Review

Antibiotics: A Bibliometric Analysis of top 100 classics

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Abstract: Citation frequencies represent the most significant contributions in any respective field. This bibliometric analysis aimed to identify and analyze the 100 most-cited publications in the field of antibiotics and to highlight the trends of research in this field. “All databases” of Clarivate Analytics’ Web of Science was used to identify and analyze the 100 publications. The articles were then cross-matched with Scopus and Google Scholar. The frequency of citation ranged from 940 to 11051 for the Web of Science, 1053 to 10740 for Scopus, and 1162 to 20041 for Google Scholar. Five hundred thirteen authors made contributions to the ranked list, and Robert E.W. Hancock contributed in six articles, which made it to the ranked list. Sixty-six scientific contributions originated from the United States of America. In contrast, five publications were linked to the University of Manitoba, Canada, that was identified as the educational organization, which made the most contributions (n=5). According to the methodological design, 26 of the most cited works were review-type closely followed by 23 expert opinions/perspectives. Eight articles were published in Nature journal, making it the journal with the most scientific contribution in this field. Correlation analysis between the publication age and citation frequency was found statistically significant (P = .012).

Keywords: citation classics; top-cited articles; antibiotics; bibliometric analysis; antibacterial; antimicrobials

1. Introduction

The bibliometric analysis provides a quantitative review of literature in any field of research based on the citation frequency of the conducted research. This type of analysis identifies the countries, organizations, and authors who were affiliated with the most prominent scientific
contributions [1,2]. The thrust areas of the past research in a specialty can be identified by analyzing the most-cited work currently, which information can then be used to channel the future research.

The bibliometric concept of "citation classics" was described by the founder of the Institute for Scientific Information (ISI), Dr Eugene Garfield, in 1977. Its purpose was identification as well as acknowledgment of frequently cited research of authors and their peers that would consequently encourage the respective work and its impact on the specialty [3]. The eligibility of a scientific contribution to be counted as a "classic" depends on the specialty being analyzed. While some analysts believe that 100 or more citations of a publication are sufficient [4-7], others believe that a publication must be cited more than 400 times to be counted in the list [8]. Leading scientific databases like Web of Science (WoS), Elsevier's Scopus (ES), and Google Scholar (GS) and influential publishers like BioMed Central, Nature, Wiley, Frontiers, Elsevier and PLOS are developing and embedding options to perform on-site citation analysis [4,8-11].

Several bibliometric analyses have been conducted in other fields of health sciences, which include the specialty of dentistry [4,8,9,12,13] and medicine [14-18]. However, the "classics" in the field of antibiotics has not been identified. The aim is to identify and analyze the top 100 classics in the specialty of antibiotics to highlight the notable advancements made on this very topic over the recent decades.

2. Materials and methods

2.1. Search strategy

Two independent reviewers (A.I.A) and (P.A) conducted a literature search on 21st March 2020 using ‘All-Databases’ collection of WoS. The search terms were identified after consulting field experts from different institutions, and a final search string was developed and agreed upon unanimously. No language restrictions, publication year range, or methodology selections were applied.

2.2. Eligibility criteria

Titles of the articles published in peer-reviewed journals were selected when either of the following search terms identified: “antibiotics” OR “antibiotic” OR “anti-bacterial” OR “antibacterial” OR “anti-infective” OR “anti-infectious” OR “anti-microbial” OR “antimicrobial”

Articles having less than 400 citations according to the WoS and ES database were excluded. Articles published in low or no impact factor journals were not included in the marked list.

