Wearable Technology and Consumer Interaction: A Systematic Review and Research Agenda

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Abstract

There has been exponential growth is the use of wearable technology, and these are now considered to be of critical importance in certain consumer goods and services sectors, including healthcare. However, research on this topic remains fragmented, and the approaches to aid its study and enhance the understanding of how these technologies are used and its implications for the future have not yet been delimited. Thus, this study aims at identifying the different trends and themes prevailing in the literature on wearable technology. Through a systematic literature review, using bibliometric analysis, we identify five themes: i) Wearable technology decision-making; ii) Wearable technology well-being; iii) Wearable technology consumer behavior; iv) Wearable technology utility, and v) Wearable technology and big data analytics. Our analysis of the review data suggests that despite being multidisciplinary, there is a lack of integration between this research field's micro and macro perspectives of this research field. This lack of integration and dialogue has led to several disconnected constructed terminologies, overlapping research questions, studies that are not based on appropriate results, fragmentation, and mixing or confusion of different theories. The study articulates key questions that could drive future research on wearables and consumer interaction.

Keywords: wearable technology; digital technologies; consumer behavior; systematic literature review; bibliometric techniques

1. Introduction

There has been a remarkable growth in consumers' interaction with technology and artificial intelligence over the last decade (Ameen, Tarhini, Reppel, & Anand, 2021). The use of wearable technology by consumers is part of this contemporary technological revolution. Wright and Keith (2014) describe wearable technology, wearable devices, or simply wearables as intelligent computers incorporated into different accessories, including clothing, fashion accessories, and other everyday items worn by consumers. These devices are designed to provide users with a seamless, integrated solution that has long been expected of computers. There has been a rapid increase in the introduction of new computer wearables, with contemporary products featuring a combination of sensors and computing devices embedded in clothing and fashion accessories, such as activity tracking bracelets or smartwatches (Friedman, 2017; Nieroda et al., 2018).

An extension of the wearables is the *wearable healthcare technology*, which has the potential to offer an effective way to meet the growing demand for equipment to assist and support the elderly (Srizongkhram et al., 2018; Talukder et al., 2020). Specifically, the technology can be used to monitor the health of the elderly, to decrease the rate of hospitalization and mortality, alert caregivers/medicos about diseases, improve mental life, provide a healthier lifestyle, and assist in emergency management (Kekade et al., 2018; Lee & Lee, 2018). Thus, wearables are intended to help consumers achieve a state of self-connection by using sensors and software that facilitate data exchange, communication, and access to information in real-time. For this reason, wearable devices are a large part of the content of the Internet of Things (IoT) (Kalantari, 2017; Sharma & Biros, 2019; Sun et al., 2016; Wang, 2015). Therefore, reflecting its contemporary usage, wearables can be said to include smart electronic devices that are worn close to or on the skin's surface and can transmit data and related information to the users.

The technological changes brought about by these products have disrupted the marketing environment (Barczak, 2016). Rajagopal and Burnkrant (2009) suggest that incorporating technology into everyday products has ultimately yielded numerous complex, multifunctional hybrid products, such as activity trackers and organizers in watches. The most complex part of these devices is that since they perform multiple activities, wearables require a different design, marketing, and positioning approaches than those used for traditional products. These developments provide the opportunity for research on wearable technology and its consumption trends to be used by marketers and the scientific community to make the theoretical and practical advances needed to enhance the global knowledge-based economy.

As wearables' manufacturing and marketing have extended beyond fashion, so has the academic literature in this area. There have been some efforts to attempt to systematize the literature on wearable technology. For example, Khakurel et al. (2017) intended to provide a heuristic overview of recent trends in wearable technology while assessing its potential in the workplace. Kalantari's (2017) review of the literature focused on the differences in the speed between adopting wearables and adopting other types of technologies. Recently, Khakurel et al. (2018) undertook a systematic review in which they aimed to expand current knowledge on the trend of wearable technology to assess its potential in the workplace and the challenges related to the use of wearables in the workplace. Wu and Luo (2019) focus on wearable technology applications in healthcare, and Mahloko and Adebesin (2020) addressed the factors that influence the accuracy of

the data collected by the consumer wearable health device for measuring heart rate, physical activity, and monitoring sleep patterns.

Despite these studies' existence, the topic area remains scattered between the healthcare and marketing areas and lacks a holistic review of the literature. Such a review is required to clearly and effectively map the evolution of knowledge in this field and highlight the contextual approaches and guidelines that support it. To stimulate academic improvement and provide a better sense of direction, we offer in this research a systematic review of this literature based on the following questions: i) what are the various concepts and issues covered in the wearable technology literature? and ii) what are the theoretical, contextual, and methodological guidelines applied in wearable technology research?

This study makes several important contributions. First, we present a systematic literature review on wearable technology using bibliometric techniques. Our review highlights not only what the previous literature has analyzed about wearable technology but also prepares the ground for the second wave of research on this topic, synthesizing the main gaps in knowledge and the emerging trends in studies. Second, we review several prevailing theoretical/conceptual assumptions in wearable technology research and offer perspectives that may shape future research. Third, we articulate a roadmap for a future research agenda by proposing multiple directions that can open new avenues for future research and construct relevant and appropriate theories for measuring wearable technology contributions.

In a systematic review of 74 publications on wearable technology, we summarize and categorize existing studies in this field using bibliometric analysis. More specifically, this study aims to i) identify the fundamental contributions of research in this area of knowledge; and ii) determine the lines of research that constitute the most prominent intellectual structure to contribute to the definition of a future research agenda.

