How to Cite:
Alharbi, S. S., Algfari, S. M., Alahmad, A. I., Alshammry, M. M., Alqahtani, N. S., Alharbi, S. H., Alanazi, Zaid H., Alwaked, M. H., Alrashidi, A. A., Alrasheedi, B. B., Alsarimi, F. A. H., Alghufaili, R. S. A., & Alotaibi, M. S. M. (2018). Use of wearable health devices for early detection of medical disorders: Applications at different medical departments. *International Journal of Health Sciences*, *2*(S1), 201–218. https://doi.org/10.53730/ijhs.v2nS1.15147

Use of wearable health devices for early detection of medical disorders: Applications at different medical departments

Sultan Sulaiman Alharbi
KSA, National Guard Health Affairs

Sultan Mohammed Algfari
KSA, National Guard Health Affairs

Ahmed Ibrahim Alahmad
KSA, National Guard Health Affairs

Mshaweh Mohammed Alshammry
KSA, National Guard Health Affairs

Naif Saad Alqahtani
KSA, National Guard Health Affairs

Shayem Hamdan Alharbi
KSA, National Guard Health Affairs

Zaid Helal Alanazi
KSA, National Guard Health Affairs

Mohammed Hamoud Alwaked
KSA, National Guard Health Affairs

Abdulaziz Ahmad Alrashidi
KSA, National Guard Health Affairs

Bander Batti Alrasheedi
KSA, National Guard Health Affairs

Fayez Abdullah Hussain Alsarimi
KSA, National Guard Health Affairs

Rayan Salem Abdulaziz Alghufaili
KSA, National Guard Health Affairs

International Journal of Health Sciences E-ISSN 2550-696X © 2018.
Corresponding email: *akk29337@gmail.com*
Manuscript submitted: 01 Jan 2018, Manuscript revised: 09 Jan 2018, Accepted for publication: 15 Jan 2018

Meshal Saeed M Alotaibi
KSA, National Guard Health Affairs

***Abstract*---Background:** Wearable Health Devices (WHDs) represent a rapidly advancing technology that enables continuous monitoring of vital signs in various settings, including personal and clinical environments. Emerging in the late 1990s, these devices integrate biomedical technology with micro- and nanotechnology, materials engineering, and information and communication technologies. WHDs aim to enhance patient empowerment by facilitating self-management of health and improving interaction with healthcare providers. **Aim:** This review evaluates the current applications and technological advancements of WHDs in different medical departments, including emergency care, health information systems, nursing, and pharmacy. It explores their role in continuous monitoring, diagnostics, and patient management. **Methods:** A comprehensive literature review was conducted, focusing on recent developments in WHD technology, their applications in various medical contexts, and future trends. Key areas of investigation included vital sign monitoring, sensor technologies, and device usability. **Results:** WHDs have shown significant promise in diverse applications. In emergency care, they provide real-time monitoring for critical conditions, improving early detection and response. In health information systems, they enhance data collection and integration with electronic health records. Nursing applications focus on continuous patient monitoring and managing chronic conditions, while pharmacists benefit from accurate medication adherence tracking. **Conclusion:** WHDs are transforming healthcare by offering continuous, non-intrusive monitoring and valuable data for various medical departments. Their ability to integrate with existing healthcare systems and provide actionable insights is crucial for advancing patient care and management. Future improvements in accuracy, battery life, comfort, and interoperability will further enhance their efficacy and adoption.

***Keywords*---**Wearable Health Devices, Vital Signs, Continuous Monitoring, Medical Applications, Healthcare Technology.

Introduction

Wearable Health Devices (WHDs) are a growing invention that minimizes discomfort and minimizes disturbance to regular human activities (work, home, physical exercise) or within clinical environments, so enabling continuous monitoring of human vital signs in a variety of settings [1]. Originally proposed in the late 1990s, WHDs are part of personal health systems—a concept that helps people to be at the center of healthcare delivery, therefore allowing them to manage their own health and interact with healthcare providers—also known as "patient empowerment." Improving public interest in their own health, raising the standard of treatment, and using the features of new technologies were the goals here. Among the several scientific disciplines these gadgets combine are biomedical technology, micro- and nanotechnology, materials engineering, electronics, information and communication technologies [2,3].

The use of WHDs allows for continuous monitoring and acquisition of vital signs outside of clinical settings and over several days or weeks, so facilitating the gathering of important data during various activities and so supporting medical diagnostics and hastening the recovery from medical conditions or injuries. By recording their physiological reactions in dangerous environments to better control their effort and occupational health, WHDs also significantly contribute to sports/fitness monitoring, athlete performance assessment, or assistance of first responders and military personnel. Always aiming at monitoring the human body, these devices can be used for both medical and fitness/wellness needs. Given this context, "health" is the most fitting word; so, the acronym WHDs results. The particular application areas will help to improve the terminology. Whichever its intended use, WHDs have to satisfy four fundamental design criteria: low power consumption, dependability and security, comfort and ergonomics [4,5].

According to Statista [6], the wearable device market's worldwide income right now is over \$26 billion and is expected to reach almost \$34 billion by 2019. Within the framework of healthcare and related medical applications, this industry is projected to reach about \$15 billion worldwide by 2019 [7]. Anticipating their development in the next years, this evaluation attempts to compile new insights on WHDs and evaluate the present scene of these devices. Vital indicators and WHDs integrated in textiles take front stage here. The study is broken out into seven components. Emphasizing areas of technical development, Section 2 addresses the main measurements required for medical, personal, personal, fitness, and sports activities. Section 3 lists recently developed technologies used to track every found vital sign. Section 4 presents a broad system design meant to improve knowledge of WHD components, procedures, and device variants. Section 5 looks at several kinds of WHDs, with an emphasis on heart activity monitoring sensors, contrasts commercialized WHD t-shirts, addresses their features and shows some prototypes. Section 6 is a market study meant to forecast future developments in this field. Section 7 ends finally with future difficulties and viewpoints for WHDs.

This evaluation stands out from other works by combining and linking several aspects of WHDs that are sometimes not considered or put together. For example, although recent studies (e.g., [8,9]) give a comprehensive description of the technical aspects related to physiological sign monitoring, acquisition techniques, and device fabrication, they offer limited information regarding the relevance of these signs for human health or the WHD system architecture. Conversely, some studies—as shown in [10]—focus mostly on WHD architecture and technological features. While other research might concentrate on other facets, this review offers a thorough examination of the key elements concerning WHDs. This review also covers two subjects seldom discussed in WHD publications: recognizing the most important vital signs, which incorporates some medical issues, and doing a market trend analysis to project the future of these devices. One unique aspect of this review is the thorough analysis of cardiac activity monitoring, a main field of WHDs, to assess the present level of this technology.

