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Effects of Smart Homes and the Internet–of–Things on Elderly Healthcare: an empirical study in the context of Africa

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Abstract: **Globally, the recent advancement in the internet- of- things (loT), and smart home services in healthcare offered crucial advancement in elderly remote monitoring. This study widened the scope of UTAUT-unified theory of acceptance and use of technology framework, and make an addition of perceived trust as an external factor to the model. This scholarship examined the motivational factors behind the acceptance of IoT and smart-homes services /solution in African countries. Data was collected from April 2019 to June 2019, on a large scale from several countries of Africa. The valid response analyzed by using structural equation modelling. The finding of the study involves a significant effect used variables (i.e., social influence, effort expectancy, performance expectancy, and perceived trust) on elderly intention. More specifically, the insignificant positive relationship found among facilitating conditions and behavioural intention. This study assists the executives of IoT and smart-homes, healthcare services/solution providers, in building strategies, and the behaviour of the elderly towards the purchase of offerings. Also, this work offered the groundwork to investigate the process of acceptation of IoT and smart- home service s/solution s for healthcare by old age people.**

Keywords: **smart- homes services, healthcare services, internet- of- things (loT).**

1. INTRODUCTION

It is a general phenomenon, due to ageing and growing populations, higher prevalence of chronic the necessity for medical support also grows, which may lead to unexpected frequently visits to the doctors. Based on the approximation for a demographic growth, lifespan is anticipated to an increase in populace ageing (Astaras et al. 2015). The usual "socio -economic conditions " upset the global demographics of elderly (Malwade et al. 2018). The recent improvements in the internet-o f- things **(loT)** technology and more advanced tools can lead to an establishing appropriate healthcare system for the old people (Pal et al. 2018). In most of the African nations, "severe pressure on the public healthcare sector and lack of adequate facilities are driving how health services delivered to the patients" (MacGregor et al.2018). There is a growing trend from the "once physician-centered environment to a more patient-centric healthcare system" (Faralhani et al. 20 I 8). Too, smart- homes, which assimilate health and other ambient assisted living tools/technologies, can play a significant role in modernizing the approach in which healthcare amenities offered to the older people (Majllmder et al. 20 I7).

Globally, health care expenditures are continuously growing projected to rise at an annual rate of 5.4%, between 2017 to 2022, which is approximately $7.724 trillion to $10.059 trillion (Deloitte 20 I 9). Indeed, "the emergence of personalized medicine, increased use of exponential technologies, entry of disruptive and non- trait to competitors, the demand for expanded care delivery sites, and revamped payment and public funding models are all impacting the financial performance of the health care ecosystem." Interestingly, as per (MWA 2019) report the average life of people in Nigeria is 52 years, Ghana 61 years, and South Africa 57 years. Besides, according to facts and figure (Nsiah-Asare 2017), on average healthcare expenditure as percentage to GDP in African countries are 5.6%, especially in Ghana is 5.9%. Moreover, the prevalence of infectious disease shown higher. Additionally, there are several smart- homes healthcare, for instance, wearable sensors, sleep monitoring, environmental monitoring, security system, activity detection, communication network, computing, sensors and actuators, and decision.

Apart from the above statistics, the healthcare industry has experienced marvelous changes in most of the developing countries due to immediate improvement in information technology **(IT)** and (JCT) information, and

communication technology. In general, aged people apply various strategies to pursue healthy ageing, but we do not know /know little about their views and usage of personal health information to achieve those ends.

Meanwhile, the elderly show certain types of behaviour towards IoT and smart- homes. Hence, this scholarship based to understand their needs, specific behavior, and interac6on with IoT and smart- homes and services, also the motivational factors behind the decision. This work is designed to answer what are the determinants which influence an elderly towards the welcoming of smart- homes for health? And what could be core proposed framework? More specifically, the challenges of the study include understanding the behaviour of older people for a service. Though, we emphasize on the determinants influences older people regarding the adoption of smart- homes for healthcare from a theoretical perspective.

