Digital Business 2 (2022) 100021

Contents lists available at ScienceDirect

Digital Business

journal homepage: www.elsevier.com/locate/digbus

The impact of trust in the internet of things for health on user engagement

Khalid Samhale

Hassan 1st University, N° B 113 Al Wifaq Bensegao 80000 Agadir, Settat, Morocco

ARTICLE INFO

Article history:
Received 12 April 2021
Received in revised form 15 January 2022
Accepted 15 January 2022

Keywords:
User trust
Perceived autonomy
Desire for self-development
Internet of things
Health
User engagement

ABSTRACT

The Internet of things (IoT) representing the online exchange of data from real devices is a major revolution that is transforming the whole of society. IoT has penetrated in the health field by facilitating healthcare exchanger for users and professionals. This article aims to examine several factors reinforcing user engagement. A theoretical framework was developed and includes the perceived autonomy, the desire for self-development, and the user trust to predict IoT user engagement in the medical context. The partial least squares structural equation modeling (PLS-SEM) approach was conducted with a sample of 109 French users. The findings highlight the relationship between trust and engagement in the use of the IoT device to improve health behavior. This research is part of a long-term IoT customer/designer relationship based on interaction and trust. It can enable IoT providers, medical professionals, and marketers to optimize patient communication to target potential users more accurately and reduce user abandonment of devices.

1. Introduction

Internet of things is an emerging technology that reflects the connected whole, by anyone, anywhere, and anytime. It has several advantages such as advanced device connectivity, systems, as well as services that go beyond machine-to-machine (M2M) scenarios. It offers solutions for large-scale applications in the field of safety, sport, connected cities, road traffic management, health, and logistics (Höller, Karnouskos, Avesand, Mulligan, & Tsiatsis, 2014). This new technology is present everywhere in our daily lives, benefiting from the rapid growth of internet infrastructure (Wi-Fi,[1] 4G) and RFID[2] chips (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012; Palattella et al., 2013). It is the basis for the future ICT market[3] (Boswarthick, Elloumi, & Hersent, 2012). The IoT is in a phase of rapid growth as shown by the number of IoT devices tripled in the period between 2010 and 2015 (Greenough & Camhi, 2015). This number of IoT devices is expected to continue increasing and reach 43 billion by 2023 (Fredrik, Mark, Alexander, & Jonathan, 2019).

Healthcare can take advantage of the potential benefits of IoT devices. According to a recent study conducted by Allied Market Research,[4] the global internet of things in the healthcare market was valued at $113.751 billion in 2019 and is expected to reach $332.672 billion by 2027, registering a CAGR of 13.20% from 2020 to 2027. Smart devices based on IoT technology offer several possibilities of applications such as online surveillance, monitoring of fitness and diseases programs, taking medication, and caring for the elderly. For Almotiri, Khan, and Alghamdi (2016), the IoT for health is revolutionizing clinical research and disease therapies. The data is recorded and transferred online which helps doctors to make a quick and accurate diagnosis. Safavi and Ratliff (2018), declared that the internet of things would better the quality of care and the way it was provided. According to them, 85% of doctors confirmed that handheld medical devices encourage patients to take better care of themselves, and 75% of patients believed that using this technology can help them improve their health.

The growing role of IoT technology in the health field faces several challenges such as security, privacy, and confidentiality. According to Almotiri et al. (2016), security concerns include unwarranted access to health data, confidentiality obliges professionals who have access to patient data to hold it in confidence, and privacy refers to the patient right to make decisions about treatment of his data. Al-Fuqaha, Guizani, Mohammadi, Aledhari, and Ayyash (2015) argue that security and privacy concerns are the top priority for IoT applications followed by reliability, availability, scalability, interoperability, performance, and management. These several challenges need to be addressed by service providers to implement an efficient service and build user trust.

E-mail address: khalid.samhale@uhp.ac.ma.

[1] Wireless Fidelity technology
[2] RFID (Radio Frequency Identification) is a method of storing data remotely using “radio tags”
[3] ICT Information and Communication Technologies
[4] https://www.alliedmarketresearch.com/press-release/internet-of-things-iot-healthcare-market.html. Consulted on 17/08/2021.

http://dx.doi.org/10.1016/j.digbus.2022.100021

The conceptualization of this research is based on the relationship-marketing literature (Palmatier, Dant, Grewal, & Evans, 2006). The latter impacted the choice of our theoretical variables. Engagement and trust form the basis for maintaining an effective long-term relationship (Hikkerova, Pupion, & Sahut, 2015). Trust is essential in relational exchanges (Van Tonder & Petzer, 2018) by reducing perceived risk, which increases user engagement (So, King, & Sparks, 2014). In the context of healthcare, trust significantly influences decision-making related to the use of IoT for health (Nisha, Iqbal, & Rifat, 2019; Zhao, Ni, & Zhou, 2018) and positively impacts customer engagement (Agariya & Singh, 2011). Due to the importance of engagement in this field, many researchers recommend more research about this concept (Kosiba, Boateng, Okoe, & Hinson, 2020). The success of IoT devices for health face several obstacles including use abandonment. According to Moreno (2017), the abandonment rate was 50% within the first eighteen months of use. This point is one of the major issues we discuss in this research, so we are working on the factors that reinforce engagement in the use of IoT for healthcare.

The selection of the focal constructs (trust) and outcomes (engagement) for our research was influenced by the theory of Morgan and Hunt (1994) who confirmed that the relationship between trust and engagement is influenced by a perceived benefit. We operationalize these constructs through the satisfaction of the desire for self-development and perceived autonomy. Although the adoption of IoT in healthcare has been recognized, the impact of trust on user engagement remains underexplored theoretically and empirically in the IoT context. Given this gap, the purpose of this study is to examine the impact of trust on the engagement in the use of IoT for healthcare. This objective leads to the following question:

To what extent does trust reinforce the engagement in IoT usage for healthcare settings?

Our theoretical model can help to answer this question by analyzing the trust-engagement relationship in the use of IoT devices based on experience and influenced by utility and concerns related to the security and privacy. A non-probability convenience sample was collected of 109 French patients, and the data were then processed using the PLS-SEM approach. This method is chosen for three reasons: it requires neither (1) a large sample size (2) nor data normality and is perfectly adapted (3) to analyze complex structural models with numerous mediating and moderating constructs (Richter, Cepeda Carrión, Roldán, & Ringle, 2016).

The remainder of this paper first discusses the current literature on the IoT for health with a brief review of the variables that influence user engagement. Therefore, the theoretical hypotheses are proposed, and the research model is presented. Then, the research methodology adopted is explained in Section 3 followed by the findings in Section 4. The Section 5 provides the discussion and implications. Finally, Section 6 concludes this article by providing limitations and research perspectives.

2. Literature review

This section reviews the current literature about the IoT for healthcare. It analyzes several variables such as user trust, perceived autonomy and desire for self-development that strongly influence the user engagement. We proposed relevant hypotheses and presented the research model at the end of this section.

