The Ciência & Engenharia - Science & Engineering Journal
ISSN: 0103-944X
Volume 11 Issue 1, 2023
pp: 2425 - 2441

A Bibliometric and Cluster Analysis of the Adoption of Wearable Fitness Device

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Abstract
Wearable fitness devices are used to track routine health data like calories burned, steps walked, heart rate, and sleep pattern of users, and hence, they are considered an important tool for health management. The present study systematically reviews the existing literature in the domain of wearable fitness device adoption for the past decade and presents a bibliometric and cluster analysis. The paper begins with the methodology adopted followed by Bibliometric and Cluster analysis and finally,a conclusion is drawn and the future scope of research is recommended. We included articles published in Scopus and Web of Science-indexed journals.
Keywords: smart watches, health management

Introduction

The use of Wearable fitness devices has increased manifold in the last decade. Wearable fitness devices or smartwatches use sensors to generate health-relatedinformation about the user when attached to the body, usually the wrist. These wrist-worn devices are used to track routine health data like calories burned, steps walked, heart rate, and sleep pattern of users and therefore, they are considered an important tool for health management. The global smartwatch market was worth USD48.44 billion in 2020 and is expected to reach USD 130.92 billion by 2025 with a compound annual growth rate of approximately 18.32% (Market Data Forecast, 2020). The devices are used for varied reasons by consumers of different age groups. Originally designed for health management, these devices are now used for sharing location, status symbols, gaming, and VR experience also. The multiplicity of uses and increasing health concerns have created a big market for these devices and developers are continuously adding innovative features and improving user interface to meet the increasing demands.

Older adults use wearable fitness devices for their healthcare and alert functions (Yu-Huei, Ja-Shen, & Ming- Chao, 2019), their (in particular elderly diabetic patients) usage behavior is positively influenced by Perceived usefulness, Perceived ease of use, perceived Irreplaceability, perceived Credibility, Compatibility and social influence (Ahmad, Rasul, Yousaf, & Zaman, 2020). However, technology anxiety and resistance to change demotivates them to use these devices (Talukder, Sorwar, Bao, Ahmed, & Palash, 2020).

Over the past few years, most studies on smartwatches have focused on how they can be used for various purposes (design, health, etc.) and have applied exactly the determinants from prior theories (e.g. TAM) to explain their adoption (Choi& Kim 2016). Similarly, many other

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techniques like the Unified Theory of Acceptance and use of Technology (UTAUT), Senior Technology Acceptance and Adoption Model, Diffusion of Innovation Theory Framework, The Theory of Planned Behavior framework, Technology Readiness and Adoption Model, Diffusion of Innovations Theory, etc. have been applied to test and explain adoption intention, intention for continuance use and product recommendation among different users. Further, post purchase behavior has also been studied by many scholars.

Given the above background, The present study systematically reviews the existing literature in the domain of adoption of Wearable fitness devices for the past decade and presents a bibliometric and cluster analysis. The paper begins with the methodology adopted followed by bibliometric and cluster analysis and finally conclusion is drawn and the future scope of research is recommended.

Research Methodology and data statistics

We conducted an exhaustive review of domain-specific articles. Suitable keywords were identified and different themes in the literature were studied. We followed the given approach for the selection of articles:

