Traffic medicine research: a scientometric and density-equalizing analysis

Beatrix Groneberg-Kloft\textsuperscript{1,2}, Doris Klingelhöfer\textsuperscript{1}, Simona E Zitnik\textsuperscript{1*}, Cristian Scutaru\textsuperscript{3*}

1 Department of Medical Sociology, Goethe-University, Frankfurt, Germany
2 Otto-Heubner-Center, Charité-Universitätsmedizin Berlin, Free University Berlin and Humboldt-University Berlin, Germany
3 Institute of Occupational Medicine, Charité-Universitätsmedizin Berlin, Free University Berlin and Humboldt-University Berlin, Germany

Email: Beatrix Groneberg-Kloft – beatrix.groneberg-kloft@charite.de; Doris Klingelhöfer – klingelhoefer@med.uni.frankfurt.de, Simona E Zitnik – kloftzitnik@med.uni-frankfurt.de, Cristian Scutaru – cristian.scutaru@charite.de;

Corresponding author: Doris Klingelhöfer - klingelhoefer@med.uni-frankfurt.de

*equal contribution
Abstract

Objective:
Traffic crashes and related injuries are important causes of morbidity and mortality. However, research in this area is often under-funded. The primary aim of this study was to provide an in-depth evaluation of research yield in traffic medicine from 1945 to 2008, using large-scale data analysis, the employment of bibliometric indicators of production and quality, and density-equalizing mapping.

Design:
Data were retrieved from the Web of Science (WOS) Science Citation Expanded database using the NewQuis protocol; this was performed searched using the Boolean operator, 'OR', with different terms related to traffic medicine including "traffic* securit*", "car crash*", "car accident*", "transport* accident*", "transport* crash*", "traffic* safet*", "car safet*", "vehicle crash*", "vehicle safet*". Data were then extracted from each file, transferred to Excel charts and visualised as diagrams. Mapping was performed using density equalizing calculation procedures.

Results:
A total of 5193 traffic medicine-associated items were produced between 1900 and 2008. The United States returned the greatest level of output (n = 2,330), followed by the Germany (n = 298) and Canada (n = 219). International cooperation peaked in 2003, relationships between the United States and other countries formed the basis for the most common forms of bilateral cooperation.

Conclusions:
Traffic medicine related research output continues to increase annually but is relatively low in comparison to other research areas. The present findings may provide useful information for those tasked with improving that research performance in this area.
**Introduction**

Traffic crashes and related injuries belong to the most important anthropogenic causes of morbidity and mortality and affect public health in all parts of the world [1-3]. Due to the improved safety in industrialized countries, a greater proportion of the burden of injury and disability is found in developing countries [4]. In detail, road crashes account for approximately 1.2 million deaths each year. In the same time, about 50 million people are injured. With regard to the younger, road traffic injuries have been reported to be the second leading cause of death among young people aged 15–29 years and among children aged 5–14 years in developing countries [5, 6]. Therefore, it can be assumed that all means to increase traffic safety may help to reduce the global burden of disease. Studies analysing the potential effect of an absence of concerted efforts at prevention have concluded that there might be a dramatic increase in mortality and morbidity. In this respect, it was calculated that road traffic deaths would increase from the 10th position in the list of the top 24 causes of death in 2002 to position eight by 2030 if concerted efforts at the prevention of road crashes are not implemented [7].

The last 50 years can be characterized by an exponential increase in medical, social and technical research in general [8, 9]. To deal with the large amount of data, quantitative and qualitative assessment tools for scientific output have become increasingly important. They now play a key role in the allocation of funding and prioritisation of resources as being demonstrated by the Research Assessment Exercise in the UK [10].

