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Original article

Deaf and technology: A bibliometric analysis of scientific literature

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Summary

Introduction. Technology has the potential to reduce isolation, increase independence, provide educational, financial and social opportunities for users, but there may still be barriers, especially for people with disabilities or sensory deficits. Therefore, it is very important to determine what science has been dealing with in this area, more precisely in the area of the deaf. The main aim of this paper was to map the progress and trends of scientific literature in the field of technology for the deaf (children and adults).

Methods. A bibliometric analysis in VosViewer was performed to determine the set goals. The Dimensions database was chosen for literature analysis. The unit of analysis consisted of 1242 publications and VosViewer was applied.

Results. The results show that this topic in science has experienced exponential growth in the last decade. Also, the most productive authors, journals, institutions and countries, as well as their collaboration network, were identified through a visual analysis of co-citations. Based on the analysis of co-words, we can draw a conclusion that the words: student, sign language, cochlear implant, classroom, parent, outcome are the most frequently repeated words, which would mean that the topics covered in this domain are mainly focused on children and their functioning in the environment and school system.

Conclusion. Providing the main lines of research generated in this field allows scientists to follow the trends themselves. Also, therapists can use our analysis to identify sources that can indicate how and in what context deaf children can use technology.

Key words: deaf, technology, VosViewer

Introduction

In a modern society, every person is surrounded by technological achievements. Kaye believes that technology has the potential to reduce isolation, increase independence, provide educational, financial and social opportunities for users, but there may still be barriers, especially for people with disabilities or sensory deficits [1]. The fact is that the progress of technology is taking place rapidly, while bringing new forms of communication into the daily life of an individual. Our daily life activities and interactions with other people have been radically changed in terms of new forms of communication (eg. smart phones with a wide range of applications).

As a result, we have a situation where people spend much more time communicating through these media than face to face [2]. New ways of communication are based mainly on written communication, through text messages, as well as, multimedia content. On the other hand, oral communication is a key difficulty for the deaf, which can cause additional problems. Namely, clinicians and researchers agree that access to communication at home, at school and with peers is important for the linguistic, cognitive and socioemotional development of deaf children [3, 4, 5]. Deaf children use different ways to communicate with their hearing community. Such a model that incorporates the use of all forms of communication in order to achieve interaction with the environment is called total communication. Thus, Purwowibowo believes that the total communication learning model has the potential to improve their language capacity in terms of speaking, writing and reading [6]. This model enables deaf children to learn new words and their meanings, as well as, to communicate in society. However, we should be mindful of the fact that the main method of communication for deaf children is sign language. However, using only this method the deaf can remain completely isolated from the hearing community. Therefore, Arthur claims that "technology is extremely promising for people with disabilities", and that new technologies can bring new opportunities to bridge the gap between deaf people and the hearing community [7]. Even the classroom has changed significantly compared to a few decades ago. The introduction of computers in the education of the deaf in 1980 made a big change. Now, along with smart boards, laptops, educational websites and online learning tools, students very often have their own technology (smartphones, tablets) with which they have been familiar since the youngest age [8]. Deaf children have learned to communicate at a distance without reading the interlocutor's mouth. Before that, deaf people could not imagine communicating with someone who was not in their vision field. Dunham hypothesized that technological progress in the field of deafness would have three directions: hearing aids, communication technology, and brain research in cochlear implanted children [9]. Therefore, this paper focuses on the evolution and trends of scientific publications on the mentioned topic. An initial search of the Dimensions database did not find any papers on a similar topic, so the aim of this paper is to:

1) to determine the progress of scientific literature on the topic of deaf- technology;
2) determine the most relevant aspects of this topic and the relevant journals;
3) determine the most productive authors, institutions and countries as well as their network of collaboration.

Methods

This paper dealt with bibliometric analysis of scientific literature on the topic of deaf and technology. For this purpose, the Dimensions database was chosen. Mapping of scientific publications and their analysis was done in the VosViewer program, intended for bibliometric and visual data analysis. The advantage of this methodology is in the quantitative and comprehensive evaluation of scientific literature [10]. In order to reduce the researcher's bias, the analysis procedure protocol was established [11]. The research design is based on the analysis of co-words. Also, the different performances of the program allowed the generation of maps with nodes in order to answer the research questions.