Improving Wearable Health Devices (WHDs) involves advancements across several critical areas to enhance their performance, usability, and overall integration into healthcare systems. First, enhancing the accuracy and reliability of these devices is essential. This can be achieved by developing more advanced sensors capable of capturing a wider range of physiological data, such as blood pressure, oxygen levels, and glucose measurements, with greater precision. Additionally, incorporating sophisticated machine learning algorithms would allow for real-time analysis of the collected data, improving predictive capabilities and providing timely alerts for early medical intervention. Another important area of improvement is battery life and power efficiency. WHDs should be designed with low-power consumption components to ensure that they can operate for longer periods without the need for frequent recharging. This is particularly critical for continuous monitoring in clinical and non-clinical settings. Improving comfort and ergonomics is also a priority. WHDs must be lightweight, flexible, and discreet to ensure they do not interfere with daily activities, making them more appealing for extended use by patients and consumers alike. Furthermore, enhancing the interoperability of WHDs with existing healthcare systems is crucial. Devices should be compatible with electronic health records (EHRs) and integrate seamlessly with telemedicine platforms to enable efficient data sharing between patients and healthcare providers. Finally, addressing privacy and security concerns is essential. With the increasing volume of sensitive health data being transmitted, ensuring robust encryption and data protection protocols will help maintain patient confidentiality and trust in these devices.

WHD and Vital Signs:

Vital signs are critical indicators of the human body's physiological state, encompassing a range of signals from electrical to biochemical. These biosignals can be measured to assess overall health and how the body responds to external stimuli. Before examining how these signals are generated and how wearable sensors capture them, it is essential to identify the key biosignals that are crucial for analyzing human health. Modern technology and wearable devices allow for classifying WHDs into three categories: the environment of use (home/remote or clinical), the type of monitoring (offline or real-time), and the user type (healthy individual or patient) [11]. Based on this classification, WHDs can be divided into two primary domains: activity monitoring (1) and medical monitoring (2), with the latter having three subcategories.

The first domain, the **activity area**, encompasses fitness, wellness, and non-medical applications, including self-monitoring and rehabilitation. The medical area is divided into three subcategories: **prediction**, which focuses on identifying potential events before they occur, offering medical insights to prevent chronic conditions and support diagnostic decisions [11]; **anomaly detection**, which identifies irregular patterns that deviate from expected behaviors using classification methods to differentiate between normal and outlier data, often raising alarms when anomalies are detected [11]; and **diagnosis support**, which is a crucial aspect of clinical monitoring that aids in medical decision-making based on vital signs, health records, and anomaly detection [11]. This categorization helps clarify the diverse applications of WHDs, emphasizing their multi-functional use. The monitoring capabilities of WHDs depend on the specific signals they can capture, a significant topic discussed throughout this review. Among the myriad physiological variables measurable from the human body, identifying the most useful signals, both for medical and non-medical purposes, is critical. To better comprehend the research advancements in WHDs, a survey of the Web of Science™ main collection was conducted. The identified vital signs are based on their frequency in the literature and are divided into medical and activity areas to highlight where research is concentrated. In medical literature, five traditional vital signs are deemed crucial for monitoring clinical deterioration: heart rate, blood pressure, respiratory rate, blood oxygen saturation, and body temperature. These signs are generally recognized as essential for health assessment, particularly in patients. Ahrens [12] introduced two additional vital signs—capnography and stroke volume—that should be promptly measured in critical situations. Elliott and Coventry [13] emphasized three more vital signs, including pain, level of consciousness, and urine output, suggesting that these combined with the five traditional signs provide a comprehensive understanding of patient physiology. Electrocardiography is also vital for analyzing the heart's electrical activity, aiding in the diagnosis and prediction of cardiovascular conditions [14]. Monitoring glucose levels is especially critical for individuals with diabetes mellitus, a field where substantial research is being directed toward developing non-invasive methods [15,16]. Beyond these medical parameters, other important factors, such as skin perspiration and actigraphy, are relevant for assessing neurological function, rehabilitation, posture, motion control, and sports performance [15,16]. The subsequent section delves into these signals, exploring their origins, health significance, and the latest advances in wearable sensor technology.

Important Vital Signatures

ECG, or electrocardiograms

Clinically, electrocardiograms (ECGs) are used extensively as diagnostic instruments that offer understanding of the cardiac electrical cycle. Five peaks and valleys—P, Q, R, S, T, and U—that reflect changes in the electrical potential of the heart—which causes muscle contraction and consequent cardiac motion—distinct the ECG waveform. Found in the QRS complex, the most notable R-peak marks ventricular depolarization, a location of great differential potential. As so, cardiac cycles are measured using the R-R interval [17]. Evaluating heart rhythm, ischemia alterations, and forecasting as well as treating acute myocardial infarctions and coronary events depends on ECG waveforms in major part. Diagnosing cardiovascular diseases (CVD) such atrial fibrillation, angina, atherosclerosis, cardiac dysrhythmias, congestive heart failure (CHF), coronary artery disease, bradycardia, and tachycardia [14,17] depends critically on the pattern analysis of ECG waveforms. Particularly in improving the early identification of atrial fibrillation resulting from prolonged, continuous monitoring compared to the standard yearly 24-hour Holter recordings, wearable health devices (WHDs) with ECG monitoring capabilities have demonstrated advantages.

Ag/AgCl (wet) electrodes are now the most often employed to translate the ionic currents from the heart into electronic currents via metallic wires. Although these electrodes are affordable, small, and dependable, their adhesive and wet compound character could cause skin irritation after long use. Moreover, the gel dries out with long sessions, therefore limiting contact between the skin and electrode and rendering the gel inappropriate for discreet continuous monitoring. Alternative materials such as dry electrodes and fabric-embedded electronics have been investigated to help to solve these problems [5,14]. These substitutes are clinically useless at present as they avoid skin irritation but are prone to artifacts brought about by body movement. Though their attachment to the skin still limits their use outside clinical diagnostics, Luo et al. [18] presented dry, flexible, and stretchable sensors to eliminate movement artifacts and skin discomfort. Development of dry electrodes devoid of sticky characteristics might also be a possible answer since they fit wearable use. For example, Chi et al. [19] devised wearable sensors initially described in 1969 that could gather ECG signals through insulating materials such as cloth. Many times integrated into textile fibers, wearable electrodes must be low current, low impedance, conductive. Often plated metal or carbon, these fibers have to resist stretching, bending, and washing [14, 20]. Another option is non-contact capacitive electrodes, which may record ECG signals without direct skin contact, although are still more sensitive to motion artefacts than traditional electrodes [21].

