Determinants of Wearable Healthcare Technology Usage in Vietnam*

Van-Anh T. Truong[1][0000-0002-8798-1934] and Bao Quoc Truong-Dinh[1,2,**][0000-0002-4825-0717]

[1] University of Economics, The University of Danang, Vietnam
[2] Department of Business Administration, National Central University, Taiwan
{vananhtt,baotdq}@due.edu.vn

Abstract. The outbreak of the COVID-19 epidemic has been motivating people to rethink health-related threats, causing the development of healthcare wearable technology. Nevertheless, previous studies on smart devices focus too much on the nature of wearables technologically. Moreover, there is a lack of research examining consumers' physical and social elements in a relationship-oriented country like Vietnam. Therefore, this study considers the antecedents of the actual use behavior of wearables users by inheriting the earlier models (i.e., TAPB, TPB) to determine which and how internal and external factors affect consumer's adoption of wearable devices in healthcare. The quantitative methodology with Vietnam wearables users survey is conducted during the third wave of pandemic spread in June 2021. We use the PLS technique to analyze the data from 143 questionnaires, representing the suitability of the research model. Except for knowledge reflected via information search, all remaining dimensions positively affect wearables adoption in healthcare. Some implications are proposed for future directions theoretically and practically.

Keywords: smart healthcare, wearable technology, actual use behavior, design, Vietnam.

1 Introduction

National sustainability can be perceived via upheavals like war, natural disasters, and epidemics. The COVID-19 outbreak, therefore, has been changing many aspects of human life. As stated by the Grand View Research [1], this pandemic has extended the usage of wearable medical technologies from monitoring ordinary healthy lifestyles or health indexes to warning early signs of miner's viral infection symptoms.

** Corresponding author.

Technological wearables can be used as smart accessories, embedded clothes, even implanting or tattooing forms on the body with huge growth in market sizes, sales, shipments, and usage [2]. They are considered electronic devices such as smartwatches, wristbands, wearable fitness technology. Notably, smartwatches are well-known among the other trends, including fitness trackers, smart glasses, hearables, smart clothing, skin patches, disease-orientated devices, AI/ML/cloud solutions/biosensors in wearables [3].

Connect wearable devices number had increased double within 2016-2019 period year and has been estimated up to one billion by 2022 [4]. This forecast includes both healthcare devices and earwear technologies. According to Phaneuf [5], healthcare wearables are willing to be worn by more than 80% of consumers. These technological wearable devices are designed for enhancing user's experience and collecting their health information (i.e., physical activities, heart rhythms, blood pressure, sleep, electrocardiograms) which can be shared with healthcare professionals. Users can be beneficial because of 89% reduction or prevention the health issues. Therefore, doctors, healthcare staffs, and insurers are beneficial as well. Wearable healthcare devices are desired by 35% of employers (wellness and insurance program), 88% of physicians (health parameters monitoring), and hospitals (reduction of 16% of hospital costs within five years, reduction of USD billions within coming 25 years) [6].

In Vietnam, the wearable technology market reached 65 USD trillions in 2020 with the penetration of many big brands and even domestic distributors, especially towards smartwatches [7]. Regarding low and middle-income countries like Vietnam, Brophy, Davies, Olenik, Cotur, Ming, Van Zalk, O'Hare, Guder and Yetisen [8] suppose that physical access to wearables could be the obstacle to this market growth. Besides, although it is necessary to pay attention to the design aspect of healthcare wearables [9], there is a lack of studies that mention at least the aesthetics attributes of these devices and their influence on user's acceptance. Sharma and Biros [10] state the relationship between usage and design of wearable devices via the functional and interactive features. Additionally, previous research focuses on demographic differences or market trends rather than user acceptance and actual use [11]. Hence, with a preventive health-oriented approach, this study considers influential elements of actual use behavior of healthcare wearables in the case of Vietnam. We try to solve the research problem related to which and to what extent the internal and external variables affect users' behaviors towards wearable technologies in healthcare. The empirical study is expected to theoretically contribute to researches on developing countries. It also gives some implications to increase performances of applying wearable tech and reduce the burden of Vietnam's healthcare system.