The next section presents an overview of wearable technology and consumer reactions, followed by an explanation of the methodology used in this systematic review. This study's results in terms of the core domains of wearable technology, their intellectual and collaborative structures, and the results of co-citation networks are then discussed. The final section concludes by suggesting paths for future research and discusses the limitations of the study.

2. Wearable technology and consumer reactions

The history of wearable computers as an idea can be traced back to 1955 when Edward Thorp and Claude Shannon invented a device that was small enough to be worn by a person around their body and was used to beat Las Vegas casinos at the roulette wheel by predicting where the ball would land (Fernández-Carmés & Fraga-Lamas, 2018). Further advancements in the field were made in the 1960s (experimentation with smart glasses and helmets), 1970s (wearable devices to assist photographers with lighting), and 1980s and 1990s (augmented reality and smart shirts aimed at monitoring an individual's vital signs) (Fernández-Carmés & Fraga-Lamas, 2018). The market for wearables is expected to grow to US$160 billion by the year 2026 as the technology shifts from detachable components to embedded systems such as textile-embedded sensors, actuators, and therapeutic solutions (Jayathilaka et al., 2019).

Consumer reactions are behavioral intentions that later turn into real behaviors or as the acceptance of technology (Davis, 1989; Fishbein & Ajzen, 1975; Venkatesh et al., 2012). Some studies suggest that intentions are associated with the use of a particular good or service (Kim et al., 2008; Kim & Forsythe, 2008). Thus, consumer reactions can be considered a response that expresses and predicts consumers' intentions to adopt the technology, often described as a linear process (Rogers, 2003). However, this process is iterative as consumers may later change their intentions towards the technology (Joseph, 2005; Kleijnen et al., 2009; Laukkanen et al., 2008). Hence, the term wearable technology or "wearables" has more relevance in today's digital world that we live in. Wearables are not just any items that can be used or carried on the body; they are strongly linked to advanced technology (Kalantari, 2017). For this study, we consider wearables as technology-based products that are not only worn by consumers but are also intelligent enough to incorporate information technologies that communicate autonomously and process information in motion (Park et al., 2014).

Thus, wearables cover various devices such as smartwatches, smart glasses, activity trackers, head-mounted monitors, contact lenses, smart clothing, jewelry (e.g., smart rings), tiaras, and bracelets. Kalantari (2017) gives several examples of wearables such as Google Glass, Microsoft HoloLens, Apple Watch, Pebble Smartwatch, Fitbit fitness tracker, Oculus Rift virtual reality goggles, 9Solutions' Real-Time Locating Systems, iKey wearable keyboard, among others.

Robson, Pitt, and Kietzmann (2016) highlight how firms can equip employees with wearables to identify and overcome performance bottlenecks. The data generated from the wearables can play an important role in improving key business processes and

can help companies achieve savings while increasing efficiency in manufacturing, service, industry, and commerce (Abraham & Annunziata, 2017). From smart clothing used to observe individuals working with hazardous materials, to accelerated access to information in real-time, wearable technology can improve service industries' decisions and actions. In general, this technology can be used as an evolutionary tool for workforce training and provide remote customer services like technical support to solve problems more efficiently (Kalantari, 2017).

As highlighted earlier, the health sector is of particular importance for using wearables as they can provide solutions to reduce medical costs (Behkami & Daim, 2012). According to Roman et al. (2015), if the vast majority of individuals adopt wearable healthcare devices, the national health services' savings could reach billions of dollars. However, despite the expected benefits of wearable healthcare devices, the market for these devices is still at an early stage. Barnes, Kauffman and Connolly (2014) concluded that while many people are interested in wearable healthcare devices, only a small number have adopted a wearable healthcare device. Therefore, to expedite the adoption of wearable health services through devices, it is critical to understand which factors influence consumers' intent to adopt them (Lee & Lee, 2018).

A challenge faced by the sector is ensuring that the use of wearable technology by consumers can be sustained. Lee, Kim, Ryoo, and Shin (2016) address this issue and highlight that a third of American consumers stop using wearable products within six months of their purchase. Hence, the interaction between wearables and the consumers needs to move from being seen as a short-term status symbol or fad to be considered a necessary accessory that enhances their day-to-day activities. Addressing this and other related limitations and challenges are key to such technologies' future growth and success. By systematically consolidating and categorizing the literature, this study attempts to highlight the current research trends on the use of wearables and the challenges associated with it and provides directions for future research.

3. Methodology

This study uses the systematic literature review method to identify and review the extant research on wearable technology. The method was chosen as it allows the synthesis of the literature accurately and according to rigorous standards (Malinen, 2015; van Laar et al., 2017). As highlighted by Tranfield, Denyer, and Smart (2003), systematic literature

reviews differ from traditional narrative reviews in that they adopt a process that is replicable, scientific, and transparent. Literature reviews can either attempt to chronologically trace back the origins of an issue (author-centric review) or guide readers through how prior studies have contributed to the development of concepts and phenomena of interest (theme-centric review) (Linnenluecke, Marrone, & Singh, 2020). As this study's focus is to highlight the current development of the field and areas of future research interest, we followed the theme-centric review process.

We followed the review steps identified by Linnenluecke et al. (2020) to undertake a systematic literature review. The first step involves identifying literature for inclusion by setting criteria such as search keywords and searching for them within established databases. The next step involves cleaning the data and removing duplicates, followed by the analysis and synthesis of the evidence. This includes thematic coding to synthesize and categorize studies. The final step involves the presentation of the results from the systematic literature review. Some ways of presenting it include qualitative or quantitative meta-analyses or bibliographic mapping (Linnenluecke et al., 2020).

