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A Detail Review on Digital Health Technologies

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Abstract: ***The term "digital health technology" describes the application of technology, including telemedicine, m-health, and e-health, to diagnose and enhance healthcare. Plenty of research and advancements in technology have been conducted to enhance and advance the field. Digital health technologies are frequently used in the pharmaceutical industry at different stages of medication design, data analysis for clinical trials, etc. Research and inquiries in the disciplines of biotechnology and bioengineering are increasingly concentrating on technology and healthcare. The study analyzes aspects of the digital ecosystem, digital health, and innovation pertinent to the healthcare industry. By fusing information technology and health services, digital health technology has completely transformed the healthcare sector.***

I. INTRODUCTION

Digital health, often known as digital healthcare, is a broad, multidisciplinary idea that encompasses ideas from the point where technology and healthcare converge. By integrating software, hardware, and services, digital health brings digital transformation to the healthcare industry. Wearable technology, telemedicine, which electronic health records, mobile health apps, and personalized devices are numerous instances of digital health technology.

"Application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of health" is how the World Health Organization, or WHO, describes digital health technology. Improvements in patient care, disease management, and operational effectiveness within healthcare systems have benefited from the integration of these technologies. With an emphasis on how digital health technology is influencing the future of healthcare, this seeks to explore the development, significance, difficulties, and prospects of this field.

II. TELEMEDICINE

The American Telemedicine Association defines telemedicine as the "natural evolution of healthcare in the digital world" (1). According to the World Health Organization, "the delivery of healthcare, where distance is a critical factor, by all medical professionals using information and communications technology for the exchange of valid information for the diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the ongoing training of health care providers, all in the best interest of advancing the health of individuals and communities" is commonly referred to as telemedicine (2). The practice of using communication networks to treat and diagnose patients virtually from any location in the world is known as telemedicine. Telemedicine is being used by more individuals as payers become aware of the reduced cost of care, doctors become aware of its benefits, and patients (3)

A. The Evolution of Telemedicine

In remote locations with limited access to healthcare, telemedicine gained popularity as a means for people to consult specialists remotely. The U.S. Department of Health and Human Services, NASA, the Public Health Department, and the Department of Defense all devoted time and resources to telemedicine research in the 1960s and 1970s. The collaboration between NASA and the Indian Health Services was one of these government initiatives that was the most successful. Under the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project, medical care was made available to astronauts in orbit as well as Native Americans living on the Papago Reservation in Arizona. Electrocardiographs, X-ray pictures, and other medical data were transferred to and from the Public Health Service hospital via microwave technology. Clinicians from the University of Nebraska were the first to employ video communication for medical purposes.

B. Historical Outlook

The benefit of telemedicine is its long-distance medical data transfer capability. Electrocardiogram transmission over telephone lines was the first documented use of telemedicine in a published paper during the first decade of the twentieth century (1).

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The Apollo Hospital in the Andhra Pradesh village of Aragonda in the Chittoor District created the country's first telemedicine program. Through telemedicine, it was connected to Apollo Hospital in Chennai. A few notable instances of the successful use of telemedicine services in India are mammography services at Sri Ganga Ram Hospital in Delhi, oncology at Regional Cancer Center in Trivandrum, and surgical services at Sanjay Gandhi Postgraduate Institute of Medical Sciences in Lucknow (4).

C. *Advantages*

1) Less time spent around sick people.
2) A more efficient and timely commute.
3) Increased seclusion.
4) Simpler follow-up with patients.
5) Adjustable work schedules.
6) Improved availability of specialized medical advice.
7) Potential approaches to catastrophe management.
8) Accurate analysis utilizing data that has been stored**.**

D. *Drawbacks*

1) Insufficient proof. The effectiveness of telemedicine is not well supported by the available data.
2) An absence of rules. The practice of telemedicine is not subject to any regulations.
3) Privacy and security issues.
4) Technical difficulties.
5) Restricted availability.
6) Unequal accessibility.
7) Geographical obstacles.
8) Differing time zones