2 Theoretical Background

2.1 Healthcare Wearable Technology

Healthcare wearable technology is considered novel wearables with advanced technological features that can track or monitor healthcare issues (i.e., heart rate, blood pressure, exercise) biologically and physically to improve health behaviors [10]. It is the

type of e-technology attached to wearable accessories in the healthcare and medical industries [12]. The success of wearable devices shown via smart wearables acceptance is helpful to predict IT devices' future directions [13].

The Technology Acceptance Model (TAM) proposed by Davis [14] is acknowledged as one of the most influential models in theory regarding user's adoption of technology-related objects. Almost all extensions of the TAM on healthcare wearables researches keep the core variables related to perceived usefulness (PU) and perceived ease of use (PEOU), attitude, the intention with supplement variables, and some modifications on external variables. Some external variables can be listed such as healthcare professional trust [15]; initial trust, consumer innovativeness, compatibility, and health interest [16]; task-technology fitness, characteristics of users and wearable devices, social influence factor [13]; technology readiness [17]; health-related variables, privacy protection, consumer innovativeness, and reference group influence [18].

Towards m-health interventions for behavior change, Cho, Lee, Islam and Kim [19] synthesize theories including behavioral learning theory (BLT), health belief model (HBM), integrated theory of health behavior (ITHB), social cognitive theory (SCT), transtheoretical model of behavioral change (TTMBH). These models are often used along with extensions of the TAM models. Similarly, protection motivation theory (PMT) and the theory of acceptance and use of technology 2 (UTAUT2) are combined in studying healthcare wearables acceptance [20] in which technology, health, and privacy are the antecedents of healthcare wearable devices adoption.

In the research of Hwang, Chung and Sanders [21] on intelligent clothing, perceived performance risk and environmental concern are supplementary, while the external factors are functionality, expressiveness, and aesthetics (FEA). The authors imply the attention of product-makers should move from technical aspects to user-centric aspects, especially compatible aesthetics depicted in the design.

The recent study on luxury fashion wearable technology of Blazquez, Alexander and Fung [22] focuses on three-stage of attitudes, including cognition, affection, and conation. In these stages, PU and PEOU belong to functional dimensions besides individual and social factors. On the other hand, PEOU is only mentioned as a component of innovation characteristics, while PU can be reflected via health-related information. Individual traits can be considered moderators that affect the remaining relationships [23].

2.2 Research Framework

In this research framework, we do not focus on the prerequisite of technology acceptance in healthcare, as demonstrated in earlier researches. The prerequisite can be any element related to perception on usefulness and ease of use that affecting actual usage via attitude and consumer intention. The purpose of this study considering the user's healthcare tech-related psychological process on wearable aspects as sufficient conditions that can lead to actual use behaviors. We adapted and modified the work of Lee and Lee [11] to introduce the conceptual framework (Figure 1). The framework contains five antecedents of actual use behavior toward healthcare wearable technology. The five antecedents are classified into two groups, internal and external variables.

Internal variables

The internal variables are added in the research model by Lee and Lee [11], who apply the knowledge, attitudes, practices, and belief (KAPB) model in healthcare wearable devices research. In the integrated theory of health behavior change introduced by Ryan [24], knowledge and beliefs are essential dimensions that lead to self-management behaviors. The more information about specific health behaviors and beliefs that persons have, the more health behaviors are engaged.

Knowledge. Knowledge concept is not only understanding but the acquisition, management, and technological knowledge usage [11]. Individual traits such as self-efficacy, motives, and usage patterns are the basement of healthcare technology design for customization [25].

Hypothesis 1. Knowledge has a positive influence on actual use behaviors towards healthcare wearable technology.

Attitude. According to Blazquez, Alexander and Fung [22], attitude can be considered subjective evaluation or individuals' learned tendency related to an object. Its features (cognitive, affective, conative) reflect the process (of learning, feeling, and doing) that effectively predicts actual behavior, especially attitude towards a specific behavior.

Hypothesis 2. Attitude has a positive influence on actual use behaviors towards healthcare wearable technology.

Belief. Towards IT-related personal innovativeness, health belief that belongs to health motivation is the antecedent of preventive health behaviors [23]. Besides, the health belief model (HBM) is the fundamental theory in the study of Chau, Lam, Cheung, Tso, Flint, Broom, Tse and Lee [12], Cheung, Chau, Lam, Tse, Ho, Flint, Broom, Tso and Lee [18] on smart technology for healthcare in which perceived health belief is the predictor of user's adoption.

