

Scandinavian research in anaesthesiology 1981–2000: visibility and impact in EU and world context

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Background: We wished to assess the development in number and impact of publications in anaesthesiology and intensive care medicine from 1981 to 2000 in the four Scandinavian countries: Sweden, Norway, Finland, and Denmark. For comparison, we also analyzed data from the UK and the Netherlands.

Methods: Publication and citation data from 1981 to 2000 were gathered from National Science Indicators (2001), covering 33 journals indexed in Current Contents. Data were analyzed in running 5-year periods. The following informetric indicators were used: absolute number of publications; absolute number of citations; absolute citation impact (average number of citations per publication per 5-year period); citation impact relative to the European Union and the world; and the percentage of cited papers from each country.

Results: The annual number of publications from Denmark was stable over the 20-year period. Sweden increased its production by 35%, while the remaining four countries showed increases from 100% to 146%. Thus, Sweden and Denmark lost visibility within the European Union (EU) and in world context. The EU and world citation shares of Finland and Norway increased slightly, whereas those of Sweden, Denmark, the UK, and the Netherlands all declined significantly. The absolute citation impact (ACI) increased for all the four Scandinavian countries. The ACI of the Netherlands did not change and was

surpassed by all the Scandinavian countries by 1994–98, while the UK finished below the other five countries.

Conclusions: (1) The annual number of publications from Sweden, Norway, Finland, the UK, and the Netherlands increased after the late eighties, whereas the net publication output from Denmark was stagnant over the 20-year period investigated; (2) the international publication and citation visibility of Finland and Norway increased slightly, as opposed to the significant decrease seen by the other four countries; (3) judging from the increase in absolute and relative citation impact and in the percentage of cited papers, the recognition of publications from the four Scandinavian countries increased over the past 20 years.

Accepted for publication 16 April 2004

Key words: anesthesiology*/ trends; anesthesiology*/ statistics and numerical data; anesthesiology*/ standards; bibliometrics*; publishing/ trends; publishing/ statistics and numerical data; publishing/ standards; research*/ trends; research*/ statistics and numerical data; research*/ standards.

© Acta Anaesthesiologica Scandinavica 48 (2004)

DURING the past two decades, the scientific output from medical institutions has been increasingly subjected to quantitative and qualitative analysis. Besides the obvious significance for the academic status of these institutions, the evaluation of their research has become the focus of political attention in regard to allocation of research funds and other resources (1–3).

Likewise, changes in the publication pattern of specific medical specialties have been investigated both nationally (4–6) and internationally (7–10). In addition to the quantitative assessment of publication output, most of these studies have attempted to estimate the international recognition of the published articles by use of surrogate parameters such as total Journal Impact Factor (JIF) (11).

The present study attempts to elucidate the development from 1981 to 2000 in publication and citation impact of anaesthesiological research in the four Nordic countries: Sweden, Norway, Finland, and Denmark

Methods

The four Nordic countries were evaluated relative to each other, the European Union (EU), and the world (Iceland was omitted because of its negligible quantitative contribution). For comparison, we included in the analysis two additional countries: the United Kingdom (UK) and the Netherlands. The UK was

included because of its position as the largest contributor to the total publication output of the EU, while the Netherlands was chosen on account of its similarity to the Nordic countries with regard to socio-cultural conditions and number of inhabitants.

For each country, the following informetric indicators were used: absolute number of publications; number of publications as a percentage of total EU and world publication output; absolute number of citations; number of citations as a percentage of total EU and world figures; absolute citation impact (ACI, average number of citations per publication per 5-year period); relative citation impact (RCI, citation impact relative to the EU and world ACI); and the percentage of papers receiving citations during the period of investigation.

All data in tables and figures are presented in running 5-year periods.

The survey is based on publication and citation data extracted from the relational software product National Science Indicators (NSI), 2001 Deluxe Edition, produced by the Institute for Scientific Information (ISI), Philadelphia, PA. NSI covers the period 1981–2000 for approximately 100 scientific domains and almost all countries of the world. It contains the publication types: journal articles, research notes, and review articles from the Science Citation Index (SCI), Social Science Citation Index and Arts and Humanities Citation Index, all originally produced by ISI. More than 6000 international journals are covered by NSI. For Denmark, it has been shown that in the domain of medicine, NSI provides journal coverage of approximately 75%, while the coverage of internationally published health research articles is close to 90% (12).

