

ново
нордиск
фонден



Societal impact of
Novo Nordisk Foundation
Grants 2018

The Foundation's
vision is to contribute
significantly to
research and
development that
improves people's
lives and the
sustainability of society.



Societal impact of
Novo Nordisk Foundation
Grants 2018

Contents



Chapter 1

Creation of knowledge and research talent

Foreword	7
The Impact Report 2018 at a glance	9
Summary	10

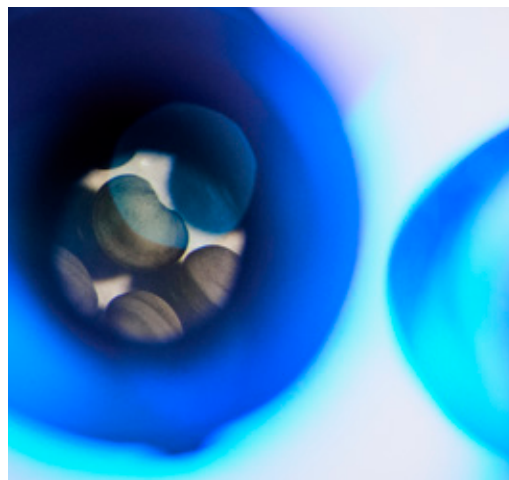
1	Creation of knowledge and research talent	25
1.1	Creation of knowledge: journal articles and collaboration across institutions, fields of science and countries	25
1.2	Research talent: PhD students and postdoctoral fellows	31



Chapter 2

Dissemination and use of knowledge within the public sector

2	Dissemination and use of knowledge in the public sector	47
2.1	Dissemination and use of knowledge in academia	47
2.2	Public healthcare	76
2.3	Three cancer projects	87



Chapter 3

Dissemination and use of knowledge within the private sector

3	Dissemination and use of knowledge in the private sector	99
3.1	Grant recipient collaboration with companies	99
3.2	Dissemination and use of public research in patents	110
3.3	Impact of innovation programmes	120



"The overall conclusion of the report is that investing in research and development in society contributes to creating knowledge, employment, growth, innovation and invention of products and services to benefit people."

Lars Rebien Sørensen, Chairman, Board of Directors,
Novo Nordisk Foundation.

Foreword

The Novo Nordisk Foundation has a vision to contribute significantly to research and development that improves the lives of people and the sustainability of society. Through our grant-awarding activities for public research, we want to promote excellent research and innovation, development of talent at all career stages and world-class education.

We are a Danish foundation with corporate interests. We see investment in science in the public and private sector as vital to continuing growth and for improving the health and welfare of people. One of our missions is to develop knowledge-based environments in which innovative and talented people can carry out research of the highest quality and translate discoveries into new treatments and solutions. Through our investment in public research, we promote the creation of new knowledge, we improve education, and we support innovation and the development of new medicine, prevention and treatment to benefit people and society.

This Impact Report 2018 provides analyses about the outputs, outcomes and impact of the research activities of our grant recipients. It documents the results of the activities in 2018 and earlier years.

We hope you will enjoy reading the analysis.



The Novo Nordisk Foundation's grant-awarding activities lead to actions that address many of the UN Sustainable Development Goals:



No Poverty



Good Health and Well-Being



Quality Education



Industry, Innovation and Infrastructure



Reduced Inequalities



Sustainable Cities and Communities



Partnerships for the Goals

The Impact Report 2018 at a glance

- In 2018, our grant-awarding activity delivered the following results:
 - We paid out DKK 1.7 billion equivalent to an estimated 7% of the expenditure on public research in Denmark.
 - We received 2614 applications and awarded DKK 3.9 billion in 463 grants.
 - Our funds fully or partly supported 3000 people in science.
 - We funded 8% of the PhD students in Denmark.
 - Our grant recipients reported 2876 new publications.
 - 63 spin-outs supported by our innovation programmes (2007–2018) employed more than 350 people and attracted DKK 3.3 billion in additional funding.
- In 2017, our grant recipients published 6.8% of the journal articles originating from Denmark.
- Of the journal articles based on research that we have funded in 2018 and earlier:
 - 23% were among the world's 10% most frequently cited articles in 2014–2016.
 - 53% were co-authored with international researchers.
 - 11% were co-authored with researchers from industry.
 - 5.8% were cited in patent documents in 1994–2017.
 - 55% of grant recipients' journal articles were published by interdisciplinary research teams in 2015–2017.
 - Interdisciplinary research teams had a higher share of articles among the world's 10% most frequently cited articles.

Summary

Chapters 1, 2 and 3 of the Impact Report 2018

This summary recaps the broad findings in Chapters 1, 2 and 3 of the Impact Report 2018. Chapter 1 focuses on creation of knowledge and research talent. Chapter 2 analyses the dissemination and use of knowledge in the public sector. The focus is on the research community and the public health sector. Chapter 3 presents analyses of the private sector dissemination and use of Foundation-funded public research and the impact of the innovation programmes of the Foundation.

The three chapters also present results from the following in-depth analyses and evaluations

- analysis of interdisciplinary collaboration in Foundation-funded journal articles;
- study on PhD students and postdoctoral fellows funded by the Foundation;
- study on three cancer research projects;
- citation peak analysis – how long journal articles take to peak in citations;
- analysis of citation spread across open-competition grants;
- analysis on the disruptive content of Foundation-funded research; and
- study on the Foundation's pre-seed and exploratory pre-seed grants.

Chapter 1

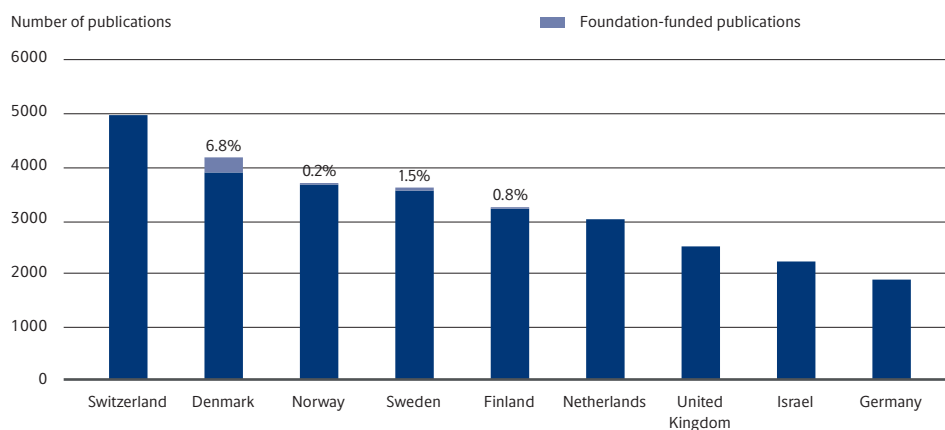
Creation of knowledge and research talent

Creation of knowledge: publications

The Foundation's grant-awarding activities have historically focused on scientific purposes, mainly for research in the medical and health sciences. The Foundation has increasingly contributed to Denmark's top placements in international research rankings with its substantial share of public research funding. Researchers in Denmark published more journal articles per million population than researchers in most other European countries in 2017. Only researchers in Switzerland published more articles per million population (Figure 1). The recipients of Foundation grants published 329 publications per million population, which is 6.8% of the journal articles from Denmark.

Figure 1

Number of publications per million population in selected countries, 2017

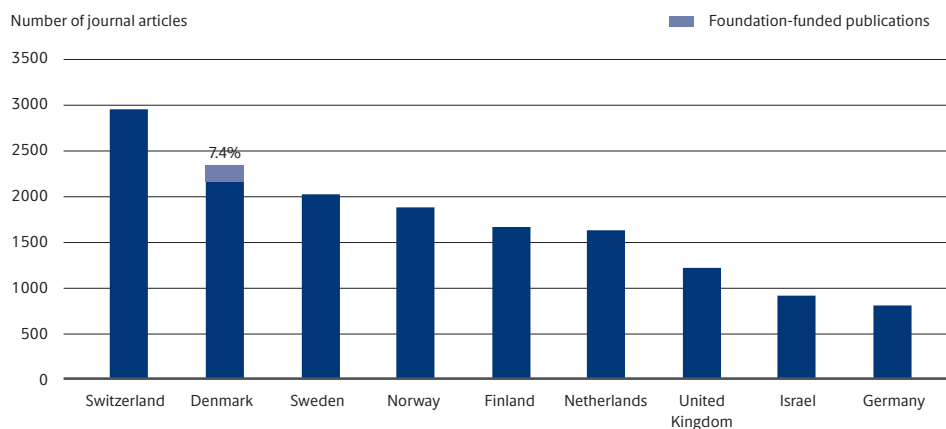


Sources: Novo Nordisk Foundation/researchfish® and the European Commission (European Innovation Scoreboard).

International research collaboration

In 2017, 2346 academic journal articles with international co-authors were published per million population in Denmark, second to Switzerland (2946 per million population). The number for Denmark includes 173 articles per million population by the recipients of Foundation grants (Figure 2). Grant recipients account for 7.4% of the journal articles across all scientific fields in Denmark. Moreover, 53% of their journal articles were co-authored with international researchers in 2014–2018.

Figure 2 Journal articles with international co-authors per million population in selected countries, 2017



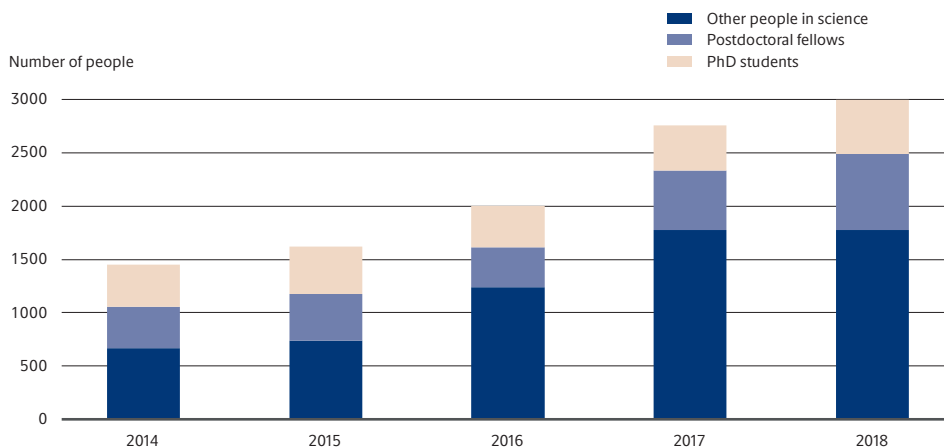
Sources: Novo Nordisk Foundation/researchfish* and the European Commission (European Innovation Scoreboard 2018).

Research talent: PhD students and postdoctoral fellows

In 2018, the Foundation's grant-awarding activity fully or partly funded 2998 people within science. This was 203 people more than in 2017. The Foundation's direct support for people within science has been steadily increasing since 2014, (Figure 3).

Figure 3

Number of people in science supported fully or partly by Foundation grants, 2014–2018



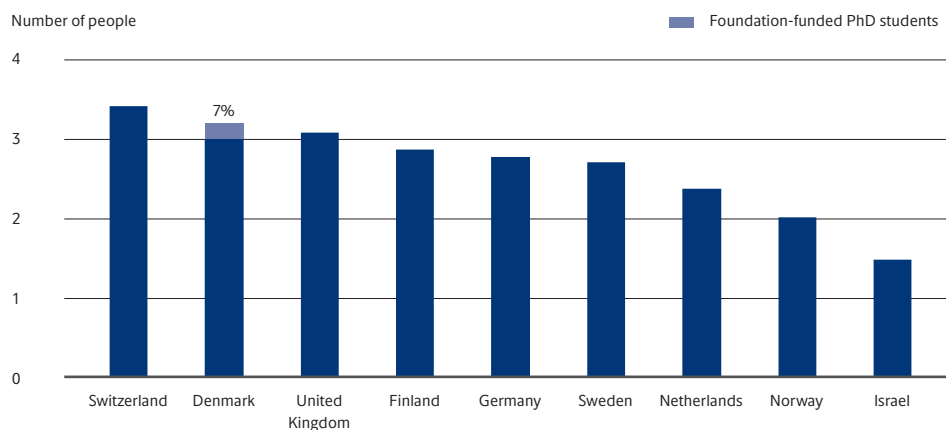
Source: Novo Nordisk Foundation/researchfish*.

In 2018, the Foundation fully or partly funded 506 PhD students and 719 postdoctoral fellows, an increase from 2014 (Figure 5). The Foundation currently funds about 8% of all PhD students in Denmark. In 2017, the Foundation funded 14.1% within the medical and health sciences and 6.6% within the natural sciences.

Denmark has the second highest number of new PhD graduates per 1000 population in Europe. Figure 4 shows that the number of new PhD graduates per 1000 population 25–34 years old in Denmark is higher than in all other countries except Switzerland in 2016 (data for 2017 or 2018 are not yet available). In 2016, Denmark produced 3.2 new PhD graduates per 1000 population. Of all new PhD graduates, the Foundation funded about 0.2 per 1000 population (equivalent to 7% of all new graduates).

Figure 4

New PhD graduates per 1000 population 25–34 years old in selected countries in 2016



Sources: Novo Nordisk Foundation/researchfish® and European Commission (European Innovation Scoreboard 2018).

Chapter 2

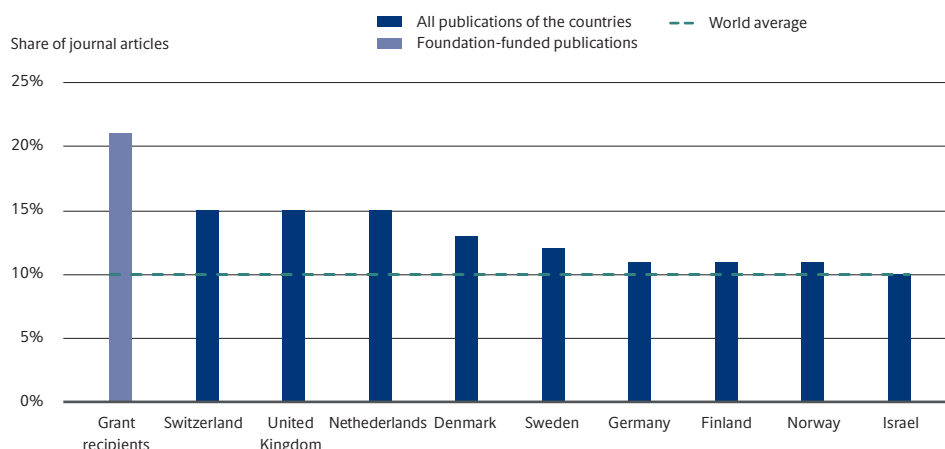
Dissemination and use of knowledge within the public sector

Dissemination of journal articles within academia

Denmark ranks high worldwide in terms of the world's 10% most frequently cited articles per million population. In terms of cited articles, the Foundation's grants support activities that increases the average level in Denmark, since 21% of the grant recipients' journal articles (in 2015) are among the world's 10% most frequently cited articles versus 13% for all journal articles from Denmark (2015-figures). This overall share is higher for researchers in the Netherlands, United Kingdom and Switzerland (Figure 5).

Figure 5

Share of all journal articles in the top 10% most frequently cited articles worldwide in selected countries, 2015

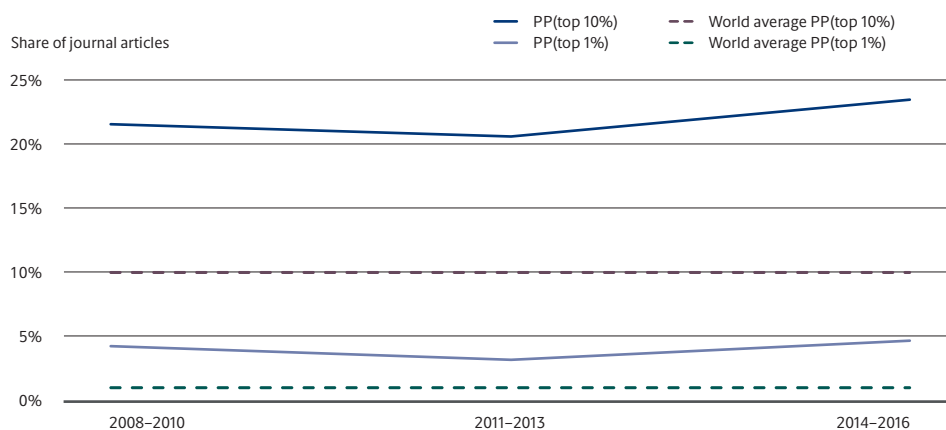


Sources: Novo Nordisk Foundation/researchfish® and European Commission (European Innovation Scoreboard 2018).

Figure 6 shows the trend in citation impact of Foundation-funded journal articles from 2008 to 2016. The share of journal articles of the grant recipients of the Foundation among the 10% most frequently cited journal articles in the world increased from 20.6% in 2011–2013 to 23.4% in 2014–2016. The share for 1% most frequently cited journal articles increased from 3.2% in 2011–2013 to 4.6% in 2014–2016.

Figure 6

Share of all journal articles by recipients of Foundation grants in the top 1% and top 10% most frequently cited articles worldwide



Sources: Novo Nordisk Foundation/researchfish® and the Danish Centre for Studies in Research and Research Policy.

Treatment of patients

Through the public–private partnership model of the Steno Diabetes Centers, the Foundation will support the advancement of all aspects of diabetes care in Denmark throughout the lifespan of people with diabetes. Until 2016, the Foundation supported the Steno Diabetes Center, which treated 5500 people in 2016. In 2017, it became Steno Diabetes Center Copenhagen. In 2018, an additional three Steno Diabetes Centers were established in Aarhus, Aalborg and Odense. In 2018 the four centres treated 20,480 people with diabetes: 45% with type 1 diabetes, 44% with type 2 diabetes and 4% children and young people. A Steno Diabetes Center will also be established in Region Zealand.

The services provided at the Steno Diabetes Centers include a wide range of diabetes health-care services, including endocrinological examinations and diagnoses, treatment of diabetes, eye scanning and examination, podiatry, dietary guidance and courses in a food laboratory. The Steno Diabetes Centers conduct clinical research activities, health promotion and education within diabetes.

Chapter 3

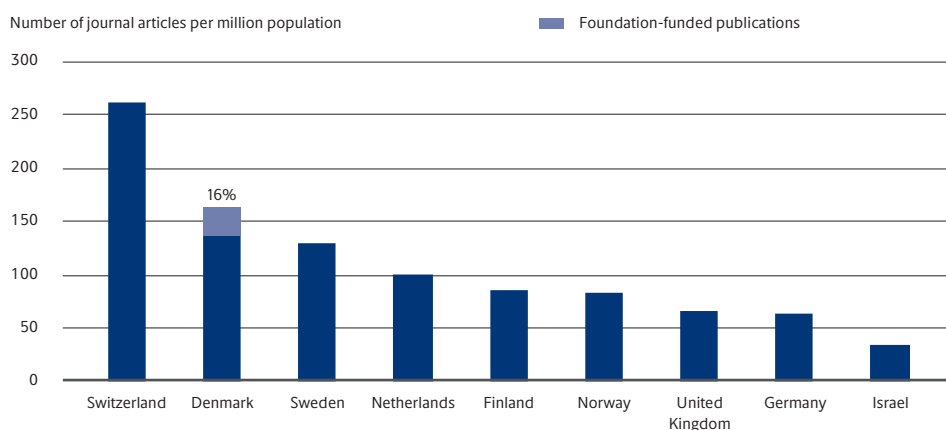
Dissemination and use of knowledge within the private sector

Academia-industry co-publications

Academia–industry co-publication and collaboration are important channels for disseminating public research to companies. Researchers in Denmark publish more academia–industry co-authored journal articles per million population than researchers in most other European countries (Figure 7). In 2017, Denmark published 163 academia–industry co-authored journal articles per million population; researchers in Switzerland had the highest production at 260 per million population. The recipients of Foundation grants published the equivalent of 26 academia–industry co-authored journal articles per million population based on Foundation grants. The Foundation funded 16% of the Danish academia–industry publications.

Figure 7

Number of journal articles co-author by academia and industry per million populations in selected countries, 2017

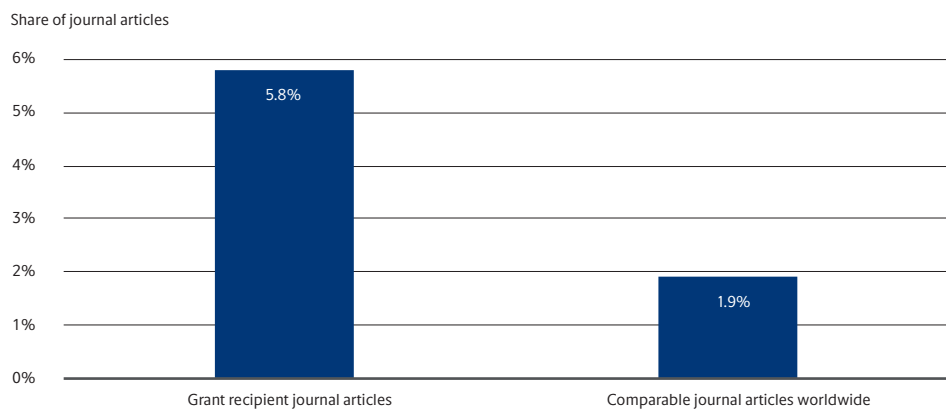


Sources: Novo Nordisk Foundation/researchfish* and European Commission, (European Innovation Scoreboard 2018).

Use of public research in patents

The Foundation's analysis shows that two-thirds of research-active companies in Denmark depend on access to public research and collaboration with universities. Further, Foundation-funded public research has led to 1 of 18 journal articles being cited in patents and patent applications – an indication of the quality, novelty and applicability. This share is three times higher than the world average share within the scientific fields the Foundation supports (Figure 8).

Figure 8 Percentage of journal articles cited by patent documents worldwide, 1994–2017



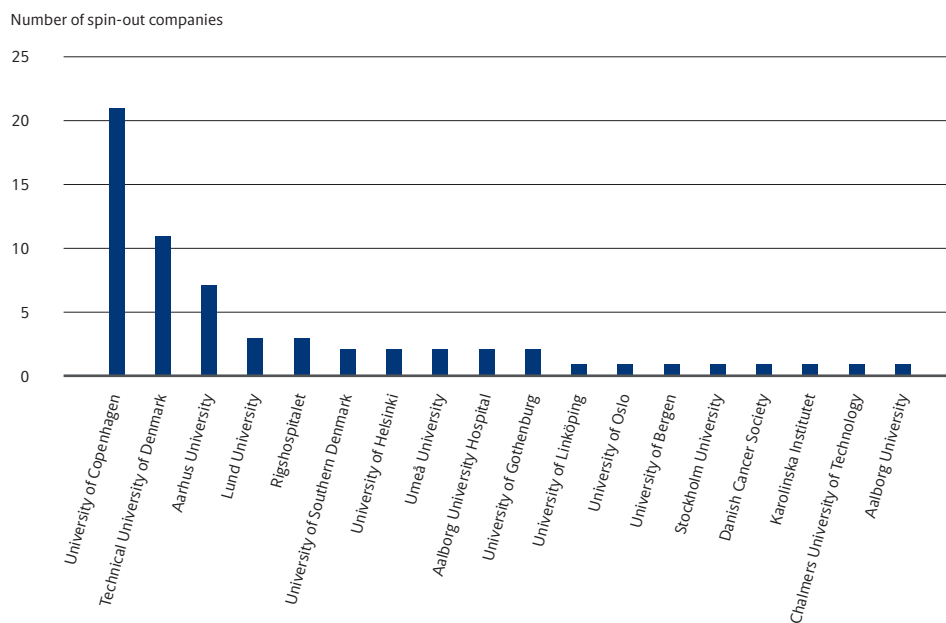
Note: The world average is based on a stratified random sample of 4842 journal articles matching the distribution of subject categories of Foundation-funded journal articles.

Source: Novo Nordisk Foundation.

Spin-outs from universities

The Foundation's innovation grants have created 63 spin-outs; of which 89% exist today, with total employment of 350 people in 2018. Figure 9 shows the distribution among universities and other institutions.

Figure 9 Origin of university spin-outs generated by exploratory pre-seed and pre-seed grants



Sources: Novo Nordisk Foundation/researchfish® and Accelerace.

Background

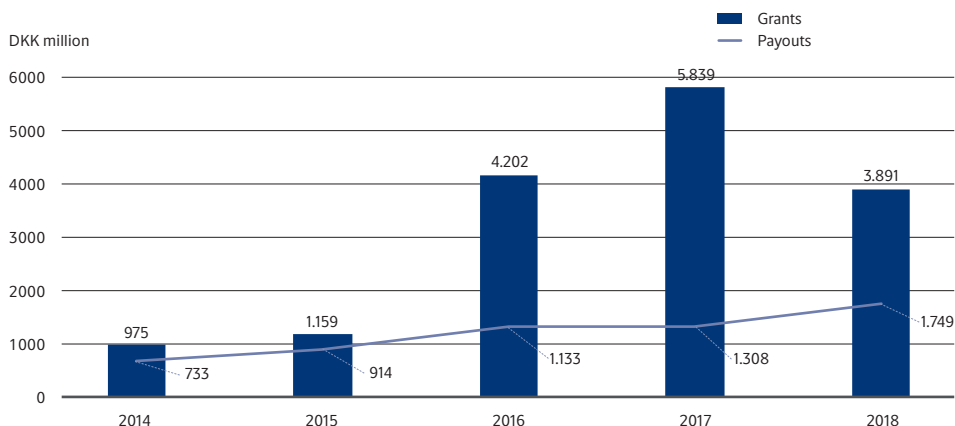
Background on funding public research in Denmark

Trends in the Foundation's grant-awarding and payouts

Since its beginning more than 90 years ago, the Foundation has primarily supported public research at universities and hospitals in Denmark and the other Nordic countries. The duration of a grant can vary from 1 to 13 years. From 2014 to 2018, the amount paid out doubled. In 2017 and 2018 combined, the Foundation awarded grants totalling nearly DKK 10 billion and paid out more than DKK 3 billion (Figure 10).

Figure 10

Grants and payouts from the Novo Nordisk Foundation, 2014–2018



Note: In 2018, the Foundation received 2614 applications and awarded DKK 3.9 billion in 463 grants.
 Source: Novo Nordisk Foundation/researchfish*.

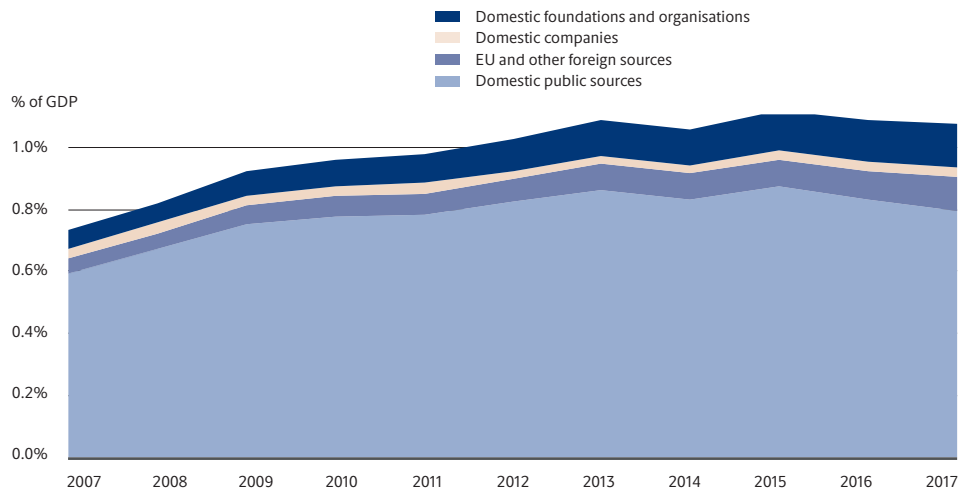
The Foundation's share of spending in public research in Denmark

Investment in public and private research in 2017 was DKK 66 billion, equivalent to 3% of gross domestic product (GDP). DKK 22.4 billion was invested in public research. The payout from the Foundation for public research amounted to 5.5% of the total investment in 2017. This share was expected to increase to 7% in 2018. Across the fields of research, this amounts to 15% of total public research spending in Denmark within the medical and health sciences, 7% within engineering and technical sciences, 3% within the natural sciences and 2% within the humanities.

The Foundation is one of many private domestic foundations and organisations supporting public research in Denmark. In 2017, their total share of funding for public research was 0.14% of GDP, up from approximately 0.06% of GDP in 2007 (Figure 11). In 2018, the Foundation's share of public research is expected to be approximately 0.08% of GDP, or almost half of that provided by the domestic foundations and organisations.

Figure 11

Expenditure in public research in Denmark as a percentage of GDP by funding source



Source: Statistics Denmark.

Chapter 1

Creation of knowledge
and research talent



1. CREATION OF KNOWLEDGE AND RESEARCH TALENT

The Foundation supports public research through a variety of grant types such as centres, programmes, projects and individual fellowships. This chapter presents the creation of knowledge and the support for research talent based on the Foundation's grants. The increase in grant amounts and payouts resulting from the Foundation's Strategy 2014–2018 has affected the level of activity, outputs and outcomes. In 2018, the Foundation paid out 30% more than in 2017, comprising an estimated 7% of the expenditure on public research in Denmark.

1.1 Creation of knowledge: journal articles and collaboration across institutions, fields of science and countries

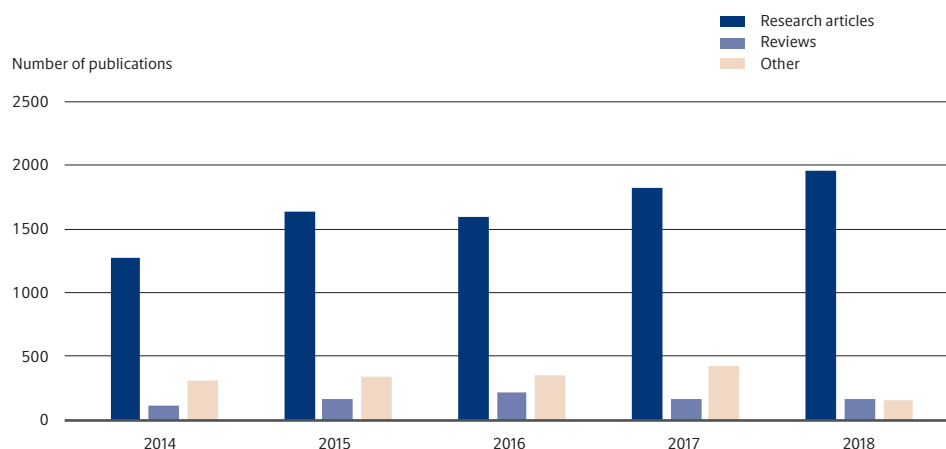
1.1.1 Production of journal articles

Since 1927, the recipients of Foundation grants have published more than 23,500 publications of which more than 10,700 have been published from 2014 to 2018. Because recipients of Foundation grants typically obtain additional funding and multiple authors contribute to a publication, the Foundation does not exclusively fund all these publications.

Researchers supported by the Foundation are required to report annually on the outputs and outcomes from the funded research. In January 2019 grant recipients reported 2876 new publications of which most were published in 2018. Of the publications published from 2014 to 2018 funded by Foundation grants, about 80% were journal articles (original research articles and reviews) and 20% were other types of publications, such as policy papers, technical reports, letters and book chapters (Figure 1.1).

