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Output distributions and topic maps of safety related journals

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ABSTRACT

This paper presents topic maps of six core safety journals, based on analysis of 13,028 articles published in those journals as downloaded from the Web of Science. Bibliometric mapping methods were used to visualize the map of the topics covered in each journal. Analysis was also made of the changes in topics over time. The results show that safety science research in those journals has grown very rapidly over the last half century, with USA as the most productive in total and also in each year in the period. The topic clusters of these journals reveal the focus of each journal, which may be determined by the dominant methodologies used, the activity whose safety is studied or the object of study (e.g. workplace, safety management, regulation, etc.). The different journals also show regional differences in the papers they attract. The field in total is highly multidisciplinary. The topics of *Safety Science* have been focused on major hazard, transportation and work safety; *Journal of Safety Research* divides its attention between work and traffic safety, with a smaller cluster on statistics; *Accident Analysis and Prevention* is concerned almost exclusively with road safety; *Injury Prevention* is concerned mainly with injury mechanisms, but includes topics not treated by the other 5 journals, such as violence, suicide and other intentional injury and child safety at school and in the home. *Reliability Engineering and System Safety* and the *Journal of Loss Prevention in the Process Industries* focus mainly on major hazard, with the latter most concerned with the technology of failure mechanisms and the former on quantitative risk assessment.

1. Introduction

It is important for (potential) authors to know what are the main topics or research themes accepted by a certain journal, so that they can pick which journal to submit a paper to. They can get guidance from what is printed on the journal homepage about its aims and scope. But even with this guidance it is sometimes hard to determine whether a candidate paper will fit into the scope of a certain journal, since this scope will also be changing as the discipline it covers changes. Andrew Hopkins in a recent paper in *Safety Science* (Hopkins, 2014) remarks that he found one of the papers he was sent for review to be outside the current community of interest of *Safety Science*, but other reviewers accepted the paper and the journal finally published it. This suggests that the issue of the scope and focus of a journal, or a set of journals, serving a research area or community is an interesting one for analysis. This paper presents bibliometric mapping analysis of a set of journals serving the broad area of safety science, a multidisciplinary area of research and practice. It aims to add to the discussion of journal scope some descriptive analysis of what the topics have been of 6 of the core journals serving that area.

In recently years there have been a number of articles which have mapped topics of research published in journals. Some examples are the paper of Mane and Börner (Mane and Börner, 2004) who collected 47,073 papers published in the *Proceedings of the National Academy of Sciences* (PNAS) in the USA in the years 1982–2001. Using knowledge domain visualization, they identified the 50 most important topics in PNAS. They also used software to detect sudden increases in topics, so-called 'topic bursts' (Kleinberg, 2003) over a short period of time in the journal. In 2011, Linton (2011) the Editor-in-Chief of the journal *Technovation* used the visualization technique to reveal the topics of that journal, and answer the question: '*What does journal fit and focus look like: A visual representation*'. Saravanan and Dominic (2014) analysed the data of the *Review of Palaeobotany and Palynology* (2003–2012) from the Web of Science, to assess the publication output, exponential growth rate and authorship patterns, etc. of the journal. Other works in the journals of bibliometric research related to our research include (Kumar et al., 2008; Ramos-Rodríguez and Ruíz-Navarro, 2004; Saravanan and Dominic, 2014; Wang et al., 2010).

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In the safety science area, Hale, using a simple classification of the topic area of journal articles, suggested the main focus of 9 safety related journals (Hale, 2014, 2006). The classification in Hale's research was largely subjective, but, based on his research, Li used a data-download from the journal *Safety Science* (SS) over the period 1991–2012 to draw the map of the topics of SS (Li et al., 2013), together with the annual distribution of the publications, authors, institutions, and keywords. Similar methods have also been applied to draw a knowledge map of safety culture (Li and Guo, 2014) and patient safety (Rodrigues et al., 2014). In a more recent article Li and Hale (2015) have used co-citation analysis to show the relationships between *SS* and other journals in the area of safety science and how knowledge flows between them. That flow depends on how certain topics are distributed between the journals, cluster across them or differentiate between them, but does not make explicit what those topics are. On the basis of that research Li published a book named "*Introduction to Knowledge Map of Safety Science*". The contents include publication output, the cooperation network responsible for the publications (including authors, institutions and countries/territories), and also a preliminary study of the dominant topics and frontiers of research of safety science (Li, 2015).

The distribution of outputs of the publications are also important. Hence, in this paper two aspects will be discussed: (1) the distribution of outputs of the six journals over time and by geographical region; (2) we use advanced bibliometric mapping methods (from CWTS)[1] to make explicit how the topics and themes distribute themselves within each of the selection of six core safety-related journals.

2. Data and methodology

2.1. Data sources

Within the constraints of our study we had the capacity to analyse six journals. These were chosen partly on the basis of our earlier study (Li and Hale, 2015). We took the five broad safety science journals which had emerged from our co-citation analysis based on *SS,* as being the most prolific sources of citations from SS and to SS. These were *Safety Science* itself (*SS*), the *Journal of Safety Research (JSR)*, *Accident Analysis and Prevention (AAP)*, *Reliability Engineering and System Safety (RESS)* and the *Journal of Loss Prevention in the Process Industries (JLPPI).* To these we added *Injury Prevention (IP)* as another less closely related journal according to the co-citation study, but still one with a stated scope covering safety in a wide range of situations. This was included to see whether our analysis would reveal an explanation for that lower relationship in the topics of IP compared to the other five journals. The basic information about each of these six journals is given below.

