

# The rise of smart healthcare in smart cities: A Bibliometric Literature Review and avenue for a research agenda

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**Abstract.** The purpose of this paper is to review and critique the literature on the role of smart cities within the healthcare context, providing an overview of the state of research and outlining a future research agenda. Initially, six hundred and seventeen newspaper articles were extracted from Scopus, and their content was analysed for the article selection process by the two researchers in parallel. Finally, forty-six articles dealing with smart cities in healthcare and published in various academic journals have been analysed through content analysis and bibliometric analysis. The results show that the literature on this research topic is somewhat scarce and dominated by unrelated research. Content analysis provides the emergence of three main strands of research: 1) Smart cities as a tool for health security; 2) Smart cities as sources of opportunities for data communication in healthcare; 3) Smart cities for the creation of knowledge and skills in healthcare. The paper presents the first attempt to provide a comprehensive, structured literature review of the role of smart cities in the healthcare environment after the outbreak of the Covid-19 pandemic. Despite the growing literature on smart cities, this research area contextualised the healthcare context is still fragmented and under-theorised. More systematic and holistic studies are needed, considering the technological, economic, and social aspects of the importance of smart cities in the healthcare system.

## 1 Introduction

Technological progress and subsequent digitalisation are revolutionising the healthcare system globally [1, 2]. The introduction of computer technologies, such as the Internet of Things (IoT), Cloud Computing (CC), Big Data Analysis (BDA), Artificial Intelligence (AI), Machine Learning (ML) and so on, invites clinical governance to welcome and implement digital technologies in different healthcare systems [3-5]. Hence the birth of the concept, first and then the phenomenon of Smart Healthcare (SH) [6-9].

The primary purpose of smart cities, through the current state-of-the-art technologies and techniques available to citizens, is to create the conditions for a better quality of life for humanity. The health and well-being agenda aims to place smart cities at the heart of social objectives [10].

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The improvement of digital solutions in the healthcare sector will also provide quality healthcare at a reduced cost and valuable help during the stages of prevention and treatment of diagnosis. [11].

Digitalisation in the clinical routine will enhance the entire organisational process in many ways (productivity, transparency, information sharing, sustainability, resilience, et cetera) [12-16]. In addition, the adoption of digital technologies will facilitate healthcare organisations to identify bottlenecks of different clinical processes, avoid possible adverse events, as well as facing unpredictable pandemics, generating, from an economic point of view, increased opportunities for earning health facilities and from a social point of view, moving from Smart City to Smart Citizens [17-21]. Javed et al. [22] argue that including Internet technologies of nano-things during clinical practice is crucial to enable humans to live healthier lives in future smart cities. Only in this way will medical activities previously considered impossible before the age of nanotechnology become part of the clinical routine.

Through the use of digital technologies to significantly improve health processes, the health of patients and, therefore, the quality of life of citizens, SH wants to become a standard term [23]. For example, Singh et al. [24] state that the adoption of digitisation for the healthcare sector is no longer just a choice but a requirement for the survival of healthcare systems, hence the transition from traditional healthcare to SH.

The COVID-19 pandemic highlighted the importance of digital technologies and the consequent digitalisation in healthcare by providing innovation and sustainability to different clinical processes and improving the health services provided to citizens [25-28].

For all these reasons, this study seeks to provide support and adoption of SH, its implementation and enhancement. Based on these considerations, this work provides a bibliometric analysis of the scientific literature in the field to determine the main scientific trends, with subsequent considerations in terms of theoretical and practical implications, highlighting possible limitations of the investigation and suggesting future potential research developments.

## 2 Methodology

This study borrows the structured literature review (SLR) methodology to investigate and determine the essential Research Areas (RAs) affecting SH, recognising trends, knowledge advances and future potential in this promising area of research [29-33].

According to Massaro et al. [31], the first step in performing an SLR is establishing the research questions related to how the literature has developed, the focus, and the implications. Regarding this, the research questions in this study are formulated as follows:

*RQ1. "How is the SH e literature developing based on the strong adoption of digitisation?"*

*RQ2. "What are the main research focuses of the scientific literature investigating digitisation for SH?"*

*RQ3. "What are the implications for research?"*

In addition, a protocol for data search and article selection was defined. Firstly, the most scientific databases by focus area were identified afterwards, then those collecting items regarding socio-economic and related issues. The scientific database used to obtain articles was Scopus, a database that supplies more comprehensive coverage of academic journals as it includes over 20,000 peer-reviewed journals [34], and it is ampler than the Web-of-Science (WoS) database [35]. In addition, documents indexed in WoS are almost included in the Scopus database (97%) [36]. Therefore, the Scopus database is a suitable data warehouse for structured literature revision.