Figure 1.1

Total number of publications published by recipients of Foundation grants, 2014–2018

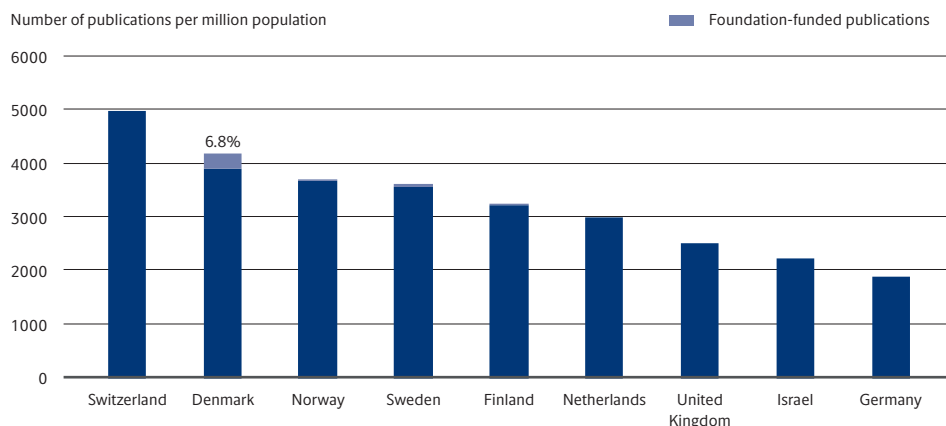


Source: Novo Nordisk Foundation/researchfish®.

Researchers in Denmark published more journal articles per million population in 2017 than researchers in most other European countries. Only researchers in Switzerland published more articles per million population (Figure 1.2). Grant recipients published 329 publications per million population based on Foundation grants, or 6.8% of the journal articles from Denmark.

Figure 1.2

Number of publications per million population in selected countries, 2017



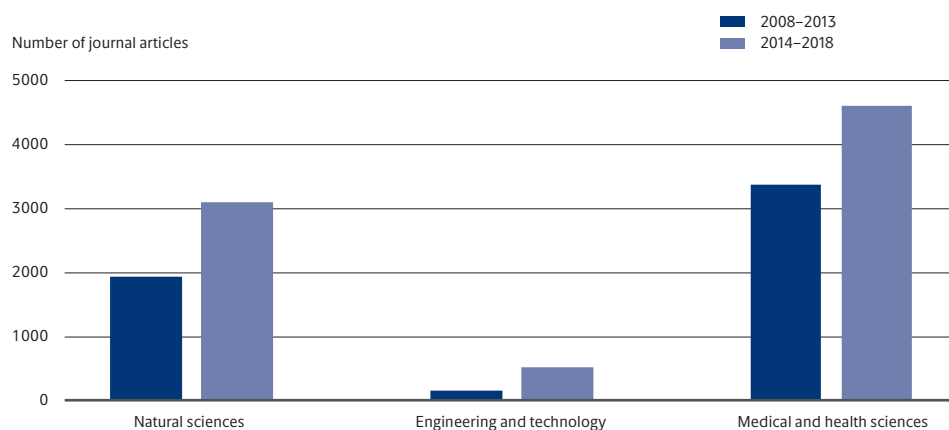
Sources: Novo Nordisk Foundation/researchfish® and the European Commission (European Innovation Scoreboard).

1.1.2 Fields of science for journal articles

Journal articles in the citation database Web of Science are registered according to the subject category assigned to the journal of publication. The OECD has aggregated these detailed subject categories into fields of science and technology. Figure 1.3 and Figure 1.4 show the number of Foundation-funded journal articles across the OECD-defined fields of science.

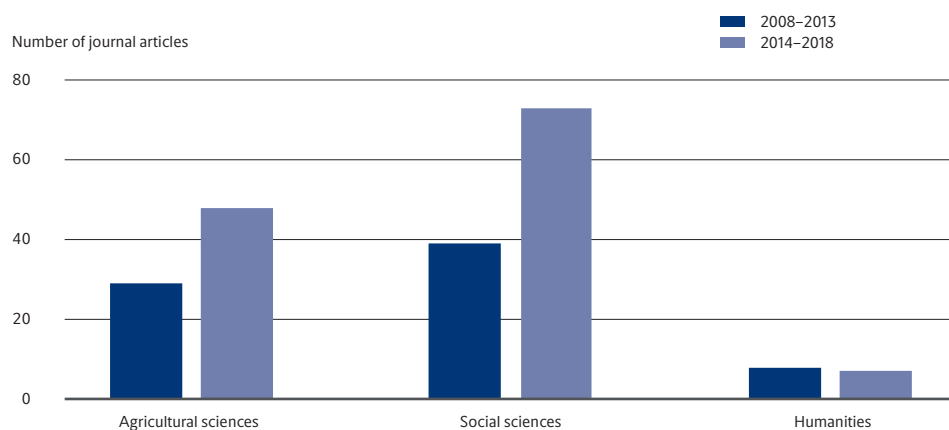
The number of journal articles increased substantially from 2008–2013 to 2014–2018. Because of delayed reporting, the 2014–2018 production will continue to increase. In 2014–2018, medical and health sciences (55%) was the most common field for Foundation-funded journal articles to be published in followed by natural sciences (37%) and engineering and technology (6%). The number of journal articles for the remaining fields (Figure 1.4) is very small, comprising 2% of all Foundation-funded journal articles.

Figure 1.3 Journal articles within the natural sciences, engineering and technology, and medical and health sciences



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Figure 1.4 Journal articles within agricultural sciences, social sciences and humanities



Note: Researchers within the humanities publish few journal articles. More often they publish books, book chapters, monographs and other formats.

Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

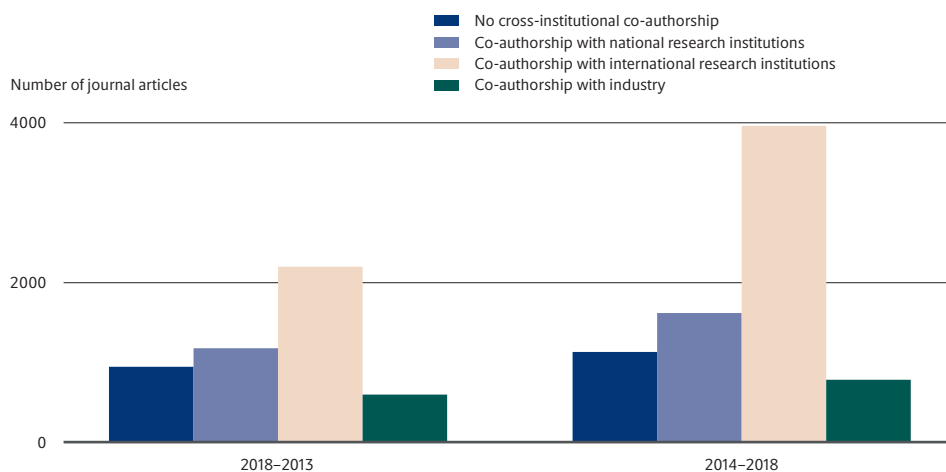
1.1.3 Co-authorship – sectoral and geographical collaboration

This section describes the co-authorship patterns of journal articles. The affiliations of the co-authors are used here to identify the nature of the sectoral and the geographical collaboration. Collaboration is important for research outcomes. Research collaboration crosses national borders and can involve both public researchers at such institutions as universities, hospitals, and industrial researchers. Collaboration results from a search- and match process between researchers with the main purpose of improving research outcomes. It can involve collaboration between disciplines (interdisciplinary collaboration) and lead to cross-disciplinary research. It can improve the dissemination and wider use of the knowledge generated, such as knowledge spillover from public sector research to private sector use and research and vice versa.

The journal articles are divided into the following types of collaboration: 1) articles co-authored with researchers from two or more national academic research institutions only, 2) articles co-authored with researchers from international, academic research institutions, and 3) articles co-authored with industrial researchers employed in companies. The remaining fourth group covers journal articles with a single author or with authors from the same organization (called “no cross-institutional co-authorship”). Figure 1.5 shows the number of articles by type of co-authorship.

Figure 1.5

Number of journal articles by co-authorship

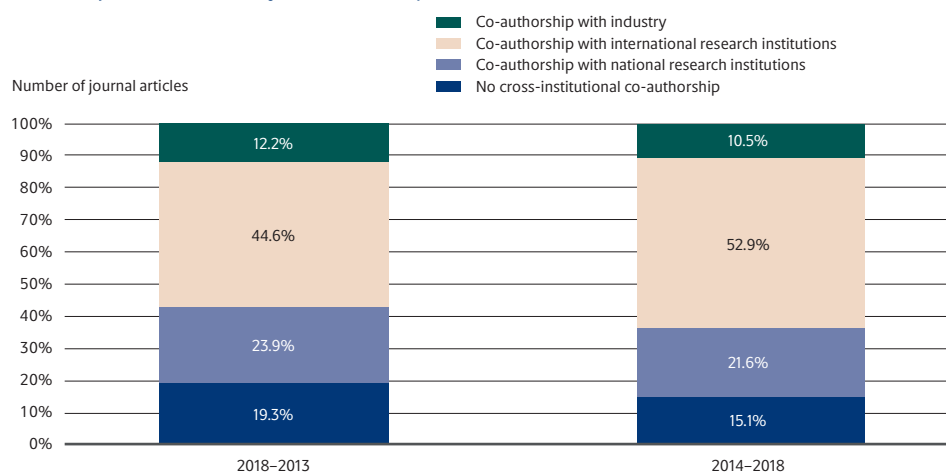


Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Journal articles co-authored with researchers from international research institutions had the largest increase in the number and percentage of journal articles involving co-authors from 2008–2013 to 2014–2018. This number nearly doubled, from 2207 to 3954 (see Figure 1.5), and 53% of journal articles from 2014 to 2018 were published with international researchers. This type of collaboration was also the most common type in both periods (see Figure 1.6).

Figure 1.6

Share of journal articles by co-authorship



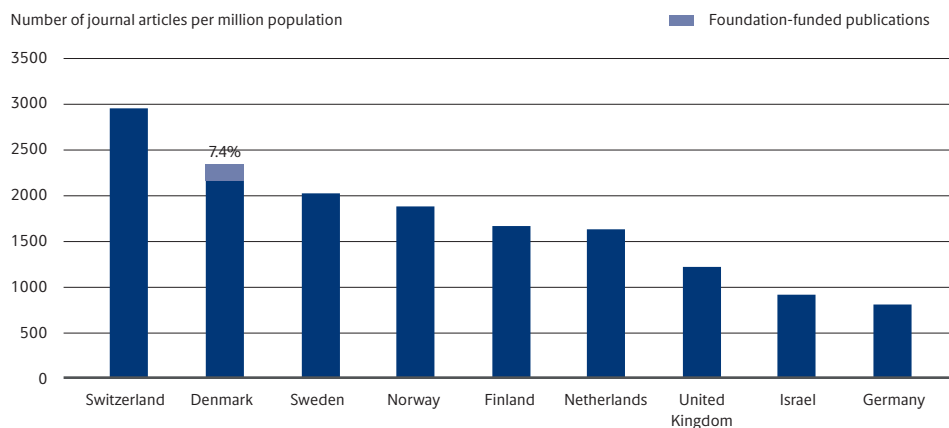
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

1.1.4 Benchmark of journal articles with international co-authorship

In 2017, 2346 academic journal articles with international co-authors were published per million population in Denmark, second to Switzerland (2946 per million population) within all scientific fields. The number for Denmark includes 173 (7.4%) articles per million population by the recipients of Foundation grants (Figure 1.7).

Figure 1.7

Journal articles with international co-authors per million population in selected countries, 2017



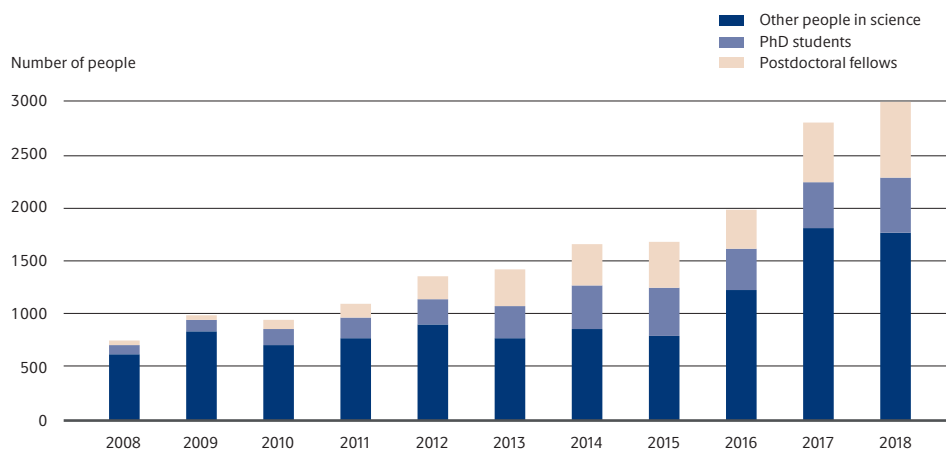
Sources: Novo Nordisk Foundation/researchfish* and the European Commission (European Innovation Scoreboard 2018).

1.2 Research talent: PhD students and postdoctoral fellows

The Foundation aims to promote the development of research talent at all career stages through grants for research and education, including support for researcher education and training for PhD students and postdoctoral fellows. This applies to research centre grants, research programmes, project grants and investigator grants as well as individual PhD and postdoctoral grants.

In 2018, the Foundation’s grant-awarding activity fully or partly funded 2998 people within science. This was 203 people more than in 2017. The Foundation’s direct support for people within science has been steadily increasing since 2008. Figure 1.8 shows the distribution between Foundation-funded postdoctoral fellows, PhD students and other persons in science grants.

Figure 1.8 Number of people in science supported fully or partly by Foundation grants, 2008–2018



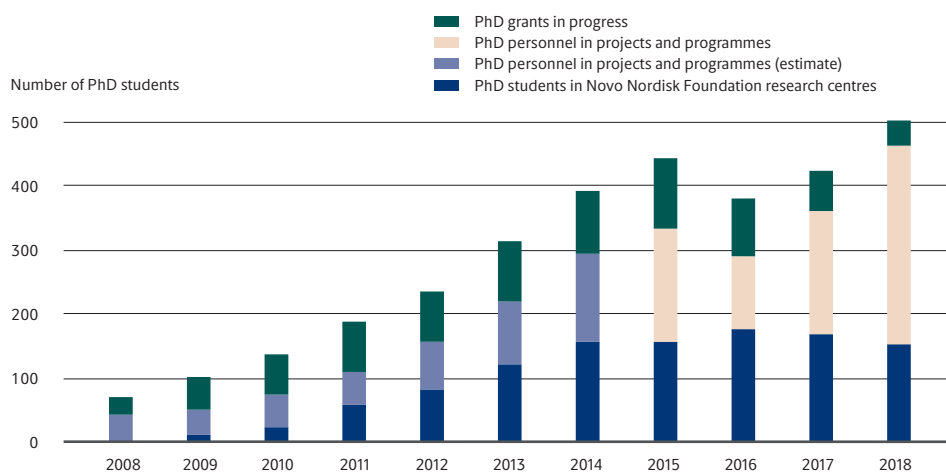
Note: The numbers of team members were not collected before 2015 and are therefore estimated.
 Source: Novo Nordisk Foundation/researchfish®.

1.2.1 Research-based education for PhD students

The number of current PhD students fully or partly funded by Foundation grants has grown from less than 100 in 2008 to more than 500 in 2018. By the end of 2018, 506 PhD students are individual grant recipients or employed full time or part time by recipients of the Foundation's programme grants, project grants, investigator grants or four research centres. This is 19% more than at the end of 2017. The research centres employed 156 PhD students in 2018 (Figure 1.9).

Figure 1.9

Number of PhD students in progress supported by Foundation grants, 2008–2018

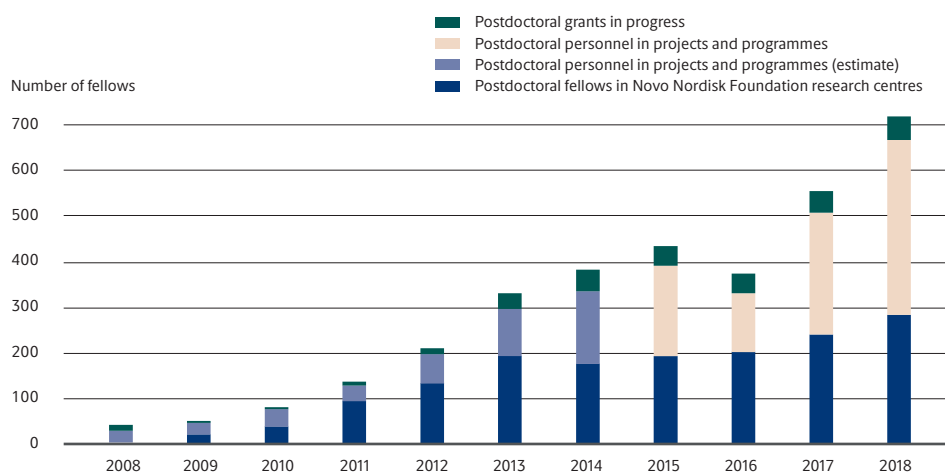


Source: Novo Nordisk Foundation/researchfish®.

1.2.2 Research training for postdoctoral fellows

The number of current postdoctoral fellows (a fellowship typically lasts 1–3 years) either fully or partly funded by the Foundation has increased from less than 100 in 2008 to more than 700 in 2018 (Figure 1.10). At the end of 2018, 719 postdoctoral fellows were individual grant recipients supported full time or part time by the Foundation's project grants, programme grants, investigator grants or four research centres. This is 30% more than in 2017. The research centres employed 286 postdoctoral fellows in 2018.

Figure 1.10 Number of postdoctoral fellows in progress supported by Foundation grants, 2008–2018



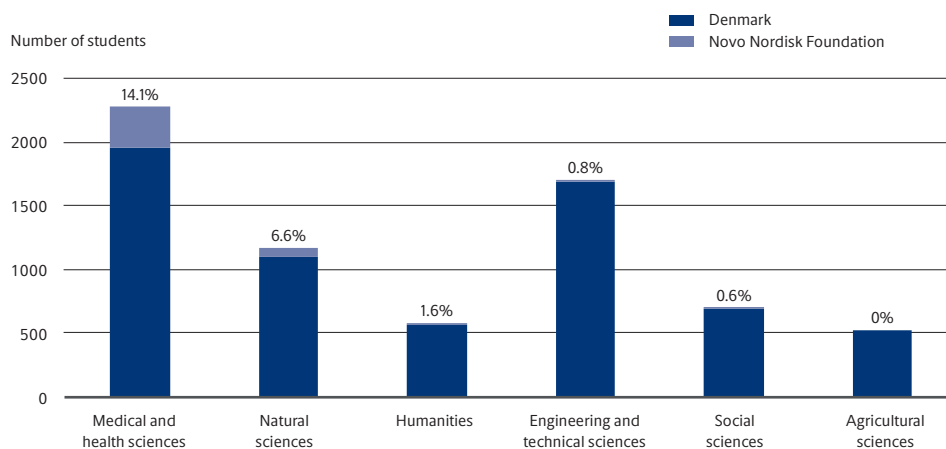
Source: Novo Nordisk Foundation.

1.2.3 PhD students in the six fields of science in Denmark in 2017

In 2017, Denmark had 6974 current PhD students across the six fields of science (OECD fields of science and technology). In the same year, 426 current PhD students worked on individual grants or were employed full time or part time by the Foundation's programme grants, project grants, investigator grants or four research centres. The Foundation funded or partly funded 14.1% of the PhD students within the health and medical sciences and 6.6% of the PhD students within the natural sciences in Denmark (Figure 1.11).

Figure 1.11

Share of PhD students in progress supported by Foundation grants within the six fields of science, 2017

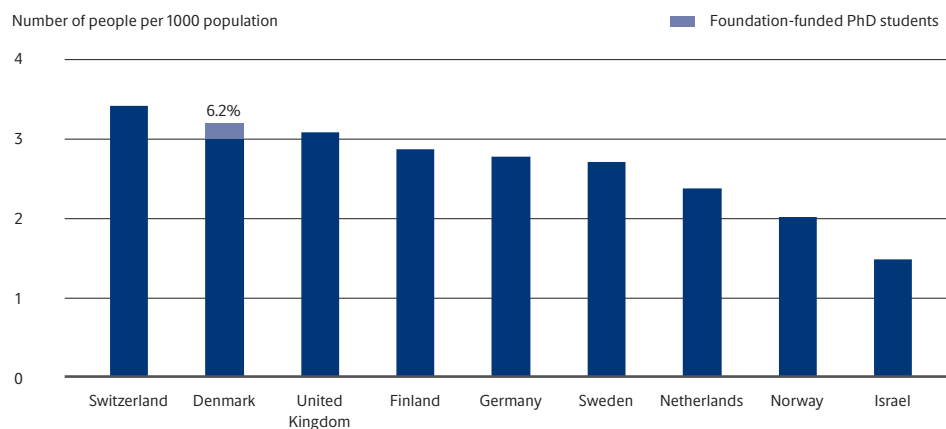


Sources: Novo Nordisk Foundation and Statistics Denmark.

1.2.4 International benchmark of new PhD graduates

Denmark has the second highest number of new PhD graduates per 1000 population in Europe. Figure 1.12 shows that the number of new PhD graduates per 1000 population is higher than in all other countries except Switzerland in 2016 (data for 2017 or 2018 are not yet available). In 2016, Denmark produced 3.2 new PhD graduates per 1000 population. Of all new PhD graduates, the Foundation funded an estimated 0.2 per 1000 population (equivalent to 6.2% of all new PhD graduates).

Figure 1.12 New PhD graduates per 1000 population in selected countries, 2016



Sources: Novo Nordisk Foundation/researchfish® and European Commission (European Innovation Scoreboard 2018).

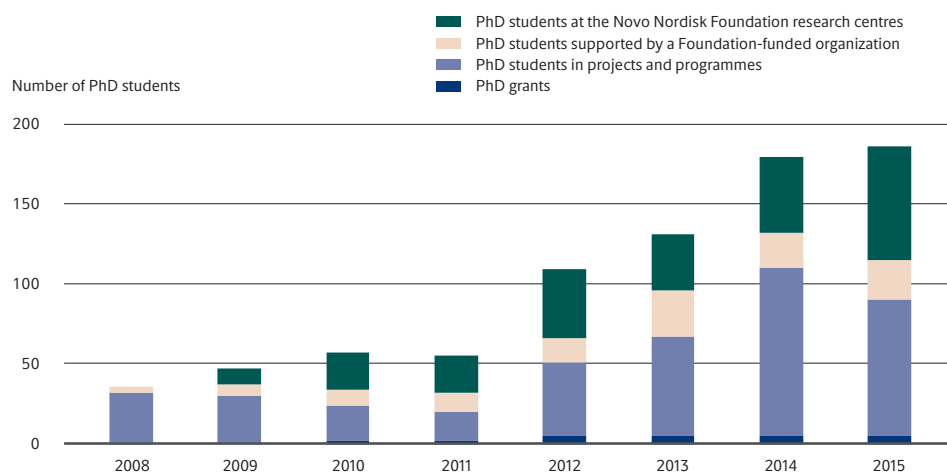
1.2.5 A study of Foundation-funded PhD students and postdoctoral fellows

The Foundation-funded PhD students and postdoctoral fellows can receive a grant either directly from the Foundation or indirectly. Those who are indirectly funded by the Foundation can have a position in a research project or programme supported by the Foundation, receive a grant from an organization supported by the Foundation, such as the Danish Diabetes Academy, or be working at a research centre supported by the Foundation. The Foundation has tracked publication activities, citation impact and collaboration patterns of PhD students and postdoctoral fellows benchmarked against all medical and health science PhD students from Aarhus University and the University of Copenhagen in the period 2008–2015. The benchmark was chosen because most PhD students and postdoctoral fellows funded by the Foundation work at these two institutions. This section presents the results.¹

In the period analysed, 1715 individuals received funding for PhD studies or postdoctoral research. Of these, 1284 (75%) were identified in Web of Science and analysed for their research output and outcomes. Figures 1.13 and 1.14 show the number of PhD students and postdoctoral fellows for each year for each funding source. The main funding source for PhD students and postdoctoral fellows is indirect funding through large grants such as project grants and employment at Foundation research centres.

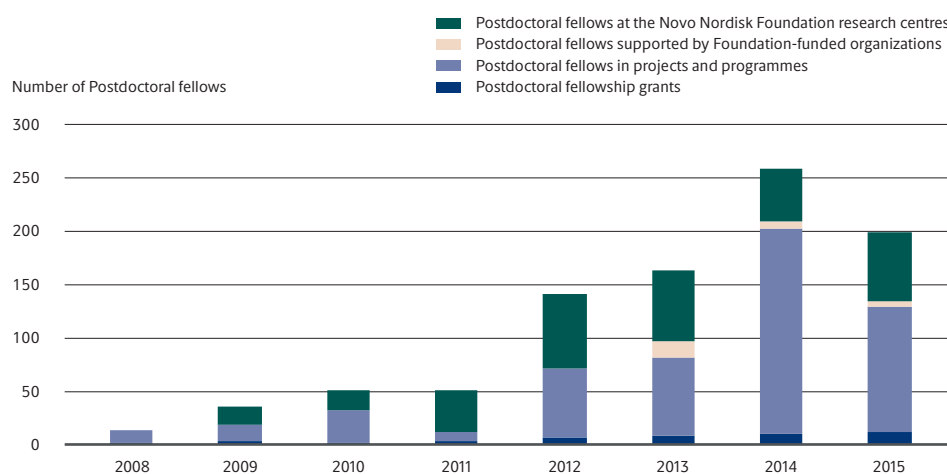
¹ The benchmark group consists of individuals who received a Danish health science PhD degree during the period analysed (2008–2015). Some individuals may have continued in postdoctoral positions, as is also the case for the PhD students receiving a grant from the Foundation.

Figure 1.13 Number of distinct PhD students, by type of source, 2008–2015



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Figure 1.14 Number of distinct postdoctoral fellows, by type of source, 2008–2015



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

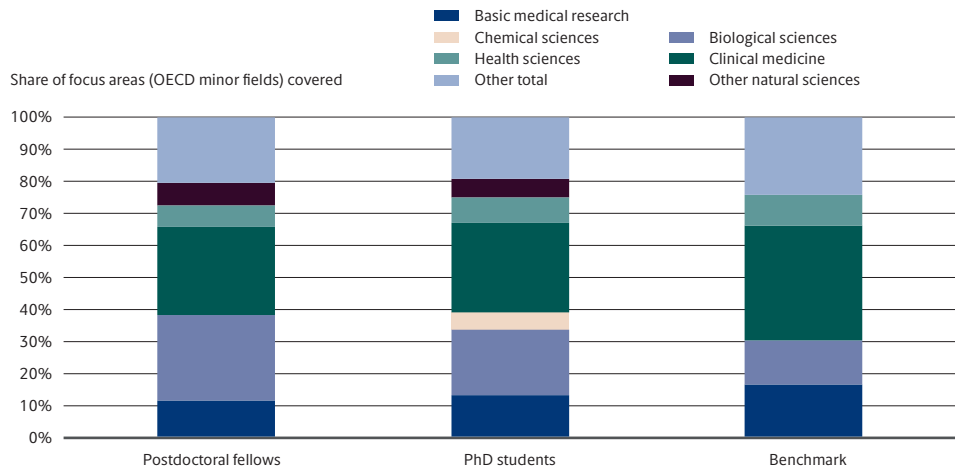
Field of science

Applying the disaggregated version of the OECD classification of the fields of science and technology (OECD field of science, minor field), Figure 1.15 shows the overall distribution of scientific fields within which the supported individuals primarily conduct their research for the PhD students and postdoctoral fellows funded by the Foundation and the benchmark group.

The benchmark group, all PhD students from Aarhus University and the University of Copenhagen, has published less within the biological sciences and a residual group of natural sciences and more within clinical medicine.

Figure 1.15

Share of OECD minor fields covered by PhD students and postdoctoral fellows supported by Foundation grants and the benchmark group

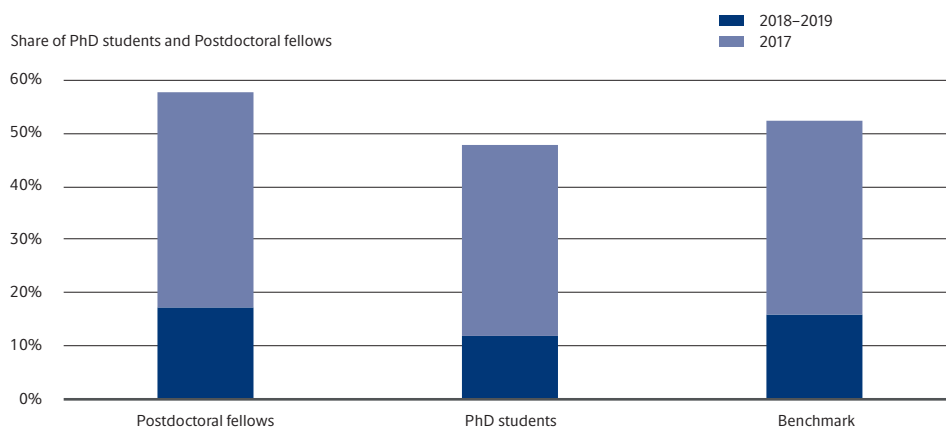


Sources: Novo Nordisk Foundation/ researchfish* and Danish Centre for Studies in Research and Research Policy.

Publications

Figure 1.16 shows the proportion of PhD students and postdoctoral fellows who have published at least one publication since 2017. The full height of the bar represents the proportion of individuals funded in 2008–2015 still publishing in 2017 or later. The light blue represents individuals publishing only in 2017, and the dark blue represents individuals also publishing in 2018–2019.

Figure 1.16 Share of postdoctoral fellows and PhD students supported by Foundation grants with at least one publication since 2017



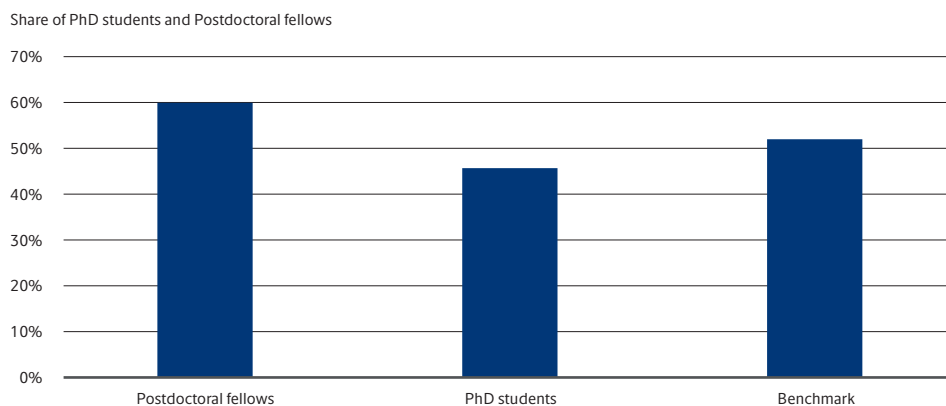
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

There is a lag in the Web of Science author classifications, explaining the low proportion of the dark blue. The share of Foundation-funded PhD students who continue to publish in 2017 or later, 48%, is close to the benchmark share, 52%. The Foundation-funded PhD students relatively often start publishing during their grant period compared with the benchmark.