SS is a monthly journal in the field of safety, published formerly under the title of the *Journal of Occupational Accidents* (1976–1990). It is published by Elsevier Science BV in the Netherlands. The subject categories in the Journal Citation Report (JCR) Science Edition for 2013 to which SS is assigned are currently "Industrial Engineering", where it is ranked 12th out of a total of 43 journals in that category on impact factor (IF) and "Operations Research & Management Science", where it ranks 20th out of a total of 79 on IF. On the homepage of SS, Elsevier categorizes it in both their Safety and Transportation portals.

JSR is a bimonthly journal published by Pergamon-Elsevier Science Ltd in the United States. The subject categories to which it is assigned in the JCR Social Sciences Citation Edition 2013 are "Ergonomics" (ranked 4th of 16 journals), "Public, Environmental & Occupational Health" (ranked 72th of 143 journals), "Social Sciences, Interdisciplinary" (ranked 14th of 93 journals) and "Transportation" (ranked 16th of 29 journals). By Elsevier it is listed under both their Safety and Transportation portals.

AAP is a monthly journal, published by Pergamon-Elsevier Science Ltd in England. It is affiliated to the Association for the Advancement of Automotive Medicine. The subject categories to which AAP is assigned in the JCR Social Sciences Citation Edition 2013 are "Ergonomics" (ranked 1st out of 16 journals), "Public, Environmental & Occupational Health" (Ranked 18th of 143 journals), "Social Sciences, Interdisciplinary" (ranked 4th out of 93 journals) and "Transportation" (ranked 2th out of 29 journals).

IP is a bimonthly journal published by BMJ Publishing Group in England, which is indexed in both the Science and Social Science Editions of JCR. The subject category assigned to IP in the JCR Social Sciences Citation Edition 2013 is "Public, environmental & occupational health (ranked 38th out of 143 journals)". It is categorized under a heading of the same name in the Science Citation Edition 2013, (ranked 63th out of 162 journals), the only one of the 6 journals studied to be included in both indices.

RESS is a monthly journal, published by Elsevier Science in England. RESS is assigned in the JCR Science Citation Edition to the subject categories of "Engineering, Industrial" (ranked 6th out of 43 journals) and "Operations Research & Management Science" (ranked 8th out of 79 journals).

JLPPI is a bimonthly journal published by Elsevier Science in UK. of In the JCR Science Citation Edition JLPPI is assigned to the subject category "Engineering, Chemical" (ranked 66th out of 133 journals).

We were interested, in this paper, only in journals with a broad range of topics in several safety areas, rather than in narrower journals focused on safety in one specific area, such as drug safety, fire safety, food safety or structural safety. We wanted to focus on broadly competing journals where an analysis of the topics covered might throw more light on their differential focus and strengths.

The data in our research were retrieved and downloaded on 17th March, 2014 from the online version of the Thomson Reuters' Web of Science (for the instructions on *how to download Web of Science data* see this article's webpage[2]). The Web of Science database not only has a long history with large amounts of scientific data, but also has selected the records of the world's most impactful and high quality journals into its database.[3] In this sort of research work, researchers almost always choose the Web of Science as their data source.

The retrieval was guided by the following search terms:
Publication Name = "full title of the journal name",
(e.g. Publication Name = "*safety science*")
Document Type = "article"

Timespan = 1900–2013 (This use of 1900 was because we were not certain of the timespan of availability of all the journals in the database and we wanted to get all of the data relating to them that were to be found there. In fact the earliest year found was 1969.).

In total 13,028 records were obtained from the target journals; the detailed information about our data is shown in Table 1. The timespans are the periods for which the journals are indexed in Web of Science. SS did start publication as the *Journal of Occupational Accidents*[4] earlier than 1991, but it was not possible to merge those data with those under the SS title.

[1] Advanced Bibliometric Methods. http://www.cwts.nl/Advanced-Bibliometric-Methods.

[2] https://sites.google.com/site/mappingsafety/appendix.

[3] For a short introduction to the Web of Science™ Core Collection see: http://wokinfo.com/products_tools/multidisciplinary/webofscience/ If a link does not work from the paper directly, please copy the link and paste into your explorer.

[4] There are in total 334 records, including 277 articles publish in *Journal of Occupational Accidents* from 1977 to 1990. For the annual distribution of JOA publications visit http://blog.sciencenet.cn/blog-554179-865155.html.

Table 1
Detailed information on the dataset.

No.	Journal title	Timespans	TRECS	AREC	IF 2015	Issues/Year	Country	ISSN
1	*SS*	1991–2013	1986	1827	1.831	10	Netherlands	0925-7535
2	*JSR*	1969–2013	1437	1258	1.87	6	USA	0022-4375
3	*AAP*	1975–2013	4189	3884	2.07	12	England	0001-4575
4	*IP*	2002–2013	2315	865	1.891	6	England	1353-8047
5	*RESS*	1981–2013	3783	3456	2.41	12	England	0951-8320
6	*JLPPI*	1988–2013	1892	1738	1.406	6	England	0950-4230

