A Bibliometric Analysis of Deafness Gene Literature From 2009 to 2018 based on Web of Science

Linhu Li1,*, Gefei Shi2,*, Zhigang Yang1, Zhihao Shen1

1ENT Department, Affiliated Jiading Central Hospital of Shanghai University of Medicine & Health Sciences, Shanghai, China
2Shanghai Key Laboratory of Forensic Medicine, Key Laboratory of Forensic Science, Ministry of Justice, PRC, Shanghai Forensic Service Platform, Academy of Forensic Science, Shanghai, China

ORCID IDs of the authors: L.L. 0000-0002-6881-5949; G.S. 0000-0002-5809-9993; Z.Y. 0000-0002-3671-3542; Z.S. 0000-0001-9137-2923.

Cite this article as: Li L, Shi G, Yang Z, Shen Z. A bibliometric analysis of deafness gene literature from 2009 to 2018 based on web of science. J Int Adv Otol. 2021;17(6):541-550.

INTRODUCTION

According to World Health Organization’s report, a person is said to have hearing loss if he or she is not able to hear or has hearing thresholds of 20 dB or better in both ears, and a person is said to be deaf if he or she has a profound hearing loss, which implies very little or no hearing, who often use sign language for communication. It was reported that over 5% of the world’s population—or around 466 million people—have disabling hearing loss (hearing loss greater than 40 dB in the better hearing ear in adults and a hearing loss greater than 30 dB in the better hearing ear in children), and 34 million of these are children. In children under 15 years of age, 40% of hearing loss is attributed to unpreventable causes. Can we find the relative gene to protect cue hearing loss and deafness? It is the reason why the deafness gene is researched by otolaryngologists around the world. To explore the research trends and hotspots of deafness gene, we employed bibliometrics and a graph theory to study documents retrieved from the Web of Science (WoS).

MATERIALS AND METHODS

Data Collection

The data were collected from the WoS Core Collection, including the Science Citation Index Expanded (SCIE) and the Social Sciences Citation Index, on September 19, 2019. The keywords were detected with Medical Subject Headings (MeSH) (https://www.ncbi.nlm.nih.gov/mesh). “Deafness,” “acquired deafness,” “extreme hearing loss,” “deaf mutism,” “complete hearing loss,” “bilateral
deafness,” “prelingual deafness,” “cistron,” “cistrons,” “genetic materials,” “genetic material” were the terms researched. The timespan was from 2009 to 2018. The publication type of document was limited by article. The full records were exported to plain text files for analysis with Python 3.7. The pathway for selecting the papers is shown in Figure 1. The data were aggregated as secondary data without personal information. Thus, informed consent was not required.

Analysis
Data cleaning, data reorganization, the descriptive statistics and figures of publishing year, countries/regions, authors, and affiliations were done by Python 3.7. R was used for two-side statistical analysis with \( \alpha = 0.05 \). The difference among group were accounted by \( \chi^2 \) test.

Five keywords per article were extracted from the abstract of all documents with jieba package for Python 3.7. According to Zip’s second law\(^5\) and cumulative frequency of word frequency (34%),\(^6,7\) the dividing word frequency of high-frequency keywords is determined. KeyWords plus\(^8\) (ID-keywords) and the papers’ WoS categories also were used to analyze the research topic.

The class was determined by modularity\(^9,10\) using Gephi 0.9.2. Modularity is a measure of the relative density of a network. A community (called a module or modularity class) has high density relative to other nodes in its module but low density relative to those outside.\(^11\) ForceAtlas2 was used to draw the network.

Eigenvector centrality and betweenness centrality were addressed using Gephi 0.9.2. Eigenvector centrality,\(^12\) also called eigencentrality, is a measure of the influence of a node in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. Betweenness centrality\(^13,14\) is a measure of centrality in a graph based on shortest paths. The betweenness centrality for each vertex is the number of these shortest paths that pass through the vertex. As a result, betweenness centrality of a vertex can express the degree to which nodes stand between each other.