Most postdoctoral fellows remain active researchers during the first 5 years after their initial publication. The PhD student sample is limited to those who had their first publication in 2013 at the latest, to enable the comparison. Postdoctoral fellows are more likely to continue publishing activities (Figure 1.17).

Figure 1.17

Share of postdoctoral fellows and PhD students supported by Foundation grants with no more than 2 years without publications in the first 5 years since the first publication year



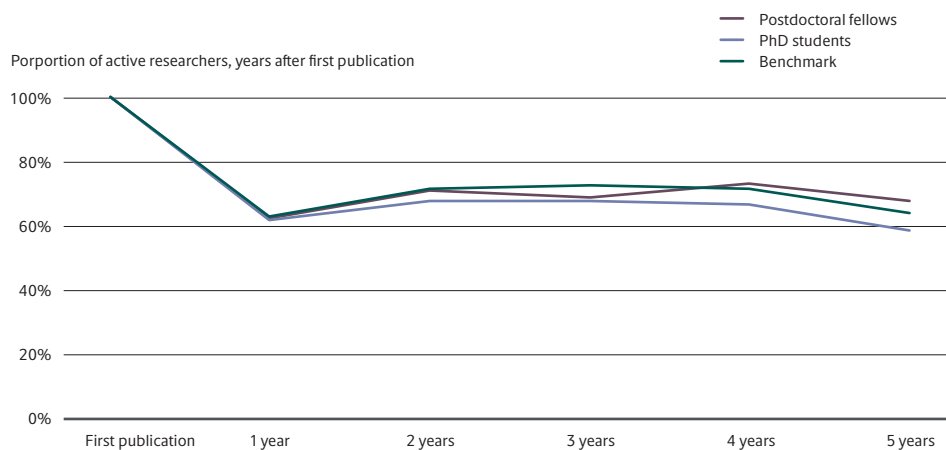
Sources: Novo Nordisk Foundation/ researchfish* and Danish Centre for Studies in Research and Research Policy.

Proportion of active researchers

Figure 1.18 shows the share of individuals having at least one publication in each year up to 5 years after their first publication. The PhD student group has the lowest share.

Figure 1.18

Proportion of active researchers among postdoctoral fellows and PhD students supported by Foundation grants, years after first publication



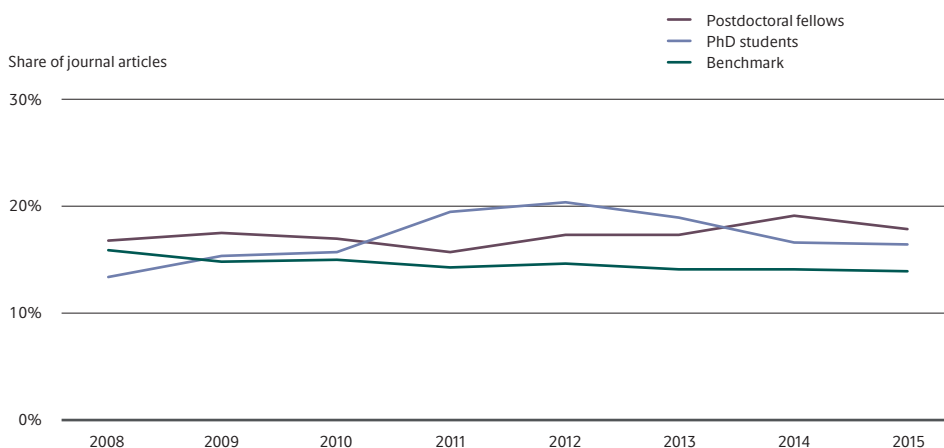
Sources: Novo Nordisk Foundation/ researchfish® and Danish Centre for Studies in Research and Research Policy.

Citation impact

For all three groups in the analysis, the share of journal articles authored or co-authored by post-doctoral fellows or PhD students cited among the 10% most frequently cited worldwide within their research field, PP(top 10%), exceeds the 10% world average (Figure 1.19). For comparison the Foundation grant recipients have a PP(top 10%) at 23.4% within all sciences for 2014–2016.

Figure 1.19

Citation impact of postdoctoral fellows and PhD students supported by Foundation grants, measured by PP(top 10%)



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Collaborations and co-authorship

Figures 1.20 and 1.21 show the shares of journal articles by funded PhD students and post-doctoral fellows and by the benchmark group co-authored with industrial researchers and international researchers, respectively.

Figure 1.20 Share of journal articles co-authored with researchers from industry

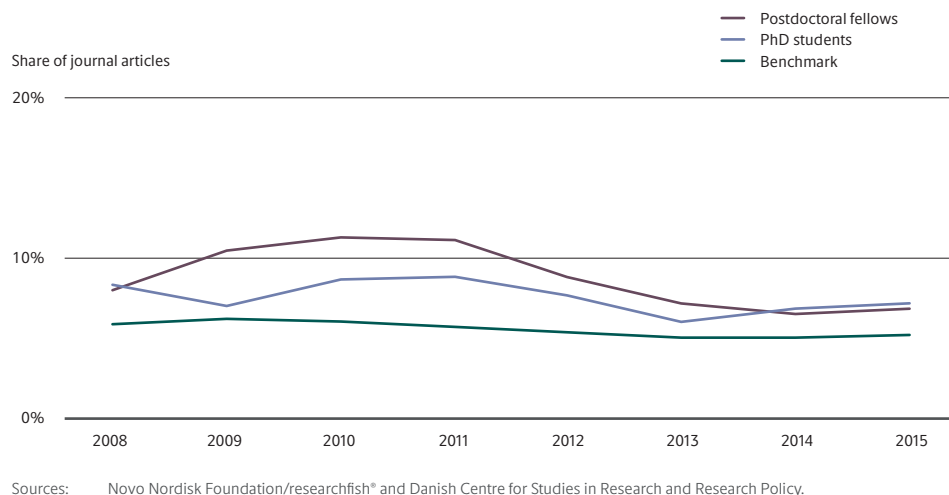
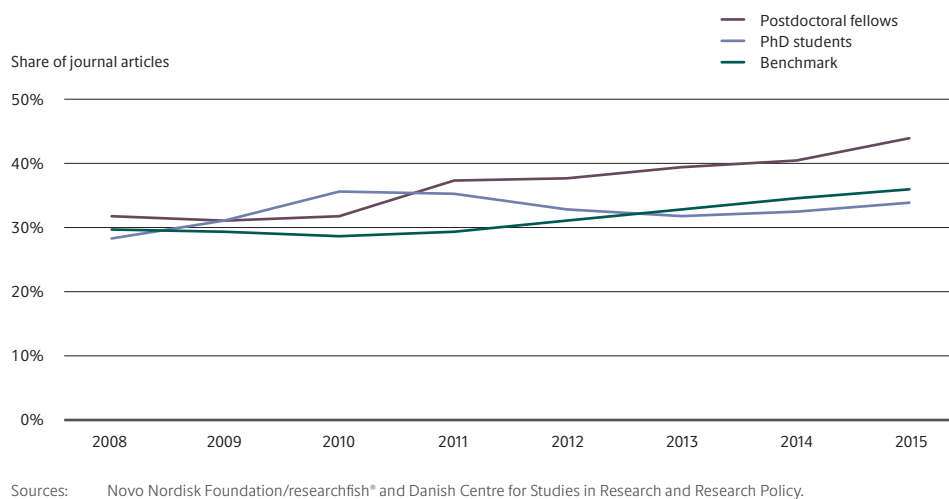


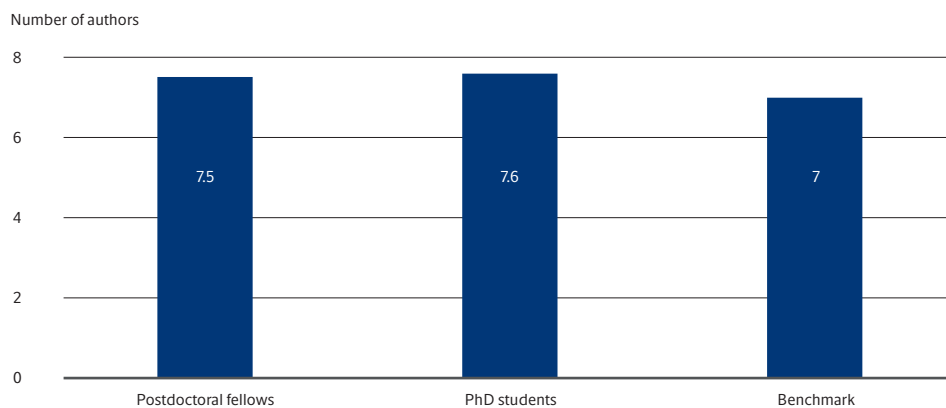
Figure 1.21 Share of journal articles co-authored with international academic researchers



Expanding on the analysis of collaboration, Figure 1.22 shows the median number of authors per journal article across each of the three samples. The results of Figure 1.22 imply that 50% of the postdoctoral fellows have 7.5 or fewer authors on their average journal article, and the other 50% of the postdoctoral fellows have 7.5 or more authors on their average journal article. The PhD students typically have 7.6 authors on their average journal article, and the benchmark articles have 7.

Figure 1.22

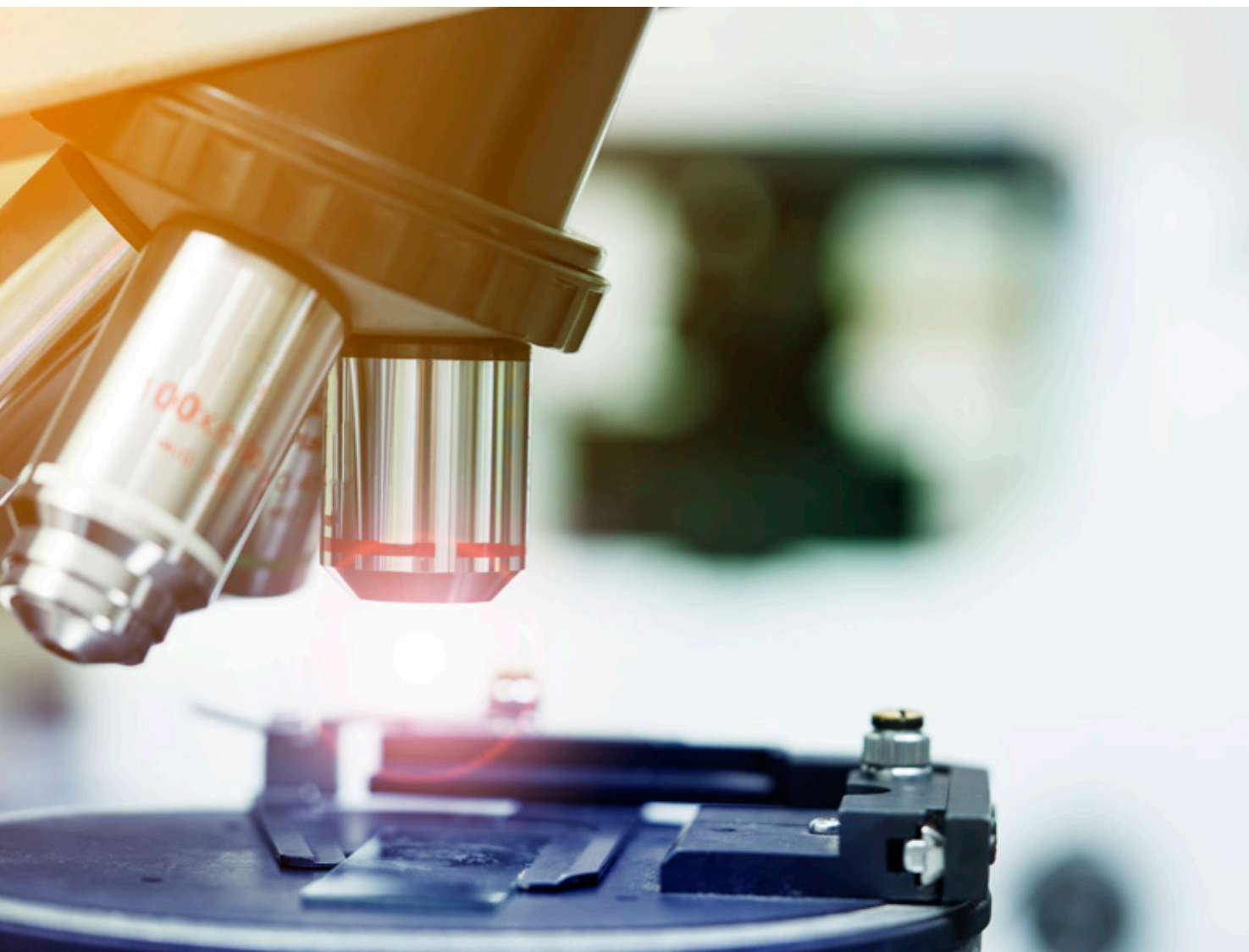
Median number of the average number of authors per journal article



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Chapter 2

Dissemination and use of
knowledge within the public sector



2. DISSEMINATION AND USE OF KNOWLEDGE IN THE PUBLIC SECTOR

This chapter analyses the dissemination and use of Foundation-funded knowledge in the public sector. It focuses on the dissemination and use of knowledge in public research communities. Further, it presents the outcomes from Foundation-funded public research activities related to public healthcare and findings from an evaluation of three completed cancer projects funded by the Foundation.

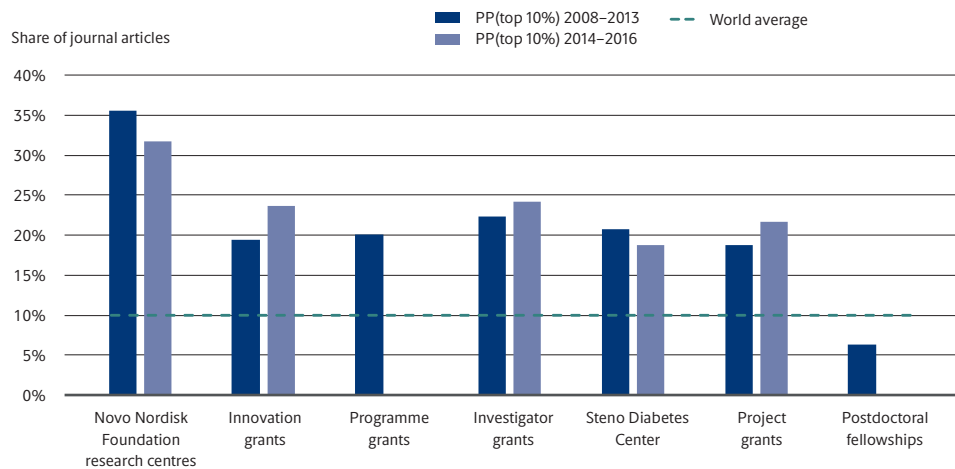
2.1 Dissemination and use of knowledge in academia

This section focuses on how knowledge created by the recipients of the Foundation's research grants is disseminated and used within academia. The Foundation's research grant portfolio comprises several types of grants. The duration of grants varies: for example, 1–4 years for postdoctoral fellowships and projects, 3–7 years for investigator grants and programmes and up to 13 years for research centres. The dissemination and use of the outcomes of different types of grants should therefore be expected to vary. The analysis uses Leiden University's bibliometric indicators, which is an internationally recognized benchmarking system for citation analysis.

2.1.1 Citation impact of journal articles reported by all grant recipients, according to type of grant within all sciences

Figure 2.1 and Figure 2.2 present the share of Foundation-funded journal articles (all subject categories, all fields of research) among the world's top 10% and 1% most frequently cited journal articles within 2008–2013 and 2014–2016 by all grant recipients according to the type of grant. Project grants and investigator grants have a higher share of frequently-cited journal articles in the period 2014–2016 compared with 2008–2013. The citation analysis is based on a 3-year citation period starting from the year of publication. The Foundation's research centres have the highest share of citations above the world average among type of grants. However, this share was lower in 2014–2016 than in 2008–2013. The time lag (because of how citations are measured) may explain some of the differences in the number of citations between the two time periods.

Figure 2.1 Share of journal articles by recipients of Foundation grants among the top 10% most frequently cited in the world by type of grant - PP(top 10%)

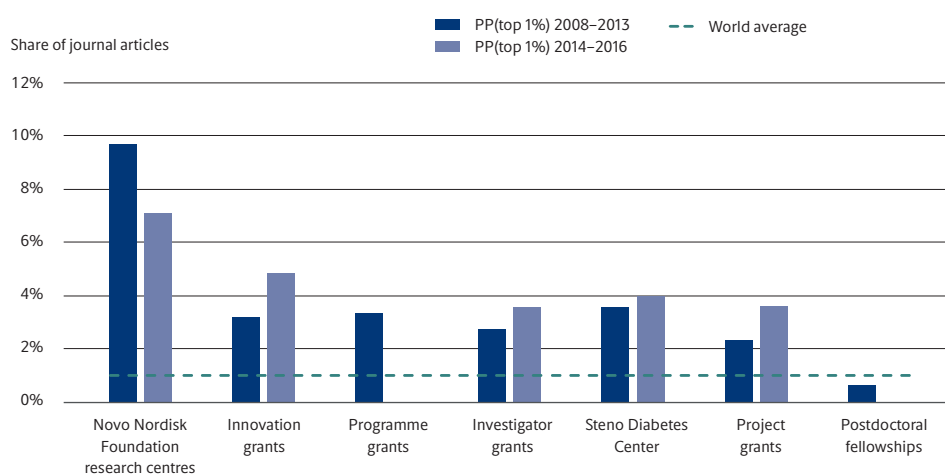


Note: Programme grants and postdoctoral fellowships in 2014–2016 have insufficient number of journal observations to calculate PP(top 10%). The number of journal articles 659 for 2008–2013 and 1140 for 2014–2016.

Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Figure 2.2

Share of journal articles by recipients of Foundation grants among the top 1% most frequently cited in the world by type of grant - PP(top 1%)



Note: Programme grants and postdoctoral fellowships in 2014-2016 have insufficient number of journal observations to calculate PP(top 1%). The number of journal articles 659 for 2008-2013 and 1140 for 2014-2016.

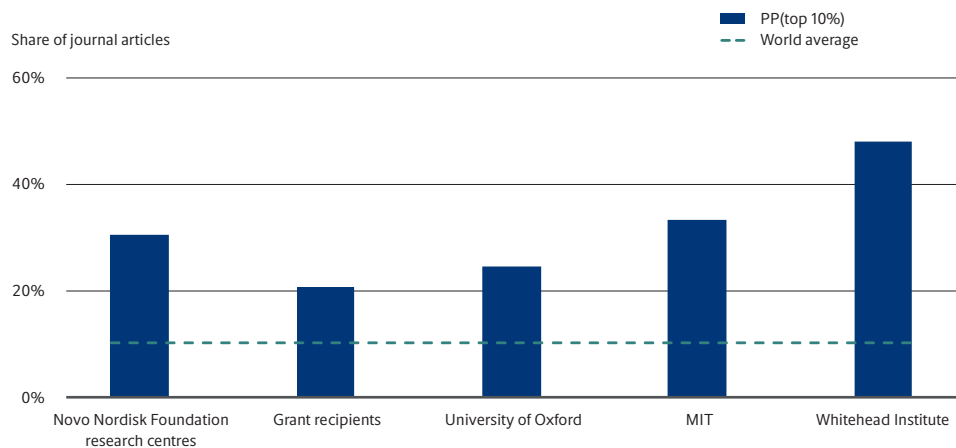
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

2.1.2 Citation impact of journal articles by grant recipients related to grants within the biomedical and health sciences

A benchmark of citation impact for the grant recipients of Foundation grants shows, that they are just a few percentage points lower than the university with the highest citation impact score in Europe for the 10% most frequently cited publications in 2014–2016 within the biomedical and health sciences (Figure 2.3). Further, the citation impact of the Foundation's four research centres is 3 percentage points lower than for articles from the university with the highest citation impact score in the world and 18 percentage points lower than articles from the Whitehead Institute, a leading independent research centre affiliated with the Massachusetts Institute of Technology (MIT).

Figure 2.3

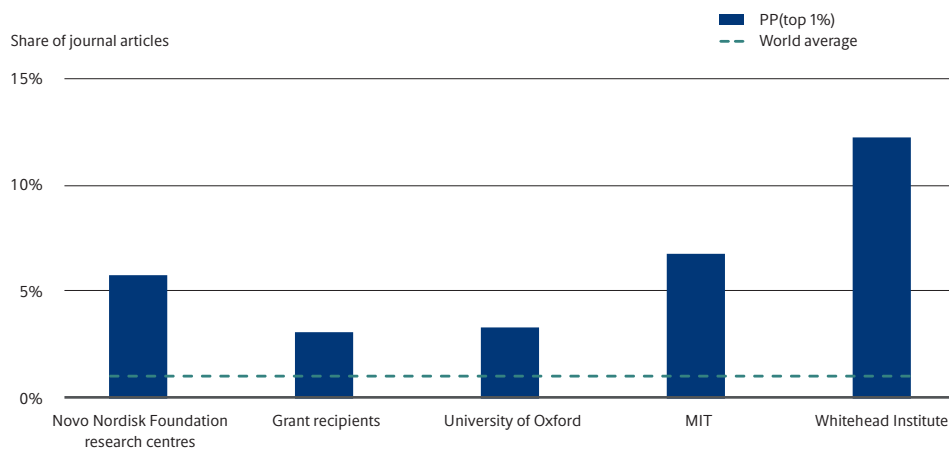
Benchmark of citation impact of journal articles within the biomedical and health sciences - PP(top 10%), 2014–2016



The share of journal articles by recipients of Foundation grants among the top 1% most frequently cited publications in the world (PP(top 1%)) in 2014–2016 is almost the same score as the university with the highest percentage in Europe (University of Oxford) and about 4 percentage points lower than the university with the highest percentage in the world, MIT (Figure 2.4). The Foundation's four research centres are close to the best university in the world and about 6 percentage points lower than the Whitehead Institute.

Figure 2.4

Benchmark of citation impact of journal articles within the biomedical and health sciences - PP(top 1%), 2014–2016

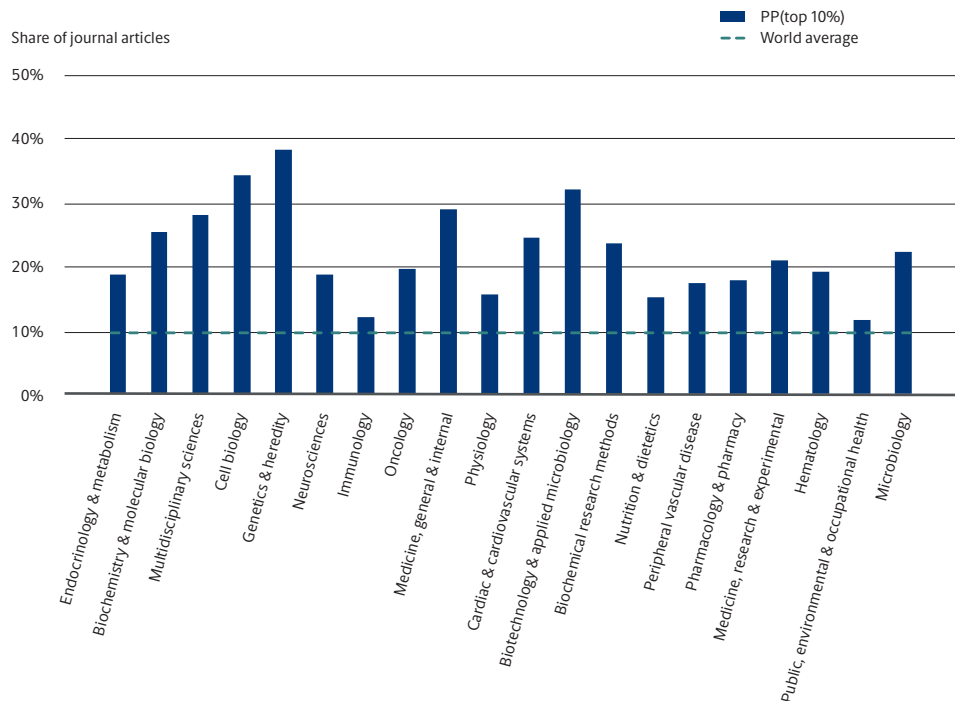


2.1.3 Citation impact by journal subject category, all sciences

This section divides citation impact by journal subject category as defined by Web of Science. The journal subject category assigned to an article follows the journal of publication. The category of multidisciplinary sciences tends to be a catchall category for journals accepting submissions from a range of scientific fields. These journals also include high-impact journals, such as Nature, that attract journal articles with frontline research regardless of subject category.

The share of Foundation-funded journal articles in the top 1% and top 10% most frequently cited articles worldwide within the same scientific field and year is a way of tracking research excellence. Figure 2.5, 2.6, 2.7 and 2.8 show the trend for citation impact of journal articles among the grant recipients in general and across the journal subject categories. Citation impact scores are weighted and normalized by journal subject category and publication year to enable the citation impact of journal articles to be compared across journal subject categories and published in different years.

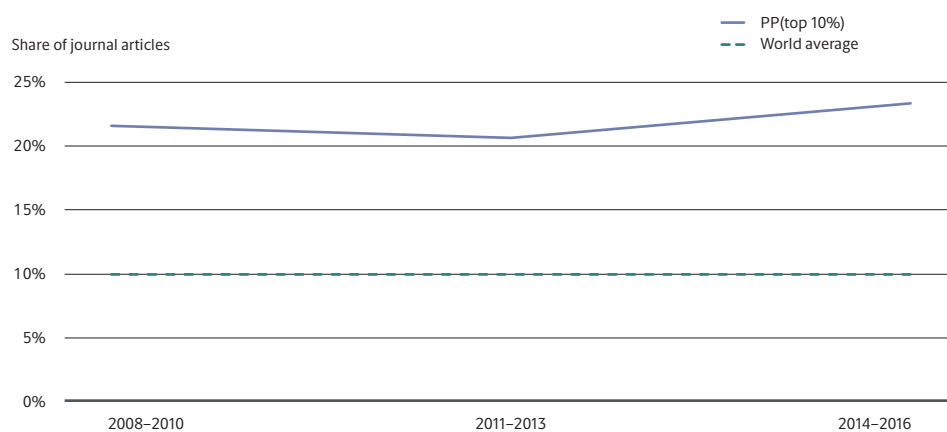
Figure 2.5 Share of Foundation-funded journal articles by journal subject category among the top 10% most frequently cited in the world - PP(top 10%), 2008–2016



Note: Subject categories are sorted according to number of articles, descending from left to right.

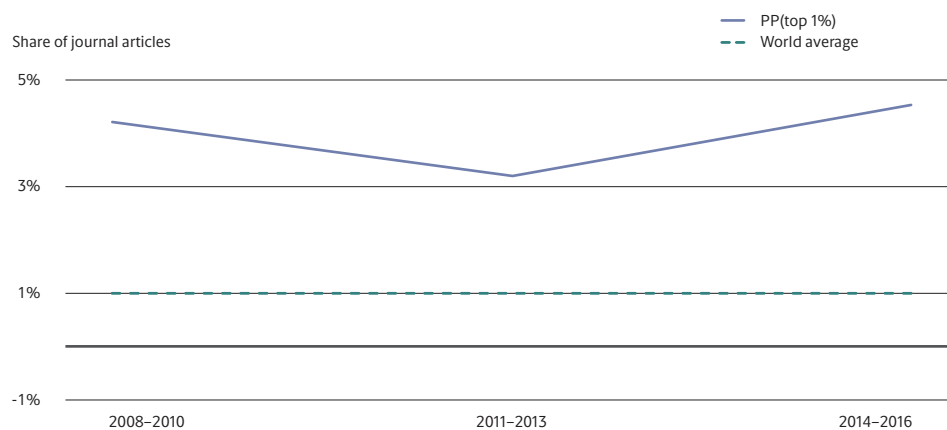
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Figure 2.6 Share of journal articles by grant recipients of Foundation grants among the top 10% most frequently cited in the world - PP(top 10%), 2008–2016



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

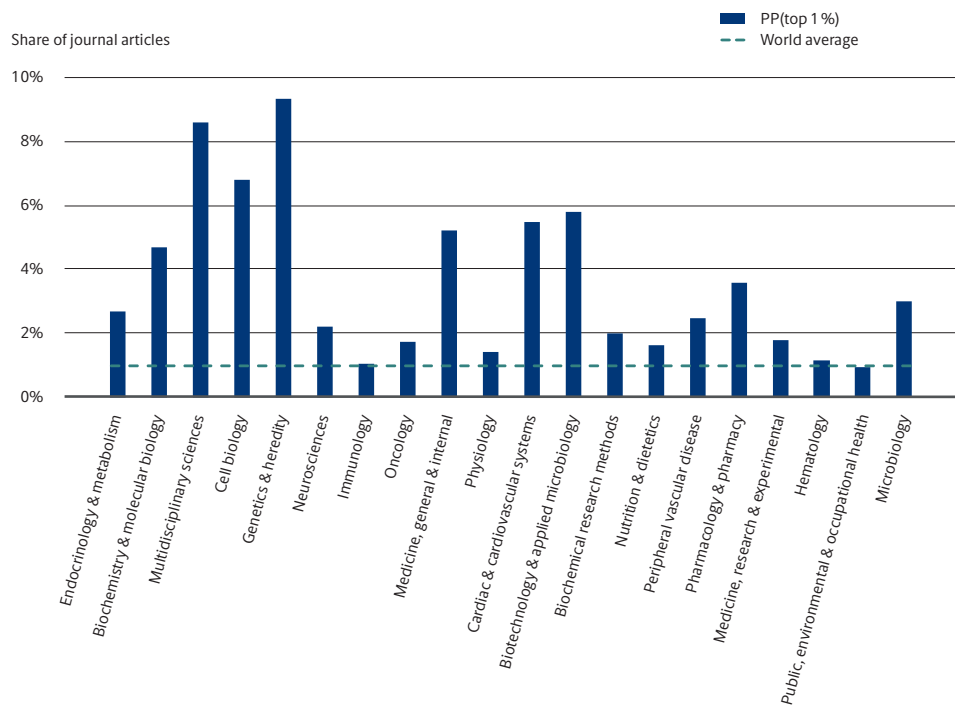
Figure 2.7 Share of journal articles by grant recipients of Foundation grants among the top 1% most frequently cited in the world - PP(top 1%), 2008–2016



Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Figure 2.8

Share of journal articles by recipients of Foundation grants by journal subject category among the top 1% most frequently cited in the world - PP(top 1%), 2008–2016



Note: The subject categories are sorted according to the number of articles, descending from left to right.

Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Main results:

- Altogether, 23.4% of the grant recipient's journal articles are among the world's top 10% and 4.6% in the world's top 1% most frequently cited in 2014–2016.
- 18% of the journal articles by grant recipients are published within endocrinology & metabolism. Of these, 19% are among the top 10% most frequently cited worldwide, and 3% are among the top 1% most frequently cited worldwide.
- In multidisciplinary sciences, which has the third largest number of journal articles, 28% of the journal articles by grant recipients are in the top 10%, and 9% are in the 1% most frequently cited worldwide.
- In general medicine and internal medicine, 29% of the journal articles by recipients of Foundation grants are among the top 10% most frequently cited worldwide within their field, and more than 5% are among the 1% most frequently cited.