E. *Application*

1) *Tele-Education:* Using telecommunication technologies, distance learning is feasible. It is also very adaptable and interactive. A flexible and captivating online learning program that provides more convenient instruction and updates on the latest advancements for more accurate and effective treatment techniques Initial foremost
2) *Tele-Home Healthcare:* Telemedicine technology may be employed to provide in-home care for elderly or underprivileged patients who are confined to their homes because of long-term medical issues. Instead of having to drive great distances to check on recuperating or chronically ill patients, it allows home healthcare providers to monitor patients from one central place. Remote patient monitoring provides a more economical and timely alternative (1)
3) *Remote skin treatment (Tele dermatology):* TLM may assist people who struggle with skin conditions. Skin disorders are determined by a combination of medical history, physical exam, and biopsy. When treating issues with the skin via telemedicine, color photos with high resolution should be provided from the site of the complication. The biopsy can be mailed to a specialized facility. Furthermore, for many ailments, patients and professionals do not need to interact in real time. (5)
4) *Remote Consultation:* Telehealth can be employed for promotion, prevention, and long-distance medical service delivery. A consultation or follow-up could be the format. The issue of providing healthcare at sizable Indian gatherings has also been tackled with telemedicine. For example, during Maha Kumbha melas, the Uttar Pradesh government uses mobile telemedicine vans that are outfitted with videoconferencing systems to facilitate visual communication. For expert counsel, this allows doctors who are located in remote areas to connect with any hospital that provides telemedicine services, even super specialized facilities. Sixth (6)

III. E-HEALTH

In the health care sector, where demand for services grows due to an aging population and an influx of new ailments, digitization has proven especially difficult. Therefore, funding for novel therapies is required to ensure that everyone has equitable access to the healthcare system (6,7,8). E-health refers to medical treatments like mobile health and telehealth that use electronic devices to deliver healthcare information, resources, and services (9). Electronic health records (EHRs) or online prescriptions is known as e-health.

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A nation's ability to implement e-health is contingent upon a number of elements, such as user acceptance and the kinds of systems, infrastructure, and management that are being used (10,11). The expression "mobile health," or "m health," encompasses the use of mobile devices by patients to manage or monitor treatment or challenges or other health-related issues, use apps to verify information, and electronically demand services (12).

E-health strategies, that involve the creation of norms, laws, or regulations, must be executed in an integrated manner in order to effectively regulate the use of information technologies in healthcare. This is true regardless of the domain—telehealth, mobile health, or specific domains like e-health (learning in health) or electronic medical records. (13, 14). The three major parts of an e-health strategy are policies, equipment and processes, and knowledge management. (15).

Review:

A. History of eHealth

In the past, medical professionals kept paper records detailing the medical history and current condition of their patients. However, the development of electronic tracking systems has been driven by the rise in health care costs and technical improvement. Therefore, the term "digital health," also known as "eHealth," came into being to refer to the application of information and communication technologies (ICT) in the healthcare industry. The field of eHealth is a developing area at the intersection of public health, business, and medical informatics, and it describes the health services and information that are enhanced or distributed via the internet and related technologies.

B. Application

1) Digital health interventions (DHIs), like aided therapy, have been demonstrated to be successful in treating mental health issues in children and adolescents using e-health.
2) Mental disorders, various diseases (diabetes mellitus 1 and 2), stress, depression, and anxiety, cancer, eating disorders, chronic sickness, cardiovascular diseases, and sexually transmitted diseases (STDs) are the most prevalent diseases that are treated. We found the following nations where research has been carried out in relation to those that presently use e-health: Countries: United States, Canada, Australia, Germany, Africa, Sub-Saharan Africa, Netherlands, Sweden, Switzerland, China, Italy, Greece, Finland, Iran, Iraq, Bangladesh, Pakistan, Saudi Arabia, United Kingdom, Spain, France, Italy, and Portugal. (16)
3) E-health enables users to share text, video, and other types of data with healthcare providers in person as well as view medical records, do health information research, and connect with them via email.
4) Strengthening and endorsing the application of ICT (information and communication technologies) to the advancement of health.
5) Creating plans and schedules for assessments to assist member states in choosing, accepting, adjusting to, and valuing Health explanations in order to bolster deserving decisions about investment and governance.
6) Encouraging and assisting Member States in integrating e-health solutions into their national e-health policies by means of a coordinated multi-sectoral and multi-stakeholder approach.
7) Tracking and disseminating information on trends and advancements in digital public health to inform national policies and practices and to regularly report on the usage of e-Health in the Region.