Despite its aforementioned disease burden caused by traffic crashes, relatively little effort has previously been made to understand the trends emanating from traffic medicine-associated literature. While there has been some concentration on the bibliometrics of occupational medicine generally [11-16], only little is known about specific scientific output related to traffic. Thus, the NewQiS platform project [17, 18] decided to perform a detailed analysis of research yield in traffic medicine from 1900 to 2008. We apply large-scale data analysis, bibliometric indicators of production and quality, and density-equalizing calculations.
Methods

NewQiS-platform

The present study is integrated into the project New quality and quantity indices in science (NewQiS). In this project, bibliometric tools were combined to visualizing techniques [17, 18].

Data source

All analyzed data will be retrieved from Thomson Scientific’s online-database “Web of Science” (WoS). The PubMed Database lacks citation information of the articles. This is why all analysis were conducted in the WoS database.

Time span

The time frame is limited to the period between 1900 and 2008. For this purpose, the “Change Limits and Settings” function is adjusted initially and the query is made under this presetting. The year 2009 was excluded in order to focus the study exclusively on completed years.

Data categorization

Data categorization was performed as previously described [19]. In brief, the “Web of Science” database provides several tools to analyze entries according to specified parameters. The data set is analyzed by means of publication country, publication year, publishing author, publishing journals and published document type. Multiple distributions led to higher publication numbers when adding up results after analysis; for example, when a super regional publication is distributed to several countries. A common data processing program is used to display the results in tables, charts and diagrams.

Target parameters

The following target parameters were analysed in the present project in relation to traffic security and traffic medicine.
Search strategies
For the query, the terms "traffic* securit*", "car crash*", "car accident*", "transport* accident*", "transport* crash*", "traffic* safet*", "car safet*", "vehicle crash*", "vehicle safet*" were connected with the Boolean operator “OR” and entered in the search field “Topic”. The asterisk stands as a placeholder for different word variations.

Primary data
For a first insight, the total number of published items was recorded together with the type of publication (original article, meeting abstract, review etc), assigned subject areas, and publishing journals.

Citations per year
The information concerning the publication year was analyzed. This way it was possible to assess the total number of citations which published items from a given year have achieved until the date of analysis, an average citation per item was computed for years with at least 30 published items.

Analysis of origin / language
The information about the address of the authors was analyzed in order to determine the country of origin of the articles. For countries like the former USSR which split up the current location of the city (country) was taken into account when determining the origin of the article.

Citation characteristics - average citation rate (countries)
For all countries with at least 30 published items the average citation rate was calculated. This limit was necessary in order to filter out mavericks.

Citation Characteristics - Modified H-Index for countries
The theory of the H-Index (Hirsch) was extrapolated on all articles originating from a given country. For these published items the associated H-Index was computed. This algorithm was performed for all other countries from which articles were published.

Citation characteristics - average citation rate (publications and authors)
**Publication type**
The publications in which the articles were issued were analysed under following aspects:

- Number of published items
- Total number of citations
- Average number of citations
- Evolution of the length of articles

Assuming that the page form of the journals is rather identical, the length of the articles was computed given the start and end page. Given the fact that this information was not for all of the analyzed items available only for years in which 30 articles had this information were taken into account. For these years the average length was calculated. This step was completed.

**Citation quantities**
Results are also analyzed by means of citation. Therefore, the feature “Citation Report” is used to calculate the citation rate of both authors and citations per year of citation. The complete Citation Report was downloaded and by special VBA Software in Microsoft Excel further analyzed. Afterwards, the ten most productive authors’ publications are put under citation analysis. The average citation rate is the quotient of the total citation number divided by the publications listed for the author in question.

**Density-equalizing mapping**
The basic principle of Density-Equalizing Mapping was reported by Gastner and Newman [20] and used in recent NewQis projects [21]. In brief, the software using the method of density-equalizing mapping is employed to determine international correlations. This method resizes countries proportionally according to a predefined variable. In this study, the territory with the highest number of publications is depicted largest on the associated map.
Results

Number of published items
The search query returned 5193 results. The oldest article was published 1907. The highest number of publications was published in 2007 (533), followed by 2006 (495) and 2008 (467) (Fig. 1 A). Starting with 1990 we see a dramatic increase in the number of published items.