2.1.4 Interdisciplinary co-authorship in journal articles

This section divides citation impact by journal subject category as defined by Web of Science. Interdisciplinarity is one of the grant-awarding principles of the Foundation. This principle implies that the Foundation facilitates connectivity across disciplines to generate new ways of discovery and to solve complex problems in the search for solutions to significant global and societal challenges. The Foundation believes that interdisciplinary research will drive future waves of discovery and innovation. It advocates and supports the removal of barriers between traditional disciplines and fields of research.

This section investigates interdisciplinary collaboration on journal articles published by recipients of Foundation grants. First, the background – academic specialization and field of science – of the authors who have written an article together is investigated. Second, the citation impact of journal articles with monodisciplinary co-authorship and interdisciplinary co-authorship is analysed. The co-authors' background on an article defines whether an article is monodisciplinary or interdisciplinary.

The reader should bear in mind that investigating the social and cognitive phenomena in interdisciplinary research is challenging and no single method captures the whole picture. The analysis presented here does not investigate the interdisciplinary nature of the research carried out, it solely investigates interdisciplinary collaboration by the background of the co-authors on a journal article.

Two definitions of interdisciplinary collaboration

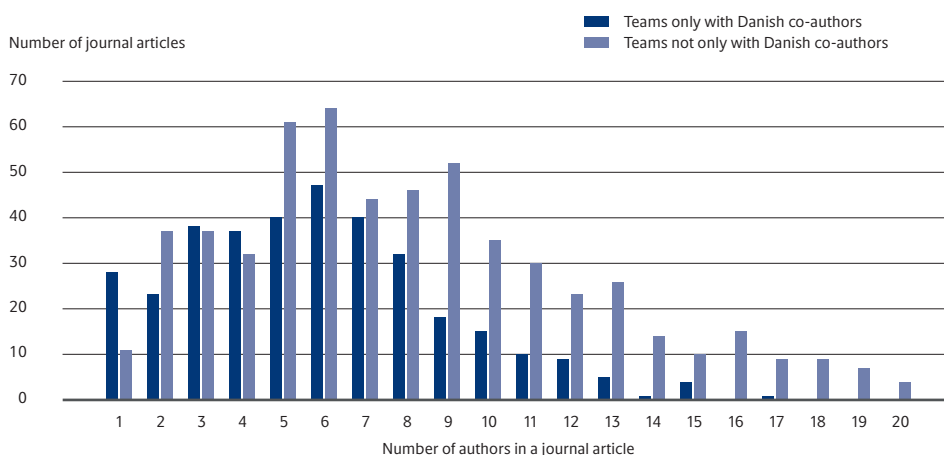
- Interdisciplinary collaboration can be said to take place if the co-authors on a journal article have **different academic specializations** such as endocrinology, microbiology, genetics, physiology, biotechnology, chemistry and biochemistry.
- Interdisciplinary collaboration can also be said to take place if the co-authors on a journal article have a background from more than one **field of science** according to OECD's definition: medical and health sciences, natural sciences, engineering and technology, agricultural sciences, social sciences and humanities.

The analysed data comprises 914 journal articles randomly selected from 4569 Foundation-funded journal articles published in 2015–2017. Only articles with 20 co-authors or less are included in the analysis. The 914 articles had 6605 authors; the academic specialization was identified for 96% of the authors resulting in 159 identified academic specializations such as endocrinology, biotechnology and chemistry. The academic specializations were further mapped to the six field of science defined by the OECD: medical and health sciences, natural sciences, engineering and technology, agricultural sciences, social sciences and humanities. The Foundation's Impact Report 2017 (http://impact.novonordiskfonden.dk/wp-content/uploads/NNF_impact_report.pdf) describes the methods used to identify, harmonize and map the backgrounds of authors.

Diversity in the number of authors writing a journal article

In the sample, the average number of authors writing a journal article is 10 and the most frequent number of authors writing an article is 6, ranging from 1 to 20. Most frequently, 5–6 co-authors write an article (Figure 2.9). One third of the teams only have authors from institutions or other organizations in Denmark.

Figure 2.9 Number of journal articles by number of authors in a sample of Foundation-funded journal articles, 2015–2017

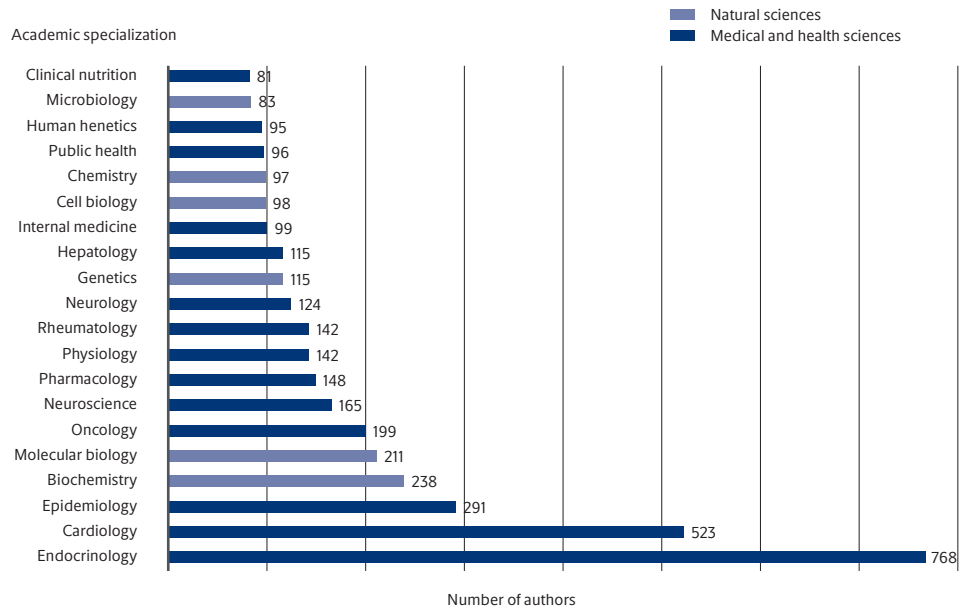


Sources: Novo Nordisk Foundation and DAMVAD Analytics.

The co-authors' academic specializations and fields of science

The most common academic specializations among the co-authors are endocrinology, cardiology and epidemiology (Figure 2.10). Looking at the fields of sciences overall, 72% of the authors' academic specializations are within the medical and health sciences and 23% within the natural sciences, engineering and technology, and social sciences and humanities comprise 5%.

Figure 2.10 Number of authors within the 20 most common academic specializations



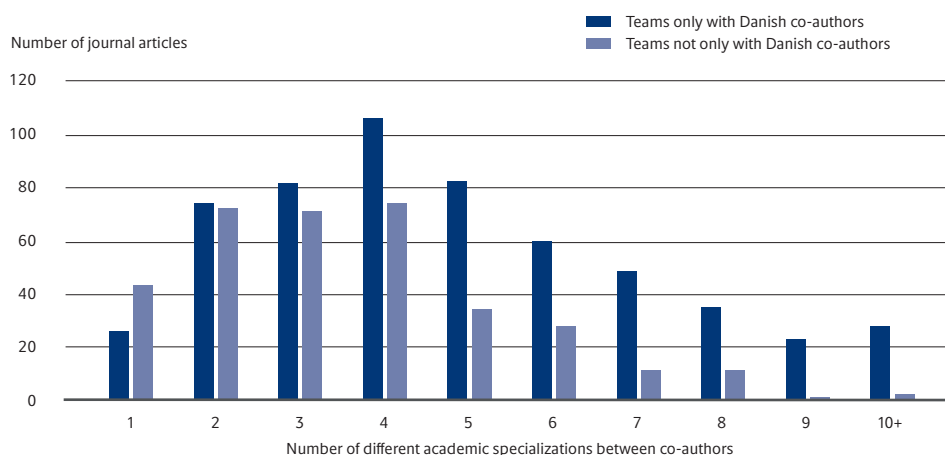
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Diversity of the co-authors' academic specializations and fields of science for articles

Figure 2.11 shows the number of journal articles co-authored by the numbers of academic specializations among co-authors. For 7% of the journal articles published between 2015 and 2017, all authors have the same academic specialization. About 65% of journal articles involve authors with two to five academic specializations. The co-authors on journal articles are categorized as teams with all co-authors from Denmark (“teams only with Danish co-authors”) and teams with at least one co-author from outside Denmark (“teams not only with Danish co-authors”). The greater the diversity in the academic specializations among the authors, the more often the teams only have co-authors from Denmark.

Figure 2.11

Journal articles by number of academic specializations among co-authors in a sample of Foundation-funded journal articles

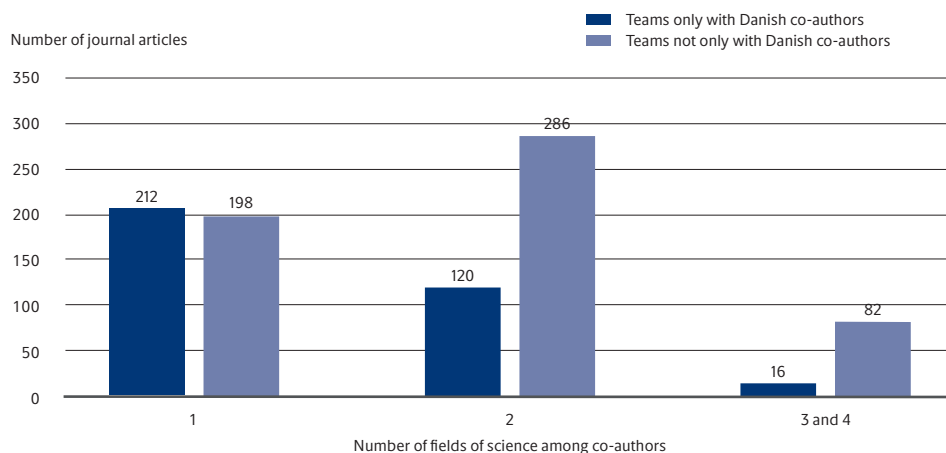


Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 2.12 shows the number of journal articles by number of fields of science among the authors. In 55% of the journal articles the authors are from two to four fields of science. The greater the diversity among the co-authors, the more often the teams do not only have Danish authors. It is very rare to observe journal articles with authors from five or six fields of science.

Figure 2.12

Journal articles by number of fields of science among co-authors in a sample of Foundation-funded journal articles



Sources: Novo Nordisk Foundation and DAMVAD Analytics.

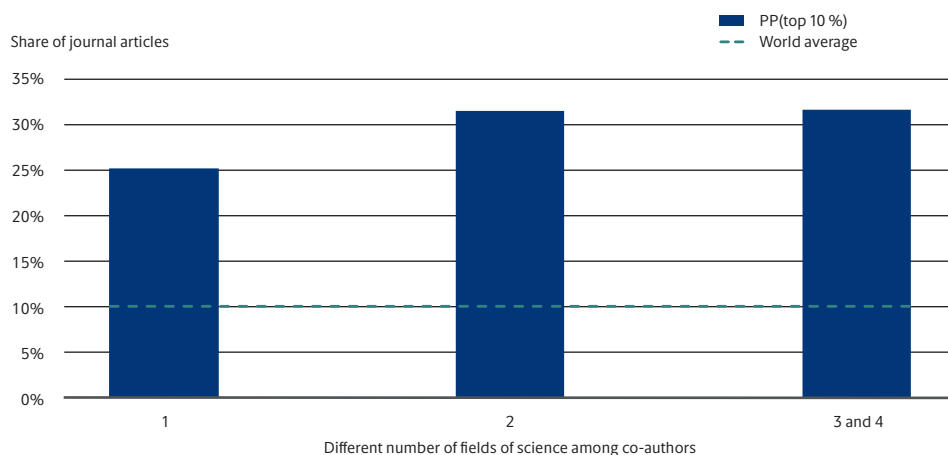
Citation analysis

The citation analysis of the 914 journal articles shows, that journal articles involving collaboration between co-authors from at least two fields of science have higher citation impact than journal articles published by co-authors from the same field of science (Figures 2.13 and 2.14).

The share of journal articles in the world's 10% most frequently cited articles is 31.5% for journal articles published by authors from two or more fields of science and 25.1% for journal articles published by authors within the same field of science.

Figure 2.13

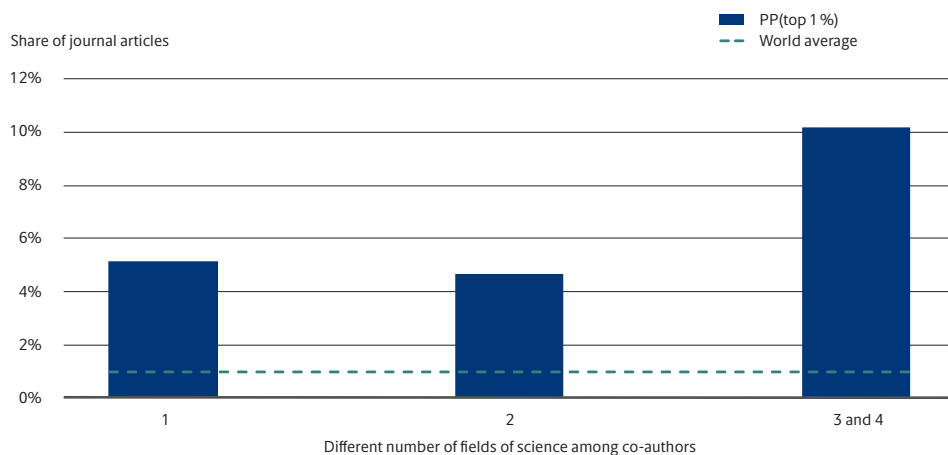
PP(top 10%) by number of fields of science among co-authors in a sample of Foundation-funded journal articles, 2015–2017



Sources: Novo Nordisk Foundation and Danish Centre for Studies in Research and Research Policy.

Figure 2.14

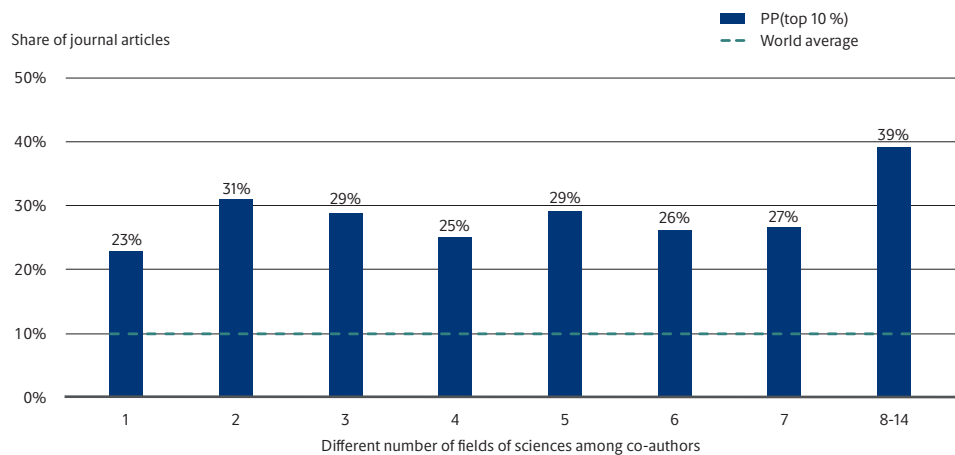
PP(top 1%) by number of fields of science among co-authors in a sample of Foundation-funded journal articles, 2015–2017



Sources: Novo Nordisk Foundation and Danish Centre for Studies in Research and Research Policy.

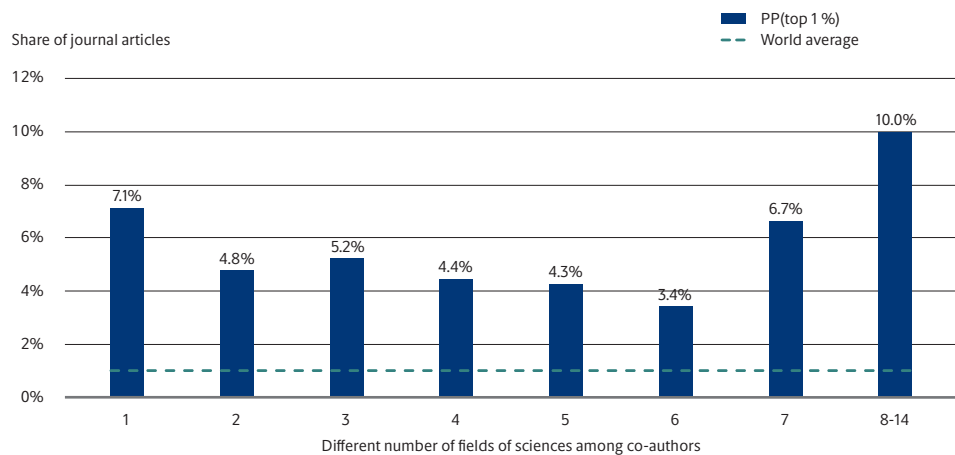
The citation impact changes with the number of academic specializations among the authors. PP(top 10%) is higher for journal articles published by co-authors with more than one academic specialization (Figure 2.15). Figure 2.16 shows no clear correlation between the number of academic specializations among co-authors and the PP(top 1%) score.

Figure 2.15 PP(top 10%) by number of academic specializations among co-authors, 2015–2017



Sources: Novo Nordisk Foundation and Danish Centre for Studies in Research and Research Policy.

Figure 2.16 PP(top 1%) by number of academic specializations among co-authors, 2015–2017



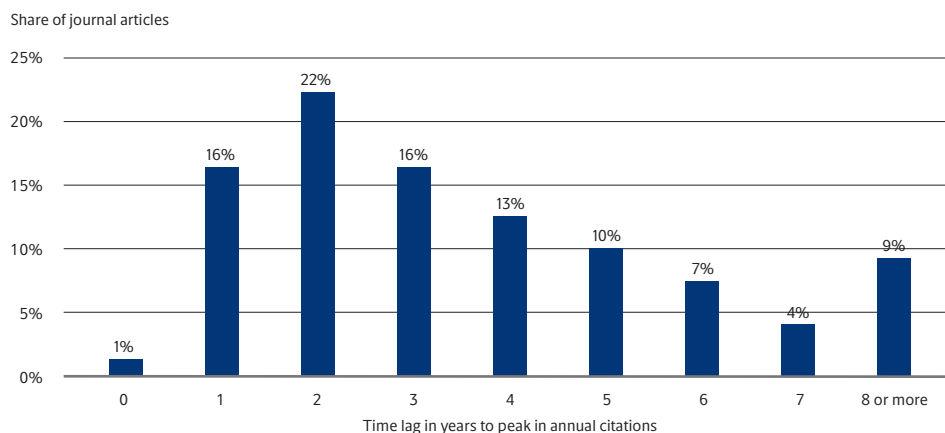
Sources: Novo Nordisk Foundation and Danish Centre for Studies in Research and Research Policy.

2.1.5 Peak year of annual citations and the three-year citation window

This section analyses how long it takes articles to receive the peak number of citations within a year. This approach to citations compared with the standard citation analysis presented elsewhere in the report shows a different side of the absorption and recognition of knowledge since it considers the time perspective. The approach demonstrates that many journal articles take more than 3 years to reach peak annual citations. Because many journal articles take more than 3 years to reach peak annual citations, the validity of the 3-year citation window used in the citation analysis above is addressed. The analysis in this section uses all journal articles by grant recipients published in 2012 or earlier to observe delayed citation peaks.

Figure 2.17 shows the distribution of articles by the number of years between the publication year and the year a journal article receives its peak annual citations. 56% have a citation peak at most 3 years after the publication year. The share of articles peaking within 5 years is 79%. Two years is the most common period in which annual citations peak.

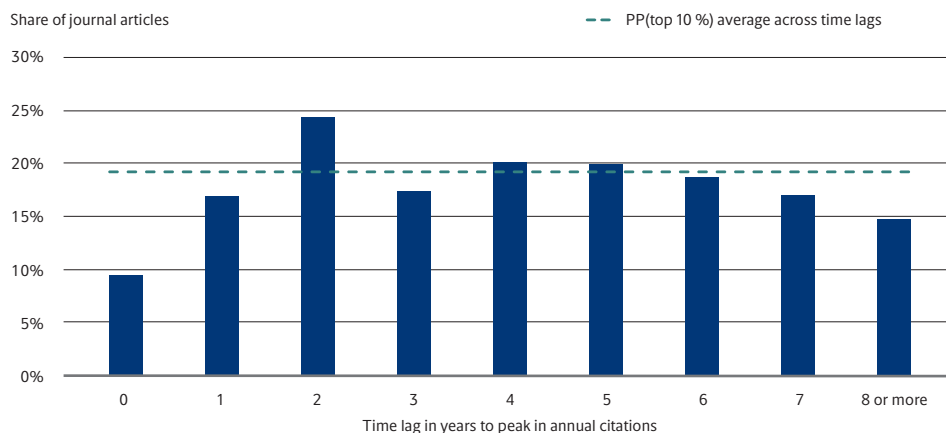
Figure 2.17 Number of years before a journal article by a grant recipient reaches its peak annual citation year



Note: The data include a sample of Foundation-funded journal articles published in 2012 and earlier.
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Figure 2.18 shows the share of journal articles that are among the top 10% most frequently cited worldwide. The weighted average for all articles (published in 2012 or earlier), regardless of peak citation year, is 19% based on the standard 3-year citation window. This aggregated share is broken down into shares for articles according to their time lag to peak citation. The result shows that articles that peak after 2 years contribute positively to PP(top 10%), while articles peaking after 1 year or in 3 to 7 years are somewhat above or below the 19% average share.

Figure 2.18 Share of journal articles by grant recipients among the 10% most frequently cited worldwide, according to citation time lag peak



Note: The data include a sample of Foundation-funded journal articles published in 2012 and earlier.

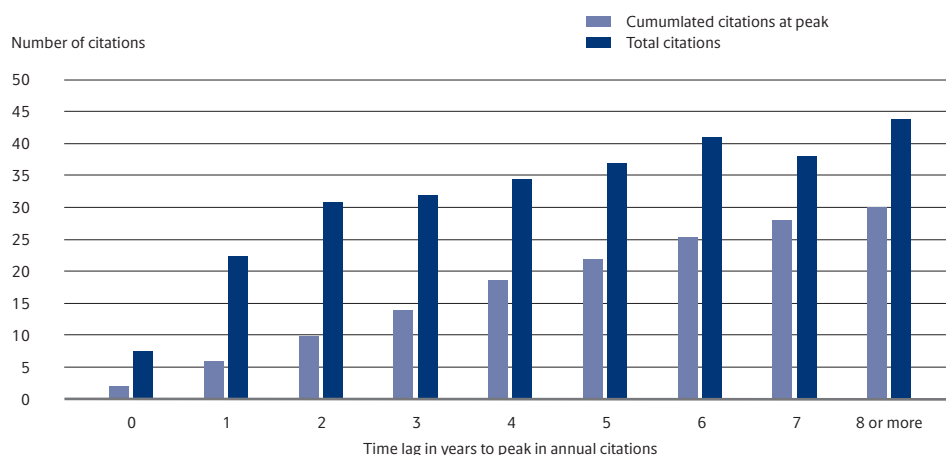
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

This suggests that the 3-year citation-window somewhat also captures the performance of articles that have not peaked within the first 3 years of being published. By comparing the median values of the cumulative citations from publication to peak year with the total number of citations they receive, Figure 2.19 shows that:

- the total number of citations tends to be higher for articles that peak later rather than earlier; and
- looking across the years required to reach peak-level citations, the cumulative citation share of total citations grows steadily from 25% for articles peaking in year 1 after being published to +77% for articles peaking in year 8.

Figure 2.19

Median number of citations of journal articles by grant recipients in the peak year and median number of total citations



Note: The data include a sample of journal articles published in 2012 and earlier.

Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

This suggests that the 3-year citation window picks up trends from articles that peak late, because the cumulative citation shares build up steadily (as they contribute considerably to the citation impact score), and the 3-year citation window also picks up articles that are rapidly cited or absorbed by the research community (since they increase the average citation score).

2.1.6 Developing or disruptive research: An application of a new theory for identifying the nature of research

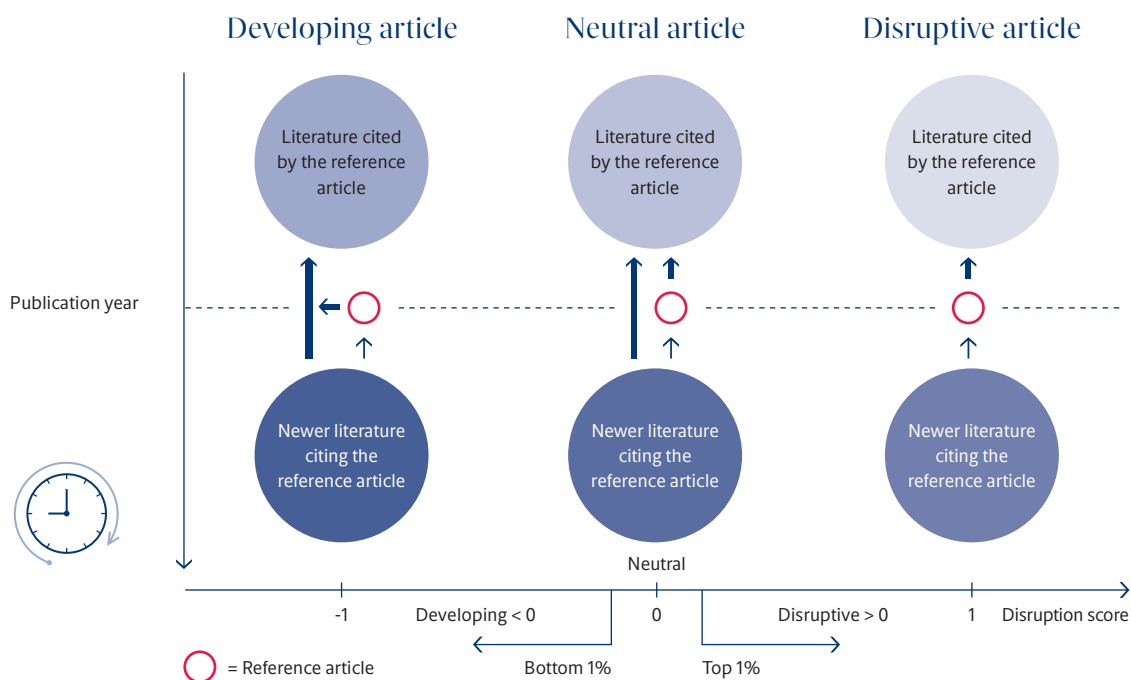
This section applies a new theory for the identification of the nature of research according to the developing or disruptive tendency in the content of journal articles.¹ A so-called “disruption score” is calculated for each journal article (call it the reference article). The score varies from -1 to +1, from developing to disruptive, and expresses the degree of overlap in citations made by the reference article and other articles that cite the reference article.

For example, if a reference article is cited by newer journal articles and the reference article and the journal article citing the reference article have no citations to previous literature in common, the article receives a score of 1. Wu et al. (2019) argue that such an article contains *disruptive* research which starts new strains of research. At the other end of the scale, a reference article will receive a score of -1 if the journal articles citing that reference article also cite the previous literature that the reference article cites. Wu et al. (2019) argue that such an article contains research that further develops an existing strain of research. Therefore, the disruption score varies from complete overlap in the citations made by a reference article and articles citing that reference article (*developing* article) to reference articles with a 50% overlap of citations (*neutral* articles) to a reference article with no citations in common with articles citing that reference article (*disruptive* article).

¹ Wu L, Wang D, Evans JA. Large teams develop and small teams disrupt science and technology. *Nature* 2019; 566:378–382 (<https://www.nature.com/articles/s41586-019-0941-9>).

Figure 2.20 sums up the two extreme cases of no and complete citation overlap, respectively, and the case of a neutral article. The actual scores lie in between these three article examples. Most articles in the global sample from Wu et al (2019) are centred relatively far from -1 and +1 and thus close to zero. The cut-off score for the highest top 1% scores is +0.063, and the cut-off score for the world's lowest 1% scores is -0.049.

Figure 2.20 Degree of overlap in citation pattern between a reference article and literature that cites the reference article determines its disruption score



Source: Wu L, Wang D, Evans JA. Large teams develop and small teams disrupt science and technology. *Nature* 2019;566:378–382 (<https://www.nature.com/articles/s41586-019-0941-9>).

Wu et al (2019) address a recent discussion concerning novelty in research.² The findings of Wu et al (2019) highlight a tendency of more disruptive articles coming from small research teams defined as the number of authors of an article, and more developing articles from large research teams. They further highlight a strong tendency for “Nobel Prize articles” to be disruptive (top 2%). However, the disruption score does not express research quality. As an example, the authors highlight an article by K. B. Davis et al (1995)³ on Bose-Einstein condensate with a disruption score of -0.58, a strong indication of developing content. This article represented a refined experimental study that further developed a well-established theory dating back to the 1920’s proving, that the Bose-Einstein condensate could be created. In 2001, Wolfgang Ketterle, last author on K. B. Davis et al (1995) and head of the lab of the discovery, received one-third of the Nobel Prize for this breakthrough in science “for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates” (Nobel Prize website).⁴

Table 2.1 shows the placement of journal articles by grant recipients relative to the worldwide distribution of disruption scores. The sample is limited to 2000–2014, when the disruption scores are available for funded journal articles by grant recipients. An estimated three journal articles by grant recipients are in the top 1% most disruptive worldwide, 0.04% of the funded journal articles by grant recipients. A total of 149 journal articles by grant recipients are among the top 10% worldwide (1.9%). Journal articles by grant recipients are therefore less frequently represented among the 1% and the 10% most disruptive journal articles than the world average. An underlying and potentially important cause may be unknown details about the distribution by field of science in the Foundation sample compared with the full sample from Wu et al (2019) in the data for this analysis.

² See also Stephan P, Veugelers R, Wang J. Reviewers are blinkered by bibliometrics. *Nature* 2019, 544, 411–412

³ Davis K. B., Mewes M. -O., Andrews M. R., van Druten N. J., Durfee D. S., Kurn D. M., and Ketterle W. Bose-Einstein Condensation in a Gas of Sodium Atoms. *Physical Review Letters* 1995, 3969

⁴ <https://www.nobelprize.org/prizes/physics/2001/ketterle/facts/>

Table 2.1

Disruptive content of journal articles by recipients of Foundation grants

Journal articles by grant recipients:	Number of journal articles	Percentage of journal articles by grant recipients
Among the top 1% disruption scores worldwide	3	0.04%
Among the top 10% disruption scores worldwide	149	1.9%
With positive disruption scores	739	9.6%
Worldwide percentage of journal articles with positive disruption scores		26.4%

Note: James Evans & Lingfei Wu generously provided the disruption scores from the original article. The Foundation is solely responsible for the further interpretation and calculations it performs. Data cover journal articles published in 2000–2014. The global sample from Wu et al (2019) covers 7.33 million publications within the period, while the Foundation sample covers 7609 journal articles and 106 citable letters.