C. Advantages

1) Making patient records quickly accessible to promote better organized and effective care.
2) Safely exchanging digital data with patients and other medical professionals.
3) Assisting healthcare professionals in safer patient care, medical error reduction, and more accurate patient diagnosis.
4) Enhancing convenience of health care as well as interactions and communication between patients and providers.
5) Making prescribing safer and more dependable.
6) Supporting the promotion of clear, comprehensive documentation as well as precise, efficient coding and billing.
7) Improving patient data security and privacy.
8) Assisting providers in enhancing work-life balance and productivity.
9) Making it possible for providers to increase productivity and accomplish their objectives.
10) Cutting expenses by reducing paperwork and promoting better health, safety, and fewer tests.
11) Providing complete, accurate, and current patient data at the time of care.

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D. Its drawbacks are

1) Opposition from physicians who feel they are losing control over the medical procedure.
2) A possible drop in income for medical service providers.
3) Insufficient high-quality scientific research on the effects of e-health

IV. GENOMICS

1) What are Genetics and Genomics?

The study of genes and how they affect heredity is known as genetics. Examples of single-gene illnesses that fall under the category of "Genetics" are PKU (phenyl ketonuria) and cysticercosis. (17) Because complex diseases like cancer, diabetes, asthma, and heart disease are more often caused by a combination of hereditary and environmental factors, scientists studying genomics research these conditions. (18) Gaining knowledge of the connections between these variables at the population level may open up fresh possibilities for intervention and prevention.(19).

2) Why is genetics and genomics important to our health?

Health and illness are influenced by both genomes and genetics. Understanding why some people become ill from specific illnesses, environmental variables, and behaviors while others do not is made easier with the use of genomics. The secret to these variations lies in genomics. (20) Humans share 99.9% of their genetic makeup with each other. Variations in the remaining 0.1% provide crucial hints on the origins of illnesses. Our ability to prevent and improve health is being enhanced by our growing understanding of the ways that genes and the environment interact.

3) Why Is Genetic And Genomic Important To Our Family's Health

For illnesses that have a genetic or genomic origin, family history is a valuable tailored tool that captures many of the gene/environment interactions. (22) The foundation for understanding genetic and genomic circumstances in family and individual disease prevention can be found in the family history. (23)

4) Impact Of Gene Regulation On Health And Disease

Their particular area of study is how regulation has evolved over the course of millions of years of human evolution. In order to achieve this, they fused two techniques from genome research: population genetics and the search for single nucleotide polymorphisms (SNPS), which can indicate the proper expression of genes. Using this approach, researchers can find genetic variants that can lead to human disease in addition to studying gene regulation (24). Sections of the genetic molecule DNA called genes are what carry the instructions for making proteins, which are the fundamental units and molecular machinery of life (25). 3,2 billion nucleotides are found in one molecule of DNA. However, the nucleotide sequence varies from person to person in the human race. Adenine (A) nucleotides, for instance, can be found in one person but cytosine (C) nucleotides can be found in another at the same location (26). It is estimated by researchers that there are eleven million single nucleotide variations, or SNPs, in the human genome. Finding these SNPs and learning more about how they affect health and illness is their goal. Mutation is the key to human variety (27). Lastly, if a mutation disrupts a vital bodily function, it may directly cause illness (28).

5) Genetics, Genomics and Patient Management

In addition to praising the value of genomics, the 2002 World Health Organization study on genomics and global health also raised concerns about a potential "genomic divide," which would make it more difficult for developing nations to benefit from genomic research and exacerbate existing disparities in health around the world. (29). By linking genotypes to phenotypes, detecting predisposing genetic variation (disease susceptibility) early, improving diagnostic techniques, improving disease prevention and treatment, and avoiding drug side effects, personalized medicine has the potential to revolutionize the health care industry. (30)

V. IMAGING IN HEALTHCARE

The term "medical imaging" describes the methods and procedures used to produce images of the human body (or portions of it) for a range of clinical applications, including diagnosis and treatment, as well as medical scientific applications including the examination of normal anatomy and function. It falls under the larger category of biological imaging, which also includes microscopy, radiography, endoscopy, thermography, and medical photography.