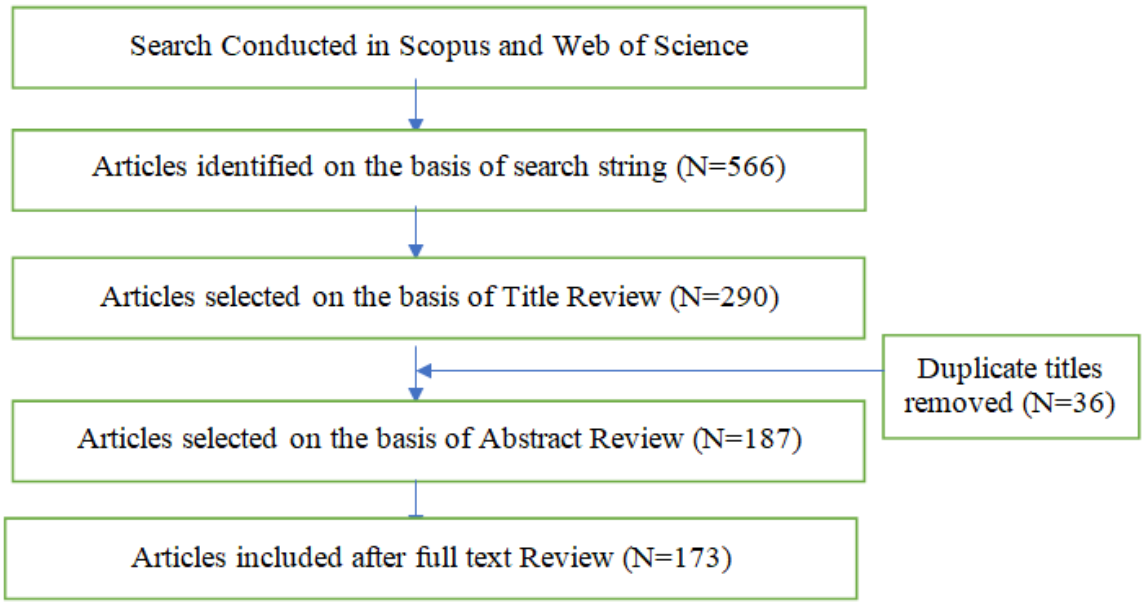

Figure 1 Methodology of the review

The figure above explains the methodology adopted for this review. First we identified relevant papers for review in Scopus and Web of Science databases using search strings. The keywords included Wearable devices, Wearable trackers, fitness bands, fitbit, smartwatches, Wearable healthcare devices, Wearable Medical devices, Wearable Technology, Wrist-worn wearables, Smartbracelets, Wrist device, Fitness Wearable, use, adoption, intention, attitude, behavior and willingness. The search was refined by Business, Management and Accounting, Social Sciences, Information Technology and Decision Sciencessubject areas. Initial search fetched about 566 results. Of which, 290 articles were selected on the basis of Title review,

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remaining 276 articles were found irrelevant to the theme and rejected. In the next step, 36 duplicate titles were removedand we proceeded with abstract review. Out of these 254 articles 187 were identified suitable for the study. In the next stage, these selected 187 articles were studied. Out of them, 173 articles were finalized for the purpose of this study. These papers studied intention to adopt wearable fitness devices, continuance intention to use activity trackers as dependent variables and antecedents of Wearable fitness trackers adoption, post purchase behavior, factors affecting continuance intention as Independent variables.

The exclusion criteria

We excluded literature reviews, rationale studies, interview based papers and observational and interventional studies.

Descriptive Statistics

Descriptive Statistics in a bibliometric analysis is explanation about spread of articles over a number of years, in different disciplines, in different journals, author wise contribution, affiliation wise contribution, co-citation network and so on.