Sources: Wu L, Wang D, Evans JA. Large teams develop and small teams disrupt science and technology. *Nature* 2019;566:378–382 (<https://www.nature.com/articles/s41586-019-0941-9>); Novo Nordisk Foundation/researchfish*; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

As mentioned, positive scores indicate that the research behind the journal article has more disruptive content than development content. Of the journal articles examined for recipients of Foundation grants, 739 (9.6%) published in 2000–2014 have positive disruption scores. The percentage for journal articles by grant recipients with positive disruption scores is about half the worldwide percentage (26.4%). The scores of articles by grant recipients are more compressed than the worldwide distribution of scores: ranging from -0.31 to $+0.019$, with a variance one tenth of the worldwide distribution but with a similar mean and median. However, the tails of the distributions matter greatly for the estimated differences in variance.

2.1.7 Citation score dynamics from the grant team perspective

Citation analysis in general shows that most journal articles are rarely cited, a few are relatively frequently cited and a few of the frequently cited articles are disproportionately highly cited. The citation impact results in the previous sections do not reveal how the various articles linked to Foundation grants contribute to the overall distribution of all Foundation-funded articles. Does a subset of highly successful grants or a broad range of grants deliver high-impact articles? Answering this question requires data that link grant recipients to journal articles and team members of the grant recipient's funded research team, their academic titles and how team members are represented in the articles reported for a specific grant.

The analysis uses a sample of 316 open-competition grants that have been concluded between 2013–2017 with grant amounts between DKK 100,000 and DKK 11 million. Table 2.2 sums up the sample distribution of grants, articles and funding.

Table 2.2 Distribution of grants and articles, and the funding size in the analysed sample

Grant type	Share of grants, # (%)	Share of articles, # (%)	Funding, MDKK		
			Min.	Median	Max.
Project grants	274 (71.0%)	1482 (66.4%)	0.15	0.8	10
Investigator grants	74 (19.2%)	606 (27.2%)	0.15	2.5	11
Innovation grants	17 (4.4%)	62 (2.8%)	0.5	2.5	3.0
Other	21 (5.4%)	82 (3.7%)	0.13	2.5	3.9

Note: The total number of grants in the analysed sample is 316. The total number of grants in the table, 386, reflects that 61 grants share 74 journal articles.

Source: Novo Nordisk Foundation/researchfish*

The cap of DKK 11 million ensures the inclusion of the five-year Hallas-Møller Investigator grant. All other grants are at most DKK 10 million with 89% below DKK 5 million and 70% below DKK 1 million.

The grant recipients in this sample have reported 1992 journal articles, 96% of which were published in 2012–2016. The grants cover 963 researchers funded through the 316 grants of which 647 were team members and 316 were the reporting principal investigators.

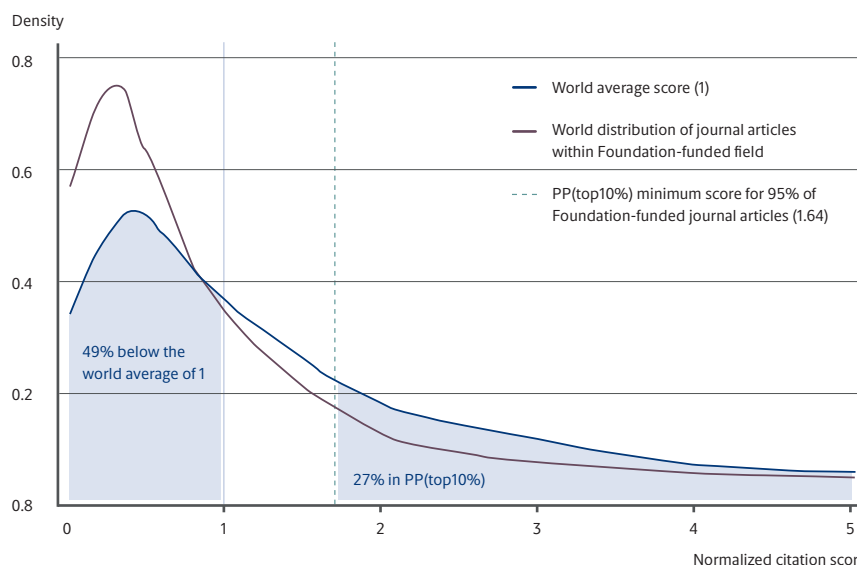
Variation in citation scores of journal articles across and within grants

The citation scores vary substantially both across and within grants. A small group of highly successful grant recipients produces most of the disproportionately highly cited journal articles (normalized citation score above 5); however, more than half the grants deliver at least one article cited among the top 10% most frequently cited worldwide (most of which have normalized citation scores below). Further, not all grants result in frequently cited journal articles, and many of the grants deliver both frequently cited and infrequently cited or uncited journal articles.

Figure 2.21 shows the distribution for 93% of the sample journal articles that have a normalized citation score of less than 5 times the world average. The peak of the density curve (the mode) indicates the most common scores in the distribution. The journal articles to the left of the vertical line at 1 have a normalized citation score below the world average score (of 1). A total of 49% of the journal articles have a citation score below 1 and are centred around 0.4 to 0.6.

Figure 2.21

Distribution of journal articles by recipients of open-competition grants by normalized citation score, benchmarked against world distribution



Note: The figure shows the distribution of the journal articles according to normalized citation score. A score of 1 indicates the world average score. For 95% of the articles, the minimum score for being cited among the 10% most cited worldwide within a Web of Science subject category is 1.64. However, the cut-off varies across subject categories. The world distribution is based on 4914 journal articles sample based on a stratification that matches the distribution of Foundation-funded journal articles according to subject categories.

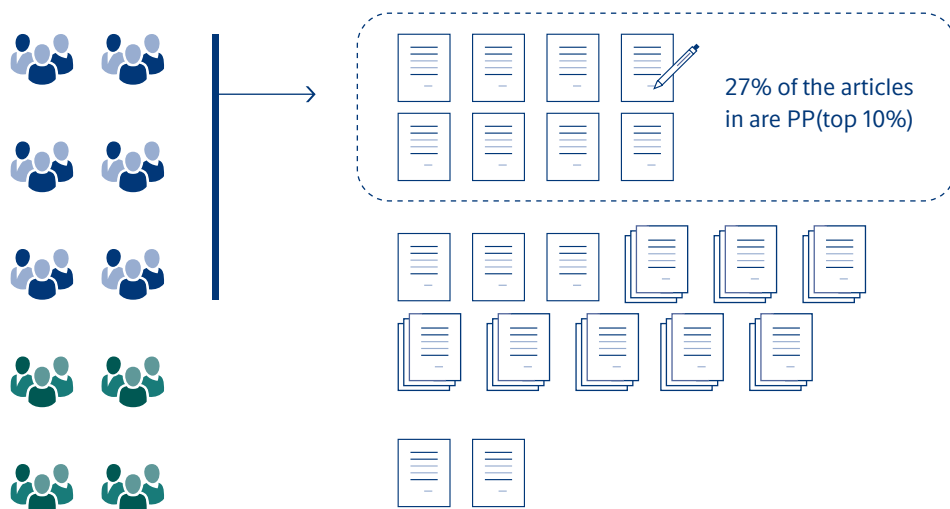
Sources: Novo Nordisk Foundation/researchfish®, Web of Science, CWTS Leiden and Danish Centre for Studies in Research and Research Policy.

The share of Foundation grants with at least one PP(top 10%)-article

Of all journal articles by recipients of open-competition Foundation grants, 27% are among the 10% most frequently cited worldwide (Figure 2.22) – a sign of research excellence. However, these articles originate from 61% of the grants, demonstrating that Foundation-funded success is based on a broad range of grants and not only a small subset of especially successful grants.

Figure 2.22

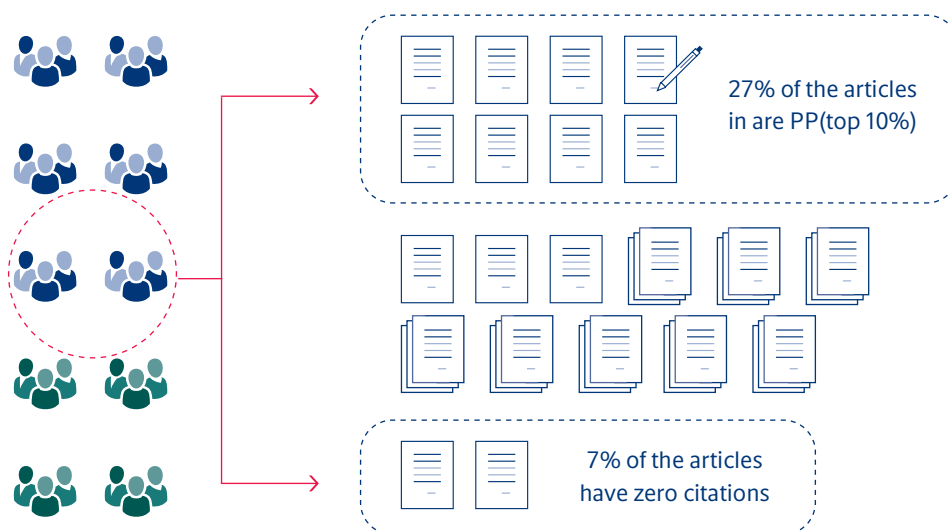
61% of the grant teams deliver at least one PP(top 10%) journal article



Note: These results are based on the analysed sample of 309 open-competition grants that led to 1957 journal articles.
Sources: Novo Nordisk Foundation/researchfish*, Web of Science, CWTS Leiden and Danish Centre for Studies in Research and Research Policy.

Zero-citation journal articles are also distributed on multiple grants. Of the 316 grants analysed, 86 grants (27%) produced at least one of the 143 of the 1992 (7%) journal articles in the sample with zero citations. Of the 86 grants that produced at least one zero-citation article, 63 or 20% also produced articles in the PP(top 10%) (Figure 2.32).

Figure 2.23 20% of the grant teams deliver at least one journal article in PP(top 10%) and at least one journal article with zero citations



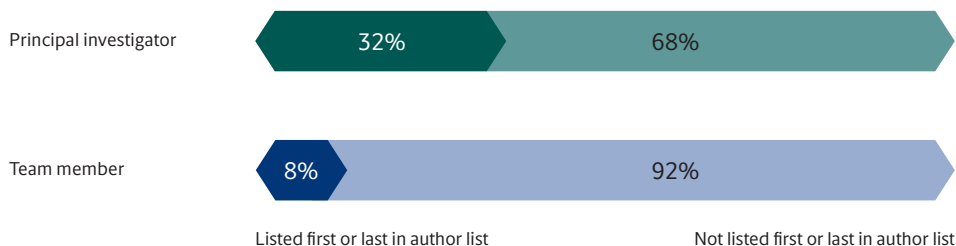
Note: These results are based on the analysed sample of 309 open-competition grants that led to 1957 journal articles.
Sources: Novo Nordisk Foundation/researchfish⁸, Web of Science, CWTS Leiden and Danish Centre for Studies in Research and Research Policy.

First or last author of Foundation-funded journal articles

Many of the journal articles by grant recipients are in the biomedical and health sciences and the natural sciences. Here the sequence of authors matters somewhat, since the first author is usually the main author and the last author often heads the research activity. Figure 2.24 shows that 32% of the principal investigators (the grant recipients) are listed as the first or last author of journal articles that are among the 10% most frequently cited worldwide. Other team members from 8% of the grant teams are also listed as the first or last author of journal articles that are among the 10% most frequently cited worldwide. These other team members were either postdoctoral fellows or PhD students.

Figure 2.24

Share of principal investigators and share of open-competition grants with team members listed as the first or last author of PP(top 10%) journal articles

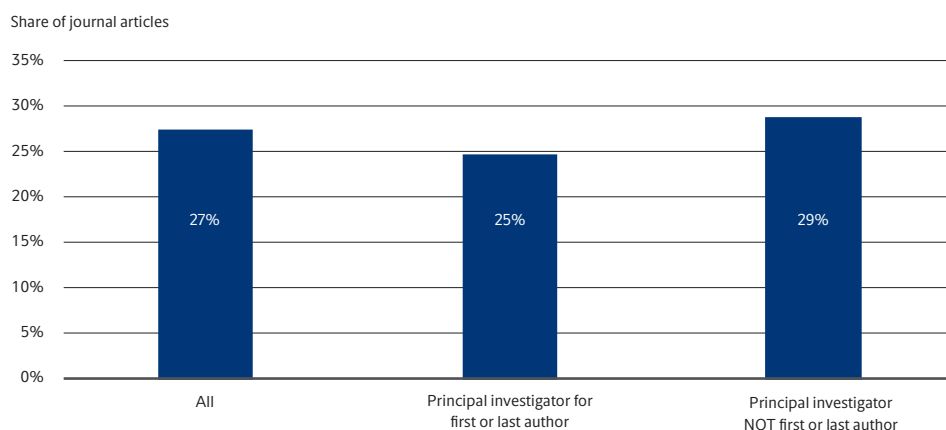


Sources: Novo Nordisk Foundation/researchfish*, Web of Science, CWTS Leiden and Danish Centre for Studies in Research and Research Policy.

These results indicate that the principal investigator tends to have a more secondary role in the research behind frequently cited publications arising from two thirds of the grants. However, because this type of analysis requires information on how and who is funded for the research conducted (grant recipient or team member), there is no well-defined benchmark for the results.

Figure 2.25 compares the PP(top 10%) shares for journal articles in which the principal investigators are the first or last author with other reported journal articles in the PP(top 10%). A total of 25% of journal articles with the principal investigator as the first or last author are among the 10% most frequently cited worldwide, whereas the corresponding number for journal articles without the principal investigator as the first or last author is higher, at 29%.

Figure 2.25 Within-group share of journal articles based on grants in open competition in PP (top 10%) categorised according to the principal investigator's position in the sequence



Note: Based on 536 journal articles among the 1957 articles analysed in the open-competition sample of 309 grants.
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

2.2 Public healthcare

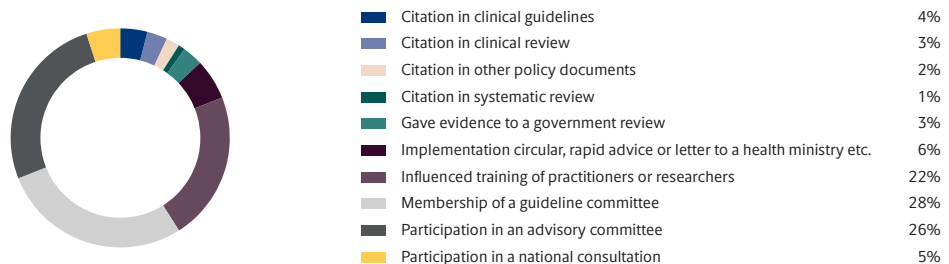
2.2.1 Contributions to practice, guidelines and advisory functions

Some recipients of Foundation grants act as experts who advise, or present evidence to government institutions and other authorities because they are engaged in research activities and can provide new knowledge. They contribute to training practitioners and researchers and they contribute by developing and revising clinical guidelines with recommendations for clinicians on diagnosing, treating and managing diseases.

Grant recipients reported 115 such contributions for 2017 and 2018: 28% related to being a member of a guideline committee, 26% participating in an advisory committee, 5% participating in a national consultation and 22% training practitioners or researchers. The remaining activities cover a wide field of advisory functions, such as working as a health or scientific expert in guidelines or being cited in clinical reviews and specific guidelines, policy documents etc. (Figure 2.26).

Figure 2.26

Contributions to practice, guidelines and advisory functions by grant recipients, 2017–2018



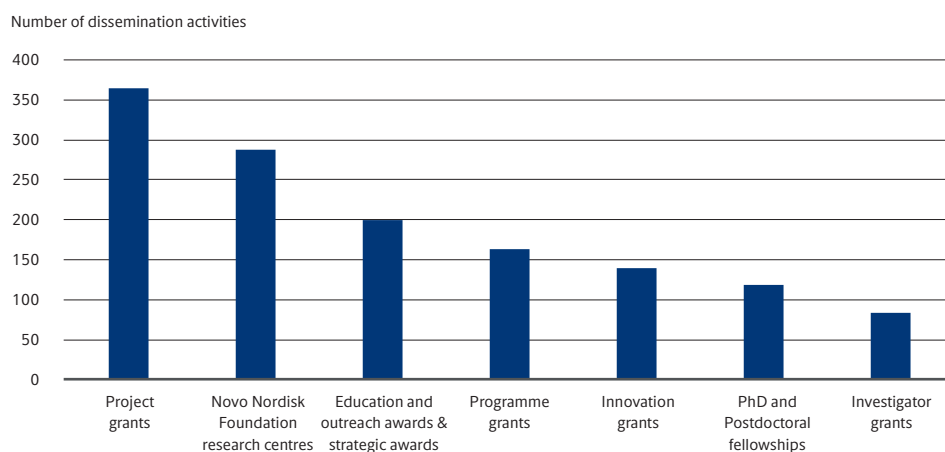
Note: Grant recipients reported 115 contributions. The percentages do not total 100% because of rounding.
 Source: Novo Nordisk Foundation/researchfish*.

2.2.2 Research-based teaching activity for healthcare professionals

Research-based teaching activity for professionals is an important part of the impact of research in the public sector, both within and beyond academia.

The Foundation's grant recipients disseminate their knowledge to professionals in the public sector through courses, conferences, speeches, reports and meetings. They also do this by contributing to training practitioners and researchers. For 2017–2018, the Foundation's grant recipients reported 1422 dissemination activities targeting healthcare professionals. Most dissemination activities stem from recipients of one-off project grants (strategic awards) and the four Foundation research centres (Figure 2.27).

Figure 2.27 Dissemination targeting health professionals, patients and caregivers, 2017–2018

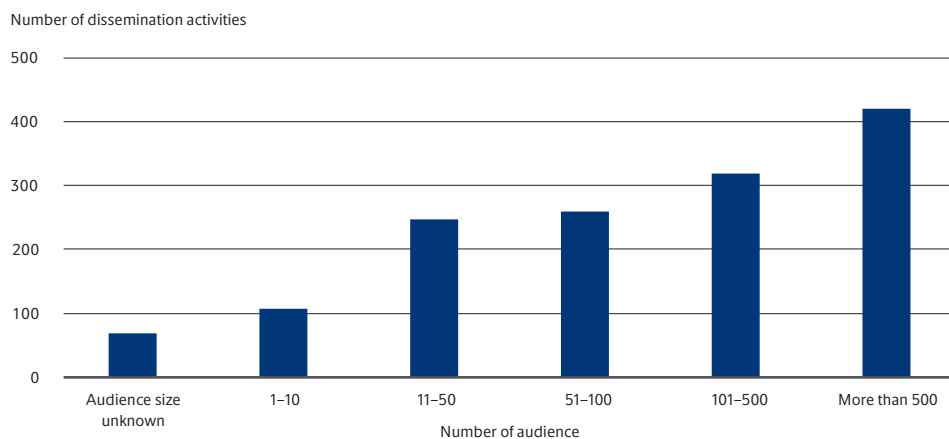


Note: The number of dissemination activities for this group for 2017–2018 was 1422.

Source: Novo Nordisk Foundation/researchfish®.

The recipients of Foundation grants had more than 1400 dissemination activities in 2017–2018 targeting health professionals, patients and caregivers. The dissemination activities reached a large audience. More than 50% of the activities reached an audience of more than 100 people for each activity (Figure 2.28).

Figure 2.28 Number of participants in dissemination activities targeting health professionals, patients and caregivers, 2017–2018



Note: The number of dissemination activities in 2017–2018 was 1422.
Source: Novo Nordisk Foundation/researchfish*.

2.2.3 Steno Diabetes Center activities

The Steno Diabetes Centers specialize in treating people with diabetes. The services provided at the Centers include a wide range of healthcare services related to diabetes, including endocrinological examination and diagnosis, treatment of diabetes, eye scanning and examination, podiatry, dietary guidance and courses in a food laboratory.

A substantial part of the donation is allocated to supplementary treatment developing new, innovative treatment for diabetes and preventing the complications of diabetes. Centre activities also include clinical research, health promotion and education, all interacting to ensure the vision of a longer life and better quality of life for people with diabetes.

Each Steno Diabetes Center has taken the lead in developing an important diabetes-related issue:

- Steno Diabetes Center Copenhagen: education and health promotion
- Steno Diabetes Center North Denmark: digital health
- Steno Diabetes Center Aarhus: integrated health care
- Steno Diabetes Center Odense: type 2-diabetes
- Steno Diabetes Center Zealand: inequality in health and comorbidities

Steno Diabetes Center Copenhagen was established in 2017. Steno Diabetes Center North Denmark, Steno Diabetes Center Aarhus and Steno Diabetes Center Odense were all established in 2018. Steno Diabetes Center Zealand was established in January 2019. The Foundation grants to the Steno Diabetes Centers total DKK 7.5 billion.

At the end of 2018, 514 people, corresponding to 462 full-time employees, were involved in research, clinical or other activities at one of the four active Steno Diabetes Centers. The numbers of personnel were: Steno Diabetes Center Copenhagen 356, Steno Diabetes Center Aarhus 63, Steno Diabetes Center Odense 72 and Steno Diabetes Center North Denmark 23.

A total of 330 peer-reviewed journal articles, 142 conference proceedings or abstracts and 46 publications of other types were registered in 2018 for the Steno Diabetes Centers (Figure 2.29). Because the Centers were established relatively recently, the citation impact cannot be determined for the journal articles.

Figure 2.29 Number of publications from the Steno Diabetes Centers by type, 2018



Source: Novo Nordisk Foundation/researchfish*.

Only Steno Diabetes Center Copenhagen organized courses in 2018. The courses target various healthcare professionals, including dietitians, nurses, occupational therapists, physiotherapists, podiatrists, professional practitioners, psychologists, social care and healthcare workers, and target caregivers and/or patients. The number of courses by geographical reach and primary audience are shown in Tables 2.3 and 2.4 and Figure 2.30.

Table 2.3 Geographical reach of courses by Steno Diabetes Center Copenhagen, 2018

Geographical reach	Number of courses	Percentage
Local	1	4%
Regional	11	46%
National	11	46%
International	1	4%
Total	24	100%

Source: Novo Nordisk Foundation/researchfish*.

Table 2.4

Primary audience of courses by Steno Diabetes Center Copenhagen, 2018

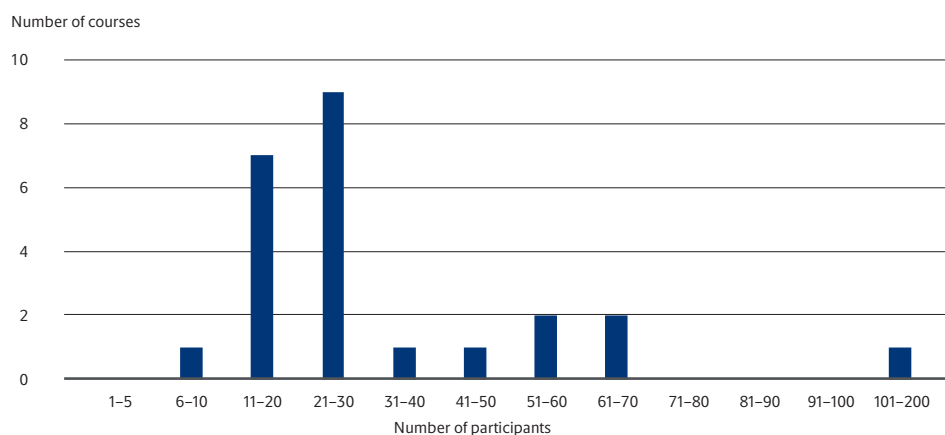
Primary audience of courses	Number of courses	Percentage
Nurses	13	54%
Professional practitioners	8	33%
Social and healthcare workers	1	4%
Undergraduate students and others	2	8%
Total	24	99%

Note: This table does not add up to 100% because of rounding.
 Source: Novo Nordisk Foundation/researchfish®.

The number of attendees per course ranged from 6–10 to 101–200. Figure 2.30 presents the distribution of the numbers of attendees.

Figure 2.30

Distribution of numbers of attendees at courses by Steno Diabetes Center Copenhagen, 2018



Source: Novo Nordisk Foundation/researchfish®.

Steno Diabetes Center collaborations

Collaboration between researchers and other stakeholders can help increase the dissemination of knowledge, and collaboration can promote cross-disciplinary research and foster novel research results. Project collaboration can provide a variety of opportunities for research, innovation and dissemination. The constellation of collaborations can be complex since a single collaboration may involve more collaboration partners. These partners may vary as the collaborative activity develops over time. The Steno Diabetes Centers reported 274 collaborations (Table 2.5 and Figure 2.31) in 2017–2018.

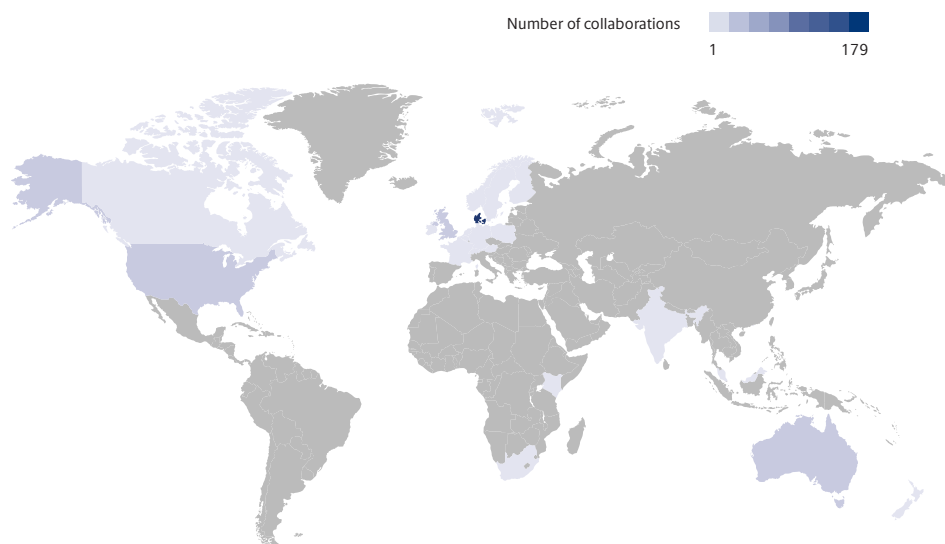
The Steno Diabetes Centers had collaboration partners from 22 countries. Most of the collaboration partners were in Denmark; 35% of the collaborators were located in countries outside Denmark such as the United Kingdom (8%) and the United States (5%).

Table 2.5 Shares of collaboration partners in countries with the most partners, 2017–2018

Country	Share of total
Denmark	65%
United Kingdom	8%
United States	5%
Australia	2%
Germany	1%
Ireland	1%
Kenya	1%
Sweden	1%
Total	84%

Source: Novo Nordisk Foundation/ researchfish*.

Figure 2.31 Map of the collaboration partners of Steno Diabetes Centers, 2018



Source: Novo Nordisk Foundation/researchfish®.

The Steno Diabetes Centers have most of their collaboration partners in the academic sector (43%), followed by hospitals (18%), other public institutions (12%) and private institutions (11%) (Table 2.6).

Table 2.6 Collaborations by sector

Collaborations by sector	Percentage
Academic	43%
Hospital	18%
Public	12%
Private	11%
Non-profit	7%
Unknown	11%
Total	100%

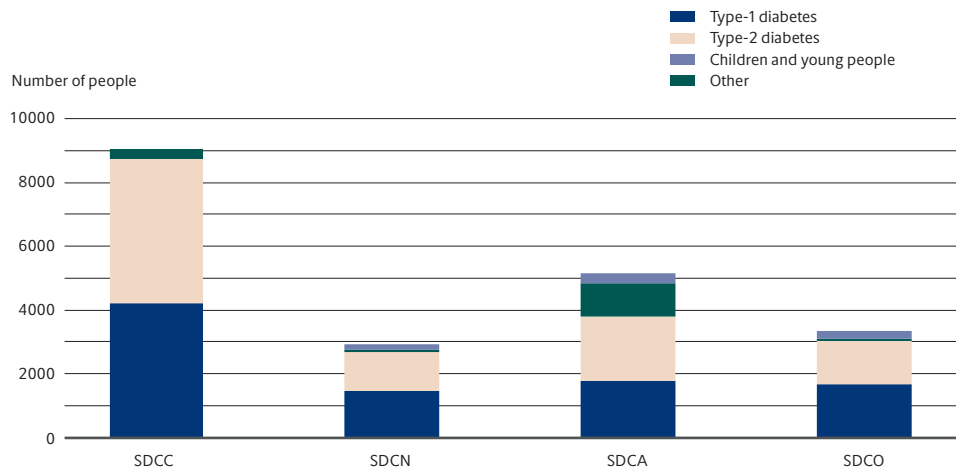
Source: Novo Nordisk Foundation/ researchfish®.

2.2.4 Treatment at the Steno Diabetes Centers

The Steno Diabetes Centers specialize in treating people with diabetes. Until 2016, the Foundation supported the Steno Diabetes Center, the predecessor to Steno Diabetes Center Copenhagen, which treated 5500 people in 2016. In 2018, the four Centers treated a total of 20,480 people with diabetes, which is far more than in 2017, when Steno Diabetes Center Copenhagen, as the only Steno Diabetes Center, treated 6503 people. The Steno Diabetes Centers aim to treat 44,000 people with diabetes annually by 2023. The distribution of people treated at the Steno Diabetes Centers is 45% type 1–diabetes, 44% type 2–diabetes and 4% children and young people (Figure 2.32).

Figure 2.32

Number of people with diabetes treated at the Steno Diabetes Centers by type of diabetes and age



Note: Steno Diabetes Center Copenhagen (SDCC), Steno Diabetes Center Odense (SDCO) and Steno Diabetes Center Northern Denmark (SDCN) and Steno Diabetes Center Aarhus (SDCA).

Source: Novo Nordisk Foundation.

The additional treatment initiatives are a key part of the Foundation's grants to the Steno Diabetes Centers and are designed to develop and document new and improved therapies. The Steno Diabetes Centers launched almost 50 treatment initiatives in 2018.

Three examples of treatment initiatives:

1. Steno Diabetes Center Copenhagen has launched an intersectoral initiative. The purpose of this is to target and strengthen the intersectoral collaboration that already exists between the Capital Region of Denmark, the City of Copenhagen and the practice sector. The collaboration focuses on people with diabetes or those who are at risk of developing diabetes through tracking, prevention and targeted initiatives for vulnerable groups. There are also collaborations on optimizing seamless treatment for people with diabetes, patient education, quality development, tools, knowledge, skills and competencies.
2. Steno Diabetes Center Aarhus has initiated a shared patient clinic together with the Department of Renal Medicine of Aarhus University Hospital. The purpose is to strengthen the collaboration between clinical efforts in diabetes and renal medicine by increasing coordination, organizing multidisciplinary conferences and establishing a shared patient clinic.
3. Steno Diabetes Center North Denmark has an initiative targeting pregnant women with pregestational and gestational diabetes. They are offered optimized control and treatment during their pregnancy. This includes extra consultations with endocrinologists and dietitians stage of their pregnancy for women who live remotely from the hospital.

Steno Collaborative Grants

The Foundation attempts to ensure collaboration between research groups from the established Steno Diabetes Centers and research communities outside the Centers in Denmark. The Foundation launched this new programme in 2018 and awarded nine grants totalling DKK 50 million within the following fields: clinical research in the broadest sense, including translational research, epidemiology and big data; research on the characteristics of the Steno Diabetes Centers, including digital health and diabetes; continuity in patient care; type 2 diabetes; and health promotion research and education.

