European Economic Letters
ISSN 2323-5233
Vol 14, Issue 3 (2024)
http://eelet.org.uk

An Overview of Factors Impacting Usage of Wearable Internet of Things for Health Care Monitoring

Ayse B. Ersoy, Philip Eappen, Abidemi Fasanmi
Cape Breton University, Cape Breton University, Cape Breton University
Ayse_ersoy@cbu.ca, Philip_Eappen@cbu.ca, abidemi_fasanmi@cbu.ca

Abstract

Canada's healthcare system, renowned worldwide for its commitment to universal medical access, confronts numerous enduring and emerging challenges. These issues stem primarily from an aging population, a shortage of healthcare professionals, and the prevalence of chronic diseases such as diabetes, cardiovascular diseases, dementia, and hypertension. The integration of IoT technology into healthcare has shown significant progress, offering powerful tools for real-time data collection. This review commences with exploring various Wearable Internet of Things (WIoT) available in the market, juxtaposed with Canada's healthcare system. It delves into how these wearables contribute to addressing the nation's healthcare challenges, accompanied by a statistical examination of market growth and influence. This qualitative study aims to understand the factors impacting the use of wearable Internet of Things in health care management in Canada. Online observations of WIoT devices scrutinize various intelligent wearable products, their predominant usage patterns, and the challenges faced by the users. This preliminary investigation into Canada's healthcare WIoT market endeavors to enhance our understanding and guide further research to fulfill pertinent marketing requirements in a quantitative study.

Key Words: Wearable Internet of Things, Healthcare, Technology Adoption

I. Overview of wearable IoT devices in monitoring health and wellbeing and healthcare management

Wearable Internet of Things (WIoT) technologies have transformed prevention, treatment and healthcare management by allowing real-time data collection and analysis, resulting in pre-emptive healthcare interventions and personalized treatment regimens. Patients remote monitoring drastically reduce the number of unwanted hospital visits and breakthrough technology gadgets such as WIoT devices aid in the early detection of health issues, forecast complications, and aid timely intervention, making them particularly helpful for older or chronically ill patients. WIoT devices equipped with accelerometers and gyroscopes can also detect falls in elderly individuals and automatically notify caregivers or emergency services, offer fall prevention features by providing balance training and activity reminders (Pech et al., 2021; Warrington et al., 2021). WIoT devices are also effective instruments for tracking and controlling chronic diseases such as hypertension, diabetes, respiratory diseases, and cardiac diseases by facilitating the monitoring process (Labrador et al., 2023). In addition, WIoT for example, wearable glucose monitoring devices help patients gain insights into their health, thereby, preventing complications, and contribute to the effective management of their ongoing health issues.

Furthermore, WIoT can help patients with medication adherence, improved symptom management, and lifestyle adjustments, contributes to improving the overall patient well-being and holistic health. WIoT-enabled medication adherence devices also remind patients to take their medications regularly on time and track compliance.

WIoT devices can track sleep patterns, including duration, quality, and disturbances, which provides insights into sleep disorders such as insomnia and sleep apnea (Karasneh et al., 2022). WIoT devices can create recommendations for improving sleep hygiene and optimizing sleep routines (Al Mahmud et al., 2022). Additionally, some wearables detect vital signs and stress by measuring metrics, such as heart rate variability and skin conductance, and provide feedback or prompts for relaxation techniques like deep breathing or mindfulness exercises. WIOT wearables can also help users track their physical activity, exercise routines, calorie intake, and weight management goals. These tools offer gamification, goal-setting, and social sharing features to motivate users toward a healthier lifestyle (Hydari et al., 2023).

The healthcare management system also benefits from the use of WIoT devices transforming healthcare in incredible ways and providing valuable solution to monitoring the needs of patients, especially from rural areas. Researchers can also use WIoT devices to collect real-world data for clinical trials and population health studies. Moreover, these devices offer insights into patient behavior, treatment efficacy, and disease progression in diverse populations.

Innovative health technologies such as WIoT integrate traditional healthcare procedures with contemporary technology to deliver a high-quality healthcare across geographical boundaries. Healthcare providers can use various technologies, including wearable Internet of Things, to track patient symptoms and send data to distant servers for diagnosis and treatment

(Vajjhala & Eappen, 2023; Waleed et al., 2023). Depending on the communication range that separates the devices from the servers, the technologies employed by intelligent healthcare devices can be divided into two categories: short-range and long-range. According to Ahad et al. (2020), body area networks and WiMAX are examples of long-range wireless technologies. In contrast, Wi-Fi and Bluetooth are important short-range alternatives in competent healthcare.

Ahad et al. (2020) defined three categories that encompass the main requirements of intelligent healthcare systems — things-oriented, app-oriented, and semantics-oriented—. Ahad et al. (2020) asserts that intelligent healthcare systems are centered on responsiveness, reduced power consumption, increased efficiency, and flexible application. The legitimacy of data exchanges between smartphone applications and sensors is the main emphasis of app-oriented, novel healthcare designs. Semantic-oriented systems manage natural language execution techniques, emphasizing user experience and computational capabilities (Ahad et al., 2020).

Healthcare wearable devices and internal implants are commonly connected to servers via a pervasive computing application (Guk et al., 2019). This connection enables the devices to monitor a patient's sensor readings and alert physicians to positive or negative changes (Strang & Sun, 2019). Sensors have been used for a long time with pervasive computing applications to gather data from the physical environment (Strang, 2023). Binary sensors, such as pressure pads, door sensors, movement detectors, and contact switch sensors, are attached to household objects or infrastructure (Shen & Zhang, 2014). WIoT devices can effectively collect body temperature, blood pressure, pulse, oxygen saturation, electrocardiogram, blood glucose levels, and body movement and detect falls, car crashes, and chemical presence (Vaidhyanathan & Bulock, 2014; Strang, 2023).

