A bibliometric overview of public health research in Europe

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Background: Our aim, within the collaborative study SPHERE (Strengthening Public Health Research in Europe), was to produce a bibliometric overview of public health research literature for Europe. Methods: A search strategy ('filter') was designed to interrogate the Science Citation Index (SCI) and the Social Science Citation Index (SSCI) databases for research articles published between 01/01/1995 and 31/12/2004 in any language. We analysed output for country by population, Gross Domestic Product (GDP), burden of disease using DALYs, and language. Results: Overlap between the two databases SCI and SSCI was 35%. 210 433 publications were identified after duplicates were removed, a world total of about 20 000 per year. Approximately 7000 papers per year were produced in Europe and 9400 by the USA. Thirteen of 28 individual European countries produced more than 100 public health papers per year. Publications per capita were highest in northern European countries. In multiple regression analyses, GDP was a modest predictor ($r^2 = 0.53$, $P < 0.02$) of publications for European countries, while population size and disability adjusted life years were not significantly related. Smaller countries and lower producers of public health research were more likely to collaborate with other countries. Of the publications, 3.5% were published in a non-English language, with German the most common. Conclusion: There is marked variation in public health publication by country in Europe. Eastern and southern European countries appear to under-invest in public health research compared with northern European countries and compared to relative health need.

Keywords: Bibliometrics, public health research, literature review, Europe

O ur aims, as part of the European collaborative study SPHERE (Strengthening Public Health Research in Europe), were to produce an overview of the public health research literature in Europe for the 10 years from 1995 to 2004 and to compare country publication rates by population, GDP, burden of disease and language in Europe with other major producer countries in the world.

Methods

Bibliometric methods were used to identify published public health research. Bibliometrics is the scientific and quantitative study of publication¹ and is a research method used in library and information science, to describe patterns of publication within a given field or body of literature.¹ ² ³

A previously described bibliometric method was used.¹ ² ³ The Social Science Citation Index (SSCI) and the Science Citation Index (SCI) were selected to identify published public health research. These citation index databases were chosen because of (i) the enhanced possibility they offer to download, store and manipulate the anticipated large quantity of publications and (ii) the greater accuracy with which they record address (and country) of each participating author compared with MedLine. In addition the SSCI allowed for the inclusion of potentially relevant social science publications.¹

Search strategies or ‘filters’ were designed to interrogate these databases

Search strategy

Public health research: definition for the study

Several definitions of public health have been formulated. These typically reflect the wide scope of public health itself.⁴ ⁵ Definitions of both public health and public health research accept that the key common points are the population approach (public health) and the production of generalizable knowledge (research). The definition formulated for the SPHERE project was:

Research which contributes to the understanding of how population health is influenced by determinants (genetic, environmental, social . . . ) or to the identification of effective interventions for improving health and reducing health inequalities. Public health research differs from public health practice (which also uses scientific methods), as it is designed to obtain generalisable knowledge rather than to address specific programmes for service delivery.⁶

To operationalize this definition for searching the literature, it was agreed that each eligible publication should include at least one of the following:

- a clearly defined or clearly implied population and
- an identifiable implicit or explicit exposure or context or intervention and
- an identifiable implicit or explicit health outcome and
- generalizability or the implication of generalizability beyond the immediate population described or
- constitute methodological research relating to investigating these.

Using this definition we constructed the filter to identify ‘population’, ‘context’, ‘health conditions’, ‘health determinants’ and ‘health outcomes’ words.
First stage inclusion and exclusion criteria

Only research articles and systematic reviews were included. At the initial stage, all countries were included, with articles published in any language. The search covered a 10-year period from 1 January 1995 to 31 December 2004, and was limited to humans.

A mixture of MeSH headings and keyword lists was used to construct the search strategy. Both MeSH headings and keywords were used to ensure inclusion of all population groups or MeSH ‘persons’, (e.g. children, adults, elderly). As comprehensive as possible a list of headings and keywords or phrases relating directly to public health (e.g. ‘public health’, ‘health impact assessment’) was generated by the authors and included. Similarly, MeSH and keyword lists of countries, major cities, population groups and population characteristics were produced (e.g. employees, refugees, France).