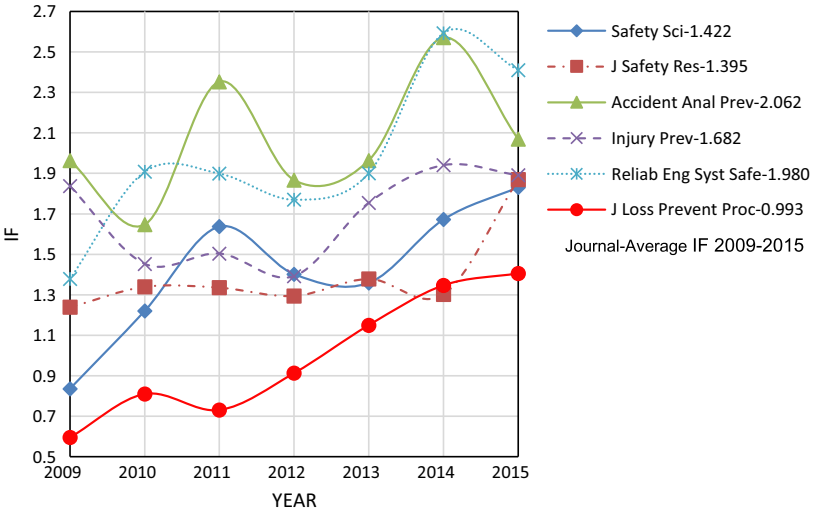

Fig. 1. Impact factor trend graph of six core safety journals.

The column labelled 'TRECS' gives the Total RECordS published in each journal in the period; 'AREC gives' the total number of Articles in the TRECS.

The impact factor (IF) is a measure of the frequency with which the "average article" in a journal has been cited in a particular period (the IF we used was the one based on citations in the two years after publication of the original article). The IF reflects not only the influence of a certain journal, but also can reveal the amount of scientific attention to the area. The IF of each safety journal was taken from the Thomson Reuters Journal Citation Report (JCR) 2008–2014. This includes the Science Citation index in which SS, IP, RESS and JLPP are indexed and the Social Science Citation index in which JSR, AAP and IP are indexed. The impact factors for the years 2009–2015 could then be accessed from the period 2008–2014.

The trends in impact factors over the period were collected from the JCR database. (For the detailed information of "*How to Get the Impact Factor of Journals*" refer to article's webpage[5]). The trends in the IFs of our sample of journals are shown in Fig. 1. The average IF for each journal over the period is given after the name in the top right corner of Fig. 1. AAP and RESS have the highest impact in the period from 2010–2015, but all are quite variable, with AAP and SS having a marked increase in 2011 and IP showing an initial fall and later recovery. JSR shows hardly any change over the early part of the period, but suddenly increases in 2015; the rest have shown net increases compared to 2009, at least in 2014. The increase of journals' IFs shows the increased attention paid to published safety research.

2.2. Methodology

In our research, the software HistCite[6] was used to analyse the basic statistical information in the data set, covering particularly the time distribution and geographical distribution of the data (Garfield et al., 2006). VOSviewer (Van Eck and Waltman, 2010) was chosen as the tool for analysis and visualization of the topics of each journal. This software has been updated many times, and it has been applied in many different research projects with a similar purpose as ours[7].

The words representing the themes or topics of each journal were extracted from the titles and abstracts of the articles by using the natural language process and automatic topic identification techniques from the dataset. Ten was set as the minimum number of occurrences of each topic for it to be included in the visualization (van Eck et al., 2010b). This number of occurrences of the topic we call its weight. The VOS (*Visualization Of Similarities*) mapping method was used to calculate and locate each topic in a two dimensional map, which is closely related to the well-known statistical method of multidimensional scaling (van Eck et al., 2010a); the closer each topic in the analysis space, the more related they are.

The VOS clustering method was applied to cluster topics into different groups, and each cluster was marked with a different colour (Waltman et al., 2010). The size of the nodes and of the font of the label represent the frequency of each topic; the larger the node and font, the more frequent the topic. For some of the topics only a circle is displayed, in order to avoid labels overlapping. The whole topics list can be found in our spreadsheet online. A short

[5] https://sites.google.com/site/mappingsafety/appendix.

[6] HistCite stands for *History of Cite* and can be freely downloaded from http://interest.science.thomsonreuters.com/forms/HistCite/.

[7] The full list of these publications using VOSviewer for different types of research in different areas can be found by visiting the website http://vosviewer.com/publications/.

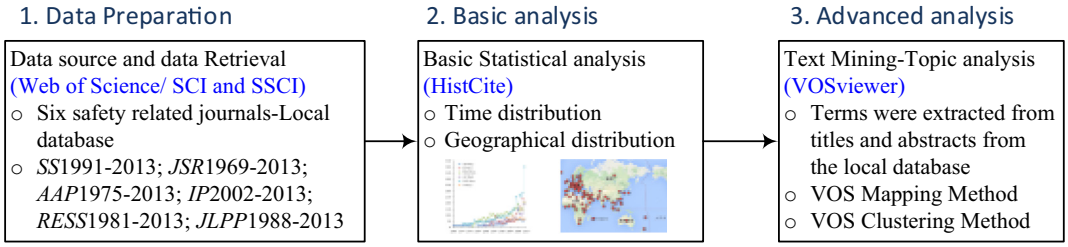

Fig. 2. Steps of journal topics research.