For each publication all the authors and their national affiliation at publishing time are indexed in the citation databases and hence in NSI. The European Union (EU) as well as the research field in question (the world) form baselines. This implies that the international cooperation between countries has been cleaned up, so that possible overlaps of publications, for instance within the EU, have been deleted. It hence becomes possible to directly compare the Nordic countries to the EU as well as to the world for publication and citation activities.

Each research domain in NSI is covered by a number of journals corresponding to the list in Current Contents, produced by ISI. The list for anaesthesia and intensive care (including emergency medicine and pain therapy) is shown as Appendix A.

Articles on anaesthesia and intensive care from general journals such as *Nature* and *Science* are classified to their proper domain and thus included in the NSI data presented in this article.

In NSI, citation analysis can be done within this so-called ISI landscape, that is, citations to a country are counted from all journals indexed by ISI in the citation databases. Citations from books, journals outside the ISI 'world', and from conference papers are thus *not* counted in NSI. Hence, both publication and citation analysis performed on NSI data mirror the international visibility and impact of *central* journal publications – foremost published in English.

Results

Publication analysis

The publication volume of the selected countries: Denmark, Norway, Finland, Sweden, the Netherlands, and the UK, as well as the EU region and the world, is shown in Table 1 and Fig. 1. Overall, the European Union (EU) and the world show a comparable, steady increase in publication output (corresponding to 148% and 142%, respectively).

The Danish publication growth is slightly negative from the period 1985–89 onwards (Fig. 1), Sweden and Norway both demonstrate a positive growth after 1990, while Finland increases its output throughout the entire 20-year period. The Netherlands sees a steady increase of 146%, similar to the EU and world figures (Table 1). Likewise, the UK shows a uniform, yet smaller increase of 100%.

As regards the national shares of the total EU publication output, Sweden and Denmark see a considerable decline, with Sweden's share falling from 11.1% to 6.1% and Denmark's from 6.4% to 2.7%. On the whole, Finland and Norway keep their positions (4.5% to 4.0% and 1.6% to 1.5%, respectively). Over the same period, the Netherlands also sustains a constant share (4.7% to 4.6%), while the UK shows a decline from 39.6% to 32.0%.

With respect to world publication shares, the relative changes for all six countries are practically identical to those seen in the corresponding EU shares. Thus, Sweden and Denmark experience a marked decrease (4.6% to 2.5% and 2.6% to 1.1%, respectively), while Finland (1.8% to 1.7%) and Norway (0.7% to 0.6%) demonstrate a rather constant contribution. Similarly, the Netherlands' share remains constant (1.9%) while the UK sees a decline from 16.2% to 13.4%.

Citation analysis

Table 2 and Fig. 2 show the development in total number of citations in the investigated countries. The EU and the world show a parallel increase of 241% and 227%, respectively. Of the Nordic countries, Norway

Table 1

Publications 1981–2000.

Publications	Denmark	Finland	Norway	Sweden	Netherlands	UK	EU	World
1981–85	277	195	70	485	203	1726	4354	10,656
1982–86	308	200	81	507	222	1851	4564	11,222
1983–87	322	199	86	502	228	1955	4790	11,964
1984–88	355	219	94	553	256	2109	5211	12,983
1985–89	380	243	103	581	278	2184	5677	14,044
1986–90	371	273	101	542	302	2283	6058	14,846
1987–91	351	300	100	540	323	2336	6327	15,552
1988–92	341	316	96	509	349	2456	6585	16,170
1989–93	329	346	107	495	363	2536	6900	17,117
1990–94	301	340	102	489	379	2709	7234	17,967
1991–95	310	368	135	527	378	2880	7660	19,409
1992–96	315	375	149	572	410	3090	8329	20,937
1993–97	306	407	165	630	426	3191	8992	22,459
1994–98	306	402	168	643	461	3356	9740	23,709
1995–99	315	425	177	683	474	3384	10,250	25,010
1996–00	293	427	160	657	499	3457	10,807	25,839

Numbers in bold indicate periods of decline.