European countries included were the 25 EU member states at the time of the study in 2006, and Iceland, Norway and Switzerland. (Since this study was completed, the European Union has expanded to include Bulgaria and Romania.) We also investigated four comparator countries—USA, Canada, Australia and New Zealand—a larger total of 32 countries. Drawing from the WHO Global Burden of Disease project,7,8 we calculated country totals of DALYs (disability adjusted life years) for conditions contributing at least 0.1% of the burden of disease in the Europe subregion A. In addition a further MeSH headings and keyword list of important exposures or determinants of environmental and population health (e.g. air quality, hazardous substances, pollution, tobacco) was also included. A subset of specialist public health journals was identified and all articles in these journals were included.

Filter testing

We tested the precision (proportion of filter output considered to be ‘Public Health’) and recall (proportion of known public health publications retrieved) for iterations of the filter.3 Marking was undertaken by two public health specialists (A.C., O.G.). On each occasion the markers were given the same random samples of 400 titles of publications drawn from the whole retrieval of a given filter, mixed with 100 titles of publications from public health departments.

Markers were asked to decide whether titles represented public health research publications. Iterative amendments were made to the filter. Keywords or headings were included or excluded on the basis of the findings, and markers were given new testing samples. The aim of iterative testing of the filter was to reach a precision and recall each of at least 0.65. Final precision and recall scores for the amalgamated output of the final filters (SCI and SSCI) were used 0.61 and 0.68, respectively.

As each version of the filter was tested, kappa scores were generated to assess levels of agreement between markers. Five sets of scoring were undertaken before the filters were finalized and Kappa scores for these interim filters ranged between 0.4 and 0.6. For the final version, all disagreements between markers were noted and an agreed decision reached.

Second stage inclusion and exclusion criteria

Some topic areas were found difficult to categorize between raters (e.g. clearly described population, exposure and outcome but very rare condition). Two further public health experts were invited to adjudicate on these topic areas resulting in the following additional inclusion and exclusion criteria. Included therefore at this stage were: health economics research where a clear population, exposure and outcome could be identified and health services or health services management research where research clearly related to the health or healthcare of populations. Excluded at this stage were papers relating to very rare conditions or to individual treatment pathways.

The final agreed filter was run on both databases (SCI and SSCI) for the 10-year period. The output was merged and duplicates removed. Although the time lag in adding publications to the SCI and SSCI is shorter than in MedLine,9 a time lag in indexing publications still exists, so the output for 2004 was inflated by 10% to adjust for this. Country or countries of authorship as listed in the SCI and SSCI were noted. All European countries were separately identified, and also the USA, Canada, Australia and New Zealand. Publications with no country address identified were also noted.

Analysis

Geographical analysis

We performed two geographical analyses, one using integer counts and one using fractional counts based on publication years. An integer count gives each country involved per publication a score of one. The overall number of publications is therefore overestimated by the number of authors from different countries involved per publication. This typically averages 20%, although varies with subject and time period.10 Fractional counts are based on the actual number of publications and are the number of times a country appears as a fraction of the total number of addresses is noted. The total fractional count equals the number of papers with addresses. All addresses were treated equally with no extra weight given to the ‘reprint address’.11 The ratio of fractional to integer counts was calculated for each country as a measure of international collaboration.

Analysis by population, GDP and burden of disease

Average numbers of public health research publications produced over the 10-year period by country were compared by population (millions), GDP (billions of US dollars) and burden of disease, measured using DALYs per million population. Denominator data were derived from WHO routine data.7 Multiple regression using population, DALYs and GDP as predictors of annual publications was carried out using SPSS (version 14).

Language analysis

Language of publication was assessed using the stated language within the SCI and SSCI and a fractional count. German, French, Spanish and Portuguese were considered separately. All other European languages were grouped together.