Intending to present a comprehensive review of the literature on wearable technology, we searched for relevant publications in the Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index - Science, Conference Proceedings Citation Index - Social Science & Humanities and Emerging Sources Citation Index (ESCI) compiled by Clarivate Analytics' online Web of Science databases.

The search was conducted using the following expression "TS = ("wearable*" or "fashion technolog*" or "tech tog*" or "fashion electronic*") and ("consumer*" or "buyer*" or "purchaser*" or "customer*" or "shopper*") and SU = ("BEHAVIORAL SCIENCES" OR "BUSINESS ECONOMICS" OR "PSYCHOLOGY" OR "SOCIAL SCIENCES OTHER TOPICS" OR "COMMUNICATION" OR "OPERATIONS RESEARCH MANAGEMENT SCIENCE" OR "PUBLIC ADMINISTRATION"). The search was conducted in January 2020 and covered all documents published until the year 2019.

The search resulted in 74 publications, 54 of these were journal articles and 14 published in conference proceedings. Table 1 provides a summary of these publications, with the earliest research published in 2007.

Table 1 ***Summary of documents***

Description	Results
Documents	74
Sources (Journals, Books, etc.)	51
Keywords Plus (ID)	257
Author's Keywords (DE)	284
Period	2007 - 2019
Average citations per documents	11.23
Authors	215
Author Appearances	238
Authors of single-authored documents	8
Authors of multi-authored documents	207
Single-authored documents	9
Documents per Author	0.33
Authors per Document	3.03
Document types	
Article	54
Editorial Material	1
Meeting Abstract	1
Proceedings Paper	14
Review	1

A descriptive analysis of the 74 publications was undertaken, mainly graphic methods, frequency tables, and descriptive measurements (mean and standard deviation). The analysis of co-citations has been adopted as the standard since the 1970s and has enjoyed a predominant position in the bibliometric analysis. This form of analysis is useful because if a set of articles is cited simultaneously by some references, potentially there are common ideas among these articles that generally represent the central themes and intellectual structures of an area of knowledge (Leydesdorff & Vaughan, 2006).

For the graphic mapping of the co-citation analysis, network theory was used, and the determination of clusters was performed using the methodologies adopted by Waltman, van Eck, and Noyons (2010). All calculations were performed using Microsoft Excel, NetDraw version 2.148 (Borgatti, 2002), and VOSviewer version 1.6.5 (van Eck & Waltman, 2009, 2010).

4. Results

4.1 Characterization of bibliographical references

Figure 1 shows the annual evolution of the number of studies published during the duration of the period covered in this study. The average year of publication is 2017.1 ± 2.3, which shows that this is an emerging research field. The results show that research

on the subject began to be published more frequently from 2016 onwards. The year 2018 (20 publications) was the one in which the greatest number of publications were observed. This increase in publications coincides with the development and launch of smartwatches by Apple, Samsung, Sony, and other technology firms. The widespread acceptance and use by consumers of these wearables could be seen as a driver for the increased number of studies.

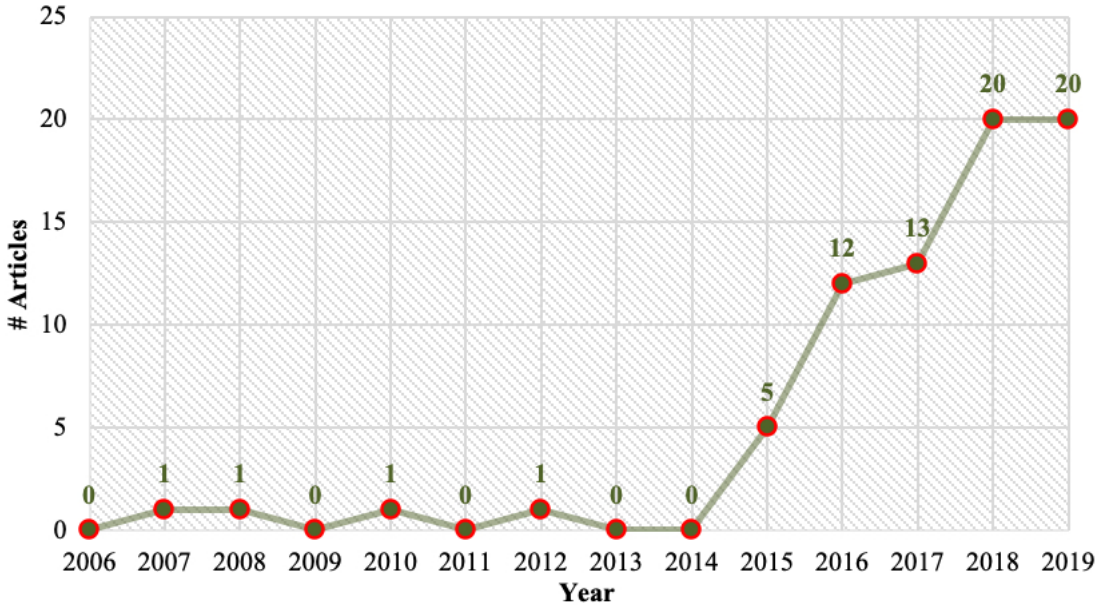

Fig. 1 Number of articles by year of publication

The 74 references have an average of 11.0 ± 15.9 citations, 21 references (28.4%) had no citations, and approximately half of the references (38) had a maximum of 4 citations. Table 2 presents the five most cited references and the five references with the highest citations per year.