2. REVIEW OF LITERATURE

2.1 Theoretical Support

In general, though the concept of smart- homes more common in developed countries, but is relatively new among the African countries. Moreover, the involvement of older people with **IoT** and smart- homes throughout the developing countries is less probable, subsequently usually the elderly are unwilling to assent any new innovative products/solutions (Wu and Hu 2018). Also, the adoption of the elderly is more complex comparative to adults and influenced by several factors (Lee and Coughlin 2015). Present scholarship involves proper understanding of elderly behaviour, their motivational factors, and decision-making is the main challenge in adoption of smart- homes and like technology.

Most importantly, the technology acceptance model **(TAM)** employed to study the influences which impact older people intention. This model administered in a multiple context to get idea towards the acceptance of novel technology (Mital et *al.* 2018). Since decades this model widely used and evolved in social sciences, medicine, psychology in predicting human behaviour for acceptation and rejection of new technology (Pal et al.2018). The new derivatives of UTAUT are **TAM.**

There are four direct determinants of the UTAUT model such as facilitating condition, effort expectancy, social influence and performance expectancy, while behavioral intention is dependent on latent variable. The conceptual framework is mediated and moderated by many factors, for instance, age, experience, gender and other (Q. Min et al. 2008; Abubakar and Ahmad 20 I 3; Kohnke et al. 2014). Furthermore, previous scholars also used the external factor to the framework based on the situation and case (C.-F. Liu et al. 2013). The scholars used external factors to understand better and comprehend human behaviour towards the acceptance of a proposed model.

Based on the present literature related to smart- homes and IoT. We have employed perceived trust as an external determinant in the context of African countries to study and explain the elderly behaviour. Conversely, in order to endorse and stimulate tile older people towards the use of smart- homes, and **IoT,** it is critical to estimate the behaviour and insight for using such services. Thus, we purpose theoretical framework (Refer to picture I)

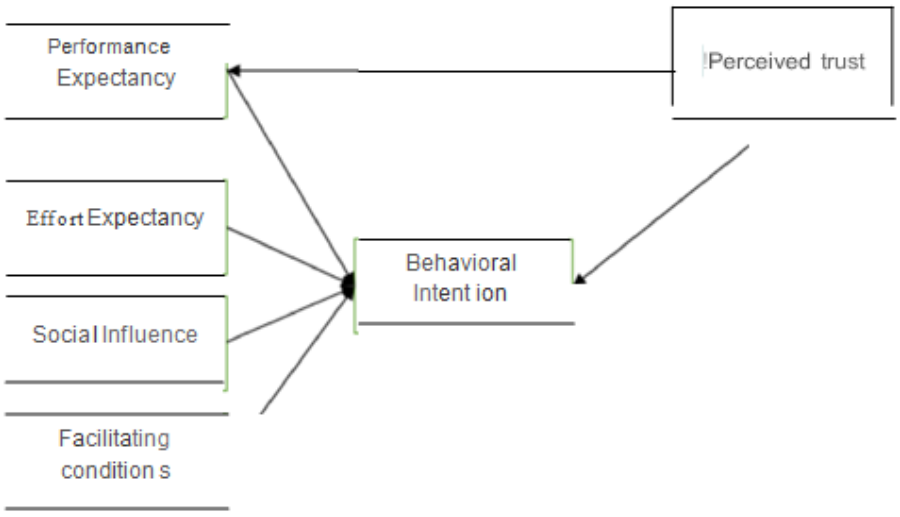

Figure 1: Theoretical framework

2.2 Hypotheses development

2.2.1 Performance expectancy

Accorting to (Keranen et al. 20 I 7) PE is the extent in which technology in use delivers sort of advantages in performing some activities·. Prior scholar also confirmed the importance of intention towards the adoption of new technology from elderly perspective (Yang et al. 2016). Their doubts and fear of using new technology generate negative impacts and influence the acceptation rate (Zhao et al. 2018). Furthermore, (Jang et al. 2016) rectified the positive association among usefulness and intentions towards the use of smart care services. However, if the usage of loT and smart- homes services improve their health, their perception of technology will become positive. Therefore, we have proposed a hypothesis as following:

Hl: Performance expectancy have a significant influence on the behavioural intention of the elderly towards the use of loT and smart-homes.

