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Progress and Application of Wearable Devices in Oncology: An In-Depth Review of Biosensors, Cancer Detection, And Patient Care

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KEYWORDS

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ABSTRACT:

Wearable devices are electronic devices or those that can be incorporated into some other objects that are worn by individuals mainly for physical and health monitoring. They could measure heart rate, physical activities, blood pressure etc when they are worn close to the body. Wearable devices have increasingly become integral to healthcare, particularly in oncology. This article reviews the applications of wearable technology in cancer diagnosis and management, emphasizing the role of biosensors in tumor detection. It highlights how these devices enable early detection and continuous monitoring of tumors, which can significantly enhance personalized treatment strategies, including chemotherapy and radiation therapy. It explains about biosensors, it's components and it's mechanism of action. Biosensors enable us to detect tumour cells and it also helps in selection of chemotherapy. It helps to categories biosensors that can be used to treat various types of cancer. The article also covers various aspects of wearable devices, such as their patient compatibility, and the methods for collecting, storing, and managing patient data. Overall, the article provides a comprehensive overview of how wearable devices are transforming oncology by improving diagnosis, treatment, and patient management. This review has also discussed about a case study on a smart watch for cancer patients.

1. Introduction

During these modern times, it is necessary to maintain our health to led a peaceful lifestyle. It can be done by maintaining diet and regular monitoring of our health. Wearable technology is any device designed to be operated while on the person. Smartwatches and smart glasses are popular examples of wearable technology. The surface of the skin is commonly in close proximity to or on top of wearable electronics, which collect, analyze, and transmit data such as vital signs and/or environmental data. These gadgets also allow the wearer to receive instant biofeedback under specific conditions.[1]

For the past 10 years, wearable technology has gained enormous attention from practioners, sellers, customers and researchers. Technological advancements promote customer empowerment, well-being, and customized, healthy lifestyles. Previously, mobile-based health data storage and tracking platforms with an emphasis on well-being, medical issues, and fitness were introduced.[2]

New directions for study and development have been made possible by the advancement of portable and wireless technologies. As a result, more people are using wearable technology, which offers more information and insights and aids in the modeling of user behavior for organizations, government agencies, security departments, and healthcare departments. Wearable technology cannot exist without the advancement of detectors, technological innovation, combining data techniques, chemical engineering, communication methods, variable batteries, and data storage.[1]

Wearables in health care:

People with long-term disorders, such as insulin resistance, mental problems, and heart issues, require constant monitoring in order to offer the best care possible. The World Health Organization (WHO) reports that long-term illnesses have a major cost burden and lead to roughly a third (75%) of deaths worldwide. Consequently, several approaches are needed for the tracking and identification of these illnesses, and HWDs are a useful approach in this context. Devices worn on the human body or attached to clothing are referred to as wearable technology. A transducer and a target receptor make them up. A receptor reacts appropriately after identifying the target analyte. The receptor's reaction is subsequently transformed into a usable signal by the transducer.[3]

The creation and research of wearable biosensors is receiving a lot of attention these days due to the promise they have for monitoring and customizing patient health. Wearable biosensors (WBSs) are portable devices that enable detecting, gathering data, and deciding utilizing portable technology. They incorporate sensors into an individual's body in the form of tats, protective clothes, footwear, and gadgets. It is well recognized that WBSs promote patient and physician input. Moreover, these instruments provide the secure and instantaneous assessment of several biochemical indicators in physiological liquids including tears, perspiration, saliva, and tissue.[4]

Incidence of cancer:

Global demographics suggest that during the next several decades, there will be an increase in the incidence of cancer; by 2025, it is anticipated that there will be 420 million instances of cancer yearly. According to estimates, there were 14.1 million cases detected and 8.2 million deaths caused by cancer in 2012. Female breast, colon, prostate, and lung cancers were the most prevalent malignancies diagnosed in Europe in 2012. Globally, lung cancer remains the primary cause of both cancer incidence and death from cancer.

The main objective of this article is to deliver knowledge about wearable devices that are used for medical purposes to human welfare and also acknowledge about its importance in real time life. It also discusses about recent development of this wearable medical devices. It includes smart watch, fitness tracker, blood pressure monitor, biosensors, ECG monitor, ear wear, smart clothing, medicinal patches. It also covers the crucial component of wearable technology in the field of cancer detection and therapy and aids in the management of cancer patients through the use of wearable technology.