II. Factors impacting utilization of IoT in healthcare.

Numerous endeavors have been made to forecast emerging markets, such as the burgeoning market for Internet of Things (IoT)-based healthcare and the diverse applications offered by IoT platforms. Projections suggest that the demand for these devices will persistently rise, paralleling the rapid expansion of the healthcare sector. The relationship between personalization and the intention to continue using a service was found to be partly influenced by perceived utility and community immersion. Moreover, the link between interactivity and the intention to continue usage was completely influenced by perceived usefulness and community immersion. Since the initial implementation of IoT devices, numerous advantages have emerged for patients, healthcare professionals, and the healthcare sector.

Gandhi and Ghosh (2018) note that five benefits of WIoT influence the utilization of IoT in healthcare. They also address the relationship between personalization and the intention to continue using a service. These five benefits are: a. Real-time Health Monitoring, b. Cost Reductions, c. Better patient experience, d. Enhanced Medication Management and, e. Real-time data analytics and predictive insights. All these benefits have been shown to impact the perceived utility, perceived usefulness, and community immersion.

III. Focus on the Canadian healthcare context

Canadian healthcare recognizes WIOT devices as valuable tools for improving healthcare delivery, enhancing patient outcomes, and optimizing resource utilization. Due to Canada's vast geography and dispersed population, remote patient monitoring is a valued application of WIoT devices (Tadrous et al., 2020). WIoT equips Canadian healthcare providers to monitor patients with chronic conditions remotely, reducing the need for frequent visits and improving access to care, especially in remote and rural areas.

WIoT devices enable aging while ensuring safety and well-being for Canada's growing elderly population. WIoT features such as fall detection, activity monitoring, and vital sign tracking help caregivers and healthcare professionals monitor elderly individuals and provide timely interventions (Buyting et al., 2022). Furthermore, chronic diseases such as diabetes, cardiovascular diseases, and respiratory conditions pose significant challenges to the Canadian healthcare system (Buyting et al., 2022). WIoT devices empower patients to manage their conditions by continuously monitoring critical health indicators and adherence to treatment plans, reducing hospital admissions and healthcare costs and providing better patient outcomes.

Telemedicine and virtual care adoption have accelerated in Canada, particularly in response to the COVID-19 pandemic. WIoT devices complement telehealth services by enabling remote consultations and facilitating the exchange of real-time health data between patients and healthcare providers, ensuring continuity of care and improving patient access to specialist consultations (Waleed et al., 2023). Canadian researchers leverage WIoT devices to conduct clinical trials, population health studies, and epidemiological research. These devices enable the collection of real-world data on patients' daily activities, health behaviors, and disease progression, contributing to evidence-based healthcare decision-making and developing personalized treatment strategies' devices have the potential to address disparities in healthcare access and outcomes across diverse populations in Canada, including Indigenous communities and underserved urban areas. By

facilitating remote monitoring, health education, and preventive interventions, WIoT devices help bridge gaps in healthcare access and improve health equity (Patterson et al., 2022).

WIoT technology offers a proactive and personalized solution, enabling seniors to manage their well-being and monitor their health. This transformative technology collects and transmits vital signs, activity levels, and medication adherence data to healthcare professionals and caregivers, enabling timely interventions and personalized treatment plans (John Dian et al., 2020). By embracing wearable IoT technology, seniors in Atlantic Canada can experience better health outcomes, fewer hospitalizations, and greater peace of mind. The number of older adults aged 65 and older in Canada has been increasing since 2017 and is predicted to grow. Atlantic Canada will have the most substantial number of seniors aged 85 or older in Canada, with people in that age group expected to make up more than 6% of each province's population (Davenport et al., 2009). Acting fast to provide our seniors with the quality healthcare facilities they deserve is crucial.

Investing in wearable IoT technology is a way to monitor seniors' health proactively, tailor treatment plans to their specific needs, and provide timely interventions when necessary. With this transformative technology, we can offer seniors in Atlantic Canada the care and support they need to live independently, happily, and healthily. Despite the growing elderly population and increased healthcare challenges, Atlantic Canada has a critical shortage of medical resources (Davenport et al., 2005; Giguere et al., 2018; Channer et al., 2020). Wearable technologies have emerged as potential solutions to resource shortages in the healthcare industry. Wearable devices monitor health metrics, aid in fall detection, and manage chronic diseases. Adoption depends on technological perceptions, psychological mindsets, socio-cultural influences, and cost. In addition, future trends show that wearable technology will integrate more AI (artificial intelligence) for precise health predictions. It is crucial to ensure the reliability and adoption of these technologies as the elderly population grows.

In Canada, strict regulations govern collecting, storing, and transmitting personal health information to protect patient privacy and confidentiality. Moreover, WIoT device manufacturers and healthcare organizations must adhere to federal and provincial privacy laws, such as the Personal Information Protection and Electronic Documents Act (PIPEDA) and provincial health information protection legislation, to ensure the secure handling of health data (Scassa, 2010)

There is a constant need to ensure that these devices conform to safety standards as well as comply with universal design standards such as equitable use, flexibility, simple and intuitive use, perceptible information, error tolerance, low physical effort, and being of the appropriate dimensions (Shapira & Goldenberg, 2005). To ensure these standards are met, research must constantly identify challenges in the intended users' requirements, design, and validation of WIOT devices. The growing population of older adults and decreased access to healthcare service centers is becoming more challenging in many parts of Canada, and the gap has been increasing for a while. WIoT, undoubtedly, has a significant role in addressing healthcare delivery gaps in Atlantic Canada.

IV. Theoretical Framework: Technology Acceptance Model (T.A.M..)

Davis (1989) introduced the Technology Acceptance Model (TAM) to explain the factors that influence people's adoption of information technologies, with a focus on perceived usability and ease of use as key drivers for technology adoption. The Innovative Technology Acceptance Model (TAM), as proposed by Davis (1989), highlights the factors that affect users' acceptance and usage of new technologies, emphasizing perceived usefulness and ease of use. Perceived usefulness refers to the extent to which users believe a system enhances job performance, while perceived ease of use indicates the level of effort required. Both factors collectively shape behavioral intentions and the adoption of technology (Bagozzi, Davis, & Warshaw, 1992).

