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Healthcare service evolution towards the Internet of Things: An end-user perspective

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ABSTRACT

For the last two decades the Internet of Things (IoT) has been a subject of growing global interest. Particularly dynamic industries such as the healthcare service sector have just begun to understand the benefits of the IoT for the provision of a new, more advanced type of services. However, whilst the healthcare service industry is yet to fully grasp the benefits of information systems for its practitioners and managers, and for patients and families, there is a need for a better understanding of the challenges and opportunities associated to IoT-based healthcare systems as another disruptive wave of technologies. In particular, research on the relevance of users' skills for adoption of IoT-based healthcare services has been limited. Using the current Internet-based healthcare service landscape as a platform for the formulation and testing of its hypotheses, this paper explores the relationship between patients' capabilities for effective use of information and communication technologies and the success of IoT-based healthcare services. The resulting theoretical model for effective use of information and communication technologies and the success of IoT-based healthcare services was then validated. The validation was based on data collected from a randomly selected sample of 256 users of Internet-based healthcare services provided by the public healthcare system of the Region of Murcia in Spain. The findings of this research inform future strategies for the implementation of new generations of health and well-being services based on IoT technologies.

1. Introduction

1.1. Motivation

Healthcare and its management have for decades been recognised as an information-based discipline. As information technologies have evolved, numerous scholars have explored the challenges, barriers and opportunities associated to the use of information in healthcare management. Throughout this process, information systems have become an imperative in every attempt to improve healthcare and its management. Despite advances already made in this sector, the World Health Organization (WHO, 2010) have acknowledged that even well-developed countries are expected to face major challenges in the way current healthcare services are delivered. The argument is based on the growing importance of 1) an ageing population, 2) an increased life expectancy, and 3) an inevitable population growth. In response to these and other challenges, innovative technologies for empowering patients and moving from traditional approaches to healthcare management towards new mechanisms for health and wellness monitoring are continuously being developed. From medical informatics and electronic medical records (e.g. Williams et al., 2015) to healthcare systems based on cloud computing (e.g. Sobhy et al., 2012), the field has continuously sought to benefit from developments in the information technologies arena. This has also led to the emergence of new business models for the successful delivery of electronic healthcare services, always expected to target the many stakeholders of such services, from the managerial and practitioners side to patients and their carers and families.

Unfortunately, the fast pace of developments in the information technology sector, among other factors, has not always allowed for healthcare systems to be fully adopted by their ultimate beneficiary: the patient and their family and carers (Ludwick and Doucette, 2009). Lack of regular use of the new healthcare system by individuals has often resulted in limitations in their success (Wu et al., 2011). Furthermore,

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research (Furukawa et al., 2014) has shown that an inconsistent use of online healthcare services by patients could bring a significant cost for public health institutions, many of which are currently running on already constrained resources.

This research is therefore motivated by the imperative to understand the challenges of the adoption of new developments in information technologies, in particular disruptive technologies such as the Internet of Things. We seek to contribute to the existing body of knowledge on the interaction between technologies and society by focusing on healthcare, an essential determinant in the well-being, productivity and social integration of individuals and in society in general.

1.2. Healthcare service provision and the Internet of Things

As healthcare practitioners and scholars seek to progress in their efforts to understand and benefit from developments in the information technologies arena, new challenges continue to emerge. The growing availability of wireless communication platforms and their use to develop and interconnect smart devices have transformed the landscape where initial electronic healthcare systems had evolved. Network-enabled devices have become embedded in everything from industrial machinery to household items and cars, to health and care management systems in what has been labelled as the Internet of Things (IoT).

Many definitions of the Internet of Things can be found in the extant literature. These are often derived either from the term 'Internet' and lead to an 'Internet-oriented' vision of IoT, or from the term 'Things', leading to an 'entity-oriented' notion of the concept (Yang et al., 2012). However, regardless of the approach to the understanding of the concept, there is agreement in the fact that the IoT offers new technological opportunities to create new types of services that users can benefit for both their personal and professional lives (Jäppinen et al., 2013).

IoT has been described as a vision of connectivity which may have a dramatic impact on our daily lives, similar to the Internet in the past 10–20 years. The IoT has been referred to as the next evolution in Internet technology (Dijkman et al., 2015; Ebersold & Glass, 2015; Uden et al., 2017; Pauleen, 2017a, b) and an extension of today's Internet to the real world of physical objects (Zheng et al., 2011; Sumbal et al., 2017; Pauleen, 2017a). On these basis, we argue that lessons learned from Internet-based services in sectors such as healthcare over the last two decades will help minimise the risk of failure for IoT-based services.

The IoT research and practice communities have soon realised the potential of this new technology to move the healthcare service industry beyond the use of traditional information technologies to providing a more advanced type of service (Su et al., 2011). 'Traditional', Internet-based information systems such as electronic health records management systems (Takian et al., 2012) undoubtedly allowed for healthcare service innovation (Currie and Seddon, 2014), improved efficiency and effectiveness of the healthcare service personnel (Agarwal and Perry, 2015) and a reduction in the expenses associated to the organisational performance of healthcare institutions (Stanimirovic, 2015). There is agreement that IoT-based technologies have the potential to allow for services such as patient localisation inside large hospitals, monitoring of vital signs, position and posture monitoring, optimisation of patient flow in hospitals, hospital inventory management and personnel and equipment tracking, as well as care for elderly people (Da Xu et al., 2014).