Using SPSS 22.0 (IBM SPSS Corp.; Armonk, NY, USA) hierarchical clustering and multidimensional scale analysis were carried out on the co-occurrence matrix of high-frequency keywords, application year high-frequency keyword occurrence matrix, and subject high-frequency keyword occurrence matrix. The hierarchical clustering of high-frequency keyword co-occurrence matrix uses “Euclidean distance” to transform data and uses Ward method to cluster. For multidimensional scale analysis of high-frequency keyword co-occurrence matrix, namely alternating least-squares algorithm (ALSCAL) method is used to calculate and select “Euclidean distance” in interval measurement, select “original” in “level of measurement” in model dialog box, and check “untie tied observations.” Whether the model fit is reasonable is judged by stress value <20% and namely, r-squared (RSQ) > 0.6.

RESULTS

General
There are 2828 article documents analyzed in the research. Figure 2 shows that 2015 published more articles (319 articles) than other years, while 2009 published much less than others. On average, there were 282 articles published per year. There was no significant difference among the years (\( \chi^2 = 13.03, P = .16 \)).

All documents came from 651 journals. On average, 4.34 papers were published per journal (median 1.00 papers; lower and upper quartiles were 1.00 and 3.00, respectively). The journals publishing more than 30 papers (18 journals, 2.76%, Figure 3 and Table 1) published 36.42% (1030) of all documents.

Based on the number of documents (Table 1), PLoS ONE published the most articles (168 papers). Among the 18 journals, there were 8 journals from the United States, followed by England (4 journals), Netherlands (2 journals), Denmark (1 journal), Norway (1 journal), Ireland (1 journal), and Japan (1 journal). All journals were included in SCIE. The journals were categorized as follows:

- Genetics & heredity (n = 10)
- Otorhinolaryngology (n = 4)
- Biochemistry & molecular biology (n = 3)
However, there were 8, 7, 7, and 3 journals in Q1, Q2, Q3, and Q4, respectively. The average 2020 impact factor (IF) was 4.19 among the 18 journals (Table 1). The articles published on Q2 journals (339 articles, 32.91%) were more than other quartile zones, followed by Q3 (318 articles, 30.87%), Q1 (252 articles, 24.47%), and Q4 (121 articles, 11.75%).

Table 1. The Information of Journals Publishing More Than 30 Articles About Deafness Gene Per Journal in 2009 to 2018

| Sources                                      | Number of Documents | Country   | 2020 Impact Factor | 2020 Quartile | Categories                                    |
|----------------------------------------------|---------------------|-----------|--------------------|---------------|-----------------------------------------------|
| PLoS One                                     | 168                 | USA       | 3.240              | Q2            | Multidisciplinary sciences—SCIE               |
| International Journal of Pediatric Otorhinolaryngology | 162                 | Ireland   | 1.675              | Q3            | Otorhinolaryngology—SCIE                      |
| American Journal of Medical Genetics Part A  | 88                  | USA       | 2.802              | Q3            | Genetics & heredity—SCIE                     |
| Human Molecular Genetics                     | 53                  | England   | 6.150              | Q1            | Biochemistry & molecular biology—SCIE         |
| Clinical Genetics                            | 53                  | Denmark   | 4.438              | Q2            | Genetics & heredity—SCIE                     |
| European Journal of Human Genetics           | 46                  | England   | 4.246              | Q2            | Biochemistry & molecular biology—SCIE         |
| Human Mutation                               | 45                  | USA       | 4.878              | Q1            | Genetics & heredity—SCIE                     |
| Scientific Reports                           | 44                  | England   | 4.380              | Q1            | Multidisciplinary sciences—SCIE               |
| American Journal of Human Genetics           | 44                  | USA       | 11.025             | Q1            | Genetics & heredity—SCIE                     |
| Acta Oto-Laryngologica                       | 43                  | Norway    | 1.494              | Q4            | Otorhinolaryngology—SCIE                     |
| BMC Medical Genetics                         | 39                  | England   | 2.103              | Q4            | Genetics & heredity—SCIE                     |
| Genetic Testing and Molecular Biomarkers     | 39                  | USA       | 1.795              | Q4            | Genetics & heredity—SCIE                     |
| Otology & Neurotology                        | 36                  | USA       | 2.311              | Q2            | Otorhinolaryngology—SCIE                     |
| Gene                                         | 36                  | Netherlands | 3.688          | Q2            | Genetics & heredity—SCIE                     |
| Biochemical and Biophysical Research         | 35                  | USA       | 3.575              | Q3            | Biochemistry & molecular biology—SCIE         |
| Communications                              |                     |           |                    |               |                                               |
| Proceedings of The National Academy of       | 33                  | USA       | 11.205             | Q1            | Multidisciplinary sciences—SCIE               |
| Sciences of The United States of America     |                     |           |                    |               |                                               |
| Journal of Human Genetics                    | 33                  | Japan     | 3.172              | Q3            | Genetics & heredity—SCIE                     |
| Hearing Research                             | 33                  | Netherlands | 3.208          | Q1            | Audiology & speech-language pathology—SCIE   |
|                                             |                     |           |                    |               | Q3 Neurosciences—SCIE                        |
|                                             |                     |           |                    |               | Q1 Otorhinolaryngology—SCIE                   |

