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Building Trust in Wearables for Health Behavior

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Abstract

Advances in Internet of Things (IoT) have given users the ability to monitor heart rate, calories burned, steps walked, time spent exercising, and the electrical activity of the heartbeat. Although major players in the wearable industry have marketed their wearables using the health and activity tracking features, a noteworthy health behavior change has not been observed at individual or societal level. A prominent barrier to adoption of healthcare features in these devices is lack of user trust. This research conceptualizes the formation of user's initial trust in wearables. Here, wearable systems are proposed as three-dimensional framework constituting the device, the organization (manufacturer or app-maker), and the Internet. Understanding the formation of initial trust on wearable systems' healthcare features can lead to improvement in user's health-related behaviors, which in turn has the potential to cause a societal change in primary healthcare delivery.

Keywords: Healthcare, IoT, trust, technology use, smart watch, conceptual.

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1. Introduction

Rapid advancements in electronics and connectivity have enabled users to connect everyday 'things' such as home appliances, vehicles, and watches to each other. Connectivity among these 'things' help users better monitor themselves (wearable technologies) and their environments (thermostats and motion sensors), increase convenience in everyday tasks (smart speakers, baby monitors), and automate a plethora of other activities such as storefronts, smart locks, smart beds, and vacuum cleaners. The Internet of Things (IoT) is defined as '*connectivity of physical objects equipped with sensors and actuators to the internet via data communication technologies*'(Oberländer et al. 2018). Wearables are a subset of IoT that includes 'things' that can be incorporated into clothing or worn on the body as accessories. Smart Watches such as Apple watch and Fitbit have emerged as the most popular form of wearables. The number of wearable units is projected to grow to 378.8 million in the USA by 2021 (Statista 2019). Total shipments of wearable devices is projected to increase by 25.8% worldwide by end of 2019 and by over 153% in 2022(Gartner 2018).

In recent years, wearables have become technologically advanced with features that are capable of monitoring heart rate, calories burned, steps walked, blood pressure, time spent exercising, and the electrical activity of the heartbeat. Wearable-makers have marketed these devices as tools to improve health behaviors. With features such as steps tracker, calories tracker, and exercise tracker, wearables have been in forefront of the quantified self-movement. Quantified self refers to the engagement of individuals in self-tracking of their biological and physical behaviors (Swan 2013). Capabilities such heart rate monitoring tend to make these devices a secondary personal diagnostic tool. Recently, numerous reports have surfaced where wearables alerted their users of previously undiagnosed and potentially fatal heart conditions (Reisinger 2018). These capabilities put wearables in the position to be a monitor of health behavior and instigator of health behavior change. Health behavior refers to individual's belief and action regarding their health and well-being.

For all the perceived health benefits, wearables face barriers in their adoption. Recent news reports of major data breach in fitness-tracking apps (Dickey 2018) and wearable devices data compromising the location of secret military bases (Taylor 2018) underscore the security consequences and instigate a lack of trust. Both IS and medical literature have outlined various barriers to wearable systems such as affordability, inconsistent accuracy, and ability of feedback to motivate health and activity related actions (Benbunan-Fich 2018; Hamel et al. 2014; Piwek et al. 2016). Other barriers to adoption are related to the maturity of the technology regarding their perceived ease of use and perceived usefulness (Davis et al. 1989b). These barriers were faced by many pervasive information systems in the past such as e-commerce and mobile banking during this phase of their diffusion (Awad and Ragowsky 2008; Rogers 2010). Formation of user's trust on information systems has played an imperative role in user's acceptance of these technologies (Kim et al. 2009; McKnight et al. 2002).

Wearables have the potential to be the information system that can bring about a significant change in user's lifestyle and healthcare behavior. Barriers faced by wearables have been investigated by IS and medical literature but the factors that influence the formation of trust have not been explored by present literature(Patel et al. 2015; Piwek et al. 2016). For research, we identify wearable system as a multidimensional information system constituting the device, the organizations associated responsible to collect and provide health-related data (manufacturer or app-maker), and the internet. This paper draws on existing trust literature in IS and proposes a theoretical model for the formation of user's initial trust on wearable systems and their health monitoring features. We add to the cumulative research by differentiating wearable systems from other information systems and positing specific additional factors that can affect formation of trust in wearable systems: source expertise, tech-savviness, and automation bias. For practice, we expect that this research allows practitioners to design and market wearable systems that instigate positive health behavior changes.