2.2.5 Nursing programme

The Foundation awards grants for research-based nursing in Denmark focusing on research on disease prevention and health promotion, rehabilitation and palliative care and management and organization with the aim of improving treatment for patients. In 2018, the Foundation awarded 15 grants: one programme grant of DKK 7.5 million, three PhD scholarships totalling DKK 5.4 million, three postdoctoral fellowships totalling DKK 5.4 million and eight projects totalling DKK 3 million. The goals are to strengthen nursing research through long-term research funding, to attract and develop talented researchers, to base nursing research on current problem-solving by health professionals, to accelerate the development of new treatment methods within nursing and/or to create project constellations in which nursing researchers may obtain research experience at the highest level.

The Foundation has awarded grants for nursing research since 2013. Tables 2.7 and 2.8 show some of the outcomes and outputs. It is still too early to measure the results of the programme, but several outputs have already been reported.

Table 2.7

Dissemination activities related to the Foundation's nursing programme, 2013–2018

Dissemination	Dissemination activities
A formal working group, expert panel or dialogue	7
A press release, press conference or response to a media enquiry/interview	29
A talk or presentation	61
Participation in an activity, workshop or similar	4
Scientific meeting: conference or symposium etc.	2
Total	103

Source: Novo Nordisk Foundation/researchfish*.

Table 2.8 Publication activities related to the Foundation's nursing programme, 2013–2018

Publications	Number of publications
Conference proceedings or abstracts	11
Journal articles	71
Other, including book chapters, theses, guides and monographs	8
Total	90

Source: Novo Nordisk Foundation/researchfish*.

2.3 Three cancer projects

This section demonstrates how grant recipients from the Foundation's three cancer projects (Cancer 1, Cancer 2, and Cancer 3 from 2006 to 2018) contributed outputs and how they complemented and inspired Denmark's and international cancer plans and guidelines.

In the early 2000s, the waiting time for cancer treatment in Denmark was long and the regional differences were excessive. Waiting for cancer to be diagnosed and treated may cause great mental health stress. This called for more systematic measuring and monitoring of cancer-related healthcare processes. Lack of capacity and long waiting times were identified as important obstacles for implementing national cancer plans in Denmark. In 2005, the Foundation initiated research projects with the aim of obtaining well-documented evidence on ways of reducing delays in cancer treatment, improving healthcare pathways and communication in Denmark's healthcare system on cancer treatment. The following box describes the specific purposes of each project.

Cancer 1 – Coherence Treatment for Cancer Patients (2006–2009).

This aimed to enhance coherence for cancer patients without delay in the many treatment processes for the individual patient, especially when several areas of the health sector are involved. The focus was on continuity, coordination and logistics for cancer treatment. In addition, the project aimed to identify the best solutions in terms of enhancing communication, organization and economic and cultural conditions for cancer treatment plans. This project also included an education component in terms of creating PhD projects.

Cancer 2 – From Symptom to Treatment (2009–2013).

This aimed to identify the reasons for the extended time between people experiencing the first symptoms and treatment being initiated. Some of the objectives for this project relate to the following questions. What influences people's behaviour in reporting their symptoms late? How can family physicians and general practitioners be trained to identify people with cancer symptoms more quickly? How can the collaboration in the health sector related to people with cancer be optimized?

Cancer 3 – Returning to Daily Life (2010–2018).

This focused on the optimal way of helping people who have completed treatment back to a normal life after cancer. In 2009, more than 30,000 people in Denmark completed cancer treatment, and although some relapsed, more than half the people who survive cancer are expected to die from other causes. They continue to live, although many people have after effects of surgery, chemotherapy and radiation therapy and worries about their future.

The Foundation awarded grants totalling DKK 45 million, and additional funding from the Danish Cancer Society and other funders made the total grants for the three projects DKK 116 million from 2006 until 2018. Table 2.9 shows the distribution of grants over the years.

Table 2.9 Grants for the Cancer 1–3 projects (DKK millions)

	Cancer 1 (2006–2009)	Cancer 2 (2009–2013)	Cancer 3 (2010–2018)	Total (2006–2018)
Novo Nordisk Foundation	15	15	15	45
Danish Cancer Society	-	15	15	30
Other external funders	-	8-10	33	41-43
Total	≥15	38-40	63	≥118

Sources: Novo Nordisk Foundation and Copenhagen Economics.

The Foundation and the Danish Cancer Society collaborated on Cancer 2 and Cancer 3. In total, the three projects received DKK 75 million from the two organizations. The projects succeeded in attracting additional external funding. In Cancer 1, additional funding for an unspecified amount was also attracted to supplement the grant. Cancer 2 received DKK 8–10 million in additional funding and Cancer 3 obtained additional external funds for DKK 33 million. The additional funding was used to cover PhD students' salaries, additional studies and other expenses.

In addition to the Foundation's cancer projects (Cancer 1, Cancer 2 and Cancer 3), the Foundation has funded many cancer research projects. This can be identified in various outputs that are not presented here.

Figure 2.33

The Foundation's three cancer projects

(Cancer 1–3 from 2006–2018)

The Foundation's cancer projects interacted with Denmark's national cancer plans (Cancer plan I, Cancer plan II, Cancer plan III and Cancer plan IV). Figure 2.33 shows the timeline for the cancer projects and Denmark's national cancer plans.

Cancer 1

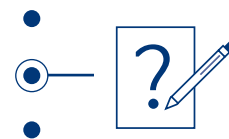
Coherence for Cancer Patients
2006–2009

The faster the course, the
higher the survival rate.

"In 1999, an 18-year-old cancer patient asked for a fitness bicycle."

— Lis Adamsen
Professor

Problem



Cancer 1 – 2006–2009



2000

2005

Cancer plan I, 2000

Focused on the epidemiology of cancer in Denmark compared with the other Nordic countries and on increasing capacity in relation to radiation therapy and pharmaceutical and surgical treatment.

Denmark's national cancer plans

Cancer plan II, 2005

Focused on improving the coherence and organization of the patient course, which resulted in the subsequent preparation of the package courses. In addition, there was a focus on preventing smoking and strengthening cancer surgery. In 2007, the Danish Health Authority followed with a professional review, which indicated a need for increased efforts to develop cancer packages, cancer surgery, clinical guidelines, monitoring, coherence in patient care and prevention of smoking.

Cancer 2

From Symptom to Treatment
2009–2013

Optimizing the diagnosis of cancer, focusing on rapid and efficient assessment and referral of the cancer patient. Research therefore focused on cancer symptoms, new technologies and how to organize progress for patients.

Cancer 3

Returning to Daily Life
2010–2018

The purpose of the project was to optimize the rehabilitation of cancer patients after treatment has been completed. The project focused on how to give patients the best possible support in their life after cancer.

Impact of cancer projects
in Sweden and Norway



Cancer 2 – 2009–2013

Cancer 3 – 2010–2018

2010

2016

Cancer plan III, 2010

Focused on improving and expanding the parts of the patient care before and after treatment in the hospital, including early detection, rehabilitation and palliative care. In addition, the cancer packages were revised.

Cancer plan IV, 2016

Focuses on the previous cancer plans, and the ambition behind cancer plan IV is to strengthen prevention so that fewer people develop cancer and to improve diagnosis and treatment, so that more people survive cancer. Everyone must find that their course of treatment was well designed and that they were involved along the way.

2.3.1 Output and outcomes of the cancer projects

Cancer 2 and Cancer 3 each created a centre, and both were integrated with a university or research hospital. After the grants were awarded for Cancer 2, the Research Centre for Cancer Diagnosis in Primary Care at Aarhus University was established in 2010. Cancer 3 established the Centre for Integrated Rehabilitation of Cancer Patients at the University of Copenhagen and Rigshospitalet the year after receiving the grants.

Table 2.10 Numbers of publications and authors for Cancer 1–3 projects

	Number of publications	Total number of authors
Cancer 1 (2006–2009)	45	65
Cancer 2 (2009–2013)	93	144
Cancer 3 (2010–2018)	68	174
Total	206	356

Source: Cancer project publication overview, Copenhagen Economics A/S.

Table 2.11 shows a low share of journal articles among the 10% most frequently cited articles worldwide. The reason is that the cancer projects were applied research and instead cited in policy papers and official documents leading to Denmark's official national cancer plans.

Table 2.11 Citation impact of journal articles produced by Cancer 1–3 projects

	Journal articles	PP(top 10%)
Cancer 1 (2006–2009)	41	12%
Cancer 2 (2009–2013)	82	9%
Cancer 3 (2010–2018)	34	1%

Sources: Danish Centre for Studies of Research and Research Policy.

The number of references in public policy documents, such as the scientific decisions and documents for the national cancer plans and clinical guideline service, indicate an effect of the cancer projects. Tracking the references from the cancer project publications cited in the public policy documents identified such publications, especially in Denmark's third national cancer plan. In the documents leading to Denmark's second national cancer plan, 2 of 12 documents contain a reference from the cancer project's grant recipients.

Twenty-six PhD projects were established as part of the projects. The three cancer projects hosted or initiated several conferences, workshops and presentations, including international conferences (Table 2.12). The Cancer 3 project affected at least 2000 patients. In addition, the results from several randomized controlled trials from the cancer projects, regarding clinical guidelines for screening children, are in the pipeline for publication (Cancer 3). Further, the results from the cancer projects are included in teaching materials at universities in Denmark.

Table 2.12 PhD projects and dissemination activities related to Cancer 1–3 projects

	PhD projects	Workshops	Conferences	Presentations
Cancer 1 (2006–2009)	11	-	2	50
Cancer 2 (2009–2013)	6	-	-	300
Cancer 3 (2010–2018)	9	7	76	76
Total	26	7	76	406

Sources: Novo Nordisk Foundation/researchfish® and Copenhagen Economics A/S.

Other outputs or inspiration can be found in Denmark's fourth national cancer plan, which shares many of the same prospects, such as early detection of cancer and supporting coherence in treatment. This also includes people's wishes to focus on having a good quality of life after cancer. This, in turn, justifies a shift in focus to side-effects rather than solely measuring the impact on survival. Figure 2.34 shows the tracking of the cancer project into Denmark's national cancer plans (Denmark's fourth national cancer plan).

The text coloured in red indicates the inspiration or overlap with the Foundation's cancer projects. References, use of wording as well as interviews with 20 stakeholders point in the direction of a positive influence on the development of the national cancer plans.

Figure 2.34 Relations between Denmark's fourth national cancer plan and the Cancer 1–3 projects



2.3.2 International outcome of the cancer projects

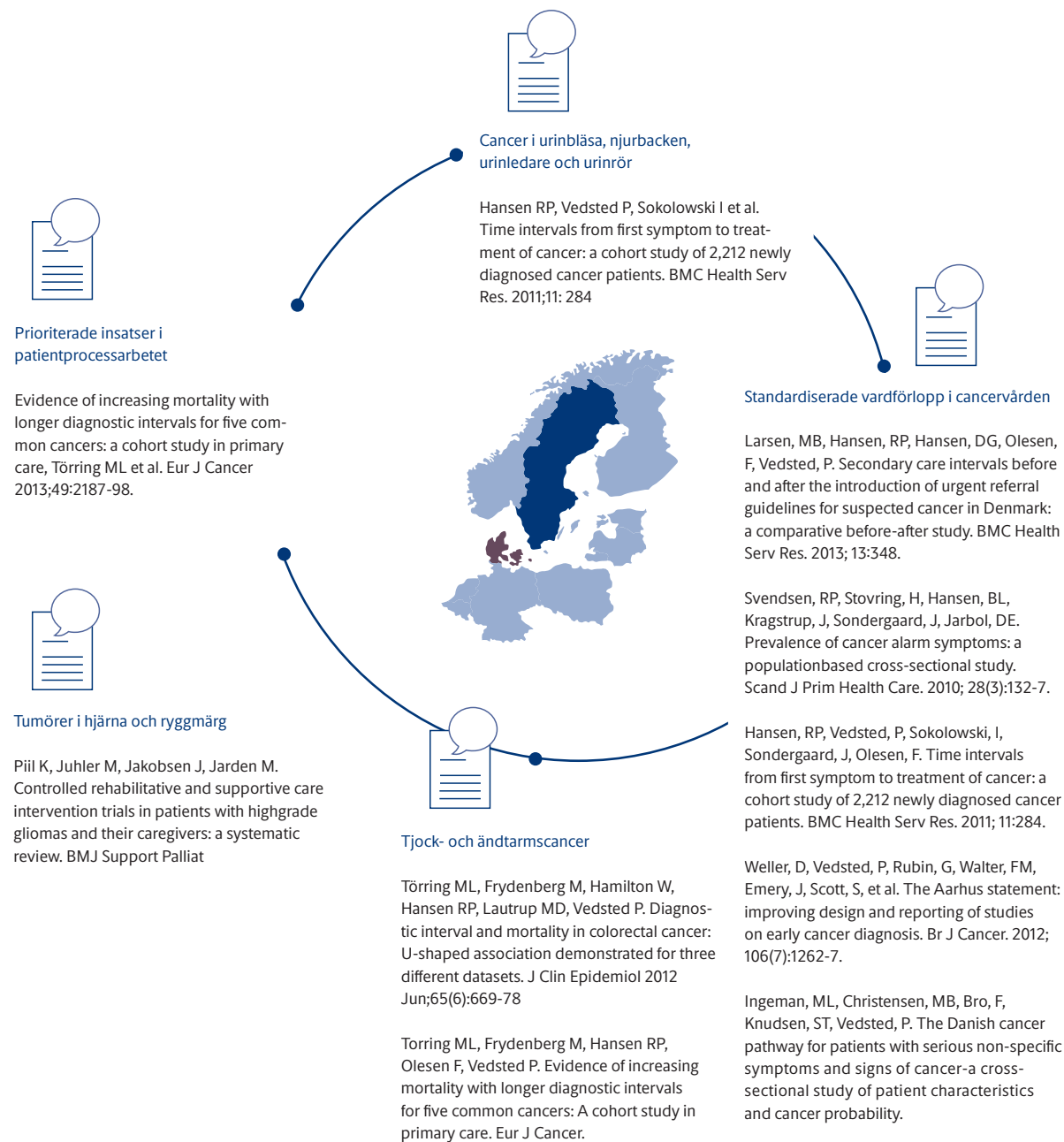
Denmark's national cancer plans have been disseminated, especially in Scandinavia, in developing other national cancer treatment plans. In Sweden, this is called the Danish model; in Norway, where Denmark's principles were adopted, the programme is called "within 48 hours". Several of the grant recipients from the cancer projects established and influenced international network activities. Several of the principal investigators from the cancer projects were deeply involved in developing the national cancer plans for Sweden and Norway by providing knowledge from Denmark's national cancer plans and Cancer 1–3 projects. Several of the principal investigators and key stakeholders were invited to facilitate workshops, and one received a cancer prize in Norway. As an example, Figure 2.35 shows how Sweden's national cancer plans (Figure 2.35) were influenced by publications by grant recipients in the cancer projects.

2.3.3 Key drivers for the success of the projects

To analyse the importance of contributions to Denmark's national cancer plans and guidelines, several key stakeholders of the three projects were interviewed. The interviews indicate that Cancer 1 acted as a filter for promising research. One subproject from Cancer 1 on diagnosis became the focus in Cancer 2, which created the Research Centre for Cancer Diagnosis in Primary Care at Aarhus University.

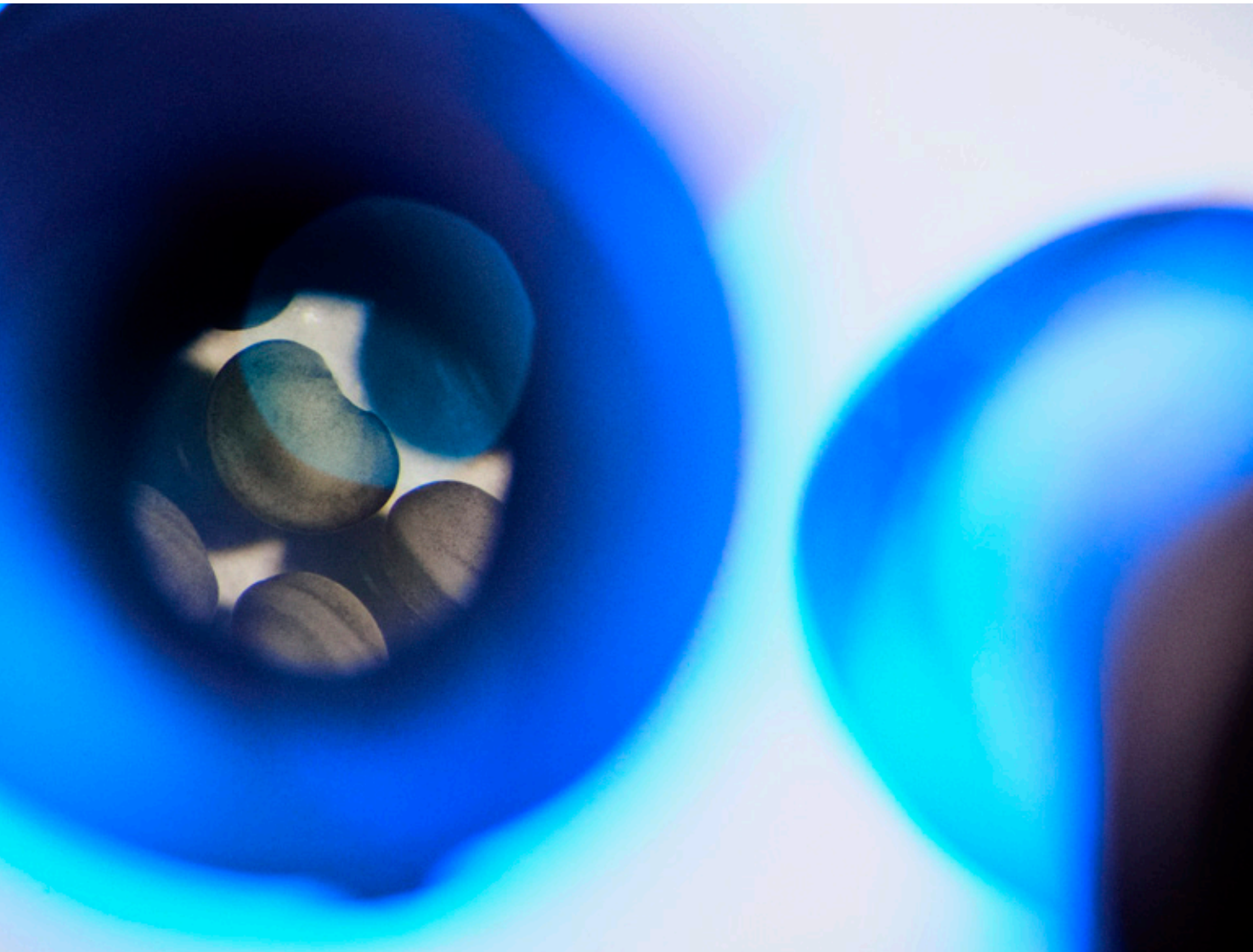
The key stakeholders of the projects greatly emphasized direct face-to-face communication and disseminating results to relevant recipients, which also inspired Denmark's national cancer plans and the multidisciplinary Cancer Group clinical guidelines. The interviews indicated that the results from especially Cancer 2 and Cancer 3 were disseminated in a process beyond the ordinary. The research results were communicated at different levels. Policy-makers and decision-makers were addressed at conferences and by the Danish Cancer Society and the Danish Health Authority's Committee on Cancer. The direct dissemination of the research results has also been decisive for the projects' subsequent impact. The key stakeholders were both high-level decision-makers who directly and indirectly influenced Denmark's national cancer plans and physicians who implemented the results in their daily routines.

Figure 2.35 References to journal articles produced by Foundation grant recipients in Sweden's national cancer plans



Chapter 3

Dissemination and use of
knowledge within the private sector



3. DISSEMINATION AND USE OF KNOWLEDGE IN THE PRIVATE SECTOR

This chapter focuses on three types of private sector uptake of research-based knowledge generated from Foundation-funded public research activities: collaboration with companies, use of research in patents and the Foundation's innovation grants for start-up companies exploring the commercial potential of public research.

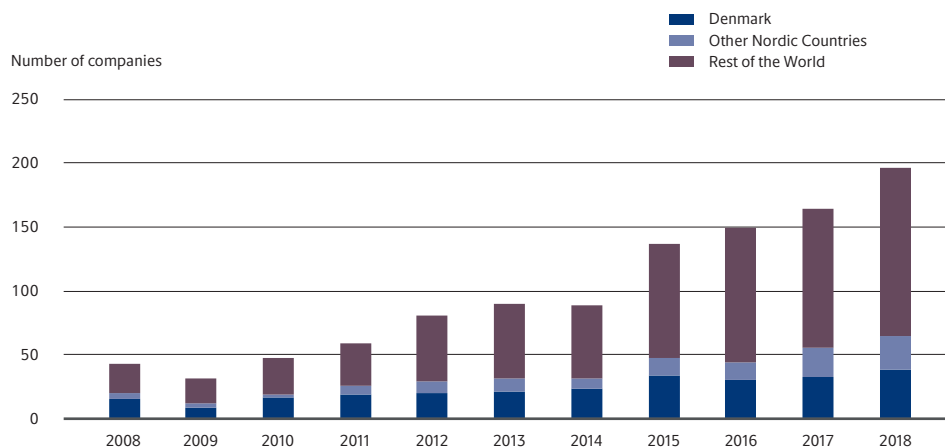
3.1 Grant recipient collaboration with companies

This section presents evidence on the transmission channel from public research to the private sector through research collaboration. Figure 3.1 presents the number of distinct companies collaborating or co-publishing with recipients of Foundation grants per year. Figure 3.2 shows the number of Foundation-funded journal articles co-authored with industrial researchers, and the number of active project collaborations.

The number of journal articles co-published with industrial researchers and active project collaborations with private companies increased rapidly from 2008 to 2018. A total of 196 distinct companies collaborated with grant recipients in 2018 versus 165 distinct companies in 2017 (see Figure 3.1).

Figure 3.1

Number of distinct companies, by location, co-publishing with grant recipients and number of distinct collaborations between companies and grant recipients, 2008–2018

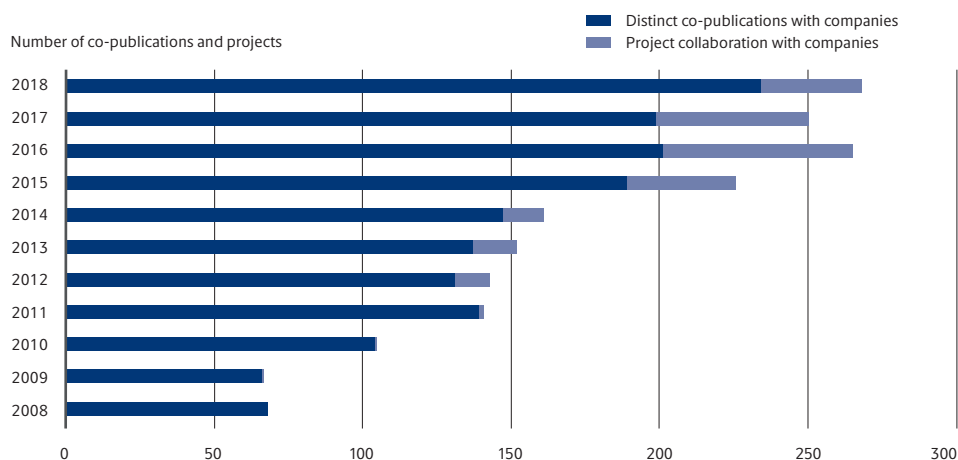


Note: The nationality of companies refers to the country in which a legal entity is registered and located regardless of the nationality of ownership. For example, Novo Nordisk A/S is a Danish company, but Novo Nordisk Inc. is a United States company.

Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics based on Scopus data.

In 2018, the companies jointly collaborated on 234 journal articles and 34 projects (Figure 3.2). In 2017 the numbers were 199 journal articles and 51 projects.

Figure 3.2 Number of distinct collaborations such as co-publications and project collaborations between companies and grant recipients, 2008–2018

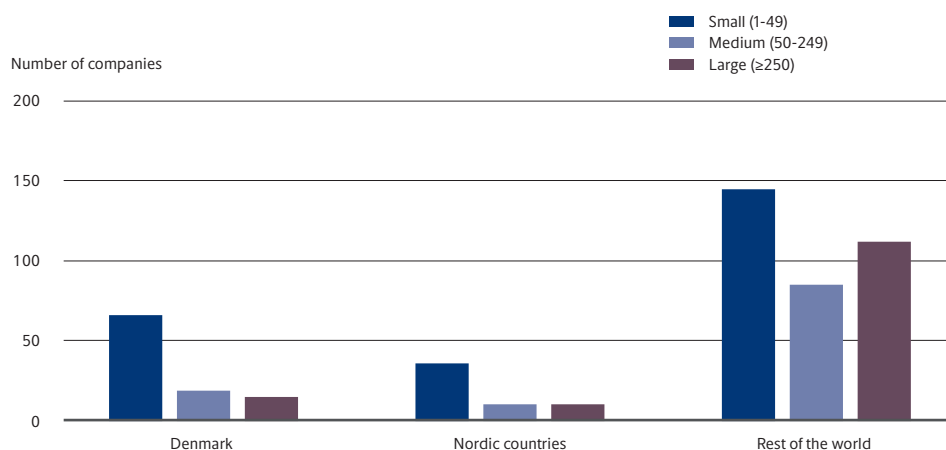


Sources: Novo Nordisk Foundation/researchfish* and DAMVAD Analytics based on Scopus data.

The collaboration with companies outside Denmark has grown the most in recent years. Grant recipients primarily collaborate with small companies, measured by the number of employees, at all three geographical levels (Denmark, the other Nordic countries and the rest of the world). Medium and large collaborating companies are mainly located outside the Nordic countries (Figure 3.3).

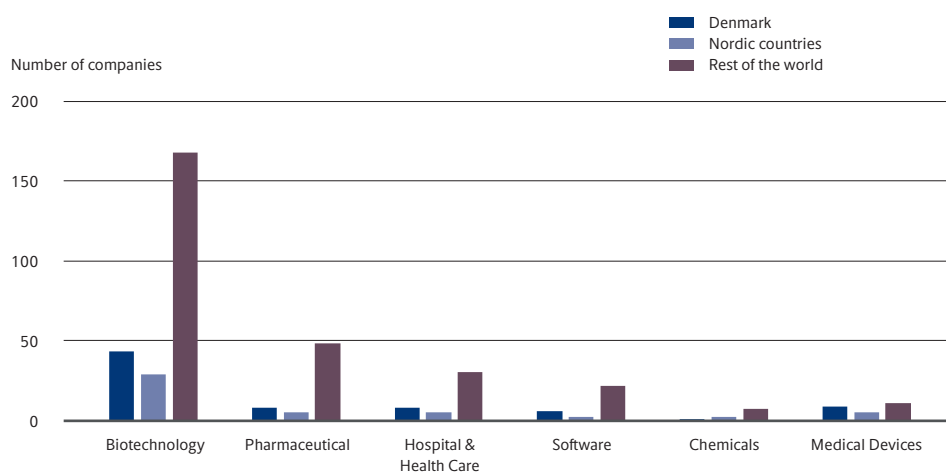
Grant recipients collaborated with 339 biotechnology companies and 99 pharmaceutical companies during the past decade. The companies in Denmark are primarily within biotechnology and hospital and healthcare. The companies outside Denmark are primarily within biotechnology and pharmaceuticals, and some are within software and hospitals and healthcare.

Figure 3.3 Companies collaborating with the recipients of Foundation grants by number of employees and location



Note: Time period: 2014–2018. The number of companies are distinct for each type of grant.
Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics based on Scopus data.

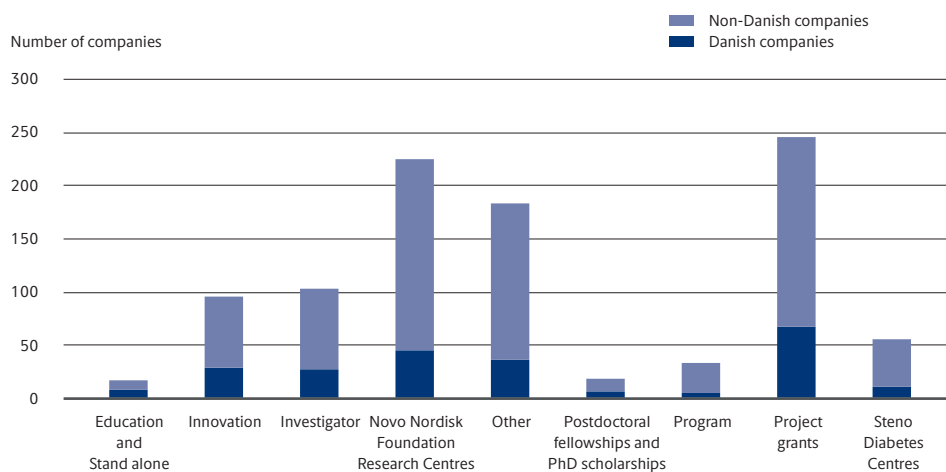
Figure 3.4 Companies collaborating with the recipients of Foundation grants by industry



Note: Time period: 2014–2018. The categories of industries follow the international standard classification codes. The number of companies are distinct for each type of grant, but companies may collaborate with more than one grant recipient and therefore be counted more than once across types of grants.
Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics based on Scopus data.

Figure 3.5

Companies collaborating with the recipients of Foundation grants by types



Note: Time period: 2014–2018.

Sources: Novo Nordisk Foundation/researchfish* and DAMVAD Analytics based on Scopus data.

3.1.1 Co-authored journal articles with researchers from industry

The data used in this section cover Foundation-funded journal articles between 2008 and 2018. Table 3.1 shows that 11.1% of the journal articles in 2008–2018 were co-authored with companies. About half of these were co-authored by industrial researchers working for companies in Denmark. A somewhat comparable share for all journal articles co-authored by researchers located in Denmark for 2013–2017 is 7% (*Forskningsbarometer 2018*, the Denmark's Ministry of Higher Education and Science).

Table 3.1 Foundation-funded journal articles according to the type of collaboration, 2008–2018

	Number	%
Total articles based on the Foundation's grants	14,990	100
Articles only co-published with academia	13,323	88.9
Articles in collaboration with one or more companies	1667	11.1
- Articles in collaboration with Danish companies only	731	4.9
- Articles in collaboration with non-Danish companies only	936	6.2
- Articles in collaboration with both Danish and non-Danish companies	64	0.04

Note: Time period: 2008–2018.