2.1. IoT for healthcare

The Internet of Things (IoT) is a technological revolution that aims to connect anything, anywhere and anytime, giving rise to new innovative applications and services. It makes objects smart through data (Lu, Papagiannidis, & Alamanos, 2018) and transforms multiple healthcare application areas such as home care, mobile health (m Health), e-health, and hospital management (Akkas, Sokullu, & Çetin, 2020). The IoT devices are made available through connection protocols (such as Bluetooth, Wi-Fi) to facilitate the exchange of information. These objects enable healthcare professionals to analyze a lot of data in real-time, better diagnose diseases, reduce healthcare costs, and improve patient-centered practices (Arfi, Nasr, Kondrateva, & Hikkerova, 2021). For patients, IoT for health help to be more involved in monitoring their health and improving the user experience.

The growth of the IoT is increasing at a strong pace all over the world. According to the Facts & Factors research,[5] the global IoT Healthcare Market is anticipated to reach around USD 21 billion by 2025. In France, the same trend is emerging. A study conducted in 2019 by Xerfi[6] shows that the e-health sector is exploding, and investors' interest is growing steadily. It explains how the funds raised by the top 50 French start-ups have tripled in two years. Despite the efforts made by the government, this sector is still facing difficulties related to user's trust. A survey conducted by Ifop[7] (French Institute of Public Opinion) in 2017 emphasized this point. According to the results of this study, the French respondents give a trust rating of 5.2/10 to IoT devices. They mainly demand visibility into the use of data collected by the IoT (56%) and the creation of labels certifying the quality and security of devices (46%).

The success of IoT technology is also related to the user experience. Ng and Wakenshaw (2017) believe that not all IoT devices are accepted by users. They add that these tools must satisfy the user's needs which motivates the purchase decision.

2.2. Trust in the use of IoT for health

In relational marketing, the impact of trust has been considerably confirmed in various research contexts. For Jang, Kim, and Lee (2016), trust is an individual's confidence in an information system. It helps maintain long-term relationships and reduces the risk related to the exchange (Hikkerova et al., 2015). Social exchange theory stated that individuals analyze costs and benefits before deciding to engage in a transaction. Trust seems to be essential in this process, it moderates customer perceived costs and uncertainty (Morgan & Hunt, 1994). When customers believe that IoT device offers high performance, they will perceive their services as very high quality and trustworthy (Balaji & Roy, 2017). Defending the same opinion, Kovač and Žabkar (2020) consider that online services based on relationships require customer trust. They explained that users should believe that the provider has relevant expertise and is trustworthy.

Trust plays a major role in the process of adoption of new technology. For Gao, Krogstie, and Siau (2011), the user trust is related to his belief that the device has a high level of security and privacy protection (Gao et al., 2011). These two factors are important antecedents of trust. According to Viljanen (2005), customer trust is reinforced by the identity, experiences, capabilities, and actions of the technology providers. These criteria clearly show the user's concern for security and confidentiality, who seeks reassurance by looking for a reliable service provider.

In the healthcare context, the use of IoT devices enables better diagnosis and monitoring of patient health (Kang, Pang, & Wang, 2013). These devices collect, manage, and analyze user-health data which raises concerns about security and trust and may affect users' adoption of this technology (Arfi et al., 2021). Trust plays a crucial role in the acceptance and use of IoT devices. It helps customers overcome the perception of risk related mainly to security and privacy (AlHogail & AlShahrani, 2018). Patients must be informed by healthcare professionals of how, by whom, and what type of data will be collected and used (Hengstler, Enkel, & Duelli, 2016). Arfi et al. (2021) explain that hospital staff must have access to patient data for administrative purposes (registering patients, billing, obtaining information on age, gender), but are not allowed to know the details of patients' medical conditions. Data protection aims to ensure adequate access rights for medical staff without revealing confidential patient

[5] https://www.fnfresearch.com/iot-healthcare-market-by-component-type-medical-devices-297 consulted on 01/06/2021

[6] https://www.xerfi.com/presentationetude/E-sante-les-marches-de-la-medecine-connectee-a-l-horizon-2025_9CHE45 consulted on 01/06/2021

[7] https://solidarites-sante.gouv.fr/IMG/pdf/applications_et_objets_connectes_-_usages_et_opinions_des_francais_env_dicom_050717.pdf consulted on 01/06/2021

information. They add that by doing so, patients can trust IoTs to monitor their health conditions without compromising their privacy.

AlHogail and AlShahrani (2018) found various factors affecting trust including utility. The utility represents the expectations of IoT users which are presented in our theoretical model by the perceived autonomy and the desire for self-development. In addition, Trust has been largely linked to the concept of engagement. These two concepts form the basis for maintaining an effective long-term relationship (Hikkerova et al., 2015). This idea is also supported by Pansari and Kumar (2017) who argue that user engagement occurs only after the development of a relationship based on trust. We then considered trust in the internet of things for health to be a determining factor of user engagement, and we make the following hypotheses:

H1a: Trust in the internet of things positively influences perceived autonomy.

H1b: Trust in the internet of things positively influences the desire for self-development.

H1c: Trust in the IoT positively influences engagement in the use of this technology for health.

2.3. Perceived autonomy

The theory of self-determination confirmed the individual's need for the ability to act autonomously. For Deci and Ryan (2000), intrinsic motivation is autonomous and reflects self-engagement in interesting activities. It is supported by the satisfaction of autonomy. According to Nikou and Economides (2017), the need for autonomy refers to the ability to regulate and control a self-behavior.

In the health context, Standage, Sebire, and Loney (2008), argued that self-determined motivation positively influences engagement in physical practice, and considered that perceived autonomy encourages healthy attitudes. Meanwhile, a recent study[8] about IoT use to treat chronically ill patients, has shown that user autonomy is positively related to the degree of use; the more patients are connected, the more autonomous and engaged they become. Therefore, users highly appreciate the autonomy granted to them by connected applications (Asimakopoulos, Asimakopoulos, & Spillers, 2017). From these discussions, the following hypothesis is proposed.

H2: Perceived autonomy encourage engagement in the use of IoT for health purposes.

2.4. Desire for self-development

The desire for self-development refers to the individual's intention to improve the self (Zawadzka, 2014). It increases long-term well-being. Aristotle, in the fourth century, considered pleasure-seeking a vulgar lifestyle. He argued that well-being is achieved through eudaimonia by seeking to develop the best of oneself (Huta & Ryan, 2010). Meanwhile, Szabowska-Walaszczyk, Zawadzka, and Wojtaś (2011) showed that the willingness to self-improvement is positively correlated with self-esteem and success values.

The desire for self-development moderates neuroticism and anxiety (Zawadzka, 2014). This finding leads us to believe that users of IoT for health who focus on self-development will experience less anxiety when using this technology, which will promote their engagement (Brodie, Hollebeek, Juric, & Ilic, 2011). Concerning the desire for self-development, users are attentive to the new possibilities offered by IoT for healthcare which help them to get better (Boudokhane-Lima, 2018). According to the same study, this technology promotes better self-knowledge through measurement, which allows performance to be optimized. Then, we make the following hypothesis:

[8] Chair of Social Networks and IoT at the Institut Mines-Telecom, 2019

H3: The desire for self-development fosters engagement in the use of IoT for healthcare.