SCIE, Science Citation Index Expanded.
There were 26 documents (0.92%) published in the top 10 journals based on the IF in 2020 journal citation reports (Table 2). From Table 2, it was shown that New England Journal of Medicine had the top IF (91.245), but only one paper was published in the journal while Nature published the most articles (7 papers). There were 8 journals from the United States, followed by England (3 journals). The journals (Table 2) were categorized as follows:

- Medicine, general, & internal (n = 3)
- Biochemistry & molecular biology (n = 2)
- Cell biology (n = 2)
- Biotechnology & applied microbiology (n = 1)
- Clinical neurology (n = 1)
- Medicine, research, & experimental (n = 1)
- Multidisciplinary sciences (n = 1)
- Genetics & heredity (n = 1)
- Immunology (n = 1)

**Countries/Regions**

There were nine countries/regions (Figure 4) focused on the study of deafness gene. On average, 1 country/region published 30.41 papers in the field. The United States listed in the top with 852 papers, followed by the People’s Republic of China (509 papers), Germany (242 papers), Japan (233 papers), England (208 papers), France (208 papers), Italy (204 papers), Netherlands (134 papers), South Korea (111 papers), and Iran (94 papers).

According to the Eigenvector centrality, United States (1.00), England (0.97), Germany (0.93), France (0.92), Netherlands (0.89), Canada (0.88), Italy (0.88), Turkey (0.86), Japan (0.84), and Australia (0.83) listed in the top 10. Meanwhile, United States (609.12), Germany (319.44), England (231.46), France (220.13), Japan (179.41), Turkey (177.86), Canada (164.91), India (142.54), Iran (125.18), and Italy (117.42) were the top 10 countries based on the betweenness centrality.

**Table 2. Top 10 Journals Based on Impact Factor in 2020 Journal Citation Reports (JCR)**

| Sources                                      | Number of Documents | Country    | 2020 IF | 2020 Quartile | Categories                      |
|----------------------------------------------|---------------------|------------|---------|---------------|---------------------------------|
| New England Journal of Medicine              | 1                   | USA        | 91.245  | Q1            | Medicine, general, & internal—SCIE |
| Lancet                                       | 1                   | USA        | 79.321  | Q1            | Medicine, general, & internal—SCIE |
| JAMA - Journal of the American Medical Associ| 1                   | USA        | 56.272  | Q1            | Medicine, general, & internal—SCIE |
| Nature                                       | 7                   | England    | 49.962  | Q1            | Multidisciplinary sciences—SCIE  |
| Cell                                         | 4                   | USA        | 41.582  | Q1            | Biochemistry & molecular biology—SCIE |
| Nature Biotechnology                          | 3                   | USA        | 54.908  | Q1            | Biotechnology & applied microbiology—SCIE |
| Nature Medicine                              | 1                   | USA        | 53.440  | Q1            | Biochemistry & molecular biology—SCIE |
| Lancet Neurology                             | 1                   | England    | 44.182  | Q1            | Clinical neurology—SCIE          |
| Nature Genetics                              | 6                   | USA        | 38.33   | Q1            | Genetics & heredity—SCIE         |
| Immunity                                     | 1                   | USA        | 31.745  | Q1            | Immunology—SCIE                  |

SCIE, Science Citation Index Expanded.
In all, 3148 organizations published articles in the deafness gene field. On average, 3.00 organizations published 1 paper, and 1 organization published 0.91 articles. One article with 57 co-organizations listed in the top in the study. The top 10 organizations were People's Liberate Army General Hospital (98 papers, China), University of Miami (68 papers, USA), Radboud University Nijmegen (68 papers, Netherlands), the University of Iowa (62 papers, Italy), Harvard University (51 papers, USA), Shinshu University (46 papers, Japan), Fudan University (46 papers, China), Shanghai Jiao Tong University (44 papers, China), National Institute of Deafness and Other Communication Disorders (44 papers, USA), and Baylor College of Medicine (43, USA).