2.3. Data extraction and bibliometric parameters

A total of 124,122 publications were initially identified using the search string described above. The publications were sorted based on the frequency of citations in a descending manner. The list of top 100 classics was marked based on the citation frequency. The marked list was then cross-matched with GS and ES databases. The marked lists from the A.I.A and P.A was then shared with the field experts, and all authors unanimously agreed upon the final list. Bibliometric parameters for the articles available in “All Databases” were recorded from WoS database, which includes the title of the article, journal title, citation count, current citation index (CCI) 2019 (total citations received in 2019), publication year, names of authors along with their affiliated organizations, and country of origin. Each publication was then hand-searched to identify evidence level, keywords, and the methodology of the study. The missing data was then cross-matched with ES database to ensure the accuracy and correctness of collected information.
2.4. Methodological design

The publications were then categorized according to the methodology of the study as review articles, expert opinion, clinical practice guidelines, cross-sectional study, new material or technique, clinical studies, and laboratory studies.

2.5. Institution and Country of origin

The author’s affiliation and origin country of publication were retrieved from the ES database as complete information for the marked list was not available from the WoS database. The retrieved information was then hand-searched and compared with the original text for each manuscript. Although corresponding addresses are considered a reliable source to identify the country of origin of publication; however, upon searching manually, it was seldom recorded. Each institution contributing to the publication was recorded as a single entry.

2.6. Data analysis

The “Visualization of Similarities (VOS) viewer software” is widely to graphically illustrate the bibliometric parameters in mapping networks, which allow easy visualization of critical elements [2,19-21]. The current study used VOS to represent a graphical mapping of keywords as identified bibliometric analysis to identify the focus of research in recent decades.

2.7. Statistical analysis

The descriptive data and associations of citation frequency, citation density, publication age, and CCI were analyzed using IBM SPSS Statistics®, version 22, using the Spearman rank test. The normality of data was checked using the Shapiro-Wilk test. To explore the difference between two or more independent groups, the Kruskal-Wallis test was performed. Post-hoc testing was performed to confirm the difference between variables. Mann-Kendall trend test was performed to determine increasing and decreasing time trends. A p-value of < .05 was considered statistically significant.

3. Results

3.1. Bibliometric parameters

The marked list of top 100 classics received a sum of 167320 citations based on WoS, 165947 citations based on ES, and 262727 based on GS database. The frequency of citations ranged from 940 to 11051 (WoS), 1053 to 10740 (ES), and 1162 to 20041 (GS). Citation density is defined as the average number of citations/ annum; it was calculated as 2742 (WoS), 2720 (ES), and 4307 (GS) for the 100 classics. “Antibiotic susceptibility testing by a standardized single disk method” was identified as the most cited ‘classic’ with 11051, 10740, and 20041 citations according to WoS, ES, and GS databases, respectively, with a citation density of 205 [22]. “Antimicrobial peptides of multicellular organisms” was ranked second with 5685, 5668, 7994 citations according to WoS, ES, and GS databases, respectively, with a citation density of 316 [23]. “Transformation of mammalian cells to antibiotic resistance with a bacterial gene under the control of the SV40 early region promoter” was ranked third with 3891, 2319, 3875 citations according to WoS, ES, and GS databases respectively, with a citation density of 102 [24]. The marked list of top 100 classics along with their citation frequency from WoS, ES and GS databases, publication age, citation density, and CCI 2019 has been presented in Table 1. Shapiro-Wilk test revealed non-normal data on the citation frequency, citation density, and age of publication (years). Figure 1A shows a statistically significant upward trend of citation frequency was noted with the increase in publication age (R²= 0.044, p= −0.012). Figure 1B shows a downward trend of citation density was noted with an increase in the age of publication (R²= 0.304, p=−0.551), which was not statistically significant. The supplementary figure S1 illustrates the distribution of citation frequency over the last six decades.
Table 1. List of 100 classics of antibiotics ranked based on their citation frequency according to the Web of Science, Scopus, and Scholar database along with citation density and current citation index (2019).