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While not intended to create images per se, measurement and recording methods like magnetoencephalography (MEG) and electroencephalography (EEG) might be considered medical imaging since they generate data that can be displayed as maps.
Within the clinical setting, radiology or "clinical imaging" is typically used interchangeably with medical imaging. The application and interpretation of medical imaging research is often.
The preservation of radiography and the medical subdiscipline pertinent to the illness or field of study in medicine (psychiatry, neuroscience, cardiology, psychology, etc.). Numerous methods created for medical imaging have further uses in science and business. Before computed tomography (CT) for X-ray imaging, which led to computer-aided tomography (CAT), and isotope emission tomography, which led to PET and single Positron Emission Computed Tomography (SPECT) scans, there was little significance in biomedical work. After that, magnetic resonance imaging (MRI) dominated the other modalities in many ways as the most informative medical imaging methodology (31).
A number of methods have been developed to allow 3D images to be produced for doctors to use with CT, MRI, and ultrasound scanning software. In the past, CT and MRI scans gave 2D static output on film. Several scans were then done to construct a 3D model, which a doctor could edit, to make 3D images.
Overview:
Biological imaging, which has been around since the 19th century, includes medical imaging. Here is a quick rundown of medical imaging. Although more intriguing, MRIs, ultrasounds, and X-rays continued to rule the 21st century.
Both macroscopic and microscopic biological structures are being studied using tools, particularly imaging (thermal imaging, electrical impedance tomography, scanning probe techniques etc).
In the future, getting functional and metabolic data in addition to structural (image) data will be more important. To some extent, magnetic resonance spectroscopy (32) and radioactive tracers (such PET) can be used for this.

VI. TECHNIQUES AND APPLICATIONS

The development of image, visualization, and graphics workstation technologies has sparked a variety of new medical imaging procedures and methods. The use of wavelet transformations in medical imaging, image segmentation, and virtual medical imaging subsystems are among the most crucial ones.
Medical image creation and capture techniques:

A. Wavelet Transform Technology Application

The wavelet transform has multi-resolution and multi-scale properties. All that occurs in scaling is "stretching" and "compressing." We confine ourselves to utilize discrete wavelet transform (DWT) and binary scaling (33).

1) Differential threshold, slope, areas, and other methods were the main methods used in the past to detect QRS waves; however, in circumstances where interference is severe, these methods have a higher error rate. Bradie (34) suggests condensing the signal lead ECG using wavelet packages. The differential threshold, slope, areas, and other methods that were previously the major methods used to detect QRS waves have a higher error rate when there is substantial interference. Bradie suggests condensing the signal lead ECG using wavelet packages.
2) The primary tool used for assessing diseases and symptoms in the nervous system, particularly epilepsy, is the EEG signal. Kalayic (36). Wavelet transform can be used to identify EEG spikes. Zhou Weidong (n = 37). Examine the methods for identifying and denoising EEG signal singularity based on the dyadic WT modulus maxima. The de-noising approach is capable of eliminating noise while preserving the original EEG singularity.
3) Wavelet packet transform is one of the most recent and highly promising approaches to appear in the field of WT-based picture compression algorithms (38, 39). The ideal design parameters for a data compression strategy applied to medical images of various imaging modalities are found by A. S. Tolba (40). The suggested approach seeks to preserve diagnostic integrity while lowering the cost of transmission.

B. Segmentation of medical images (using LEGION method)

Segmenting binary and grey-level images has shown to be a successful use of LEGION, a computational paradigm for image analysis that Terman and Wang (41, 42) described as biologically plausible.⇒Medical image repository and image categorization:

1) Generic Medical Image Repository with COTS Similarity:

Data Access Layer (DAL)-based generic storage component is referred to as a "Medical Image Repository" (43).
COTS product is defined by the evaluation process for COTS software products as

- one that is maintained and developed by the vendor, who is still the owner of the intellectual property.
- Acquired in numerous, exact replicas.
- Employed with no internal system adjustments.
- Made available by a seller hoping to make a profit.
- Made available to the general public by sales, renting, or licenses.