There were 160 organizations with the frequency between 10 and 98, whose cumulative frequency was 36.93%. From Figure 6A, 19 groups were found based on the modularization. Though People's Liberate Army General Hospital (China, 0.15 and 333.9) got the highest frequency, the Eigenvector centrality score and betweenness centrality score were lower than Harvard University (USA, 1.00 and 1166.75) (Figure 6B-C). It was followed by University of Amsterdam (Netherlands, 0.72), University of Groningen (Netherlands, 0.59), Charite (Germany, 0.59), and University of British Columbia (Canada, 0.59) based on Eigenvector centrality score and followed by Radboud University Nijmegen (Netherlands, 1080.72), University of Miami (USA, 1001.92), Baylor College of Medicine (USA, 499.97), and Emory University (USA, 455.93) based on betweenness centrality score.

**Keywords and Subjects**

From 2828 abstracts, 2858 keywords were extracted by Python. The high-frequency keywords were shown in Table 4, and the total cumulative frequency of these keywords was more than 48%. They were divided into 4 groups based on the modularity class with modularity score 0.315 (reflecting the quality of class), and each group was named with the word who had the highest Eigenvector centrality score in its own group. As a result, the 4 groups were mutation group (including 15 words), cell group (including 6 words), hearing group (including 2 words), and syndrome group (including 2 words). These also could be viewed from the co-occurrence network (Figure 7A). The top 5 keywords based on Eigenvector centrality score were mutation, gene, patient, hearing, and loss (Table 4). The top 5 keywords based on betweenness centrality were mutation, gene, family, GJB2, and patient (Table 4, Figure 7B). Mutation and gene listed the top according to all bibliometric indicators.

There were 2786 papers with the content of ID-keywords. 5595 ID-keywords were extracted and analyzed by Gephi 0.9.2. According to Table 5, the citing references of 2786 papers mainly focused on the gene research of deafness because of the inner ear of family diseases or Pendred syndrome.

Hierarchical clustering (Table 4) of 25 high-frequency keywords has shown that 2 groups were classified. Group 1 includes mutation, hearing, loss, gene, patient, family, and GJB2, and other keywords were collected in group 2. Group 1 indicated that the documents focused on the gene mutation of deafness. Group 2 has shown the research objects, methods, factors, and gene locus. The phenomena also were discovered by the multidimensional scale (Figure 7C).

As the stress value (6.24%) and RSQ (0.99) were both reasonable, the multidimensional scale got the high model fit. So, the result was reliable. The keywords were classified with X-axis zero scale in Figure 7D. Group 1 was on the left of X-axis zero scale, and group 2 on the other side. The keywords in the group 1 were all farther from Y-axis zero scale than that in group 2. The keywords above Y-axis zero scale...
scale indicated the research character, namely which told that the disease’s causes were the mutation or variant of relative gene. The keywords below Y-axis zero scale gave the research details, namely which told that the research focused on the patients about hearing, syndrome or family disease, hair cell, GJB2 or (and) SLC26A4 gene loci.

The keywords from Dai Pu and Smith Richard J. H.’s articles were analyzed, respectively. Figure 8A shows the co-occurrence network of keywords from Dai Pu’s articles. The top 10 keywords based on the Eigenvector centrality score were mutation (1.0 score, 33 times), hearing (0.73 score, 23 times), patient (0.67 score, 16 times), family

![Figure 5](image_url)

**Figure 5.** The co-occurrence network based on authors. (A) Nodes size and color based on the frequency and modularity class, respectively; (B) nodes size and color based on the Eigenvector centrality; (C) nodes size and color based on the betweenness centrality (the lines between the nodes represent the number of co-occurrence, the nodes were filtered by 6-52 frequency, and the edges were filtered by 2-36 frequency).
(0.61 score, 16 times), gene (0.55 score, 10 times), loss (0.50 score, 12 times), \textit{GJB2} (0.43 score, 8 times), \textit{SLC26A4} (0.40 score, 7 times), deafness (0.32 score, 5 times), and \textit{TMC1} (0.28 score, 3 times). While the top 10 keywords (Figure 8B) from Smith Richard J. H.’s articles based on the Eigenvector centrality score were hearing (1.0 score, 23 times), loss (0.93 score, 20 times), gene (0.72 score, 11 times), mutation (0.68 score, 14 times), genetic (0.60 score, 10 times), variant (0.56 score, 8 times), family (0.53 score, 8 times), deafness (0.46 score, 4 times), population (0.46 score, 4 times), and cell (0.42 score, 7 times).