(Source: National Science Indicators, ISI, 2001).

and Finland show the largest increase (315% and 263%), considerably above Denmark and Sweden (118% and 83%, respectively).

Analogously with the findings of the publication output analysis, Sweden and Denmark show a significant decline in EU citation shares (14.9% to 8.0% and 6.2% to 4.0%, respectively), whereas Finland (4.6% to 4.9%) and Norway (1.7% to 2.1%) both present a slight increase in citation visibility. The Netherlands sees a decrease from 7.4% to 5.5% while the UK declines substantially from 46.2% to 31.0%.

Not surprisingly, the trend within the EU is paralleled by changes in world citation shares: Sweden (5.7% to 3.2%) and Denmark (2.4% to 1.6%) again present major decreases, while Finland (1.7% to 1.9%)

and Norway (0.6% to 0.8%) both gain ground. At the same time, the shares of the Netherlands (2.8% to 2.2%) and the UK (17.5% to 12.2%) clearly decrease.

Citation impact analysis

The citation impact can be shown as two indicators: (1) the *absolute citation impact (ACI)* which signifies the *average* number of citations received per publication for a given time period, i.e. 5 years in the present study; and (2) the citation impact *relative to a baseline*, e.g. the EU or the world, for a similar period in the same field.

The ACI development over time for all six investigated countries can be derived from Tables 1 and 2. The ACI of all the four Scandinavian countries increases significantly during the period, ending comfortably above the EU and world levels. By contrast, the ACI of the Netherlands undergoes no net change and is surpassed by the Scandinavian countries by 1994–98. The UK finishes significantly below the other five countries, as well as slightly below the EU level. Both the EU and world ACI show a distinct net increase from 1991–1995 onward.

The citation impact of the Scandinavian countries relative to the EU is seen in Fig. 3. The citation impact (RCI) relative to both the EU and the world increased for Denmark, Finland, and Norway, while that of Sweden remained practically unchanged. However, all the Scandinavian countries did demonstrate substantial fluctuations over the entire period.

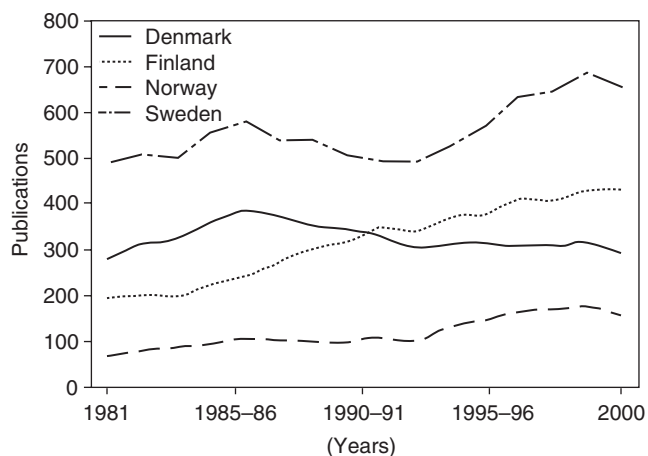


Fig. 1. Publications in Anaesthesia and Intensive Care in the Scandinavian countries 1981–2000 (Source: National Science Indicators, ISI, 2001).

Table 2

Citations 1981–2000.

Citations	Denmark	Finland	Norway	Sweden	Netherlands	UK	EU	World
1981–85	595	441	164	1430	713	4428	9582	25,300
1982–86	637	460	238	1606	798	4370	10,118	26,268
1983–87	569	353	213	1626	666	4743	10,087	26,923
1984–88	691	376	267	1654	704	4996	10,678	28,296
1985–89	765	436	300	1760	633	5091	11,423	30,331
1986–90	738	527	235	1551	744	5022	11,603	31,121
1987–91	797	688	268	1560	722	4994	12,419	33,657
1988–92	882	777	266	1400	845	5384	13,173	36,338
1989–93	1055	999	231	1214	990	5855	14,589	40,174
1990–94	1026	998	198	1221	1101	6307	15,369	42,721
1991–95	1010	1047	204	1396	1211	6508	16,419	47,892
1992–96	1300	1129	317	1779	1579	7765	20,537	58,828
1993–97	1217	1251	437	2370	1605	8462	23,973	68,047
1994–98	1070	1329	574	2371	1583	8655	26,061	73,246
1995–99	1238	1564	738	2733	1630	9257	29,183	80,213
1996–00	1300	1604	681	2621	1807	10122	32,663	82,674