Citation information
Looking at the evolution of citations we see a similar evolution, with a very strong increase after 1990, however after 2004 the number of total citations drops dramatically. This is because these articles are “to new” and have not gained the final number of citations. Publications published 2004 have reached the highest number of citations (3314), followed by 2000 (3241) and 1998 (2949) (Fig. 1 B). Analyzing the average citation per item for years in which at least 30 publications were issued, we see a descending trend starting with 1992 which holds the highest value of 17.19 citations per item (Fig. 1 C).

Citations in each year
For all articles from 1956 (1955 had no published item) until 2008 a detailed citation analysis for each year was performed. For each year the total number of citations was computed (Fig. 1 D). In 2008 the highest number of citations was reached, followed by 2006 and 2007. Years prior to 1955 do not hold individual citation information in WoS and were excluded from this analysis.

Article length
The average length of the articles remained rather constant (8 pages) over the last 20 years, with a minimum of 6.24 pages per article in 1989, a maximum of 10.53 in 1990 (Fig. 2 A).

Evolution of citations for the average article
For the “average published item” the evolution of citations was computed. As previously stated, articles which were published in the last years have not achieved the final number of citations which brings a bias to this analysis. This is why three
different time periods were analyzed: articles published between 1956 and 2007, 1956 and 2002 and respectively 1956 to 1997. Years prior to 1955 are hold together in decades in the WoS making it impossible to get individual values for each year. In 1955 no article concerning traffic safety was published.

For each article the received citations were distributed over the analyzed time period in percent for the first year after publication, second etc. Finally, an average value was computed for each of these years. The evolution of the three time periods is in Figure 2B presented.

From the same data it is possible to calculate the half-life for the average article. The half-life in literature stands for the number of years after which an article has reached 50% of his total citations. A small value means that the articles gains very fast his citations, but becomes after that uninteresting. A high value on the other hand means that the article is longer interesting and therefore longer cited. For the three time periods the computed half-lifes values are: 6 (1956-2007), 9 (1956-2002) and respectively 12 years (1956-1997) (Fig. 2 B).

Evolution of the average number of authors per published item

The average number of authors per published item was computed for years in which at least 30 published items appeared. The highest value was calculated for 2008 (6.29) followed by 2007 (5.85) and 2006 (5.40). For the other year this value was pretty much constant varying between 2.52 and 3.55 (Fig. 2 C).

Evolution of the cited references

The average number of cited references per article varied over the last 20 years between a maximum of 27.67 in 1995 and a minimum of 15.08 in 1998 with a slight increasing tendency (Fig. 2 D).

Language related analysis

95.22% of all analyzed publications have been written in English. The second language by number of publications is German with only 2.87% followed by French (0.83%), Spanish (0.80%) and other (0.67%). All other languages with less than 10 publications are Russian (7), Portuguese (6), Japanese and Norwegian (each 4), Turkish (3), Chinese (2), and Croatian, Czech, Dutch, Italian, Lithuanian, Polish, Romanian, Slovene and Swedish each with 1 publication.
**Document type related analysis**

Most of the analyzed publications are originating articles (60.37%) followed by proceedings papers (27.40%), editorial material (2.95%), reviews (2.25%), letters (1.77%), book reviews (1.12%), notes (0.94%), news items (0.35%) and reprints (0.21%).

**Country related analysis**

**Published items**

In total 87 different countries were identified as source for the 4,775 articles. 418 articles had no information concerning the origin of the authors. The USA is with a total of 2,330 published items, the country with the highest output, followed by Germany (298), Canada (265), UK (219) and Australia (191). From the corresponding cartogram we can observe that North America, Europe, Australia and eastern Asia have concentrated the great majority of all published items, with very little contributions from Africa, Asia, and South America (Fig. 3 A).