The rest of the paper is organized as follows. In section 2, we briefly review the literature on trust and how it applies to wearables context. We further introduce wearable systems as a three dimensional information system and explain constructs that are used in initial trust formation model. In section 3, we discuss theoretical and practical implications of this research, and possible challenges and limitations of this work.

2. Theoretical Background

Scholars of various disciplines have attempted to study, define, and measure trust. Trust has diverse underlying assumptions across various disciplines. For example, economists view trust as calculus based or institution based while psychologists view trust in terms of attributes of trustor and trustee (Williamson 1975; Zucker 1986). However, there are

commonalities that exist in trust related literature across disciplines. For example, most scholars agree that trust is not static, it has phases of formation, stability and dissolution (Rousseau et al. 1998). The presence of trust indicates that parties involved in exchange have confident positive expectations from each other, and show willingness to be vulnerable. Mayer et al. (1995) defines trust as '*willingness of a party (trustor) to be vulnerable to the actions of another party (trustee) based on expectations that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party'*. Meyer et al. (1995)'s model of trust has been used in various IS research to understand the proliferation of e-commerce (Dwyer et al. 2007; Gefen et al. 2003; Malhotra et al. 2004; McKnight et al. 2002). This model describes trust as a unidirectional relationship between trustee and trustor based on trustor's disposition to trust and their perception about the trustee's trustworthiness. The trustor's perception of trustworthiness is formed by their perceptions about trustee's ability, credibility, and benevolence. Here, *ability* is defined as the group of skills, competencies, and characteristics that enable a party to have influence in specific domain. *Benevolence* is the extent to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive. *Integrity* is trustor's perception that trustee adheres to a set of principles that trustor finds acceptable (Mayer et al. 1995).

Due to the novelty of wearable devices and the introduction of health information, users who adopt these devices form their perceptions about the wearable's trustworthiness. Information acceptance in context of wearables heavily depends on the formation of *initial trust* between users and the wearable system. Formation of initial trust has been studied for e-commerce and social media (Pavlou and Fygenson 2006; Ridings et al. 2002). Initial trust is defined as trust in an unfamiliar trustee (McKnight et al. 1998). Trust formation in web-based information systems such as e-commerce and social media hinged on user's perceptions at two levels: trustworthiness of specific e-commerce enabler or social media websites and trustworthiness of internet as an institution. Wearable information systems constitute three dimensions: the device, the organization, and Internet as an institution (as shown in Figure 1). For user to trust a wearable device to provide reliable and actionable information about their health, the user must have a positive perception of the device's ease to use, accuracy, and quality of feedback (Piwek et al. 2016; Spil et al. 2019).