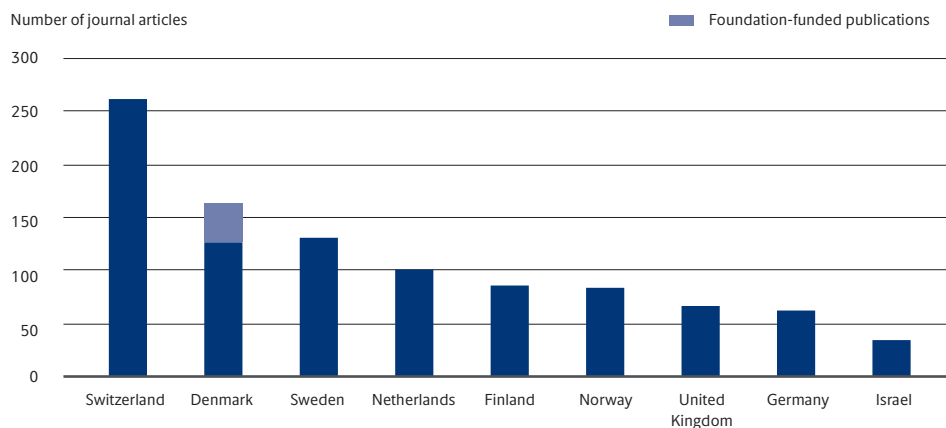
Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics based on Scopus data.

International benchmark of academia–industry co-publications

Researchers in Denmark publish more public-private (academia–industry) co-authored journal articles per million population than researchers do in most other European countries (Figure 3.6). In 2017, Danish researchers published 163 academia–industry co-authored articles per million population in; researchers in Switzerland had the highest production at 260 per million population. The recipients of Foundation grants published the equivalent of 26 academia–industry co-authored journal articles per million population based on Foundation grants.

Figure 3.6

Academia–industry co-publications per million population, 2017



Sources: Novo Nordisk Foundation/researchfish® and European Commission, (European Innovation Scoreboard 2018).

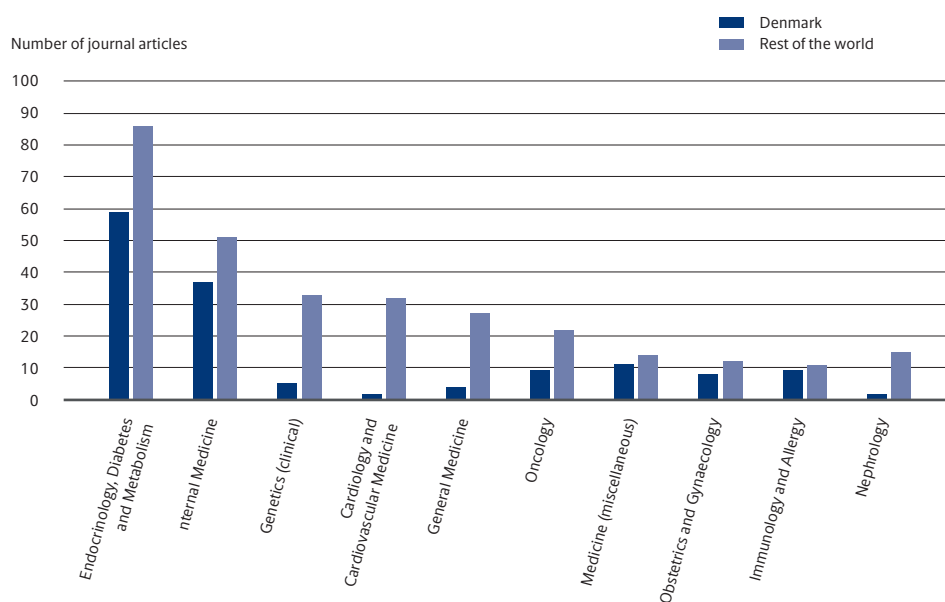
Subject categories for public–private co-publications

Figure 3.7 shows the numbers of journal articles by the recipients of Foundation grants co-authored with industrial researchers in companies in Denmark and the rest of the world across journal subject categories according to the location of the industrial co-authors.

The numbers for Denmark reflect journal articles with industrial co-authors located only in Denmark. The numbers for the rest of the world always includes industrial co-authors located outside Denmark but may also include industrial co-authors located in Denmark.

Figure 3.7

Journal articles by recipients of Foundation grants co-authored with industrial researchers according to location and top 10 journal subject categories, 2014–2018

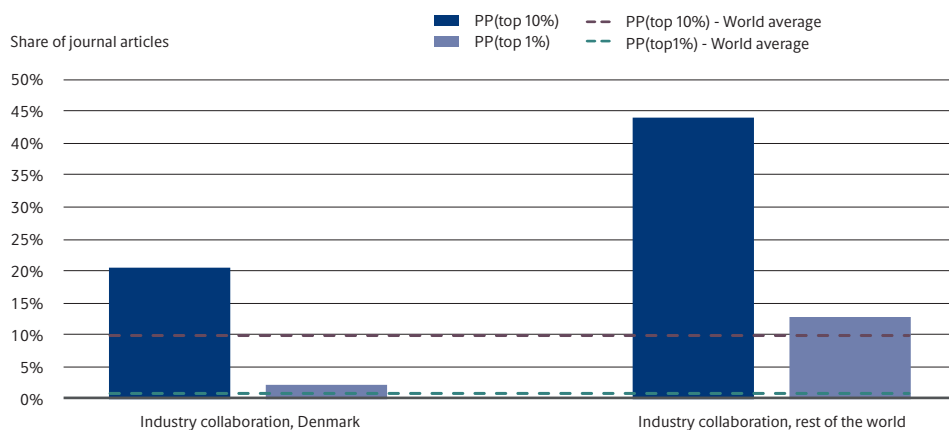


Note: Time period: 2014–2018. Subject categories from Web of Science.

Sources: Novo Nordisk Foundation/researchfish[®]; DAMVAD Analytics based on Scopus data; and Danish Centre for Studies in Research and Research Policy and Web of Science.

Journal articles co-authored with industrial researchers both in and outside Denmark have high citation impact. Co-authored collaborations with industrial researchers outside Denmark have the highest impact (Figure 3.8).

Figure 3.8 Citation impact of publications by recipients of Foundation grants co-authored with Danish and non-Danish companies, 2016–2017



Sources: Novo Nordisk Foundation/researchfish* and DAMVAD Analytics.

3.1.2 Companies' experience in research collaboration with grant recipients

What types of motivational factors, incentives and other factors influence collaboration between research companies and recipients of Foundation grants? This section focuses on the companies' experience with and motivational factors for entering into research collaboration with grant recipients at public research institutions. It presents results from survey interviews from 152 research-active companies in Denmark about their research collaboration culture, motivation for collaborating with public researchers and publishing research; 37 of the companies in the sample (about 24%) have collaborated with recipients of Foundation grants.

The survey sample of companies was generated from a sample of 1200 companies from Denmark's Central Business Registry, which were matched to publication data. Then 314 research companies were identified, and 152 were interviewed (the rest were not successfully reached or did not pass the screening questions).

Among the surveyed companies, all of which publish articles in scientific journals, 85% have co-published with public researchers. Most of the companies have collaborated with public researchers for more than 6 years.

According to the research literature, companies collaborate, publish and share knowledge with public researchers for many reasons, some of which this analysis explores. It demonstrates that public research plays an important role in the companies.

Figures 3.9 and 3.10 present the degree of importance of the motivational factors for collaboration between companies and public researchers. The responding companies rated the motivational factors on a scale including "not at all", "less", "some", "high" or "very high". These figures only show the share rating the answers high or very high degree.

Many companies reported positively that enhancing competencies is a motivational factor for collaboration: 50% of research companies collaborating with recipients of Foundation grants have answered that strengthened competencies to a high or a very high degree is a motivating factor for collaboration. The value is 37% for research companies not collaborating with recipients of Foundation grants companies.

Further, access to research infrastructure at public research institutions is a highly or very highly motivating factor for 45% of research companies collaborating with recipients of Foundation grants versus 26% for research companies not collaborating with recipients of Foundation grants.

Research companies collaborating with recipients of Foundation grants generally weight various causes for motivational factors for collaboration higher than research companies not collaborating with recipients of Foundation grants, except for "access to applied research" (Figures 3.9 and 3.10).

Figure 3.9 Share of companies that attribute high or very high value to collaboration with public research in various categories

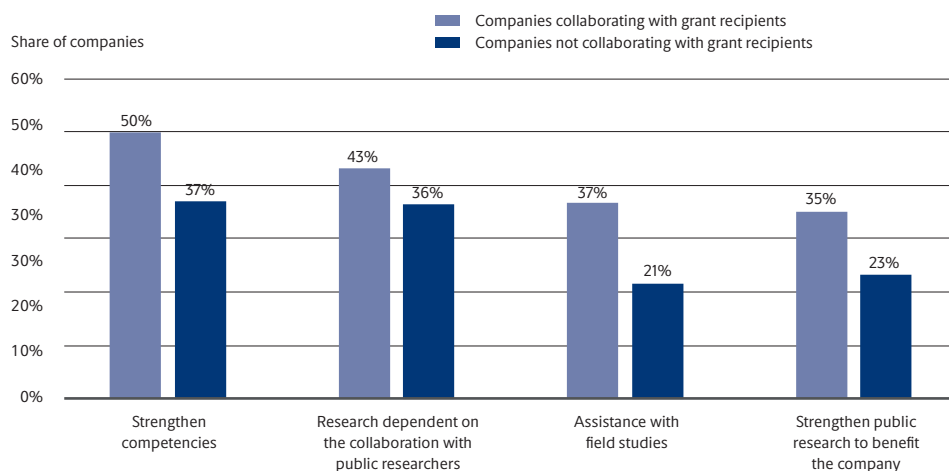
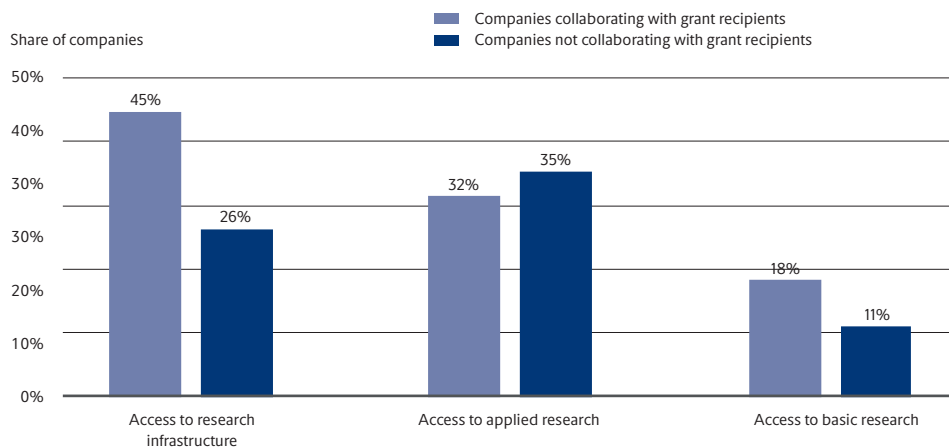


Figure 3.10 Share of companies that attribute high or very high value to collaboration with public research in various categories

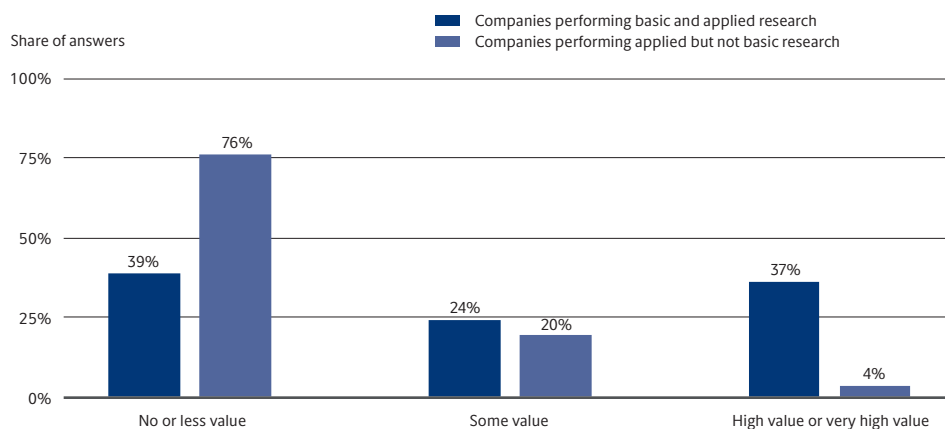


Based on the answers to six of the seven survey questions shown in Figures 3.9 and 3.10 on the specific motives for collaborating with public researchers (strengthening competencies; obtaining assistance with field studies; strengthening public research to benefit the company; accessing infrastructure; accessing applied research; and accessing basic research), the common motivational factor across companies is especially strong for accessing infrastructure, accessing applied research and obtaining assistance field studies.

Twenty-nine percent of the companies in the survey consider themselves companies performing basic research. Within this group, companies differ greatly in their motivation for collaborating with public researchers to improve access to basic research. Thirty-seven percent of the basic research companies attribute high or very high value to accessing basic public research, whereas 39% only less value or not at all. Only 4% of companies referring to themselves as applied research companies (and not basic research companies) attribute high or very high value to accessing basic public research and 76% attribute little or no value to accessing public research (Figure 3.11).

Figure 3.11

Value attributed to accessing public basic research as motivation for collaborating with public researchers



Sources: Novo Nordisk Foundation and Jysk Analyse.

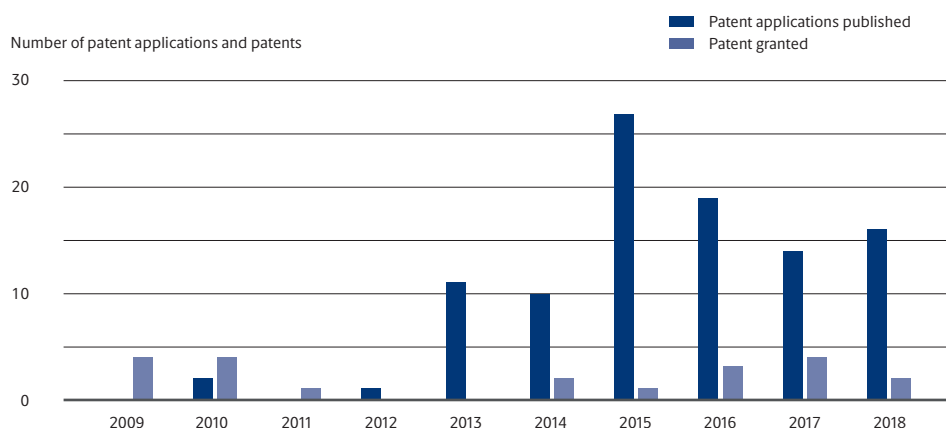
3.2 Dissemination and use of public research in patents

Patents linked to Foundation-funded public research constitute two identifiable channels of knowledge flow from public researchers to the private sector for commercial use. The first channel is grant recipients who file for patents based on Foundation-funded research, which links research grants to inventions based on reported patenting activity. The second channel is any patent application or patent that cites journal articles stemming from research funded by the Foundation, which is a traceable share of the wider dissemination of research-based knowledge.

3.2.1 Self-reported patent activity by grant recipients

From 2015 to 2018, grant recipients reported publishing 76 patent applications and 10 granted patents (Figure 3.12). The Foundation collected patent activities reported by grant recipients for the first time in 2015. Grant recipients reported activities in 2014 and earlier in the 2015 reporting round. These reported activities are sporadic and are not included in the further analysis below.

Figure 3.12 Number of distinct, published patent applications and patents reported by recipients of Foundation grants, 2009–2018



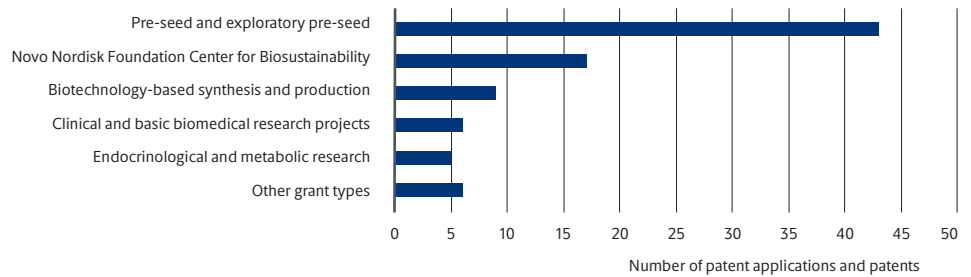
Note: Patent applications and patents are pinned to the publication year of the patent application.

Source: Novo Nordisk Foundation/researchfish*.

The most common types of Foundation grants involved in patent activity are pre-seed and exploratory pre-seed grants. These grants target research-based inventions and their commercialization (Figure 3.13). Section 3.3 further evaluates the impact of these two grant types.

Figure 3.13

Number of patent applications and patents reported by recipients of Foundation grants according to the type of grant



Note: The data cover patent applications and patents for which the patent application was published in 2015–2018.

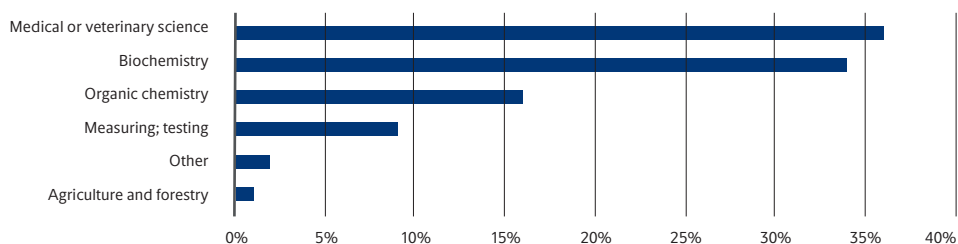
Sources: Novo Nordisk Foundation/researchfish® and European Patent Office DOCDB database.

The patent classifications reveal that the main broad technology areas of the reported patents are medical or veterinary science, biochemistry and organic chemistry (Figure 3.14). Within each of these, the technologies primarily focus on:

- preparations for medical or dental purposes, within medical or veterinary science;
- microorganisms or enzymes and fermentation or enzyme-using processes to synthesize a desired chemical compound, within biochemistry; and
- peptides and heterocyclic compounds, within organic chemistry.

Figure 3.14

Grant recipient patenting activity distributed on main technology areas
(Cooperative Patent Classification level 2)

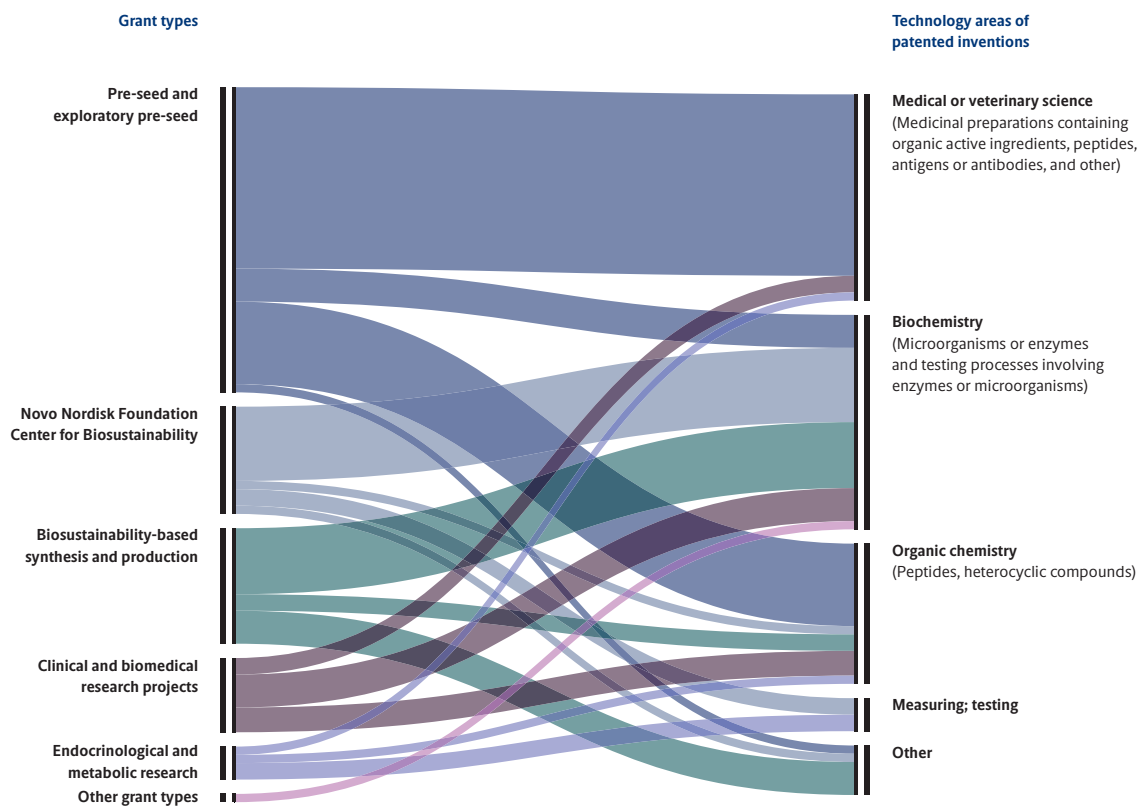


Note: The first three Cooperative Patent Classification codes listed in order of priority for each patent are used as a proxy for main technology areas.

Sources: Novo Nordisk Foundation/researchfish® and European Patent Office DOCDB database.

Linking types of grants (Figure 3.13) and the main broad technology areas (Figure 3.14) shows that pre-seed and exploratory pre-seed grants are the main drivers for patent applications and patents by grant recipients within medical or veterinary science and organic chemistry (Figure 3.15). Patent activity reported by the Novo Nordisk Foundation Center for Biosustainability mostly applies to the protection of biochemical inventions and, secondly, to inventions focusing on measuring and testing and organic chemistry.

Figure 3.15 Links between types of grants and the main broad technology areas for patent applications and patents (Cooperative Patent Classification level 2)



Note: The first three Cooperative Patent Classification codes listed in order of priority for each patent are used as a proxy for the main technology areas. The types of grants on the left side are ordered according to the number of reported patent applications and patents but deviate relative in size compared with Figure 3.13 because the number of technology areas attached to each patent varies. CPC level 2 codes applied.

Sources: Novo Nordisk Foundation/researchfish® and European Patent Office DOCDB database.

3.2.2 References to journal articles in patent documents

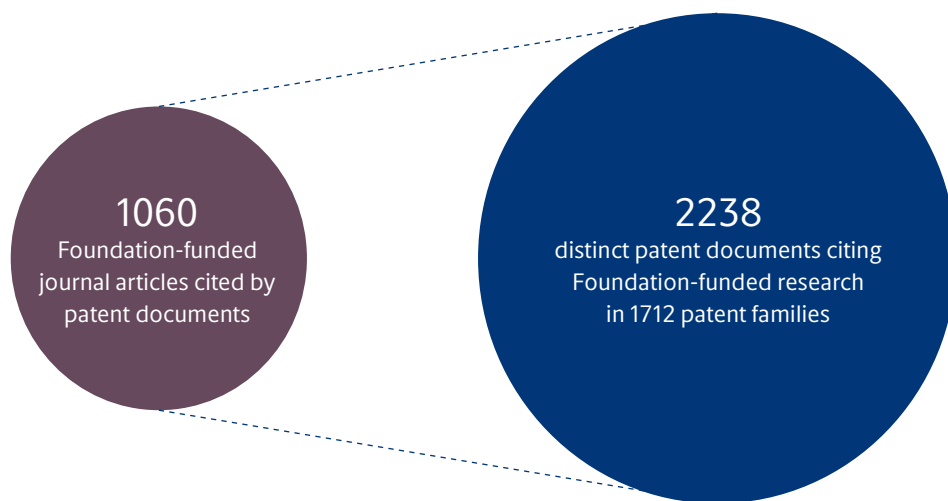
This section investigates how patent documents (applications and granted patents) refer to public research and, specifically, to Foundation-funded public research. Research-based patents may contain references to journal articles. These links between journal articles and patent documents constitute an observable channel of knowledge transfer from academia to industry, estimating the wider benefit of public research and indicating research-based innovation. References provided personally by the applicants clearly comprise the strongest link between public research cited in patent documents and the patented inventions. With 89.9% of these links added by the applicants, in the patent documents identified in this analysis, the links are reliable. Other sources of references added to patent documents include search reports (10.05%), patent examiners (0.01%) and third-party interventions (0.04%).

Journal articles are cited worldwide in patents and patent applications. The Foundation has access to the DOCDB patent database of the European Patent Office (EPO), with worldwide coverage from more than 90 reporting countries, including the countries behind the five biggest offices (the IP5) in the United States (USPTO), the EU (EPO), Japan (JPO), South Korea (KIPO) and China (SIPO).

More than 30 million references to non-patent-literature publications in more than 6 million patent documents were searched from within the DOCDB database and matched with research publications from the Foundation's publication database, which comprises publications funded or co-funded by Foundation grants. The DOCDB database contains all citations of other patents and non-patent literature such as peer-reviewed original articles and review articles, white papers, grey literature research papers, research working papers, letters, notes, books, news items, web pages and others.

From 1994 to 2017, 2238 distinct patent applications or patents cited 1060 distinct journal articles from the Foundation's publication database (Figure 3.16). This is an increase of 80 distinct publications and 124 distinct patent applications or patents compared with last year's search for 1994–2016. Last year, 2114 distinct patents or patent applications cited 980 distinct publications by recipients of Foundation grants.

Figure 3.16 Number of distinct, published patent applications and patents reported by recipients of Foundation grants, 2009–2018

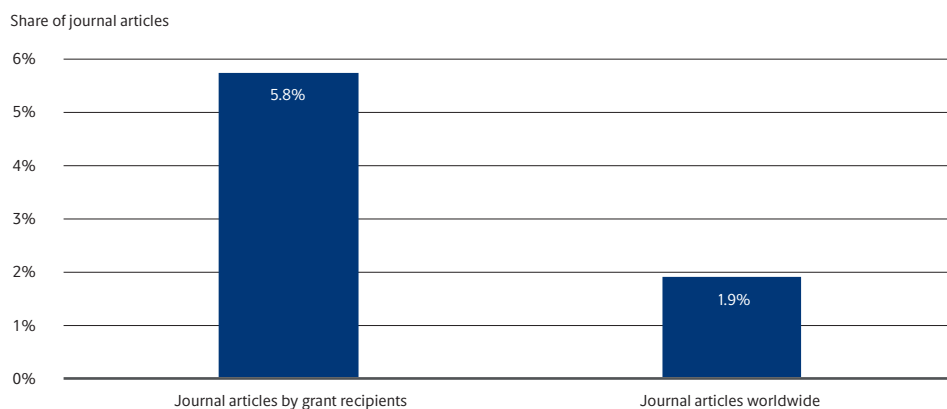


Sources: Novo Nordisk Foundation/researchfish®, European Patent Office DOCDB database; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

Journal articles by grant recipients appear three times more often in patent documents worldwide than to comparable journal articles registered in Web of Science (Figure 3.17).

Figure 3.17

Share of Foundation-funded journal articles versus comparable sample of journal articles worldwide cited by patent documents, 1994–2017



Note: The world average is based on a stratified random sample of 4842 journal articles matching the distribution of subject categories of Foundation-funded journal articles.

Sources: Novo Nordisk Foundation/researchfish*, European Patent Office DOCDB database; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

The EPO groups patents and patent applications for similar technologies into simple patent families. The 1060 publications are included in more than one patent document or family of patent documents, which is why the total distinct number of patent families at 1712 exceeds the number of journal articles cited.

Table 3.2 Fields of Science and technology for Foundation-funded journal articles cited in patent documents

OECD field of science, minor field	Web of Science subject category	Share of fields of science, %
Biological sciences (50% of the journal categories absorbed in patent documents)	Biochemistry & molecular biology	42
	Cell biology	27
	Other	31
Clinical medicine (23% of the journal categories absorbed in patent documents)	Endocrinology & metabolism	27
	Oncology	20
	Haematology	15
	Cardiac & cardiovascular systems	7
	Other	31
Basic medical research (16% of the journal categories absorbed in patent documents)	Medicine, research & experimental	33
	Immunology	21
	Pharmacology & pharmacy	13
	Neurosciences	10
	Other	22

Note: The research classification follows the OECD fields of science and technology (minor fields).

Sources: Novo Nordisk Foundation/researchfish*, European Patent Office; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

Table 3.2 shows the distribution of journal subject categories within each of the three predominant OECD minor fields of science and technology: biological sciences, clinical medicine and basic medical research. Research within these three fields covers 89% of the variation in the fields of science and technology associated with the journal articles.

The subject categories biochemistry & molecular biology and cell biology comprise most biological sciences. Within clinical medicine, the main subject categories are endocrinology & metabolism, oncology and haematology; within basic medical research, the major subject categories are medicine, research & experimental; immunology; and pharmacology & pharmacy.

Table 3.3 presents the mirror image of Table 3.2, showing the main broad technology area classifications of the patent documents citing Foundation-funded research. One system widely used is the Co-operative Patent Classification (CPC). The CPC codes on a patent document are listed in order of priority. In the data, patent documents on average have 7.5 detailed CPC codes. For the analysis presented in Table 3.3, the first three codes were used to determine broad technology areas (from aggregated CPC-level codes).

Table 3.3 Distribution of patents according to broad technology areas for articles by recipients of Foundation grants cited in patent documents

Broad technology area, CPC level 2	CPC-level 3	Share of broad technology area, %
Medical or veterinary science (38% of the absorption of journal articles by grant recipients)	Preparations for medical, dental, or toilet purposes	93
	Other	7
Organic chemistry (27% of the absorption of journal articles by grant recipients)	Peptides	76
	Heterocyclic compounds	19
	Other	5
Biochemistry (18% of the absorption of journal articles by grant recipients)	Microorganisms or enzymes; compositions thereof	57
	Measuring or testing processes involving enzymes or microorganisms	34
	Other	9

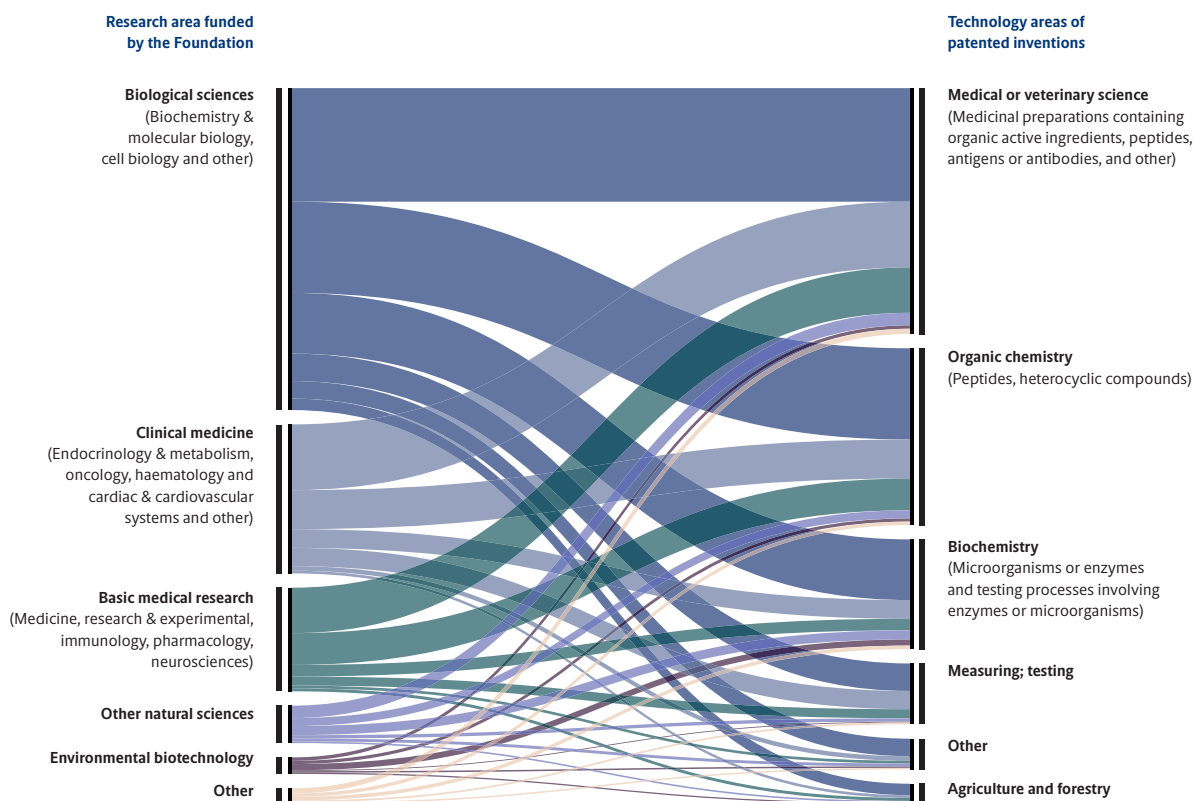
Note: The first three Cooperative Patent Classification codes listed in order of priority for each patent are used as a proxy for the main technology areas. CPC levels 2 and 3 codes applied.