This review article's goal is to improve our knowledge about wearables in the treatment of cancer sector. It helps in gaining knowledge about how the bio sensors used in wearables, wearables that helps in early diagnosis and treatment of cancer.[5]

BIOSENSOR:

"Biosensor" can be shortened to "biological sensor." The device consists of a sensor and an organic component, such as a biological agent, antibodies, and a DNA sequence. Analyte interaction occurs between the bio element and the transducer, which then transforms the biological reaction into an electrical signal.[6]

Benefits of wearable sensors:

- Real-time, ongoing observation
- Early identification and treatment of illness
- Personalized and enhanced medical care
- Improved management of chronic illnesses
- Lower number of hospital visits
- Involvement and empowerment of patients
- Population health analysis
- Results from clinical trials and digital biomarkers [7]

Wearable Biosensors

An electronic gadget known as a wearable sensor may be included into a variety of wearable devices, including wristwatches, smart garments, and implants. In addition to other measurements, it checks cardiovascular health, cardiac rate, and blood sugar level.

In modern times, we know that these detectors are generating a signal to improve the state of the globe. A patient's present level of fitness might be seen from a different angle thanks to their enhanced functionality and convenience of usage. Better clinical decisions will be made possible by this data accessibility, which will also improve patient outcomes and enable more skillful utilization of healthcare systems. Through the early identification of health conditions, these sensors may be able to save lives by preventing hospitalization. Use of these devices to reduce hospital stays and readmissions in a few years will surely gain positive attention. Additionally, research indicates that WBS will undoubtedly introduce reasonably priced wearable medical technology to the global market.[8]

Figure 1; Types of biosensors

MECHANISM OF BIOSENSOR:

A device or sensor that incorporates a component of electricity with an organic component, such a protein or antibodies, to generate an identifiable signal is called a biosensor. The electronic part detects, logs, and sends information about a change in the body's condition or the presence of different chemical or biological elements in the environment. Biosensors can identify and quantify even trace amounts of particular diseases, hazardous substances, and pH values. They are in various forms and sizes. [10]

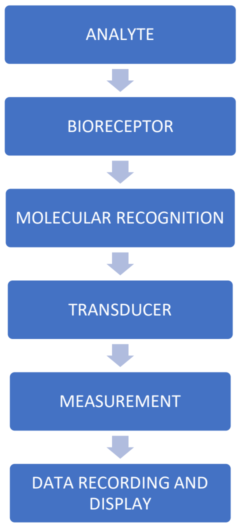

Figure 2; Mechanism of biosensor

Components:

A typical biosensor consists of the following components are described in table 1;

Table 1;

1.	**Analyte:**	A material of interest, such as glucose, ammonia, alcohol, or lactose, whose components are being identified or detected.
2.	**Bio receptors:**	Enzyme molecules, tissues, aptamers and nucleic acids (DNA or RNA), and immunoglobulin are examples of bioreceptors. Biological components or biomolecules with the capacity to identify the target substrate also referred to as an analyte are called bioreceptors. The process by which a bioreceptor interacts with an analyte to create signals is known as biorecognition.
3.	**Transmitter**	It is an apparatus that transforms radiation into a different form. The transducer of a biosensor is an essential part. The biorecognition action is converted into a quantifiable signal of electricity that indicates the presence or quantity of a chemical or bio target. The electrical conversion process is known as "signaling."
4.	**Measurement:**	The information that has been changed has been examined and is ready to be shown. After being amplified, and the electrical signals originating from the sensor are transformed into digital format.
5.	**Display:**	The display unit consists of a user translation system that generates results so that the user may comprehend the associated answer. This system can be operated by a laptop or printer. A figure or a quantitative, graphical, or statistical value may be the output, depending on the requirements of the end user.[10]

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BIOMARKERS:

In general, biomarkers are characteristics that may be systematically examined to establish if an organism's biological circumstances are normal or abnormal. Biomarkers include things like RNA, DNA, lipids, amino acids, organic substances, and more.

Biomarker in the early diagnosis of cancer:

Their association with specific malfunctions of biological systems and/or the biological mechanisms of cancer serves to facilitate the application of therapeutic/interventional strategies. Three categories can be used to group cancer biomarkers according to how they are used. Predictive biomarkers are the first of them; they offer responses to particular therapeutic processes. The second type of biomarkers are prognostic biomarkers, which are derived from clinical outcomes and predict the probability of upcoming advancement of the disease or a return of cancer.