| R^1 | Author [Reference]             | Year | CD^2 | CCI^3 2019 | WoS^4 | ES^5 | GS^6 |
|-----|--------------------------------|------|------|------------|-------|------|------|
| 1   | Bauer, Kirby, Sherris and Turck [22] | 1966 | 205  | 621        | 11051 | 10740| 20041|
| 2   | Zasloff [23]                    | 2002 | 316  | 398        | 5685  | 5668 | 7994 |
| 3   | Southern and Berg [24]          | 1982 | 102  | 3          | 3891  | 2319 | 3875 |
| 4   | Cowan [25]                      | 1999 | 179  | 292        | 3749  | 4598 | 11203|
| 5   | Sondi and Salopek-Sondi [26]    | 2004 | 212  | 353        | 3397  | 3677 | 5471 |
| 6   | Brogden [27]                    | 2005 | 224  | 302        | 3363  | 3353 | 4941 |
| 7   | Kumar, et al. [28]              | 2006 | 214  | 291        | 2996  | 3185 | 5039 |
| 8   | Cohen, et al. [29]              | 1972 | 59   | 17         | 2809  | 1775 | 3754 |
| 9   | Kim, et al. [30]                | 2007 | 201  | 311        | 2615  | 2818 | 4164 |
| 10  | Stewart and Costerton [31]      | 2001 | 130  | 217        | 2474  | 2602 | 4113 |
| 11  | Hancock and Sahl [32]           | 2006 | 170  | 139        | 2373  | 2391 | 3185 |
| 12  | Kovach, et al. [33]             | 2006 | 167  | 244        | 2337  | 2319 | 3019 |
| 13  | Liu, et al. [34]                | 1995 | 93   | 166        | 2332  | 2458 | 3571 |
| 14  | Dorman and Deans [35]           | 2000 | 110  | 177        | 2201  | 2407 | 4479 |
| 15  | Sharma, et al. [36]             | 2009 | 188  | 240        | 2071  | 2269 | 3196 |
| 16  | Mah and O’Toole [37]            | 2001 | 108  | 183        | 2043  | 2127 | 3529 |
| 17  | Neu [38]                        | 2003 | 116  | 119        | 1970  | 2071 | 3413 |
| 18  | Chopra and Roberts [39]         | 2001 | 104  | 230        | 1967  | 2026 | 3414 |
| 19  | Davies and Davies [40]          | 2009 | 178  | 312        | 1963  | 2037 | 3817 |
| 20  | Ganz [41]                       | 2010 | 195  | 395        | 1952  | 1983 | 3115 |
| 21  | Zasloff [42]                    | 2006 | 138  | 257        | 1935  | 1805 | 2643 |
| 22  | Kuemmerer [43]                  | 1992 | 69   | 82         | 1930  | 2007 | 2734 |
| 23  | Dellit, et al. [44]             | 1987 | 58   | 67         | 1915  | 1951 | 1732 |
| 24  | Wiegand, et al. [45]            | 2010 | 187  | 146        | 1871  | 1898 | 2848 |
| 25  | Yeaman and Yount [46]           | 2007 | 144  | 146        | 1869  | 1846 | 2702 |
| 26  | Nathan, et al. [47]             | 2003 | 108  | 169        | 1842  | 1246 | 2033 |
| 27  | Cushnie and Lamb [48]           | 2008 | 153  | 384        | 1839  | 2052 | 3983 |
| 28  | Goossens, et al. [49]           | 2005 | 121  | 230        | 1811  | 1850 | 2904 |
| 29  | Sarmah, et al. [50]             | 1983 | 47   | 31         | 1737  | 1817 | 2638 |
| 30  | Kumarasamy, et al. [51]         | 2005 | 115  | 149        | 1726  | 1842 | 3071 |
| 31  | Mast, et al. [52]               | 2005 | 115  | 70         | 1719  | 645  | 1868 |
| 32  | Rabea, et al. [53]              | 2003 | 99   | 71         | 1689  | 1719 | 2523 |
| 33  | Anthonisen, et al. [54]         | 2001 | 87   | 38         | 1650  | 1898 | 3065 |
| 34  | Magill, et al. [55]             | 1987 | 49   | 57         | 1633  | 1601 | 2294 |
| 35  | Niederman, et al. [56]          | 2014 | 260  | 337        | 1562  | 1893 | 2319 |
| 36  | Liang, et al. [57]              | 1999 | 74   | 96         | 1552  | 1525 | 2168 |
| 37  | Zankari, et al. [58]            | 2001 | 80   | 81         | 1518  | 1489 | 2039 |
| 38  | Gewirtz [59]                    | 2006 | 108  | 102        | 1512  | 1550 | 2177 |
| 39 | Steers, et al. [60] | 2006 | 106 | 121 | 1482 | 596 | 1288 |