Numbers in bold indicate periods of decline.
(Source: National Science Indicators, ISI, 2001).

Percentage of cited papers

Table 3 shows the percentage of cited papers (including self-citations) over 5-year running periods. It appears that the percentage of papers cited at least once increased in all the Scandinavian countries from approximately 55% (Sweden 63%) to approximately 70%, with Denmark and Norway showing the most pronounced increases.

The absolute and relative growth seen by Denmark, Finland, and Norway exceeds that of the Netherlands and the UK, as well as the EU and the world. Sweden presents an increase below the EU and world mean. However, owing to its high initial figure, Sweden finishes on the same level as the other Scandinavian countries.

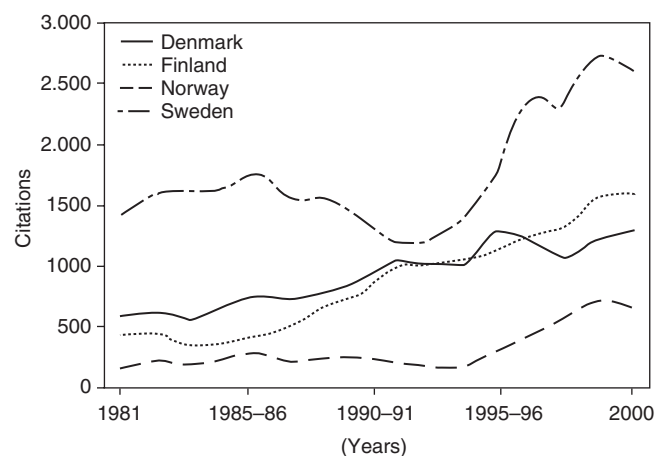


Fig. 2. Citations in Anaesthesia and Intensive Care in the Scandinavian countries 1981–2000 (Source: National Science Indicators, ISI, 2001).

Discussion

The main findings of our study can be summarized as follows:

1. The annual number of publications from Sweden, Norway, Finland, the Netherlands, the UK, the EU, and the world has increased significantly since the late eighties – as opposed to the net stagnation seen in Denmark during the same period.
2. The international publication and citation visibility of both Danish and Swedish anaesthesiological research has decreased over the past 20 years of the twentieth century, whereas that of Finland and Norway has increased slightly.
3. As judged from the increase in absolute citation impact, in citation impact relative to the EU and the world, and in the percentage of papers cited at least once, the recognition of publications from the Scandinavian countries has increased over the same period. Apparently, this is caused primarily by a larger proportion of papers obtaining citations. Conversely, we observe that the UK's decline in citation impact is mainly due to fewer papers being cited.

Methods

A systematic research survey like the present study encounters several methodological problems. First and foremost, the ambition of 100% publication coverage within a given medical speciality is impossible to achieve by use of the available scientific databases, alone or in combination. This is mainly due to limitations in journal coverage for SCI and NSI. For Medline, the limitation lies in the lack of affiliations for all