Cancer can be detected and tracked using two main techniques: imaging and histological analysis. The typical process varies based on the kind of cancer and entails completing a number of imaging protocols before determining the kind and stage of cancer using tissue samples. In order to get around these restrictions, researchers are increasingly using liquid biopsies. Circulating tumour cells (CTCs), circulating tumor DNAs (CT DNAs), and exosomes are just a few of the several indicators discovered in a liquid biopsy that can be utilized to monitor the development of cancer. Furthermore, it is simple to track the progression of an individual's cancer and metastatic sickness in real time by collecting many liquid samples at frequent times.

The fluid or blood products have been the subject of examination. epigenetic, genetic, proteomic, and glycomic studies to aid in the treatment, prognosis, and epidemiology of cancer.[11]

Biofluids provide a quick way to assess and monitor health conditions. Sweat, blood, saliva, urine, and other biofluids are important sources of information regarding the illness under study. The monitoring and identification of cancer involves the use of CSF, urine, blood, saliva, and other biofluids. Salivary proteins with a high level of accuracy and specificity in detecting lung cancer include calprotectin, AZGP1, and HP. [12]

Selection of chemotherapy:

Together with your doctor, biomarker testing can help you select the best cancer treatment. Only when specific cancer patients' tumors have specific biomarkers present in them, they may benefit from particular cancer treatments, such as immunotherapies and targeted medications.
Conceptual representation of individual genetic information. Patients talk about genomic data’s use in cancer treatment. Participants in the workshop talked about privacy, data sharing and other topics.

For example, EGFR inhibitors, which target specific genetic alterations in the EGFR gene, are available for cancer patients with such mutations. In this case, biomarker testing can identify if an EGFR gene change in a person's malignancy renders EGFR inhibitors a useful therapeutic choice.[13]

Biomarkers testing:

After obtaining an amount of your cancer cells, your medical team will choose whether to incorporate biomarker testing into your course of therapy. If the tumor is solid, a sample may be taken during surgery. If you have not had surgery, you may need a tumor biopsy.

You will need a blood sample if you're diagnosed with tumors in your blood or are undergoing a liquid biopsy, which is a biomarker test. You could be offered a liquid biopsy test if getting a tumor biopsy is not safe, perhaps because the tumor is hard to access with a needle.

Certain tests for biomarkers that analyze genes may also require an amount of your healthy cells. For this study, a little portion of your skin, blood, or saliva is often obtained. These tests look for genetic alterations (also known as somatic mutations) that have happened over your lifetime by comparing tumor cells to your healthy ones. Most malignancies are caused by somatic mutations, that are not inherited from family members.[13]

Biosensors:

The biological signals resulting from the reaction of a target biomarker with biorecognition molecules are transformed into electrical or optical signals by the transducer, which can then be evaluated. The different types of cancer biomarkers, transducer types, and biological response types can be used to categorize cancer biosensors into groups.[14]

1.Nucleic acids biomarkers:

Nucleic acid-based biomarkers are extremely significant since they help in the early cancer identification even the outward symptoms are absent. One nucleotide mutation, reverse transcriptase PCR, microarrays, luminescence in

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situ hybridization, genetic fingerprinting, and sequencing-based diagnostic tools may all be used to track down nucleic acid-based biomarkers.

2.Protein biomarkers:

Changes in the function of proteins that are involved in the management of the cell cycle might negatively impact regular physiological functions and even cause cancer. Proto oncogenes that become active or tumor suppressor genes that become inactive control aberrant cell proliferation in cancer. Gene duplications, alternative splicing, genetic mutations, and post-translational modifications like glycosylation, phosphorylation, and methylation all contribute to the variability in protein structure and function that results in these functional deviations.[15]

3.Multiple biomarker diagnosis:

A few literature reviews reported on the increase in research interest in developing a multi-biomarker detection tool due to the absence of a single biomarker for a given cancer. According to research by Chik Kaveeraiah et al., an immunosensor with limits of detection of 0.30 pg/mL and 0.23 pg/mL, respectively, may identify IL-6 and PSA, two biomarkers specific to prostate cancer.