2.5. User engagement

In the beginning, marketing focused on attracting customers rather than making efforts to retain them. However, this vision has changed with the emergence of relationship marketing (Buttle, 1996). This shift from product-based to customer-focused organizations has led to the development of new concepts in relationship marketing and customer management (Boulding, Richard, Michael, & Wesley, 2005). One of these concepts that have emerged and taken a central position in the marketing discipline is customer engagement. This variable has been treated in several disciplines. In the field of sociology, for example, “civic engagement” has been explored. In psychology, “social engagement” has been examined. Meanwhile, educational psychology has been studied “student engagement”. Political science has focused on the “engagement of nation-states”. Further, in the organizational behavior/management literature, the term “employee engagement” has been used.

In marketing, customer engagement reflects his behavior towards a brand or company beyond the act of purchase (Doorn et al., 2010; Hollebeek, 2011a; Islam & Rahman, 2016), and his willingness to invest his resources (time, energy, money) in the brand beyond those spent at the time of consumption (Keller, 2013). For Brodie, Ilic, Juric, and Hollebeek (2013), customer engagement is a multidimensional concept that includes cognitive, emotional, and/or behavioral dimensions. It reflects efforts made by the person to maintain a relationship for the long term and plays a central role in the process of relational exchange influenced by a set of other concepts that are either antecedents and/or consequences (Morgan & Hunt, 1994).

The massive use of social networks has made it possible to develop brand communities in which users share their reviews and experiences. These networks require effective management by companies to make the customer relationship successful in the form of trust, word-of-mouth, and loyalty (Hollebeek, 2011b; Islam & Rahman, 2016; Vivek, Beatty, & Morgan, 2012), and to reinforce engagement, which has a positive effect on customer behavior and brand performance (Brodie et al., 2011; Gambetti & Graffigna, 2010).

In the context of IoT devices, engagement is defined as a process that includes the following four steps with distinguishable attributes inherent at each stage: Non-engagement, Entry Point of Engagement, Sustained Engagement, and Long-term Engagement (Xiao, Wu, Buruk, & Hamari, 2021). In this paper, we focus on the entry point of engagement that reflects the capture of user's attention and represents the initialization of engagement. As use continues and users do not abandon the experience, it will expand to frequent use and lead to long-term engagement (Xiao et al., 2021).

Keeping in view the above literature and hypotheses, the proposed research model is framed as shown in Fig. 1.

3. Research methodology

The present study aims to determine factors affecting engagement in the use of IoT for healthcare. To test our hypotheses, we are using an exploratory approach within the framework of a questionnaire survey. The recommendations of this research will be validated through a deductive approach that consists in confronting the hypotheses with reality. The perspective adopted follows the “positivist” epistemology. The data for the study were collected from French customers. They were asked to complete an online questionnaire consisting of the model variable measurement scales used in previous studies.

3.1. Instruments for measuring model variables

For the sampling strategy, a non-probability convenience sample was collected. This questionnaire starts with a definition of IoT for health to

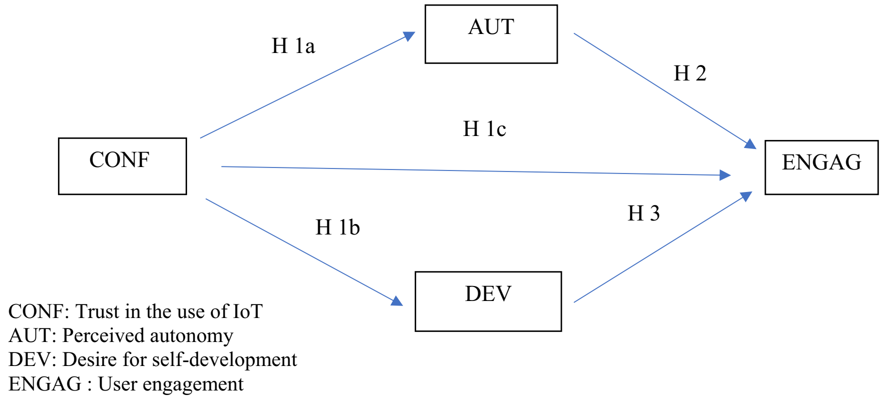

Fig. 1. Framework Model of user engagement determinants.

be sure that all respondents understand this technology. It was followed by a question about the use of these devices to filter and retain, thereafter, just the users of this technology. We have chosen to collect answers online via Facebook. This network has the advantage of being very popular and it facilitates the targeting of IoT users for healthcare. A pretest with 67 questionnaires was collected to verify our theoretical model. Then, a total of 165 completed questionnaires were received within one month. Of these, 109 respondents use IoT for health. As our study was conducted in France, the questionnaire was administered in French. Respondents were asked to rate their agreement with the items of each variable on a 5-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree". To better adapt the scale to the French context, it was translated into French and discussed with marketing researchers who are fluent in English. It was then verified on a test sample to ensure the reliability of selected items. You find below a summary of online survey stages (Table 1).

The questionnaire variables were operationalized using measurement scales adapted from the literature (Appendix A). We tested trust in the internet of things for health by the five-item scale of Gao et al. (2011). Concerning perceived autonomy, we adopted the measurement scale of Nikou and Economides (2017). For the desire for self-development, we used the measurement scale established by Zawadzka (2014) measured with three items. Also, we analyzed user engagement using the scale provided by Islam and Rahman (2016) with five items.

3.2. Target population and questionnaire administration

In our research context, and according to available resources, we chose the questionnaire data collection method with the online administration mode. This method has become the most widely used by researchers because it allows getting a graphically clear and interactive presentation and guarantees the anonymity of respondents (Gavard-Perret et al., 2012).

We limited our study to French people who use this technology with filter questions to obtain answers based on experience and interaction with devices. Our data were collected in groups of Facebook that focus on wellness and illness. For better understanding, we started the questionnaire with an introduction that explains IoT for health. Generally, the questionnaire collection method does not allow interaction, but, in our study, we were able to cover this gap depending on Facebook that facilitated interaction with respondents via comments and private messages.

Table 1
Summary of the online survey steps.

Periods	Stages of the Survey
April–May 2020	Development of the research questionnaire (initial version)
June 2020	Testing the initial version of our study questionnaire (Sample of 67 responses)
September 2020	Development of the research questionnaire (final version)
October – November 2020	Collection of 165 responses with the final version of the research questionnaire
December 2020	109 responses retained (only users of the IoT devices for healthcare)

3.3. Statistical tool for empirical analysis

To empirically examine our theoretical model, we chose the PLS-SEM approach and used SmartPLS software to test the empirical model. This method is based on variance analysis and optimization of the explanatory power of manifest variables (Fernandes, 2012). It is the most suitable for our research context because it requires neither a large sample size nor data normality. It is more adapted to handle variables with single and multi-item measures (Hair, Hult, Ringle, & Sarstedt, 2021) and to solve complex models that contain mediating and moderating variables (Richter et al., 2016). It offers an original methodology for dealing with incomplete and missing data and is adapted to new situations where theory is less developed.