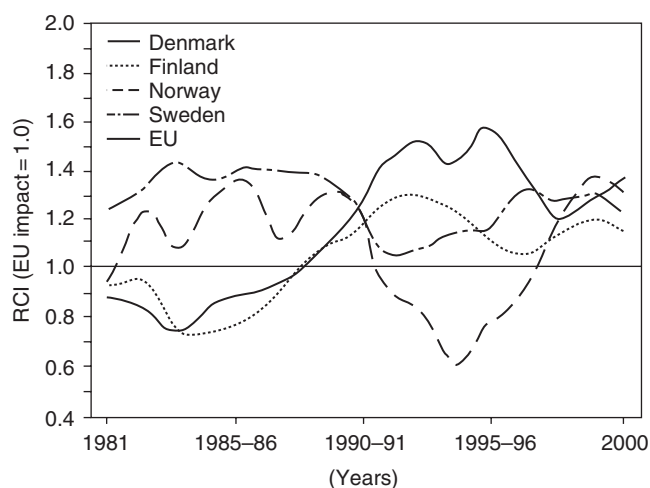


Fig. 3. Citation impact of the Scandinavian countries relative to total EU citation impact in Anaesthesia and Intensive Care 1981–2000 (Source: National Science Indicators, ISI, 2001).

secondary authors; it is estimated from tests of first vs. secondary authorships in internationally co-authored papers that approximately 20% of the national contributions will be omitted from analysis (12). In the case of NSI, national (non-English) and regional journals are generally not included. Furthermore, there can be a considerable replacement of journals over a given time period, especially within the group of journals with a low Journal Impact Factor (JIF) (13). When a journal disappears from the database, so do all its citations to other publications. Naturally, this may affect national visibility. Moreover, each research domain is covered by a number of specific journals; this implies that articles from one domain that are

published in another Current Contents category (not an unusual phenomenon) will not be retrieved in a specific domain search.

Finally, the list of journals covering a given domain may be criticized, as different countries have particular strengths and weaknesses within specific scientific subspecialties (14). We do recognize that within the NSI domain of anaesthesia and intensive care, the specialties of pain and regional anaesthesia are only represented by one single journal (*Regional Anaesthesia and Pain Medicine*, Appendix A).

With due consideration of these reservations, we believe that our study design provides the best achievable survey of *central* publications produced by Scandinavian anaesthesiologists over a twenty-year period. The SCI/NSI landscape permits a simple, efficient and reproducible domain search on a national and international level. Compared with other established databases such as EMBASE and MEDLINE, SCI offers the distinct advantage of listing all co-authors and institutions as well as received citations. Thus, SCI/NSI has been shown to provide almost 90% coverage at an article level for all Danish health science research. This figure can justifiably be applied to the other Scandinavian countries as well (12), while corresponding data for the UK and the Netherlands are not presently available.

Publication analysis

Two previous studies by Pomaroli et al. (15) and Boldt et al. (16), although using different methodologies, permit a rough evaluation of the development during the 10-year period from 1987 to 1997. In the period

Table 3

Proportion of cited papers 1981–00.

Cited papers	Denmark	Finland	Norway	Sweden	Netherlands	UK	EU	World
1981–85	52.71	54.87	53.51	62.68	56.65	52.75	50.71	52
1982–86	51.62	55.72	62.19	63.08	55.4	52.36	51	51.35
1983–87	50.15	51.5	58.61	59.34	56.14	55.24	49.9	50.69
1984–88	52.38	51.82	67.01	59.14	57.81	53.48	49.88	50.56
1985–89	54.71	53.69	62.13	63.65	52.52	52.41	48.87	50.07
1986–90	54.15	54.74	56.43	60.69	53.97	52.76	47.69	50.24
1987–91	55.52	55.15	53.99	60.37	52.01	49.85	47.41	50.98
1988–92	52.92	60.57	52.08	62.08	55.3	51.61	48.73	52.47
1989–93	59.57	63.69	52.33	60.6	55.37	51.71	48.92	52.36
1990–94	62.12	63.05	56.43	61.24	55.61	50	48.04	51.64
1991–95	57.42	61.79	53.54	59.92	55.49	48.58	47.69	51.46
1992–96	64.12	63.46	57.85	63.03	59.5	50.86	51.31	54.56
1993–97	68.95	65.27	66.45	63.52	62.23	55.11	55.03	57.35
1994–98	67.97	66.33	67.3	68.54	62.58	54.54	55.4	58.08
1995–99	71.11	66.12	70.62	67.2	66.88	57.39	58.19	60.83
1996–2000	69.28	67.45	71.88	67.28	67.13	58.4	59.11	61.02

Consecutive periods in bold for comparison and trend analysis. (Source: National Science Indicators, ISI, 2001).