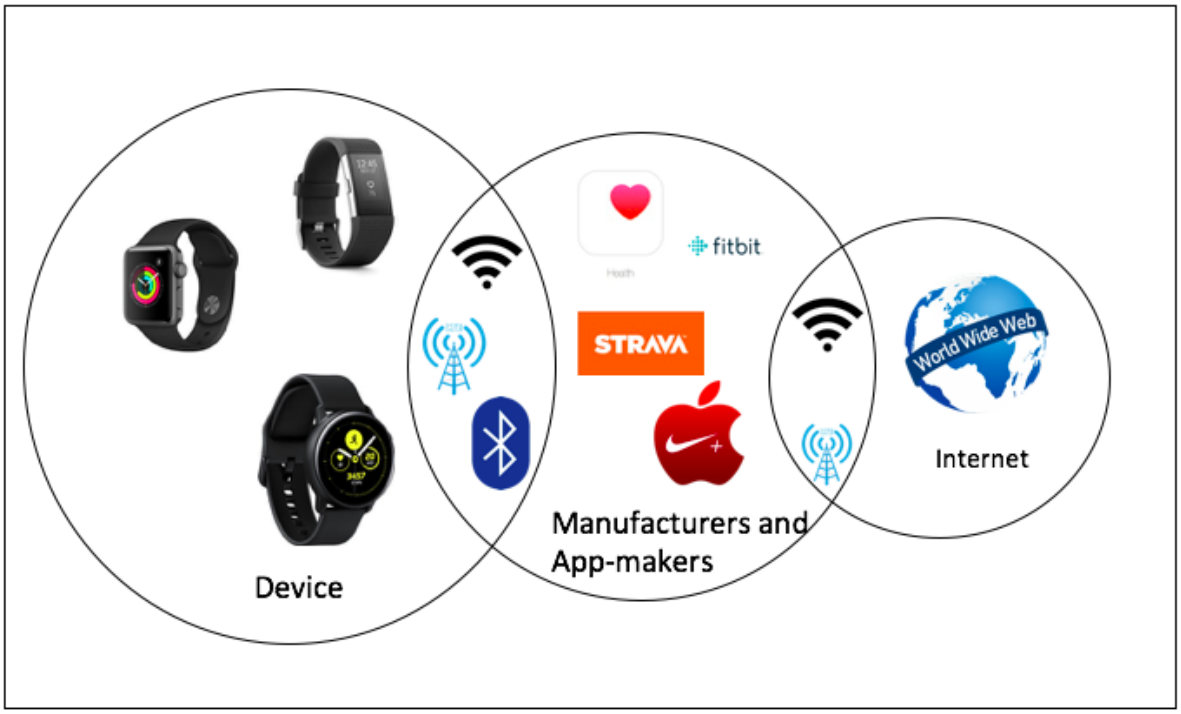

Figure 1. Wearable Information System

First, the design of the device should appeal to the users, i.e. the wearable must be easy to set-up and use. Benbunan-Fich (2018) investigated the relationship between simplicity of design and complexity of use using affordances lens. Wearable devices, which are currently in the market have a high variability in design. Devices like Fitbit Flex and smart rings have minimalistic design with limited feedback. In contrast, smart watches such as Apple watch and Fitbit Versa have interactive displays and larger portfolios of applications and functionalities. Users found simple and minimalistic designs of wearables complex to use. Conversely, wearables with interactive displays and shared platform with smart

phones (Apple watch, Galaxy watch, Fitbit) have found more appreciation and acceptance. Becker et al. (2017) further showed that limited functionality, support devices, and comfort form insufficiencies in user's tendency to use wearables. Wearable devices have had incremental changes in quality of design and ease of use. Thus, users' competence to use technologies factor into the formation of trust in wearable devices. Second, the users must trust the feedback or information provided by the wearable device (i.e. they should be able to accept the data provided by their wearable as accurate to a degree to which it can influence an action) (Jung et al. 2016).

The capabilities of these devices such as heart rate tracker and breathing volume monitor, can be used as a personal secondary diagnostic tool to detect sleep apnea, anxiety, obesity, asthma, panic disorders, and more (Piwek et al. 2016). However, the accuracy of activity-tracking and health-monitoring features of wearables vary across devices. Wang et al. (2017) conducted lab experiments with to test the accuracy of wearables in detecting heart rate. Devices such as Apple watch and Fitbit Charge were included in the study and it was found that, no device achieved the accuracy of chest-strap based monitor. Hamel et al. (2014) categorized wearable devices as a part of mobile health and proposed recommendations for regulations that legitimizes the mobile health systems without inhibiting innovation. Industry and the government has responded to recommendations such as these, and as a result, Apple Watch Series 4 along with numerous other wearables have been cleared or approved by the U.S. Food and Drug Administration. Lastly, the feedback of the device must motivate the user to take action. These actions can cause a positive health behavior change only if the feedback the user gets is convincing. For example: if a user gets notified by their device to incorporate more standing, the user must see value in that feedback to actually stand up. Research dealing with e-commerce has showed that perception of information quality, system quality and information presentation drives decision making satisfaction (Bharati and Chaudhury 2004; DeLone and McLean 1992). Here, system quality refers to the ease of use of the design of the device and information quality refers to the perceived accuracy of information provided by the device. Information presentation has been measured based on characteristics of the interface that make the information easier to process (Bharati and Chaudhury 2004). In context of wearables, actions related to health and activity behavior are taken by the users when information presented to them is able to motivate them.