TAM has been widely utilized in studies investigating technology acceptance and usability, leading to subsequent revisions such as TAM 2 (Venkatesh, 2000; Venkatesh & Davis, 2000) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). It serves as a fundamental framework for research and development across various technological domains.

Research on smart devices and healthcare clothing has identified factors that influence user acceptance. For example, Chae et al. (2009) examined the acceptance process of smart clothing, considering value variables such as sales price, and found that perceived ease of use indirectly influenced acceptance intention through perceived utility, while perceived usefulness influenced attitudes toward perceived value. Similarly, Noh and Park (2011) revealed that perceived usefulness and ease of use of sensor-based smart clothing positively impacted attitudes toward smart clothing, with price search behavior enhancing the TAM effect.

Perceived usefulness and ease of use are crucial variables in explaining technology acceptance within the TAM framework. These factors have been adapted in various ways to accommodate different age groups, target audiences, and device types

in the smart healthcare field, influencing acceptance intentions. Hsiao and Tang (2015) explored technology acceptance among the elderly for mobile healthcare systems, while Lunney et al. (2016) found that both perceived usefulness and perceived usability of TAM significantly influenced the acceptance of wearable fitness trackers, which are popular healthcare devices. Attitude influenced by these factors predicts users' inclination to adopt technology.
Just as systems and technologies are perceived as more useful when they are easier to use (Venkatesh & Davis, 2000), the ease of use during the adoption process and perceived usability after use are closely linked. They are fundamental factors that directly or indirectly impact the acceptance of smart devices. Therefore, developing user-friendly content and facilitating straightforward usage methods can enhance user acceptance of smart healthcare devices by simplifying the adoption process and ensuring effective health management post-usage.

V. Perceived utility and ease of use of WIoT in healthcare

A. Perceived Utility

While the smartwatches and wearable devices market is rapidly expanded, current sales remain relatively low (www.idc.com). Much research has examined consumer acceptance of new technologies and intelligent devices (Ziefle, Wilkowska, Schaar, 2010; Campbell, Aturinda et al., 2017). However, few studies have specifically measured acceptance levels in the realm of wearable health technologies. For instance, Chuah et al. (2016) developed a theoretical instrument based on the technological acceptance of smartwatches. Their instrument was completed by 226 students from the University of Malaysia, revealing that ease of use indirectly influences attitudes towards these devices. Chae (2009) and Basoglu (2017) found similar results regarding wearable technologies.

Literature reveals that aesthetic appeal positively affected usage intentions, though health impacts had no significant effect. Additionally, concerns about privacy and security have emerged as sophisticated online attacks target the vulnerability of these devices and the confidentiality of information. Demographic variables, such as age, also significantly influence the acceptance and use of health-related technological devices. Ziefle (2017) found that older adults were more favorable toward e-health technologies than younger individuals. Still, contradictory findings were reported, suggesting older adults may be more hesitant to adopt new technological devices due to cultural factors and previous experiences.

Furthermore, Rupp et al. (2018) analyzed motivation and confidence to use wearable technologies across different age groups, finding that age influenced usability. Older adults often experience more difficulty learning new technologies compared to younger individuals, which could lead to anxiety. Similar age-related differences have been observed in mobile health services, highlighting the importance of considering user age in designing and implementing wearable health technologies.

Monitoring capabilities are also one of the important features expected by the users. This is the ability to continuously monitor vital signs, such as heart rate, blood pressure, and blood glucose levels, and provides users with real-time feedback on their health status. Monitoring capabilities enable early detection of potential health issues, allowing for prompt intervention and preventive measures. Users can track their physical activity, sleep patterns, and other health-related metrics, gaining insights into their overall well-being.

B. Perceived Ease of Adoption

For a wearable device to be practically valuable in the real world, it must fulfill three key objectives: mobility, augmentation of reality, and context-sensitivity (Billinghurst & Starner 1999). Wearable devices need to seamlessly integrate into our daily lives by combining collaboration, computation, and context awareness to enhance personal productivity. These computational capabilities aim to free up mental resources, allowing individuals to focus more on creative activities. In a study focusing on the design factors of smart glasses, Ok, Basoglu, and Daim (2015) identified price as the most crucial and desired value, followed by the standalone nature of the device (i.e., not reliant on a smartphone), field of view (preferably wider), display resolution (higher resolution), and interaction method (hand gestures preferred over voice recognition and touchpad). Similarly, a study on smartwatches conducted by Jung, Kim, and Choi (2016) found that users prioritize the shape of the device, standalone communication capabilities (independent of smartphones), price, display size, and brand. Kim and Shin (2015) developed a Technology Acceptance Model (T.A.M.) that incorporated key psychological determinants of smartwatch adoption, including affective quality, relative advantage, mobility, availability, and subcultural appeal. Their research indicated that smartwatches' affective quality and relative advantage were associated with perceived usefulness, while mobility and availability contributed to perceived ease of use. Subcultural appeal and cost were identified as factors influencing user attitude and intention to use.

VI. Health Management Needs from WIoT Devices

A. Chronic condition management

Hospitals are using wearable technologies to monitor patients' blood pressure, temperature, blood glucose, and heart rate remotely instead of bringing them into a hospital environment (Torous et al., 2020; Eappen & Olujinmi, 2023). This advancement is especially important for patients with chronic diseases such as cardiac, hepatic, renal, and many other conditions, as monitoring vital signs such as blood pressure, temperature, and blood glucose is crucial (Eappen, 2022). Wearable technologies and digital health innovations can educate healthcare professionals and empower patients with real-time clinical alerts and prompt, live decision support from providers (Almallah & Doyle, 2020; Eappen, 2022).