The PLS-SEM approach proceeds in two steps. First, the latent variables are estimated by the scores of observed variables and coefficients in the measurement model. The second step calculates the final estimate of outer weights and loadings and the structural model's path coefficient (Hair et al., 2021). In addition, we used bootstrapping method to analyze the measurement and structural models. This method provides approximate t-values for structural path significance tests and a standard bootstrap error that assesses the reliability of indices (Wong, 2013).

4. Findings

In this section, we present all the results and analyze the factor loads that confirm the hypotheses put forward in our literature review. The data analysis consists of three phases. In the first stage, we examined the demographic profile of respondents. The second step inspected measurement model analysis and the third step consisted of structural model analysis using Smart PLS and Structural Equation Modeling (SEM). The final step was an analysis of the mediator effect using the macro process for SPSS recommended by Hayes (2017).

The Table below explains the characteristics of our study sample. First, it shows that the number of respondents is almost equally divided between men and women. They are mainly Executives, or they have Intermediaries professions. Finally, half of the respondents are between 25 and 39 years old (Table 2).

The verification of variable reliability was done by measuring the internal consistency of the constructs: Cronbach's alpha, and composite reliability (Fornell & Larcker, 1981).

Based on the results presented in the Table above (Table 3), we can say that our research model is validated. The composite reliability (CR), which represents the advantage of taking measurement errors into account, and Cronbach's Alpha values are all above 0.7, demonstrating a high level of

Table 2
Characteristics of the study sample.

		Nb	(%)
Gendre	Men	55	51%
	Women	54	49%
	Total	109	100%
Professional category	Farmers, craftsmen, traders, entrepreneurs	9	8%
	Executives and Intermediaries professions	53	48%
	Employees, workers	28	26%
	Inactive	19	18%
	Total	109	100%
Age	Less than 25 years	17	16%
	25–39 years	54	49%
	40–54 years	29	27%
	55 years and more	9	8%
	Total	109	100%

internal consistency (Fornell & Larcker, 1981). We also confirmed, the convergent validity of the variables with all loadings higher than 0.7 and average variance extracted (AVE) values exceeding 0.5 (Chin, 1998; Fornell & Larcker, 1981).

To analyze the discriminant validity, we used the cross-loading test with SmartPLS to verify that items explain their variable more than others. The Table below presents the results obtained (Table 4).

In addition, the discriminant validity requires that the square root of variable AVE be higher than the variation between this variable and the others in the model (Bagozzi & Yi, 2012). The Table below (Table 5) presents the results and validates the discriminant validity of all variables.

The above results show that the square root of the AVE of each variable is superior to its correlation with the other variables in the model. Therefore, the discriminant validity is verified.

The results obtained show that our model variables explain the engagement in the use of the internet of things for health ($R^2 = 24\%$). According to the size of our sample, we can say that the value of R^2 exceeds the minimum threshold of 0.13 (Wetzels, Odekerken-Schröder, & Van Oppen, 2009). This means that our research model is significant.

To validate our research hypotheses, we adopted bootstrap analysis on SmartPls ($n = 109$, 5000 iterations) (Hair, Ringle, & Sarstedt, 2011). The results are presented in the Table below (Table 6).

H1a: User trust positively influences perceived autonomy.

This hypothesis which explains the relationship between user trust and perceived autonomy is not validated.

H1b: User trust positively influences the desire for self-development.

The test carried out confirms this hypothesis and indicates that trust encourages the user to adopt this technology aiming to develop his performance.

Table 4
Cross-loading technique results.

	AUT	CONF	DEV	ENGAG
AUT 1	**0.6539**	0.054	0.0253	0.181
AUT 2	**0.9436**	0.1533	0.2154	0.4026
CONF 1	0.2018	**0.7774**	0.2588	0.2721
CONF 2	0.052	**0.7841**	0.2091	0.1963
CONF 3	−0.0434	**0.7456**	0.1588	0.178
CONF 4	0.0633	**0.777**	0.1515	0.1306
CONF 5	0.1847	**0.8029**	0.1368	0.2044
DEV 1	0.1391	0.256	**0.9179**	0.2823
DEV 2	0.2341	0.1761	**0.9085**	0.3553
DEV 3	0.1273	0.2507	**0.9163**	0.2528
ENGAG 1	0.3144	0.1535	0.2327	**0.8844**
ENGAG 2	0.3355	0.2932	0.2866	**0.9045**
ENGAG 3	0.2923	0.3093	0.3395	**0.9163**
ENGAG 4	0.382	0.1792	0.3008	**0.8837**
ENGAG 5	0.4195	0.2464	0.2926	**0.8939**

The scales of the same variable are bolded to differentiate them from items of other variables.

Table 5
AVE square root and correlations between variables.

	CONF	AUT	DEV	ENGAG
CONF	**0.7776**			
AUT	0.1438	**0.8118**		
DEV	0.2479	0.1842	**0.9142**	
ENGAG	0.2673	0.3918	0.3264	**0.8966**

The values of the square root of the AVE are bolded to differentiate them from the values of the correlation between the variables.

Table 6
Validation of research hypotheses.

Hypothèses	T	P	Vérification
CONF - > AUT	1.300	0.1964	Not validated
CONF - > DEV	2.649	0.0093	Validated
CONF - > ENGAG	1.688	0.0943	Validated*
AUT - > ENGAG	3.586	0.0005	Validated
DEV - > ENGAG	2.804	0.0060	Validated

* We agree to validate this hypothesis with a 10% risk.

H1c: User trust positively influences engagement in the use of IoT for health.

This hypothesis is especially validated with a $0.05 < p < 0.1$. This finding indicates that user trust reinforces engagement in the use of the internet of things for health.

Table 3
Results of model variables analysis.

Variables	Scales	Loadings	Alpha Cronbach	AVE	Composite reliability	R scare
IoT Trust (CONF)	If I have a clear conception of the functionality of the IoT for health	0.7774	0.8422	0.6046	0.8843	
I could use the IoT for health…	If I feel confident that I can keep the IoT for health under control	0.7841				
	If I feel confident that the data collected by the IoT for health is reliable	0.7456				
	If I believe it is risk-free to use the IoT for health	0.7770				
	If it is safe to use the IoT for health	0.8029				
Perceived autonomy (AUT)	I feel a sense of freedom while using the IoT for health	0.6539	0.5365	0.6590	0.7891	0.0207
	The IoT for health provides me with interesting options and choices	0.9436				
Desire for self-development (DEV)	I really want to improve my performance	0.9179	0.9019	0.8358	0.9385	0.0614
	I actively strive to be better	0.9085				
	I really want to improve my skills	0.9163				
User engagement (ENGAG)	Anything related to IoT for health grabs my attention	0.8844	0.9392	0.8039	0.9535	0.2455
	I like to use more the IoT for health	0.9045				
	I pay a lot of attention to anything about IoT for health	0.9163				
	I spend a lot of my discretionary time on IoT for health	0.8837				
	I am passionate about IoT for health	0,8939				

H2: Perceived autonomy encourages engagement in the use of IoT for health.