These factors differentiate wearables from technologies such as e-commerce and social media and thus, warrants a study on formation of user's initial trust in wearables. McKnight et al. (1998) proposed an integrative model for formation of initial trust. This model used the theoretical framework from the theory of reasoned action (TRA) which states that beliefs lead to attitudes which leads to behavioral intentions which, in turn, leads to behaviors. Applying TRA to the formation of trust, they theorized that trusting beliefs lead to trusting intentions which in turn, leads to trusting behavior. Individual's disposition to trust and institution based trust were explained as antecedents of trusting beliefs. McKnight et al. (2002) developed and validated measures for testing the formation of initial trust of users on e-commerce. This paper uses McKnight et al. (2002) 's model to understand the formation of initial trust between users and wearables. The model proposed in this paper seeks to adapt McKnight et al. (2002)'s model in the wearable context. The core constructs studied in McKnight et al. (2002): personal disposition to trust, institution based trust, trusting beliefs, trusting intentions, and trusting behaviors are explained in the context of wearables in the following subsections. Additionally, we posit three additional factors that affect the formation of trusting that are specific to wearable and health monitoring features.

2.1. Trust Related Behaviors

Trust-related behaviors are user's actions that demonstrate dependence on a wearable. These actions may make one vulnerable to the device and organization associated with it or increase one's risk (Mayer et al. 1995). In the current context, trust related health behaviors are individual's actions regarding their health and well-being. Common trust related behaviors with respect to wearables include sharing personal information, purchasing health monitoring and advising subscriptions, and acting on information provided by wearables. Sharing personal health information on a wearable device and app-maker or manufacturer shows that a users' trusts the wearable system with the privacy and security of their information. Purchasing a monitoring and advising subscription shows that user sees value in the information generated by wearables and trusts that the information will be reliable and actionable.

2.2. Trusting Intentions

Trusting intentions means the trustor is willing to depend, or intends to depend, on the trustee. McKnight, et al., (2002) defined two sub-constructs of trusting intentions: *willingness to depend* and *subjective probability of depending*. Willingness to depend is defined as one's tendency to make oneself vulnerable to others. A user shows willingness to depend on a wearable if they regularly check their blood pressure or heart rate on it. The subjective probability of depending is defined as the perceived likelihood that trustor will depend on the trustee. A user has higher subjective

probability of depending on their wearable if they share their personal information on their device (with the organization associated). Based on our definitions of trusting intentions and trusting behaviors, TRA, and findings from McKinght et al.'s (2002) model, we posit the following proposition:

Proposition 1: Users' trusting intentions are positively associated with trust related behaviors.

2.3. Trusting Beliefs

Trusting beliefs refers to the confident trustor perception that the trustee—in this context, a specific wearable system (comprising of device and manufacturer or app maker) —has attributes that are beneficial to the trustor. Information provided by wearables such as heart rate and suggestions regarding activities are supposed to instigate positive health behavior change. Hence, it is imperative that users believe that the system is providing them with reliable information. Here, the user is the trustor and the wearable system is the trustee. The wearable system collects personal information and provides measured health information, diagnostics, and activity prompts and thus, is seen as a source of risk. Trustor's judgement of trustworthiness is seen as a cornerstone for formation of trust beliefs. Users project the attributes (competence, integrity, and benevolence) of manufacturer or application makers to the wearable devices. McKnight et al. (2002) posited that the valance and intensity of trusting beliefs lead to trusting intentions. Based on findings from McKnight et al. (2002) and consistent with TRA, we posit the following proposition:

Proposition 2: Users' trusting beliefs are positively associated with trusting intentions.

2.4. Institution Based Trust

Institution-based trust is the belief that needed structural conditions are present (i.e., for IoT) to enhance the probability of achieving a successful outcome in an endeavor like health monitoring. This is the sociological dimension of trust and deals with structures that make an environment trustworthy. Factors that may contribute in institution based trust in health IoT may range from reputation of manufacturers, institutions involved, and general sentiment towards giving health data to apps. Institution based trust has two dimensions: *structural assurance* and *situational normality*.