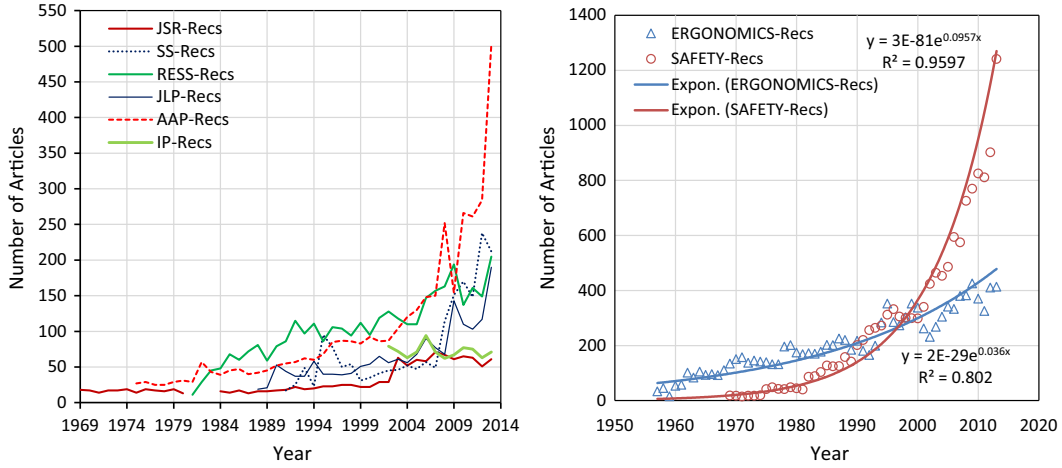

Fig. 3. Annual (left) and cumulative (right) distribution of articles in six safety science (left and right) and four ergonomics (right) journals.

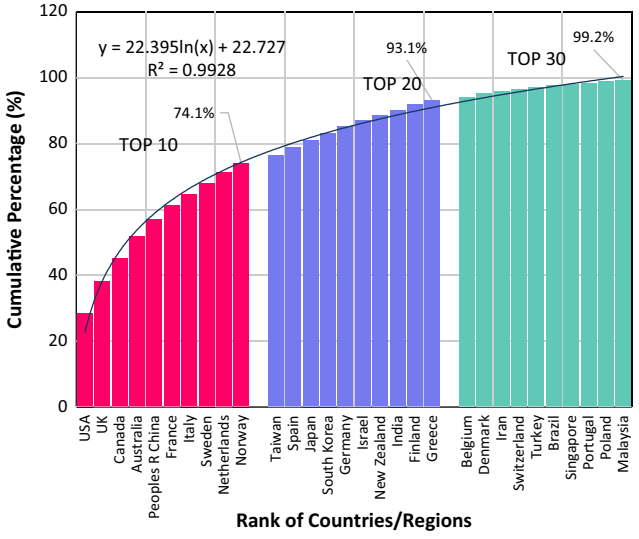

Fig. 4. Articles cumulative percent of top 30 countries/territories.

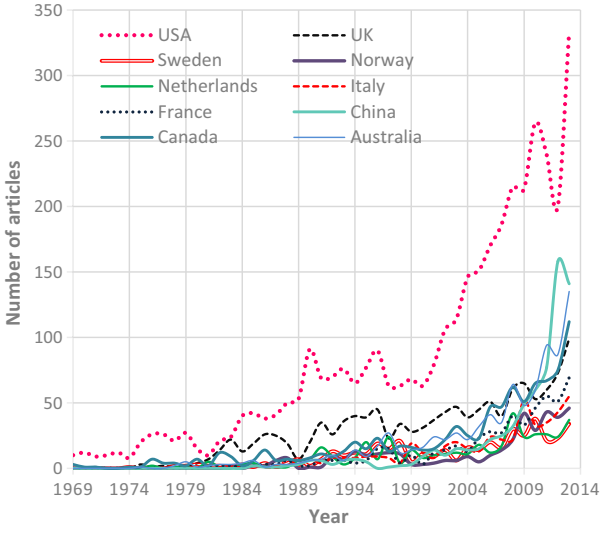

Fig. 5. Annual distribution of top 10 countries/territories.

introduction to the detail of how to use VOSviewer to create topic maps is given in the note to the additional material relating to this research (see *How to create terms maps using VOSviewer* in this article's webpage[8]).

A further analysis (the new version of VOSviewer) allowed us to analyse the time period of the appearance and dominance of the topics in the maps. It indicated which topics were more used towards the beginning or towards the end of the analysis period, indicating changes in emphasis. We have reported in this paper only a sample of this analysis (Rodrigues et al., 2014).

[8] https://sites.google.com/site/mappingsafety/appendix.

The basic steps of our research are shown in Fig. 2. (1) Data preparation, (2) basic analysis and (3) advanced analysis.

3. Results and discussion

3.1. Output distributions

3.1.1. Time distribution

The annual distribution of articles for each journal is given in Fig. 3 (left hand graph), and their cumulative increase on the right

Table 2
Articles of top 10 countries in each journal.

Countries	Journals						
	SS	JSR	AAP	IP	RESS	JLPPI	Total
USA	275	722	1329	444	767	275	3726
	15%, 7%	***57%***, 19%	***34%***, ***36%***	***51%***, 12%	***22%***, 21%	16%, 7%	28.6%, 100%
UK	226	33	305	82	363	226	1235
	12%, 18%	3%, 3%	8%, ***25%***	9%, 7%	11%, ***29%***	13%, 18%	9.5%, 100%
Canada	98	85	362	107	154	91	897
	5%, 11%	7%, 9%	9%, ***40%***	12%, 12%	4%, 17%	5%, 10%	6.9%, 100%
Australia	142	59	445	119	78	24	867
	8%, 16%	5%, 7%	11%, ***51%***	14%, 14%	2%, 9%	1%, 3%	6.7%, 100%
Peoples Republic of China	189	21	99	31	215	134	689
	10%, ***27%***	2%, 3%	3%, 14%	4%, 4%	6%, ***31%***	8%, 19%	5.3%, 100%
France	83	8	124	10	216	87	528
	5%, 16%	1%, 2%	3%, ***23%***	1%, 2%	6%, ***41%***	5%, 16%	4.1%, 100%
Italy	49	3	50	6	231	132	471
	3%, 10%	0%, 1%	1%, 11%	1%, 1%	7%, ***49%***	8%, ***28%***	3.6%, 100%
Sweden	97	32	219	16	53	9	426
	5%, ***23%***	3%, 8%	6%, ***51%***	2%, 4%	2%, 12%	1%, 2%	3.3%, 100%
Netherlands	141	9	101	10	115	40	416
	8%, ***34%***	1%, 2%	3%, ***24%***	1%, 2%	3%, ***28%***	2%, 10%	3.2%, 100%
Norway	106	2	65	7	142	53	375
	6%, ***28%***	0%, 1%	2%, 17%	1%, 2%	4%, ***38%***	3%, 14%	2.9%, 100%
Total of top 10 countries in journal	1406 (77%)	974 (77%)	3099 (80%)	832 (96%)	2334 (68%)	1071 (62%)	9630 (74%)
Grand total in journal	1827	1258	3884	865	3456	1738	13,028

