial intelligence in medical imaging research** "without doubt, artificial intelligence (AI) is the most discussed topic today in medical imaging research, both in diagnostic and therapeutic. for diagnostic imaging alone, the number of publications on AI has increased from about 100–150 per year in 2007–2008 to 1000–1100 per year in 2017–2018. researchers have applied AI to automatically recognizing complex patterns in imaging data and providing quantitative assessments of radiographic characteristics. in radiation oncology, AI has been applied on different image modalities that are used at different stages of the treatment. *i.e*. tumor delineation and treatment assessment. radiomics, the extraction of a large number of image features from radiation images with a high-throughput approach, is one of the most popular research topics today in medical imaging research. AI is the essential boosting power of processing massive number of medical images and therefore uncovers disease characteristics that fail to be appreciated by the naked eyes. the objectives of this paper are to review the history of AI in medical imaging research, the current role, the challenges need to be resolved before AI can be adopted widely in the clinic, and the potential future.

RESULTS: -

1. Improved Diagnostic Precision

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The findings demonstrated that using digital algorithms and artificial intelligence (AI) in conjunction with physical principles in medical imaging techniques (such as MRI, CT, and nuclear imaging) has significantly improved diagnostic accuracy, decreased human error, and accelerated disease detection.

2. Enhanced Efficiency and Customization of Treatment

Particularly in radiotherapy and proton therapy, where radiation doses are determined with extreme precision using digital physical models backed by machine learning algorithms, the combination of medical physics and AI has helped to develop targeted and customized treatments for patients.

3. Decreased Health Risks and Radiation Doses

The findings showed that employing AI and digital physical modeling approaches helps lower needless radiation exposure while preserving the quality of medical imaging, improving patient and healthcare worker safety.

4. Quicker Big Data Analysis

AI built on physical principles has made it possible to analyze vast volumes of medical data quickly and effectively, assisting medical decision-making and helping with physiological pattern analysis and disease prediction. 5. Enhancing Clinical Response and Health Monitoring Systems

5. The findings demonstrated that the creation of continuous and precise health monitoring systems that can identify crucial key changes in real time was aided by the integration of smart physical sensors with digital technologies and artificial intelligence.

6. Encouraging Smart Medical Device Innovation

The findings showed that physics is essential to the design of smart medical devices based on digital simulation and physical modeling, which improves performance, lowers costs, and boosts reliability.

7. Encouraging Multidisciplinary Medical Research

The findings demonstrated how the combination of digital technology, artificial intelligence, and physics opened up new avenues for multidisciplinary scientific research and connected fundamental science with practical medical applications.

RECOMMENDATIONS:

1.To improve the credentials of professional staff, colleges and hospitals should provide advanced medical physics education and training programs.

2. To guarantee the most effective and secure use of medical technology, physicists and doctors should work together more closely.

3. Make scientific research investments to advance medical technologies, such as the application of AI in image analysis and treatment planning.

4. Create regulations to advance medical physics and safely and successfully incorporate it into healthcare teams.

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