Structural assurance refers to 'one's belief that structures like guarantees, regulations, promises, legal recourse, or other procedures are in place to promote success' (Zucker 1986). For example, an individual may be more inclined to use a wearable system for health monitoring purposes if it was FDA approved. The regulations such as FDA approval or clearance are structural assurances for the wearable system. These structural assurances strengthens trust of users in wearable systems and institutions associated (such as manufacturer, app-makers, etc.).

Situational normality refers to 'one's belief that the environment is in proper order and success is likely because the situation is normal or favorable' (Baier 1986). Individuals are more inclined to use wearables if they can perceive them to be trustworthy enough to have a normal outcome. The perception of organization's (manufacturer, app-maker, etc.) trustworthiness can be measured as individual's perception of their competence, integrity, and benevolence. McKnight et al (2002) posited that institution based trust has a positive effect on trusting beliefs and trusting intentions. Based on findings from McKnight et al. (2002) and consistent with TRA, we posit the following propositions:

Proposition 3: Users' institution-based trust is positively associated with trusting beliefs.
Proposition 4: Users' institution-based trust is positively associated with trusting intentions.

2.5. Disposition to Trust

Disposition to trust is extent to which a person displays a tendency to be willing to depend on others across a broad spectrum of situations and persons. Early theories of trust defined it as *'an expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon'(Rotter 1967).* From this definition and various anecdotes and prior conceptualizations, it was inferred that some parties are more likely to trust other parties (Conlon and Mayer 1994; Williams et al. 1988). McKnight et al (2002) used two sub-constructs to measure an individual's disposition to trust: *faith in others* and *trusting stance*. Individual's faith in others refers to one's assumption that people and organizations are usually upright and well meaning. Trusting stance means that, regardless of what one believes about people's attributes, one assumes better outcomes result from dealing with people as though they are well meaning and reliable.

Disposition to trust has significant impact on trust building strategies, which lead to initial trust. Individual's choice of wearable in many instances driven by disposition of trust. Companies such as Apple, Samsung, and Google have dominated digital mobile and computer applications market for a long time (Gawer and Cusumano 2008). These companies have played a pivotal role in diffusion of wearable systems and have emerged as market leaders in this domain (Metcalf et al. 2016). Thus, if an individual has high disposition to trust, they may have more affinity towards wearables sold by these established companies, while individuals with low disposition to trust may be skeptical of any trust building attempts. McKnight et al (2002) stated that disposition to trust has a positive effect on institution based trust, trusting beliefs, and trusting intentions. Based on findings from McKnight et al. (2002) and consistent with TRA, we posit the following propositions:

Proposition 5: Users' disposition to trust is positively associated with institution-based trust.
Proposition 6: Users' disposition to trust is positively associated with trusting beliefs.
Proposition 7: Users' disposition to trust is positively associated with trusting intentions.

2.6. User Technology Interaction Factors

User-technology interaction has been extensively studied in IS literature using perceived usefulness and perceived ease of use (Davis et al. 1989a). Wearable systems are a relatively new technology with limited but rapidly increasing market share (Gartner 2018). *Tech-savviness* is defined as user's competence in usage of technology (Davis et al. 2009). Users' competence to use the wearable systems has an effect on trusting beliefs as first users of these technologies are tech-savvy early adopters (Rogers 2010). Thus, if a user is more tech savvy, the more he or she will tend to form trusting beliefs for wearable systems. Also, the relationship between disposition to trust and trusting beliefs and institution based trust and trusting beliefs will be moderated by users' tech savviness. Based on these conclusions, we posit the following propositions:

Proposition 8a: Users' tech savviness is positively associated with trusting beliefs.
Proposition 9a: Users' tech savviness has a moderating effect on relationship between users' disposition to trust and trusting beliefs; i.e. presence of higher levels of tech savviness strengthens the relationship between disposition to trust and trusting beliefs.
Proposition 10a: Users' tech savviness has a moderating effect on relationship between users' institution-based trust and trusting beliefs; i.e. presence of higher levels of tech savviness strengthens the relationship between institution-based trust and trusting beliefs.