The test shows that there is a valid relationship between perceived autonomy and user engagement. This finding indicates that if the user of IoT for health feels autonomous, he will be more engaged.

H3: The desire for self-development reinforces engagement in the use of IoT for health.

This hypothesis is confirmed. It shows that if the user considers that this technology will enable him to develop this performance, he will be more engaged.

4.1. The mediating effect of desire for self-development

The results of our study examined the mediating role of desire for self-development and perceived autonomy in the relationship between user trust and engagement. To analyze these effects, we used the macro process for SPSS recommended by Hayes (2017). After running the Bootstrap technique, we verified the indirect relationship between user trust and engagement. As the results in the Table below (Table 7). This relationship is significant (Hayes, 2017).

Next, we calculated the confidence interval for the relationship between user trust and engagement with the desire for self-development as a mediator. As shown in the Table below (Table 8), the two limits of this confidence interval are greater than zero, which allows us to confirm the mediating role of the desire for self-development (Hayes, 2017).

We then examined the relationship between user trust and engagement with perceived autonomy as a mediator. But, as we note in the Table below (Table 9), zero belongs to the confidence interval. Therefore, perceived autonomy has no mediating role in this relationship (Hayes, 2017).

5. Discussion and implications

According to the results of our study, the impact of trust on perceived autonomy is not validated. Unlike the study of Lie and Brittain (2016) carried out specifically on elderly people, this category is not well represented in our sample (represents only 8%).

The impact of users' trust on engagement has been widely discussed (Agariya & Singh, 2011; So et al., 2014). Trust remains the key to improving engagement in use because it helps to moderate worries about new technologies. It encourages the perceived usefulness of the IoT and reinforces its role in the development of personal performance (Samhale, 2019). This makes it very challenging for companies to take care of their image, maintain a good relationship with users, gain their trust and launch useful new features to motivate them to use and recommend this technology.

Based on the results of our research, we confirmed that perceived autonomy influences engagement in the use of the internet of things for health. Indeed, the user will be more engaged if he feels autonomous when using this technology. This finding is consistent with other researchers who explained that the need to monitor health status autonomously drives the demand for home care and home support services (Van Hoof, Kort, Rutten, & Duijnstee, 2011; Vines et al., 2013). IoT service providers should, thus, work on this point to make life easier for users and help them to be more autonomous.

Furthermore, our study shows the impact of desire for self-development on user engagement. Users will be more engaged in the use of the internet of things for health when they perceive that this technology allows them to develop their performance. The results, also, prove the mediating effect of desire for self-development on the relationship between user trust and engagement. In other words, a user who trusts this technology and wishes to improve his performance will be more engaged in its use. This finding is consistent with Morgan and Hunt (1994) who argued that the relationship between trust and engagement is influenced by its gains.

Table 7
Total effect of user trust on engagement.

Effet	Se	T	P	LLCI	ULCI
0.4667	0.1792	2.6045	0.0105	0.1115	0.8220

Table 8
Results of the mediating effect of the desire for self-development.

	Effect	Boot SE	Boot LLCI	Boot ULCI
The desire for self-development	0.1088	0.0643	0.0132	0.2599

Table 9
Results of the mediating effect of perceived autonomy.

	Effect	Boot SE	Boot LLCI	Boot ULCI
Perceived autonomy	0.0541	0.0608	−0.0419	0.1968

5.1. Theoretical implications

The major theoretical contribution of our study is the relationship between trust and user engagement in a medical context for IoT use. The role of trust in the use of IoT for healthcare is already validated (Arfi et al., 2021). Its impact on user engagement is confirmed in the current study accordingly to the previous ones. The empirical findings of the current research show that trust reinforces engagement in the use of IoT devices for healthcare. We noted that customers have trust issues in the IoT for health related to some factors such as privacy and security. Their certainty regarding these issues informs their decisions to engage in the use of IoT for healthcare. The findings support our hypotheses, and they are consistent with the existing literature (Agariya & Singh, 2011; Samhale, 2019; So et al., 2014).

Furthermore, our study confirms the positive impact of perceived autonomy on user engagement, and suggests, accordingly, that IoT service providers should focus on how to make the IoT devices simple and do without assistance. It, also, validates the influence of the desire for self-development on this engagement and encourages those firms to take advantage of the data collected by this device to offer useful features that facilitate user performance improvement.

To our knowledge, our study is the first to validate the relationship between trust and engagement in the use of IoT for healthcare. On the one hand, it considers the specificities of the IoT devices, the purposes of use, and the motivations of users. On the other hand, it analyzes the mediating effect of the desire for self-development in the relationship between trust and engagement in the use of IoT for healthcare.

5.2. Managerial implications

The results of this research allow us to come up with interesting managerial implications in favor of IoT service providers, doctors, and users. In the context of IoT devices for healthcare, the data exchanged is sensitive (personal data, geographical location, etc.). Therefore, the IoT providers should work on the relationship with users, focus on communication and transparency. The same recommendation has already been confirmed in previous studies of new technologies (Hengstler et al., 2016). The IoT service providers need to interact clearly and credibly with users via different communication channels such as collaborating with social network influencers. By placing the user at the center of their strategy, the IoT service providers will be able to anticipate the use of IoT, and therefore, give users value. According to AlHogail and AlShahrani (2018), the trust is reinforced by the IoT devices' utility. This latter is presented in our theoretical model by the perceived autonomy and the desire for self-development. In today's hyperconnected world, it is paradoxical to see how IoT service providers have become "disconnected" from users. This distance contributes to the low usage of IoT for healthcare. In addition, The IoT service providers must also consider other facets of trust related to the health industry, such as the reliability of the measuring instruments and the information transmitted. They, of course, must secure the collected data by introducing Blockchain technology (Genestier, Letondeur, Zouarhi, Prola, & Temerson, 2017; Yu et al., 2018).

The internet of things for healthcare is relatively recent on the market and requires the collaboration of all actors in the field for the success of this technology. First, the healthcare providers have an important contribution. They can, at the same time, recommend the use of this technology to their patients and provide feedback to designers for further development. Therefore, the IoT companies should communicate with them about data collection procedures, new features, security, and privacy solutions. Finally, a governmental will is required to encourage access to this technology, to subsidize the purchase of these tools, teach citizens how to use them, and guarantee the protection of collected data. We invite them, in collaboration with customer protection associations, to create a label certifying the quality and safety of IoT for healthcare.