Explains additional requirements that are generally included in any COTS-like component in addition to the ones that were previously mentioned. Among these requirements are:

Interoperability: It defines Information Objects, which are abstractions of
real information entities such as CT Image, MR Image etc.

Diversity in requirements: A generic medical image repository must
satisfy the following criteria:

Support for multiple modalities.

Different information models.

Versatility

Usability

Effectiveness

Dependability

Portability

2) In the online CISMeF health catalogue, the content-based automatic medical envision classification techniques are highlighted in ref. (44). The recommended feature representation/transformation technique is similar to Vector Quantification (VQ), in which the prototype blocks' indexes are used to label pixel blocks (44).

3) Web-based interactive applications of high-resolution 3D medical image data:

The amount of medical image data that needs to be shared on the Internet for computerized visualization and analysis is steadily increasing. These data sizes, which can range from several hundred megabytes to several dozen gigabytes (45), put a significant strain on networks and storage systems and provide numerous difficulties for developers of Web-based interactive applications. Web-based interactive applications are restricted to low- or medium-resolution image data due to limitations in Internet speed, which are frequently insufficient for dependable use in clinical diagnostics.

A software package (standalone system) called MACOSTAT has been created by Gustafson et al. for the building and browsing of 3D brain atlases (46).

◊ Data storage structure:

- Creating buckets out of the entire high-resolution 3D image data.
- Any known lossless or lossy compression technique can be used to compress or decompress each data bucket, which is a small portion of the entire 3D picture data set method (47), based on the application in question.
- Disk space is allotted to the data buckets in Hilbert curve order to aid in disk access optimization. The Hilbert curve is a linear order to visit each data bucket in the three-dimensional space exactly once. It is a space filling approach that transforms a multi-dimensional data space into a one-dimensional data space.

VII. M-HEALTH

A. Patient Follow-Up And Medication Adherence

Among the review's findings (n = 19), actions to enhance patient lifestyle and medication adherence, as well as therapy follow-up, were the most prevalent. Six studies reported on the outcomes of pilot projects aimed at informing birth outcomes (48), reporting side effects from medications, monitoring TB patients (49), observing behavioral changes in diabetic patients (50), and identifying pregnant women in need of antenatal care and referral services (51). RCT studies were also frequently conducted on this subject (n =8), with findings on patient adherence, ART monitoring, and competent de-livery attendance reported (52, 53). These projects made use of phone calls, SMS, and multimedia communications (MMS).

Additional discoveries comprised two mixed-methods studies, one for supporting patients with breast cancer during their oncological treatment (55), and an additional to monitor adherence to treatment and care provided by caregivers of HIV-infected children. The cross-sectional study examined the feasibility of using mobile phones to remind patients regarding their medications and appointments in an anti- Retroviral treatment (ART) health facility.

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The review investigated the effectiveness of SMS on patient adherence to ART.

B. Advantages

1) Reduction in health spending.
2) Healthy population.
3) Adoption of existing mHealth services.
4) Enforcement of policies.
5) IP & investment opportunities.
6) Opportunities for Research and Development.
7) Demonstrates commitment to achieving NCD reduction targets.
8) Positions the country as a leader in NCD innovations.

C. Disadvantages

Data Privacy: The health applications constantly gather and examine the user's medical information. The risk that a hacker will reveal personal information and share it with unaffiliated parties is a serious worry.

VIII. HEALTH PROMOTION STRATEGY

A. Methods Search strategy

Three excellent practices served as the basis for the review: the Center for Reviews and Dissemination's 1996 Undertaking Systematic Reviews of Research on Effectiveness, the EPI-Center's 1996 Review Guidelines on Data Collection. The study dealt with older adults either fully or partially. The goal of the intervention was to either completely or partially prevent or lessen social isolation and/or loneliness. The study detailed treatments that promoted health and gave older adults more control over their health. The research collected data on outcome measures in Trevan, either in conjunction with or apart from process measures.