B. Preventive healthcare monitoring

WIoT devices such as smartwatches and rings can continuously monitor human beings in real-time and detect illnesses early, including respiratory conditions, infectious diseases, and cardiac diseases. These devices collect physiological measurements and metrics such as body temperature, oxygen saturation, sleep patterns, step counts, and pulse rates (Guk et al., 2019). Wearable technology can also detect early indicators of contagious illnesses; some WIoT devices can also detect respiratory viral infections such as coronavirus (Cheong et al., 2022). Recent research suggests that it may even identify symptoms earlier. However, studies on respiratory viral infections have only focused on identifying symptoms at their onset and only looked backward to identify pre-symptoms. Infrastructure to carry out large-scale testing to predict respiratory virus infections is lacking in many healthcare systems; however, an early detection technique that uses a monitoring warning system could enable early self-isolation, treatment, and available resource allocation with high efficiency (Alavi et al., 2021).

In addition to enabling patients to be monitored from their homes, remotely accessible programs help manage their health better by preventing unnecessary travel that could expose patients to pandemics and infections (Haleem et al., 2021). Hospitals around the world, including Canada, the United Kingdom, the United States, and Australia, are investing heavily in innovative health informatics technologies such as WIoT to reduce the spread of diseases in emergency rooms, intensive care units, surgical units, pediatric units, and other departments (Haleem et al., 2021; Leite et al., 2020; Eappen & Olujinmi, 2022).

VII. Research Methodology

A. Research Objective

Research Objective.: To analyze the impact of WIoT in HCM within Canada and strategize for the future integration of WIoT to enhance health services in Canada.

B. Research Questions

2. What are the major application sectors of WIoT in healthcare in Canada, and how do these applications contribute to overcoming specific challenges within the healthcare system?

3. How do regional policies and programs in Canada impact the pricing and affordability of WIoT technologies in healthcare management, and to what extent do they encourage or hinder their usage?

4. What is the patient engagement and satisfaction level with WIoT-enabled healthcare services in Canada?

5. What are the major adoption barriers of WIoT usage or access, and how will new features help advance the future market of WIoT?

C. Methodology

This study explores factors that influence the adoption of wearable Internet of Things devices for healthcare monitoring and management.

The integration of WIoT devices within healthcare has garnered significant interest recently, with the promise of transforming healthcare monitoring and management through real-time data and personalized insights. However, the widespread adoption of WIoT devices faces numerous challenges, including concerns surrounding data security, technology utilization, and user acceptance. This qualitative research study explores the factors influencing the adoption of WIOT devices for healthcare monitoring and management, specifically focusing on understanding human behavior, experiences, and perspectives.

A qualitative research approach, commencing with the establishment of a research objective and the selection of a suitable methodology is used. Engagements across various social media and the internet were monitored and purposeful sampling conducted, explicitly targeting discussions related to WIoT devices in healthcare management.

Qualitative data collected through observing online impressions and engagement were analysed. Online observation is a technique utilized to examine interactions within virtual communities within their natural digital habitat. These communities offer various activities, such as social interactions and production processes, making them valuable for research. To ensure the methodological integrity of such studies, it is crucial to explicitly address the roles of online observers (Kristianssen, 2022). Academics have extensively explored internet-based data collection methods (Kanzaki et al., 2004; Pang et al., 2018; Shields, 2003), yet with the continuously evolving technological environment, there is a need for an updated reference. This article provides guidance and resources for researchers who need to shift their projects from traditional face-to-face qualitative data collection to methods that accommodate social distancing measures. The research methodology is rooted in understanding human behavior, experiences, reviews, feedback, and opinions directly from respondents. Identified barriers to adopting WIoT include data security and privacy, inadequate technology utilization, battery life, device design, and data inaccuracy, which hinder users from embracing this technology.

Primary research data collection involved observing reviews and feedback from various online platforms, including Google, Amazon, Twitter, and brand websites, across three categories of WIoT devices: Smartwatches, heart rate monitoring, blood sugar monitoring devices, and fall detection devices. A total of 2796 consumer posts were collected from 11 different WIoT brands over two months from October to November 2023, with a breakdown provided for each device type and brand.

Table 1

WIoT Device Type	**Brand**	**Online posts**
Smart Watches	Fitbit	529
	Fossil	172
	Apple Watch	147
	Google Pixel	110
	Hexoskin	840
	Venu SQ2	72
	Vivo Smart	232
Heart Rate/Blood Sugar Monitoring Devices	Kardia Mobile	110
	Oura Ring	100
	Lively Mobile Plus	17
Fall Detection	Life Assure	467
Total		**2796**

Content of data collected through observation and document analysis, were subsequently analysed to reveal prevalent patterns and themes. The findings are presented through narrative descriptions and pertinent quotations.

To ensure a rigorous qualitative analysis, the study employed advanced QSR NVivo software, known for its precision and reliability in content analysis. The meticulous application of this software contributes to the accuracy and appropriateness of outcomes within the context of qualitative research methodologies. Qualitative content analysis serves as a means for researchers to identify patterns and meanings within written or visual information, facilitating a more profound understanding across various fields such as sociology, psychology, education, and communication.

VIII. Research Results

Qualitative data analysis research results are given below under three main categories: Fitness trackers, health monitoring wearable garments, and fall detection devices.

A. Fitness activity tracking device results

i. Fitbit

Fitbit is a fitness and activity tracker worn on your wrist to help you keep track of your everyday lifestyle. Fitbit usage was tracked online by examining user engagement regarding the health-tracking features they prioritize when

purchasing Fitbit devices and their satisfaction levels. Five key health-tracking features were identified: blood glucose, oxygen saturation, heart rate, blood pressure, and body temperature. Comments from various online sources, including blogs, forums, and social media platforms, were gathered, assessed, and categorized for each tracking feature using 40 predefined codes. This classification enabled the quantification of code occurrence and frequency calculation for each feature. Generally speaking, comments reviewed for Fitbit are positive concerning accuracy and user interface. Key findings of the content analysis are summarised in Table 2 below.