2.2.2 Effort Expectancy

According to (Marup i ng et al. 20 I 7), EE is the extent in which we have ease to use any kind of system. It has a significant effect on the intention to utilize the health informatics and has a significant impact on its adoption (Cimperman et al. 2016). Most importantly, when it comes to new technology, ease of its usage has more significant effects on the adoption behaviour of elderly (Macedo 20 l7). According to (Kim and Park 2012), findings apart from the direct effects of PE and effort expectancy, over behavioural intentions, the effort expectancy also affects performance expectancy. Thus, we hypothesized as

H2a: Effort expectancy has a significant influence on the behavioural intention of elderly towards the use of **IoT** and smart- homes.

H2b: Effort expectancy has a significant effect on the performance expectancy of older people.

2.2.3 Social Influence (SI)

In an initial stage of new technology, usually, utmost of the targeted customers are not having all of the necessary information to take particular decision towards the purchase. In such stages, customers /end-use rs accumulate the particular information from online reviews, opinion leaders, family, friends and other people in their closer circle (Mueller et al. 20 I 7). The prior researcher also found the significant association among social influence and the intention (Hsu and Lin 201 6; de Sena Abrahao et al. 2016; Nisha et al. 2016; Dehghani et al. 2018; Azimi et al. 2017). We, therefore, we suggest the following hypothesis:

H3: Social influence has a significant influence on the intention of older adults towards the use of loT and smart-homes.

2.2.4 Facilitating Conditions

FC is the extent in which user of the new technology hold beliefs that technical and organizational infrastructure exists to support the use of the system. It one of the important factors of behavioural intention, and most preferably used when it is the case of acceptance of any technology (Oliveira et al. 2016; Ni\kou and Economides 2017). Too rectified by (Bhattacherjee and Hikmet 2008), in healthcare viewpoint. Also, when we talk about the older people, the facilitative conditions related to technology augments the intentions (Heart and Kalderon 201 3; **K.** Chen and Chan 2014; Portz et al. 2019; Y. Chen et al. 2018). In contrast (Pal et al. 20 I 8), found the insignificant link among FC and behavioural intention. Therefore, we propose the hypothesis as following:

H4: Facilitating conditions significantly influence the behavioural intention of the elderly towards the use of **IoT** and smart- homes.

2.2.5 Perceived trust

Unquestionably, even when we think of the internet and its ' related tools and devices work with it. Here comes the factor of trust, as because when we access the internet, we are permitting to know about us. The information not only is accessed by only good people and companies even some of the hackers are also available on different sites. According to (Wilson et al. 2017), "When smart- homes are used for providing healthcare facilities, they can collect, manage, monitor, and analyze the personal health data belonging to the individuals. This raises severe security and

trust issues that current literature reports and it can adversely affect the adoption of these smart- homes by the end-users in general." Also, most of the old age people have negative feedback and opinion towards the internet and its usage (L. Liu et al. 2016; Ali and Awad 2018). In contrast, (Gu et al. 2016), shown that perceived trust has significant influence on the perceived usefulness. Henceforth, our suggested hypothesis is mentioned below:

H5a: Perceived trust significantly influence the behavioural intention of the elderly towards the use of **IoT** and smart- homes for healthcare purpose

H5b: Perceived trust significantly influence performance expectancy of the elderly towards the use of loT and smart- homes for healthcare purpose.