Bibliometric and visual analysis was used to map the scientific literature in the field of deaf-technology. The Dimensions database was used for the search. Publications are collected using the following search strategy: deaf AND technology. The search is refined by: DOCUMENT TYPES: (ARTICLE). The search was conducted in September 2022 and a total of 1242

articles were found. Articles with the words deaf and technology in the title or abstract in all research categories were included. The research covers all citation databases, without an exact time frame. Exclusion criteria were studies that include additional difficulties other than hearing impairment (eg deaf-blindness). Figure 1 shows the flowchart according to the PRISMA protocol, which consists of the phases that were carried out during the research.

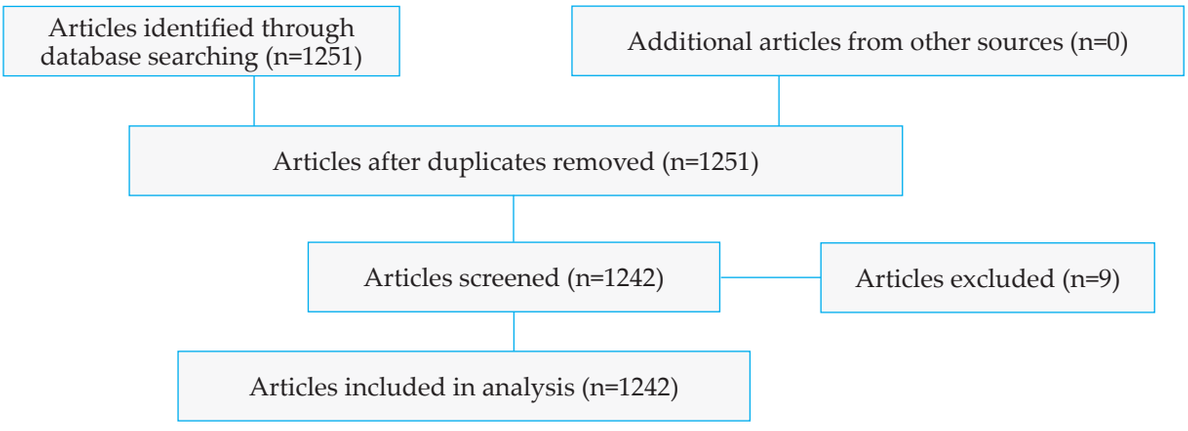


Figure 1. Flowchart according to PRISMA

Results

At the figure 2 we see the evolution of scientific production on this topic from almost five decades ago to today. This evolution had two clearly defined periods, the first from 1978–2007 where the number of publications was very small and the second from 2007 to the present day where scientific production grew exponentially, reaching its peak in 2021.