4.DNA based electrochemical sensing:

By hybridizing ssDNA and immobilizing an additional DNA and RNA molecule (probe) on the modified electrode's surface, DNA-based biosensors are able to collect the ordered sequence of the target-DNA and give an electrical signal specific to the analyte under study. Chen et al. used functional multidimensional graphene and AgNPs to create a DNA-based biosensor for CYFRA21-1 identification.[14]

Case study:

Case 1-OncoWatch1.0:

The study design is an exploratory feasibility investigation that looks at the adherence to smart watch usage, heart rate variations, and exercise during head and neck cancer radiation treatment. Population: Ten patients over the age of eighteen were to be included in this trial, which was designed to treat squamous cell carcinoma of the head and neck with postoperative or primary curative radiation therapy at the Department of Oncology at Rigshospitalet in Denmark. Severe cognitive impairments were not permitted; all patients had to be able to read and speak Danish. On their first visit to the Oncology department, the patients had to be admitted one after the other.

Device:

A smart Watch Series 5 was worn as a wearable. There was an iPhone 8 gadget linked to the watch. The healthcare facility provided the smartphone and wristwatch. At the end of the trial, the patients were required to return the devices. Neither their phones nor their smartwatches could be used by the patients. During the trial time, the smartwatch could only be worn by the patients. A distinct password was required to activate the phone and watch. It was the patients' responsibility to charge the phone and watch. For taking part in the trial, the patients received no compensation or benefits. Developed by ZiteLab ApS, the OncoWatch software gathers data on the HealthKit and transmits it to a protected cloud server. We gathered information on heart rate and steps. With access to the database was the principal investigator. Patients weren't meant to engage with the OncoWatch app or smartwatch during this feasibility trial.

Goal: The purpose of this study was to ascertain how closely patients with HNC having curatively intended RT adhered to using a smart watch.

Research question: Can patients wearing such watches use them throughout their treatment? Patients who used the device for at least 12 hours a day during the trial period were considered to be adherents.

Planned outcomes: The patients who wear the wristwatch for at least half a day during the trial period was the primary endpoint, which was used to assess the wearability and adherence to the device. The proportion of positive data gathering events and changes in physical activity and heart rate were secondary goals.

Patients included: Fifty-three patients, 48 men and 15 women, ages thirty to eighty-two, were screened for participation in the OncoWatch 1.0 trial during the selection period that ran from January 22, 2021, to December 1, 2021. Of the sixty-three patients, twenty-seven were never questioned because of competing procedures (n = 13), the healthcare professionals' evaluation (n = 3), or the lack of a valid explanation for missing information (n = 11). Twenty-three out of the sixty-three patients rejected to participate, mostly citing inability to supervise participation. Of the sixty-three patients, three had widespread illnesses that had not been diagnosed at first

Information gathered: Over the course of the trial, wear periods of more than 12 hours per day ranged from 0 to

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55 days, with an average of 5. Days that any data was registered ranged from 4 to 59.Over the course of the investigation, 61% of the data were acquired. The study's whole data collection included 196,389 data points about ten patients. Additional details on the period and occurrence of data collection are available in the reference.

Outcomes attained: For 90% of the research duration, only two patients wear it for more than 12 hours per day. Wearing the timepieces for more than 12 hours each day was adhered to by 31% of participants during the research period. Regarding the biometric data outcome, the study's whole data file included 196,389 data points for ten patients. Analyzing heart rate and step count data was prearranged. Due to limited adherence and the exploratory nature of the objective, only step count and descriptive heart rate information were examined for the four patients who complied best. The four patients' results varied and sent conflicting messages; these analyses have been published elsewhere and should only be considered display examples.

Limitations/Strengths: The study's strengths were a well-defined methodology and the way it conducted the study in a uniform system of healthcare where everyone had equal admittance to medical treatment. The fact that four individuals registered their final data before their treatment cycle concluded was a significant constraint. A number of patients reported experiencing technical issues or thought charging and using the wristwatch would be too taxing. Elaborative statistics for rate of heart beat and step count were only examined on the four patients who had the better compliance because of the low adherence, with mixed signals were seen among the four patients. This was done to investigate the viability of characterizing and interpreting the outcome data. When combined, the study's findings were unfavourable.[16]

Chemotherapy management:

Chemotherapy side effects, including as weakness, vomiting, pain, sickness, and dehydration, often require unscheduled health care encounters (UHEs), such as ER visits, and are frequently linked to substantial toxicity. Patients who are more prone to have UHEs have been identified using performance status (PS) evaluations, such as the Eastern Cooperative Oncology Group (ECOG) scale, to assist medical personnel in actively promoting preventative interventions to enhance patients' quality of life.