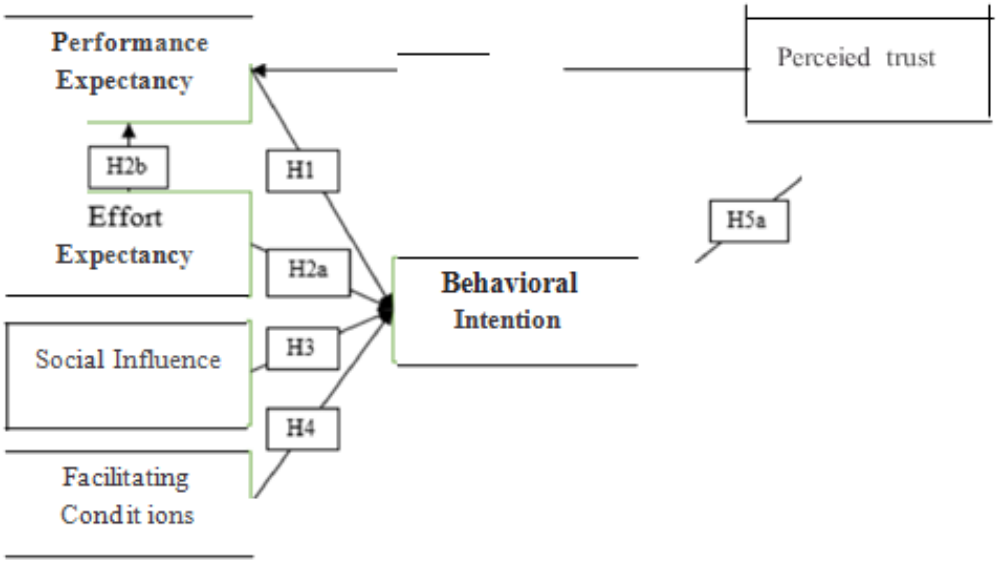

Figure 2: Hypotheses development and framework

3. METHODOLOGY

3.1 Data Collection

The present study employed an online -based survey, a self-administered questionnaire utilized to assess the insights of the aged audience towards the employment of loT and smart-homes offerings for healthcare purpose. The data was collected from African countries (Nigeria, Ethiopia, Democratic Republic of the Congo, South Africa, Ghana, Kenya, Egypt, Morocco, Zambia, Cameroon, Sudan and other) from April 2019 June 2019. An online questionnaire designed via Google form and spread through emails, WhatsApp, and other social media applications. The online survey is generally used to accumulate more information and to reach scattered population (Kuila et al.2019). In order to ensure the relevance and validity of the survey an opinion has been sought from two experts based in Ghana and Morocco. The survey instrument divided into two sections. The first section of the questionnaire contains demographic questions such as respondents age, gender, country, total family members, email id, mobile number, most frequently used social application in order to confirm validity, and to minimize the biases and to ensure the respondents have enough knowledge about IoT and smart- homes one general questions asked "Do you know about the IoT and smart-homes technologies and ser vices? " the response measured in Yes/ No. All of the respondents filtered out from the survey who responded ' o".

3.2 Sample Characteristics

The respondents who are in age above 50 years are considered for the analysis. According to (MW A 2019) report, the average life of people in Nigeria is 52 years, Ghana 61 years, and South Africa for 57 years. For surety purpose that respondents are falling in that age criterion, we have randomly contacted them via email id, social application and mobile number. We received 530 responses in three months 406 respondents qualified to sample while rest of 124 disqualified from the analysis. Demographically (74.0%=300 .4) of respondents were male, (26.0%=105.6). Average age was 56 years. From a country perspective (I 8.3%=74.3) belong to Ghana, (I 5.5%=63) to Nigeria, rest include other countries.

3.3 Measurement Instrument

In order to measure the constructs well -established scale employed. The total fifteen items adopted from (Pal et al. 2018), to assess PE by using [five items], for EE [four items], for SI [three items] used, and for FC three items employed. The scales were modified as peruse. The three items scale used to measure the behavioural intention of elderly, the scale for the construct adopted from (Huang 20 IO; Mital et al. 2018). Moreover, the three items used to evaluate the trust of the elderly towards the IoT and smart- homes products/services the scale borrowed from the (Stojkoska and Tri vodaliev 2017). All the items were assessed by five -point Likert scale, where, [1 = strongly disagree, 5 = strongly agree].

3.4 Mathematical Tool

Present study da ta collected through an online survey, after screening out of invalid respondents analyzed by using structural equation modelling (SEM). Both approached namely SEM and confirmatory factor analysis to test the appropriated model. The approach of CFA utilized to test convergent validity and reliability of the construct, items having a value less than 0.5 eliminated from the construct (Hair et al. 2019). Besides, SEM is used in several disciplines, for instance, social science (Hair Jr et al. 20 I 7), psychology (Willaby et al. 20I 5), medicine (Berglund et al. 2013). The acceptability of PLS -SEM is growing since last two decades (W. Li et al. 2020).