Note: The first percentage in each box in the table is the number of papers from each country divided by the grand total of papers in the journal (e.g. for USA in SS, 15% = 275/1827, etc.).

hand graph of that figure. The figures show that there has been a dramatic increase in the safety science publications in the 45 years they have been published. As comparison the publications in a related area of research and publication, a set of 4 ergonomics journals, is plotted on the same graph over the same period to show that, though they have increased, it has not been at anything like the exponential rate of the safety science journals. The data for the ergonomics journals are taken from four journals: Applied Ergonomics (2295 articles, 1969–2013); Ergonomics (4888 articles, 1957–2013); Human Factors (3026 articles, 1958–2013) and International Journal of Industrial Ergonomics (1621 articles, 1994–2013).

Of the safety science journals JSR[9] and IP have shown the least growth and AAP dramatically the most, particularly over the last few years.

3.1.2. Geographical distribution of the data

The geographical distribution of the total set of the 6 journals' papers covers 102 countries/territories. The USA ranks in first place with 3726 published articles (28.6%), followed by UK (1235, 9.5%), Canada (897, 6.9%), Australia (867, 6.7%), Peoples Republic of China (689, 5.3%) and France (528, 4.1%). The cumulative percentage distribution of articles in the top 30 countries is shown in Fig. 4. It shows that the top 10 countries have published 74.1% of the articles, the top 20 have published 93.1% and the top 30 99.2%. The top 4 countries are, as might be expected, English-speaking countries. The Peoples Republic of China, ranking fifth, heads the non-English speaking countries and shows the most rapid growth after the USA, particularly in the last few years. English is the academic language in China, and a large amount of Chinese national journals are also published in English. Fig. 5 presents just the top ten countries contributions to the total publications over the whole analysis period. It shows the increasing dominance of the USA, particularly since 2000. The rise of China and Australia in the last 5 years is also striking.

The matrix of publications per journal for the top 10 countries is shown in Table 2. Two percentages have been calculated, the first is the percentage of that journal (column) coming from each of the countries shown; the second is the percentage of the total papers written in each country which are published in each of the journals. The top row for each country is the absolute number of articles from that country in the journal over the period studied. The percentages in bold and italics are commented on below.

The USA published the highest percentage of papers in every one of the 6 journals, being particularly dominant in JSR, IP and AAP and to a lesser extent RESS. SS and JLPPI have the most even spread over the top ten countries, with no country publishing more than 16% of the journal. China, Sweden, Norway and the Netherlands publish a high percentage[10] (over 20%) of their papers in SS, whilst China and the Netherlands also have publish those high percentages of their papers in RESS. RESS also attracts a high percentage of the papers from UK, Norway, France and Italy. Italy is the only country publishing a high percentage of its papers in JLPPI. Finally AAP attracts a high percentage of the papers not only from USA, but also from UK, Canada, Australia, France, Sweden and the Netherlands. There are therefore clear national preferences for research journals, to which a high percentage of the countries' papers will be directed. These stand out from a broad groundswell of publications spread over the whole spectrum of the 6 journals and the top ten countries.

The top ten countries publish more than 70% of the papers in all of the journals except JLLPI and RESS, which have a longer tail of articles from the remaining 92 countries not shown in the tables.

3.2. Mapping topics of the safety journals

3.2.1. Safety Science (SS)

The topics map of *SS* is shown in Fig. 6. It shows four clusters, to which we have assigned suggested labels in Table 3. Table 3 lists the top 15 topics in each of the four clusters, which we have used to inform that assignment. Fig. 7 shows the time-based analysis of

[9] In the years 1981–1983 JSR failed to meet the quality criteria of the Web of Science (see the Thomson Reuters Journal Selection Process http://wokinfo.com/media/essay/journal_selection_essay-en.pdf), thus producing a gap in the record for the journal at that point.

[10] Where the text speaks of 'high percentage' in all cases it means more than 20%.