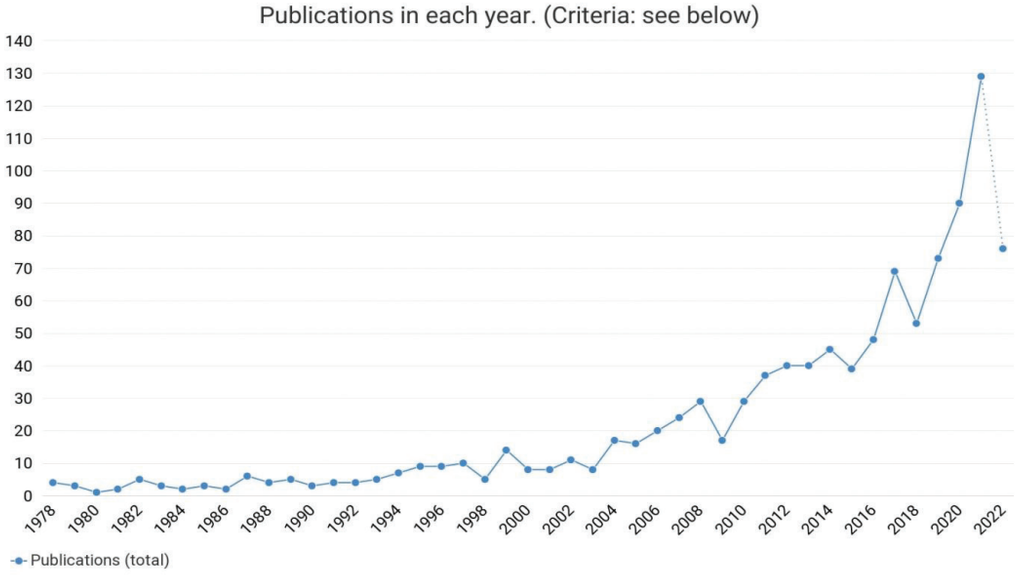


Figure 2. Evolution of scientific production

Figure 3. The most dominant research categories

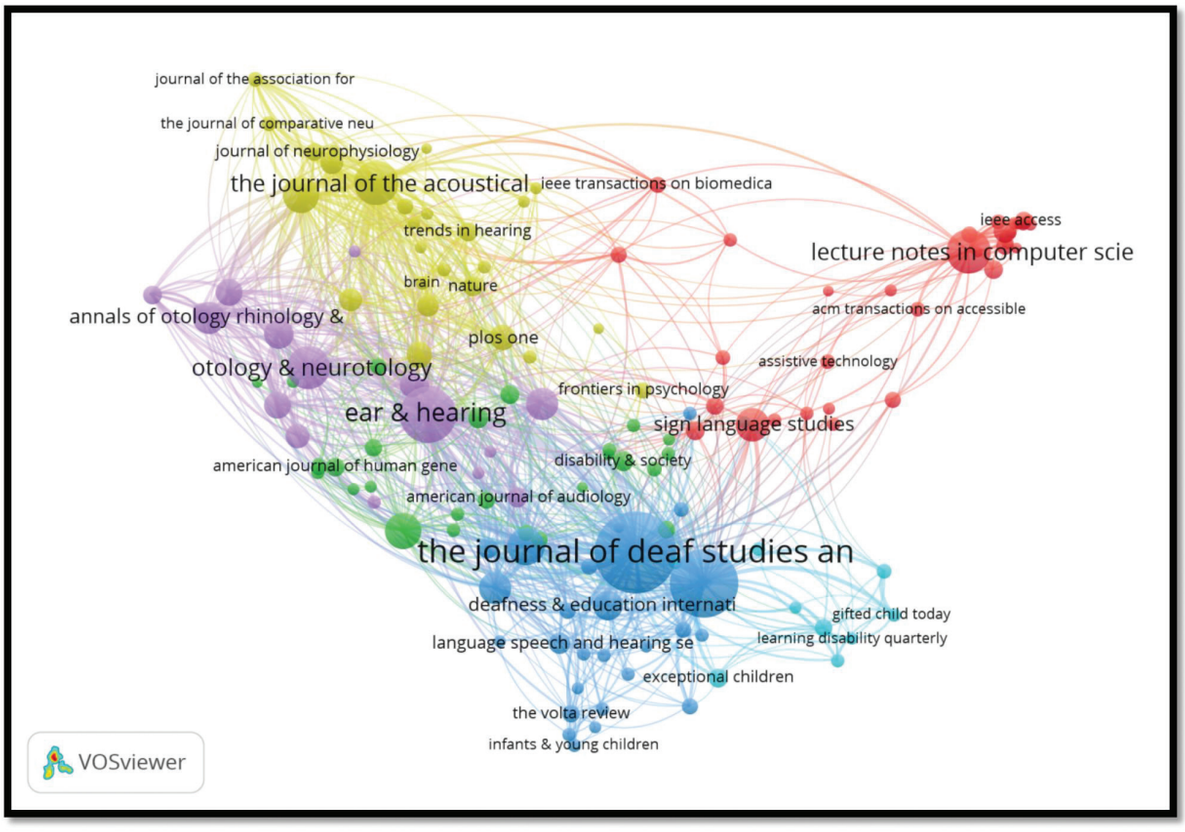
At figure 3, we see research categories that have more than 50 published articles in this area. As we can see, the analyzed articles are mainly from the fields of medicine and health sciences, education, language and communication, as well as information sciences.