4. RESULTS AND DISCUSSION

Partial least square SEM has been used for the result analysis. The analysis of results divided into two measurement and structural model.

4.1 Assessment of measurement model

As per (Ahmed et al. 2020) suggestions in order to measure the model of study scholars are required to evaluate the " individual item reliability, internal consistency, content validity, convergent validity, and discriminant validity" . An outer loading of the items used to validate the individual item reliability. According to (J. **Min** et al. 2020) items value exceeds 0.7 (see Table I). Furthers, the proposed value of Cronbach ' s Alpha must exceed 0.7 (C. **Li** et al. 2020). As displayed in Table **l,** the values of CA falls in the range of 0 .757 to 0.905 (refer Table l). Regarding, internal consistency reliability assessed through composite reliability, recently **(Tian** et al. 2020) proposed that it must exceeds 0.7 (see Table I) Furthermore, to assess the convergent reliability of the model (Fornell and Larcker 198 I) suggested to look for the value of average variance extracted (AVE) and recommended value be must be equal or above 0.5 (see Table I). Besides, related to discriminant validity " the square root of A VE for each construct should exceed the inter -correlations of the construct with other model constructs" (Fornell and Larcker I 98 I) (refer Table 2).

4.2 Assessment of the Structural Model

The structural model used to reveal the path coefficient, their significance, coefficient of determination R^2 (Henseler et al. 2009). In order to do so, authors used bootstrapping techniques in **SMARTPLS** 3.2.8 version with 5000 bootstraps and 506 cases (refer Table 3). $\mathbf{R^2}$ used to assess the variance of constructs employed. (Cohen 1998) proposed that the value of $\mathbf{R^2}$ 0.60, 0.33 and19 respectively described as substantial, moderate and weak. However, (Hair et al. 2010) argued that R^2 value is subject to the condition, it can be 0.10 (Falk and Miller 199 2) (refer Tab le 5). Keeping in view the reflective nature and based on (Ringle et al. 20 I 2), recommendation, this study used cross-validated redundancy measure Q^2 for further assessment of structural model. The *q2* values of 0.02, 0.15, and 0.35, respectively, indicate that an exogenous construct has a small, medium, or considerable predictive relevance for a specific endogenous construct (refer Table 4). It demonstrates that model has small (Completeness), medium (Information quality and purchase intention), and large (Concise and consistent representation) predictive relevance.

Table 3 illustrates that all other hypotheses proposed are0 significant except one based on criterion (p-va l ue <0.05, t-value > 1.96). Among them effort expectancy having beta = 0.596 shown with greater influence on the behavioural intention towards the usage of loT and smart-home services. Also, effort expectancy has a greater impact on performance expectancy as beta = 0.245 results of the hypotheses consistent with (Yen et al. 2017). Moreover, the performance expectancy (beta = 0.22 1) and social influence beta = 0. 19 6) also have positive and significant impacts. Additionally, perceived trust has greater effects on performance expectancy rather than behavioural intention, as (H5b, beta = 0.14, in contrast, H5a, beta = 0.117), the result of hypothesis consistent with work of **(Pal** et al. 2018). Furthermore, the value of $\mathbf{R^2}$ = 0.669, we can say that 66.9% is the explaining power of the model, we have constructed (refer Figure 1)

Table 1: Measurement Model

Constructs	Item	L-Oadjng	CA	CR	AVE
Behavioral	Bil	0.839	0.8 16	0.891	0.731
Intention	812	0.854			
	813	0.87			
Effort	EEi	0.72	0.757	0.845	0.579
Expectancy	EE2	0.766			
	EE3	0.825			
	EE4	0.821			
Facilitating	FCI	0.978	0.893	0.944	0.894
Condition	FC3	0.912			
Performance	PE I	0.857	0.899	0.924	0.709
Expectancy	PE2	0.82 1			
	PE3	0.854			
	PE4	0.856			
	PE5	0.823			
Perceived	PT!	0.907	0.822	0.893	0.737
Trust	PT2	0.868			
	PT3	0.797			
Social	Si l	0.9 32	0.905	0.94	0.84
Influence	SI2	0 .932			
	SB	0.885			