Sources: Novo Nordisk Foundation/researchfish*; European Patent Office DOCDB- database; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

The results in Table 3.3 show that 38% of the absorption of Foundation-funded research-based knowledge through journal articles is linked to inventions within the broad technology area medical or veterinary science. Almost all activity, 93%, is tied to *preparations for medical, dental or toilet purposes*. Within organic chemistry, the second largest group of broad technologies, links to peptides dominate, comprising 76% of the group. The subgroup *microorganisms or enzymes; compositions thereof* and the subgroup *measuring or testing processes involving enzymes or microorganisms* jointly comprise 91% of the activity within the third of the three largest broad technology areas: biochemistry. Jointly, the three broad technology areas comprise 83% of the total dispersion of broad technologies among patent documents citing Foundation-funded public research.

Figure 3.18 shows that major links between research published in journals directed towards biological sciences and clinical medicine are relatively well represented in the three largest broad technology areas medical or veterinary science, organic chemistry and biochemistry. Biological sciences constitute about 40% of the research and have a similar citation share in the three largest broad technology areas, as does clinical medicine. The flows from basic medical research, in contrast, being more skewed towards the two largest broad technology areas and less towards biochemistry.

Figure 3.18 How Foundation-funded research is used for different technology inventions



Note: Research classification (left side) follows the OECD Field of Science and Technology (minor fields). The Cooperative Patent Classification was used to map research to patent technology area (right side) at level 2. The first three detailed CPC-codes listed in order of priority on each patent document are used as a proxy for main technology areas.

Sources: Novo Nordisk Foundation/researchfish[®]; European Patent Office DOCDB-database; Danish Centre for Studies in Research and Research Policy and CWTS Leiden.

3.3 Impact of innovation programmes

This section describes the outcome and impact of grants awarded through the Exploratory Pre-seed Programme and Pre-seed Programme 2007–2018 established by the Foundation to support academic research projects with commercial potential. The analysis combines data from the Foundation's grant data and researchfish® reporting data from grant recipients with other private and public data sources. The dataset established the tracking of each grant recipient's progress from university project to a spin-out company (defined as a new company that depends on licensing or being assigned the institution's technology to be initiated). This enables short-term outcomes to be assessed, company characteristics to be compared, development trajectories to be mapped and the relative increase in human and financial resources before, during and after participating in the programmes.

3.3.1 The Foundation's innovation programmes and control group spin-outs from public innovation programmes

The Exploratory Pre-seed Programme aims to accelerate the commercialization of biomedical research findings at a very early stage and the development of novel techniques within the health sciences. It seeks to support researchers based at universities and hospitals in the Nordic countries. The goal is to stimulate entrepreneurship and to test new ideas that may lead to the development of new medical treatments, disease prevention, devices and diagnostic methods.

Table 3.4 Exploratory Pre-seed and Pre-seed grants

Programme	Pre-2011	2011	2012	2013	2014	2015	2016	2017	2018	Number of grants	Total, DKK mill.
Exploratory Pre-seed Program	-	-	27	20	19	18	20	17	9	130	67.8
- Follow up grants	-	-	-	-	2	3	6	6	2	19 ^a	4.3
Pre-seed Grant Program	7	3	4	7	7	6	8	9	6	57	148.1
- Follow up grants	-	-	1	1	1	1	-	-	-	4 ^a	2.2
Total grants	7	3	31	27	26	24	28	26	15	187	222.5
Distinct grant recipients	7	3	30	24	25	20	24	21	12	165 ^b	222.5

Note: Grant recipients can receive more than one grant, which is why the total number of grants add up to more than the number of distinct grant recipients.

^a Follow-up grants have been added to the original grant recipient.

^b Fourteen grant recipients have received both exploratory pre-seed and pre-seed grants.

Sources: Novo Nordisk Foundation/researchfish® and Accelerace.

The Exploratory Pre-seed Programme provides grants with a maximum of DKK 0.5 million per grant.¹ Since 2012, 130 exploratory pre-seed grants have been awarded out of 698 applications, with 19 follow-up grants awarded for specific commercialization-related activities (see Table 3.4). Each grant recipient is allocated an adviser from Novo Seeds (part of Novo Holdings A/S) to provide commercial advice and to help to develop the research project to a stage at which applying for additional funding may be appropriate.

The Pre-seed Programme awards up to DKK 3.5 million per grant to early-stage, academic research projects with promising commercial potential. It has resulted in 57 pre-seed grants and four follow-up grants being awarded.² An exploratory pre-seed grant is not required to receive a pre-seed grant, but a project that receives an exploratory pre-seed grant can also receive a pre-seed grant.

The research projects supported by the Exploratory Pre-seed Programme and Pre-seed Programme are long-term in nature, and most grant recipients have started their commercial endeavours within the past few years. The time span of the data excludes the observation of long-term outcomes and thus also wider benefit and the socioeconomic impact of the programme. Instead, several short-term outcomes are used to measure programme quality and short-term impact: 1) attracted funding after spinout (public funding and private funding); 2) spin-out rate; 3) survival rate; 4) employment growth; 5) PhD graduates; and 6) competencies in the companies. The short-term outcomes of recipients of Foundation grants are benchmarked against a matched control group of non-participants from two public early stage innovation programmes: Copenhagen Spin-outs and the Danish National Proof-of-Concept Programme.³

¹ Except for two grants, which received DKK 700,000 DKK and DKK 661,024, respectively. Follow-up grants for Exploratory Pre-seed Programme have in 2018 a maximum of DKK 500,000.

² The Pre-seed grant and follow-up grant cannot exceed DKK 3.5 million.

³ Control group data were constructed using only publicly available sources, whereas data for the Foundation group draw on reports from the recipients as well as public sources. Control group data may therefore be more prone to underreporting of spin-outs and public funding than the Foundation sample.

Description of the public innovation programmes used as control group

Copenhagen Spin-outs

Copenhagen Spin-outs is a collaboration between the academic research environment and industry to foster innovation and to accelerate up the commercialization of biotechnology research between universities, research parks and investors in the Capital Region of Denmark. A spin-out is defined as a new company that depends on licensing or being assigned the institution's technology to be initiated. From 2012 to March 2015, Copenhagen Spin-outs supported 64 potential spin-out projects with DKK 61 million in funding, which led to 41 patent applications, 20 licensing agreements, and 21 spin-out companies in the areas of medical devices, diagnostics, pharmaceuticals, industrial biotechnology and food. Copenhagen Spin-outs was funded with DKK 20 million from the European Regional Development Fund, DKK 8 million from the Growth Forum for the Capital Region of Denmark and DKK 12 million from the partners.

The Danish National Proof-of-Concept Programme

The Danish National Proof-of-Concept Programme of the Ministry of Education and Science was active from 2006 to 2013 with an annual budget of DKK 20-25 million to support researchers at public research institutions with the early development of projects to a stage at which they were mature enough to apply for funding from incubators, professional investors and private companies. The Programme provided up to DKK 0.75 million per grant to support a period of 18 months.⁴ From 2008 to 2013, the consortium in eastern Denmark anchored at the Technical University of Denmark supported 127 projects with DKK 86.3 million. This led to 64 new or improved patent applications, 7 licensing agreements and 32 spin-out companies in the areas of biotechnology, cleantech, software and manufacturing.

The control group includes in total 33 identified spin-out companies based on the two public innovation programmes.

⁴ In 2009 the upper grant limit for larger and more complex projects was raised from one to two times DKK 0.75 million.

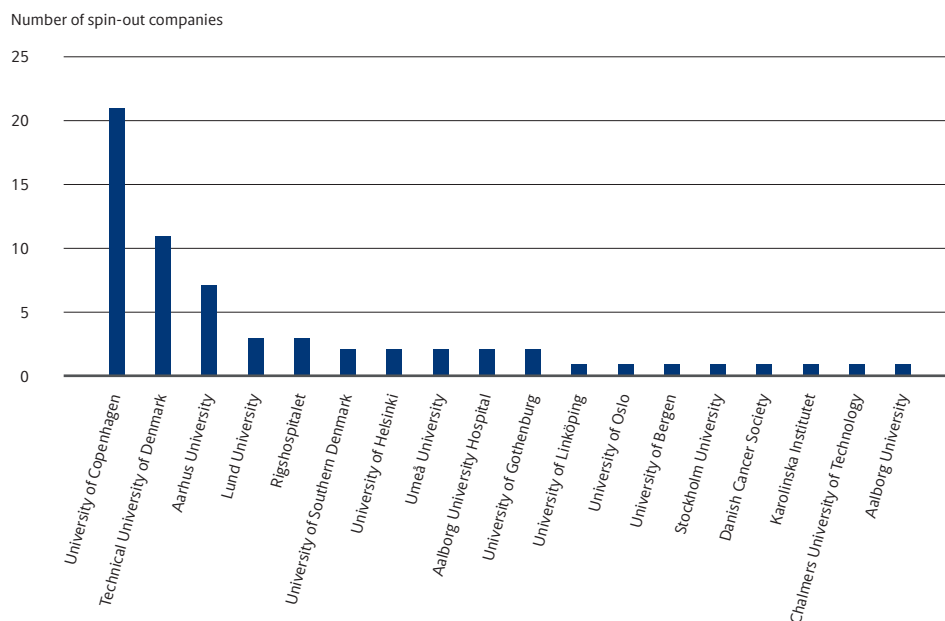
3.3.2 Spin-outs

The Exploratory Pre-seed Programme and Pre-seed Programme constitute a virtual pipeline to project maturation, and the recipients of Foundation grants created 63 spin-out companies partly or fully based on the exploratory pre-seed and pre-seed grants. Fifty-four of these have existed for more than 2 years and are used as a benchmark in this analysis and are referred to as the Foundation group.⁵ A total of 36% of the Foundation's grant recipients that have received exploratory pre-seed and/or pre-seed grants created spin-out companies from 17 universities in the Nordic countries of which most are located in Denmark (77%) and Sweden (16%) (Figure 3.19).

Figure 3.19 provides an overview of the university affiliations. The spin-out companies develop research projects in biotechnology (68%), pharmaceuticals (19%) and medical devices (11%). These new products and drugs address unmet medical needs and could change therapeutic (65%), industrial (9%) and diagnostic (24%) areas of intervention.

Figure 3.19

Origin of university spin-outs generated by exploratory pre-seed and pre-seed grants



Sources: Novo Nordisk Foundation/researchfish[®] and Accelerace.

⁵ Including spin-outs registered until April 2017.

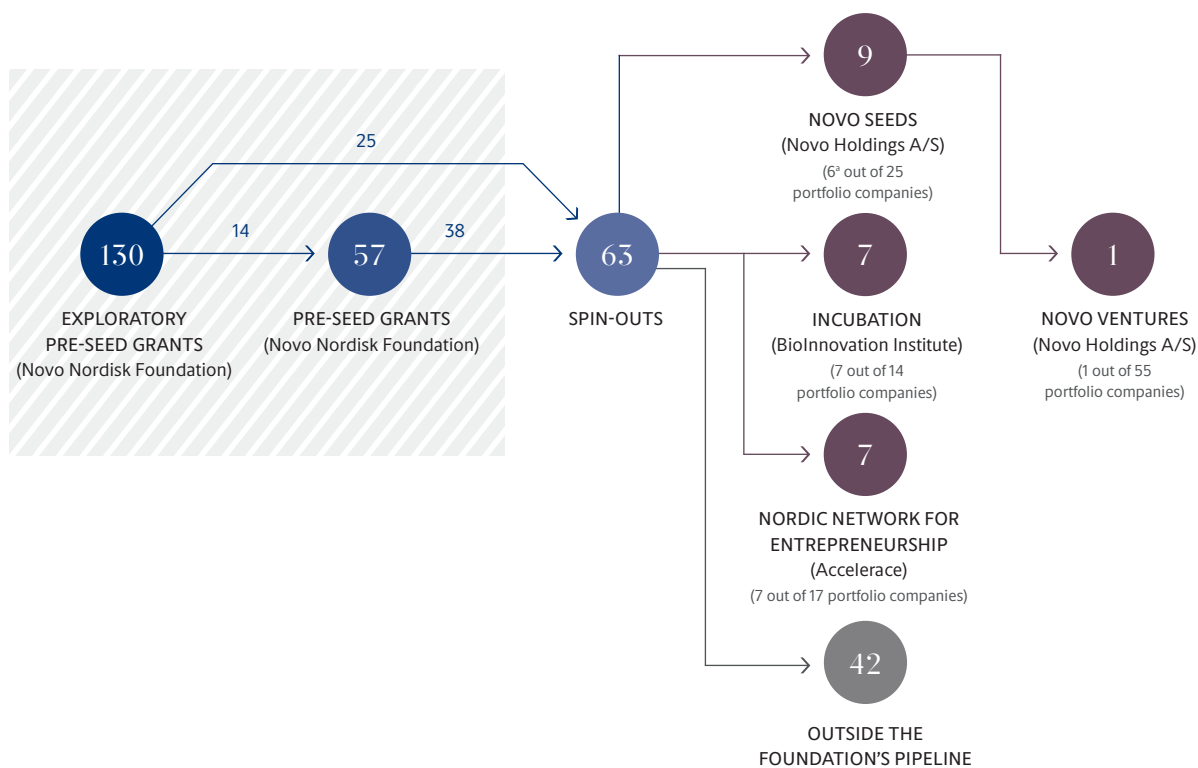
Pipeline graduates

The Foundation's Exploratory Pre-seed Programme and Pre-seed Programme are part of a greater Foundation ecosystem. Fourteen of the 130 exploratory pre-seed grants also received a pre-seed grant, and 9 of the 14 created a spin-out which gives a spin-out rate of 64%. The remaining 116 exploratory pre-seed grants generated 25 spin-outs and the 43 pre-seed grants that did not receive a prior exploratory pre-seed grant generated 29 spin-outs, giving spin-out rates of 22% and 60%, respectively. Figure 3.20 illustrates the pipeline.

Some of the 63 spin-outs arising from the two innovation programmes succeeded in other Foundation initiatives. Nine spin-outs received equity investments from Novo Seeds, including Biosyntia ApS, BioPhero ApS and Antag Therapeutics ApS. Orphazyme A/S went from a pre-seed grant in 2009 to a pre-seed equity investment in 2010 from Novo Seeds to a series A investment by Novo Ventures in 2011. Today Novo Holding A/S owns 15% of Orphazyme A/S.

The spin-outs are also represented in other initiatives by the Novo Nordisk Foundation. Forty-one percent of the companies in the portfolio of the **Nordic Mentor Network for Entrepreneurship** are spin-outs from the Exploratory Pre-seed and Pre-seed Programmes, and the share for the **BioInnovation Institute** is 50%.

Figure 3.20 Overview of spin-outs of the Foundation's pipeline from the Foundation's Exploratory Pre-seed and Pre-seed Programmes



Note: ^{a)} Two companies no longer exist and one company moved to Novo Ventures. The number of companies on the right side of the figure does not add up to 63 because three spin-outs are present in multiple initiatives.

Sources: Novo Nordisk Foundation/researchfish[®] and Accelerace.

3.3.3 Additional public and private funding

The ability of grant recipients to attract additional funding for commercialization is a key market-based indication of the application value of the research projects. Two years after grant start, 30% of the Foundation group companies had attracted private funding versus 24% in the control group. The Foundation group companies had raised DKK 366 million in public funding and DKK 88 million in private funding. The control group raised DKK 44 million in public funding and DKK 15 million in private funding during the first 2 years. By the end of first quarter 2019, the Foundation group companies have raised DKK 774 million in public funding and DKK 2.57 billion in private funding. The control group companies have also changed the ratio between public funding and private funding, with DKK 238 million in public funding and DKK 249 million in private funding raised currently (Figure 3.22).

The spin-out companies from the Foundation group and the control group have ratios exceeding 80% for attracting additional funding (Figure 3.21). However, the total amount raised shows the difference between the two groups (Figure 3.22). The Foundation group raised more than four times as much per spin-out company as the control group. However, three very successful companies accounted for 62% of the total funding in the Foundation group. The additional funding for the companies in the Foundation group ranges from less than DKK 1 million to more than DKK 500 million (Figure 3.23). Apart from the top three companies the Foundation group raised an average of DKK 30 million per spin-out company.

Public organizations drove about 81% of the observed growth in funding levels 2 years after the first grant was awarded. Of the DKK 366 million in public funding after 2 years, most was provided by government institutions (47%), foundations that support innovative research (39%) and universities (6%). The largest public grant was DKK 63 million provided to Pluvia AS by the Research Council of Norway to support the development of drug candidates to target rare diseases caused by protein misfolding. The European Commission (EU), Tekes (Finnish Funding Agency for Technology and Innovation), Vinnova (Sweden), the Research Council of Norway and Innovation Fund Denmark have provided DKK 500 million in funding through 90 grants to the recipients of Foundation grants so far.

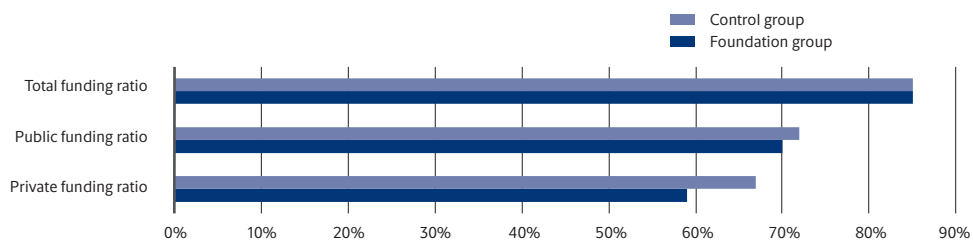
Cases of private funding

The spin-out company Orphazyme A/S, which received a pre-seed grant in 2009, managed to raise DKK 600 million in an initial public offering (IPO), which is the highest amount raised by companies originating out of the Exploratory Pre-seed Programme and the Pre-seed Programme.

However, Galecto Biotech AB secured the largest round of private financing, raising DKK 590 million in series C funding to advance galectin modulators for treating severe diseases, including fibrosis and cancer. Galecto Biotech AB was built based on a pre-seed grant received in 2010. NMD Pharma ApS, which received a pre-seed grant in 2014, raised DKK 267 million in series A funding to advance novel treatments of neuromuscular disorders. The NMD round was led by new investors Inkef Capital and Roche Venture Fund, and existing investors Lundbeck Emerge and Novo Seeds also participated. More evidence of the commercial potential of the spin-out companies is represented by the decision by Swedish healthcare company BioGaia AB to further extend its holdings in MetaboGen AB in 2018, resulting in a shareholding of 92% of equity in the company. MetaboGen AB received its pre-seed grant in 2013.

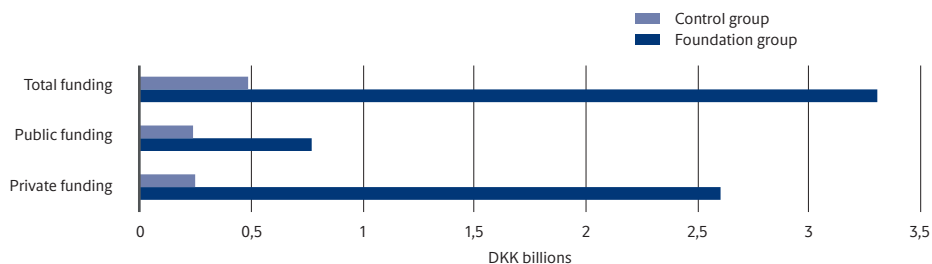
So far, 23% of the spin-out companies have raised more than DKK 10 million in funding from private investors, including Avilex Pharma ApS (DKK 11.5 million), Biosyntia ApS (DKK 42.3 million), UNION Therapeutics A/S (DKK 49.4 million), MonTa Biosciences (DKK 25.8 million), Var2 Pharmaceuticals ApS (DKK 67 million), Gesynta Pharma AB (DKK 15.8 million) and BioPhero ApS (DKK 26.3 million).

Figure 3.21 Funding ratios for spin-outs since the grants were awarded



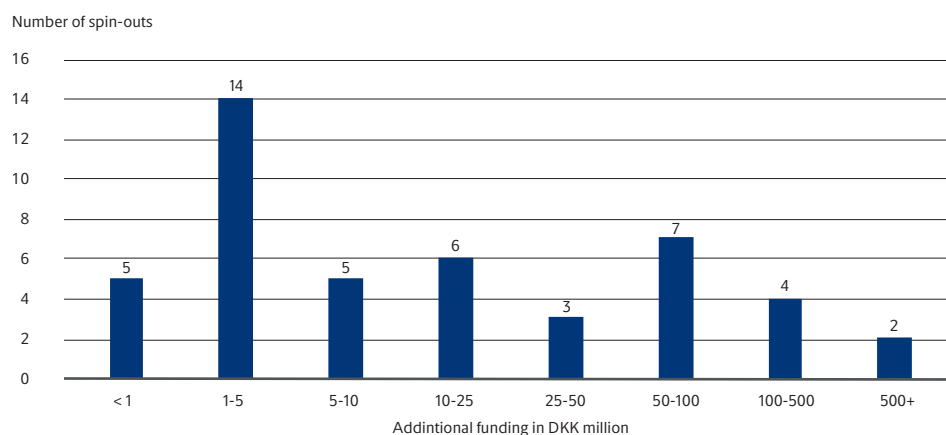
Note: Based on 54 Foundation group spin-outs and 33 control group spin-outs.
Sources: Novo Nordisk Foundation/researchfish* and Accelerace.

Figure 3.22 Funding for spin-outs since the grants were awarded



Note: Based on 54 Foundation group spin-outs and 33 control group spin-outs.
Sources: Novo Nordisk Foundation/researchfish* and Accelerace.

Figure 3.23 Funding attracted by Foundation group spin-outs since the grants were awarded



Sources: Novo Nordisk Foundation/researchfish® and Accelerace.

3.3.4 Patents

Of the grant recipients in the Foundation group, 22.2% created 85 patent applications. Compared with the control group, the number of patents per total amount of awarded funding is less than half for the exploratory pre-seed and pre-seed grants. Of the 85 patent applications, 28 came from just three grants.

3.3.5 Employment and survival rate

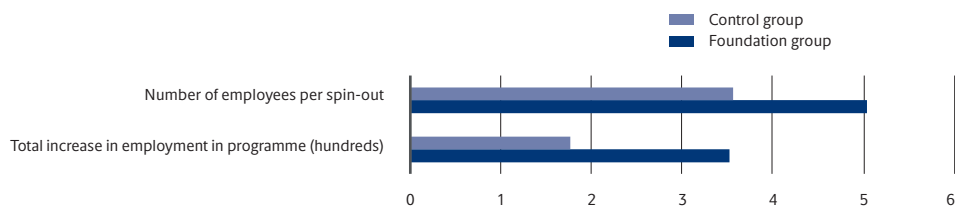
Before receiving the grants, the spin-out companies in the Foundation group had an average of 1.86 founders and 0.24 employees. The average increase in the number of employees per spin-out since a grant was awarded is 5.03 employees⁶ for the Foundation group and 3.57 employees for the control group. By the end of first quarter 2019, the Foundation group created 352 new jobs versus 176 new jobs in the control group (Figure 3.24).

The spin-out companies employ 74 PhD graduates and postdoctoral fellows⁷ in the Foundation group and 39 in the control group. These young researchers were employed in 44% of the spin-out companies in the Foundation group and in 39% of the control group. Companies that have attracted many young researchers include Biosyntia ApS, Orphazyme A/S and NMD Pharma A/S.

The survival rate of spin-outs by the end of first quarter 2019 was 89% for the Foundation group versus 93% in the control group.

Figure 3.24

Increase in employment rate of spin-outs since grant-awarding



Note: Based on 54 Foundation group spin-outs and 33 control group spin-outs.

Sources: Novo Nordisk Foundation/researchfish* and Accelerace.

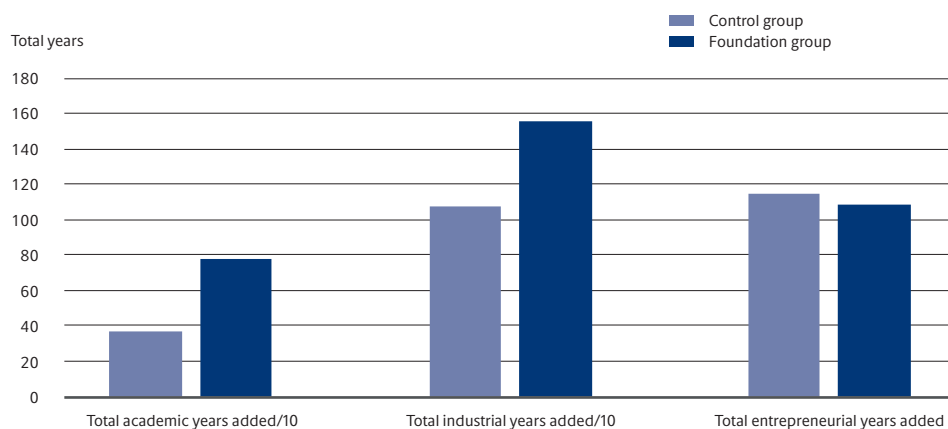
⁶ The number of employees does not include full-time founders, but they are included in all other statistics.

⁷ Defined as team members who have just finished a PhD or postdoctoral fellowship before engaging in the spin-out.

3.3.6 Attracting senior experts to spin-outs

Figure 3.25 shows the change in the total years of experience in the spin-out companies in the Foundation group versus the control group. The average number of years added per spin-out company is almost the same for the Foundation group and the control group on academic and industrial experience. The control group spin-out companies have in average 70% more entrepreneurial years added per spin-out company than the Foundation group. By the end of first quarter 2019, the Foundation's exploratory pre-seed and pre-seed grants have added 776 years of academic expertise, 1577 years of industrial expertise and 108 years of entrepreneurial expertise.

Figure 3.25 Overall experience levels of spin-out companies since grant-awarding



Note: Based on 54 Foundation group spin-outs and 33 control group spin-outs.

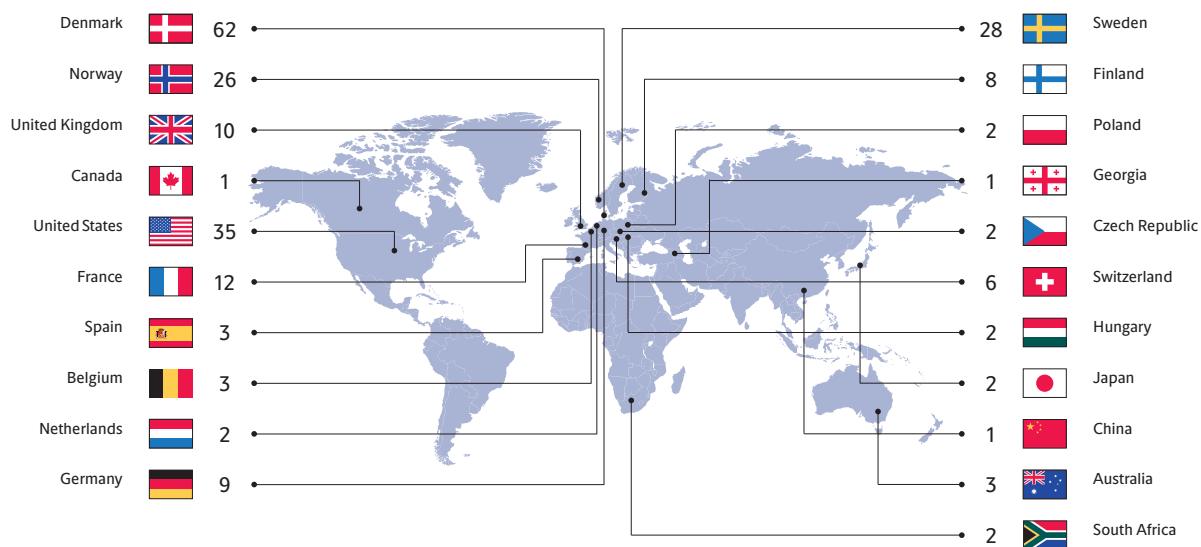
Sources: Novo Nordisk Foundation/researchfish® and Accelerace.

The ability of grant recipients to form partnerships with other researchers, universities and companies is an indicator of the spin-outs' ability to seek and attract the competencies required to enable research ideas to develop and translate into new commercial applications. By forging partnerships with international organizations with long track records of producing high quality research outputs or generating commercial revenue, grant recipients can reduce technology risks by stimulating new research activities in collaboration with key stakeholders. These interactions can help in providing early validation of the technology in question and attract interest from private investors.

A total of 49% of the recipients of Foundation grants formed 220 partnerships with partners in 21 countries; 124 (56%) were from the Nordic countries and 35 (16%) from the United States (Figure 3.26). These partnerships included organizations such as Stanford University and Harvard University and major pharmaceutical companies like Johnson & Johnson and Pfizer. Most partnerships were formed with universities (50%), hospitals (23%) and private companies (21%). These partnerships provide grant recipients with access to research facilities to test ideas, opportunities to collaborate with like-minded researchers and insight into commercialization routes. Grant recipients have reported that 85 of the new partnerships provided value in areas of impact such as economic (71%), policy (67%), social (22%) and cultural (7%).⁸ The rest of the partnerships either had no impact at the time or no answer was given.

⁸ The percentages sum up to more than 100 because a partnership can have more than one area of impact.

Figure 3.26 Geographical location of partnership organizations for recipients of Foundation exploratory pre-seed and pre-seed grants



Sources: Novo Nordisk Foundation/researchfish® and Accelerace.





Novo Nordisk Foundation
Tuborg Havnevej 19
DK-2900 Hellerup
Denmark

T +45 35276600
E [nnfond@novo.dk](mailto:nfond@novo.dk)
W novonordiskfoundation.com

**novo
nordisk
fonden**

©2019 Novo Nordisk Foundation
All rights reserved
ISBN: 978-87-994858-7-1
2nd edition

Layout: Marianne Siem

Creating knowledge

Novo Nordisk Foundation
Tuborg Havnevej 19
DK-2900 Hellerup
Denmark

T +45 3527 6600
E [nnfond@novo.dk](mailto:nfond@novo.dk)
W novonordiskfoundation.com

ISBN: 978-87-994858-7-1