| 40 | Hirsch, et al. [61] | 1999 | 70 | 82 | 1474 | 1549 | 2469 |
| 41 | Jenssen, et al. [62] | 2012 | 184 | 484 | 1468 | 1462 | 2257 |
| 42 | Laxminarayan, et al. [63] | 1959 | 24 | 1 | 1453 | 1454 | 2387 |
| 43 | Park, et al. [64] | 1995 | 58 | 30 | 1447 | 1511 | 2483 |
| 44 | Kohanski, et al. [65] | 2002 | 79 | 22 | 1421 | 1431 | 2062 |
| 45 | Shai [66] | 2013 | 201 | 326 | 1410 | 1403 | 1990 |
| 46 | Boman [67] | 2007 | 108 | 147 | 1405 | 1420 | 2100 |
| 47 | Hoiby, et al. [68] | 1999 | 66 | 65 | 1391 | 1395 | 2249 |
| 48 | Dethlefsen, et al. [69] | 2010 | 137 | 201 | 1372 | 1373 | 1981 |
| 49 | Hughes, et al. [70] | 2008 | 112 | 124 | 1347 | 1641 | 1790 |
| 50 | Nathan and Hibbs [71] | 1999 | 64 | 99 | 1346 | 1230 | 1789 |
| 51 | Li, et al. [72] | 1991 | 46 | 25 | 1336 | 1399 | 1975 |
| 52 | Hidron, et al. [73] | 2008 | 111 | 72 | 1334 | 1418 | 2028 |
| 53 | Hammer, et al. [74] | 2008 | 110 | 146 | 1323 | 1492 | 3055 |
| 54 | Ong, et al. [75] | 2002 | 71 | 70 | 1286 | 1446 | 2058 |
| 55 | Herrero, et al. [76] | 2011 | 142 | 165 | 1280 | 1205 | 1714 |
| 56 | Burke [77] | 1999 | 61 | 45 | 1278 | 1007 | 1773 |
| 57 | Kollef, et al. [78] | 2001 | 67 | 45 | 1269 | 1462 | 2254 |
| 58 | Freifeld, et al. [79] | 2000 | 63 | 45 | 1259 | 1493 | 2753 |
| 59 | Ibrahim, et al. [80] | 1990 | 41 | 46 | 1243 | 1405 | 2098 |
| 60 | Pigeon, et al. [81] | 1961 | 21 | 18 | 1234 | 1268 | 1917 |
| 61 | Bennett, et al. [82] | 2009 | 112 | 149 | 1232 | 704 | 1187 |
| 62 | Chambers and DeLeo [83] | 1994 | 47 | 29 | 1213 | 1209 | 2058 |
| 63 | Davies [84] | 1966 | 22 | 4 | 1194 | 1294 | 2295 |
| 64 | Cherepanov and Wackernagel [85] | 2010 | 117 | 184 | 1171 | 1157 | 1708 |
| 65 | Kong, et al. [86] | 1995 | 46 | 79 | 1154 | 1233 | 1741 |
| 66 | Hamblin and Hasan [87] | 2000 | 58 | 33 | 1153 | 1226 | 1740 |
| 67 | Carter, et al. [88] | 1985 | 33 | 34 | 1152 | 1155 | 1677 |
| 68 | Ganz, et al. [89] | 2004 | 72 | 112 | 1152 | 1024 | 1628 |
| 69 | Ceri, et al. [90] | 1997 | 49 | 17 | 1135 | 1159 | 1716 |
| 70 | Classen, et al. [91] | 2005 | 75 | 46 | 1129 | 1318 | 2194 |
| 71 | Ventola [92] | 1992 | 40 | 34 | 1128 | 1214 | 2398 |
| 72 | Baddour, et al. [93] | 1999 | 53 | 98 | 1119 | 1198 | 1889 |
| 73 | Bartlett, et al. [94] | 1981 | 28 | 45 | 1110 | 949 | 1625 |
| 74 | Lande, et al. [95] | 1998 | 50 | 35 | 1099 | 1119 | 1597 |
| 75 | Harder, et al. [96] | 2007 | 84 | 84 | 1096 | 1128 | 1716 |
| 76 | Hancock and Lehrer [97] | 2015 | 218 | 458 | 1091 | 1055 | 1628 |
| 77 | Shai [98] | 1978 | 26 | 21 | 1080 | 1074 | 1500 |
| 78 | Rothstein, et al. [99] | 2015 | 215 | 413 | 1075 | 1087 | 1402 |
| 79 | Steiner, et al. [100] | 2001 | 56 | 38 | 1072 | 968 | 1615 |
| 80 | Ruparelia, et al. [101] | 2005 | 71 | 58 | 1071 | 1080 | 1518 |
81 Dethlefsen and Relman [102] 1975 23 65 1045 1045 1533
82 Fischbach and Walsh [103] 1999 50 51 1044 1031 1603
83 Vezina, et al. [104] 2002 58 70 1041 1118 1699
84 Hancock and Chapple [105] 2009 94 99 1034 1058 1608
85 Andersson and Hughes [106] 2011 115 161 1032 1021 1625
86 Harder, et al. [107] 2006 74 144 1029 1069 1684
87 Epand and Vogel [108] 2008 85 135 1022 1009 1442
88 Ling, et al. [109] 2010 101 154 1004 1067 1857
89 Cohen [110] 1999 48 35 968 991 1448
90 Umezawa, et al. [111] 1992 35 23 961 1015 1587
91 Cabello [112] 2015 198 198 959 988 1598
92 Kenawy, et al. [113] 2008 81 135 975 1000 1303
93 Hancock [114] 1997 42 30 968 991 1444
94 Moazed and Noller [115] 2008 80 84 963 900 1281
95 Baquero, et al. [116] 2007 74 91 961 1015 1587
96 Spellberg, et al. [117] 1966 18 17 959 988 1598
97 Wang, et al. [118] 2000 48 46 956 985 1476
98 Zhang, et al. [119] 1987 29 27 947 1053 1162
99 Krause, et al. [120] 1993 35 30 944 950 1549
100 Prezant, et al. [121] 2004 59 59 940 906 1397