Hypothesis 3. Belief has a positive influence on actual use behaviors towards healthcare wearable technology.

External variables

Social factors. Social factors are mentioned in many studies on wearable technology [22, 26, 27]. Social factors reflect consumers' psychology concerning their social groups, including perceived conspicuousness and subjective norm towards specific behaviors. Individuals decide to act based on self-assessments due to their social relationships [13] or reference groups [18].

Hypothesis 4. Social factors have a positive influence on actual use behaviors towards healthcare wearable technology.

Design. In the book of Baisya and Das [28], the authors mention aesthetic attributes in harmony with quality and other product elements as an attractive component leads to purchase. Later, Mazzalovo [29] psychologically analyses the consumption aestheticization linked with the product choice process. Depending on information processing or receiving, it can be relevant to both internal (cognitive) and external (brand-manifested) factors. The extent of aesthetics is based on product features. In hi-tech products (technology-attached products), the aesthetics attributes are often known as design. Playing the role of the visual communicator for a wearable product, design can directly affect consumer's acceptance or actual use behaviors in healthcare wearables. The design of healthcare wearables mentioned by the earlier researchers [9, 30, 31] is the suitable representative of compatible aesthetic attributes that emphasized in the study of

Hwang, Chung and Sanders [21], Kalantari [26], Jeong, Kim, Park and Choi [32] or wearability and fashionableness mentioned by Chang, Lee and Ji [13].

Hypothesis 5. The design has a positive influence on actual use behaviors towards healthcare wearable technology.

3 Research methodology

The measurement scales of all constructs in the study were adopted and minor modified from prior validated scales in English-written literature. The back-translation was adopted to translate all items to Vietnamese, and the pre-test process was performed to modify the ambiguous items. All four-item of knowledge and both three-item scales of attitude and belief were adopted from Johnston and Warkentin [33]; Ko, Moon, Kim and Paik [34]. A four-item scale of social factors and actual use behavior were taken from Johnston and Warkentin [33], Venkatesh, Morris, Davis and Davis [35], Venkatesh, Thong and Xu [36]. Finally, a three-item scale of Hwang, Chung and Sanders [21] was used for wearable design.

The field study was carried out in Danang city, Vietnam. The COVID-19 pandemic increases the awareness of people in protecting and improving their health. Wearable technology devices have become more popular among people. We collected the data from sport and gymnastic centers in the city during a rare period of non-lockdown and non-keep distance of 2021. Only respondents who currently use wearable technology devices were invited to fill the questionnaire. Totally, 143 useable questionnaires were satisfied to use for data analysis.

Our sample contained 38.5% male and 61.5% female. The respondents in a group from 18 to 24 years old occupied 69.2% of the sample, while the group of 25 to 49 years old and the group over 50 accounted for 27.3% and 3.5% of the sample. 55.9% of the participants in the sample were students, while employees and self-employed accounted for 30.8% and 6.3%. Another occupation was 7% of the sample. The sample showed the majority of respondents currently use a smartwatch, accounting for 67.3%. Health tracking devices, heart rate monitor chest straps represent 16.4% and 13.3%, respectively. Other types of devices related to mask, sensors, etc., define 3% of the sample.

4 Data Analysis

We used the partial least square (PLS) technique to analyzed the data with SmartPLS software [37]. Multiple criteria are used to test the measurement model, such as reliability, convergent validity, and discriminant validity, with the results presented in Table 1. For reliability, the Cronbach's alpha of all constructs was higher than the threshold of 0.5 after removing two items of knowledge construct. Besides, the convergent validity was confirmed to be satisfied by the assessment on two types of indices. First, both composite reliability (CR) and average-variance-extracted (AVE) values were higher than the suggested threshold of 0.7 and 0.5, respectively. Second, the item loadings of all indicators were higher than the highest cross-loading with each other indicators and

higher than the threshold of 0.5. As for discriminant validity, the values of the square root of AVE exceeded the correlation of all constructs. As such, the preliminary analysis supported the confirmation of the scale accuracy.