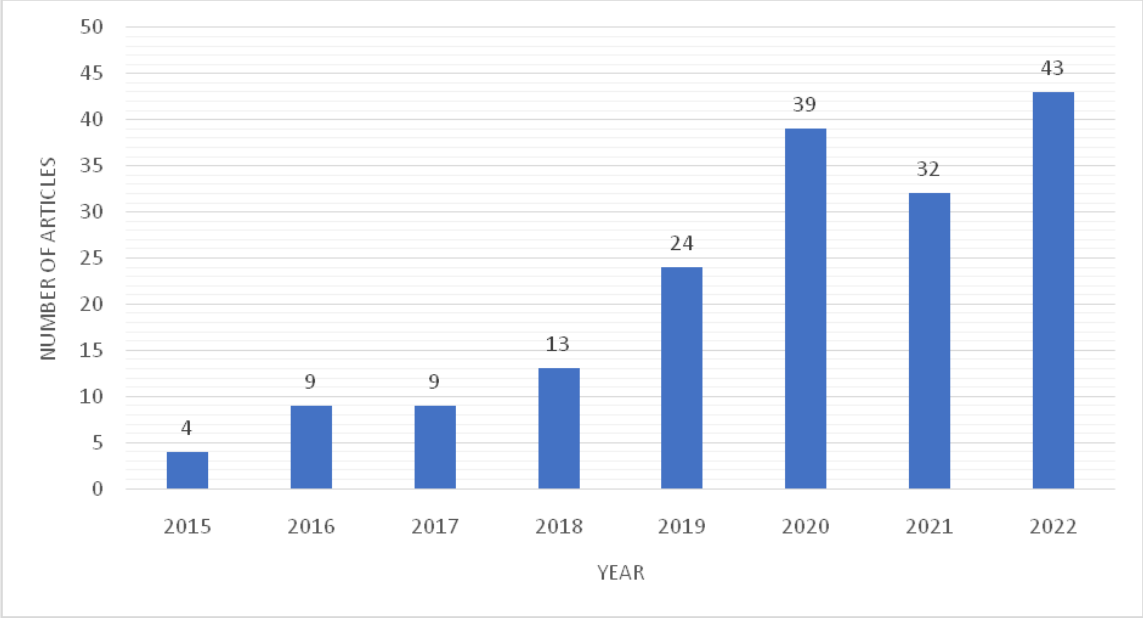

Figure 2 Number of Articles published in different years

As evident from the figure above, there is an increasing trend of scholarly contribution on adoption of Wearable fitness trackers and continuance intention. Highest contribution was made in year 2022 and it is expected to grow in years to come.

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Journal wise publication	
Sources	**Articles**
American Journal of Community Psychology	1
American Journal of Health Education	4
American Journal of Health Promotion	2
Annals of Applied Sport Science	1
Applied Ergonomics	4
Asia Pacific Journal of Information Systems	1
Asian Journal for Public Opinion Research	1
Behavioral Sciences	1
Behaviour and Information Technology	10
Canadian Journal of Administrative Sciences	1
Cogent Business and Management	1
Cyberpsychology, Behavior, and Social Networking	1
Education and Information Technologies	2
Educational Gerontology	1
Educational Technology and Society	1
Electronic Markets	2
Eurasian Business Review	1
European Journal of Information Systems	2
Evaluation and Program Planning	1
Fashion, Style and Popular Culture	1
Frontiers in Sports and Active Living	1
Games for Health Journal	1
Global Business and Finance Review	1
Global Health Research and Policy	1
Health (United Kingdom)	1
Health and Social Care in the Community	1
Human Factors	1
Human Factors and Ergonomics In Manufacturing	1

Human Technology	1
IEEE Transactions on Engineering Management	1
Industrial Management and Data Systems	3
Information and Management	1
Information Development	1
Information Services and Use	1
Information Technology and People	4
International Journal of Applied Business and Economic Research	1
International Journal of Audiology	1
International Journal of Business	1
International Journal of Clothing Science and Technology	1
International Journal of Data and Network Science	1
International Journal of eBusiness and eGovernment Studies	2
International Journal of Economics and Business Administration	1
International Journal of Enterprise Network Management	1
International Journal of Fashion Design, Technology and Education	1
International Journal of Human Computer Studies	3
International Journal of Human-Computer Interaction	9
International Journal of Industrial Ergonomics	1
International Journal of Information Management	4
International Journal of Innovation and Technology Management	1
International Journal of Interdisciplinary Studies in Communication	1
International Journal of Scientific and Technology Research	2
International Journal of Sports Marketing and Sponsorship	4
International Journal of Technology Management	1
International Journal of Technology Marketing	4
Internet of Things (Netherlands)	1
Internet Research	2
JMIR Aging	4
Journal of Asia Business Studies	1

Journal of Business Research	1
Journal of Communication Inquiry	1
Journal of Computer Information Systems	1
Journal of Construction Engineering and Management	1
Journal of Electronic Resources in Medical Libraries	1
Journal of Enabling Technologies	1
Journal of Fashion Marketing and Management	1
Journal of Global Information Management	1
Journal of Global Marketing	1
Journal of High Technology Management Research	1
Journal of Hispanic Higher Education	1
Journal of Research in Interactive Marketing	1
Journal of Retailing and Consumer Services	4
Journal of Science and Technology Policy Management	1
Journal of Services Marketing	1
Journal of Silk	1
JurnalKomunikasi: Malaysian Journal of Communication	1
Kappa Delta Pi Record	1
Learning, Media and Technology	1
Library Hi Tech	1
Management (Croatia)	1
Media International Australia	1
Medical Reference Services Quarterly	1
Mobile Media and Communication	1
Patient Preference and Adherence	1
Polish Journal of Management Studies	1
Proceedings of the Association for Information Science and Technology	1
Profesional de la Informacion	1
Qualitative Research in Sport, Exercise and Health	1
SAGE Open	3