We conducted a case investigation having a group of patients with solid tumors receiving highly emetogenic treatment in order to assess the viability of utilizing activity monitors in cancer chemotherapy.[17]

People with colorectal cancer often have side effects from the treatment during chemotherapy, which can lead to a loss in their physical abilities and a consequent decline in their standard of life. Among those receiving treatment for colorectal cancer, 46% reported feeling somewhat to severely weary, and this sensation typically worsened after chemotherapy. Therefore, when it comes to the cancer care spectrum for patients with colon cancer, controlling loss of function, treatment-related toxic effects, and overall quality of life is equally as critical as managing the core illness.

The delivery of medical services or services connected to health care via portable electronics, particularly smartphones, is known as mobile health (mHealth). In the field of medicine, mobile health has great promise for enhancing patient education and may be a useful strategy for closing the "health care gap" by opening up new avenues for outreach to marginalized communities. It might also work well as a tool to increase patient compliance with self-management regimens. Consequently, Health is an approach that is gaining traction throughout the whole spectrum of cancer care, from early detection to evaluation, therapy, and survival.

Nowadays, most chemotherapy treatments are administered as outpatient procedures for a number of main malignancies, including colorectal cancer. Therefore, it is the patients' obligation to properly manage at home any adverse reactions and other treatment-related concerns. Cancer patients may feel less stressed and obtain full treatment with the support of mHealth, which provides an abundant number of health care knowledge and managed self-regulation. According to a study by Kearney *et al*., advanced symptom management system (ASyMS) for mobile phones proved successful in helping cancer patients manage toxicity from chemotherapy.

Despite these advantages of mHealth in medicine, no research has yet examined the efficacy and validity of an exercise program based on smartphone applications for patients with colorectal cancer receiving chemotherapy.[18]

There is a significant risk of possibly fatal infections in pediatric cancer patients who are experiencing chemotherapy-induced neutropenia. Research-grade or consumer-grade wearable devices physical activity data can predict clinical outcomes in adult oncology, according to studies. However, the data supporting other vital signs, such as heart rate, is weak. In certain

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situations, it has been demonstrated that continuous vital sign monitoring can identify illnesses earlier than discrete readings.[19]

RADIATION THERAPHY MANAGEMENT

Acute treatment-related ailments, such as pneumonia, inhalation, pain, and trouble swallowing, are linked to neck and head radiation and chemoradiotherapy. About one-third of individuals getting neck and head radiotherapy had an unexpected hospital visit while undergoing treatment, per two studies. This finding is representative of the side-effect profile that commonly leads to hospitalization. Not only is this expensive, but it also suggests that the patient has a high chance of developing more serious health issues. A signal of worsening prior to clinical decompensation in this patient cohort would be ideal for clinicians to have.

Wearable, non-invasive fitness trackers that can accurately track heart rate, sleep activity, and step counts are becoming a common consumer product. Numerous studies have evaluated the usefulness of these devices, which have previously been used to evaluate and track patients receiving radiation therapy. In a prior investigation, step counts of 38 patients undergoing chemoradiotherapy were prospectively monitored by Dr. Ohri *et al*. The results showed an inverse relationship between step counts and hospitalization risk. Additionally, a decline in step counts during a radiation therapy course was linked to a decline in quality of life.[20]

Patients confined to limited areas throughout their hospital stay need regular operator-mediated monitoring of critical and noncritical data, including radiation levels. To detect residual radiation in patients, nuclear medicine departments typically use ecological instruments, supplying fixed, time-based information that yield only an estimate of the estimated release curve.

When a patient uses a wearable, mobile device for everyday activities, they can obtain continuous, precise measurements and instantaneous samples of the radiation they are emitting. In addition, this strategy would enable improved sample accuracy and the optimization of professionals' exposure, which would result in safer patient release. Technology supports the use of wireless devices in secure, regulated spaces with patient-only access through patient-wearable, portable equipment. This presents a chance to assist in the proper administration of nuclear medicine units. This method could make it possible to monitor multiple medical variables and residue energy in one modular device at the same time. It has already been successfully used to monitor cardiology patients during everyday activities.