1987–91, the UK was second after USA in absolute figures; Sweden was no. 7, Denmark no. 9, followed by the Netherlands, Finland, and Norway. In terms of publications per million inhabitants (PpM), the first four positions were occupied by the UK, Denmark, Sweden, and Finland, respectively, with the Netherlands as no. 10 and Norway as no. 16 (15). By 1996–97, with respect to total items, the UK was still second after the USA but had dropped to sixth place in terms of PpM, followed by (publications/PpM): Sweden (no.7/2), Finland (no. 10/1), Denmark (no. 12/4), the Netherlands (no. 13/16), and Norway (no. 18/9) (16).

In a third, newly published study by Figueredo et al. (17), the geographic distribution of articles published in the 1997–2001 period in 10 core journals in anaesthesia and intensive care was analyzed. The PpM data in this study clearly indicate a continuation of the trend established in the first two studies, ranking Finland first, Sweden second, Denmark third, the UK seventh, Norway tenth, and the Netherlands fifteenth in publications per million inhabitants.

The three above-mentioned studies all surveyed the publication output from various countries in important anaesthesia journals. They were limited to specific journals and time periods and employed different search strategies; however, if used as reference points (for lack of directly comparable studies), they do support our findings to a large extent. Note in particular the decline of Denmark and the UK, accompanied by Finland's steep ascension to first position in PpM.

In another recent, more specific analysis of publications in the subspecialty of paediatric anaesthesia (18), the UK ranks above Sweden in publication number, followed by Denmark and the Netherlands. In PpM, Denmark surpasses the UK, Sweden, and the Netherlands, respectively. Finland and Norway are not listed among the top 13 countries. These findings clearly differ from those of the three general surveys, thus illustrating the differences in scientific standing of individual nations within a single anaesthesiological subspecialty.

As for the Danish decline in publication output throughout the nineties, this finding has previously been replicated in a national study showing a 15% decrease in the annual production of anaesthesia papers during the 7-year period, 1992–98 (6).

In all the international studies mentioned (15–18), it is noted that small highly industrialized nations make over-proportional contributions to the total publication output. This is consistent with a recent analysis on world publication output covering science and engineering as well as medicine (19).

Citation analysis

In our qualitative evaluation, we have used citation impact as the principal parameter. By accumulating the number of actual citations given to the published articles, their 'true' impact is reflected. This is in accordance with current bibliometrical standards (13, 20, 21), as opposed to using the journal impact factor (JIF) which only provides information on the *average* number of peer citations given during 1 year to papers published in a specific journal over the previous 2 years. Thus, it is well established that the JIF can be grossly misleading when used as a measure of an individual article's impact (1, 14, 22–26).

The citation impact itself does not necessarily mean quality but signifies an explicit use and recognition of the cited work, as it has been put onto a reference list by an investigator (including the author himself as a self-citation). The impact in one domain cannot be directly compared with other domain impacts, because the number of citations is dependent on the publication and citation behaviour of the researchers in the field and the amount of publications actually providing citations (14).

To our knowledge, our study is the first research survey in the field of anaesthesia that employs an actual citation count rather than the JIF. Consequently, our findings cannot be directly collated to any previous studies. It would be an interesting exercise to compare our work with a corresponding compilation covering the same time period and using the journal impact factor as a qualitative parameter, if such a study existed. However, the three available studies using the JIF provide only limited basis for comparison. The analysis on paediatric anaesthesia (18) is a subspecialty study that cannot be correlated with the entire domain of anaesthesia and intensive care. Further, it lists the whole of Scandinavia as one geographic entity. The study by Boldt et al. (16) covers only the period 1996–97 and lists 30 journals divided into five different subspecialties. Total JIF and JIF per million inhabitants are used as impact parameters. Within the group of general anaesthesia journals, Finland ranks first, Sweden second, the UK fourth, Denmark sixth, the Netherlands fifteenth, and Norway sixteenth in JIF per million inhabitants. Figueredo et al. (17), on the other hand, uses 'mean national JIF' (total JIF score divided by total number of publications) to measure the impact of national contributions. Assessed in this manner, the Netherlands ranks second (after USA), followed by the UK, Finland, Sweden, Denmark, and Norway, respectively.