Heart Rate (HR):

Often assessed in both medical and exercise environments, heart rate (HR) is a critical indicator. Keeping an eye on this signal reflects changes in the heart cycle and provides information about physiological state. Though their morphologies and physiological sources differ, HR can be calculated from both ECG (R-peak) and photoplethysmography (PPG) signals since they both include identical HR information [15]. Although they exist, alternative approaches include inertial sensors [22] or scales (ballistocardiogram, BCG) [19] are less efficient than ECG and PPG for HR measurement. HR monitoring is important in sports and activity environments to evaluate cardiovascular reactions during exercise and recuperation. Simple indication of cardiovascular health and measure of psychophysiological conditions like stress and fatigue, HR variability analysis has become popular [12,23]. A few medical experts support pulse signals as HR alternatives. Additional information including intensity, amplitude, and regularity comes from the pulse, a perceptible enlargement of an artery brought on by cardiac contraction and resulting from higher blood volume. On cases of irregular pulse or hypovolemia, however, lower blood volume may make pulse signals untrustworthy. Usually in combination with blood oxygen saturation measurement, pulse is estimated using pulse oximetry concepts [14].

Blood Pressure—BP:

Widely considered as the most important cardiopulmonary measurement, blood pressure (BP) tells us the force blood generates against artery walls. BP provides cell oxygen supply as well as indirect insights on blood flow during heart contraction (systole) and relaxation (diastole). Among the various physiological elements influencing it are cardiac output, peripheral vascular resistance, blood volume, viscosity, and vessel wall flexibility. Tracking hypertension, one of the main worldwide disease loads, would be best with ambulatory blood pressure monitoring—periodic measurements throughout the day—which improves CVD prediction [13,24]. Usually, BP is measured on an arm of the patient using inflated pressure cuffs and a stethoscope. Adapted for automated BP measurement using devices linking external pressure to artery volume pulsations, this technique [5] Constant monitoring with a cuff, however, could have negative effects including disturbed sleep, skin irritation, and high stress levels. As result, new methods for ambulatory blood pressure monitoring have surfaced [5]. One method is using PPG signals received from the wrist [16] or estimating BP based on pulse wave transit time between signals acquired from PPG and ECG, both recorded on the chest [25]. Using two microelectromechanical sensors positioned at nearby body sites (wrist and neck), Yu-Pin Hsu and Young [26] devised a method measuring BP using pulse wave velocity. More recently, Woo et al. [27] presented a prototype watch with a pressure sensor close to the radial artery that uses a smartphone to continuously monitor by means of real-time BP readings.

Respiration rate (RR) represents a key physiological measure in patient monitoring, providing essential and accurate health information, particularly in cases like acidosis [13]. It serves as a highly sensitive indicator in critical conditions, such as distress and the potential onset of hypoxia. According to Elliot and Convetry [13], the “respiratory rate is often not recorded in clinical settings or is simply guessed,” which is problematic since RR is one of the most reliable predictors of adverse events, including cardiac arrest. Despite the availability of multiparameter monitors in clinical environments, the authors note that RR is often neglected in favor of other parameters, such as electrocardiogram (ECG), and in instances where these devices are unavailable, RR is either estimated through brief observation (30 seconds) or entirely omitted. Elliot and Convetry [13] suggest that this neglect might stem from the belief that oxygen saturation offers a superior reflection of respiratory function. The ambulatory monitoring of RR is crucial for detecting symptoms related to respiratory conditions like sleep apnea syndrome, chronic obstructive pulmonary disease (COPD), and asthma, facilitating more timely interventions. This is particularly vital in pediatric cases involving pulmonary diseases [13,15]. Typically, RR is calculated from the respiratory waveform, which mirrors chest volume changes during inhalation and exhalation. Thoracic expansion combined with muscle activity allows for the assessment of respiratory effort, thus reflecting various physiological conditions. In the context of athletics, particularly among competitive athletes, analyzing this data can contribute to enhanced respiratory performance [13,15,23].

At present, three primary methods are used to assess respiratory function: elastomeric plethysmography (EP), impedance plethysmography (IP), and respiratory inductive plethysmography (RIP). The EP method utilizes piezo-electric sensors to convert current variations into voltage via an elastic belt. Guo et al. [28] developed a highly accurate prototype garment that uses piezoresistive fabric sensors to measure changes in chest and abdominal volumes. IP relies on impedance fluctuations on the body surface caused by breathing-induced expansion and contraction, a technique that has been applied to the design of soldier uniforms [4]. Meanwhile, RIP technology is based on a loop wire that generates a magnetic field, with chest volume changes altering the enclosed area of the loop, generating an inversely proportional current [29]. In addition to these primary methods, other technologies, such as accelerometers [30], ECG signal extraction [31], pulse oximetry derivation [32], polymer-based transducers [33], and optical fibers [34], are being employed to acquire respiratory waveforms. Al-

Khalidi's 2011 review [35] offers an in-depth exploration of the various methods used to measure RR, including those unsuitable for wearable health devices (WHDs), such as infrared cameras and acoustic techniques.
Recently, RR monitoring has advanced with the use of Polypower, a dielectric active polymer (DEAP) commercially known as Polypower. It modifies its electrical properties when stretched, offering a safer alternative to the fluid metal-based strain sensors previously employed, such as mercury or gallium–indium, which posed leakage risks. Tognarelli et al. [36] have demonstrated the potential of DEAP in monitoring chest volume changes [36,37].

Blood Oxygen Saturation (SpO2):

Blood oxygen saturation (SpO2) is an essential and easily measurable vital parameter, relying on photoplethysmography (PPG) technology and pulse oximetry. The PPG method captures blood vessel waveform variations, and by employing two wavelengths (typically 660 nm and 905 nm), blood oxygen saturation can be estimated, as this relies on the oxygen-binding properties of hemoglobin. Oximetry provides insight into the proportion of oxygen carried by blood cells, which typically ranges between 95–100%. Detecting hypoxia, characterized by levels below 95%, is critical as it signifies insufficient oxygen supply to the body. However, one challenge in SpO2 measurement arises when the patient is anemic [13,38,39]. Beyond medical applications, ambulatory monitoring of pulse oximetry has gained interest in evaluating aerobic efficiency during routine exercise. Investigating muscle capillary bed oxygenation can enhance athletic performance, while brain and limb oxygenation information is crucial in military and space contexts, where gravitational shifts affect oxygen delivery, potentially leading to blackouts. Research has shown a positive correlation between individual performance and oxygenation responses under varying task loads [23].