**Total citation analysis**

The analysis of the total number of citations per country revealed a slightly different line-up, with the USA still unreachable with a total of 26,426 citations, followed by Canada (2,841), UK (2,165), Australia (1,886) and Sweden (1,231) (Fig. 3 B).

**Average citation per item**

Computing the average citation per item for countries with at least 30 published items, shows a completely different situation with Switzerland first with an average of 17.96 citations per item, followed by Norway (12.20), USA (11.34), Finland (11.11) and Canada (10.72) (Fig. 4 A).

**Modified H-Index**

The analysis of the modified H-Index for the countries brings the USA back to the top with a value of 62, followed by Canada (29), Australia (22), UK (21), and Sweden (20) (Fig. 4 B).
**International cooperation between countries**

Out of the 5193 published items, 309 were the result of international cooperation. From the 87 countries, 69 are involved in international cooperation’s. The first international cooperation article was written 1976. Since then a steady increase in the number of cooperation’s can be observed. In 2003 the highest number of international cooperation article were published 43, followed by 2007 (41) and 2008 (40) (Fig. 5 A).

The highest number of cooperation articles are the result of a bilateral cooperation (261 out of the 309), followed by cooperation’s between 3 countries (32), cooperation’s between 5 countries (8), cooperation’s between 4 countries (5), cooperation’s between 6 countries (2) and finally 1 published item was the result of a collaboration between 7 different countries (Fig. 5 B).

The USA and Canada have the highest number of articles written in cooperation (44), followed by the USA and UK (17), Australia and New Zealand (16), USA and Sweden (15), UK and Australia, USA and Australia and USA and South Korea each with 12 published items. A radar chart shows the complete cooperation network of the 69 countries (Fig. 6). Colours and thickness of the line code the amount of cooperation between two countries. The numbers behind the name of the country represent total number of articles respectively total number of international cooperation’s.

**Journal analysis - Published items**

The largest number of articles were published in the Accident analysis and prevention journal (414), followed by the Journal of Trauma (297) and Transportation research record (150). The JAMA Journal with 44 published items reached the highest citation rate of 57.06 per published item. In second place we found the Journal of the American Geriatric Society (30 published items) with a ratio of 23.07 citation per item. Third is the American Journal of Public Health (38 published items), with 20.82 citations per item.
Institution analysis - Cooperation between institutions
For all institutions with at least 10 published items the cooperation network was computed. A total of 79 institutions out of the total of 3965 identified have reached this threshold.
The Children’s Hospital Philadelphia and the University Penn from Philadelphia hold the highest number of cooperating articles (42). The second highest cooperation is between the National Highway Traffic Safety Administration of US from Washington together with the University of California Irvine from Irvine (17 published items). In third place with 14 published items we find the same National Highway Traffic Safety Administration of US from Washington together with the E Carolina University (Greenville) and respectively the George Washington University (Washington) and The University of California Irvine with the George Washington University and the E Carolina University. The only non-US cooperation which reaches the threshold of 3 articles is formed by Australian institutions: University Sydney – University of Auckland (5) and University of Auckland with the Royal Alexandra Hospital for Children (3) (Fig. 7 A).

Author analysis - Cooperation network
Similarly to the Institution analysis, the cooperation network for all authors with at least 10 published items was computed (a total of 57 authors, leading authors see Fig. 21). The highest level of cooperation is reached by Durbin, DR and Winston, FK from the USA with 23 published items, followed by Richter, M and Otte, D from Germany with 17 publications and McGwin, G and Owsley, C from USA with 15 published items. For some authors it was not possible to retrieve the country affiliation as this information was not available in the WoS database (Fig. 7 B).