On this basis, healthcare and medical applications at home and in hospitals have emerged as an "early-bird application of the IoT" (Su et al., 2011). However, as such technologies develop, limited research has been conducted to understand and address the acceptance of such technologies by citizens as their primary stakeholders. Mital et al. (2017) suggest that there is strong need for theoretical extension in the context of IoT in different sectors such as healthcare area. Moreover, assuming that such new technologies are being initially accepted -as an important first step for their adoption, the ultimate success of an IoT-based healthcare system will in most cases rely on their continued use by society (Bhattacherjee, 2001). Hence, the loyalty of citizens (i.e. patients and their carers and families) to IoT-based healthcare services (eLoyalty hereafter) becomes key for their success. Previous research has focused on understanding the pillars of new IoT-based business models, with emphasis on how customers should engage to benefit from the value delivered by organisations in fields such as healthcare (Metallo et al., 2018; Taghizadeh-Nastaran et al., 2018). Scholars such as Chang et al. (2015) have highlighted the importance of e-loyalty in this context, arguing the value and sustainability of IoT-based tools depends on the ongoing participation and willingness of users to recommend them to others (Wolter et al., 2017). Thus, it is essential to understand what motivates users to continue using these tools. This research has been set to inform current and future developments in the IoT-based healthcare management field of the importance of citizen engagement for the success of current approaches to IoT-enabled healthcare services.

Thus, complementing the motivation and objective of this research, our main focus is the study of the antecedents of e-loyalty in the context of Internet-based healthcare information services. To achieve this, we develop an integrated model outlining the relationship between patients' capabilities for effective use of information and communication technologies and the success of IoT-based healthcare services. Our model for effective use of information and communication technologies and the success of IoT-based healthcare services is based on Seddon's (1997) Information System success model. Our model is then tested by using the Structural Equation Modeling (SEM) approach.

The remainder of this paper is organised as follows: In Section 2 the theoretical background of this research is presented and hypotheses are developed. The methodology adopted to construct the questionnaire and the details of the sample are presented in Section 3, with the results from the hypotheses testing being detailed in Section 4. Conclusions and further research are finally discussed in Section 5.

2. Theoretical background

According to the marketing literature, loyalty exists when favourable attitudes for a brand are manifested in repeat buying behaviour (Keller, 1993). We understand that Keller's (1993) definition of loyalty can be adapted to the context of the healthcare sector and related IT-based services without losing its validity (Chaney & Martin, 2017; Martínez-Caro, Cegarra-Navarro, & Solano-Lorente, 2013). In particular, we understand loyalty in this context as the favourable attitude of the healthcare end-user (i.e. patients and their families and carers) towards an Internet-based healthcare service that results in a continuous-use behaviour. For the purpose of this paper we refer to loyalty to an Internet-based healthcare service as e-loyalty.

Despite the opportunities that the healthcare sector can offer as a result of the creation and nurturing of e-loyalty in its end-users, healthcare providers have been slow to achieve such loyalty since early developments in Internet-based healthcare systems (Brakensiek, 2002). According to Brakensiek (2002), this is largely because very few organisations are prepared to face the challenges this process involves. In particular, the initial stages of the implementation of Internet-based services in the healthcare environment can be difficult as its success depends to a large extent on the attitude of the individuals involved (Singh et al., 2018). In fact, Cheng et al. (2017) found that organisations within the healthcare industry would cease to invest in disruptive technology if they failed to lead their users to an early adoption or if they experience disappointing performance. However, assuming that most technical barriers are gradually overcome, the question remains as to whether people are willing to use these new technological achievements (Aggelidis and Chatzoglou, 2009).

In order to study the antecedents of end-users e-loyalty on Internet-based healthcare services, this research adopts the concept of users' e-skills (European Comission, 2004). Such skills are essential to ensure that non-ICT sectors, as well as society as a whole, can benefits from technological advances, especially through productivity gains and better social integration. User e-skills cover the use of both common software tools as well as specialised tools supporting business functions within specific industries such as healthcare services provision. At a general level, e-skills are covered by the concept of 'digital literacy', that is, the skills required for the confident and critical use of ICT for work, leisure, learning and communication, leading to an adoption of the technology (Verdegem and De Marez, 2011) and in the context of this research, a prerequisite for the success Internet-based healthcare services.

A considerable volume of academic research focused on measuring systems success has been reported in the information systems (IS) literature. Based on the analysis of what defines a successful information system and the corresponding measures, DeLone and McLean (1992) proposed a taxonomy and an interactive model as frameworks for conceptualizing and operationalising Information Systems (IS) success. Six dimensions of IS success have been reported, namely system quality, information quality, IS use, user satisfaction, individual impact and organisational impact. Although DeLone and McLean included temporal and causal interdependencies between these dimensions, they failed to provide empirical validation of their model. Later on, Seddon (1997) argued that DeLone and McLean's model was too generic and that it has an added degree of complexity as it mixes both process and casual explanations of IS success. On these basis, Seddon (1997) proposed an extended version DeLone and McLean's model with a view to provide a clearer, more consistent conceptualisation of the relationships between the various factors that determine IS success.