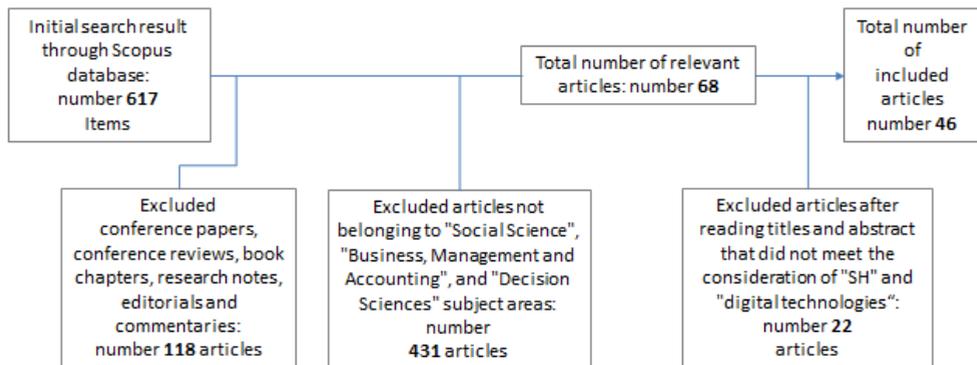
Regarding the survey perimeter, the fields "Title" OR "Keywords" OR "Abstract" OR "Authors" were examined, each with the following query syntax: "smart cit\*" AND "smart health\*" in journals, with the exclusion of conference papers, book chapters, research notes, editorials and commentaries [37]. This is required to consider only papers with empirically validated knowledge [38]. The indicated search criteria result to be reproducible, comprehensive and unbiased.

The first result was a total of 617 documents published in the period from 2016 to date, where 2016 is the year seeing the first paper. Data were collected in November 2022. Both researchers were employed to read the papers' abstracts and titles to select the appropriate papers for further analysis. In order to select the items, the following steps were carried out:

- By querying the Scopus database through the query defined above, 617 documents were found;
- 118 documents were excluded, not in the English language and not published in journals (thus,  $617-118= 499$ );
- 431 documents were excluded as not specifically relevant to the Business Management and Accounting sectors (thus,  $499-431= 68$ );
- 22 documents were excluded after examining titles and abstracts because they did not present a combination of the terms "SH" and "digital technologies" but only as terms in the text (thus,  $68-22= 46$ );
- 46 documents were finally identified as being in line with the research focus.

Following the diagram suggested by Vlaanderen et al. [39], Figure 1 recaps the data collection workflow.

The data set includes case studies and empirical studies, qualitative and quantitative. All these documents were applied for descriptive and content analysis through bibliometric analysis.



**Fig. 1.** Workflow of data selection. Source: authors' figure

Two kinds of analysis were conducted on the selected papers (46): descriptive and cluster analyses. The descriptive analysis focuses on some features of the publications, such as the evolution in time of published papers [40]. In addition, the authors have also evaluated the impact of each paper by comparing the number of citations and the Citations per Year (CPY).

The data were analysed using VOSviewer, a tool for constructing and visualising bibliometric networks and clusters [41]. VOSviewer permits researchers to cluster and analyse the relationships among articles through bibliographic coupling analysis, co-citation analysis, and co-occurrence of keywords. The authors used the VOSviewer

software for bibliographic coupling analysis for its attention to graphic representations of maps [42]. Bibliographic coupling evaluates the relation of the articles in the sample [43]; this technique occurs when an article is cited by two other articles [44] to appraise the overlapping literature between articles. Co-citation occurs when a third one cites two papers. Co-occurrence of keywords exists when a group of keywords appear in at least two papers. As Van Eck and Waltman [41] discussed, the clustering technique is opportune for performing bibliometric analysis by VOSviewer developers. The starting point of the clustering process [45] is to consider the distances between nodes; therefore, the groups are determined by minimising such distances. Fractional counting is used for all the analyses performed with VOSviewer [46].

Finally, content analysis was managed to supply an overview of emerging RAs, research gaps, and future directions. In the next section, the main findings are introduced and explained.