Trust in healthcare-related information provided by variables can lead to critical decisions. For example, a user may incorrectly decide to not visit a doctor based on the vital diagnostics check from their device. *Automation bias* is defined as 'tendency to use automation as a heuristic replacement for vigilant information seeking and processing'(Skitka et al. 1999). Thus, users may believe that wearable system is trustworthy, when they have a higher automation bias. Also, the relationship between disposition to trust and trusting beliefs and institution based trust and trusting beliefs will be moderated by users' automation bias. Based on these conclusions, we posit the following propositions:

Proposition 8b: Users' automation bias is positively associated with trusting beliefs.
Proposition 9b: Users' automation bias has a moderating effect on relationship between users' disposition to trust and trusting beliefs; i.e. presence of higher levels of automation bias strengthens the relationship between disposition to trust and trusting beliefs.
Proposition 10b: Users' automation bias has a moderating effect on relationship between users' institution based trust and trusting beliefs; i.e. presence of higher levels of automation bias strengthens the relationship between institution-based trust and trusting beliefs.

Lastly, the availability of healthcare information is an important aspect of wearables. However, the sensitivity and criticality of healthcare-related readings vary among users. *Source expertise* refers to the extent that user is aware of the context of information provided by the wearables. Source expertise can have a positive effect on trusting beliefs. For example, a healthcare professional may find the feature to measure heart rate more useful than users who have limited knowledge of the field. Source expertise, in select cases of wearables, can adversely affect the formation of trusting beliefs as users may be aware about the variability in accuracy of wearable devices, compared to medical equipment (Wang et al. 2017). The awareness of users about the benefits and shortcomings of wearables' ability to monitor and provide health and activity-related information affects the formation of trusting beliefs. Also, the relationship between disposition to trust and trusting beliefs and institution based trust and trusting beliefs will be moderated by users' source

expertise. Based on these conclusions, we posit the following propositions:

Proposition 8c: Users' source expertise is negatively associated with trusting beliefs.

Proposition 9c: Users' source expertise has a moderating effect on relationship between users' disposition to trust and trusting beliefs; i.e. presence of higher levels of source expertise weakens the relationship between disposition to trust and trusting beliefs.

Proposition 10c: Users' source expertise has a moderating effect on relationship between users' institution based trust and trusting beliefs; i.e. presence of higher levels of source expertise weakens *the relationship between institution-based trust and trusting beliefs.*

2.7. Initial Trust Formation for Wearables

Based on the constructs discussed above and their relationships according to the theory of reasoned action, we propose initial trust formation model for wearables (Figure 2). This model takes into account the characteristics of the user, the user's perception about the device and organizations associated with them, and their overall perception of wearable systems. According to characteristics of users, their disposition to trust should have a positive relationship with user's institution based trust, user's trusting beliefs, and user's trusting intent to engage in trust related behaviors with wearables. User's institution based trust should have a positive relationship with user's trusting beliefs and trusting intentions. According to TRA, trusting beliefs should lead to trusting intentions, and finally, trusting intentions should lead to trust related behaviors.