5.3. Social implications

The social impact of IoT in the healthcare industry is related to confidentiality and privacy. The user must be aware of and give his consent on the way of data treatment. Conversely, the IoT design relies heavily on automatic interaction between devices for so-called intelligent actions. Furthermore, a user feels a loss of control due to this constant transfer of data between devices. This lack of control can limit the individual's sense of freedom (Ebersold & Glass, 2016). By using the IoT, users delegate some actions to devices. The realized actions must be those asked by the user and not be misleading (Ebersold & Glass, 2016).

Our study has shown that the desire for self-development, perceived autonomy, and trust influence the engagement in the use of IoT for healthcare. These factors will help to moderate the risk associated with the use of these devices and to retain users.

Another important aspect of IoT technology in the fight against social inequalities. These are the systematic differences in health observed between social groups according to the socio-economic position of individuals or according to territories. IoT devices have a crucial role to play here. They eliminate distances and allow each person to be autonomous and to become an actor of his health.

6. Conclusion

Several studies have focused on engagement in the use of new technologies through several visions such as brand attachment or user engagement. The latter is an important factor that explains the customer relationship. Using the PLS-SEM approach, we treated the initialization of the engagement in the use of internet of things that reflects the capture of the user's attention.

The major development of internet of things is mainly due to the need for self-quantification and improvement of physical performances. From a managerial point of view, our study has generated recommendations to strengthen the relationship between the user and IoT devices. It contributes to better understanding the impact of trust on user engagement in the context of IoT for healthcare. It, also, seeks to analyze the mediating role of the desire for self-development in this relationship. Finally, the research recommends facilitating the development of personal performance and autonomy to gain the user's trust and to encourage him to use this technology.

6.1. Research limitations, and perspectives

This exploratory research on engagement in the use of internet of things for healthcare has some limitations. It was analyzed regardless of sociodemographic categories and without considering the brand effect, the purchasing power, the product price, and the culture since these variables require an in-depth study which may make our theoretical model more complex and difficult to measure. We proposed, then, to analyze these constructs in further studies.

Our study analyzes the entry point of engagement in the use of IoT for healthcare that represents the initialization of engagement which means when the users' attentions are first captured. we recommend, therefore, to analyze in further research projects, the user sustained engagement through the measurement of the repeated use of these connected devices to improve healthcare behavior.

Despite the mobilization of relevant variables that maximize the explanation of user engagement, there are still other variables influencing this behavior. New research with sociological and psychological variables will enrich the analysis, provide a framework for an in-depth understanding of the use of IoT for health and generate interesting contributions.

Trust has been analyzed in several previous research and has been defined differently depending on the research context. We have limited our research to the study of trust in the context of relationship marketing without sufficiently analyzing the other facets of this concept in the healthcare industry. Therefore, we propose studying this concept in-depth in future research.

The major methodological limitation of our research is the choice of the data collection method. To carry out our empirical analysis, we administered our research questionnaire online while limiting ourselves to the French context and without being able to ensure the representativeness of the sample studied. The study of the questionnaire in another country with a different culture from France, an Asian country for example (a collectivist culture) will allow us to enrich the analysis and compare the results to weigh the impact of the national culture on the acceptable behaviors of IoT for healthcare.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Study Questionnaire

The trust in the internet of things (Gao et al., 2011).

I could use the IoT for health…

CONF 1 – « If I have a clear conception of the functionality of the IoT for health ».

CONF 2 – « If I feel confident that I can keep the IoT for health under control ».

CONF 3 – « If I feel confident that the data collected by the IoT for health is reliable ».

CONF 4 – « If I believe it is risk-free to use the IoT for health ».

CONF 5 – « If it is safe to use the IoT for health ».

The perceived Autonomy (Nikou & Economides, 2017).

AUT 1 – « I feel a sense of freedom while using the IoT for health ».

AUT 2 – « The IoT for health provides me with interesting options and choices ».

The desire for self-development (Zawadzka, 2014).

DEV 1 – « I really want to improve my performance ».

DEV 2 – « I actively strive to be better ».

DEV 3 – « I really want to improve my skills ».

The user engagement (Islam & Rahman, 2016).

ENG 1 – « Anything related to IoT for health grabs my attention».

ENG 2 – « I like to use more the IoT for health».

ENG 3 – « I pay a lot of attention to anything about IoT for health».

ENG 4 – « I spend a lot of my discretionary time on IoT for health».

ENG 5 – « I am passionate about IoT for health».

References

Agariya, A. K., & Singh, D. (2011). What really defines relationship marketing? A review of definitions and general and sector-specific defining constructs. *Journal of Relationship Marketing, 10*(4), 203–237. https://doi.org/10.1080/15332667.2011.624905.

Akkas, M., Sokullu, R., & Çetin, H. (2020). Healthcare and patient monitoring using IoT. *Internet Things*, *11*(100173). https://doi.org/10.1016/j.iot.2020.100173.

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of things: A survey on enabling technologies, protocols, and applications. *IEEE communications surveys & tutorials*, *17*(4), 2347–2376. https://doi.org/10.1109/COMST.2015.2444095.

AlHogail, A., & AlShahrani, M. (2018). Building consumer trust to improve Internet of Things (IoT) technology adoption. *International Conference on Applied Human Factors and Ergonomics* (pp. 325–334). Cham: Springer. https://doi.org/10.1007/978-3-319-94,866-9_33.

Almotiri, S. H., Khan, M. A., & Alghamdi, M. A. (2016). Mobile Health (m-Health) System in the Context of IoT. *2016 IEEE 4th International Conference on Future Internet of Things and Cloud Workshops (FiCloudW)*. https://doi.org/10.1109/w-ficloud.2016.24.

Arfi, W. B., Nasr, I. B., Kondrateva, G., & Hikkerova, L. (2021). The role of trust in intention to use the IoT in eHealth: Application of the modified UTAUT in a consumer context. *Technological Forecasting and Social Change*, 167. https://doi.org/10.1016/j.techfore.2021.120688.

Asimakopoulos, S., Asimakopoulos, G., & Spillers, F. (2017). Motivation and user engagement in fitness tracking: Heuristics for mobile healthcare wearables. *Informatics*, *4*(1), 5. https://doi.org/10.3390/informatics4010005.

Bagozzi, R., & Yi, Y. (2012). Specification, Evaluation, and Interpretation of Structural Equation Models. *Journal of the Academy of Marketing Science*, *40*, 8–34. https://doi.org/10.1007/s11747-011-0278-x.

Balaji, M. S., & Roy, S. K. (2017). Value co-creation with Internet of things technology in the retail industry. *Journal of Marketing Management*, *33*(1–2), 7–31. https://doi.org/10.1080/0267257X.2016.1217914.

Boswarthick, D., Elloumi, O., & Hersent, O. (2012). M2M Communications: A Systems Approach. *Wiley Publishing*. https://doi.org/10.1002/9781119974031.