Table 2

Construct	Description	Data Collection	User Comments
Glucose level measurement feature	How satisfied are the users in terms of measuring the glucose level	Consumer remarks and impressions online	People expected Fitbit to be able to measure glucose levels, but what this feature does is log data to see how glucose levels trend over time as well as see how glucose levels change throughout the day and react to physical activity,
Oxygen level measurement feature	How satisfied are the users in terms of measuring the oxygen level	Consumer remarks and impressions online	Predominantly negative perceptions. A majority of users indicated widespread dissatisfaction. Major issues, with 39% criticizing the quality and 29% doubting its reliability.
Accessibility	How seniors obtain and use Fitbit, focusing on channel distribution and user-friendly features.	Evaluation of Fitbit's privacy policy and security measures, analysis of customer reviews and feedback	Seniors find Fitbit easy to obtain and use, with appropriate channel distribution and user-friendly features.
User Interface	User-friendliness of the	Evaluation of Fitbit's privacy policy and security measures, analysis of customer reviews and feedback	Seniors find the Fitbit interface easy to use and navigate, and it meets the needs and preferences of both seniors and elderly care providers.
Trustworthiness	Fitbit's reliability with the privacy and accuracy of the health data it collects.	Analysis of customer reviews and feedback	Seniors trust Fitbit to protect their privacy and the accuracy of their health data.

ii. Apple Smart Watch

Apple.com defines Apple smartwatches as the ultimate device for a healthy life by measuring movements and providing meaningful health insights, innovative safety features, and a connection to the people you care about most. The key findings of the content analysis are summarised in below Table 3.

Table 3

Construct	Description	Data collection	Consumer comments
Reliability	How satisfied are the users in terms of the reliability of the Apple Smartwatch	Consumer remarks and impressions online	succeeded in creating devices that meet or exceed users' expectations regarding functionality and performance.

Data Accuracy	How satisfied are the users in terms of data and measurement accuracy	Consumer remarks and impressions online	Data accuracy is a critical factor in the effectiveness of wearable IoT devices. Based on the analysis, we concluded that 94.5% of the customers are satisfied with Apple watches' data quality and accuracy.
Accessibility	How satisfied are the users in accessing the device and internet connection?	Consumer remarks and impressions online	Opinions on accessibility were split, with 45-50% of respondents finding it difficult and easy to access wearable IoT devices. This indicates a lack of uniformity in user experiences
Cost	How satisfied are the users regarding the cost of acquiring an Apple Smartwatch?	Consumer remarks and impressions online	A significant 70% of respondents cited high costs as a major limiting factor in adopting wearable IoT devices among users.
Privacy	How satisfied are the users in terms of internet security and health data sharing	Consumer remarks and impressions online	Privacy emerged as a positive aspect, with 90% of reviewers expressing satisfaction with the privacy features of wearable IoT devices from Apple.

B. Smart Wearable Garments

i. Hexoskin-Related Results

Hexoskin is a smart garment with textile sensors embedded into comfortable clothing for precise, continuous cardiac, respiratory, and activity monitoring (www.hexoskin.com). Hexoskin's expertise lies in developing cutting-edge smart shirts that integrate comfort and functionality seamlessly.

The aim is to categorize the tweets into three primary sentiment categories: positive (GOOD), neutral, and negative (BAD), to gain valuable insights into the overall sentiment expressed by users regarding Hexoskin on the Twitter platform.

The analysis indicates that Moderately Positive sentiment is the most prevalent, occurring 144 times. Additionally, Very Positive sentiments are observed 27 times, Moderately Negative sentiments appear 53 times and Very Negative sentiments are present in 4 instances.

Table 4

Analysis Type	**Data collection method**	**Key Findings**
Content Analysis	Textual data from Twitter focused on tweets employing the hashtag' Hexoskin.' The critical analytical method involves conducting sentiment analysis on the compiled tweets.	The analysis highlights Moderately Positive as the most prevalent sentiment, occurring 144 times. Furthermore, Very Positive sentiments are observed 27 times, Moderately Negative sentiments appear 53 times and Very Negative sentiments are present in 4 instances.

Thematic Analysis		The recurrent mention of "athlete" and "fitness" underscores Hexoskin's strong association with physical well-being and exercise.
		Notably, the frequent references to "shirt" and "smart shirts" highlight the wearable nature of Hexoskin's technology, positioning it prominently in discussions at the intersection of fashion and health monitoring.
		Additionally, the term "responders" suggests potential applications in emergency response, showcasing the versatility of Hexoskin's monitoring capabilities.

C. Fall Detection Wearable Devices

i. Life Assure Related Results

The Life Assure Premium Mobile Plus is an all-encompassing medical alert device. Featuring two-way, hands-free voice communication directly through G.P.S. the unit, fall detection capabilities, and G.P.S. network location services (www.lifeassure.com).

Life Assure is active on Facebook, Instagram, X, and YouTube. The company has the greatest number of followers on Facebook.

On Facebook, the company's primary focus is on sharing customer reviews from various platforms. Additionally, they posted content related to Thanksgiving, Breast Cancer Awareness Day, and Halloween, along with a few motivational posts. A similar posting pattern was observed on Instagram and another platform referred to as X, although the frequency of posts was lower compared to Facebook. However, X displayed the number of views on each post, indicating higher overall engagement than Facebook.he company's online presence also includes reviews posted on Birdeye, a social media reputation management platform. Birdeye aids local businesses in improving their search engine ranking and expanding their customer base. Out of the 279 reviews available on Birdeye, 30 were posted between mid-September and mid-November, all of which were 5-star reviews, indicating an excellent reputation for the company.