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Salute e Societa	1
Service Business	1
Service Industries Journal	1
Social Sciences	1
Sociology Compass	1
Sociology of Health and Illness	1
Sport, Education and Society	2
Studies in Systems, Decision and Control	1
Sustainability (Switzerland)	4
Technological Forecasting and Social Change	5
Technology in Society	9
TechTrends	1
Telecommunications Policy	2
Young Consumers	1
Grand Total	173

Table 1 Number of Articles published in different Journals

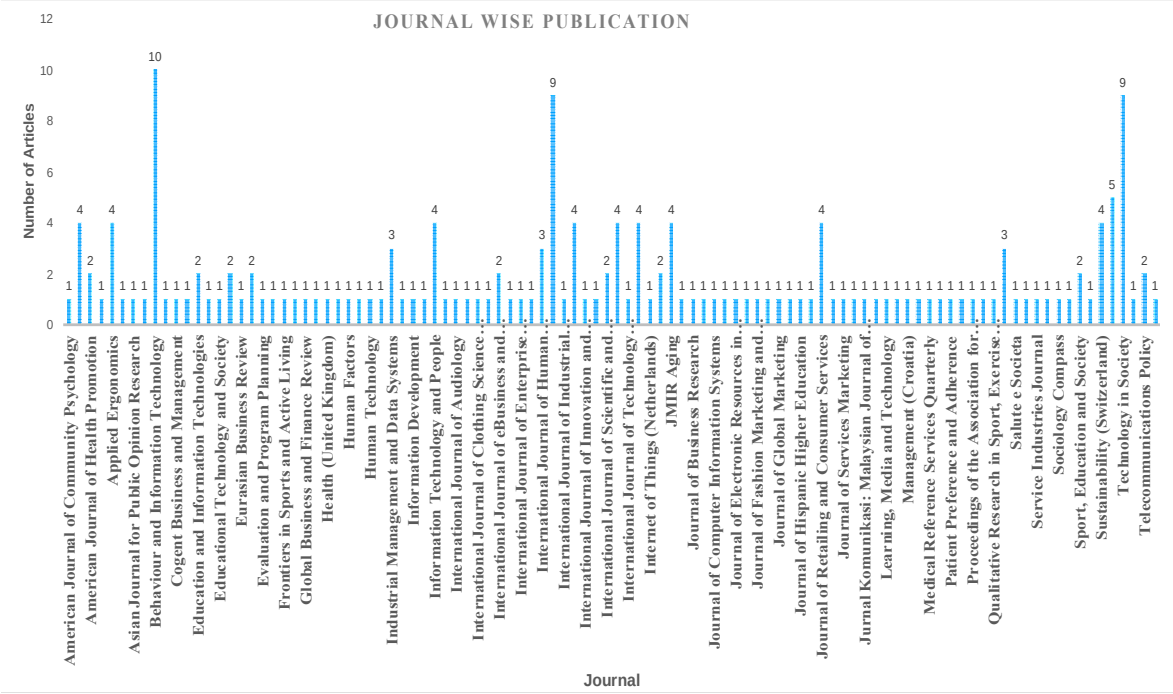

Figure 3 Number of Articles published in different Journals

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Figure 3 presents number of articles published in different journals. The above figure presents top 20 journals that are accepting and publishing literature and scholarly contribution on Wearable Healthcare devices and similar technologies. The journal "Behaviour and Information Technology", "International Journal of Human-Computer Interaction", "Technology in Society" have published 9 and more papers each. The central theme is "wearable technology", "IOT", "Internet based Technology". **As visible from the figure above there is an increasing interest among scholars about wearable technology and it is gaining**