Looking at table 1, we see five journals that mostly dealt with this topic. Thus, we notice that the journal *American annals of the deaf* had the most articles (n = 81) on this topic, and is followed by *The journal of deaf studies and deaf education* (n = 30). However, if we look at column three in table 1, we will notice that the most cited journal is *The journal of deaf studies and deaf education*, followed by *American annals of the deaf.*

Table 1. The most relevant journals in filed deaf-technology

Journals	Number of documents	Citations
American annals of the deaf	81	682
The journal of deaf studies and deaf education	30	715
Sign language studies	16	112
Universal access in the information society	13	203
International journal of pediatric otorinolaringology	13	300

The journal co-citation map shown in figure 4 gives us an overview of the structure of the scientific world. Journal clusters can be identified on the map. Clusters that are closer together on the map indicate close association. As we can see in the figure 4, we have four large clusters. Interpretation of the map is simple. The left side of the map contains three clusters (yellow, green and purple). The yellow cluster refers to neuropsychological sciences, while the green one refers to the field of public health. The purple cluster refers to the field of otorhinolaryngology. The lower part of the map is a blue cluster that refers to the areas of language, hearing and special education. The right part of the map is a red cluster related to computer science and assistive technology. From the map, we clearly see the relationship of all clusters, that is, we see that all areas that deal with this topic are very closely and tightly connected, except for assistive technology, which is very weakly connected to other areas dealing with deaf and technology.



*Note: The size of the circle is directly proportional to the number of publications of a particular journal, and the closeness of the circles and the thickness of the lines are proportional to the frequency of citations.

Figure 4. Journal co-citation map

In table 2, we see the three most cited articles in the field of deaf-technology. The most cited article is by Dermott from 2004. The author concluded that people with cochlear implants, people with cochlear implants and hearing aids, perceived music better than people who used only hearing aids.

Table 2. The most cited articles in our unit of analysis

McDermott HJ. Music perception with cochlear implants: a review. Trends Amplif 2004;8(2):49–82.	**383**
Wilson BS, Dorman MF. Cochlear implants: a remarkable past and a brilliant future. Hear Res 2008;242(1-2):3–21.	**237**
Lederberg AR, Schick B, Spencer PE. Language and literacy development of deaf and hard-of-hearing children: successes and challenges. Dev psychol 2013;49(1):15–30.	**216**