Further analysis of the reviews was conducted, categorizing them based on identified keywords. Out of 200 reviews, 40 were blank with no accompanying comments. Among the remaining reviews, Life Assure received the highest number of positive reviews for customer service, followed by troubleshooting and assistance. This is particularly noteworthy considering that the lack of troubleshooting and assistance is often cited as a challenge in the implementation of IoT. Yet, Life Assure received a commendation in this aspect. Customers also frequently mentioned the effectiveness of the Alert system, the peace of mind provided by the device, and its ease of use, all of which are crucial factors for IoT implementation.

Interestingly, there were instances where customers initially posted negative reviews but updated them later after the company addressed their concerns. Customers reported not receiving the product in two cases, resulting in a low rating. Additionally, five instances of poor customer service were noted, primarily attributed to overly aggressive sales tactics that left customers uncomfortable.

Table 4

Terms Identified	Total Mentions in Reviews
Customer Service	138
Troubleshooting & Assistance	74
Alert/Alarm	13
Peace of Mind	11
Easy to Use	13

Fast Delivery	8
Good Quality of Product	6
Pendant/Bracelet	4
GPS System	2
Best Product	2
Easy Replacement	2
Limitation of Product	1
Making Senior Independent	1
Affordable	1
Bad Customer Service	5

IX . Limitations of the Study

This cross-sectional observational study was conducted only in the Canadian context; thus, future research can generalize the results to other parts of the world. Moreover, this study is subject to the same methodological limitations affecting survey-based research, including respondents' self-stigma, response bias, and reliability. In addition, all surveys are self-reported subjective perceptions; therefore, the chances of interpretation biases are high. Although we compared different WIoT devices, we did not compare perceptions across genders, age groups, and income groups. Furthermore, results gathered from these social media sites and engagements focused on privacy and security polices around use of WIoT and seldom on healthcare providers' perception and use of WIoT in addressing health and wellness care gaps.

X . Conclusion and Limitations of the Study

In conclusion, this qualitative research study provides valuable insights into the factors influencing the adoption of WIoT devices for healthcare monitoring and management. By uncovering barriers and understanding user perspectives, this study contributes to informing strategies to enhance the acceptance and utilization of WIoT devices in healthcare settings. This paper discusses the potential of WIoT devices for remotely monitoring patients in Canada and explains factors that influence usage decisions by customers. The innovation in WIoT allows healthcare professionals in Canada to use these techniques to monitor, predict, and treat health issues in patients from a distance. Adopting innovative healthcare informatics technologies, such as WIoT, helps healthcare systems deliver flexible models of care that go beyond traditional ways. However, implementing WIoT in healthcare will require a clear and robust code of practice for managing data, privacy, confidentiality, and cybersecurity concerning the supply and use of WIoT devices . Critical gaps remain to be addressed, especially in technology and user interfaces . Finally, more research is needed in the area of policies related to WIoT and to determine consumers' and clinicians' acceptability and digital literacy in using WIoT to improve healthcare delivery and the overall experience. Health care professional perspective is missing which needs to be investigated in the future study.

References

1. Ahad, M. A., Paiva, S., Tripathi, G., & Feroz, N. (2020, October) . Enabling technologies and sustainable smart cities. Sustainable Cities and Society, p. 61, 102301. https://doi.org/10.1016/j.scs.2020.102301
2. Al Mahmud, A., Wu, J., & Mubin, O. (2022, October 18). A scoping review of mobile apps for sleep management: user needs and design considerations. Frontiers in Psychiatry, 13. https://doi.org/10.3389/fpsyt.2022.1037927
3. Alavi, A., Bogu, G. K., Wang, M., Rangan, E. S., Brooks, A. W., Wang, Q., Higgs, E., Celli, A., Mishra, T., Metwally, A. A., Cha, K., Knowles, P., Alavi, A. A., Bhasin, R., Panchamukhi, S., Celis, D., Aditya, T., Honkala, A., Rolnik, B., . . . Snyder, M. P. (2021, November 29). Real-time alerting system for COVID-19 and other stress events using wearable data. Nature Medicine, 28(1), 175–184. https://doi.org/10.1038/s41591-021-01593-2
4. Almallah, Y. Z., & Doyle, D. J. (2020, December). Telehealth in the time of Corona: 'Doctor in the House.' Internal Medicine Journal, 50(12), 1578–1583. https://doi.org/10.1111/imj.15108
5. Big data in healthcare global market and regional analysis 2022-2031: Rise in the adoption of wearables, mobile health, and internet of medical things (IoMT). (2022, May 09) . NASDAQ OMX's News Release Distribution Channel Retrieved from https://cbu.idm.oclc.org/login?url=https://www.proquest.com/wire-feeds/big-data-healthcare-global-market-regional/docview/2660893284/se-2