When the system described above is installed, it will improve the procedures for reducing radioactive and surroundings from clinical radiation and may also comply with current workplace and environmental safety laws. Observing people in hospitals in limited locations on a regular basis might assist strengthen the patient interaction by offering a more familiar approach. When all is said and done, this model can be exported.[21]

PERSONALIZED CANCER TREATMENT

The advancing years of the population has resulted in substantial advancements in the medical profession, particularly in the area of biosensor development, which enables tailored therapy, actual health checkup, and sickness prevention for types of acute and chronic conditions. Conventional illness diagnosis methods, often employed in hospitals and laboratories, are costly, time-consuming, and demand highly qualified personnel. Point-of-care technology (POCT), on the other hand, provides prompt and patient-centred diagnostics, for those with limited medical services. As healthcare laws become more individualized, the size of the worldwide wearable sensors sector is expected to expand at a CAGR (compound annual growth rate) of about 38 percent between 2017 and 2025. It is anticipated that the development of smart watches will progress rapidly.[24]

Physical activity monitors:

Research has shown that engaging in physical activity can lead to better results for cancer patients. Cancer death and rates of recurrence have been shown to be reduced in correlation with increased physical activity levels. Patients with initial stage of breast cancer experienced benefits in terms of increased physical activity and better mental health when they received weekly wellness coaching in addition to physical activity monitors.[22]

Implantable devices:

Implantable drug delivery devices protect the loaded medications from deterioration or elimination until they are released, which improves the effectiveness of cancer treatment. They also enable local drug administration to the tumor location. By permitting precise spatial control, they also lower the total the amount of drug in blood circulation, shield healthy cells from harm, and raise the overall survival rate.[23]

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Handheld computer devices:

Since the early 21st century, wearable technology has started to offer more complex types of customizable sensors and portable devices in addition to tailored health services. Currently, there are five categories in which portable electronics may be placed: feet, head (glasses and helmets), wrist (watches, necklaces and bracelets and gloves), clothes (coats, clothing, and pants), and sensory control devices (sensory modulators). Wearable monitoring systems have become increasingly commonplace in our everyday lives as a result of the growth of microelectronics and wireless communication technologies, as well as the shrinking of biosensing devices.

Wrist mounted devices:

Commercial wrist-mount physiological monitoring devices now feature shorter energy lives and smaller circuitry that translates unprocessed data into real-time, understandable data. Fitness bands and smart watches are two examples of wrist-mounted devices that are evolving from basic "smart pedometers" with accelerometers to ones that use biometrics.
Generally speaking, non-invasive monitoring devices are used for two things:

(1) electronic device communication

(2) monitoring physiological signals and human activities.
One of the most important physiological markers of an individual's health is the measurement of their blood pressure. Electrocardiogram (ECG), optical, and pressure sensors were all integrated in conventional pulse wave sensors, which monitored blood sugar levels non-invasively using cuffs.

Head-Mounted devices:

Wearable smart glasses are one type of head-mounted device that will display data. Nicholas Constant and associates invented what are known as "smart glasses," which are sensing of pulse eyewear with a photoplethysmography (PPG) sensor on the nose pad to continuously monitor heart rate. Joseph Wang and his colleagues studied nose pad glasses equipped with a lactate biosensor to track lactate levels and a potassium ion-selective electrode to detect potassium ions from sweat in real time. Furthermore, smart glasses can be equipped with sensors like magnetometers, gyroscopes, altimeters, GPS, barometers, and accelerometers.[24]

SYMPTOMS AND SIDE EFFECT MANAGEMENT BY WEARABLES:

Most cancer therapies need periodic meetings between patients' medical teams and themselves. Even during periods of severe chemotherapy treatment, the majority of the patient care is provided at home, away from the clinical setting. Patients typically present with a range of complicated side effects that require monitoring and assessment in an ambulatory setting. Patients also have to consider the difficulty of alerting their medical professionals to worsening side effects and when to report them.

Throughout critical phases of cancer therapy, wearable and mobile technologies can offer scalable, cost-effective alternatives for distant, frequently real-time patient monitoring. This technology gives medical personnel accessibility to both quantitative and patient-reported health data, which can aid in clinical decision-making.