Seddon's (1997) model has been used in knowledge management research in the last decade (Greiner et al., 2007; Wang and Byrd, 2017), considers three classes of variables:

(1) Measures of information and system quality: Information quality is concerned with such issues as the relevance, timeless, and accuracy of information generated by an IS. System quality refers to the desirable characteristics of an IS, such as ease of use or the consistency of the user interface.
(2) General measures of perception of net benefits of IS use: The two general perceptual measures are perceived usefulness and user satisfaction. Perceived usefulness was defined by Davis (1989) as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived satisfaction represents the degree to which a user's perceived personal needs and the need to perform specific tasks satisfactorily are met by an information system (Goodhue and Straub, 1991).
(3) Other measures of net benefits of IS use: Refer to the extent to which IS are contributing to the success of individuals, groups, organisations, industries, and nations. For example, improved productivity, increased sales, cost reductions, improved profits, market efficiency or economic development (Petter et al., 2008).

In this model, system quality and information quality are expected to affect perceived usefulness and user satisfaction. In turn, perceived usefulness has a direct relationship with user satisfaction. Finally, satisfaction is expected to influence other measures of net benefits of IS use.[1]

The IS success model developed by Seddon (1997) has emerged as a dominant framework for system evaluation, with a history of successful applications and empirical testing. However, while these theories add substantially to the current understanding of reasons behind the adoption of technologies, they do not explicitly focus on the factors to be considered for the study of continued use of technologies (Eriksson and Nilsson, 2007). Some researchers have modified Seddon's model to evaluate success of specific applications (Petter et al., 2008). In this study e-skills and e-loyalty have been interconnected through the use of the Seddon's model with the aim of developing an Internet-based healthcare services success model. Based on Seddon's model, our model for Internet-based healthcare services success includes three classes of variables:

(1) Measures of user's e-skills: The information and system quality variables have been replaces with e-skills since we consider them as a precondition for Internet-based healthcare services success. We considered two main categories of e-skills related to the success of these services. These are the personal innovativeness and self-efficacy of users. In a technological context, *personal innovativeness* is defined as the individual's willingness to try out any new information technology (Agarwall and Prassad, 1999). On the other hand, Bandura (1986) define *self-efficacy* as the belief that one has the ability to perform a particular task or hold a particular behaviour. In the Internet domain, Eastin and LaRose (2000) define self-efficacy as the belief that one can successfully perform a distinct set of behaviours required to establish, maintain and utilise effectively the Internet over and above basic personal computer skills.
(2) Perceptual measures of net benefits of Internet-based healthcare services use: We considered the same general measures of perception of net benefits as those used in the Seddon's model, that is, perceived usefulness and satisfaction.
(3) Other measures of net benefits of Internet-based healthcare services use: Whilst studying organisational benefits of Internet-based healthcare service use, the focus of this research is user's e-loyalty. *E*-loyalty is not generally used for the measurement of an IS success as much as other factors (e.g. productivity or profits) are used. However, in an alternative setting such as Internet-based healthcare services, continued use of a system (be it by individuals, organisations or society) becomes an important indicator of its benefits for organisations. Even in a setting where there is no alternative to the use of a system, e-loyalty could still be considered a valid measure for success of such system.

Recent research has focused on individuals' ability to innovate as a mechanism to explain the different approaches to adoption and use of innovative technologies (e.g. O'Cass & Fenech, 2003; Lewis et al., 2003; Yiu et al., 2007; Van Raaij and Schepers, 2008; Jimenez-Jimenez et al., 2014; Gaylin et al., 2011). An innate innovativeness and an overt innovative behaviour in an individual may influence how he/she perceives and uses a new information system (Lee et al., 2007). Individuals who are less willing to change will be more likely to require external reinforcement before engaging with an IT innovation. In addition, when individuals perceive that they lack resources or skills, they may be less likely to respond to efforts to integrate, use or engage in exploratory behaviour with relation to an IT (Leonard-Barton and Deschamps, 1988; Ahmed Dine Rabeh et al., 2013). On the other hand, users with higher levels of personal innovativeness are more prone to have a more favourable attitude towards new technologies, and highly innovative users are more willing to embrace new technologies into their daily routine by coping with the uncertainty associated to innovative technologies (Rogers, 1995). Personal innovativeness in IT has been shown to be a reliable antecedent to positive users' perception of the usefulness of new technologies (Lewis et al., 2003; Nov and Chen, 2008; Van Raaij and Schepers, 2008). In short, innovative individuals will be more prompt to using new systems, more able to engage with such systems and better prepared to realise their benefits than non-innovative individuals would be (Schillewaert et al., 2005). Innovative individuals are likely to know better what kind of technologies are currently available to support them in their work and home lives. They enjoy being informed of developments on this subject and are therefore more aware of the possibilities offered by new systems (Van Raaij and Schepers, 2008). Following these reasoning, the following hypothesis is

[1] For a diagrammatic representation of the model, see Seddon (1997)

proposed:

H1. Personal innovativeness is positively associated with perceived usefulness of Internet-based healthcare services.