Table 4. The High-Frequency Keywords According to the Cumulative Frequency

| Rank | Keywords    | Number | Frequency (%) | Cumulative Frequency (%) | Eigenvector Centrality | Betweenness Centrality | Modularity Class |
|------|-------------|--------|---------------|--------------------------|------------------------|------------------------|------------------|
| 1    | mutation    | 1070   | 7.60          | 7.60                     | 1.00                   | 1014484.37             | 1                |
| 2    | gene        | 573    | 4.07          | 11.67                    | 0.79                   | 509593.45              | 1                |
| 3    | hearing     | 539    | 3.83          | 15.50                    | 0.69                   | 319243.50              | 8                |
| 4    | patient     | 430    | 3.06          | 18.56                    | 0.70                   | 430559.01              | 1                |
| 5    | loss        | 394    | 2.80          | 21.36                    | 0.58                   | 196437.89              | 8                |
| 6    | family      | 285    | 2.03          | 23.39                    | 0.52                   | 152337.04              | 1                |
| 7    | cell        | 251    | 1.78          | 25.17                    | 0.49                   | 402848.22              | 10               |
| 8    | syndrome    | 226    | 1.61          | 26.78                    | 0.45                   | 231216.90              | 2                |
| 9    | \textit{GJB2} | 212    | 1.51          | 28.28                    | 0.36                   | 44176.32               | 1                |
| 10   | deafness    | 189    | 1.34          | 29.61                    | 0.48                   | 131672.42              | 1                |
| 11   | mouse       | 170    | 1.21          | 30.83                    | 0.40                   | 271344.38              | 10               |
| 12   | variant     | 157    | 1.12          | 31.95                    | 0.43                   | 86525.98               | 1                |
| 13   | mitochondrial| 118    | 0.84          | 32.79                    | 0.32                   | 76501.96               | 1                |
| 14   | genetic     | 106    | 0.75          | 33.54                    | 0.33                   | 55188.02               | 1                |
| 15   | protein     | 104    | 0.74          | 34.28                    | 0.32                   | 144753.02              | 10               |
| 16   | disease     | 93     | 1.66          | 35.94                    | 0.33                   | 83559.87               | 1                |
| 17   | hair        | 93     | 1.66          | 37.61                    | 0.25                   | 63865.95               | 10               |
| 18   | sequence    | 84     | 1.50          | 39.11                    | 0.29                   | 36715.19               | 1                |
| 19   | study       | 84     | 1.50          | 40.61                    | 0.31                   | 60210.17               | 1                |
| 20   | cause       | 74     | 1.32          | 41.93                    | 0.32                   | 46276.60               | 1                |
| 21   | expression  | 72     | 1.29          | 43.22                    | 0.26                   | 85807.97               | 10               |
| 22   | \textit{slc26a4} | 70     | 1.25          | 44.47                    | 0.23                   | 10089.12               | 1                |
| 23   | identify    | 67     | 1.20          | 45.67                    | 0.27                   | 33023.91               | 1                |
| 24   | case        | 67     | 1.20          | 46.87                    | 0.28                   | 42042.18               | 2                |
| 25   | ear         | 64     | 1.14          | 48.01                    | 0.23                   | 62691.10               | 10               |
A total of 2828 papers were from 90 WoS categories (Table 6), in which genetics & heredity, otorhinolaryngology, and biochemistry & molecular biology were listed in the top 3. The top 3 categories occupied more than 40%.

DISCUSSION
The results indicated that the research of deafness gene was stable in the nearly 10 years though the article number of every year was up and down. The deafness gene research articles were published on 651 journals. PLoS ONE published the most articles (168 articles) among the journals, followed by International Journal of Pediatric Otorhinolaryngology (162 articles). It meant that the publication of research results was relatively scattered. Among the 18 journals publishing more than 30 articles, 8 journals were in Q1 zone and 591 articles were published on Q1 and Q2 journals. These indicated that the articles had high academic level. By the way, there was 1 article published in New England Journal of Medicine,16 Lancet,17 and JAMA – Journal of the American Medicine Association,18 respectively. However, it should be noted that PLoS ONE was not in otorhinolaryngology class, International Journal of Pediatric Otorhinolaryngology was located in Q3, and 10 journals were from genetics & heredity class. So, the higher-quality professional journal in otorhinolaryngology should be promoted in the future. The results of papers’ WoS categories study were common with these. But it was indicated that otorhinolaryngology and biochemistry & molecular biology also were concerned by researchers.