6. Billinghurst, M., & Starner, T. (1999). New ways to manage information. Computer,32(1), 57–64
7. Buying, R., Melville, S., Chatur, H., White, C. W., Légaré, J. F., Lutchmedial, S., & Brunt, K. R. (2022, February). Virtual Care with Digital Technologies for Rural Canadians Living with Cardiovascular Disease. CJC Open, 4(2), 133–147. https://doi.org/10.1016/j.cjco.2021.09.027
8. Channer, N. S., Biglieri, S., & Hartt, M. (2021). Aging in rural Canada. In Aging People, Aging Places (pp. 141–148). Policy Press.
9. Cheong, S. H. R., Ng, Y. J. X., Lau, Y., & Lau, S. T. (2022, September). Wearable technology for early detection of COVID-19: A systematic scoping review. Preventive Medicine, p. 162, 107170. https://doi.org/10.1016/j.ypmed.2022.107170
10. Choi, J., & Kim, S. (2016). Is the smartwatch product or a fashion product? A study on factors affecting the intention to use smartwatches. Computers in Human Behavior,63, 777–786
11. Davenport J., Rathwell TA, & Rosenberg MW. (2009, Aug) . Aging in Atlantic Canada: service-rich and service-poor communities. Health Policy, 5(1): e145–60. PMID: 20676245; PMCID: PMC2732661.
12. Davenport, J., Rathwell, T. A., & Rosenberg, M. W. (2005). Service provision for seniors: challenges for communities in Atlantic Canada. Longwoods Review, 3(3), 9–16.
13. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. 1989, 13, 319–339. [CrossRef]
14. Davis, F.D.; Bagoz R.P..; Warshaw, P.R. User acceptance of computer technology: A comparison of two theoretical models. Manag. Sci. 1989, 35, 982–1003. [CrossRef]
15. Dian, F. J., Vahidnia, R., & Rahmati, A. (2020). Wearables and the Internet of Things (IoT), applications, opportunities, and challenges: A survey. IEEE Access, 8, 69200-69211.
16. Eappen, P. & Olujinmi, T. D. (2023). Telemedicine and Digital Public Health in Pandemic Times. In N. Vajjhala & P. Eappen (Eds.), Health Informatics and patient Safety in Times of Crisis (pp. 118-137). IGI Global. https://doi.org/10.4018/978-1-6684-5499-2.ch007
17. Eappen, P. (2022). Healthcare Informatics During the COVID-19 Pandemic. In N. Vajjhala & K. Strang (Eds.), Global Risk and Contingency Management Research in Times of Crisis (pp. 193-209). IGI Global. https://doi.org/10.4018/978-1-6684-5279-0.ch010
18. Giguere, A. M., Farmanova, E., Holroyd-Leduc, J. M., Straus, S. E., Urquhart, R., Carnovale, V., ... & Aubin, M. (2018). Key stakeholders' views on the quality-of-care services available to frail seniors in Canada. BMC geriatrics, 18, 1-14.
19. Guk, K., Han, G., Lim, J., Jeong, K., Kang, T., Lim, E. K., & Jung, J. (2019, May 29). Evolution of Wearable Devices with Real-Time Disease Monitoring for Personalized Healthcare. Nanomaterials, 9(6), 813. https://doi.org/10.3390/nano9060813
20. Haghi, M., Thurow, K., & Stoll, R. (2017). Wearable devices in the medical internet of things: scientific research and commercially available devices. Healthcare informatics research, 23(1), 4-15.
21. Haleem, A., Javaid, M., Singh, R. P., & Suman, R. (2021). Telemedicine for healthcare: capabilities, features, barriers, and applications. Sensors International, p. 2, 100117. https://doi.org/10.1016/j.sintl.2021.100117
22. Hydari, M. Z., Adjerid, I., & Striegel, A. D. (2023, July). Health Wearables, Gamification, and Healthy Activity. Management Science, 69(7), 3I.D.C.–3I.D.C.. https://doi.org/10.1287/mnsc.2022.4581
23. Forecasts Slower Growth for Wearables in 2018 Before Ramping Up Again through 2022, IDFramingham, 10 Mobile Information Systems MA, USA, 2018, https://www.idc.com/getdoc.jsp?containerIde prUS44276818.
24. J. I. Campbell, I. Aturinda, E. Mwesigwa, et al., Technology acceptance model for resource-limited settings (TAMRLS): a novel framework for mobile health interventions targeted to low-literacy end-users in resource-limited settings," AIDS and Behavior, vol. 21, no. 11, pp. 3129–3140, 2017.
25. J. M. Chae, "Consumer acceptance model of smart clothing according to innovation," International Journal of Human Ecology, vol. 10, no. 1, pp. 23–33, 2009.
26. Jang, B.; Lee, M.; Hwi Kim, M.; Jung Kim, H.; Yoo, H.; Kim, J.W. January. Infectious Disease Infection Index Information System. In Proceedings of the 2019 IEEE International Conference. in Consumer Electronics (ICCE), Las Vegas, NV, USA, 11–13 January 2019.
27. Jerew, O.; Al Bassam, N. Delay tolerance and energy saving in wireless sensor networks with a mobile base station. Hindawi Wirel. Commun. Mob. Comput. 2019, 2019, 3929876. [CrossRef]
28. Kang, M.J.; Hwang, Y.C. Exploring the Factors Affecting the Continued Usage Intention of T.A.M.-Based Healthcare Wearable Devices Using the TAM Model. Sustainability 2022, 14, 12492. https://doi.org/10.3390/su141912492
29. Karasneh, R. A., Al-Azzam, S. I., Alzoubi, K. H., Hawamdeh, S., Jarab, A. S., & Nusair, M. B. (2022, March). Smartphone applications for sleep tracking: ratings and perceptions about behavioral change among users. Sleep Science, 15(S 01), 65–73. https://doi.org/10.5935/1984-0063.20210007
30. Lavrador, M., Cabral, A. C., Castel-Branco, M., Figueiredo, I. V., & Fernández-Llimós, F. (2023). Polypharmacy and medication adherence. Elsevier EBooks: https://doi.org/10.1016/b978-0-12-823761-8.00014-8.