Table 2 Most cited references

Articles	**# citations**
Chuah et al. (2016)	75
Rauschnabel, Brem, & Ivens (2015)	54
Morris & Aguilera (2012)	51
Aladren, Lopez-Nicolas, Puig, & Guerrero (2016)	49
Venkatesh, Joy, Sherry Jr., & Deschenes (2010)	47
	# citations/year
Chuah et al. (2016)	15

Shin (2017)	10.5
Aladren, Lopez-Nicolas, Puig, & Guerrero (2016)	9.8
Choi & Kim (2016)	9.2
Rauschnabel, Brem, & Ivens (2015)	9

There were 215 researchers who authored these 74 publications. Table 3 shows the authors with at least two publications and the number of fractionalized publications (ratio of published articles to the number of authors). Rauschnabel, P. A. stands out as the authors with the highest number of published references (8 articles), followed by Li, H. (4 articles), Wu, J. (4 articles), and Lin, Z. (3 articles).

Table 3 Authors with the most publications

Authors	**# Articles**	**Authors**	**# Articles Fractionalized**
Rauschnabel, P. A.	8	Rauschnabel, P. A.	3.9
Li, H.	4	Banerjee, S.	1
Wu, J.	4	Gidaris, C.	1
Lin, Z.	3	Haggett, A.	1
Brem, A.	2	Li, H.	1
Chuah, S. H. W.	2	Lyall, B.	1
Kim, S.	2	Mastrocola, V. M.	1
Krey, N.	2	Shin, D. H.	1
Ramayah, T.	2	Wissinger, E.	1
Rauschnabel, P.	2	Wu, J.	1
Ro, Y. K.	2		
Zheng, H.	2		

Regarding these studies' sources, the 74 publications included in the review were published in 51 sources. Table 4 shows the sources with the highest number of publications, highlighting *Computers in Human Behavior* (7 references), *Augmented Reality and Virtual Reality: Empowering Human Place and Business* (4 references), *Technological Forecasting and Social Change* (4 references), and *Journal of Services Marketing* (3 references).

Table 4 Sources with the most publications

Sources	**# Articles**
Computers in Human Behavior	7

Augmented Reality and Virtual Reality: Empowering Human Place and Business	4
Technological Forecasting and Social Change	4
Journal of Services Marketing	3
Applied Ergonomics	2
Information & Management	2
Journal of Business Research	2
Journal of Retailing and Consumer Services	2
Technology in Society	2
World Conference on Technology Innovation and Entrepreneurship	2

The countries with the greatest research expertise in the area are highlighted in Table 5. Authors from the USA (32 publications), UK (12 publications), Germany (113 publications), China (11 publications), and South Korea (7 publications) had the greatest number of publications.

Table 5 Countries with the most publications

Country	**# Articles**
USA	32
UK	12
Germany	11
China	11
South Korea	7
Finland	5
Australia	5
Sweden	4
Canada	4
Brazil	3

4.2 Co-citations analysis

The initial sample of 74 publications was cited 816 times. The sample was further refined to only include publications with at least 10 citations to allow for co-citation analysis, which reduced the final number to 28 publications. To visually present the results, we used the network theory, elaborating a network for its representation (Figure 2), and later applied cluster analysis, which allowed us to obtain homogeneous groups of articles (Figure 2 and Table 6).