1 R=Rank; 2 C.D.=Citation density; 3 CCI=Current citation index; 4 WoS= Web of Science; 5 ES=Elsevier Scopus; 6 GS=Google Scholar.

Figure 1. (a) Association of citation frequency with the age of publication (years) (b) Changes in trends of citation density with the age of publication

3.2. Year of publication

Chronologically, the oldest classic with 60 years of publication age was published in 1959 [60], and three articles with four years of publication age were published in 2015 [92,109,119] made to the ‘classics’ list. Fifty articles were published during 2000-2009, followed by 22 published during 1990-1999, 13 published during 2010-2019, 7 published during 1980-1989, 5 published during 1959-1969, and 3 published during 1970-1979. Nine articles were published in 1999, marking it the year of most
publications. Interestingly, 63% of the articles were published within the last two decades. The highest number of 'classics' were published between 2000-2009 (n=50).

3.3. Methodological design and evidence level (EL)

The distribution of the list based on methodological design is illustrated in Figure 2. Based on the level of evidence, 71 publications were graded as level-V, two were graded as level-IV, one belonged to level-III, four publications were graded as level-II, and 17 were graded as level-I. The evidence level and methodological design of five publications [24,52,60,77,111] were not identified as full-text of the articles were not accessible through different electronic sources.