Publication and citation visibility

Despite the parallel increases in citation impact parameters among the Scandinavian countries seen in recent years, we have found a decreasing publication and citation visibility of Danish and Swedish anaesthesiological research. (It should be kept in proper perspective, though, that Sweden is still the undisputed leader among the Scandinavian countries in terms of absolute publication and citation figures [Tables 1,2]). What possible causes of this development can be proposed?

No simple explanation seems to be at hand; for instance, the development in publication output cannot be ascribed to national differences in healthcare expenditure. Traditionally, expenditure is defined as the percentage of the Gross Domestic Product (GDP) accounted for by the healthcare sector. However, as this parameter is highly sensitive to changes in GDP, a more accurate measure of healthcare expenditure is the actual expenditure per head of population. Calculated in this way, Norway has the third highest healthcare expenditure among the OECD countries, followed by Denmark as number five and the Netherlands as number eight (1998 figures) (27). All three countries are above the unweighted OECD average. Sweden is number 13, corresponding to the average OECD expenditure, while Finland and the UK as numbers 14 and 15, respectively, are below average. These figures illustrate that factors beyond overall healthcare expenditure must account for Finland's progress and Denmark's decline during the nineties.

One of several other possible reasons might be that research, including biomedical science, has been a domain of calculated and increasing priority in those Scandinavian countries that have enhanced their visibility in anaesthesiological research during the two decades investigated – as opposed to those who have not. Thus, a possible explanation of the pronounced progress in Finland is the high priority given by the Finnish government and health authorities to research and development during the eighties. Further, the dissolution of the former USSR in the early nineties created an economic crisis in Finland that led to the closing of several publications of the type 'Acta Universitatis' (not registered by ISI), which had previously been funded and published by Finnish universities. Plausibly, this may have increased the need for Finnish researchers to aim for publication of their work in international journals. By contrast, the prevailing political priority in the Danish health care system in recent years has been clinical productivity at the expense of academic medicine.

Also, a persisting lack of hospital doctors, caused by a markedly restricted intake of medical students from the late seventies to the early nineties might play a role. The lack of doctors has resulted in less competition for specialist positions and hence less need for meriting oneself through research. As a result, it is no longer compulsory in Denmark to publish extensively in order to obtain promotion to consultant level at university hospitals. Rather, the nominations for leading medical positions are increasingly determined by the applicants' administrative qualifications rather than their scientific merits.

It remains to be seen how national political and structural changes – and recent initiatives taken within the specialty in the Scandinavian countries (28) – will affect Nordic anaesthesia research.

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Appendix A

Current Contents (ISI) – Anaesthesia and Intensive Care Journal List

Academic Emergency Medicine
 Acta Anaesthesiologica Scandinavica
 American Journal of Emergency Medicine
 Anaesthesia
 Anaesthesia and Intensive Care
 Anaesthesist
 Anaesthesiologie und Intensivmedizin
 Anesthesia and Analgesia
 Anesthesiology
 Annales Francaises d'Anesthesie et de Reanimation
 Annals of Emergency Medicine
 British Journal of Anaesthesia
 Canadian Journal of Anaesthesia –
 Journal Canadien d'Anesthesie
 Critical Care
 Critical Care Clinics

Critical Care Medicine
 Emergency Medicine Clinics of North America
 Emergency Medicine Journal
 European Journal of Anaesthesiology
 Injury – International Journal of the Care of the Injured
 Intensive Care medicine
 International Journal of Obstetric Anesthesia
 Journal of Cardiothoracic and Vascular Anesthesia
 Journal of Clinical Anesthesia
 Journal of Critical Care
 Journal of Emergency Medicine
 Journal of Intensive Care Medicine
 Journal of Neurosurgical Anesthesiology
 Journal of Trauma – Injury, Infection, and
 Critical Care
 Paediatric Anaesthesia
 Regional Anesthesia and Pain Medicine
 Resuscitation
 Shock