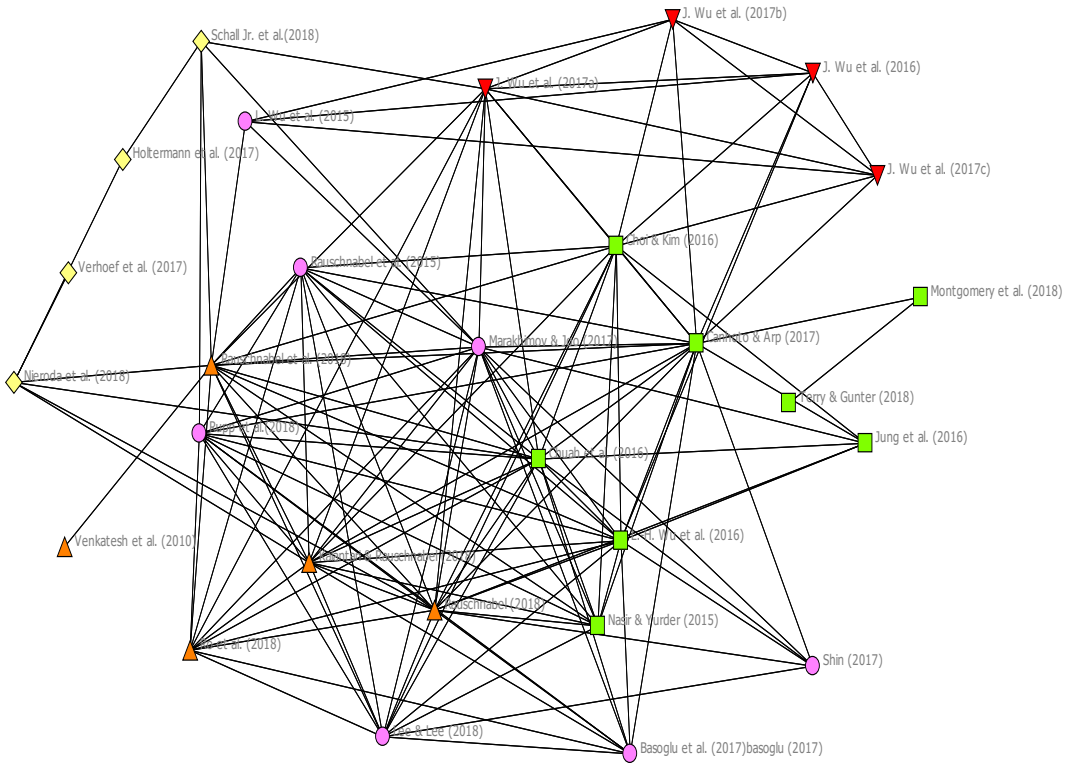

Fig. 2 Network of co-citations of the 28 publications and their clusters

Table 6 Grouping resulting from the cluster analysis of the co-citation analysis

Article	**Cluster**
Rauschnabel et al. (2015) Shin (2017) Marakhimov & Joo (2017) Rupp, Michaelis, McConnell, & Smither (2018) Wu, Fan, & Mattila (2015) Lee & Lee (2018) Basoglu, Ok, & Daim (2017)	1
Chuah et al. (2016) Choi & Kim (2016) Jung, Kim, & Choi (2016) Wu, Wu, & Chang (2016) Canhoto & Arp (2017) Nasir & Yurder (2015) Montgomery, Chester, & Kopp (2018) Terry & Gunter (2018)	2
Venkatesh et al. (2010) Rauschnabel, He, & Ro (2018) Rauschnabel (2018) Kalantari & Rauschnabel (2018) Ro, Brem, & Rauschnabel (2018)	3
Verhoef et al. (2017)	4

Schall Jr., Sesek, & Cavuoto (2018) Holtermann et al. (2017) Nieroda, Mrad, & Solomon (2018)	
Wu, Li, Cheng, & Lin (2016) Wu, Li, Lin, & Goh (2017) Wu, Li, Lin, & Zheng (2017a) Wu, Li, Liu, & Zheng (2017b)	5

These clusters represent the key themes identified in the literature and are discussed next.

5. Themes in the Wearable Technology and Consumer Interaction Literature

5.1 Wearable technology and decision-making (Cluster 1, N = 7)

Although corporate press releases highlight the potential of a new form of a wearable device that appears on the technology scene, such as augmented reality smart glasses (digital glasses that integrate virtual information into the user's field of vision), research suggests that very little is known about the consumer interaction with this nascent technology (Rauschnabel et al., 2015). Wu et al. (2015) investigated how the adoption of wearable technology by company employees (using Google Glass to check into a hotel) influences consumer assessments. The authors found that wearable technology adoption led to favorable customer assessments in situations where the service presents failures. They also found that the adoption of wearable technology by male employees led to less favorable customer evaluations.

Basoglu et al. (2017) explored the factors that influence the consumers' use of smart glasses and found that the process of adopting this type of technology was dependent on the preferences and needs of individuals. They concluded that two factors influenced the adoption: product characteristics (factors that depend on the features of intelligent glass design; independent device, the field of view, interaction, price, and display resolution according to the user's preference), and user intention characteristics (factors that depend on the self-efficacy of anxiety, involvement, risk task characteristics, fun, utility, ease of use, attitude, and intention). However, despite the benefits of these devices, they are seen to threaten the privacy not only of those who use them but of other people, thus influencing decision-making processes (Rauschnabel et al., 2015).

The exponential development of the Internet of Things (IoT) brings with it the essential challenge of meeting the quality expectations of end-users (Shin, 2017). The quality of the experience can become the guiding paradigm for quality provision management and application design in IoT. Thus, it is fundamental to have a relationship between consumer experiences and IoT quality (Shin, 2017). Consumer concerns about health risks, the privacy of IoT users, and wearable health devices have been intensified recently (Marakhimov & Joo, 2017). However, there is limited research on the impact of these concerns on consumer behavior patterns related to wearable health devices' post-operative use. The authors found that health and privacy concerns face increasing consumer concern.

Rupp et al. (2018) found that while portable fitness devices can be effective in motivating people to be active, consumers were abandoning the technology soon after purchase. Examining the profile of various users (i.e., personality, age, computer self-efficacy, level of physical activity) and device characteristics (confidence, usability, and motivational resources) on behavioral intentions to use a wearable fitness device, the authors found that computer self-efficacy, level of physical activity, and personality traits indirectly increased the desire to use a fitness device and influence perceptions of motivational resources (Rupp et al., 2018). Also, confidence, usability, and perceived motivational resources were associated with greater intentions to use physical conditioning devices.

Similarly, little is known about what influences the individual's adoption of a wearable health device has on their health and lifestyle (Lee & Lee, 2018). Studying the factors that influence an individual's intention to adopt a wearable fitness meter, which is a type of wearable health devices, Lee and Lee (2018) found that consumer attitudes, personal innovation, and health interests had statistically significant and positive associations with the intention to adopt such a meter.

5.2 Wearable technology and well-being (Cluster 2, N = 8)

Smartwatches have become an important starting point for the widespread of portable devices. Although still in the early stages of diffusion, smartwatches represent the most popular portable device (Chuah et al., 2016). However, little is known about why some people are more likely to adopt smartwatches than others. To deepen the understanding of the underlying factors that stimulate adoption behavior, Chuah et al. (2016) developed

a theoretical model based on the acceptance of technology and social psychology theories. They found that perceived utility and visibility are important factors that drive adoption intent, suggesting that smartwatches represent "fashnology" (i.e., fashion and technology).

Recognizing smartwatch as the converging point of IT innovation and fashion, Choi and Kim (2016) examined whether factors pertinent to fashion products' characteristics affect the intent to use smartwatches. They found that the characteristics of smartwatches, such as fashion products, significantly explain the intention to wear an intelligent watch, particularly the individual's desire for exclusivity. A limited effect of vanity on self-expressiveness means that the smartwatch is not yet considered luxury merchandise.

Wearable devices include objects that cover both mobile computing and fashion characteristics. While the combination of the two features is relatively new, consumers' recognition of smartwatches as a fashion accessory is increasing. However, despite the growing interest in smartwatches, sales are growing more slowly than expected. To understand this, we must understand potential consumers' perceptions of smartwatches. Jung et al. (2016), in their study, concluded that screen format and autonomous communication are the most critical factors influencing smartwatches' choices. However, brand and price have no particular influence.