Boudokhane-Lima, F. (2018). L'usage des objets connectés dans le cyclisme: étude sur les tendances et les pratiques émergentes. *Revue française des sciences de l'information et de la communication*, *12*. https://doi.org/10.4000/rfsic.3449.

Boulding, W., Richard, S., Michael, E., & Wesley, J. (2005). A customer relationship management roadmap: What is known, potential pitfalls, and where to go. *Journal of Marketing*, *69*(4), 155–166. https://doi.org/10.1509/jmkg.2005.69.4.155.

Brodie, R. J., Hollebeek, L. D., Juric, B., & Ilic, A. (2011). Customer engagement: Conceptual domain, fundamental propositions and implications for research in service marketing. *Journal of Service Research*, *14*, 352–371. https://doi.org/10.1177/1094670511411703.

Brodie, R. J., Ilic, A., Juric, B., & Hollebeek, L. D. (2013). Customer engagement in a virtual brand community: An exploratory analysis. *Journal of Business Research*, *66*, 105–114. https://doi.org/10.1016/j.jbusres.2011.07.029.

Buttle, F. (1996). *Relationship marketing: Theory and practice*. London, UK: Sage. https://doi.org/10.4135/9781446252062.

Chin, W. (1998). Issues and Opinion on Structural Equation Modeling. *MIS Quarterly*, *22*(1), 7–25.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01.

Doorn, V., Lemon, N., Mittal, V., Nass, S., Pick, D., Pirner, P., & Verhoef, P. C. (2010). Customer engagement behavior: Theoretical foundations and research directions. *Journal of Service Research*, *13*(3), 253–266. https://doi.org/10.1177/1094670510375599.

Ebersold, K., & Glass, R. (2016). The internet of things: a cause for ethical concern. *Issues In Information Systems*, *17*(4), 145–151. https://doi.org/10.48009/4_iis_2016_145-151.

Fernandes, V. (2012). En quoi l'approche PLS est-elle une méthode a (re)-découvrir pour les chercheurs en management? *Management*, *15*(1), 102–123.

Fornell, C., & Larcker, D. F. (1981). evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.2307/3151312.

Fredrik, D., Mark, P., Alexander, R., & Jonathan, S. (2019). Growing opportunities in the Internet of Things. Consulted on November 25, 2021 on https://www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/growing-opportunities-in-the-internet-of-things.

Gambetti, R. C., & Graffigna, G. (2010). The concept of engagement: A systematic analysis of the ongoing marketing debate. *International Journal of Market Research*, *52*(6), 801–826. https://doi.org/10.2501/S1470785310201661.

Gao, S., Krogstie, J., & Siau, K. (2011). Developing an instrument to measure the adoption of mobile services. *Mobile information systems*, *7*(1), 45–67. https://doi.org/10.3233/MIS-2011-0110.

Gavard-Perret, M. -L., Gotteland, D., Haon, C., Jolibert, A., Aubert, B., Avenier, M. -J., & Duymedjian, R. (2012). *Méthodologie de la recherche en sciences de gestion: réussir son mémoire ou sa thèse* (2nd ed.). Montreuil: Pearson.

Genestier, P., Letondeur, L., Zouarhi, S., Prola, A., & Temerson, J. M. (2017). Blockchains et Smart Contracts: des perspectives pour l'Internet des objets (IoT) et pour l'e-santé. *Annales des Mines-Realites industrielles*, *3*, 70–73.

Greenough, J., & Camhi, J. (2015). The Internet of Things 2015: Examining How the OT Will Affect the World. *BI Intelligence Report* Récupéré sur https://www.businessinsider.com/internet-of-things-2015-forecasts-of-the-industrial-iot-connected-home-and-more-2015-10.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*, 139–151. https://doi.org/10.2753/MTP1069-6679190202.

Hair, J. J., Hult, G. T., Ringle, C. M., & Sarstedt, M. (2021). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage publications.

Hayes, A. F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis, Second Edition: A Regression-Based Approach*. New York: Guilford Publications.

Hengstler, M., Enkel, E., & Duelli, S. (2016). Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices. *Technological Forecasting and Social Change*, *105*, 105–120. https://doi.org/10.1016/j.techfore.2015.12.014.

Hikkerova, L., Pupion, P. C., & Sahut, J. M. (2015). Fidélisation et fidélité dans l'hôtellerie: une comparaison franco-slovaque. *Management & Avenir*(4), 161–181. https://doi.org/10.3917/mav.078.0161.

Hollebeek (2011a). Demystifying customer engagement: Exploring the loyalty nexus. *Journal of Marketing Management*, *27*, 785–807. https://doi.org/10.1080/0267257X.2010.500132.

Hollebeek (2011b). Exploring customer brand engagement: Definition and themes. *Journal of Strategic Marketing*, *19*, 555–573. https://doi.org/10.1080/0965254X.2011.599493.

Höller, J., Karnouskos, S., Avesand, S., Mulligan, C., & Tsiatsis, V. (2014). From machine-to-machine to the internet of things: Introduction to a new age of intelligence. *Intelligence*. https://doi.org/10.1016/B978-0-12-407,684-6.00001-2.

Huta, V., & Ryan, M. (2010). Pursuing pleasure or virtue: the differential and overlapping well-being benefits of hedonic and eudaimonic motives. *Journal of Happiness Studies*, *11*, 735–762. https://doi.org/10.1007/s10902-009-9171-4.

Islam, J. U., & Rahman, Z. (2016). Linking customer engagement to trust and word-of-mouth on Facebook brand communities: An empirical study. *Journal of Internet Commerce*, *15*(1), 40–58. https://doi.org/10.1080/15332861.2015.1124008.

Jang, S. H., Kim, R. H., & Lee, C. W. (2016). Effect of u-healthcare service quality on usage intention in a healthcare service. *Technological forecasting and social change*, *113*, 396–403. https://doi.org/10.1016/j.techfore.2016.07.030.

Kang, K., Pang, Z., & Wang, C. (2013). Security and privacy mechanism for health internet of things. *The Journal of China Universities of Posts and Telecommunications*, *20*, 64–68. https://doi.org/10.1016/s1005-8885(13)60219-8.

Keller, K. L. (2013). *Strategic brand management. Building, measuring, and managing brand equity*. Harlow, UK: Edinburgh Gate. https://doi.org/10.1108/jcm.2000.17.3.263.3.

Kosiba, J. P., Boateng, H., Okoe, A. F., & Hinson, R. (2020). Trust and customer engagement in the banking sector in Ghana. *The Service Industries Journal*, *40*(13–14), 960–973. https://doi.org/10.1080/02642069.2018.1520219.

Kovač, M., & Žabkar, V. (2020). Do social media and e-mail engagement impact reputation and trust-driven behavior? *Market-Tržište*, *32*(1), 9–25. https://doi.org/10.22598/mt/2020.32.1.9.

Lie, M., & Brittain, K. (2016). Technologie et confiance: Le point de vue des personnes âgées sur un système de télésurveillance à domicile. *Retraite et société*, *75*(3), 47–72. https://doi.org/10.3917/rs.075.0047.