### 3 The bibliometric study: the descriptive analysis

From Figure 2, examining the temporal course of the publication, the subject under consideration appears relatively recent. Although since 2016, there has been more interest in this area of research, the research topic is still at an early stage of development. The growing trend of research interest dates back to 2019, with more significant growth over time. This increased interest is probably attributable to a greater perceived relevance of SH by clinical governance and the scientific community.

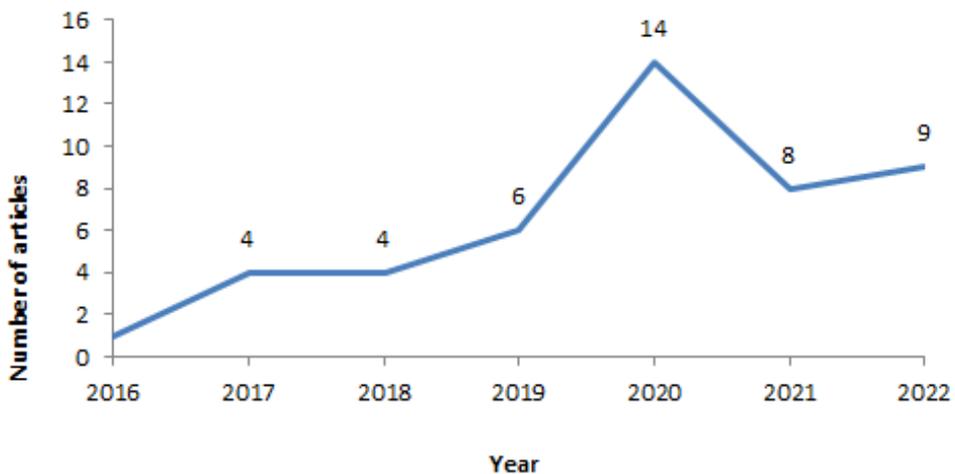
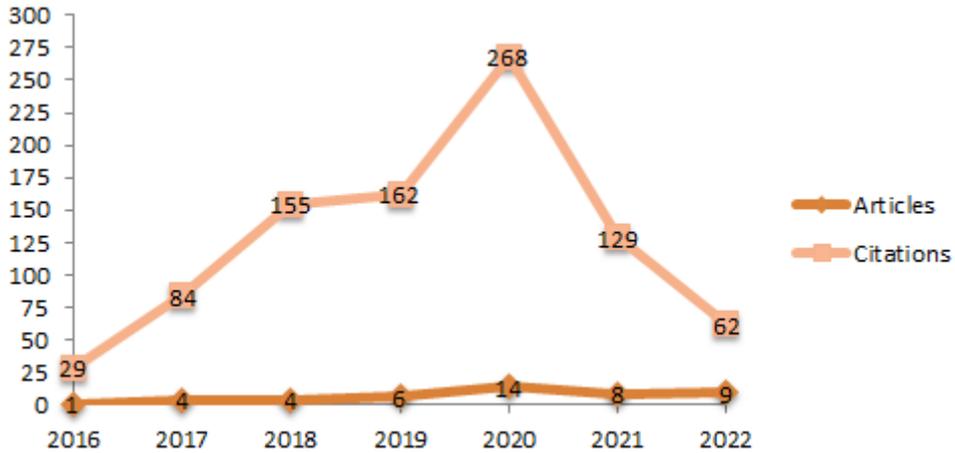


Fig. 2. Trend over time of the published research in the field. Source: authors' elaboration.

Comparing published articles' trends with the relative trend in the number of citations, Figure 3 shows consistent growth during the years 2020-2021. This evidence confirms the scientific community's recent interest towards the SH theme.



**Fig. 3.** Number of articles compared to the citations of the articles. Source: authors' elaboration.

Regarding the scientific journals retrieved from the inquiry, Table 1 lists the best 15 journals per number of scientific publications. As emerging from the investigation, Sustainability (Switzerland) is the journal with higher values, both concerning the number of published articles (8) and the number of citations (125).

**Table 1.** Top 15 journals as concerns number of records (articles/citations). Source: authors' elaboration.

Journal	Articles	Citations
Sustainability (Switzerland)	8	125
Technological Forecasting and Social Change	1	115
Sustainable Cities and Society	9	106
Production and Operations Management	1	101
Local Environment	1	59
Journal of Cleaner Production	1	56
International Journal of Health Geographics	1	45
IET Smart Cities	1	40
International Journal of Human Rights in Healthcare	1	32
Information Security Journal	1	29
IEEE Transactions on Big Data	1	22
Personal and Ubiquitous Computing	1	20
Cities	1	16
Global Transitions	1	15
International Journal on Emerging Technologies	1	12

Table 2 ranks the first ten articles and their authors according to the documents' number of CPY. The CPY is a measure of the scientific influence on the academic community, and the article, with authors Papa et al. [28], is the most cited in general and the most cited per year.