Wu et al. (2016) argue that identifying factors that influence consumers to accept a smartwatch can improve the user-centered design. The authors studied the intentions of using a smartwatch from a consumer perspective, combining the theory of diffusion of innovation, the model of acceptance of technology, the unified theory of acceptance and use of technology, and perceived pleasure. They concluded that the attitude, often identified as a weak mediator, is significant; however, the ease of use was not significant, which implies that it should be the basic specification of smartwatches (Wu et al., 2016). They also concluded that gender has no significant effect on the acceptance of smartwatches, and individuals aged 35 to 54 exhibit a significant demand for fun in using a smartwatch.

The elderly population segment is constantly growing, and this growth has been accompanied by an increase in chronic diseases, which inevitably leads to continuous changes in the health sector (Nasir & Yurder, 2015). Thus, wearable technology is becoming an important topic in the field of health technology. Mobile health applications

that work with wearables allow users to collect and store all health and fitness-related data in one place.

For Canhoto and Arp (2017), the Internet of Things (IoT) and particularly wearable products have shifted the health sector's focus to prevention programs that enable people to become active and take responsibility for their health. These benefits will only materialize if users adopt and continue to use these products, rather than abandon them soon after purchase. The authors found that the factors that signal the device's ability to collect activity data are essential for adoption, while the portability and resilience of the device are essential for sustained use.

Montgomery et al. (2018) argue that portable exercise devices can solve some of the public health problems. However, they also raise serious privacy concerns because the data they collect can be combined with personal information from other sources, increasing the spectrum of discriminatory profiles, manipulative marketing, and data breaches. According to Terry and Gunter (2018), mobile medical applications are a fast-growing category of software typically installed on personal smartphones and wearable devices. Thus, a subset of these applications aims to help consumers identify mental states and/or mental illness. Although this is still an incipient domain, many mental health devices are made available in the marketplace.

5.3 Wearable technology and consumer behavior (Cluster 3, N = 5)

In recent decades the development of new communication technologies has revolutionized the behavior of individuals tremendously. Mobile devices, in particular, have developed a mentality of "always and everywhere online". Despite numerous investigations highlighting the potential of new forms of wearable devices (intelligent augmented reality glasses that integrate virtual information into the user's field of vision), the research on this technology remains limited (Rauschnabel et al., 2018; Rauschnabel, 2018). The expected hedonic and symbolic benefits drive consumer reactions to these devices, and the users' decision-making is strongly influenced by the extent to which these devices threaten others' privacy, but not the privacy of the user (Rauschnabel et al., 2018; Rauschnabel, 2018).

Venkatesh et al. (2010) theorize and empirically investigate how consumer attitudes and preferences regarding body appearance are linked to their perceptions of fashion aesthetics. The authors based their research on three research streams - production

aesthetics, reception aesthetics, and aesthetic work. They identified four themes: fashion as wearable art, body and self-identity, body appearance and high fashion brands, and aesthetic work through fashion. The findings highlight the growing importance of aesthetics in understanding consumer behavior towards wearables (Venkatesh et al., 2010).

Ro et al. (2018) found that several investigations emphasize the emergence of a new technology called "wearable augmented reality devices", in which smart augmented reality glasses (such as Microsoft HoloLens or Google Glass) represent important examples. These technologies offer enormous innovation potential for companies and societies. Kalantari and Rauschnabel (2018) use various technology and media acceptance theories to understand how people react to augmented reality devices, using the Microsoft HoloLens as an example. They concluded that the consumer's adoption decision is motivated by several expected benefits, including utility, ease of use, and image. However, no hedonic benefits were found to influence the intent of adoption. They also found that the influence of descriptive standards on the intent of adoption outweighs the influence of injunctive standards, which are established determinants in technology acceptance research (Kalantari and Rauschnabel, 2018).

5.4 Wearable technology utility (Cluster 4, N = 4)

Today's consumers are immersed in a wide and complex variety of networks, and each network presents an interconnected group of people and companies that is growing with the emergence of the Internet of Things (IoT) (Verhoef et al., 2017). Technology, particularly the use of mobile devices, enables these connections and facilitates many types of interactions on these networks - from transactions, social information sharing to people interfacing with connected devices (e.g., wearable technology).

Wearable sensors are increasingly being promoted to improve the health and well-being of employees, and there is growing evidence to support their use as personal health and exposure assessment tools. Despite this, many workplaces are hesitant to adopt these technologies. Schall et al. (2018) collected information on wearable sensors, particularly personal activity monitors, currently used by occupational safety and health professionals. The authors found that more than half of the respondents described being favorable to wearable sensors to track risk factors related to occupational safety and health. Barriers, including concerns related to privacy/confidentiality of collected data, employee

compliance, sensor durability, cost/benefit ratio of wearing devices, and good manufacturing practice requirements, were described as challenges that prevent adoption. The study's findings suggest that the widespread adoption of wearable technology appears to depend largely on the scientific community's ability to address the barriers identified (Schall et al., 2018).

Human beings in industrialized societies spend an increasing amount of time in sedentary behavior every day. Holtermann et al. (2017) define sedentary behavior as sitting or lying down with low energy expenditure and is associated with harmful health outcomes. Despite the growing interest in the health effects of sedentary behavior, organizations remain unclear on how to address it due to the poor and diverse methods used for assessment. Therefore, good practice guidelines are needed for researchers and practitioners to evaluate sedentary occupational behavior. Although there are already many wearables that help combat sedentary behavior, no system is autonomous and capable of evaluating sedentary behavior according to its definition (Holtermann et al., 2017).