31. Leite, H., Hodgkinson, I. R., & Gruber, T. (2020, April 9). New development: 'Healing at a distance'—telemedicine and COVID-19. Public Money & Management, 40(6), 483–485. https://doi.org/10.1080/09540962.2020.1748855
32. M. A. Rupp, J. R. Michaelis, D. S. McConnell, and J. A. Smither, "0e role of individual differences on perceptions of wearable fitness device trust, usability, and motivational impact," Applied Ergonomics, vol. 70, pp. 77–87, 2018.
33. M. Ziefle and A. K. Schaar, "Technology acceptance by patients: empowerment and stigma," in Handbook of Smart Homes, Health Care and Well-Being, pp. 167–177, Springer, Berlin, Germany, 2017.
34. M. Ziefle and W. Wilkowska, "Technology acceptability for medical assistance," in Proceedings of 2010 4th International Conference on Pervasive Computing Technologies for Healthcare (Pervasive Health), pp. 1–9, Munich, Germany, March 2010.
35. Mukhopadhyay, S.C.; Suryadevara, N.K.; Nag, A Wearable sensor for healthcare: Fabrication to application. Sensors 2022, 22, 5137. [CrossRef]
36. N. Basoglu, A. E. Ok, and T. U. Daim, "What will it take to adopt smart glasses: a consumer choice-based review?" Technology in Society, vol. 50, pp. 50–56, 2017.
37. Noah, B.; Keller, M.S.; Mosadeghi, S.; Stein, L.; Johl, S.; Delshad, S.; Tashjian, V.C.; Lew, D.; Kwan, J.T.; Jusufagic, A.; et al. Impact of remote patient monitoring on clinical outcomes: An update meta-analysis of randomized controlled trials. NPJ Digit. Med. 2018, 1, 20172.
38. Okafor, K.C.; Achumba, I.E., Gloria, A.C.; Ononiwu, G.C. Leveraging fog computing for scalable IoT datacenter using spine-leaf network topology. J. Electr. Comput. Eng. 2017, 2017, 2363240. [CrossRef]
39. Patterson, P. B., Roddick, J., Pollack, C. A., & Dutton, D. J. (2022, June 30). Virtual care and the influence of a pandemic: necessary policy shifts to drive digital innovation in healthcare. Healthcare Management Forum, 35(5), 272–278. https://doi.org/10.1177/08404704221110084
40. Pech, M., Sauzeon, H., Yebda, T., Benois-Pineau, J., & Amieva, H. (2021, December 9). Falls Detection and Prevention Systems in Home Care for Older Adults: Myth or Reality? JMIR Aging, 4(4), e29744. https://doi.org/10.2196/29744
41. S. H.-W. Chuah, P. A. Rauschnabel, N. Krey, B. Nguyen, T. Ramayah, and S. Lade, "Wearable technologies: the role of usefulness and visibility in smartwatch adoption," Computers in Human Behavior, vol. 65, pp. 276–284, 2016.
42. Scassa, T. (n.d.). Information Privacy in Public Space: Location Data, Data Protection, and the Reasonable Expectation of Privacy. Schulich Law Scholars. https://digitalcommons.schulichlaw.dal.ca/cjlt/vol7/iss1/7/
43. Shapira, A., & Goldenberg, M. (2005). AHP-based equipment selection model for construction projects. Journal of construction engineering and management, 131(12), 1263–1273.
44. Smuck, M.; Odonkor, C.A.; Wilt, J.K.; Schmidt, N.; Swiernik, M.A. The emerging clinical role of wearables: FactN.P.J. for successful implementation in healthcare. NPJ Digit. Med. 2021, 4, 45. [CrossRef]
45. Statistics Canada (2022b). A Portrait of Canada's Growing Population Aged 85 and Older From the 2021 Census. Statistics Canada. https://www12.statcan.gc.ca/censusrecensement/2021/as-sa/98-200-X/2021004/98-200-x2021004-eng.cfm
46. Strang, K. D. (2023). How Could Machine Learning Help Healthcare Informatics Predict Coronavirus? In N. Vajjhala & P. Eappen (Eds.), Health Informatics a patient Safety in Times of Crisis (pp. 23-44). IGI Global. https://doi.org/10.4018/978-1-6684-5499-2.ch002
47. Strang, K. D., & Sun, Z. (2019, July 2). Hidden big data analytics issues in the healthcare industry. Health Informatics Journal, 26(2), 981–998. https://doi.org/10.1177/1460458219854603
48. Tadrous, M., Ahuja, T., Ghosh, B., & Kropp, R. (2020, May 29). Developing a Canadian Real-World Evidence Action Plan across the Drug Life Cycle. Healthcare Policy | Politiques de Santé, 15(4), 41–47. https://doi.org/10.12927/hcpol.2020.26225
49. Tam, T. (2020). Aging and Chronic Diseases: A Profile of Canadian Seniors. Public Health Agency of Canada.
50. Torous, J., Jän Myrick, K., Rauseo-Ricupero, N., & Firth, J. (2020, March 26). Digital Mental Health and COVID-19: Using Technology Today to Accelerate the Curve on Access and Quality Tomorrow. JMIR Mental Health, 7(3), e18848. https://doi.org/10.2196/18848
51. Vaidhyanathan, S., & Bulock, C. (2014, May). Knowledge and Dignity in the Era of "Big Data." The Serials Librarian, 66(1–4), pp. 49–64. https://doi.org/10.1080/0361526x.2014.879805
52. Vajjhala, N. R., & Eappen, P. (2023, April 11). The Role of 5G Networks in Healthcare Applications. Applications of 5G and Beyond in Smart Cities, pp. 87–98. https://doi.org/10.1201/9781003227861-5
53. Venkatesh, V.; Davis, F.D. A theoretical extension of the technology acceptance model: Four longitudinal field studies. Manag. Sci. 2000, 46, 186–204. [CrossRef]
54. Waleed, M., Kamal, T., Um, T. W., Hafeez, A., Habib, B., & Skouby, K. E. (2023, July 28). Unlocking Insights in IoT-Based Patient Monitoring: Methods for Encompassing Large-Data Challenges. Sensors, 23(15), 6760. https://doi.org/10.3390/s23156760

55. Warrington, D. J., Shortis, E. J., & Whittaker, P. J. (2021, November 14). Are wearable devices effective for preventing and detecting falls: a review (a review of systematic reviews). BMC Public Health, 21(1). https://doi.org/10.1186/s12889-021-12169-7
56. Wu, H. (n.d.). Nutritional Supplementation and Skeletal Muscle Health in Chronic Diseases. Scholar Works@UARK. https://scholarworks.uark.edu/etd/3591/
57. Yang, Y.; Wang, X. Modeling the intention to use machine translation for student translators: An extension of technology acceptance model. Comput. Educ. 2019, 133, 116–126. [CrossRef]