Lu, Y., Papagiannidis, S., & Alamanos, E. (2018). Internet of Things: A systematic review of the business literature from the user and organizational perspectives. *Technological Forecasting and Social Change*, *136*, 285–297. https://doi.org/10.1016/j.techfore.2018.01.022.

Miorandi, D., Sicari, S., De Pellegrini, F., & Chlamtac, I. (2012). Internet of things: Vision, applications and research challenges. *Ad Hoc Networks*, *10*(7), 1497–1516. https://doi.org/10.1016/j.adhoc.2012.02.016.

Moreno, N. (2017). *Les ventes d'objets connectés liés au sport (wearables, accessoires sportifs, vêtements de sport) devraient atteindre 253 millions d'unités d'ici 2021*. IDATE Récupéré sur https://fr.idate.org/les-ventes-dobjets-connectes-lies-au-sport-wearables-accessoires-sportifs-vetements-de-sport-devraient-atteindre-253-millions-dunites-dici-2021/.

Morgan, R., & Hunt, S. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, *58*, 20–38. https://doi.org/10.1177/002224299405800302.

Ng, I. C., & Wakenshaw, S. Y. (2017). The Internet-of-Things: Review and research directions. *International Journal of Research in Marketing*, *34*(1), 3–21. https://doi.org/10.1016/j.ijresmar.2016.11.003.

Nikou, S. A., & Economides, A. A. (2017). Mobile-Based Assessment: Integrating acceptance and motivational factors into a combined model of Self-Determination Theory and Technology Acceptance. *Computers in Human Behavior*, *68*, 83–95. https://doi.org/10.1016/j.chb.2016.11.020.

Nisha, N., Iqbal, M., & Rifat, A. (2019). The changing paradigm of health and mobile phones: an innovation in the health care system. *Journal of Global Information Management (JGIM)*, *27*(1), 19–46. https://doi.org/10.4018/JGIM.2019010102.

Palattella, M. R., Accettura, N., Vilajosana, X., Watteyne, T., Grieco, L. A., Boggia, G., & Dohler, M. (2013). Standardized protocol stack for the internet of (important) things. *IEEE Communications Surveys & Tutorials*, *15*(3), 1389–1406. https://doi.org/10.1109/SURV.2012.111412.00158.

Palmatier, R. W., Dant, R. P., Grewal, D., & Evans, K. R. (2006). Factors influencing the effectiveness of relationship marketing: A meta-analysis. *Journal of marketing*, *70*(4), 136–153. https://doi.org/10.1509/jmkg.70.4.136.

Pansari, A., & Kumar, V. (2017). Customer engagement: the construct, antecedents, and consequences. *Journal of the Academy of Marketing Science*, *45*(3), 294–311. https://doi.org/10.1007/s11747-016-0485-6.

Richter, N., Cepeda Carrión, G., Roldán, J. L., & Ringle, C. M. (2016). European Management Research Using Partial Least Squares Structural Equation Modeling (PLS-SEM). *European Management Journal*, *34*(6), 589–597. https://doi.org/10.1016/j.emj.2014.12.001.

Safavi, K., & Ratliff, R. (2018). Healthcare IT: top 5 eHealth trends reshaping the industry in 2015. Récupéré sur https://www.accenture.com/_acnmedia/pdf-63/accenture-techvision-france-health.pdf.

Samhale, K. (2019). *Le Soi quantifié et l'engagement dans l'utilisation des objets connectés pour le sport. Doctoral dissertation, Lille1.*

So, K. K., King, C., & Sparks, B. (2014). Customer engagement with tourism brands: Scale development and validation. *Journal of Hospitality & Tourism Research*, *38*(3), 304–329. https://doi.org/10.1177/1096348012451456.

Standage, M., Sebire, S. J., & Loney, T. (2008). Does exercise motivation predict engagement in objectively assessed bouts of moderate-intensity exercise?: A self-determination theory perspective. *Journal of Sport and exercise Psychology*, *30*(4), 337–352. https://doi.org/10.1123/jsep.30.4.337.

Szabowska-Walaszczyk, A., Zawadzka, A. M., & Wojtaś, M. (2011). Zaangażowanie w pracę i jego korelaty: adaptacja skali UWES autorstwa Schaufeliego i Bakkera. [Work engagement and its correlates: an adaptation of Schaufeli's and Bakker's work engagement measure - UWLS]. *Psychologia Jakości Życia*, *10*(1), 57–74.

Van Hoof, J., Kort, H., Rutten, P., & Duijnstee, M. (2011). Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users. *International Journal of Medical Informatics*, *80*(5), 310–331. https://doi.org/10.1016/j.ijmedinf.2011.02.010.

Van Tonder, E., & Petzer, D. J. (2018). The interrelationships between relationship marketing constructs and customer engagement dimensions. *The Service Industries Journal*, *38*(13–14), 948–973. https://doi.org/10.1080/02642069.2018.1425398.

Viljanen, L. (2005). Towards an ontology of trust. *2nd International conference on Trust, Privacy and Security in Digital Business* (pp. 175–184). https://doi.org/10.1007/11537878_18.

Vines, J., Lindsay, S., Pritchard, G., Lie, M., Greathead, D., Olivier, P., & Brittain, K. (2013). Making family care work: dependence, privacy and remote home monitoring telecare systems. *UbiComp*, 597–606. https://doi.org/10.1145/2493432.2493469.

Vivek, S. D., Beatty, S. E., & Morgan, R. (2012). Customer engagement: Exploring customer relationships beyond purchase. *Journal of Marketing Theory and Practice*, *20*, 122–146. https://doi.org/10.2753/MTP1069-6679200201.

Wetzels, M., Odekerken-Schröder, G., & Van Oppen, C. (2009). Using PLS path modeling for assessing hierarchical construct models: Guidelines and empirical illustration. *MIS Quarterly*, *33*(1), 177–195. https://doi.org/10.2307/20650284.

Wong, K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Marketing Bulletin*, *24*(1), 1–32.

Xiao, R., Wu, Z., Buruk, O. T., & Hamari, J. (2021). Enhance user engagement using gamified internet of things. *Hawaii International Conference on System Sciences*. https://doi.org/10.24251/HICSS.2021.583.

Yu, B., Wright, J., Nepal, S., Zhu, L., Liu, J., & Ranjan, R. (2018). IoTChain: Establishing trust in the internet of things ecosystem using blockchain. *IEEE Cloud Computing*, *5*(4), 12–23. https://doi.org/10.1109/MCC.2018.043221010.

Zawadzka, A. M. (2014). Readiness for self-improvement questionnaire tool reliability and accuracy analysis. *Acta Neuropsychologica*, *12*(1), 73–84.

Zhao, Y., Ni, Q., & Zhou, R. (2018). What factors influence the mobile health service adoption? A meta-analysis and the moderating role of age. *International Journal of Information Management*, *43*, 342–350. https://doi.org/10.1016/j.ijinfomgt.2017.08.006.