Results

Numbers of public health research publications

After exclusion of duplicates (73 652 publications, 35%) and publications without addresses (5368, 2.6%), an overall world total of 210 433 publications was identified from the two databases. Inflation of the final year figure by 10% to adjust for late publication gave an estimated total 212 726 publications in the 10-year period. The annual number of public health publications rose by 55% over the 10-years (table 1).

Figure 1 shows the average public health publications produced per year for countries producing more than 100 per year over the 10-year period. English speaking countries, led by
the USA had the largest number of publications, while 15 of 28 European countries had an average of less than 100 publications per year. Table 2 gives ISO codes of countries and indicates composition of country clusters shown in figure 1.

Figure 2 shows a map of average public health publications produced per year per million population at the mid point of the 10-year period (mid-point 2000) in Europe. The Nordic countries appear to have the highest output of public health research per capita, while several larger European countries appear to be relatively low producers of public health research publications given their population size.

Public health research publications by population size, GDP and health need

Publications were compared by country population, GDP and DALYs. For European countries, there was a moderate relationship between the number of public health publications and population size in millions ($r^2 = 0.37$) and a moderate relationship between publications and GDP ($r^2 = 0.49$, $P = 0.02$). Countries varied much less in relation to DALYs per million population than in their research production, and there was no significant relationship between public health output and DALYs per million population ($r^2 = 0.064$). When all 32 countries were considered, a strong relationship was found between public health publications and population size in millions ($r^2 = 0.89$); a strong relationship with GDP ($r^2 = 0.96$), and again no significant relationship with DALYs per million population ($r^2 = 0.0004$) (figure 3).

When these variables (annual output, GDP, population and DALYs) were included in a multiple linear regression model, for the European countries, GDP remained moderately correlated ($r^2 = 0.53$, $P < 0.022$), but population size and DALYs were non-significant contributors. In multiple regression analysis also including comparator countries—Australia, Canada, New Zealand and United States of America, there was a much stronger relationship between public health publications and GDP ($r^2 = 0.96$, $P < 0.0001$) but the contribution of DALYs per million population was not significant.

Collaboration in public health research publication

Figure 4 shows the ratio of fractional to integer counts for different countries as an index of international collaboration—the higher the ratio, the higher the level of international collaboration. Small countries tend to have higher collaboration rates than large countries.

Language of publication

Figure 5 shows that the overall proportion of public health literature published in the world in a non-English language has been relatively steady at around 3.5%. (The drop for the year 2004 is likely to be an artefact due to later processing of the non-English literature by the SCI and SSCI databases.) After English, German is the most common language of public health publication followed by French, Spanish and Portuguese.

Although, in relative terms, publication in native language for most countries is decreasing for all countries; their stable ‘share’ of the rising number of total public health publications would suggest that absolute numbers of publications in native languages are stable or increasing.
Discussion

The study has shown that European public health research appears comparable in total volume with the USA, although it shows considerable variation by country within Europe. Variations per million population appear related both to scientific traditions and to citations of non-English language publications. The extent that the database sources reflect full European publications is not known, but there is some evidence to suggest underrecording of non-English language health papers in the social science literature.12

Soteriades and Falagas,13 have undertaken bibliometric studies comparing Europe and USA. Their search strategy for public health publications was based on papers in 22 specialist disciplinary journals identified through the Journal Citation Reports of the Institute for Scientific Information (ISI) and PubMed databases, and, for a comparable 9-year period, they identified a total of 9532 USA publications and 4236 from Europe. This was fewer than 10% of the publications we identified through the SCI and SSC and using a broader filter. In an earlier study of over a million biomedical sciences publications,14 the USA had a higher publication rate per

Table 2 Country codes and comparator clusters

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Figure 2 Average annual public health publications by country (allocated to countries on a fractional basis) in the 10-year period from 1995 to 2004 per million population (mid year 2000)
Figure 3 Annual public health publications per million population, European and comparator countries. *Regression line includes US population: 291.04 million; annual papers: 9421.7

Figure 4 Ratio of integer to fractional counts for different countries as an index of international collaboration. The higher the ratio, the higher the level of international collaboration.