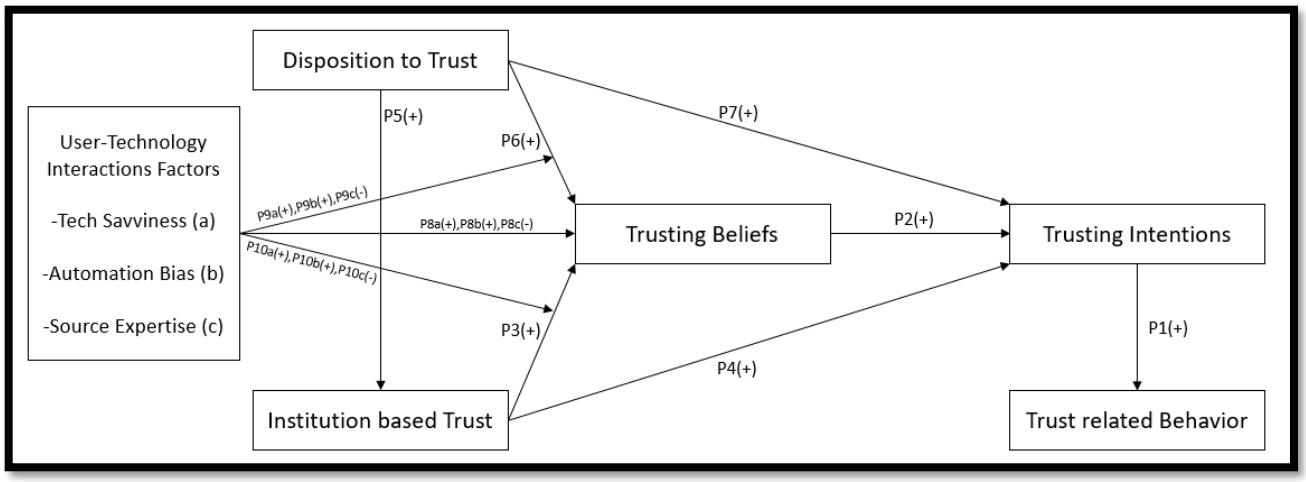

Figure 2. Proposed Theoretical Model: Initial Trust Formation in Wearables

3. Discussion

Wearables are becoming increasingly advanced and robust in healthcare-monitoring. The adoption and consequences of wearable technologies have not been studied in IS or medical literature to any noteworthy extent. Research in both disciplines have shown that wearable technologies have the potential to bring about a change in healthcare behavior at individual as well as society level (Hamel et al. 2014). Wearable technologies have also been identified as a system different from web based platforms such as social media and e-commerce. Thus, the underlying assumptions of research in those contexts may not apply to wearable context. This research summarizes the factors that affect the relationship between use of wearables and health behavior change, identified by IS and medical literature. This research posits that formation of user's initial trust can overcome these barriers. Future research can experimentally test and extend the proposed model. The constructs of disposition to trust, institution based trust, trusting beliefs, and trusting intentions have been measured and the relationships between them have been tested in numerous studies before (Kim et al. 2009; Li et al. 2008; Zhou 2012). We have identified three measureable user-technology factors that can influence the formation for trust. With suitable adjustments, scales used in previous studies can be adapted to test the proposed model to create a better understanding of formation of trusting intentions on health monitoring features of wearable systems using surveys. Controlled experiments can be used to test effect of trusting intentions formed by the various factors described in the model on health behaviors.

This research is expected to contribute to the growing literature dealing with trust in IS and use of ubiquitous technologies and IoT. This research can also generate insights and actionable recommendations to practitioners (wearable developers and marketers) to make wearables more acceptable and trustworthy for the uses. The user tech-enabled healthcare market is projected to grow remarkably in the coming years (Darie 2019). There have been attempts to overcome barriers to wearable adoption and use. Many insurance companies have attempted to release interactive insurance plans that either subsidizes wearable devices or incentivizes consumers to use wearables and share data (Paluch and Tuzovic 2017). However, these plans are still in infancy and their effect on affordability of wearables cannot be measured at this stage. Similarly, FDA regulations are aimed to increase user confidence in the wearables for health purposes. Future research can also measure the effectiveness of these attempts in wearable use and health behavior change. There are a few challenges associated with this research strand. In research on wearables thus far, the issue of endogeneity has emerged when researchers have attempted to quantity the motivational ability of wearables to cause healthy behavior. Piwek et al. (2016) has also noted that analysis of healthy behavior among wearable users faces validity concerns since, consumers with healthy lifestyle are more prone to adopt wearables. Future research must also look at research design to overcome endogeneity.

4. Conclusion

With sustained market growth and rapid advancements in design, wearables have the potential to be an information system that can bring about a significant change in user's lifestyle and healthcare behaviors. Yet, there are factors that influence this change. Our research summarizes posits that formation of initial trust will be able to overcome barriers to wearable use for health behavior change. We proposed a theoretical model that can be tested and extended by future research. This research contributes to the growing literature dealing with trust in IS and use of ubiquitous technologies and IoT.

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