Table 2: Latent variable correlation and square root of AVE

	1	2	3	**4**	5	**6**
Behavioural Intention	***0 .855***					
Effort Expectancy	0.746	***0.761***				
Facilitating Conditions	0.055	-0.003	***0.946***			
Perceived Trust	0.437	0.406	0.043	***0.858***		
Performance Expectancy	0.486	0.301	0.083	0.239	***0.842***	
Social ln f1uen ce	0.599	0.524	-0.041	0.388	0.398	***0.917***

Table 3: Path coefficients and hypotheses testing

Hypotheses	Relationship	Path Coefficient	Mean	SD	t- value	p- value	Deci s io n
HI	Performance Expectancy -> Behavioral Intention	0.221	0.219	0.047	4.719	0.000	Supported
H2a	Effort Expectancy -> Behavioural Intention	0.596	0.598	0.032	1 8.607	0.000	Supported
H2b	Effort Expectancy -> Performance Expectancy	0.245	0.249	0.061	4.009	0.000	Supported
H3	Social Influence -> Behavioral Intention	0 .1 96	0.19 9	0.045	4.377	0.000	Supported
H4	Facilitating Conditions -> Behavioral Intention	0.042	0.046	0.051	0.827	0.409	Not Supported
H5a	Perceived Trust -> Behavioral Intention	0.117	0.11 9	O.D28	4.11 6	0.000	Supported
H5b	Perceived Trust -> Performance Expectancy	0. 1 4	0.14 2	0.047	2.969	0.002	Supported

Table 4: Cross Validated Redundancy

	sso	SSE	Q2 (=1 - SSE/SSO)	Decision
Behavioral Intention	1,218. 00	652.992	0.464	Lm·ge
Effort Expectancy	1 ,624.00	1 ,6 24.00		
Facilitating Condition s	812	81 2		
Perceived Trust	1,218. 00	1 ,218. 00		
Performance Expectancy	2 ,0 30.00	1 ,8 99.24	0.064	Small
Social lnfluence	1,218. 00	1 ,218. 00		

Table 5: Coefficient of determination

	RSquare	RSquare Adjusted	Decision
Behavioral Intention	0.669	0.665	Substantial
Performance Expectancy	0 .107	0.103	Weak