Figure 2. Pie chart diagram showing the distribution of classic articles based on the methodology of the study.

3.4. Contributing authors, institutions, and countries

Robert E.W. Hancock was identified as the most contributing authoring six classics, followed by Tomas Ganz, who contributed in four classics. A total of 513 authors contributed to the top 100 classics, among them 26 authors were contributed in two 'classics' each. Complete texts for 95 publications were obtained, and five publications were not accessible through different institutions [24,52,60,77,111]. Based on the institutional address of the corresponding author as retrieved from the ES database, individuals from 29 countries contributed to the 'classic' articles. Among these, sixty-six scientific contributions were from the United States of America. Followed by 18 publications from Canada, 11 from Germany, and four from Sweden. Three publications originated from Belgium, China, and Israel. Two publications originated from California, Denmark, and India. One publication originated from Alexandria, Argentina, Croatia, Ecuador, Egypt, France, Kenya, Korea, Netherlands, New Mexico, New Zealand, Pakistan, South Africa, South Korea, Spain, Tanzania, Thailand, United Kingdom, and Western Australia.

Among 246 international institutions, the greatest contribution to the 'classic' articles was made by the University of Manitoba, Canada, in six classics followed by the Stanford University School of Medicine, USA, in five classics. “University of Washington, USA”, “University of British Colombia, Canada”, “The University of California at Los Angeles, USA”, and “Harvard University, USA” contributed in four classics. “University of Kiel, Germany” and “University of California at San Diego,
USA” contributed in three classics. “Robert Wood Johnson medical school, USA”, “Weizmann Institute of Science, Israel”, “Emory University, Atlanta, Georgia, USA”, “Laurentian University, Ontario, Canada”, “Rush-Presbyterian-St. Luke’s medical centre, USA”, “St. Agnes medical center, USA”, “the centers for disease control and prevention, Atlanta, Georgia, USA”, and “Veterans affairs Palo alto health care system, California, USA” contributed to two classics each.

3.5. Journal of publication

The 100 classics were published across 63 different journals. Figure 3 presents the list of journals in which the highest number of classics were published. The list of the remaining journals is available as supplementary Table S1.

3.5. Journal of publication

The most frequently occurring keywords in the top 100 classics were “anti-bacterial agents” and “antibiotic agent”, followed by “antibiotic resistance”, “anti-infective agent” and “antimicrobial”. Figure 4 is a graphical presentation of keywords arranged in a network of clusters. Colorful nodes represent the linkage of specific keywords to each cluster. Table S2 enlists the total number of index keywords and their frequency of occurrence based on the Elsevier Scopus database.
4. Discussion

The current study identified and analyzed the top 100 classics on antibiotics, antimicrobials, or antibacterial agents. Identification of any scientific contribution and inclusion in classics warrants the excellence and acclaimed acknowledgment by the relevant field experts, researchers, and scientists [12]. Theoretically, a higher citation frequency of a publication indicates the quality of the research conducted as identified by the scientific community [122]. Identification is imperative to study whether the classics have elaborated or explored the understanding of a problem and/or provided a comprehensive approach towards its solution, or whether the publication introduced a research trend or provided an expert opinion/summary on a topic of interest. The results of this study present the research perspective in the field of antibiotics, antimicrobials, or antibacterial agents for the last six decades. Also, it illustrates key trends of research as well as clinical practice [2,8].

The definition of ‘classics’ largely depends on the research field/specialty to which the publication belongs. In some fields, 100 or more citations of a publication are considered enough to classify it as a ‘classic’ [6]. In perspective, the article ranked as 100th in the current study received 940 citations in comparison with the article ranked as 1st in the field of homeopathy research that received 1172 citations [123] or with the article ranked as 1st in the dental caries research that received 2003 citations [19]. For the current study, the publications receiving more than 400 citations can be considered classics. However, these publications will not make it to the top 100 due to the immense availability of the highly cited publications.