Several non-invasive technologies are available for measuring SpO2 in wearable devices, with PPG being particularly prominent in clinical settings [38]. The most common method involves measuring SpO2 at the fingertip, widely adopted in clinical practice. Efforts are underway to develop ring PPG sensors, offering improved comfort and adaptability. With mobile connectivity, these sensors are evolving into more independent wearable devices [40]. Additional sites like the ear lobe are being utilized, with recent studies revealing a small chip (3 × 6 mm) capable of measuring SpO2 levels. Forehead-based PPG sensors are used to monitor brain oxygenation, as detailed in the literature [41], and a surface chest PPG reflectance prototype developed by Puke et al. [41] has demonstrated the feasibility of continuous monitoring in this region. Technological advancements by Chen et al. [42] have enabled the fine-tuning of PPG sensor parameters to improve tissue depth measurement, enhancing its clinical application. Efforts have also been made to integrate PPG sensors into textile technology. One approach involves incorporating flexible plastic strips containing LED and photodiode strips in the weft direction, with copper wires embedded to transmit the signal through the textile fibers [43]. Another method involves the use of embroidered optical fibers, as demonstrated by Krehel et al. [44], whose innovative textile technology allows for the analysis of different tissue depths using fiber-based light sources and detectors.

Skin Perspiration:

Skin perspiration, while not a standard clinical parameter, serves as a physiological indicator to analyze human responses to various conditions. Such responses are mediated by the autonomic nervous system (ANS), which can trigger increased sweating. This perspiration alters the skin's electrical conductance, facilitating the measurement of sweat production through a method known as galvanic skin response (GSR). Given that the ANS also regulates other physiological parameters such as heart rate, respiration, and blood pressure, GSR is often utilized alongside these metrics. For instance, GSR combined with heart rate variability can be instrumental in identifying mental states and detecting stress [53,54]. In sports science, continuous monitoring of skin perspiration is highly valued due to its significant applications in analyzing physiological responses and human behavior. This monitoring is particularly relevant in clinical settings for detecting dehydration, though it should be interpreted within the context of physical activity [15,54]. Sweat provides valuable information about an individual's physiological status due to its composition of various ions and molecules. This makes it an excellent biofluid for non-invasive chemical analysis to identify pathological conditions through ionic levels, which can be advantageous in clinical practice. Elevated or diminished levels of sodium, ammonium, calcium, and lactate can signal electrolyte imbalances or conditions such as cystic fibrosis, osteoporosis, and physical stress. For example, assessing physical stress can be crucial in psycho-physiological evaluations of military personnel undergoing rigorous training [15,55]. There are two primary sensor types for monitoring sweat: epidermal-based sensors and fabric/flexible plastic-based sensors:

1. **Epidermal-based sensors** achieve conformal contact with the skin using elastomeric stamps that directly print electrodes on the epidermis for continuous monitoring.
2. **Fabric/flexible plastic-based sensors**, the more commonly used type, maintain constant contact with a large surface area of the skin. These sensors can be integrated into fabric or screen-printed, allowing for specific measurements such as pH and ionic concentrations (e.g., NH4+, K+, Cl−) [55].

Recent advancements include a novel sensor by Kim et al. [53] designed for continuous GSR measurement with high wearability, utilizing a dry polymer foam electrode for stable skin contact. Additionally, microfluidic sweat analysis technology, as employed by Liu et al. [56], involves a microcontroller and Bluetooth module for real-time perspiration monitoring. Koh et al. [57] have recently developed an epidermal sweat patch featuring microfluidic channels to monitor sweat rate and various biomarkers like lactate, chloride, pH, and glucose.

Capnography:

While pulse oximetry is a prevalent method for assessing arterial oxygenation, it is less effective for evaluating ventilation. Capnography provides a non-invasive and cost-efficient technique to assess human ventilation by measuring carbon dioxide (CO2) levels in the respiration cycle. This method is crucial for preventing clinical issues and ensuring patient safety [12,58]. Capnography continuously measures the partial pressure of CO2 (PCO2) in exhaled and inhaled gases, estimating arterial CO2 levels. This measurement is achieved by capturing air just below the nose, which is then analyzed by the capnography device to quantify CO2, generating a characteristic waveform from which the respiration rate can also be derived [58,59]. Capnography has been a staple in clinical practice for over 25 years, particularly in anesthesia care, allowing for monitoring of patient consciousness during sedation. However, its use in intensive care units (ICUs) remains limited. A recent study indicates a significant correlation between morbidity and mortality rates and the underutilization of capnography in ICUs [58]. Shankar [58] suggests that capnography should be considered a routine monitoring tool, highlighting its value in assessing metabolic rates, airway integrity, cardiac output, and ventilation. Outside of clinical settings, capnography is increasingly used to monitor sleep apnea syndrome. Traditionally diagnosed using polysomnography or cardio-respiratory polygraphy—both costly and requiring specialized facilities—capnography alone has shown potential for early diagnosis of sleep apnea, as evidenced by Dziewas et al. [60]. Portable devices, like MediByte from Braebon Medical Company, offer home-based monitoring at a fraction of the cost of sleep laboratories [61]. Capnography is becoming a crucial vital sign in portable devices and is expected to see broader application outside clinical environments. Future efforts should focus on developing reliable, cost-effective, and portable capnography units with efficient calibration procedures [58]. An alternative method, **transcutaneous capnography (TcCO2)**, measures PCO2 through heated tissue but faces challenges such as calibration issues and potential burns due to high temperatures [62,63,64].

Body Temperature (BT):

Body temperature (BT) results from the equilibrium between heat production and heat dissipation in the body, making its measurement critical to prevent dysfunction caused by excessive temperatures (e.g., protein denaturation). BT is categorized into **core temperature (CT)** and **skin temperature**. Core temperature is more stable due to thermoregulatory mechanisms, whereas skin temperature fluctuates based on blood circulation, heart rate, and metabolic rate [65,66,67]. External factors like air circulation, ambient temperature, and humidity also influence thermoregulation [65,66]. Various wearable systems have been developed to monitor both core and skin temperatures, such as precision temperature sensors and adhesive devices [68,69,70]. A recent innovation includes a reusable wireless epidermal temperature sensor—a battery-less RFID thermometer—promising accurate CT estimation. Despite advances, non-invasive methods for CT measurement remain challenging due to the influence of external factors on physiological indicators. However, new algorithms like ECTempTM, which estimates CT based on heart rate and skin temperature, show potential for accurate real-time CT estimation and thermal-work strain assessment in military settings. Currently, the gold standard for CT measurement remains rectal temperature, though alternative methods such as telemetric pills offer better usability but are affected by variables like ingestion of hot or cold fluids [67,72].