Several studies have examined the influence of individuals' self-efficacy on their use of new technologies (e.g. Agarwal and Prasad, 1999; Al-Somali et al., 2009; Roca et al., 2006; Wang et al., 2003; Udo et al., 2010; Liu et al., 2012; Singh et al., 2018). Individuals' who have confidence in their own abilities to master technological innovations are more likely to perceive and reap the benefits from using such technology. Compeau et al. (1999) found that self-efficacy influences outcome expectation, a concept described by Davis (1989) as similar to perceived usefulness and are derived largely from positive benefits associated with performing a task. Gist (1989) links self-efficacy to expectations which influence action. Gist (1989) argues that behaviour-outcome relationships such as effort to performance should be considered analogous to self-efficacy because expected performance outcomes depend heavily on the type of behaviours an individual chooses to execute. Bandura (1986) also distinguishes between self-efficacy and 'outcome judgment', a concept similar to perceived usefulness. Bandura (1986) states that, in any given instance, behaviour would be best predicted by considering both self-efficacy and outcome beliefs. Several studies have found empirical evidence of a causal relationship between self-efficacy and perceived usefulness of technologies (e.g. Hanudin 2007; Igbaria and Iivari, 1995; Venkatesh, 2000; Agarwal et al., 2000; Wang et al., 2003). Therefore, the following hypothesis is proposed:

H2. Personal self-efficacy is positively associated with perceived usefulness of Internet-based healthcare services.

The Seddon's model specifies a causal relationship between perceived usefulness of an IS and user satisfaction. Seddon and Kiew (1994) argue that something is useful if it provides future benefits. User satisfaction is the net feeling of pleasure or displeasure that results from aggregating all the benefits that a person hopes to receive from interaction with the IS. Each user has a set of expected benefits or aspirations for the IS. To the extent that the system meets or fails to meet each of these aspirations, the user is more or less satisfied. At a minimum, a tool is expected to be useful. Beyond that, the more useful the tool, the more likely the user is to be satisfied with it. These considerations lead us to frame the following hypothesis:

H3. Perceived usefulness of Internet-based healthcare services is positively associated with user satisfaction.

The relationship between satisfaction and loyalty seems almost intuitive, and several researchers have found that satisfaction leads to loyalty in their studies (e.g. Anderson and Srinivasan, 2003, Wang 2007; Martin-Perez & Martin-Cruz, 2015). Satisfaction has a positive influence on user retention, likelihood of recommending, word of mouth and reuse/loyalty intentions (Van Riel et al., 2001; Taylor and Hunter, 2002; Yoon, 2002; Taherdoost, 2018). User satisfaction associated with technology usage can influence subsequent use of such technology (Menachemi et al., 2009). Moreover, Yang and Peterson (2004) and Kingshott et al. (2018) found that satisfaction exhibits a positive impact on e-loyalty. We understand that satisfaction is intrinsically coupled to the patient's well-being. In other words, the prolonged use of Internet-based healthcare services depends on how satisfied the patient (i.e. end-user of the services) is with the healthcare service. Therefore, we propose:

H4. User satisfaction with Internet-based healthcare services is positively associated with e-loyalty to such services.

Fig. 1 provides an overview of the relationships between the hypotheses H1 to H4.

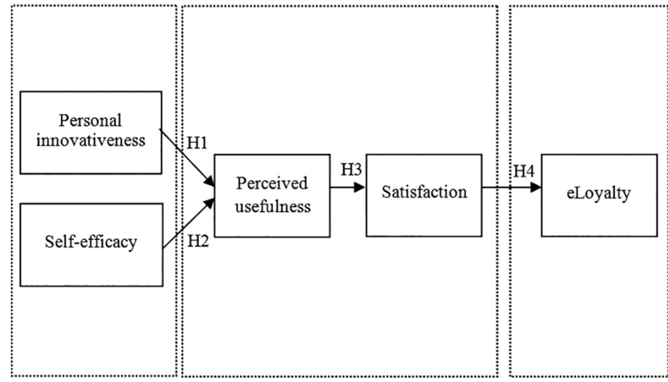


Fig. 1. Proposed research model.

3. Research methods

3.1. Data collection

The ideal case scenario for the conduct of the research would have consisted of an environment where a healthcare system was already benefitting from the use of IoT-based healthcare services. Efforts were made to achieve this, but the relatively embryonic nature of IoT-based healthcare services in Spain and the UK at the time of the research meant that these conditions were not within reach for the research team. In line with the theoretical background of the research, the research team proceeded to study the success Internet-based healthcare services as a means to inform IoT-based efforts in the domain.

Data used to test the research model were therefore gathered from a sample of users of Internet-based healthcare services provided by the public healthcare system of the Region of Murcia, in the South-East of Spain. This region was selected to carry out the research because its authorities have made an explicit commitment to exploiting technologies to support healthcare processes and their management. Such a commitment was formalised through an ambitious project of investment and implementation of information systems which has allowed the Region of Murcia to lead the exploitation of technologies in the Spanish National Health Service. The Internet-based healthcare services provided in this region include patient services such as booking appointments, checking waiting lists, making a complaint, suggestion or enquiry, identifying and sharing information with others patients with the same health problems, and reading on-line information about public health centres and their resources (e.g. medical staff, medical and care services, medical specialties covered, medical facilities), organisational issues (e.g. timetables, location and other contact details, instructions for admissions, regulations), or health-related information (e.g. news, events). The first Internet-based services were provided to the population of Murcia in 2007. Nowadays work continues on the development of new Internet-based healthcare services. In addition, according to the Spanish Statistical Office, the population of this Region shows similar levels of use of ICT to those that characterise the Spanish average. Hence, this Region presents an appropriate framework to analyse the e-loyalty of a population towards new Internet-based healthcare services.