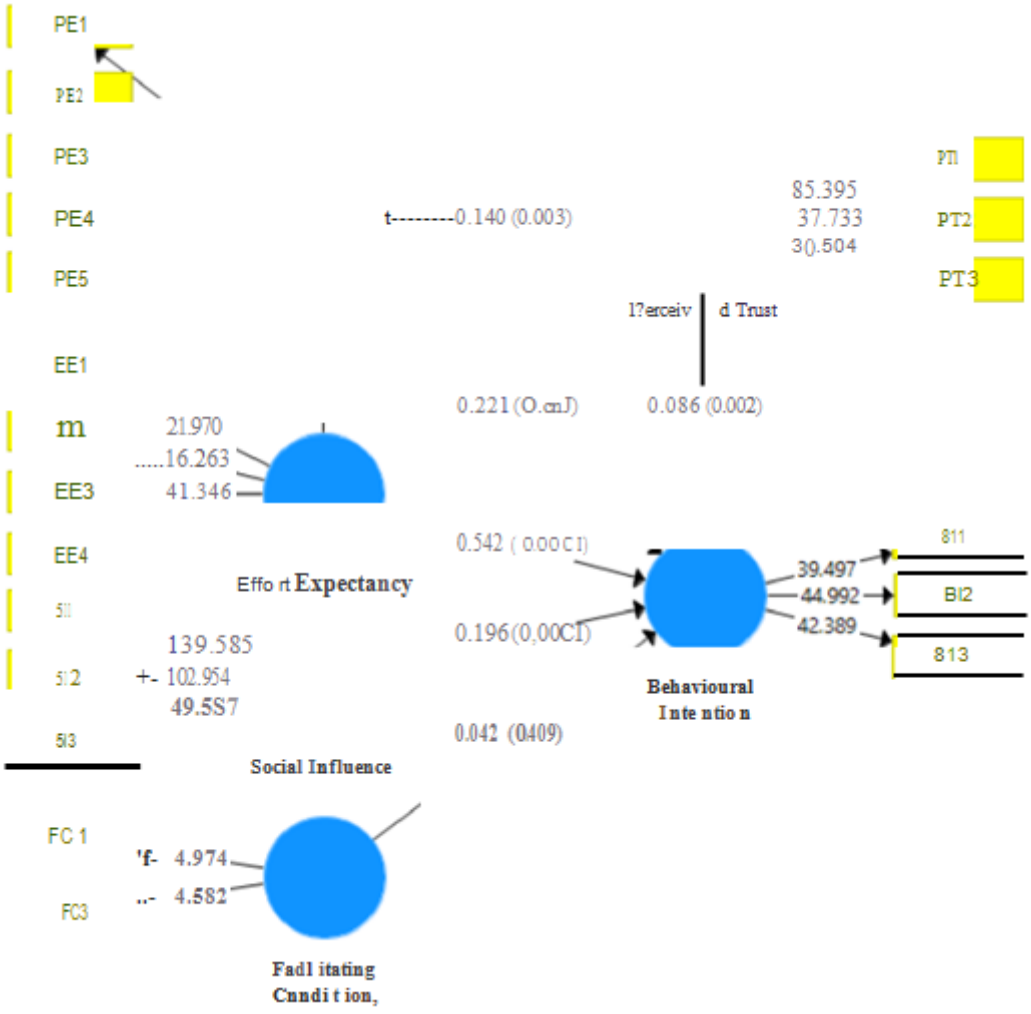

Figure 3: Structural equation modelling

5. CONCLUSION

Aforementioned, this study aims to investigate the elderly behavior toward s the intention of using smart- home s and **IoT,** given the fact that the little attention given to it. However, the first study based in African countries. Initially, we comprehend in -depth existing literature and developed framework and added one external factor (perceived trust) to model **UTAUT,** as the perceived trust is critical for adoption and use of the newest technology. As for as elderly included, they give more attention toward s the trust as there is risk of information sharing and another perspective. The

results of the study shown that the framework of the stud y has good explaining power with 66.9%. All of the results supported with the male of thumbs, reliability, validity, of the model found satisfactory. However, this implies that our framework is appropriate to elaborate the elderly intention towards usage of IoT and smart- homer with healthcare perspective in African countries.

6. IMPLICATIONS

Generally, old age people mainly belong to the particular age, yet there are distinctive determinants which elaborate their behavioural intention towards acceptance of technology. Most importantly,

IoT and smart- homes service provider should offer only those products/services which are easy to use and operates. However, companies should focus on simplicity instead of a variety of functions. Furthermore, in order to win-trust of African customers companies should assure them for the security of information as well as customized products/services, should be offered. Moreover, greater focus should be given to awareness, and online platforms should be created where from elderly learn how to operate and what should be the pros and cons of using those **IoT** and smart- home services.

7. RESEARCH LIMITATION

This study also has a few of the limitations. One though the importance of **IoT** and smart- homes in the elderly is growing globally, yet this study only focuses on African countries. Second, we have assessed the behavioural intention of elderly towards the **IoT** and smart- homes which are still not being offered to customers on commercial scale. Therefore, it should be measured in actual behaviour, even the number of users is small. Third, only one external factor is added with UTAUT model in deep dimensions of the perceived trust should be involved.

Additionally, the future studies should include the dimensions of perceived trust, and further examinations of facilitating conditions should be involved in other context like Asian countries. The upcoming stud ie s should include other external determinants to study, such as perceived risk, expert advice and others. Most importantly, the culture, gender and education can be tested with this model as moderator.

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