Eight of 18 journals were from United States. This was in common with the results of where authors came from. The co-occurrence network also showed that United States was more notable and active than other countries/regions. The number of articles from People’s Republic of China was located in the second in the list; however, the Eigenvector Centrality score and Betweenness Centrality score were not both in the top 10. It indicated that there is less cooperation between People’s Republic of China and other countries/regions in the field of deafness gene research.

Dai Pu from People’s Liberate Army General Hospital (China) published the most articles among the authors. According to modularity class operated by Gephi 0.9.2, Dai Pu group was listed in the first with...
Li et al. Bibliometric Analysis of Deafness Gene Literature from 2009 to 2018

55 members. They cooperated with Liu Xuezhong group and Kim Unkyung group. Smith Richard J. H. group, Huygen Patrick L. M. group, and Usami Shinichi group had cooperation relationship in the study. But Dai Pu group and its partners did not take any touch with Smith Richard J. H. group and its partners. According to the results, authors in the Dai Pu group got more important location in the study field about deafness gene. Liu Xuezhong and Smith Richard J. H. were followed. Meanwhile, Liu Xuezhong was more active than other authors. Except Dai Pu and Smith Richard J. H., Li Huawei (Fudan University) and Lin Xi (Emory University) also played an important role among the cooperation relationships.

Like the authors' analysis, People’s Liberate Army General Hospital (98 papers, China) published more articles than other organizations. But its position and activation were not notable according to the study. The reason would be that cooperating organization with People’s Liberate Army General Hospital was less. Harvard (United States) though published only 51 papers cooperated with more organizations than others. It is suggested to get more and more opportunities to operate with other organizations at home and abroad for People’s Liberate Army General Hospital (China). And in my opinion, it is important to build an international research system or group.

The results of keywords and ID-keywords analysis with modularity class in Gephi 0.9.2 have shown that the score was very low. It meant that the keywords were not classed. It may be related to the overconcentration of research topics. Of course, from the other side, it indicated that the articles studied in the paper focused on our research topic and that the keywords extracting function of jieba package for Python 3.7 were reliable. However, the presentation of hierarchical clustering and multidimensional scale could divide the 25 high-frequency keywords into 2 groups. Especially, the results of multidimensional scale further discovered the research character and research details. And the results also were proved by the analysis of keywords from the top 2 authors’ articles. Though Dai Pu and Smith Richard J. H. all focused on the gene mutation in deafness diseases, there were differences between their research points. Dai Pu mainly studied the mutation of gene $GJB2$, $SLC26A4$, and $TMC1$ in some family hearing diseases, while Smith Richard J. H. studied the mutation and variant of gene and the changes of cell in some family and population diseases.

CONCLUSION
The results of deafness gene research were smoothly published in a wide range of journals in the nearly 10 years. It was a pity that otorhinolaryngology field lacked the higher-quality professional journal in otorhinolaryngology. United States published more articles than other countries/regions, while Dai Pu and his organization—People’s Liberate Army General Hospital (China)—published more documents than other authors and organizations. However, People’s Liberate Army General Hospital (China) and People’s Republic of China both need more cooperation with other countries and institutions in the world. Harvard University plays an important and active role in the field. Hearing loss and deafness research mainly focused on the gene

| ID-keywords | Frequency | ID-keywords | Frequency |
|-------------|-----------|-------------|-----------|
| deafness    | 876       | mice        | 129       |
| gene        | 597       | children    | 124       |
| mutations   | 513       | families    | 120       |
| hearing-loss| 330       | sensorineural hearing-loss | 114 |
| impairment  | 325       | family      | 112       |
| expression  | 276       | variants    | 111       |
| inner-ear   | 258       | Pendred-syndrome | 107 |
| identification | 225 | hair-cells | 101 |
| sensorineural deafness | 216 | recessive deafness | 98 |
| protein     | 212       | phenotype   | 94        |
| prevalence  | 193       | DNA         | 87        |
| spectrum    | 166       | mouse       | 86        |
| mutation    | 159       | enlarged vestibular aqueduct | 86 |
| disease     | 146       | connexin 26 gene | 82 |
| population  | 145       | frequency   | 81        |

Table 5. Top 30 ID-Keywords on Frequency

Figure 8. The co-occurrence network based on keywords of Dai Pu and Smith Richard J. H. (A) The keywords from Dai Pu’s articles; (B) the keywords from Smith Richard J. H. articles (nodes size and color based on the Eigenvector centrality, the lines between the nodes represent the number of co-occurrence; the nodes were filtered by 10-1070 frequency).
mutation and variant of family and population diseases. But there were subtle differences between different research groups.