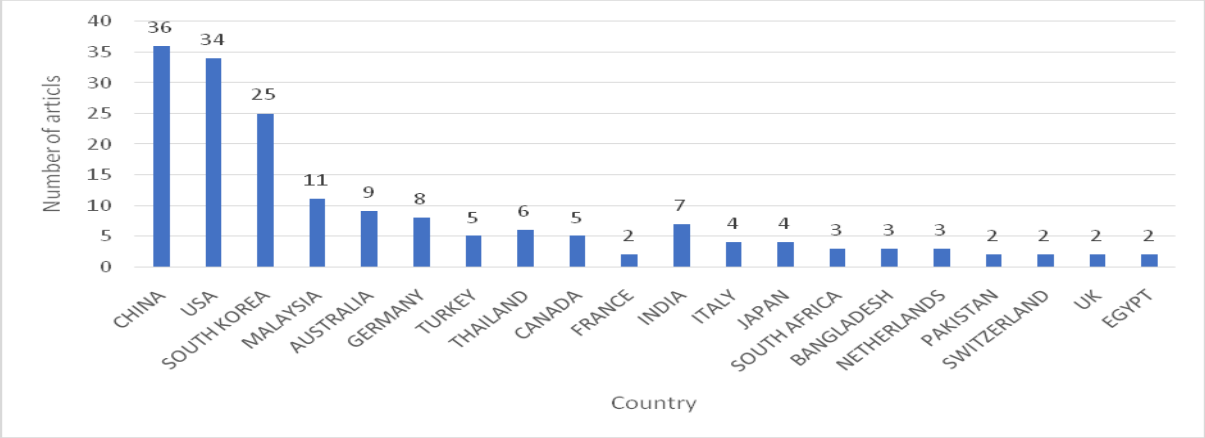

Figure 4 Number of Articles Published by different countries

The country wise contribution is presented in the above figure. There is an increasing research interest among scholars from different countries. The topic is widespread across different parts of the world and scholars are collaborating from different countries and contributing to the domain knowledge. USA, China and South Korea are the major contributors in the field. India is lacking in research with just 7 publications. Further, we have considered top 20 universities in the World which have contributed in the domain.

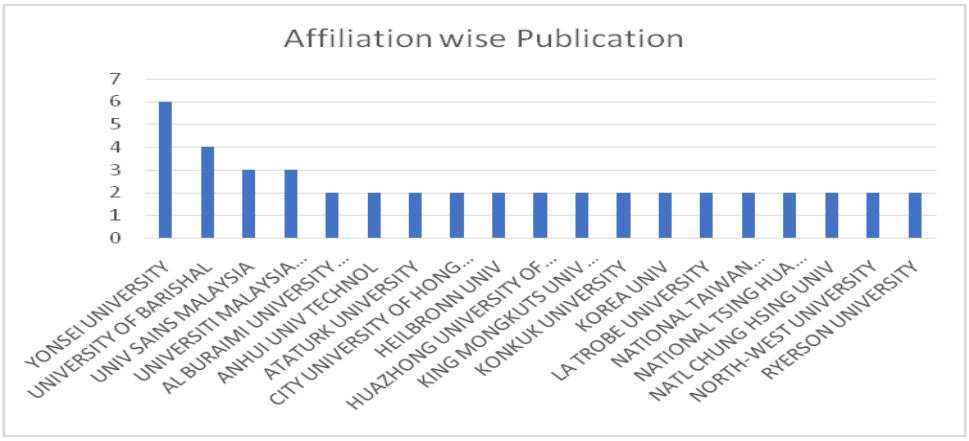

Figure 5 Number of Articles Published by different Universities

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Yonsei University (6 articles), University of Barishal (4 articles), Univ Sains Malaysia (3 articles) and Universiti Malaysia Pahang (3 articles) are the major universities contributing in the domain. Other Universities like Al Buraimi University College, Anhui Univ Tenhol, Ataturk University, City University of Hong Kong etc. have also made significant contribution. However, no University from India could maintain position in top major contributors. As can be inferred from above 2 figures research is lacking in India.