Table 1. Measurement accuracy assessment

Constructs	Alpha	CR	AVE	1	2	3	4	5	6
1. Knowledge	0.763	0.894	0.809	**0.899**					
2. Attitude	0.864	0.917	0.786	0.745	**0.887**				
3. Belief	0.859	0.914	0.780	0.765	0.774	**0.883**			
4. Social factors	0.885	0.921	0.744	0.665	0.688	0.837	**0.863**		
5. Design	0.888	0.930	0.817	0.685	0.594	0.695	0.699	**0.904**	
6. Actual use behaviors	0.906	0.934	0.780	0.731	0.732	0.806	0.786	0.732	**0.883**

The overall model fit was evaluated mainly through the R^2 of endogenous contrast, predictive relevance (Q^2), and standardized root mean squared residuals (SRMR). The value of R^2 was 0.748, represented a substantial level [38]. The values of Q^2 were ranged from 0.376 to 0.618, all above the required value of zero [39]. The value of SRMR was 0.053, which is lower than the threshold of 0.08 [40]. These indicated a good model fit of the framework. A t-test using the bootstrapping procedure of 500 samples was applied to test the direct relationships, while Cohen's Indicator (f^2) was applied to measure their effect sizes. Hypothesis 1 was rejected because the p-value was higher than 0.05. All other hypotheses (H2 to H5) were supported at least 95% confidence level (Figure 1). The f^2 values ranged from 0.038 to 0.086, indicating the effect size of accepted hypotheses was medium.

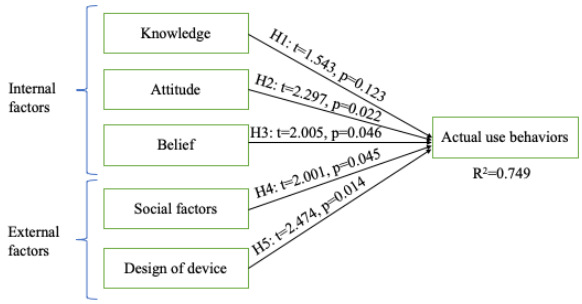

Fig. 1. The conceptual framework of Actual Use Behaviors towards Healthcare Wearable Technology

5 Discussion and Conclusion

Except for knowledge of the internal components, all independent variables are the antecedents of actual use behaviors towards healthcare wearable technology. It can be seen that the proposed model is suitable for predicting healthcare wearables usage. This

result confirms almost all the variables suggested by Lee and Lee [11]. Nevertheless, the relationship between the knowledge of users and their actual use behavior is not supported in the context of Vietnam. It means that the knowledge of health-related wearables is not needed to be the prerequisite of smart devices usage. This type of knowledge concerning with information search about healthcare wearables to manage user's health. The search is conducted by positive-oriented people towards a healthy lifestyle [41, 42]. This finding reflects the interesting insights from the Vietnam wearables users whose actions are strongly influenced by external factors and attitude, belief elements in the theory of planned behavior (TPB). In other words, consumers choose to use healthcare wearables as long as they have a positive attitude towards buying behavior and positive belief towards wearable technology usage. Hence, attitude, belief on healthcare wearables usage should be considered instead of merely improving consumers' knowledge.

Along with the spread of social networks and formalism, Vietnamese consumers are pressured to look good and act based on social norms. Consequently, it is not difficult to understand why social factors and the design of wearable devices positively influence actual use behavior. Furthermore, in a relationship-oriented society like Vietnam, health-related risks can be mentally and physically dependent on how strong individuals' relations with their social groups are. This nature can inspire producers, marketers, managers, or medical professionals to think about the cooperative mechanism to boost the wearables market. Despite the limitation in sampling due to the outbreak of the COVID-19 pandemic, this finding represents the research contribution in understanding the determinants of healthcare wearables use behavior, especially the external components regarding social norms and design of devices in the Vietnam context. Furthermore, future research can examine the predictors of the continuum of usage and the difference between patients and non-patients towards smart healthcare devices.