Research participants were selected randomly from different areas within the Region of Murcia. Five categories of municipalities were selected according of their size, following official statistics obtained from the Spanish Statistical Office. Then, the electoral register, which lists the names and addresses of everyone who is registered to vote, was used to randomly select participants from each municipality. Potential participants were contacted by telephone. Firstly, the purpose of the study was explained. Then they were asked whether they had ever used Internet-based healthcare services. Those who confirmed they had used any system they described as an Internet-based healthcare service were invited to participate in the study. Individuals who agreed to participate

Table 1
Summary of scale items.

Construct	Measure
Perceived usefulness	
USE1	Internet-based services enhance effectiveness in doing things.
USE2	Internet-based services make it easier to do things.
USE3	Internet-based services enable me to accomplish thongs more quickly.
Satisfaction	
SAT1	These Internet-based services have met my expectations.
SAT2	I am pleased with the experience of using these Internet-based services.
SAT3	My decision to use these Internet-based services was a wise one.
e-Loyalty	
ELO1	Assuming that I have access to these Internet-based services, I intend to reuse it.
ELO2	I will frequently use these Internet-based services in the future.
ELO3	I will strongly recommend others to use these Internet-based services.
Personal innovativeness	
INN1	If I hear of new technology-based tools, I look for ways to experiment with them.
INN2	Comparing myself to others, I am usually the first to try new technological tools.
INN3	I like to experiment with new technologies.
Self-efficacy	
SELF1	I could use the technology-based tools earlier if I had only a user manual.
SELF2	I could use the technology-based tools if I see someone else use it before trying it myself.
SELF3	You could use the technology-based tools if I could call someone to help me if I have problems.

were then asked to answer the questionnaire. This process continued until the number and nature of respondents represented a diverse sample with the demographic covering the region, so that a realistic picture of the population was represented.

Approximately 73% of the 380 individuals approached agreed to participate in the study. 277 questionnaires were completed, of which 256 were considered valid by the researchers. The average age of participants was 33.57 years, ranging from 18 to 81 years old. Approximately half (52%) of respondents were male, and 71.1% had completed a university degree. 14.8% of the respondents were older than 50 years, 18.8% were between 41 and 49 years of age, 20.3% were 30 to 40 years old, and 25.5% were aged between 21 and 29 years.

3.2. Measures

A questionnaire was developed as the instrument for data collection. All items (presented in Table 1) were measured using a seven-point Likert-type scale with anchors from "Strongly disagree" to "Strongly agree". The questionnaire constructs were operationalised and measured as follows:

- Personal innovativeness was measured in terms of a three-item scale adapted from Robinson Jr. et al. (2005) that captures the willingness to experiment and use new technologies.
- Self-efficacy was measured by using three items adapted from Al-Somali et al. (2009) to determine the degree to which users believe that they can successfully use Internet-based healthcare services.
- The three items used to measure Perceived Usefulness were adapted from prior work by Davis (1989) to quantify the degree to which users believe that the use of Internet-based healthcare services would be useful.
- The measures relating to satisfaction consisted of 3 items adapted from Wang (2007), Oliver (1980) and Spreng et al. (1996) to measure the features of fulfilment of expectations, gratification received from the experience and agreement to the decision of using the services.
- The measures relating to the existence of e-loyalty scale consisted of 3 items adapted from Roca et al. (2006) and Wang (2007) to measure the features of intention to reuse and to recommend others the use of the services.

4. Results

4.1. Assessment of the measures

In order to get a more robust evaluation of the quality of the measurement model, a confirmatory analysis was completed by using the covariance matrix as input via LISREL 8.50 (Jöreskog and Sörbom 2001) robust maximum likelihood method. This can be justified since maximum likelihood (ML) and generalised least squares (GLS) estimators are based on use of normal data, and if the data are not normal, the χ^2 goodness-of-fit test using these estimators can reject too many true models and produce biased parameter estimates (West et al., 1995). Therefore, the robust maximum likelihood (RML) method was used to estimate parameters for this model and fit indices that are less sensitive to non-normal data (Satorra-Bentler χ^2, CFI and IFI) were used to interpret the model fit (Olsson et al., 2000). With regards to the measurement model, we began by assessing the individual item reliability (Table 1). The indicators exceed the accepted threshold of 0.70 for each factor loading.

From an examination of the results in Table 2 it is confirmed that all of the constructs are reliable as they present greater values for both Cronbach's alpha coefficient and composite reliability than the value of 0.7, as required in the early stages of research. The fit statistics for the resulting 15 items, which are summarised in Table 2, indicate a reasonable data fit, with $\chi^2_{(80)} = 133.92$; comparative fit index [CFI] = 0.99; incremental-fit Index [IFI] = 0.99; root mean square error of approximation [RMSEA] = 0.051. The fit index of RMSEA is below 0.08, and indices of CFI and IFI are above the common standard of 0.9 (Hair et al. 1998). Although a significant chi-square value indicates that the model is an inadequate fit, the sensitivity to sample size of this test confounds this finding, and makes rejection of the model

Table 2
Construct summary: confirmatory factor analysis and scale reliability.