Web of Science was used as a benchmark database because it has citation metrics from 1945 to present [124]. A significant variance was observed when the citation metrics were cross matched with other databases. The Elsevier Scopus database reports the citations dated back to 1996, which is a severe flaw while figuring out the most-cited papers. In contrast, the Google Scholar database counts the citations based on published articles, books, conference proceedings, thesis/dissertations, technical reports, and preprints, which explains the higher citation counts reported in the current study [2].

The current study found a statistically significant correlation of the citation frequency with the age of publication, which is similar to the findings of a previous bibliometric analysis report [2].
Although there was an upward trend of citations received by the classics to the age of publication [125], the trend analysis of the influence of age of publication on the citation density revealed that certain topics after reaching maturity show a decrease in citation density. This change in trend can be also be noticed from the current citation index 2019.

It has been reported that the actual impact of a publication can only be assessed at least two decades after it has been published [2,4,17]. Interestingly, this phenomenon has been observed in the current study as the most number of classics were published in 1999. However, it is noteworthy that with the changing trends of how published work is reviewed, the accessibility of literature has been increased multi-folds, and research from around the world can be remotely reviewed without needing the access to archives, library, and published paper journals. This debate is backed up by the current study, which observed that sixty-three classics were published during the last two decades. This finding indicates that in the current era of digital technology, classics might require lesser years to reach their maturity stage.

With the evolution of research, several guidelines have been introduced to fulfill the ever-growing need for organized reporting of observational study [126], laboratory studies [127], clinical studies [128], or reviews [129]. These guidelines allow the scrutinization of scientific information and improve the quality and transparency of reports. PRISMA statement is used to report systematic review and meta-analysis mainly focusing on evaluating randomized trials to provide the highest level of evidence. Surprisingly, the current study did not identify any systematic review of literature or meta-analysis, which made it to the list. Title of the study report is another key element which is stressed upon in various guidelines. It is entirely possible that some classics were not identified in the current study owing to how their titles were designed. A title should explicitly describe the methodology of study and key elements which identify the study to allow proper indexing of the article.

Keywords play an essential role in the discoverability of any published article [130]. While searching any specific type of literature, scholars tend to methodically utilize search terms which are generally used in a specific field [131]. In this study, prime examples of such terms are antibiotics, antibacterials, or antimicrobials. However, it was noted that keywords only appeared in articles published after 1995 and more so not mandatorily in every publication. It was noted that even though keywords might have been submitted in the journal database during submission of manuscripts, the published articles did not display the keywords [55,63,109]. These incoherencies make the network analysis of keywords somewhat misleading and inconsistent with the actual data if we only rely to hand-searching. Therefore, ES database was utilized to retrieve the relevant data to allow a presentable and fair network analysis.

5. Limitations

Firstly, a large amount of 'classic' articles had to be excluded from the list as it was not considered possible to perform the bibliometric analysis of 500 or more articles in the current study. Therefore, the top 100 classics which achieved the maximum citations were selected for the present study. Secondly, the most recently published research papers are at a loss because of time effect, irrespective of their content and quality. Under this spectrum, it wouldn’t be wrong to say that the real impact of a research article cannot be accurately determined for at least five years post-publication.

6. Conclusion

This bibliometric analysis of the top 100 classics on antibiotics revealed that the increase in age of publication positively influenced the citation frequency. In spite of substantial developments and advancements in this field/specialty in recent decades, a dearth of systematic reviews and meta-analyses is warranted. Keywords are cornerstones of the discoverability of any manuscript, quality journals and publishers should mandate the inclusion of keywords in every publication to ensure maximum visibility of the publication across all databases.
Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: Distribution of citations frequency over last six decades, Table S1: List of journals which published top 100 classics, Table S2: List of keywords identified from the Elsevier Scopus database.

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