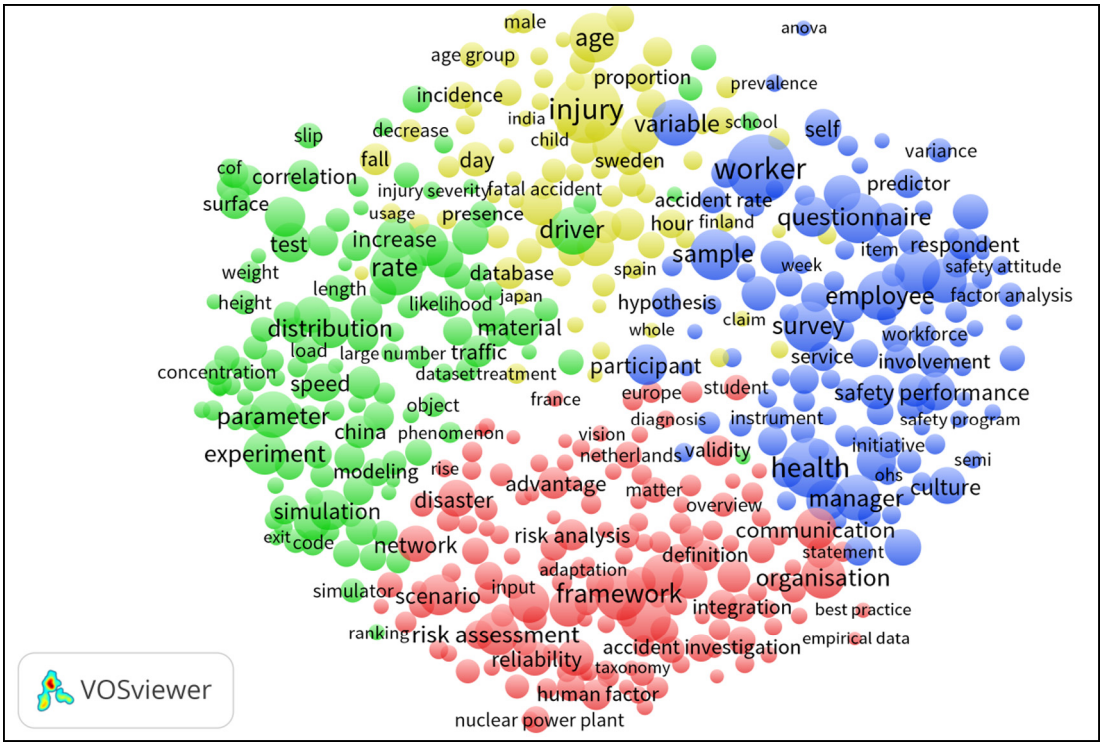

Fig. 6. Topics map of *SS:* the font and circle size reflect the frequency of each topic (its weight); the colours of the circles show the cluster to which the topics belong. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 3
Top 15 most common topics in each cluster of *SS*.

Cluster1# System modelling, Organisation, Major Hazard		Cluster2# (Road) Transport, Experimental		Cluster3# Attitude survey, Safety culture Management,		Cluster4# Consequence, Epidemiology	
Topics	Weights	Topics	Weights	Topics	Weights	Topics	Weights
Framework	128	Rate	138	Worker	222	Injury	228
Concept	125	Driver	112	Health	166	Age	115
Risk assessment	96	Parameter	103	Questionnaire	125	Fatality	82
Organisation	93	Experiment	88	Sample	125	Occupational Accident	74
Principle	85	Distribution	85	Survey	122	Population	70
Communication	82	Vehicle	83	Employee	115	Trend	67
Failure	80	Increase	81	Variable	104	Day	57
Scenario	77	Measurement	79	Perception	102	Total	53
Decision making	68	Simulation	77	Manager	101	Statistic	52
Network	67	Test	76	Attitude	92	Database	48
Disaster	65	Material	70	Safety Management	80	Fall	48
Error	65	Speed	68	Participant	79	Hour	43
Challenge	62	Fire	66	Workplace	78	Risk Factor	43
Reliability	58	Location	65	Occupational Health	74	Death	41
Expert	53	Severity	65	Safety Performance	68	Sweden	41

topics, the red circles representing more recent topics and the blue[11] ones which have faded somewhat from view over the analysis period.

The analysis shows a compact and relatively balanced picture across the four clusters, a picture reflecting a spread of topics drawn from major hazard, transport and work safety. The clusters also reflect the diversity of methods used, from theoretical modelling, to experimental studies, epidemiology and social science techniques such as attitude surveys. The clusters we find, particularly those of transportation, attitude surveys and epidemiology do not seem to map clearly to the JCR categories of Industrial Engineering and Operations Research.

The timeline analysis in Fig. 7 shows that more recent topics (red) are to be found in cluster 2 (transport) and older topics (blue) in cluster 4 (epidemiology).

These results are in line with the scope announced on the journal's web page,[12] which also emphasizes the journal's interest in papers across different types and arenas of hazard. The link by Elsevier to its Transportation portal seems to reflect less than one quarter of the journal's topics.

[11] For interpretation of colour in Fig. 7, the reader is referred to the web version of this article. https://sites.google.com/site/mappingsafety/topics-map-of-journals/safety-science.

[12] Homepage of *Safety Science*. http://www.journals.elsevier.com/safety-science/.