Subject Area analysis - Published items
The publications in the WoS database are also catalogue by the subject area to which they belong. The subject area which has been assigned the most with 976 published items is Public, Environmental & Occupational Health, followed by Transportation (933), Ergonomics (599), Transportation Science & Technology (577) and Social Sciences, Interdisciplinary (559) (Fig. 8 A).
Distribution of the published items by number of affiliated subject areas
2144 published items were assigned one subject area, 1663 were assigned to two
subject areas respectively 746 were assigned to 4 distinct subject areas. 572
published items were assigned to the Public, Environmental & Occupational Health
and Transportation, 541 between Public, Environmental & Occupational Health and
Ergonomics, 537 between Social Sciences, Interdisciplinary and Public,
Environmental & Occupational Health (Fig. 8 B, Fig. 9).

Subject Area analysis - Research focus analysis
Analysis of the evolution of the areas of research in 5 years steps shows that in the
last 5 years the highest increase was registered in the field of Transportation Science
& Technology with 49.05% of all 577 items being published in the period 2004-2008
(Fig. 10 A).
Looking at the Top 15 countries by number of published items, we find that in the
USA the highest number of published items, 25.28%, is assigned to the Public,
Environmental & Occupational Health subject area, closely followed by
Transportation with 21.85% and Ergonomics with 14.89% (Fig. 10 B). The scale of
the figure surpasses the 100% because of multiple assignments of subject areas to a
single article. In Germany (the second country by the number of published items),
most of the research concentrates on the area of Surgery (17.45%), followed by
Engineering, Electrical & Electronic (10.40%, not included in the graphic because
subject area is ranked 12), and Transportation Science & Technology (17.11%).
Canada has most of its research concentrated in the field of Public, Environmental &
Occupational Health (21.51%), followed by Transportation with 21.85%. In the UK
most research is conducted in the field of Engineering, Mechanical (16.89%),
followed by Transportation Science & Technology (14.16%) and Transportation
(11.42%). In Australia the highest percentage is reached by the area of Public,
Environmental & Occupational Health (39.27%) which also is the highest value from
all analyzed Top 15 countries. In second place we find the area of Transportation
(28.27%) followed by the area of Ergonomics (24.61%).
Top 10 most cited papers
The most cited published item is called Actual Causes of Death in the United States, 2000, with 902 received citations. It was published 2004 in the JAMA-Journal of the American Medical Association. The second most cited paper is called Epidemiology of Trauma - Frequency and Impact of Different Potentially Traumatic Events on Different Demographic Groups with 533 citations. The paper was published in the Journal of Consulting and Clinical Psychology in 1992. The third most cited paper is called Information Hiding - A Survey with 465 citations, issued in 1999 in Proceedings of the IEEE.
Discussion

The Journal BMC Public Health has published a number of studies related to scientometric analyses ([16], [22], [23]). The present study assessed the field of research related to traffic medicine using a combination of bibliometric tools and novel visualizing techniques. We found 5193 published items related to traffic medicine and starting with 1990 a dramatic increase in the number of published items was present. This is partially caused by the fact that starting with 1990 the WoS records also contained the abstract of the articles, which impacts on the search routine. Another explanation could be the rapid development of cheap and fast communication means (email, Internet).

With regard to the total output of research it can be stated that the field of traffic medicine research continues to increase annually but is relatively low in comparison to other research areas. The present findings may provide useful information for those tasked with improving that research performance in this area. In this respect, it was recently hypothesized that without the use of scientometric techniques, there will be a growing discontent among scientists for funding allocation policies [17, 18]. Therefore, the use of specific tools and benchmarking systems as shown here could be of help to implement transparency within funding allocation processes. This was the basis for the establishment of NewQIS, a scientific, non-financial platform that assesses research trends in socioeconomic important areas of science and research within delineated research projects.