**Table 2.** Top ten authors and papers per citation and Citation per Year (CPY) Source: authors' elaboration.

Authors	Title	Year	Source title	Cited by	CPY	Ranking CPY
Papa A., Mital M., Pisano P. & Del Giudice M.	E-health and well-being monitoring using smart healthcare devices: An empirical investigation	2020	Technological Forecasting and Social Change	115	57.5	1
Guha S. & Kumar S.	Emergence of Big Data Research in Operations Management, Information Systems, and Healthcare: Past Contributions and Future Roadmap	2018	Production and Operations Management	101	25.25	3
Chui K.T., Alhalabi W., Pang S.S.H., de Pablos P.O., Liu R.W. & Zhao M.	Disease diagnosis in smart healthcare: Innovation, technologies and applications	2017	Sustainability (Switzerland)	64	12.88	8
Trencher G. & Karvonen A.	Stretching "smart": advancing health and well-being through the smart city agenda	2019	Local Environment	59	19.67	5
Chauhan A., Jakhar S.K. & Chauhan C.	The interplay of circular economy with industry 4.0 enabled smart city drivers of healthcare waste disposal	2021	Journal of Cleaner Production	56	56	2
Kamel Boulos M.N., Peng G. & Vopham T.	An overview of GeoAI applications in health and healthcare	2019	International Journal of Health Geographics	45	15	7
Xu B., Li L., Hu D., Wu B., Ye C. & Cai H.	Healthcare data analysis system for regional medical union in smart city	2018	Journal of Management Analytics	42	10.5	10
Jaiswal R., Agarwal A. & Negi R.	Smart solution for reducing the COVID-19 risk using smart city technology	2020	IET Smart Cities	40	20	4

Qureshi K.N., Tayyab M.Q., Rehman S.U. & Jeon G.	An interference aware energy efficient data transmission approach for smart cities healthcare systems	2020	Sustainable Cities and Society	33	16.5	6
Rath M. & Pattanayak B.	Technological improvement in modern health care applications using Internet of Things (IoT) and proposal of novel health care approach	2019	International Journal of Human Rights in Healthcare	32	10.67	9

#### 4 The bibliometric study: the bibliographic mapping

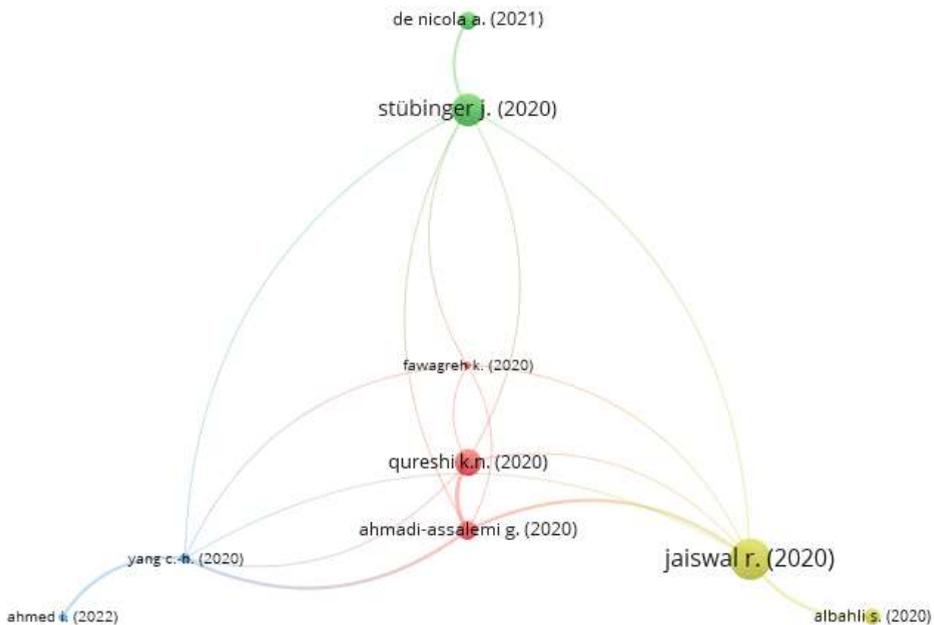
In order to identify the key issues that link the concept of digital technologies with that of SH, the bibliographic mapping technique belonging to the bibliometric analysis process has been implemented. This methodology allows it to extract information about the most influential publications [47, 48]. This type of analysis has a double advantage: on the one hand, it allows scholars to turn their scientific research toward less investigated or more discussed topics; on the other hand, it provides industry managers with an exhaustive and more comprehensible state of the art of topic intending to translate theoretical knowledge into best practices in a faster time. The bibliographic coupling techniques assess the connection of the articles based on the number of references they share [49]. Employing the tool VOSviewer for the bibliographic coupling analysis, the software was set to consider documents as units of analysis with at least 1 citation. The result of this study produced 4 clusters and nine papers.