Constructs	Items	Standardized loading	T-value	Reliability (SCR[a], AVE[b])
PU (perceived usefulness)	USE1	0.81	20.17	SCR = 0.86
	USE2	0.87	21.94	AVE = 0.68
	USE3	0.81	22.45	
SAT (satisfaction)	SAT1	0.75	19.94	SCR = 0.83
	SAT2	0.80	22.30	AVE = 0.63
	SAT3	0.83	23.11	
ELO (e-loyalty)	ELO1	0.85	25.07	SCR = 0.85
	ELO2	0.81	19.21	AVE = 0.64
	ELO3	0.73	15.80	
Personal innovativeness (INN)	INN1	0.78	18.78	SCR = 0.82
	INN2	0.79	13.92	AVE = 0.60
	INN3	0.76	20.14	
Self-efficacy (SELF)	SELF1	0.74	16.06	SCR = 0.84
	SELF2	0.88	30.57	AVE = 0.65
	SELF3	0.79	19.72	

Notes: The fit statistics for the measurement model were:
Satorra-Bentler $\chi^2_{(80)} = 133.92$; χ^2/d.f = 1.67; GFI = 0.91; CFI = 0.99; IFI = 0.99; RMSEA = 0.051.
The asymptotic covariance matrices were generated to obtain the scaled chi-square (Satorra and Bentler, 1988) and robust estimation of standard errors.

[a] SCR = Scale Composite Reliability (SCR) of $p_c = (\Sigma\lambda_i)^2$ *var.* (ξ) / [$(\Sigma\lambda_i)^2$ *var.* (ξ) + $\Sigma\,\theta_{ii}$].

[b] Average variance extracted (AVE) of $p_c = (\Sigma\lambda i2$ *var.* $(\xi))$ / [$\Sigma\lambda i2$ *var.* (ξ) + $\Sigma\theta ii$].

Table 3
Discriminant validity for each pairwise of constructs.

	Range	Mean[a]	CA[b]	S.D	Correlation matrix				
					I	II	III	IV	V
I. PU	1–7	5.02	0.85	1.10	**0.82**				
II. SAT	1–7	4.79	0.81	1.03	0.67***	**0.79**			
III. ELO	1–7	5.23	0.80	1.10	0.54***	0.68***	**0.80**		
IV. INN	1–7	4.45	0.77	1.29	0.36***	0.37***	0.34***	**0.77**	
VI. SELF	1–7	4.44	0.75	1.29	0.31***	0.21***	0.19***	0.27	**0.81**

S.D. = Standard Deviation; Intercorrelations are presented in the lower triangle of the matrix. The bold numbers on the diagonal are the square root of the Average Variance Extracted.

*** $p < 0.01$.

[a] Mean = the average score for all of the items included in this measure.

[b] CA = Cronbach's Alpha.

Table 4
Indirect effects.

Indirect effects on	Point estimate	Percentile bootstrap 95% confidence interval		
		5% Lower	95% Upper	Support
Satisfaction				
INN → PU → SAT	0.21***	0.133	0.296	Yes
Self → PU → SAT	0.21***	0.084	0.235	Yes
e-Loyalty				
INN → PU → SAT → ELO	0.19***	0.092	0.209	Yes
Self → PU → SAT → ELO	0.19***	0.058	0.170	Yes

Notes: ***$p < 0.01$.
[PU → Perceived usefulness, SAT → Satisfaction, ELO → e-Loyalty, INN → Personal innovativeness, Self → Self-efficacy].

inappropriate on the basis of evidence alone (Bagozzi 1980). However, a ratio of less than three ($\chi 2/df < 3$) indicates a good fit for the hypothesised model (Carmines and McIver, 1981).

Discriminant validity was determined by comparing the square root of the AVE (i.e., the diagonals in Table 3) with the correlations among constructs (i.e. the lower triangle of the matrix in Table 2). On average, each construct related more strongly to its own measures than to others (Fornell and Larcker, 1981). The constructs' correlation matrix, means and standard deviations are shown in Table 3.

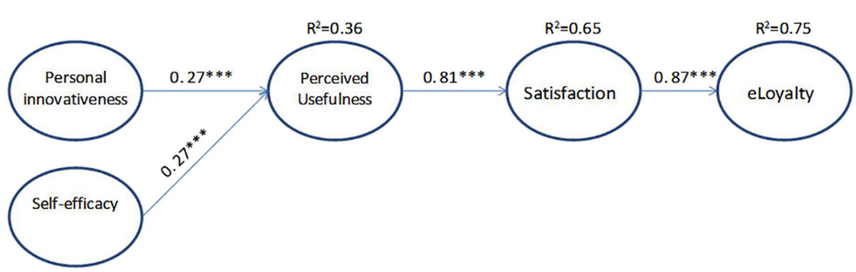
4.2. Structural model results

The fit of the structural model is satisfactory (Satorra-Bentler $\chi^2_{(85)} = 147.29$; $\chi^2/d.f = 1.73$; GFI = 0.91; CFI = 0.99; IFI = 0.99; PNFI = 0.79; RMSEA = 0.054). It is also relevant to note that the Parsimonious Normed Fit Index (PNFI) is above the common standard of 0.6 (James et al. 1982), thereby suggesting that the nomological network of relationships fits our data – another indicator of support for the validity of these scales (Churchill, 1979). The results of the hypotheses tests are also shown in Fig. 2, referred to in the text as H1, H2, H3 and H4. By testing our hypotheses, Fig. 2 shows that in all cases the relationships are highly significant and the structural model explains 75% of the variance in e-loyalty (ELO). Therefore, this analysis provides full support for H1, H2, H3 and H4. The managerial implications of the relationships observed between the factors that constitute the hypothesised relationships are discussed in more detail in the following section.