Applications in Different Medical Departments:

In the emergency department (ED), real-time physiological monitoring is crucial for immediate patient assessment and intervention. Capnography is widely utilized to evaluate ventilation, providing vital information about CO2 levels in exhaled breath, which helps in diagnosing conditions such as respiratory distress or obstructive sleep apnea. This technology is integral for managing critically ill patients and guiding resuscitation efforts. Skin perspiration monitoring can offer insights into acute stress responses and hydration status, which is valuable in trauma cases where rapid physiological changes are observed. Additionally, body temperature measurements are essential for detecting hypothermia or hyperthermia, conditions that require prompt treatment to prevent further complications.

In the realm of health information, technological advancements are transforming data management and patient care. Skin perspiration sensors contribute to non-invasive biochemical monitoring, offering potential for integrating physiological data into electronic health records (EHRs). This data can be utilized for predictive analytics and personalized medicine, enhancing the accuracy of health assessments and treatment plans. Capnography data can also be incorporated into health information systems to monitor respiratory status trends, supporting clinical decision-making and improving patient outcomes.

Nursing practice benefits significantly from these technological advancements. Skin perspiration monitoring assists nurses in assessing patient hydration and stress levels, which is particularly useful in managing chronic conditions like cystic fibrosis or diabetes. Capnography allows nurses to continuously monitor patients’ respiratory functions, ensuring timely intervention in case of respiratory abnormalities. Body temperature monitoring, whether through wearable sensors or traditional methods, helps nurses manage fever, hypothermia, and other temperature-related issues effectively, enhancing patient care and comfort.

Pharmacists can leverage these technologies to improve medication management and patient safety. Capnography is useful in evaluating the effectiveness of respiratory therapies and adjusting medication dosages accordingly. Skin perspiration sensors can provide pharmacists with insights into how patients’ physiological responses may affect drug absorption and efficacy, especially in cases involving transdermal medications. Monitoring body temperature helps pharmacists in assessing the stability of medications, particularly those sensitive to temperature fluctuations, ensuring proper storage and handling. Overall, the integration of these advanced monitoring technologies across various medical departments enhances patient care, supports accurate diagnosis, and optimizes treatment strategies, reflecting a shift towards more personalized and data-driven healthcare practices.

Conclusion

Wearable Health Devices (WHDs) have significantly impacted healthcare by enabling continuous monitoring of vital signs, which facilitates early detection and management of medical conditions. Their applications span various medical departments, each benefiting from the unique capabilities of WHDs. In emergency care, WHDs provide crucial real-time data that enhances the responsiveness and effectiveness of interventions during critical situations. Continuous monitoring of vital signs such as heart rate and blood pressure helps in promptly identifying deterioration and adjusting treatment strategies, thereby improving patient outcomes and potentially saving lives. Within health information systems, WHDs contribute to the seamless integration of patient data with electronic health records (EHRs). This integration allows for more comprehensive and accurate patient records, supporting better-informed clinical decisions and fostering more efficient healthcare delivery. The ability of WHDs to transmit data directly to EHRs enhances the workflow and collaboration between healthcare providers. In nursing, WHDs offer significant benefits in managing chronic conditions and providing continuous patient monitoring. By tracking vital signs and physiological changes, nurses can more effectively monitor patient status, detect early signs of complications, and adjust care plans accordingly. This continuous feedback loop supports better patient management and enhances the quality of care. Pharmacists also gain from WHDs through improved medication adherence monitoring. Devices that track physiological responses related to medication intake can help in assessing patient compliance and the effectiveness of prescribed treatments. This capability is particularly valuable for chronic disease management, where consistent medication adherence is crucial for therapeutic success. Looking ahead, the future of WHDs in healthcare depends on advancements in several key areas. Enhancements in sensor accuracy and reliability will improve the precision of data collected, while innovations in battery technology and power efficiency will extend device usability. Improving the comfort and ergonomics of WHDs will make them more appealing for prolonged use, and better integration with healthcare systems will enhance data sharing and utility. Furthermore, addressing privacy and security concerns is essential as WHDs handle sensitive health information. Ensuring robust data protection and encryption will maintain patient trust and compliance with regulatory standards. Overall, WHDs hold immense potential to revolutionize patient care, making healthcare more proactive, personalized, and efficient.

References

1. Marco Di Rienzo, G.P.; Brambilla, G.; Ferratini, M.; Castiglioni, P. MagIC System: A New Textile-BasedWearable Device for Biological Signal Monitoring. Applicability in Daily Life and Clinical Setting. In Proceedings of the 2005 IEEE, Engineering in Medicine and Biology 27th Annual Conference 2005, Shangai, China, 1–4 September 2005; pp. 7167–7169.
2. Lymberis, A.G.L. Wearable health systems: From smart technologies to real applications. In Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, New York, NY, USA, 30 August–3 September 2006; pp. 6789–6792.
3. Rita Paradiso, G.L.; Taccini, N. A Wearable Health Care System Based on Knitted Integrated Sensors. *IEEE Trans. Inf. Technol. Biomed.* **2005**, *9*, 337–344.
4. Seoane, F.; Mohino-Herranz, I.; Ferreira, J.; Alvarez, L.; Buendia, R.; Ayllon, D.; Llerena, C.; Gil-Pita, R. Wearable biomedical measurement systems for

assessment of mental stress of combatants in real time. *Sensors* **2014**, *14*, 7120–7141.