Table 3. The most productive authors

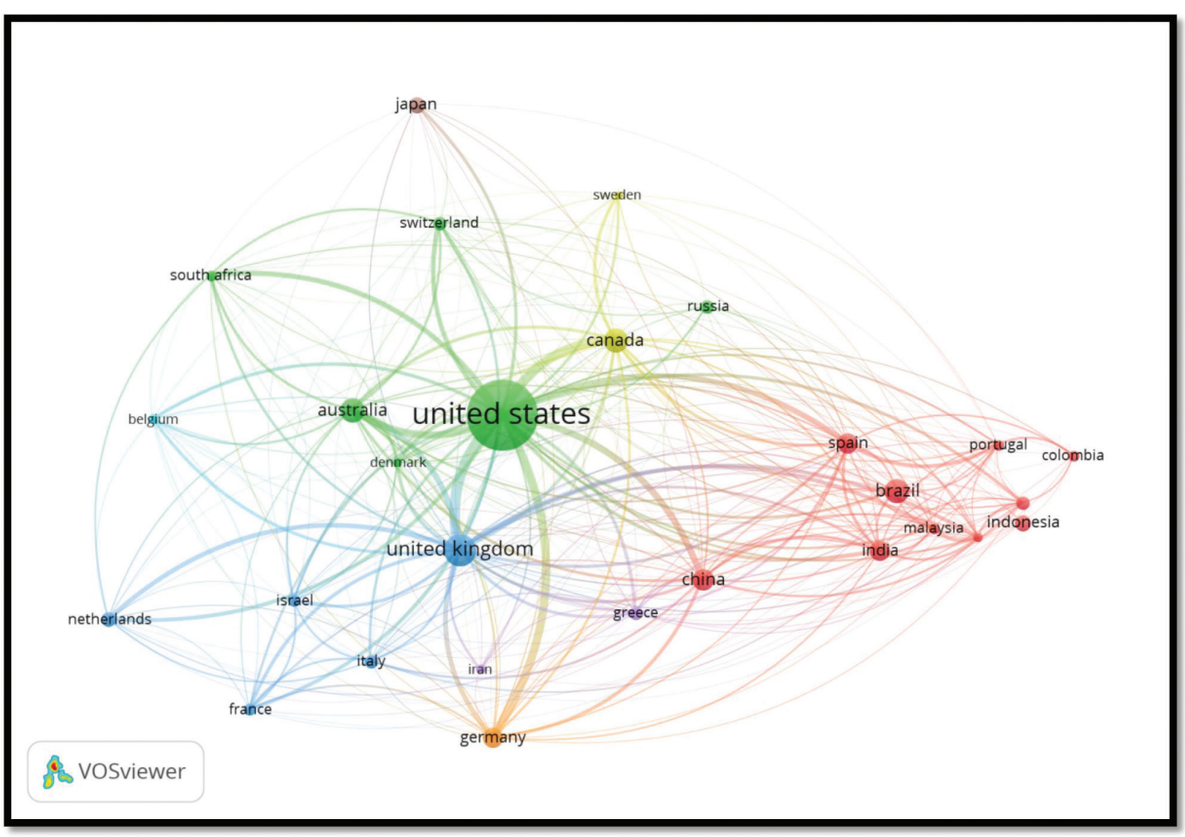
Authors	n	Citations
Huenerfauth, Matt	10	81
Kushalnagar, Poorna	9	270
Mayer, Connie	7	173

Table 4. Countries that were most productive in deaf-technology filed of science

Countries	n	Citations
USA	336	5042
United Kingdom	68	1242
Canada	40	452
Australia	40	1206
Brazil	39	130

The countries with the most publications in this field are the United States of America. Other countries are far behind them.In the third column, we see that the most quoted, as expected to be, is the USA, followed by the UK and immediately behind them is Australia. The least cited publications are from Brazil (Table 4).

Figure 5 shows the bibliographic coupling of countries, where we see that the USA is in the center of the map, as is expected. Otherwise, the term bibliographic coupling refers to the situation when two documents cite one or more in common. Thus, we see that in this sense, countries with more publications (which circles are larger) have stronger connections,



*Note: The size of the circle is directly proportional to the number of publications of a certain country, and the closeness of the circles and the thickness of the lines are proportional to the strength of the bibliographic coupling.