B. Introduction studies

"The process that enables people to increase control over their health and improve their overall health" is what the Ottawa Charter defines as health promotion. This can be accomplished through promoting change at the individual, family, and community levels as well as through education and skill development. Well-being is included in the duty for health promotion, which goes beyond the health sector. Rather of concentrating just on those who are most vulnerable to certain diseases, health promotion initiatives aim to prevent illness and promote overall well-being.

C. Strategies for health promotion

Developing strategies for health promotion requires careful consideration of three important factors: ecology, holism, and caring. Men and women must therefore emerge as equal partners in every stage of planning, carrying out, and evaluating health promotion initiatives. This is a fundamental principle that everybody involved must follow. The strategies listed below can be used to promote health:

Health-related communication
Health instruction
Policy formulation
Systems evolve
Changes in the environment

D. Advantages

The nation, states, families, communities, and individuals all benefit from improved health due to health promotion. -Health promotion makes everyone's quality of life better. -Healthy living promotes fewer preventable deaths

E. Disadvantages

Social media marketing's shortcomings include its time, resource, and personnel requirements; cause marketing, on the other hand, has advantages for both businesses and nonprofits.

IX. PERSONALIZED MEDICINE & PATIENT'S ENGAGEMENT

The use of novel, high-throughput, data-intensive biomedical assays, like proteomics, DNA sequencing, imaging protocols, and wireless monitoring devices, has uncovered a great deal of inter-individual variation in the mechanisms and contributing factors to disease processes as well as the effects of those processes.

A number of excellent reviews on personalized medicine have been written, including a growing number of textbooks on the subject meant for medical students and clinicians. It should be noted that although many use the term 'personalized' medicine interchangeably with the terms 'individualized' and 'precision' medicine (as we do here), many have argued that there are some important, though often subtle, distinctions between them. (59, 60)

Personalized medications come with a lot of difficulties, particularly when it comes to getting regulatory organizations to approve them for regular usage. Furthermore, there exist numerous concerns linked to the widespread adoption of customized medications by various healthcare stakeholders, including physicians, executives in the field, insurance providers, and patients themselves. The proof that personalized medicine strategies simply work better than traditional medicine strategies is at the center of almost all these challenges. This is because many tailored or personalized therapies, like autologous CAR-T cell transplant therapies for specific cancer types (61) and mutation-specific medications like ivacaftor to treat cystic fibrosis (62,63), can be highly expensive (64).

A. Patient's Engagement

Through patient engagement, treatment plans can take into account the opinions and preferences of the patients, making them more responsive and tailored.

By encouraging active participation, patient engagement can result in better adherence to treatment plans, better outcome, and fewer adverse events.

Active patient involvement can build trust, improve the patient-provider relationship, and raise patient satisfaction. Patient participation helps to ensure the long-term viability of global health systems by encouraging informed treatment decisions and effective resource utilization.

Patient participation promotes wise choices regarding treatment and efficient use of available resources, which contributes to the sustainable development of international health systems.

Patient participation is essential in the ever changing healthcare environment of today. Treatment quality is enhanced by active patient participation, particularly when it comes to chronic illnesses. Acknowledging its influence on health-related behaviors and results, the medical community is searching for innovative approaches to involve people.

In order to guarantee that patients are informed about their treatment, recuperation, medication choices, and other significant parts of their medical care, patient engagement refers to the active participation and collaboration between healthcare providers and patients (65,66). It is becoming more widely acknowledged as a vital component of safe, person-centered services and as an essential part of health care.

B. Health & Medical Platforms

Online healthcare consultation has become an essential part of healthcare system. Online medical platforms provide patients with a channel that allows them to make an appointment, learn about a physician, understand their severity of illness, and ask for advice on the Internet without having to leave home (67,68).

Researchers concentrate on various forms of data within the virtual health community to examine the ways in which variables influence patients' consultation practices. Physician information includes self-reported data, their internet persona, and more. Furthermore, the online medical community co-created the customer value.