Data Analysis and Findings

Further, Citation analysis was performed on data collected from Scopus and Web of Science using **bibliometric analysis in Biblioshiny application of R software.**

Top 20 Frequently used words	
Words	**Occurrences**
smartwatch/smartwatches	25
wearable devices/ wearable device	20
wearable technology	15
Technology Acceptance Model/TAM	12
Wearables	9
Adoption	7
Technology	6
technology adoption	6
physical activity	5
utaut2	5
technology acceptance	4
expectation-confirmation model/expectation confirmation model	4
Acceptance	3
China	3
Fashionology	3
Healthcare	3
perceived value	3
Privacy	3
Security	3
smart wearable devices	3

Table 2 Citation Analysis Using Biblioshiny Application in R

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Smartwatch/es, Wearable device/s, Wearable Technology, Technology Acceptance Model/ TAM, Wearables, adoption, technology, technology adoption, physical activity etc. are most frequently used words by authors. Smartwatch/es is used maximum times by authors. Further, Wearable device/s (20), Wearable Technology (15), Technology Acceptance Model/ TAM(12) and successively wearables, adoption, technology, technology adoption are used in articles. It may be inferred that most of the papers have worked on TAM and the terms used to refer to Wearable fitness devices are smartwatches, wearable devices, wearable technology, wearables and smart wearable devices where smart wearable devices is used the least.

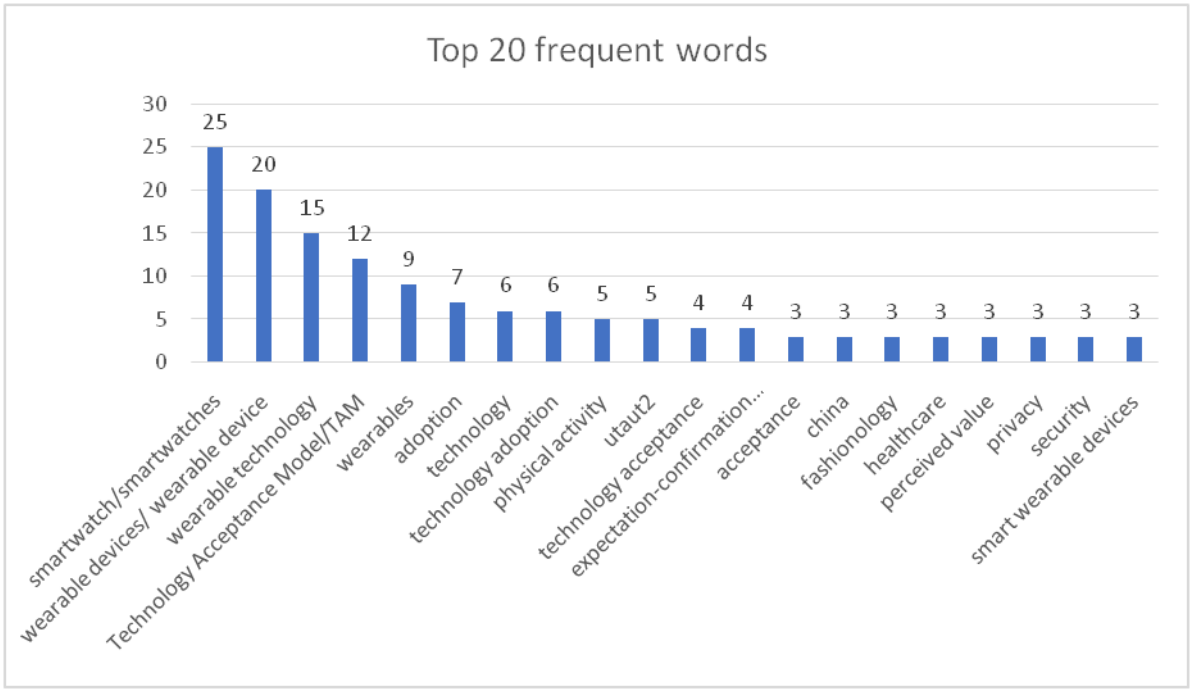

Figure 6 Citation Analysis using Biblioshiny Application in R

Cluster analysis: Articles with identical characteristics are put together and different clusters are formed by **applying Louvain algorithm**as shown in figure below:

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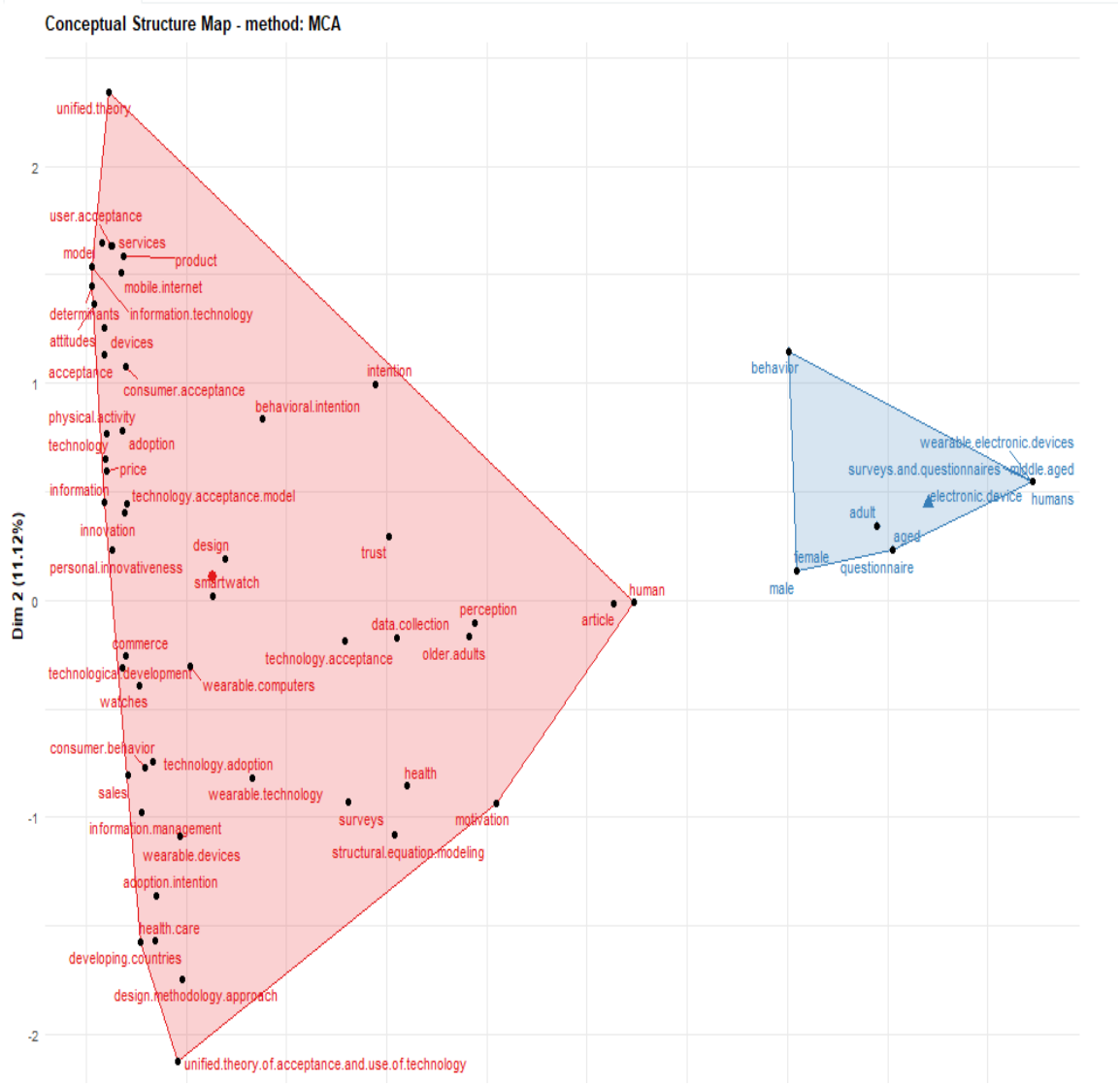

Figure 7 Cluster Analysis using Louvain Algorithm

Two clear and well identifiable clusters are formed. Analysis confirms that articles, which are cited/referred jointly, represent same domain of study and as strong co-citation status. The co-citation PageRank analysis reveals a larger figure of articles in each cluster (Mishra et al., 2018). **Cluster 1 shows adoption intention and Cluster 2 shows acceptance among older adults.** Both the clusters explain different theme where adoption intention among young adults is taken in cluster 1, a different theme is presented in cluster 2 which represents older adults. This is further explained in table below:

Cluster Number and label	Current Research
Cluster1 : Adoption of wearable healthcare devices	The focus is on factors explaining consumer intention, adoption behaviour, continuance intention and recommendation behaviour towards wearable devices. (Muller & Klerk, 2020;, Vongurai, 2020; Lee & Lee, 2018; Gupta et al., 2020; Kim & Park,

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	2019; Adapa et al., 2017; Kalantari, 2017)
Cluster 2:Acceptance among older adults	The focus was on increasing need of older adults for healthcare and assistance. Factors contributing to acceptance among older adults were explored.(Li et al, 2019; Rupp et al, 2018; Stragier et al., 2015; Ahmad et al, 2020; Khaksar et al, 2020; Farivar et al., 2020; Fang & Chang, 2016; Al-Emran, 2021.)