References

1. Grand View Research: Wearable Medical Devices Market Size, Share & Trends Analysis Report By Type (Diagnostic, Therapeutic), By Site (Handheld, Headband, Strap, Shoe Sensors), By Application, By Region, And Segment Forecasts, 2021 - 2028. Grand View Research (2021)
2. Kumar, S.: 24+ Wearable Technology Statistics (2021 Trends and More). 16best, US (2021)
3. GlobalData Thematic Research: Wearable Technology: Technology Trends. Mining Technology, UK (2021)
4. Vailshery, L.S.: Connected wearable devices worldwide 2016-2022. statista, US (2021)
5. Phaneuf, A.: Latest trends in medical monitoring devices and wearable health technology. Business Insider, US (2021)
6. eMedCert: Wearables: Future of Healthcare. EMedCert, US (2021)
7. Hữu Tuấn: Wearable Technology "The hen that laid golden eggs" for technological firms [Thiết bị đeo thông minh: “Gà đẻ trứng vàng” cho các hãng công nghệ]. Đầutuonline, VN (2021)
8. Brophy, K., Davies, S., Olenik, S., Cotur, Y., Ming, D., Van Zalk, N., O'Hare, D., Guder, F., Yetisen, A.: The future of wearable technologies. Briefing Paper, Imperial College London, Institute for Molecular Science and Engineering (2021)

9. Rodriguez Villegas, E., Iranmanesh, S., Imtiaz, S.: Wearable medical devices: high level system design considerations and trade-offs. IEEE Solid State Circuits Magazine **10**(4), 43-52 (2018)
10. Sharma, M., Biros, D.P.: Building Trust in Wearables for Health Behavior. Journal of the Midwest Association for Information Systems (JMWAIS) (**2019**)2, 35-44 (2019)
11. Lee, S.M., Lee, D.: Healthcare wearable devices: an analysis of key factors for continuous use intention. Service Business **14**(4), 503-531 (2020)
12. Chau, K.Y., Lam, M.H.S., Cheung, M.L., Tso, E.K.H., Flint, S.W., Broom, D.R., Tse, G., Lee, K.Y.: Smart technology for healthcare: Exploring the antecedents of adoption intention of healthcare wearable technology. Health Psychology Research **7**(1), 8099-8099 (2019)
13. Chang, H.S., Lee, S.C., Ji, Y.G.: Wearable device adoption model with TAM and TTF. International Journal of Mobile Communications **14**(5), 518-537 (2016)
14. Davis, F.D.: Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly **13**(3), 319-340 (1989)
15. Abbas, R.M., Carroll, N., Richardson, I.: In Technology We Trust: Extending TAM from a Healthcare Technology Perspective. In: 2018 IEEE International Conference on Healthcare Informatics (ICHI), pp. 348-349. New York City, NY, USA (2018)
16. Asadi, S., Abdullah, R., Safaei, M., Nazir, S.: An Integrated SEM-Neural Network Approach for Predicting Determinants of Adoption of Wearable Healthcare Devices. Mobile Information Systems **2019**, 8026042 (2019)
17. Kim, T., Chiu, W.: Consumer acceptance of sports wearable technology: the role of technology readiness. International Journal of Sports Marketing and Sponsorship **20**(1), 109-126 (2019)
18. Cheung, M.L., Chau, K.Y., Lam, M.H., Tse, G., Ho, K.Y., Flint, S.W., Broom, D.R., Tso, E.K., Lee, K.Y.: Examining Consumers' Adoption of Wearable Healthcare Technology: The Role of Health Attributes. International Journal of Environmental Research and Public Health **16**(13), 2257 (2019)
19. Cho, Y.-M., Lee, S., Islam, S.M.S., Kim, S.-Y.: Theories Applied to m-Health Interventions for Behavior Change in Low- and Middle-Income Countries: A Systematic Review. Telemedicine and e-Health **24**(10), 727-741 (2018)
20. Gao, Y., Li, H., Luo, Y.: An empirical study of wearable technology acceptance in healthcare. Industrial Management & Data Systems **115**(9), 1704-1723 (2015)
21. Hwang, C., Chung, T.-L., Sanders, E.A.: Attitudes and Purchase Intentions for Smart Clothing: Examining U.S. Consumers' Functional, Expressive, and Aesthetic Needs for Solar-Powered Clothing. Clothing and Textiles Research Journal **34**(3), 207-222 (2016)
22. Blazquez, M., Alexander, B., Fung, K.: Exploring Millennial's perceptions towards luxury fashion wearable technology. Journal of Fashion Marketing and Management: An International Journal **24**(3), 343-359 (2020)
23. Caliskan, S., Toker, A., Nasir, V.A.: Determinants of Consumers/Personal Health Technolgy Usage Intention. Pazarlama ve Pazarlama Araştırmaları Dergisi **11**(22), 155-170 (2018)
24. Ryan, P.: Integrated Theory of Health Behavior Change: background and intervention development. Clinical nurse specialist CNS **23**(3), 161-172 (2009)
25. Asimakopoulos, S., Asimakopoulos, G., Spillers, F.: Motivation and User Engagement in Fitness Tracking: Heuristics for Mobile Healthcare Wearables. Informatics **4**(1), 1-16 (2017)
26. Kalantari, M.: Consumers' adoption of wearable technologies: Literature review, synthesis, and future research agenda. International Journal of Technology Marketing **12**(3), 274-307 (2017)