Hybrid products, such as Apple or Fitbit devices, claim resources from different product categories (i.e., one technology and one fashion item) (Nieroda et al., 2018). As these products develop, marketers find it difficult to position and market them because they transcend traditional categories. Using wearables as examples and using product design literature, the authors propose a typology of these hybrid products that include the dimensions of (1) mono versus multi-functionality and (2) mass versus luxury fashion (Nieroda et al., 2018). In addition to being a fashion product, mono-functional wearables support one main function enabled by technology (e.g., an activity tracker), while multifunctional wearables support multiple functions (e.g., being a clock, activity tracker, and an organizer).

5.5 Wearable technology and big data analytics (Cluster 5, N = 4)

Policymakers and business professionals worldwide are making extraordinary efforts in the field of eHealth (Wu, Li, Cheng & Lin, 2016). Indeed, wearable technology's thriving development in health services is creating great opportunities and a remarkable future for health services. Wearable devices can be seen as a key link between healthcare and big data analytics (BDA) (Wu et al., 2017). The benefits of the BDA in health care have been widely recognized, but due to the uncertainty around rules and regulations regarding

patient data, some companies have been slow to adopt this technology. Applying a model of competition among mobile device companies with and without BDA strategies and considering consumer preference for BDA and network effects, Wu et al. (2017) demonstrate that investment in BDA directly affects the equilibrium price, market share, and profit of the company, and affects the performance of competitors. When a company with a BDA strategy adopts a different competitive strategy: conservative or expansive, market results are different.

For Wu et al. (2017a), the rapid growth in consumer adoption of portable devices has caught the attention of several researchers. Competition in the handheld market is substantial and complicated. The authors investigated the impact of network externality on the competition of handheld devices in a two-dimensional product differentiation model based on considering a market with a wide range of products (horizontal differentiation) and various quality levels (vertical differentiation). Studying two types of network externalities according to product compatibility in two types of market structures, Wu et al. (2017a) found that horizontal network externalities diminish robust profits. Network externalities also increase (decrease) the profit of the high quality (lower quality) company in the vertical domain.

Wu et al. (2017b) investigated the impact of the BDA on competition in the health care IT market and on optimal adoption decisions of the BDA by the IT provider. To capture the specific characteristics of the BDA in healthcare, they simultaneously modeled the BDA's efficiency and privacy risk from a consumer perspective and the BDA's benefit and cost from a supplier's perspective in a stylized two-dimensional product differentiation framework. The authors concluded that enterprises should apply optimal pricing strategies appropriate to the BDA’s efficiency and privacy risk dynamics (Wu et al., 2017b).

6. Discussion

Given the summary analysis of these five themes, we can conclude that there are advantages, disadvantages, and challenges associated with wearable technology. In terms of drawbacks and challenges, we find pressing issues related to privacy and devices’ autonomy. A critical weakness in the knowledge about wearable technology is that despite being multidisciplinary, there is a lack of integration between this research field’s micro and macro perspectives. This lack of integration and dialogue leads to several disconnected constructed terminologies, overlapping research questions, studies that are

not based on appropriate results, fragmentation, and mixing or confusion of different theories.

Our review of the literature shows that the ***decision-making*** process related to wearables' use is influenced by the duality between the benefits of the devices and the threat to privacy not only of those who use them but also of others around them. Data security concerns have been highlighted in contemporary research in the technology area (Ameen, Tarhini, Shah, et al., 2021). The process of adopting wearable technology depends on the preferences and needs of individual users. The preferences are dependent on the characteristics of the product and characteristics of the user's intention. Consumer attitudes, personal innovation, and health interests are factors in the adoption of a wearable technological device. Computer self-efficacy, level of physical activity, and personality traits indirectly increase the desire to use a physical conditioning device. The existence of a relationship between consumer experiences and the perception of the Internet of Things (IoT) quality is fundamental. For example, the adoption of wearable technology by employees leads to favorable evaluations of services by customers.

When discussing the use of wearables on ***user well-being and consumer behavior***, the literature focuses on wearables such as smartwatches and mobile health applications that allow users to collect and store all health and fitness-related data in one place (Jung et al., 2016). A subset of mobile medical applications aims to help consumers identify mental states and/or mental illness. However, there remains the challenge of ensuring sustained use of technology, with many users not continuing with wearables after a short period. Features that signal the device's ability to collect activity data are essential for adoption, while device portability and resiliency are essential for sustained use. Perceived utility and visibility are important factors driving adoption intent, suggesting that smartwatches represent a kind of "fashnology" (i.e., fashion and technology). Smartwatches' characteristics as fashion products significantly explain the intention to wear an intelligent watch, particularly the individual's desire for exclusivity. The expected hedonic and symbolic benefits of use drive consumer reactions to these devices. The consumer's decision to adopt these devices is motivated by some expected benefits, including utility, ease of use, and image. Hence, studies on consumer intentions should combine the theory of diffusion of innovation, the model of acceptance of technology, the unified theory of acceptance and use of technology, and perceived pleasure.

Today's consumers are immersed in a wide and complex variety of networks, and wearables can play a critical role in consumers' day-to-day activities. However, marketers face challenges in positioning wearable hybrids and marketing them because they transcend traditional product and consumer categories. Hence, marketers need to highlight the ***perceived utility of the wearables*** in a way that captures all segments of the market. For example, consumers favor using wearable sensors to track risk factors related to occupational safety and health (Schall et al., 2018). Technology has improved our life and enhanced comfort, leading to increased sedentary behavior in the developed world. While there is potential for wearables to address some of these concerns, a truly autonomous system lacks the evaluation of behavior such as sedentariness. For consumers, some of the barriers to adoption include concerns related to privacy/confidentiality of collected data, employee compliance, sensor durability, cost/benefit ratio of wearing devices, and good manufacturing practice requirements.