Peer Review: Externally peer-reviewed.

Author Contributions: Design and Review – L.L., G.S.; Analysis and/or Interpretation – L.L., G.S.; Literature Research – L.L., Z.Y.; Supervision – Z.S., Z.Y.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The study was funded by the project of Science and Technology Commission Shanghai Municipality (19441900500); Funding projects of basic research business fees of central scientific research institutes (GY2021G-12); Jiaoding District Health Committee Fund(2020-KY-07, 2020-KY-03); Fund (Natural General Items) of Shanghai University of Medicine & Health Sciences (No. SSF-21-16-002); the Shanghai Key Laboratory of Forensic Medicine (21DZ2270800); the Shanghai Forensic Service Platform (19DZ2292700).

REFERENCES

1. World Health Organization (WHO). Deafness and hearing loss. 2019. Available at: https://www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss.
2. Bastian M, Heymann S, Jacomy M, Jacomy M. Gephi: an open source software for exploring and manipulating networks. Proceedings of the International AAAI Conference on Weblogs and Social Media. 2009;3(1):361-362.
3. Jacomy M, Venturini T, Heymann S, Bastian M. ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software. PLoS One. 2014;9(6):e98679.
4. Clarivate Analytics. Web of Science. Available at: http://apps.webofknowledge.com/UA_GeneralSearch_input.do?product=UA&search_mode=GeneralSearch&SID=4CGQGJrHdaoHKMuhRsh&preferences Saved=
5. Donohue JC. Understanding Scientific Literature: A Bibliographic Approach. Cambridge: The MIT Press; 1973.
6. Ding H, Cao P. Research hotspots and fields of foreign media economics in 2013–based on bibliometrics. J Comm. 2015;22(4):61-82.
7. Zhang H, Cui L. Study of bioinformatics through co-word analysis. J China Soc Sci Tech Info. 2003;22(5):613-617.
8. An XR. The research on the threshold of high-frequency words based on the normal distribution in word frequency analysis. J Intell. 2014;10:129-136.
9. Lambiotte R, Barahona M, Delenne JC. Dynamics and multiscale modular structure in networks. Available at: http://www rencontrer.org/meeting8/lambiotte.pdf.
10. Blondel VD, Guillaume J, Lambiotte R, Lefebvre E. Fast unfolding of communities in large networks. J Stat Mech Theor Exp. 2008;2008(10):P0008.
11. Ladd J, Otis J, Warren CN, Weingart S. Exploring and analyzing network data with python. Available at: https://programminghistorian.org/en/lessons/exploring-and-analyzing-network-data-with-python.
12. Wikipedia. Eigenvector centrality. Available at: http://en.m.wikipedia.org/wiki/Eigenvector_centrality.
13. Freeman LC. A set of measures of centrality based on betweenness. Sociometry. 1977;40(1):35-41.
14. Wikipedia. Betweenness centrality. Available at: https://en.wikipedia.org/wiki/Betweenness_centrality#CITEREFFreeman1977.
15. FANTOM Consortium and the RIKEN PMI and CLST (DGT), Forrest AR, Kawaji H, et al. A promoter-level mammalian expression atlas. Nature. 2014;507(7493):462-470.
16. Bockenhauer D, Feather S, Stanescu HC, et al. Epilepsy, ataxia, sensorineural deafness, tubulopathy, and KCNJ10 mutations. N Engl J Med. 2009;360(19):1960-1970.
17. Schapira AH. Mitochondrial diseases. Lancet. 2012;379(9828):1825-1834.
18. Taylor RW, Pyle A, Griffin H, et al. Use of whole-exome sequencing to determine the genetic basis of multiple mitochondrial respiratory chain complex deficiencies. JAMA. 2014;312(1):68-77.