The scientific articles selected through the bibliometric clustering process (Table 3 and Figure 4) were read carefully by both researchers to identify RAs. Analysing the articles led researchers to identify three primary RAs.

**Table 3.** Clusters emerging from the bibliometric coupling. Source: authors' elaboration.

	Authors	Citations	Title
Cluster 1 (3 Items – red)	Ahmed I. <i>et al.</i> (2022)	2	Internet of health things driven deep learning-based system for non-invasive patient discomfort detection using time frame rules and pairwise keypoints distance feature
	Yang C.-H. <i>et al.</i> (2020)	3	Sustainable smart healthcare information portfolio strategy evaluation: An integrated activity-based costing decision model
	Fawagreh K. and Gaber M.M. (2020)	1	Egap: An evolutionary game theoretic approach to random forest pruning
Cluster 2 (2 Items - green)	De Nicola A. and Villani M.L. (2021)	8	Smart city ontologies and their applications: A systematic literature review
	Stübinger J. and Schneider L. (2020)	24	Understanding smart city—a data-driven literature review

Cluster 3 (2 Items - blue)	Ahmadi- Assalemi G. <i>et al.</i> (2020)	9	Cyber resilience and incident response in smart cities: A systematic literature review
	Qureshi K.N. <i>et al.</i> (2020)	17	An interference aware energy efficient data transmission approach for smart cities healthcare systems
Cluster 4 (2 Items - yellow)	Albahli S. <i>et al.</i> (2020)	6	A blockchain-based architecture for smart healthcare system: A case study of Saudi Arabia
	Jaiswal R. <i>et al.</i> (2020)	40	Smart solution for reducing the COVID-19 risk using smart city technology



**Fig. 4.** Clusters grouping items with intersected literature. Source: authors' figure.

#### 4.1 RA 1: Smart cities as a tool for health security

"Smart cities as a tool for health security" seems to emerge as the most relevant area of expertise in the debate. In this context, different qualitative and quantitative contributions have been identified, focusing on IT tools to ensure the privacy and safety of clinical data.

For example, an industry-relevant topic is related to blockchain adoption: Albahli et al. [50] highlight how blockchain technology applied to the healthcare system is a protection model to avoid possible risks and make clinical processes more robust. In addition, Anand et al. [51] proposed a secure watermarking algorithm for sharing medical records in the cloud environment among clinical personnel. Through this system, they significantly reduced the security and privacy issues of patients' personal and sensitive data when outsourcing medical data for clinical diagnosis.

Other studies seem very interesting because they provide an overview of the current state of the art of cyber threats. For example, Ahmadi-Assalemi et al. [52], through a systematic literature review, analyse empirical studies that address cyber resilience and

Digital Forensic Incident Response (DFIR) aspects of Cyber-Physical Systems (CPS) in smart cities. Their survey shows that research focused on SH and Smart Citizens has been addressed by a few studies, highlighting significant gaps in the literature to chart possible future directions for research within cybersecurity.

Also, Hassija et al. [53], in their paper they, outlined some practical security measures that can improve the safety and privacy of patients when doctors and patients use their smartphones to control and monitor implantable medical devices via the Internet or Bluetooth connections.

#### **4.2 RA 2: Smart cities as sources of opportunities for data communication in healthcare**

This aggregation includes all studies that have empirically described the importance of SH in data communication in healthcare.

The two most relevant articles about this second perspective are by Fawagreh et al. [54] and Quereshi et al. [55]. Both studies identify a concrete proposal for an integrated system based on the transmission of clinical data to assess the impact of digital technologies on healthcare organisations. In particular, through appropriate computer protocols, they carry out an accurate predictive analysis of health data to ensure a higher quality of disease diagnosis, better treatment of patients and, Thus, a better quality of life.