27. Sergueeva, K., Shaw, N.: Wearable Technology in Hospitals: Overcoming Patient Concerns About Privacy. In: Nah FH., Tan CH. (eds.) HCI in Business, Government, and Organizations: Information Systems (HCIBGO) 2016. Lecture Notes in Computer Science, vol 9752, pp. 446-456. Springer International Publishing, Cham (2016)
28. Baisya, R.K., Das, G.G.: Aesthetics in marketing. 1st edn. SAGE Publications Inc, Thousand Oaks, California, US (2008)
29. Mazzalovo, G.: Brand Aesthetics. 1st edn. Palgrave Macmillan, Houndmills, Basingstoke, New York, US (2012)
30. Klebbe, R., Steinert, A., Müller-Werdan, U.: Wearables for Older Adults: Requirements, Design, and User Experience. In: Buchem, I., Klamma, R., Wild, F. (eds.) Perspectives on Wearable Enhanced Learning (WELL): Current Trends, Research, and Practice 2019, pp. 313-332. Springer International Publishing, Cham (2019)
31. Hokroh, M., Hahan-Green, G., Soleton, M.: Factors Influencing Health Wearables Adoption and Usage in Saudi Arabia. Journal of Business and Technology Management **1**(1), 33-42 (2020)
32. Jeong, S.C., Kim, S.-H., Park, J.Y., Choi, B.: Domain-specific innovativeness and new product adoption: A case of wearable devices. Telematics and Informatics **34**(5), 399-412 (2017)
33. Johnston, A.C., Warkentin, M.: Fear Appeals and Information Security Behaviors: An Empirical Study. MIS Quarterly **34**(3), 549-566 (2010)
34. Ko, S., Moon, H., Kim, J., Paik, D.: A study on the knowledge, opinions and practices about oral health of workers in Korea. J Korean Acad Dent Health **23**(1), 95-111 (1999)
35. Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D.: User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly **27**(3), 425-478 (2003)
36. Venkatesh, V., Thong, J.Y.L., Xu, X.: Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Quarterly **36**(1), 157-178 (2012)
37. Ringle, C., Wende, S., Becker, J.: SmartPLS 3 [computer software]. SmartPLS GmbH (2015)
38. Cohen, J.: Statistical power analysis for the behavioral sciences. Revised edn. Academic Press, New York, New York, US (2013)
39. Henseler, J., Ringle, C.M., Sinkovics, R.R.: The use of partial least squares path modeling in international marketing. In: Sinkovics, R.R., Ghauri, P.N. (eds.) New Challenges to International Marketing, vol. 20, pp. 277-319. Emerald Group Publishing Limited, Bingley, UK (2009)
40. Hair Jr, J.F., Hult, G.T.M., Ringle, C., Sarstedt, M.: A primer on partial least squares structural equation modeling (PLS-SEM). SAGE publications Inc, Thousand Oaks, California., US (2016)
41. Longo, D.R., Schubert, S.L., Wright, B.A., LeMaster, J., Williams, C.D., Clore, J.N.: Health Information Seeking, Receipt, and Use in Diabetes Self-Management. The Annals of Family Medicine **8**(4), 334-340 (2010)
42. Noh, G.Y., Choi, J., Kwon, M.S.: A test of extended technology acceptance model on health information seeking on the Internet. Korean Journal of Broadcasting and Telecommunication Studies **27**(5), 49-85 (2013)