A portion of the problems facing the physician-patient interaction in China today can be attributed to the asymmetry of knowledge between the two parties (69, 70). A doctor's personal webpage can serve as a resource for patients to learn about illnesses and doctors, enabling them to select a doctor based on comprehensive information (71). This helps to mitigate information asymmetry and influences patients' consultative behavior (72). System-generated and patient-generated information for physician homepages have been separated in the literature. For instance, contribution values, etc., are considered system-produced information, but thank-you messages are data generated following a patient consultation and are categorized as patient-provided information. (73)

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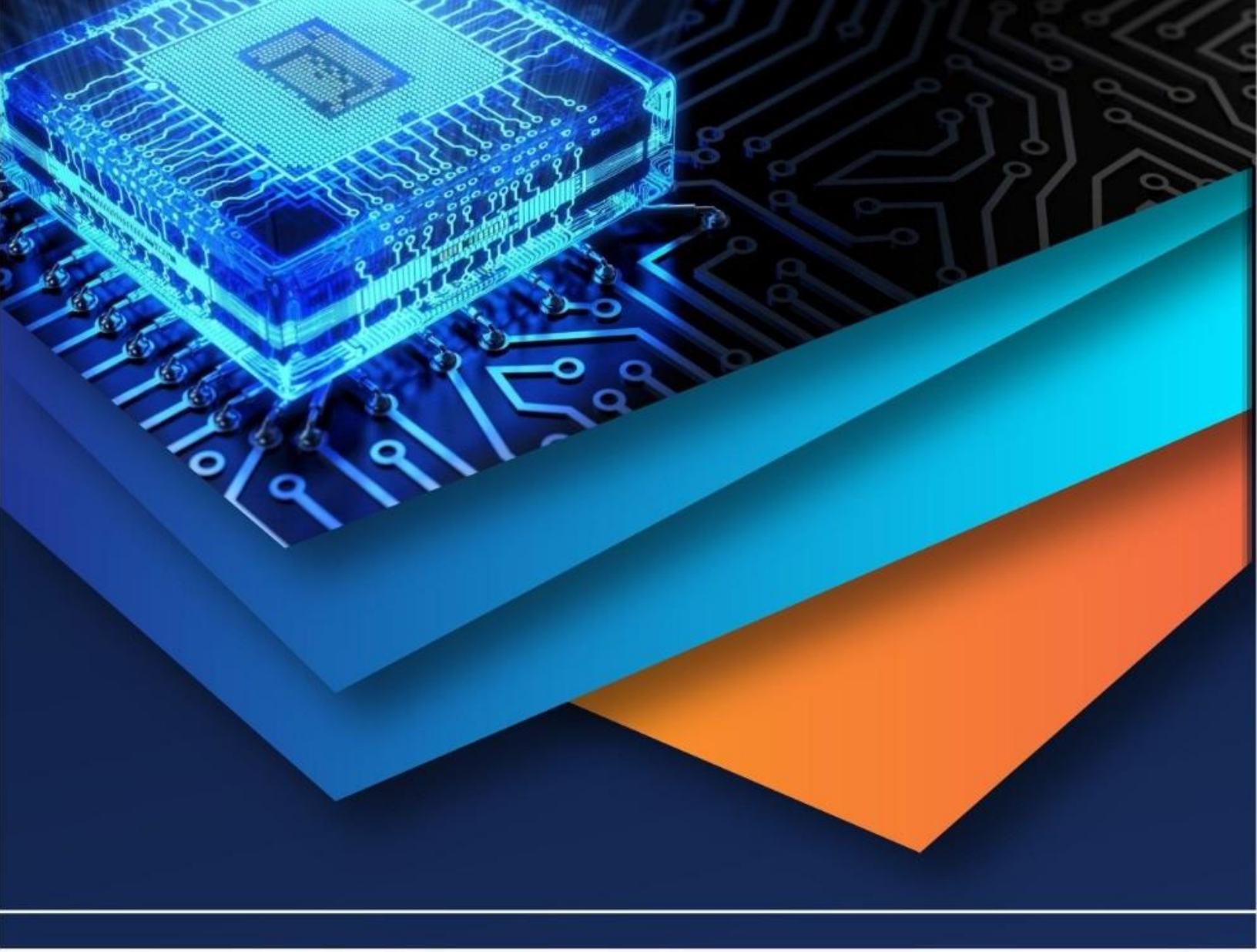

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