DATA COLLECTION AND MANAGEMENT:

Collection:

A consistent interface, like Wi-Fi or cellular connection, is required for people to connect their mobile devices to data collection systems. It seems that the majority of data from linked devices is first instantly moved to and kept in the "cloud" could present a problem for patients who travel abroad or live in remote locations. Several web-based data warehouses have been created to aggregate information from various devices. These systems have dashboards for tracking patients and displaying data for frequently used metrics like heart rate, sleep, and physical activity.

Storage:

It is necessary to move the physical activity monitor data from the wearer's gadget to a safe database with a lot of content storage capacity. Patient privacy must be ensured by transferring and storing PROs on a secure server, much like with physical activity data. Ideally, the PROs should be integrated into the electronic health record system when utilized in a clinical context.

Management:

Next, access to the data kept in the database—which could be on a local or cloud-based server—must be provided. The usual method of access is through a complex password consisting of 50–100 characters and a secure user interface. Transferring data may take a considerable amount of time, if it is not stored locally due to the volume of material.[25]

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POST OPERATIVE SURVEILLANCE AND LONGTERM REOCCURRENCE MANAGEMENT:

Since patients are vulnerable to various difficulties during the early postoperative phase, it is essential to identify and manage these issues to prevent long-term effects. Wearable technology offers a novel approach to tracking patients' post-intervention progress and has the potential to enhance patient outcomes and alleviate pressure on healthcare resources by enabling earlier and safer hospital departure.

The majority of research employed accelerometer or pedometer to monitor physical activity levels, which were used as indicators of recovery and postoperative function. This was probably brought about by the links found between earlier mobilization and better functional and survival outcomes.

One such potential instrument that exhibits this principle is the Gait Posture Index (GPi), which combines several physical activity metrics into a straightforward index. Ideally, these metrics are gathered using a wearable device. Wearable technology may also help with the execution of preventive measures, such as monitoring patients' body postures and sounding an alarm after a period time of inactivity to make sure patients are rolled to avoid pressure wounds.[26]

ENHANCING PATIENT ADHERENCE AND ENGAGEMENT:

Wearable technology has enormous potential for successfully participating in patient monitoring regimens, enabling a real-time evaluation of treatment efficiency, adherence, and compliance. In addition to cancer-related concerns, wearable technology may also be used to predict other health related problems, allowing for early intervention. Apart from providing benefits to consumers, this customized method enables healthcare providers to get a deeper comprehension of diseases and customize treatments to meet the specific requirements of each patient.

Wearable technology with artificial intelligence (AI) features can support treatment management by monitoring medication compliance and dietary adherence. A nutritious diet can reduce mortality after breast cancer diagnosis, however maintaining a Western diet has been associated with an increased risk of death overall. Silva and colleagues developed a smartphone application and wearable technology device for diet control. Food images and wearable activity data may be used to support nutritional intervention through the application of deep knowledge and machine learning models for food recognition and evaluation.[27]

Privacy and security:

Consent to the terms and conditions of the devices normally involves agreeing to the usage of data. Users allow the developer permission to share the data they provide via this consent process with outside parties for the purposes of marketing and marketing research. Users don't realize the entire extent to which their data can be used by others—either with their permission or against it. Patients may find it bothersome to utilize these devices and/or share the data if they believe that they are being tracked too much.

THE FUTURE OF WEARABLE TECHNOLOGY AND REMOTE HEALTH MONITORING IN HEALTHCARE:

The manufacturing of wearable and remote monitoring devices is expanding exponentially. Health care practices, including disease management, early detection, diagnosis, and prevention (e.g., medication dose monitoring and reminders, stress-level monitoring, dehydration warnings, activity and eating behavior tracking, etc.), will soon be impacted by these platforms, which will provide accurate assessments of physiological parameters and well-being in more convenient ways.[28]

CONCLUSION:

The take home message from this review article is that wearables play a major role in monitoring human health and disease diagnosis. These devices have emerged as crucial tools in tracking the wellbeing of induvial, particularly in context of cancer care. These devices are equipped with a variety of biosensors designed to identify specific biomarkers associated with different types of cancer. The future potential of wearable device in healthcare is immense, given their ability to continuously monitor health metrics and provide valuable insights into patient conditions. These wearable devices have greater scope on future purpose. While they hold great promise for future healthcare advancements, challenges such as ensuring patient comfort and safe guarding personal data confidentiality must be addressed to fully harness their potential.

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