5. Yilmaz, T.; Foster, R.; Hao, Y. Detecting vital signs with wearable wireless sensors. *Sensors* **2010**, *10*, 10837–10862.
6. Statista, B.I. *Wearable Device Sales Revenue Worldwide from 2016 to 2022 (in Billion U.S.Dollars)*; Statista Inc.: New York, NY, USA, 2017.
7. Yussuff, V.; Sanderson, R. *The World Market for Wireless Charging in Wearable Technology*; IHS: Englewood, CO, USA, 2014.
8. Khan, Y.; Ostfeld, A.E.; Lochner, C.M.; Pierre, A.; Arias, A.C. Monitoring of vital signs with flexible and wearable medical devices. *Adv. Mater.* **2016**, *28*, 4373–4395.
9. Majumder, S.; Mondal, T.; Deen, M.J. Wearable sensors for remote health monitoring. *Sensors* **2017**, *17*, 130.
10. Pantelopoulos, A.; Bourbakis, N.G. A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis. *IEEE Trans. Syst. Man Cybern. Part C Appl. Rev.* **2010**, *40*, 1–12.
11. Banaee, H.; Ahmed, M.U.; Loutfi, A. Data mining for wearable sensors in health monitoring systems: A review of recent trends and challenges. *Sensors* **2013**, *13*, 17472–17500.
12. Ahrens, T. The most important vital signs are not being measured. *Aust. Crit Care* **2008**, *21*, 3–5.
13. Elliott, M.C.A. Critical care: The eight vital signs of patient monitoring. *Br. J. Nurs.* **2012**, *21*, 621–625.
14. Xu, P.J.; Zhang, H.; Tao, X.M. Textile-structured electrodes for electrocardiogram. *Text. Prog.* **2008**, *40*, 183–213.
15. Chan, M.; Esteve, D.; Fourniols, J.Y.; Escriba, C.; Campo, E. Smart wearable systems: Current status and future challenges. *Artif. Intell. Med.* **2012**, *56*, 137–156.
16. Appelboom, G.; Camacho, E.; Abraham, M.E.; Bruce, S.S.; Dumont, E.L.; Zacharia, B.E.; D'Amico, R.; Slomian, J.; Reginster, J.Y.; Bruyere, O.; et al. Smart wearable body sensors for patient self-assessment and monitoring. *Arch. Public Health* **2014**, *72*, 28.
17. Saritha, C.; Sukanya, V.; Murthy, Y.N. ECG Signal Analysis Using Wavelet Transforms. *Bulg. J. Phys.* **2008**, *35*, 68–77.
18. Luo, N.; Ding, J.; Zhao, N.; Leung, B.H.K.; Poon, C.C.Y. Mobile Health: Design of Flexible and Stretchable Electrophysiological Sensors for Wearable Healthcare Systems. In Proceedings of the 2014 11th International Conference on Wearable and Implantable Body Sensor Networks, Zurich, Switzerland, 16–19 June 2014; pp. 87–91.
19. Giovangrandi, L.; Inan, O.T.; Banerjee, D.; Kovacs, G.T. Preliminary results from BCG and ECG measurements in the heart failure clinic. In Proceedings of the 2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, San Diego, CA, USA, 28 August–1 September 2012; pp. 3780–3783.
20. Syduzzaman, M.; Patwary, S.U.; Farhana, K.; Ahmed, S. Smart textiles and nano-technology: A general overview. *J. Text. Sci. Eng.* **2015**, *5*, 1000181.
21. Aleksandrowicz, A.; Leonhardt, S. Wireless and non-contact ECG measurement system—The "Aachen SmartChair". *Acta Polytech.* **2007**, *47*, 4–5.

22. Aarts, V.; Dellimore, K.H.; Wijshoff, R.; Derkx, R.; Laar, J.V.D.; Muehlsteff, J. Performance of an accelerometer-based pulse presence detection approach compared to a reference sensor. In Proceedings of the 14th Annual Body Sensor Networks Conference, Eindhoven, The Netherlands, 9–12 May 2017; pp. 165–168.
23. Xiao-Fei, T.; Yuan-Ting, Z.; Poon, C.C.Y.; Bonato, P. Wearable Medical Systems for p-Health. *IEEE Rev. Biomed. Eng.* **2008**, *1*, 62–74.
24. Turner, J.R.; Viera, A.J.; Shimbo, D. Ambulatory blood pressure monitoring in clinical practice: A review. *Am. J. Med.* **2015**, *128*, 14–20.
25. Puke, S.; Suzuki, T.; Nakayama, K.; Tanaka, H.; Minami, S. Blood pressure estimation from pulse wave velocity measured on the chest. In Proceedings of the 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Osaka, Japan, 3–7 July 2013; pp. 6107–6110.
26. Yu-Pin, H.; Young, D.J. Skin-Coupled Personal Wearable Ambulatory Pulse Wave Velocity Monitoring System Using Microelectromechanical Sensors. *IEEE Sens. J.* **2014**, *14*, 3490–3497.
27. Woo, S.H.; Choi, Y.Y.; Kim, D.J.; Bien, F.; Kim, J.J. Tissue-informative mechanism for wearable non-invasive continuous blood pressure monitoring. *Sci. Rep.* **2014**, *4*, 6618.
28. Guo, L.; Berglin, L.; Wiklund, U.; Mattila, H. Design of a garment-based sensing system for breathing monitoring. *Text. Res. J.* **2012**, *83*, 499–509.
29. Gandis, G.; Mazeika, M.; Rick Swanson, R. CRTT. Respiratory Inductance Plethysmography an Introduction. Available online: http://www.pro-tech.com/
30. Anmin, J.; Bin, Y.; Morren, G.; Duric, H.; Aarts, R.M. Performance evaluation of a tri-axial accelerometry-based respiration monitoring for ambient assisted living. In Proceedings of the Engineering in Medicine and Biology Society, Minneapolis, MN, USA, 3–6 September 2009; pp. 5677–5680.
31. Sharma, H.; Sharma, K.K.; Bhagat, O.L. Respiratory rate extraction from single-lead ECG using homomorphic filtering. *Comput. Biol. Med.* **2015**, *59*, 80–86.
32. Addison, P.S.; Watson, J.N.; Mestek, M.L.; Ochs, J.P.; Uribe, A.A.; Bergese, S.D. Pulse oximetry-derived respiratory rate in general care floor patients. *J. Clin. Monit. Comput.* **2015**, *29*, 113–120.
33. Chiu, Y.-Y.; Lin, W.-Y.; Wang, H.-Y.; Huang, S.-B.; Wu, M.-H. Development of a piezoelectric polyvinylidene fluoride (PVDF) polymer-based sensor patch for simultaneous heartbeat and respiration monitoring. *Sens. Actuators A Phys.* **2013**, *189*, 328–334.
34. Krehel, M.; Schmid, M.; Rossi, R.M.; Boesel, L.F.; Bona, G.L.; Scherer, L.J. An optical fibre-based sensor for respiratory monitoring. *Sensors* **2014**, *14*, 13088–13101.
35. AL-Khalidi, F.Q.; Saatchi, R.; Burke, D.; Elphick, H.; Tan, S. Respiration rate monitoring methods: A review. *Pediat. Pulmonol.* **2011**, *46*, 523–529.
36. Tognarelli, S.L.D.; Cecchi, F.; Scaramuzzo, R.; Cuttano, A.; Laschi, C.; Menciassi, A.; Dario, P. Analysis of a dielectric EAP as smart component for a neonatal respiratory simulator. In Proceedings of the 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Osaka, Japan, 3–7 July 2013; pp. 457–460.