Following the recommendations by Preacher and Hayes (2008)**,** this study has carried out a post-hoc indirect effect analysis to tests the indirect effects of personal innovativeness and self-efficacy on satisfaction by way of the perceived usefulness. We have also tested the indirect effects of personal innovativeness and self-efficacy on e-Loyalty by way of the perceived usefulness and satisfaction simultaneously (please see Table 4). In doing so, this study constructed bias-corrected confidence intervals (CI) around the coefficient of the indirect effect using the SPSS MEDIATE macro and a bootstrapping technique (Hayes & Preacher, 2014; Preacher & Hayes, 2008). This is justified by the fact that the bias corrected limits may have slightly elevated error rates (Fritz et al., 2012; Hayes & Scharkow, 2013). Therefore, if the 95% CI surrounding the standardized indirect effect did not include 0, we deemed the indirect effect significant. As Table 4 shows, the bootstrap intervals do not contain the zero value. Based on this analysis, perceived usefulness not only mediates the relationship between personal innovativeness and self-efficacy on satisfaction, but also satisfaction mediates the relationship between perceived usefulness and e-Loyalty, Together, from the above analysis, H1, H2, H3 and H4 found support.

5. Concluding remarks

Internet-based healthcare services, including IoT healthcare solutions, have the potential to become valuable tools for public health institutions in their efforts to enhance their effectiveness. But since users of public internet-based healthcare services can choose between using internet-based services or a traditional face-to-face alternative, they need to perceive an advantage of using the internet and feel comfortable with it in order to select that option and build e-loyalty towards it. As the implementation of these services requires a large investment, patients' e-loyalty is essential to avoid wasted resources. Patients' e-loyalty is important, and using an IS theory to create patient e-loyalty will ensure that users come to accept and use an IS. Therefore, the first contribution of this research is to question the existing models which relate to technology and patient e-loyalty in Internet-based healthcare services. Using Seddon's approach as a theoretical background, this study has proposed and empirically validated a new model for understanding individuals' behaviour towards adoption of Internet-based healthcare services. As the Internet of Things is "the next evolution in Internet technology" (Ahlmeyer and Chircu, 2016) and an "extension of today's Internet to the real world of physical objects"



Notes:
The fit statistics for the measurement model were:
Satorra-Bentler $\chi^2_{(85)}$=147.29; χ^2/d.f=1.73; GFI=0.91; CFI=0.99; IFI=0.99; PNFI=0.79; RMSEA= 0.054

Fig. 2. Model statistics.

(Zheng et al., 2011), the main benefit of this research consists of its ability to use the Internet-based healthcare service landscape to inform future strategies for the implementation of new generations of health and well-being services based on IoT technologies. In this context, the research is an early step in the process of raising awareness and to some extent understanding the importance of the people- and process-related dimensions of the implementation of IoT-based healthcare services.

To achieve its aim this research has sought to represent and understand the relationships between the likelihood of success of IoT-based healthcare system and two main factors related to the end-users of the healthcare service (i.e. patients and their families and carers). Such relationships consist of (1) the end-users' capabilities for the effective use of the healthcare information system, namely e-skills; and (2) whether the end-users' attitude towards IoT-based healthcare services is likely to result in a continuous-use behaviour, i.e. e-loyalty.

Two main dimensions of the e-skills of end-users of the IoT-based healthcare services have been studied, namely are self-efficacy and innovativeness. The concept of perceived benefit expected from Internet-based healthcare service has been understood as end-users' perception of usefulness of the service and their satisfaction with the related system(s). The model proposed by this research and validated in the context of Internet-based healthcare services in Spain shows that end-users' e-skills are a precedent to perceived benefits of the Internet-based healthcare service. It has also been found that end-users' e-skills also affect the value of Internet-based healthcare services for those organisations that constitute the building blocks of a functional healthcare system though aspects such as users' loyalty. This is an important finding, as it shows that key criteria used in traditional information systems research can be applied to the analysis of an IoT-based healthcare services environment.

The second contribution of this research is derived from the results of the empirical test of the research model, which provides significant insights into the process of creation and nurturing of end-users' loyalty to the Internet-based healthcare service. Consistent with prior studies (e.g. Bhattacherjee, 2001; Anderson and Srinivasan, 2003; Pham and Ahammad, 2017), user satisfaction was found to have strong effects on the levels of e-loyalty to the service. The results fully support the fact that user satisfaction is a precondition for any programme which focuses on the creation of e-loyalty. From this perspective, user satisfaction may be understood as an ongoing process of evaluation of healthcare technology services. Without achieving satisfaction of patients and their families and carers, well designed healthcare information systems will fail to engage their main audience regardless of the currency of the technology being implemented. Thus, it is proposed that in their efforts to use IoT technologies to provide the expected quality of services, healthcare providers should implement additional strategies that encourage and enable their target population to adopt the new systems and engage in their continuous use. In addition, this is an important finding as loyalty is not an aim by itself, but a way to improve profitability. In the opinion of Reichheld and Schefter (2000) the increase of 5% loyalty rate supposes an increase of 40 to 60% business performance. Therefore, e-loyalty intent can help public hospitals understand target market needs and, ultimately, recover the investment that has been made to obtain and maintain technologies (Zviran and Erlich 2003).