Figure 5 The percentage of all public health publications published in non-English languages by year. *Figure for 2004 likely to be affected by delay in processing of non-English literature in databases.
capita than Europe, but European countries together produced more publications per capita in the north and west of Europe than the south and east. Our study supports the findings of Rahman and Mahbubur \cite{5} that GDP is an important predictor of publications by country, but less for European countries alone than when including USA in the analysis.

**Bibliometrics**

We found it difficult but possible to use bibliometric methods to compare the quantity of public health research published in the 10 years from 1995 to 2004 for Europe and selected comparator countries. We found developing an operational definition of public health research problematic. We spent considerable time designing a filter to identify public research in the SSCI and SCI as an iterative process with a final recall of 0.61 and a precision of 0.68. Ratings typically had a kappa score between raters of 0.4–0.6, while ideally values would be near 0.8.\cite{16} Problems were identified in defining the exact boundary between health services research and clinical research.

Judgements were made by each individual rater on what constituted public health research, but inevitably because of the breadth of the definition there were differences between raters. The problems we identified were independently ratified by two additional public health experts, and rules changed. The bias introduced by these issues does not affect comparisons of the proportions of publications between countries, because all were equally subject to the same search process using the same filter. However, it may affect assessments of the absolute numbers of public health research papers published by each country and these exact figures should be treated with caution.

A further issue which may affect comparisons between countries is publication bias. Countries where the main language of publication is not English might be expected to have their research underrepresented in the two citation indices, and this may in part explain the finding of fewer public health research publications from Germany, Spain, France and Italy. However, Eastern European countries and Portugal have an even lower output of public health research publications. It is possible, for small countries, that there is some element of random variation, although using an average derived from 10 years’ worth of data should reduce that problem.

We were not able to look in detail at the content or quality of the research publications we identified—a recognized limitation of bibliometric methods.\cite{2} It may be the case that some countries produce fewer higher quality research publications or that there are important differences between countries in the areas of public health research which they cover—but we were not able to draw conclusions on these points.

**Country comparisons**

We identified ‘high’, ‘medium’ and ‘low’ producers of public health research. The Nordic countries appear to have the highest output of public health research per capita, while several larger European countries were relatively low producers of public health research publications given their population size. In some Eastern European countries, public health research publications were noticeably low on all measures. The United States is a higher producer of public health research publications than all European countries together. In multiple regression analysis, GDP was the strongest predictor of public health research publication output, although this is especially true for models where the US is included.

When we looked at health need as measured using DALYs, we found that some of the Eastern European countries with the greatest health need in the EEA had the lowest production of public health research publications on almost every measure—possibly indicating an ‘inverse research law’. Countries with the best health also had the highest output of public health research publications. The direction of relationship between public health research and health need is unclear, but a case could be made that investment in research and knowledge might lead to better health.

While much of the public health research identified may be applicable to populations other than those from which the research itself emanates; some public health research, particularly health services research, may relate to characteristics of particular health systems. In this respect the relative lack of research identified from countries with social insurance systems is noticeable. As far as publications in languages other than English are concerned, absolute numbers and proportions of publications in French, German and Spanish are rising or stable in relation to overall output of public health research, but we were unable to investigate the extent of publication bias for these countries/languages and this may cause an underestimate of overall output.

**Conclusions**

Europe is an important contributor to the world public health research literature, but there are considerable differences between countries. And although for example, the UK and the Nordic countries are relatively high producers of public health research, it is not possible to tell, using bibliometric methods, whether the research produced is generalizable to those countries which are relatively lower producers. There appears to be a relative underinvestment in public health research by many European countries, and for some Eastern European countries this may be particularly important in the light of increased health need.

We recommend (i) more investigation of the relative spending on public health research as a proportion of each country’s total research expenditure and (ii) more detailed assessment of public health research activity within each country, and its relevance to improving the health of Europe’s citizens.

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