Our final observation relates to wearables being a key link between healthcare and ***big data analysis (BDA)***. The successful development of wearable technology in health services creates great opportunities and a remarkable future for health services. Investment in data access, storage, analysis, and subsequent use in strategic decision-making is critical for firms' success. Investment in BDA directly affects the equilibrium price, market share, and profitability of the company, and at the same time, this strategy also affects the rival's performance. When a company with a BDA strategy adopts a different competitive strategy: conservative or expansive, market results are different (Wu et al., 2017 a,b). Hence, enterprises must apply optimal pricing strategies appropriate to the BDA's efficiency and privacy risk dynamics.

7. Conclusion and research agenda

Through a systematic review, this study aimed to identify the main issues prevalent in the literature on the topic of wearable technology. This study covered a total of 74 references published between 2007 to 2019. Even though the issue of wearables is still in the emerging stage, the scientific research on it has been increasing, recording in recent years the highest number of publications.

The systematization of literature made it possible to identify five themes (clusters) that concentrate the main issues discussed on this topic, among which there is a clear

interconnection of issues. This allowed us to answer the question: *what are the various concepts and issues covered in the wearable technology literature?*

The first cluster, "Wearable technology and decision-making", encompasses articles that discuss how wearable technologies can influence the individual's decision-making processes. The investigations present in this approach also take us into the field of invasion of the privacy of users of these types of devices. The second cluster, "wearable technology and healthcare", incorporates studies that analyze these devices' importance and use in the health sector. The third cluster, "Wearable technology consumer behavior", addresses consumer preferences and why they do or do not purchase wearable devices. The fourth cluster, "Wearable technology utility", looks at wearable technologies' acquisition from a consumer utility perspective. Finally, the last cluster, "Wearable technology and big data analytics", links wearable technologies to big data analytics (BDA), helping the health sector to collect key data on its users.

Our second question focused on *what are the theoretical, contextual, and methodological guidelines applied in wearable technology research?*

We found theories related to motivation, behavioral intentions, social psychology, diffusion of innovation, acceptance of technology, and media acceptance widely used in this research field. Table 7 shows the contextual and methodological guidelines of wearable technology research, and the indicative knowledge gaps and insights for future research.

Table 7 Contextual, methodological, and future research agenda for wearable technology

Theory	*What is the relevance of extant theories in the study of wearable technology?* • Should new theories be developed? • Besides those related to technology and information sciences, what subjects should also be important in the study of wearable technology consumers (psychology, behavior sciences, sociology)? • How can existing theory be developed and improved to help explain the practices of wearable technology consumers?
Context	*What are the similarities and differences in the various wearable technology approaches?* • What factors explain these differences? • How can the context lead to changes in the adoption of wearable technology consumers? • What are the institutional pressures at play in the adoption of wearable technology consumers? Within the same sector, what are the configurations that change from company to company?

	Between different sectors, what are the similarities in the organization of the companies?
Content	*What role do resources and capabilities play in choosing wearable technology?* • How do institutional logics relate to the option for wearable technology consumers? • Why do some entrepreneurs show more / less importance to wearable technology consumers? • What are the socially responsible practices in the workplace from the workers' perspective?
Method	*How can we significantly measure wearable technology adoption?* • How can we measure the impact between the use or not of wearable technology? Are they different or similar metrics? • Do different levels of wearable technology usage require different methods? • How can we combine various methods to explore wearable technology from different levels of analysis? • Can we develop large-scale databases to measure wearable technology performance?

We detail some of these future research areas identified in Table 7. Wearable technology is multi-disciplinary and has relevance for medicine, engineering, information technology and systems, strategy, marketing, data analysis, and many others. Hence, future studies could take a multi-theoretical approach and develop a wearable technology framework that incorporates the various stakeholders' interests and concerns (Loncar-Turukalo et al., 2019).

In terms of context and content, we suggest that future studies should consider the differences in the level of institutional, economic, and technological development between countries. A standardized approach to producing wearable technologies may not be suitable due to the lack of supporting infrastructure and the consumers' technological literacy, especially in emerging economies. Rammal (2019) suggests that their environment influences consumers' behavior, and digital innovation and technology may not be accepted equally worldwide. Additionally, the limited infrastructure development and weaker institutional environment in emerging economies can also raise concerns about intellectual property protection and personal data access, privacy, and security. Thus, future studies could address these issues by:

- considering the segmentation of the market and adapting of products to meet the needs of these market segments;
- Formulating strategies to protect intellectual property in countries with weak institutional system; and

- analyzing the use of technological safeguards to limit access to personal data and guard against misuse.

Finally, regarding methods, we recommend that more studies in the future apply real-time data collection and analysis methods to respond to the massive amounts of data generated from wearables (Greco, Ritrovato, & Xhafa, 2019).

Our key observations relate to the definition and delimitation of what wearable technologies are and the various areas of their application and the utility they represent. With this research, we believe that identifying the key issues faced by the sector and discussion relating to the five clusters will be useful for the managers and creators of these types of devices to better prepare themselves for their adoption and creation. This study not only provides a systematic review of the literature on wearables but also highlights the areas that future research could address. These suggestions are timely, especially in the context of the COVID-19 pandemic, and are of critical importance as policymakers and technology firms attempt to find ways that wearables can be used to monitor individuals' health and ensure that any outbreaks are contained. Issues surrounding the users' privacy and the use of data to identify and quarantine patients are some of the challenges that need to be addressed.

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