37. Guo, X.; Huang, Y.; Zhao, Y.; Mao, L.; Gao, L.; Pan, W.; Zhang, Y.; Liu, P. Highly stretchable strain sensor based on SWCNTs/CB synergistic conductive network for wearable human-activity monitoring and recognition. *Smart Mater. Struct.* **2017**, *26*, 095017.
38. Tamura, T.; Maeda, Y.; Sekine, M.; Yoshida, M. Wearable Photoplethysmographic Sensors—Past and Present. *Electronics* **2014**, *3*, 282–302
39. Dias, D.; Ferreira, N.; Cunha, J.P.S. VitalLogger: An adaptable wearable physiology and body-area ambiance data logger for mobile applications. In Proceedings of the 2017 IEEE 14th International Conference on Wearable and Implantable Body Sensor Networks (BSN), Eindhoven, The Netherlands, 9–12 May 2017; pp. 71–74.
40. Sola, J.; Castoldi, S.; Chetelat, O. SpO2 Sensor Embedded in a Finger Ring: Desing and implementation. In Proceedings of the 2006 International Conference of the IEEE Engineering in Medicine and Biology Society, New York, NY, USA, 30 August–3 September 2006; pp. 4495–4498.
41. Mendelson, Y.; Dao, D.K.; Chon, K.H. Multi-channel pulse oximetry for wearable physiological monitoring. In Proceedings of the 2013 IEEE International Conference on Body Sensor Networks (BSN), MA, USA, USA, 6–9 May 2013; pp. 1–6.
42. Chen, C.-M.; Kwasnicki, R.; Lo, B.; Yang, G.Z. Wearable Tissue Oxygenation Monitoring Sensor and a Forearm Vascular Phantom Design for Data Validation. In Proceedings of the 11th International Conference on Wearable and Implantable Body Sensor Networks, Zurich, Switzerland, 16–19 June 2014; pp. 64–68.
43. Zysset, C.; Nasseri, N.; Büthe, L.; Münzenrieder, N.; Kinkeldei, T.; Petti, L.; Kleiser, S.; Salvatore, G.A.; Wolf, M.; Tröster, G. Textile integrated sensors and actuators for near-infrared spectroscopy. *Opt. Express* **2013**, *21*, 3213.
44. Krehel, M.; Wolf, M.; Boesel, L.F.; Rossi, R.M.; Bona, G.L.; Scherer, L.J. Development of a luminous textile for reflective pulse oximetry measurements. *Biomed. Opt. Express* **2014**, *5*, 2537–2547.
45. Medtronic MiniMed, I. Continuous Glucose Monitoring. Available online: https://www.medtronicdiabetes.com (accessed on 7 July 2017).
46. Dexcom, I. Dexcom G4 Platinum. Available online: http://www.dexcom.com/pt-PT
47. MedCityNews. FDA Approval for First Glucose Monitoring App. Available online: http://healthmanagement.org/ (accessed on 10 July 2017).
48. Takahashi, M.; Heo, Y.J.; Kawanishi, T.; Okitsu, T.; Takeuchi, S. Portable continuous glucose monitoring systems with implantable fluorescent hydrogel microfibers. In Proceedings of the 2013 IEEE 26th International Conference on Micro Electro Mechanical Systems (MEMS), Taipei, Taiwan, 20–24 January 2013; pp. 1089–1092.
49. Tierney, M.J.; Tamada, J.A.; Potts, R.O.; Jovanovic, L.; Garg, S. Clinical evaluation of the GlucoWatch® biographer: A continual, non-invasive glucose monitor for patients with diabetes. *Biosens. Bioelectron.* **2001**, *16*, 621–629.
50. So, C.F.; Choi, K.S.; Wong, T.K.; Chung, J.W. Recent advances in noninvasive glucose monitoring. *Med. Devices* **2012**, *5*, 45–52
51. Sobel, S.I.; Chomentowski, P.J.; Vyas, N.; Andre, D.; Toledo, F.G. Accuracy of a Novel Noninvasive Multisensor Technology to Estimate Glucose in Diabetic

Subjects During Dynamic Conditions. *J. Diabetes Sci. Technol.* **2014**, *8*, 54–63.

52. Wieringa, F.P.; Broers, N.J.H.; Kooman, J.P.; Van der Sande, F.M.; Van Hoof, C. Wearable sensors: Can they benefit patients with chronic kidney disease? *Expert Rev. Med. Devices* **2017**, *14*, 505–519
53. Jeehoon, K.; Sungjun, K.; Sangwon, S.; Kwangsuk, P. Highly wearable galvanic skin response sensor using flexible and conductive polymer foam. In Proceedings of the 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Chicago, IL, USA, 26–30 August 2014; pp. 6631–6634.
54. Nikolic-Popovic, J.; Goubran, R. Measuring heart rate, breathing rate and skin conductance during exercise. In Proceedings of the 2011 IEEE International Workshop on the Medical Measurements and Applications Proceedings (MeMeA), Bari, Italy, 30–31 May 2011; pp. 507–511.
55. Bandodkar, A.J.; Wang, J. Non-invasive wearable electrochemical sensors: A review. *Trends Biotechnol.* **2014**, *32*, 363–371.
56. Gengchen, L.; Smith, K.; Kaya, T. Implementation of a microfluidic conductivity sensor—A potential sweat electrolyte sensing system for dehydration detection. In Proceedings of the 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Chicago, IL, USA, 26–30 August 2014; pp. 1678–1681.
57. Koh, A.; Kang, D.; Xue, Y.; Lee, S.; Pielak, R.M.; Kim, J.; Hwang, T.; Min, S.; Banks, A.; Bastien, P. A soft, wearable microfluidic device for the capture, storage, and colorimetric sensing of sweat. *Sci. Transl. Med.* **2016**, *8*, 366ra165.
58. Kodali, B.S. Capnography outside the operating rooms. *Anesthesiology* **2013**, *118*, 192–201.
59. Wac, K.; Tsiourti, C. Ambulatory Assessment of Affect: Survey of Sensor Systems for Monitoring of Autonomic Nervous Systems Activation in Emotion. *IEEE Trans. Affect. Comput.* **2014**, *5*, 251–272.
60. Dziewas, R.E.A. Capnography screening for sleep apnea in patients with acute stroke. *Neurol. Res.* **2005**, *27*, 83–87.
61. Ontario, O.B.R.-T.O.J.F.B.I. Braebon Taps into the Growing Sleep Apnea Market. Available online: http://www.mri.gov.on.ca/obr/2012/07/braebon-taps-into-the-growing-sleep-apnea-market/
62. Orlikowski, D.; Prigent, H.; Ambrosi, X.; Vaugier, I.; Pottier, S.; Annane, D.; Lofaso, F.; Ogna, A. Comparison of ventilator-integrated end-tidal CO_2 and transcutaneous CO_2 monitoring in home-ventilated neuromuscular patients. *Respir. Med.* **2016**, *117*, 7–13.
63. Chatterjee, M.; Ge, X.; Kostov, Y.; Luu, P.; Tolosa, L.; Woo, H.; Viscardi, R.; Falk, S.; Potts, R.; Rao, G. A rate-based transcutaneous CO_2 sensor for noninvasive respiration monitoring. *Physiol. Meas.* **2015**, *36*, 883.
64. Horvath, C.M.; Brutsche, M.H.; Baty, F.; Rüdiger, J.J. Transcutaneous versus blood carbon dioxide monitoring during acute noninvasive ventilation in the emergency department—A retrospective analysis. *Swiss Med. Wkly.* **2016**, *146*, w14373.
65. Gaura, E.; Kemp, J.; Brusey, J. Leveraging knowledge from physiological data: On-body heat stress risk prediction with sensor networks. *IEEE Trans. Biomed. Circuits Syst.* **2013**, *7*, 861–879.