The authors Ahmed et al.[56] describe an Internet of Health Things-driven deep learning-based system for non-invasive patient discomfort detection. The novelty lies in the transmission of clinical data: an RGB camera takes the place of sensors and wearable devices, equally ensuring the high accuracy of the result.

In 2018, Xu et al. [57] proposed a data analysis system aimed at the regional medical union as a solution to the problem of lack of communication between the healthcare workers of the different hospitals during the path of patient care.

#### **4.3 RA 3: Smart cities for the creation of knowledge and skills in healthcare**

In this last RA, describing the transfer of knowledge and the consequent creation of competence, the Authors underline the importance of Smart City Realities and, therefore, of SH in the social context.

For example, Yang et al. [58] claim that "The Smart healthcare sector needs to optimise its innovative health information strategies, creating process-activity value and reducing the cost of healthcare without sacrificing the quality of patient care. " To do this, they implement a decision model based on Activity-Based Costing and Decision Making techniques to facilitate clinical governance to understand how to allocate resources and plan them through appropriate activities cost factors.

While, Stubinger et al. [59] and De Nicola et al. [60], through two systematic literature reviews adopting a holistic vision, outline how the Smart City is conceived today, what technologies have helped shape its concept and what are the current challenges for further development.

Jaiswal et al. [61] in their study present the role and implementation of digital technologies to minimise the risk of COVID-19. The optimisation of social distancing rather than the refinement of the detection of infected people is two of the many advantages that these technologies have brought during the pandemic by SARS-CoV-2, helping clinical staff.

## **5 Theoretical and practical implications**

In the previous paragraphs, the results related to this study on SH and smart city themes highlight how scientific literature began to flourish about three years ago. In addition, attempts were made to a possible correlation and co-citation between the authors; there were no significant results. This explains the fragmentation of the studies relating to this issue. The large number of articles during the last few years shows greater interest from academics and industry managers on the subject.

From a scientific point of view, one of the most significant outcomes emerging from the analysis involves the three RAs. The knowledge, in the form of both a security tool, a facilitator in the management of data communication and the creation of skills, has a beneficial impact in enhancing technological solutions for the development of SH, with the ultimate aim of making the healthcare system a whole more sustainable. While the scientific community's interest has grown enormously in recent years, there seems to be no mature knowledge management vision for SH. This fragmentation is particularly evident concerning the different research topics. Therefore, at state of the art, the most relevant implication of the research, in addition to the three RAs as potential avenues to explore continuously, is the need to find common thoughts and methodologies that could provide more excellent stability to the subject in question, undoubtedly innovative.

From a managerial point of view, developing knowledge management in SH is essential through guidelines, protocols and projects. Through the operational application of methodologies, techniques and knowledge management tools for implementing SH, it will be possible to achieve a consolidated phase of this phenomenon.

## **6 Research limits**

The central limit of the study is identified by the low number of articles belonging to the Business, Management and Accounting sectors; the latter sector is an innovative research topic and is still mainly unexplored in the scientific literature. A comparative analysis, including the Scholar and Web-Of-Science databases, could provide a broader overview of the phenomenon.

Another limitation is probably related to the shortness of the time interval, from 2016 (the year of publication of the first article) to date. Only a more excellent scientific production can solve this time limit to expand the validity of similar research in the future.

## **7 Conclusion**

In order to understand state of the art and outline the potential research programme on the role of knowledge management in the context of SH, a comprehensive review of the scientific literature on this topic appeared to be appropriate. In particular, a BLR was conducted in this study, examining the evolution in the time of scientific literature, the major journals and the most cited authors. In addition, a bibliographic mapping with the use of the VOSviewer software helped to determine the main themes of the research field summarised in RA1 (Smart cities as a tool for health security), RA2 (Smart cities as sources of opportunities for data communication in healthcare) and RA3 (Smart cities for the creation of knowledge and skills in healthcare).

These three areas of research seem to be the most promising in the evolution of studies in the field, also because the production of research is very fragmented, and only nine articles of the 46 analysed show potential themes in common, stressing the role of the three RAs as reference points, as well as starting points, for future scientific publications.

However, the minimal sample of studies that emerges from the literature review suggests that this is still a highly narrow field of investigation and highlights, therefore, possible enormous opportunities for scientific and managerial development.

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