Figure 5. Map of bibliographic coupling of countries

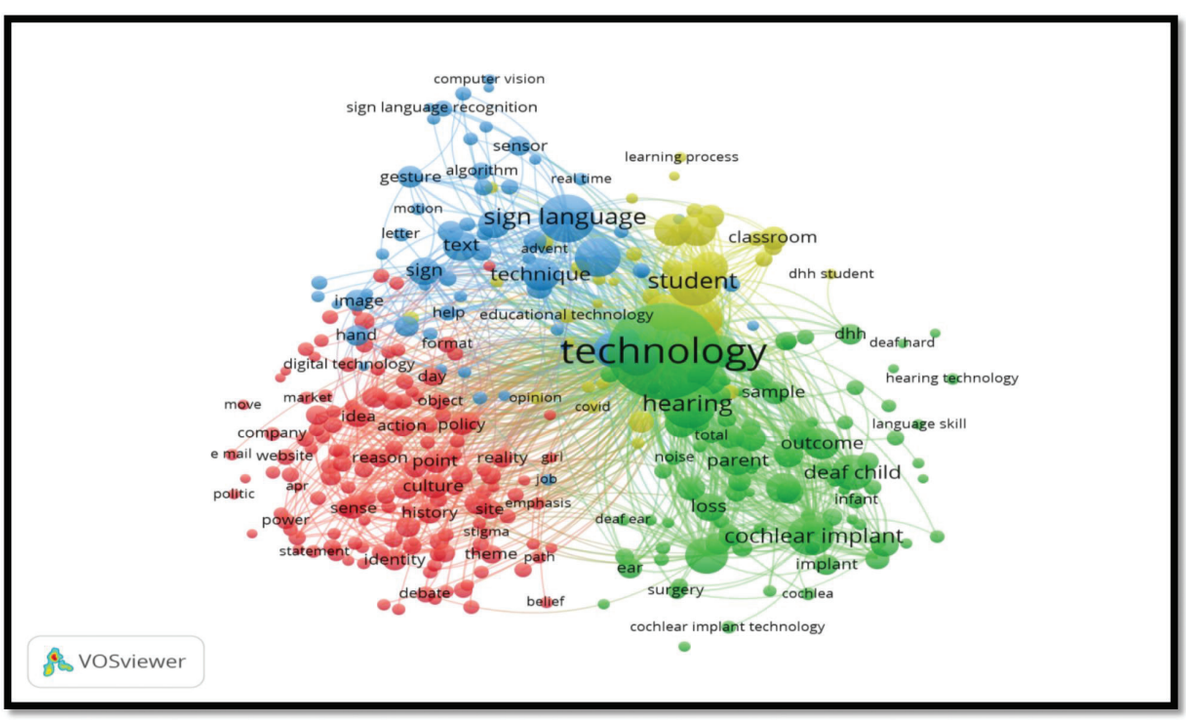
so the USA has the strongest connections with Canada, Australia and the UK, while of course, in this sense, they are also connected with other countries, but those connections are weak.

In table 5, we see that the leading institution in this field is the Rochester Institute of Technology. Rochester Institute of Technology is a private research university in the city of Henrietta in Rochester, New York metropolitan area.

Table 5. Leading organizations in the field of deaf-technology

Name of the institution	n
Rochester Institute of Technology	48
Galaudet University	34
University of Melbourne	14
University of Washington	12

At figure 6, we see a network of co-words. We notice separated four clusters (marked in red, blue, green and yellow). The larger the nodes, the more often the words are repeated. The wider the lines between the nodes, the more noticeable the connections, the topics are closer, so we see that in the green cluster we have words that mainly refer to technology in terms of hearing aids, in the red cluster we see words that refer to the barrier that deaf people havein society, the blue cluster refers to sign language, while the yellow cluster refers to the use of technologies in the educational system.



*Note: The larger the nodes the more often the word is repeated;nodes of the same color represent words that appear together most often.

Figure 6. Map of word co-occurrences

Discussion

Considering that recently bibliometric analysis has been used to examine the trends and progress of the scientific literature in different research categories, the aim of our analysis was to examine different dimensions of deaf-technology search, which includes productivity trend, leading research categories, organizations, journals and authors, as well as the most frequently treated topics. It is well known that we live in a society characterized by the continuous advancement of technology. Innovative technological achievements have spread in all spheres of life [12]. Considering that, there was a need to examine the relationship between deafand technology in literature. Until now, it is known that technology covers a wide range of assistive, adaptive and rehabilitative devices for people with special needs. During the last 15 years we have seen a huge development in the field of deaf and technology [13], which coincides with the research dynamics in this area, as evidenced by our analysis. Namely, it was established that since 2008, scientific production in this area has grown exponentially. Technology, which mainly refers to assistive technology, is divided into hardware, software and hearing aids. The main purpose of these devices is for deaf people to overcome the basic difficulty they have, that is, difficulty in communication. Noemi, in her research about autism and technology, also found sudden increase in scientific literature since 2009, which was explained by sudden increase in technological achievements in the social sphere, which also crossed over into other fields, such as the use of technology for therapeutic purposes or purposes of assistive technology [14]. Also, we see the biggest increase in the last three years, which is expected, given the dominant form of distance learning (online) during the Covid-19 pandemic. So the subject of the researcher must have been to find the best practical solutions so that the deaf could follow the class.