66. Buller, M.J.; Tharion, W.J.; Hoyt, R.W.; Jenkins, O.C. Estimation of human internal temperature from wearable physiological sensors. In Proceedings of the Twenty-Second Innovative Applications of Artificial Intelligence Conference (IAAI-10), Atlanta, GA, USA, 11–15 July 2010.
67. Buller, M.J.; Tharion, W.J.; Cheuvront, S.N.; Montain, S.J.; Kenefick, R.W.; Castellani, J.; Latzka, W.A.; Roberts, W.S.; Richter, M.; Jenkins, O.C.; et al. Estimation of human core temperature from sequential heart rate observations. *Physiol. Meas.* **2013**, *34*, 781.
68. Popovic, Z.; Momenroodaki, P.; Scheeler, R. Toward wearable wireless thermometers for internal body temperature measurements. *IEEE Commun. Mag.* **2014**, *52*, 118–125.
69. Boano, C.A.; Lasagni, M.; Romer, K.; Lange, T. Accurate Temperature Measurements for Medical Research Using Body Sensor Networks. In Proceedings of the 2011 14th IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing Workshops, Newport Beach, CA, USA, 28–31 March 2011; pp. 189–198.
70. Webb, R.C.; Bonifas, A.P.; Behnaz, A.; Zhang, Y.; Yu, K.J.; Cheng, H.; Shi, M.; Bian, Z.; Liu, Z.; Kim, Y.S.; et al. Ultrathin conformal devices for precise and continuous thermal characterization of human skin. *Nat. Mater.* **2013**, *12*, 938–944.
71. Miozzi, C.; Amendola, S.; Bergamini, A.; Marrocco, G. Reliability of a Re-usable Wireless Epidermal Temperature Sensor in Real Conditions. In Proceedings of the 14th Annual Body Sensor Networks Conference, Eindhoven, The Netherlands, 9–12 May 2017; pp. 95–98.
72. Xu, X.; Karis, A.J.; Buller, M.J.; Santee, W.R. Relationship between core temperature, skin temperature, and heat flux during exercise in heat. *Eur. J. Appl. Physiol.* **2013**, *113*, 2381–2389.

استخدام الأجهزة الصحية القابلة للارتداء للكشف المبكرعن الاضطرابات الطبية - التطبيقات في الأقسام الطبية المختلفة

الملخص:

الخلفية :تمثل الأجهزة الصحية القابلة للارتداء (WHDs) تكنولوجيا متقدمة تتطور بسرعة، تتيح مراقبة مستمرة للعلامات الحيوية في بيئات مختلفة، بما في ذلك البيئات الشخصية والسريرية. ظهرت هذه الأجهزة في أواخر التسعينات، حيث تجمع بين التكنولوجيا الطبية الحيوية وتكنولوجيا الميكرو والنانو، وهندسة المواد، وتقنيات المعلومات، والاتصالات. تهدف WHDs إلى تعزيز تمكين المرضى من خلال تسهيل إدارة الصحة الذاتية وتحسين التفاعل مع مقدمي الرعاية الصحية.

الهدف :يهدف هذا الاستعراض إلى تقييم التطبيقات الحالية والتطورات التكنولوجية لـ WHDs في الأقسام الطبية المختلفة، بما في ذلك الرعاية الطارئة، نظم المعلومات الصحية، التمريض، والصيدلة. يستكشف دورها في المراقبة المستمرة، والتشخيص، وإدارة المرضى.

الطرق :تم إجراء مراجعة أدبية شاملة، تركزت على التطورات الحديثة في تكنولوجياWHD ، وتطبيقاتها في سياقات طبية مختلفة، والاتجاهات المستقبلية. تشمل المجالات الرئيسية للتحقيق مراقبة العلامات الحيوية، تقنيات المستشعرات، وقابلية استخدام الأجهزة.

النتائج :أظهرت WHDs وعدًا كبيرًا في تطبيقات متنوعة. في الرعاية الطارئة، توفر مراقبة في الوقت الفعلي للحالات الحرجة، مما يحسن الكشف المبكر والاستجابة. في نظم المعلومات الصحية، تعزز جمع البيانات ودمجها مع السجلات الصحية الإلكترونية. تركز تطبيقات التمريض على المراقبة المستمرة للمرضى وإدارة الحالات المزمنة، بينما يستفيد الصيادلة من تتبع دقيق للالتزام بالأدوية.

الخاتمة :تحول WHDs الرعاية الصحية من خلال تقديم مراقبة مستمرة وغير مزعجة وبيانات قيمة لأقسام طبية مختلفة. قدرتها على الاندماج مع أنظمة الرعاية الصحية الحالية وتوفير رؤى قابلة للتنفيذ أمر حاسم لتعزيز رعاية المرضى وإدارتهم. ستعزز التحسينات المستقبلية في الدقة وعمر البطارية والراحة والتوافق من فعاليتها وتبنيها.

الكلمات الرئيسية :الأجهزة الصحية القابلة للارتداء، العلامات الحيوية، المراقبة المستمرة، التطبيقات الطبية، تكنولوجيا الرعاية الصحية.