Table 3 Cluster Analysis using Page Rank Analysis

Cluster 1: Adoption of wearable healthcare devices

Factors influencing adoption intention among younger adults include design aesthetics, brand name (Muller & Klerk, 2020), perceived usefulness, cost (Vongurai, 2020), interpersonal influence, IT self-efficacy, IT related innovativeness, attitude towards a wearable fitness tracker, health interest (Lee & Lee, 2018a) etc. Many theories including Technological Acceptance Model, Theory of Planned Behaviour, Unified Theory of Acceptance and use of Technology successfully explain user behaviour towards wearable devices. Further, demographic and psychological factors also influence the adoption behaviour. The continuance intention of users is determined by user satisfaction, Perceived usefulness, Perceived Health Outcomes (Gupta et al., 2020) which further leads to intentions to recommend.

Cluster 2:Acceptance among older adults

Although WT are more beneficial to older adults for consistent health monitoring and security concerns, their adoption rate is low. Older adults' perceptions about the complexity of the device demotivate them from using it (Farivar et al., 2020). However, Information source of older adults and group behaviour affect their intention to use WT. Human interactions are very important for old people to adopt wearable devices. (Huei et al., 2019). Among the different features, comfort, familiar materials and independent use are preferred for adopting any WT(Al-Emran, 2021).

Conclusion

The paper employed bibliometric analysis to study adoption behaviour of Wearable devices in different user groups. The factors affecting adoption intention, usage behaviour, continuance intention and recommendation behaviour were identified. The studies have applied existing theories (e.g. TAM, UTAUT) with some additional constructs to explore antecedents of adoption behaviour towards Wearable devices. Many studies have confirmed attitude towards wearable devices as the significant factor to determine adoption intention.

By employing bibliometric technique, the paper identified rising and vanishing themes and relevant technology adoption theories which are relevant to the domain. We presented list of journals, institutions and countries having highest and significant contribution in the domain knowledge of Wearable Technology adoption. Further, most used keywords highlight the direction of research. To conclude, wearable technology adoption has been an area of interest to many scholars from different domains and adoption behaviour has been tested in different

geographical locationsfor different age groups and by applying different theories a number of antecedents and consequent variables are identified. 2 clear clusters highlighting different themes were identified and users of the two clusters follow a different approach for wearable adoption which is an area of interest for future researchers, product designers and marketers. **The cluster analysis shows that new terms and clusters are changing over time. Our focus has been shift from selling variables to adoption for healthcare.** Scholars have focussed on continuance intention and recommendation behaviour too.

Theoretical contribution

There is a limited consolidation of vast research in the domain. Further, no author has particularly focussed on literature review on adoption intention of wearable technology. Therefore, the study has explored the dimension of adoption thoroughly and has clearly identified related themes. The bibliometric analysis has added to the work by highlighting the trend of research which provides agenda for future research. The clusters made a significant contribution in the domain and future researchers can further design their studied keeping the clusters in mind.

Limitations of study

We included articles published in Scopus and web of science indexed journals. Articles in non-Scopus and web of science journals were not included which can be taken up in future Literature review studies. All the articles included in the study were in English language. We have excluded studies in non-English language that further narrowed the scope. Our search criteria used filters where we have taken papers from Business and management, Social Sciences, Information Technology and **Decision Sciences** subject areas. Research methods used in this study is limited to bibliometric analysis. Future researches may adopt different and diverse methodologies.

Future Research

Most of the authors who worked on adoption intention suggested a cross border comparative study. They also recommended a longitudinal study to verify the efficacy of present results. Further research methods like interview and focus group developed prototypes could provide rich information and experimental study with different constructs should be undertaken.

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