When relating the present study to other fields of science, previously published NewQIS studies may be used for comparison. I.e. a recent study focussed on a scientometric analysis and combined density-equalizing mapping of environmental tobacco smoke (ETS) research [24]. 6,580 ETS-related studies published between 1900 and 2008 were identified in the ISI database and a continuous increase of both quantitative and qualitative parameters was found. The combination with density-equalizing calculations demonstrated a leading position of the United States (2,959 items published) in terms of quantitative research activities [24]. Charting techniques demonstrated that there are numerous bi- and multilateral networks between different countries and institutions in this field [24]. Again, a leading position of American institutions was found. Interestingly, there are large similarities concerning the findings on country research productivity present between traffic medicine and ETS-related research [24].
However, also differing results were recently reported [8]. I.e. one study that examined specific areas of major research activity using different organ systems reported major differences between countries. In a total of 5,527,558 published items, a dichotomy was present between Western countries such as the US, UK or Germany and Asian countries such as Japan, China or South Korea concerning research focuses [8].

With regard to the presently performed search routine, we tried to assess a large number of published items by enlarging the search terms using the Boolean operator, 'OR', with different terms related to traffic medicine including "traffic* securit*", "car crash*", "car accident*", "transport* accident*", "transport* crash*", "traffic* safet*", "car safet*", "vehicle crash*", "vehicle safet*". This is in contrast to other studies that used only one search term. However, since the used search terms can be summarized into the field of traffic medicine, the present approach appears to be useful in this area of research.

In summary, it needs to be stated that traffic medicine is a research area with important implications for public health. Research related to this field of science and medicine continues to increase annually but is relatively low in comparison to other research areas. The present data may provide helpful information for those tasked with improving research performance in this field. Also, in a period when scientometric benchmarking is increasingly employed in performance assessment, our data may provide useful information for those tasked with the allocation of research funding.
Literature


**Competing interests**

The authors declare that they have no competing interests.

**Authors' contributions**

BGK, DK, SZ, CS have made substantial contributions to the conception and design of the review, acquisition of the review data and have been involved in drafting and revising the manuscript. All authors have read and approved the final manuscript.
Figure Legends

**Figure 1. General parameters.** **A:** Evolution of the number of published items over the time period **B:** Evolution of the total number of citations for the time period **C:** Evolution of the average citation per item **D:** Total Citations in each year

**Figure 2 Evolutionary aspects** **A:** Evolution of the length of the publication over the years **B:** Lifetime for the average article **C:** Evolution of the average number of authors per published item **D:** Evolution of the number of cited references

**Figure 3 Density equalizing mapping** **A:** Distribution of published items **B:** Distribution of total citations

**Figure 4 Density equalizing mapping and advanced indices** **A:** Average citation per published item **B:** Modified H-Index of countries

**Figure 5 Cooperations** **A:** Evolution of international cooperation **B:** Distribution of the cooperation articles by the number of cooperating Countries

**Figure 6: International cooperation network**

**Figure 7 Networking** **A:** Cooperation network between institutions with at least 10 published items. Threshold was set to 3 cooperating articles for improved readability **B:** Author cooperation network. Line colour and thickness stand for amount of cooperation. The numbers behind the name are total number of published items / as first author / as senior author respectively

**Figure 8 Subject areas** **A:** Top 15 subject areas by number of published items assigned to them **B:** Distribution of the published items by number of affiliated subject areas

**Figure 9:** **Assignment of subject areas to articles.** A threshold of 30 published items was set for readability purposes. Line color and thickness show amount of linking.

**Figure 10 Research areas** **A:** Research areas evolution in 5 year steps **B:** Distribution of the Top 10 subject areas by number of published items in the Top 15 countries by number of published items
Figure 1
Figure 2

A

Average Length of Published Item (No. of Pages)

Publication Year (≥30 Published Items)

B

Average percent of total citations

Half-life 1956-2007: 6 years
Half-life 1956-2002: 9 years
Half-life 1956-1997: 12 years

Article Lifetime

C

Average number of authors per published item

Publication year (≥30 published items)

D

Average number of references per published item

Publication year
Figure 5
Figure 8