In order to satisfy the medical needs of patients, this research shows that perceived usefulness of the IoT-based healthcare systems plays a major role in the creation of a positive environment which facilitates the use of health technology services. This corroborates the findings of previous research (for example, Guriting and Ndubisi (2006), Calisir and Calisir (2004), Amin et al. (2014)), who argued that perceived usefulness is a concept strongly associated to user satisfaction. In this regard, Wu (2008) also found that the relationship between e-service value and e-service satisfaction was positively influenced by perceived usefulness. Results of this research also add to the debate by indicating that the presence of user e-skills leads to an increase in perceived usefulness of new systems. Hence, this research highlights the importance for healthcare providers to work towards improving their users' perception of the usefulness of the Internet-based healthcare systems. Collaboration with government departments and related agencies and public bodies in initiatives to increase awareness and enhance e-skills of the population would be a plausible strategy to increase the adoption of IoT-based healthcare technologies.

Another contribution of this research relies on the validation of the model in an external user context. To the best of the authors' knowledge, previous attempts to develop models for measurement of information system success have been validated and often fully conducted in the context of an organization. Those that have focused on healthcare in particular have only involved hospital personnel (for example, Pai and Huang, 2011). In this type of environment, people's attitudes, intentions, behaviours, and perceptions as well as the relationships between those factors are likely to be influenced by the presence of a vertical structure with related authorities and directives (Lanseng and Andreassen, 2007). This research has empirically supported the core concepts of Seddon's model in an open context, where respondents have been free to form their own beliefs, attitudes and intentions, as well as freely expressing their own views. Thus, these results contribute to the general validity of the model proposed.

From a managerial point of view, the research has significant implications. Our findings suggest that since healthcare user e-skills are an antecedent to perceived benefits of the IoT-based information system, as part of the strategy for design and implementation of the services, healthcare managers should consider the creation and plan for the continuous increase of their patients' e-loyalty to the new healthcare systems through strategies that improve e-skills such as personal innovativeness and self-efficacy. In order to become innovative, users of IoT-based healthcare systems also need to develop a positive attitude towards change. Informative actions (e.g. guidelines, leaflets, posters and resource packs similar to those used by healthcare providers in health-related campaigns) can help the population to discover and engage with Internet-based healthcare systems, as well as develop a positive attitude towards such services. Where feasible, such strategies could be complemented by training programs and the dissemination of user guides through different means in an effort to promote the importance of individuals' self-efficacy in the use of the systems. Furthermore, for IoT-based healthcare systems to be successfully adopted, it is essential that a large part of the target population engages in their continuous use so as to ensure that appropriate levels of e-loyalty to the services are achieved. This way, adoption of the systems by the less innovative section of the population could be driven by other, more focused strategies, provided that appropriate resources (e.g. required hardware and software) are made available. Appropriate levels of e-skills in the population and e-loyalty to IoT-based healthcare systems could bring significant financial benefits to society. Thus, policy-makers should develop appropriate campaigns to publicise the IoT-based healthcare services available to the target population, potentially finding a large percentage of highly innovative users with strong self-efficacy beliefs, able to adopt the technology and make the service successful. Later on, those individuals could become important change agents, potentially increasing the use of IoT-based healthcare services among the general public.

Data used on this study were collected during a short time span and, as a result, under these circumstances it is difficult to evaluate the causal direction when explaining relationships. Therefore, it should be noted that although our findings corroborate the Seldon's principal constituents and their relations, a further, longitudinal research is needed to conclusively replicate the findings presented here. As another limitation to our work, it must be acknowledged that in the current paper we have only tested that the perceived usefulness is a prior step in the creation of satisfaction. This assumption should be reviewed and explored. Future research should carry out more extensive empirical testing alternative hypotheses (e.g. that perceived usefulness is not a prior step, i.e. could be undertaken in parallel or is unnecessary, to satisfaction).

There are a number of areas in this domain which serve as opportunities for further research. First, replicating this study in other contexts as the IoT matures and new IoT-based healthcare services emerge and become more widely used would provide new insights into other factors affecting the success of such services. This would allow for the people and process dimensions of the IoT-based healthcare services to inform future developments in IoT-based healthcare systems.

Also, individual variables such as age, gender or level of education which may have an effect on the results of the research, have not been addressed by this study and could therefore be incorporated into the theoretical model in future studies. It could be interesting to explore other variables which potentially influence the perceived usefulness of technology, such as organisational factors potentially affecting the management and practitioner side of IoT-based healthcare systems (e.g. trust, support from senior management or resistance to change) or technological factors which can also affect patients and families (e.g. system design, customisation or cost associated to adoption of the system). In this way, the predictive capabilities offered by the model could be improved. Finally, as the study was conducted in Murcia, it is acknowledged that the testing of the model in different socio-economic contexts could offer additional insights into the domain.

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