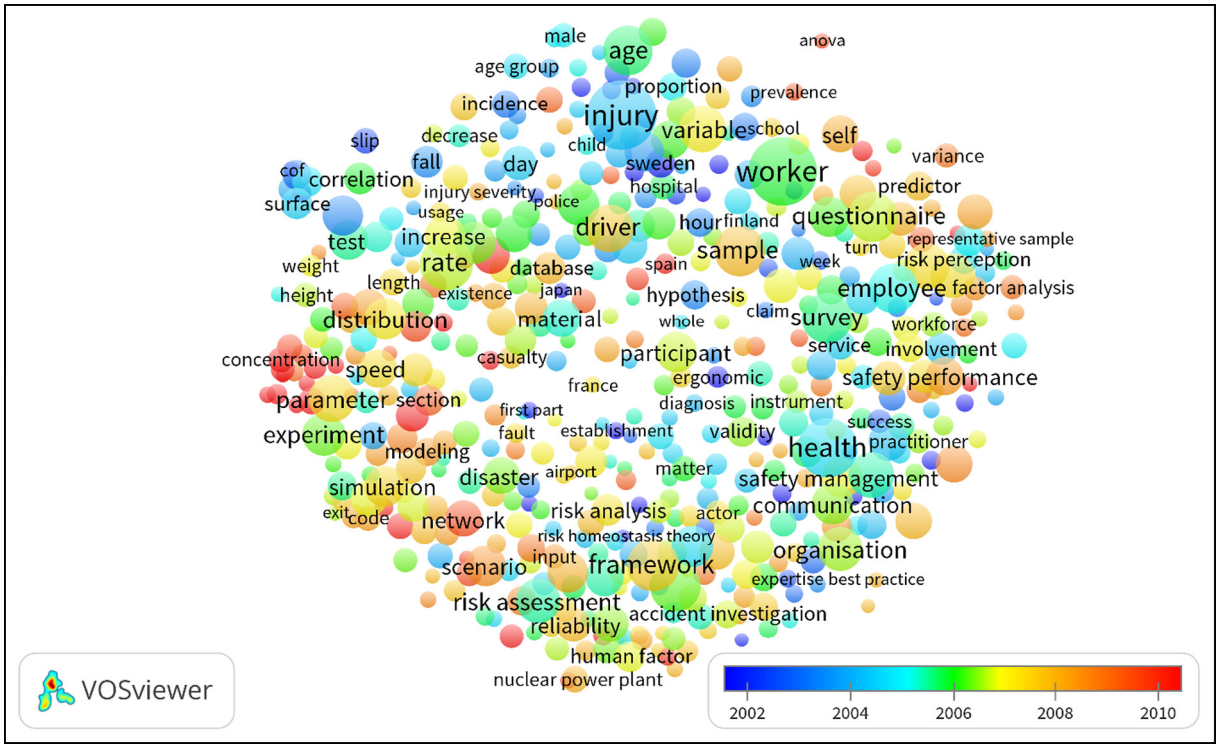

Fig. 7. Average year of mention of the topics, showing developments 2002–2010.

Similar methods were also applied in the remaining five journals, but rather than fill out this journal paper with the relevant figures for each journal, which would unnecessarily expand this paper, we have created an independent website to show the detailed results. In the paper itself we just give the interpretation of results for the remaining five journals. The detailed results per journal can be found at https://sites.google.com/site/mappingsafety/.

3.2.2. Journal of Safety Research (JSR)

Figure W2-a in the article's homepage gives the visualization of the clustering of the topics of the *Journal of Safety Research*. Table W2 shows the top 15 topics per cluster, on which we have based our suggested cluster label, which are as follows: Cluster 1# Road safety, Enforcement; Cluster 2# Work safety & health, Prevention; Cluster 3# Statistics, Consequence. The time-based analysis does not seem to provide interpretable results and is not discussed here. The analysis shows two clearly delineated application areas of work and road safety with little if any attention to major hazards. In between there is a cluster of analysis, focusing mostly on statistical analysis rather than the risk assessment and modelling approaches of SS. This may reflect the closeness to practice defined in the journal's scope.[13] The JCR categories to which JSR is assigned are completely different from those for SS, despite our clustering showing more similarities of topics between the two journals. JSR's classifications seem more appropriate than SS's.

3.2.3. Accident Analysis and Prevention (AAP)

Figure W3-a gives the visualization of AAP's topics and table W3 the top 15 topics per cluster on which we have based our suggested cluster labels: Cluster 1# Driver performance, Cluster 2# Statistics of cause & consequence, Regulation, Cluster 3# Modelling/analysis infrastructure and Cluster 4# Injury, consequence. Figure W3-b shows the time-based analysis. The clusters are all dominated by road safety topics, with a little general safety modelling added in cluster 3. Clusters 2 and 4 represent the focus on statistical analysis and on injury mechanisms. Both these areas are shown in Figure W3-b to be associated with older (blue) topics, while clusters 1 and 3 show more recent (red) topics. Clusters 1 and 3 reflect a focus on respectively the driver and the infrastructure as causal factors and have therefore more focus on prevention compared to clusters 2 and 4. The phrase in the scope[14] about interest in publishing papers on accidents at other than transportation sites does not appear to have been turned into papers on those topics in the figures; it is even difficult to discern transport modes other than road traffic. The JCR categories of this journal appear to match our clustering reasonably well.

3.2.4. Injury Prevention (IP)

Figure W4-a and table W4 (topics) give the visualization of their clustering and the top 15 topics per cluster. There are four clusters : Cluster 1# Responsibility, Child safety and Prevention; Cluster 2# Statistics of injury, Medical & public health; Cluster 3# Epidemiology and Intentional injury and Cluster 4# Road accident and enforcement. The four clusters reflect the concentration on injury mechanisms. It is the only one of our 6 analysed journals to show violence, suicide and other intentional injury as a set of topic. It is also the only one to have a cluster devoted to child safety at home and school. The JCR categorization seems to match our clusters reasonably well. The time-based analysis seems to show a picture dominated by blue, indicating a relatively stable set of topics being studied.

3.2.5. Reliability Engineering and System Safety (RESS)

The clustering of the topics and the top 15 topics per cluster are shown in Figure W5-a and table W5. There are five clusters found in RESS: Cluster 1# QRA, Safety management and Nuclear power;

[13] Homepage of *Journal of Safety Research*. http://www.journals.elsevier.com/journal-of-safety-research/.

[14] Homepage of *Accident Analysis and Prevention*. http://www.journals.elsevier.com/accident-analysis-and-prevention/.