The most productive research category on this topic is medical and health sciences, followed by education, language and communication as well as information sciences, which is expected, considering that according to the WHO (2015), there are 360 million people worldwide (over 5% of the world's population) with hearing impairment, of which 32 million are children, so it is primarily a health problem [15]. Among the various sources that share knowledge on this topic with the scientific community, the most productive is the American Annals of the Deaf, withthe highest number of publications. Other journals, such as The journal of deaf studies and deaf education, have much fewer publications, but surprisingly more citations. So, these are the two leading journals in this field, which is not surprising considering that the country with the most published publications is the USA where those originate. USA is also in the center of the bibliographic coupling map, with the closest connections with Canada, Australia and the UK. Although Brazil is also one of the five most productive countries, obviously the relationship between these two countries is not so close in this sense. Furthermore, the analysis showed that the most productive authors are Matt Huenerfauth, from the Rochester Institute of Technology, which is also a leading organization in this field, and Poorna Kushalnagar, from Gallaudet University, which is again consistent with the findings of the leading institutions, considering that this organization is right after the Rochester Institute for technology. However, the most cited author is Poorna Kushalnagar, whose fields of interest are deaf communication and the quality of life of hearing-impaired people. When it comes to the word co-occurrence map, we see that the words that appear mostly next to the keywords are: student, sign language, cochlear implant, classroom, parent, outcome, which would mean that the topics covered in this domain are mainly focused on children and their functioning in the environment and school system.

Conclusion

Our analysis has theoretical and practical implications. Theoretical implications refer to the fact that our results will be useful to future researchers in collecting adequate and interesting sources from this field of research. Also, knowing the main lines of research generated in this field allows scientists to follow the trends themselves. In this case, they do not need to check what has been previously published; thanks to this research, they can know what current topics they can cover. Among the practical implications is the fact that therapists or teachers can use our analysis to identify sources that can indicate how and in what context deaf children can use technology. Limitations of our study relate to the limitation of the search to one database, Dimensions. A recommendation for further research could be to extend the unit of analysis to other databases such as Wos, Scopus, and Pubmed.

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Ethical approval. The Ethics Committee of the University East Sarajevo, Faculty of Medicine Foca, Republic of Srpska, Bosnia and Herzegovina, approved the study and informed consent was obtained from all individual respondents. The research was conducted according to the Declaration of Helsinki.

Conflicts of interest. The authors declare no conflict of interest.

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Gluvi i tehnologija: Bibliometrijska analiza naučne literature

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Uvod. Tehnologija ima potencijal da redukuje izolaciju, poveća nezavisnost, omogući obrazovne, finansijske i socijalne prilike za korisnike, ali ipak mogu postojati i prepreke, pogotovo za osobe sa teškoćama ili senzornim deficitima, stoga je veoma važno utvrditi čime se do sada nauka bavila u ovoj oblasti, preciznije u oblasti gluvih. Cilj ovog istraživanja bio je mapirati napredak i trendove naučne literature u oblasti primjene tehnologije kod gluvih osoba (djece i odraslih).

Metode. Korišćena je bibliometrijska analiza kako bi se utvrdili postavljeni ciljevi. Za analizu literature izabrana je baza podataka Dimensions. Jedinica analize se sastojala od 1242 publikacije i primijenjen je program VosViewer.

Rezultati. Rezultati su pokazali da je ova tema u nauci doživjela eksponencijalni rast posljednju deceniju. Takođe, identifikovani su najproduktivniji autori, časopisi, institucije i zemlje, kao i njihova mreža saradnje kroz vizuelnu analizu kocitiranja. Na osnovu analize riječi koje se ponavljaju možemo da zaključimo da su riječi: učenik, znakovni jezik, kohlearni implant, učionica, roditelj, ishod, riječi koje se najčešće ponavljaju, što bi značilo da su teme koje su obrađivane u ovom domenu uglavnom fokusirane na djecu i njihovo funkcionisanje u okolini i školskom sistemu.

Zaključak. Poznavanje glavnih pravaca istraživanja generisanih u ovoj oblasti omogućava naučnicima da sami prate trendove. Takođe, terapeuti mogu koristiti našu analizu u cilju identifikacije izvora koji može ukazati na to kako i u kom kontekstu gluvi mogu koristiti tehnologiju.

Ključne riječi: gluvi, tehnologija, VosViewer