Cluster 2# Quantitative methodologies and Risk estimation; Cluster 3# Maintenance and Cost/benefit analysis; Cluster 4# Modelling, analysis and cluster 5# Chemical/Energy process. Figure W5-b shows the time-based analysis. The JCR categories are the same as for SS, but our cluster analysis shows quite marked differences between the two journals, with the JCR assignments matching the clusters of RESS better than those of SS. The clusters reflect the concentration of RESS on major hazard. The clustering is strongly based on the different industries the research published in it has been concerned with and the methodologies it has developed and used. The existence of one cluster heavily biased towards maintenance reflects the importance of that as influence on major accidents. Figure W5-b shows that there seems to have been a shift in the period 2002–2010 away from cluster 1 which houses safety management and towards clusters 2, 3 and 4, concerned modelling and maintenance. This may represent the maturity of understanding of safety management and a movement to concentrate on cost-benefit.

3.2.6. Journal of Loss Prevention in the Process Industries (JLPPI)

The results of JLPPI were visualized and listed in Figure W6-a and table W6, we named three clusters for JLPPI: Cluster 1# Risk assessment and cause analysis; Cluster 2# Mechanisms of technology failure and Cluster 3# Process of loss of control. The topics map is fragmented into two related clusters dealing with failure mechanisms and a third isolated cluster relating to risk analysis. Figure W6-b gives the time-based analysis showing a move from clusters 2 and 3 towards cluster 1. The JCR categorization completely overlooks our cluster of risk analysis, which would justify adding a category much closer to those of RESS. The bimodal structure of the mapping is striking with papers about cause and risk separated widely from papers about the technologies of loss of control and failures. The technology clusters in figure W6-b have the most blue, indicating a relatively older set of concerns, while the newer yellow and red topics, to the extent they are indicated, concentrate more in the risk and cause cluster.

4. Discussion

Of the six journals, SS, JSR, AAP and IP have topics clustering around road safety. Especially the journal AAP has a strong focus on road safety, with all four of its topic clusters relating to different aspect of road safety. Mathematical and statistical methods are widely used in safety research and form clusters in several of the journals, for example, the clusters of systems modelling, epidemiology and QRA. In SS, JSR, AAP, IP and RESS there are risk assessment clusters. Several of the journals have clusters relating to the technologies of specific areas and their failures; AAP for road safety, RESS in nuclear and chemical technology and JLPPI in mechanisms of technological failure and processes of loss of control.

The time based topics maps give the distribution of topics compared to average years. The topics which have been published more recently include transport in SS; driver performance and infrastructure modelling and analysis in AAP; quantitative methodology of risk estimation, maintenance cost/benefit analysis and modelling analysis in RESS; and risk assessment and causal analysis in JLPPI. There seemed no clear patterns in the time-based topic maps of JSR and IP.

5. Conclusions

The main contribution that this paper makes is to visualize the clustering of the research topics within and between the six journals. We do not suggest that there are right and wrong answers as to how that clustering should appear in practice. That is determined by the 'market', in which researchers and paper authors interact with journal editors and publishers. Our aim has been simply to make that market more transparent. We have shown that the six journals have distinct profiles, both in terms of topics and their regional spread of the papers.

The six journals analysed show the fast growth of the area of safety science research over the half century of its existence in refereed journals. Our analysis shows the dominance of the USA in that growth and the recent spurt of research from China, challenging that dominance. This dominance is despite four of the six journals being published in England. AAP and RESS have high IFs in relation to the other journals in their JCR categories, SS, JSR and IP are to be found in the top half of their categories on this measure, while JLPPI is relatively the lowest. However, one could question the basis used for assigning each journal to its current JCR subject categories, as there does not appear to be a clear relationship with the clusters we find in our analysis, particularly for SS and JLPPI. This reflects the difficulty of categorizing multidisciplinary journals in discipline-based categorizations.

The distribution and categorization of the six journals into either or both of the JCR Science and Social Science reports does not appear to have clear reasons behind it, though it does show the subject area's multidisciplinary nature. IP is the only one of the six indexed in both reports, whilst several more deserve to be. JSR and AAP are only included in the Social Science citation report whilst SS, RESS and JLPPI appear only in the Science Citation report. In particular SS has clusters relating to safety culture and management and to the epidemiology of accidents, making that journal lean also towards the social sciences, while AAP with its growing concern for transport infrastructure design and the technology of accident prevention leans also to the engineering sciences.

The journals show regional biases in research publication, with the USA dominating in particular JSR, IP and AAP, whilst SS and to a lesser extent RESS are more concentrated on Europe.

Looking across the clusters found in all of the journals we see some clustering on the basis of the technology, or activity. AAP is concentrated on road traffic safety, while JSR splits more or less evenly between work and road traffic. Of the major hazard journals RESS focuses on the nuclear and chemical industries and on maintenance, whilst JLPPI delves deepest into the technical mechanisms of major hazards. IP extends its coverage to child safety and to intentional injury (violence and suicide), topics not found in any of the other 5 journals, which explains to an extent the lower flow between it and SS found in our earlier study (Li and Hale, 2015). SS is the only journal with a cluster around safety management and culture.

The other basis of clustering is more methodological. This is particularly noticeable where the focus of the journal is narrow in terms of activity/industry, such as in AAP. IP with its key focus on injury mechanisms has a more reactive focus than journals such as AAP and SS, which focus more on prevention. However, the dependence of much safety research on the analysis of statistics and epidemiology shows up in the presence of clusters with these topics in most of the journals (AAP, JSR, IP and SS), supplemented by clusters around modelling and risk assessment in those journals with major hazards as a focus (RESS, SS and JLPPI).

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