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Societal Impact of
Novo Nordisk Foundation
Grants 2016



Impact
Assessment

A key purpose of the impact assessment work of the Novo Nordisk Foundation is to assess whether the Foundation is approaching its vision and is reaching its societal and strategic goals.

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Summary

- the impact report at a glance

FOUNDATION FUNDING OF RESEARCH IN THE PUBLIC SECTOR

The state, regions and municipalities fund most of the research in the public sector in Denmark (0.82% of gross domestic product (GDP) in 2015). Total spending on public research and development (R&D), 1.05% of GDP in 2015, has declined slightly in recent years even though foundations have increased their share of the total funding for public research. In 2016 alone, private foundations accounted for 14% of the total funding of research in the public sector in Denmark, and thus the foundations contribute significantly to Denmark fulfilling the target of spending more than 1% of GDP on public R&D – the highest level in the OECD.

The Novo Nordisk Foundation has three grant-awarding objectives:

- to support physiological, endocrinological, metabolic research and to support other medical research;
- to support research hospital activities within diabetes in Denmark;
- to support other scientific as well as humanitarian and social purposes.

The Foundation primarily awards grants for research within biomedicine, biotechnology, general practice and family medicine, nursing and art history at public research institutions, and in addition to this, the Foundation has a focus on awarding funds for treating people with diabetes. The Foundation also awards grants for scientific purposes within education and innovation as well as humanitarian and social causes.

In 2016, the Foundation awarded grants for DKK 4.2 billion, of which DKK 1.24 billion was awarded primarily for research but also for education and innovation. Of this, the Foundation awarded DKK 0.85 billion in research grants in open competition. The largest single amount awarded, DKK 2.96 billion, went to the Capital Region of Denmark for establishing Steno Diabetes Center Copenhagen. The Foundation often supports projects over many years; thus, for instance, the grant for Steno Diabetes Center Copenhagen covers the period 2017–2029.

The Foundation's payout of DKK 1.1 billion in 2016 to universities and university hospitals in the Nordic countries helped to ensure 2000 jobs, including funding 487 PhD students and 514 postdoctoral fellows.

WHO RECEIVES GRANTS?

About 40% of the total payout in 2016 went to the four research centres the Foundation supports at the University of Copenhagen and the Technical University of Denmark. A further 40% was paid out to universities in Denmark, and 7% to universities in the other Nordic countries. Ten percent was paid out for research, education and hospital operations at Steno Diabetes Center, and 3% was spent on education activities and humanitarian and social causes.

HIGH-IMPACT RESEARCH

As the Foundation has increased the amount paid out in the form of grants for research in the public sector, there has been an increase in the number of journal articles produced by the recipients of Foundation grants. From 2011 to 2016,

the number of journal articles doubled to about 2000 annually.

One way to assess the relevance of this scientific production to other researchers is how often the articles are cited. For journal articles published by recipients of Foundation grants between 2011 and 2014, 4% were among the 1% most frequently cited articles worldwide. More than one fifth (22%) of the research articles by the recipients of Foundation funding were highly cited being among the 10% most frequently cited in the world.

Based on the number of citations of the journal articles, the scientific impact of research the Foundation supports is equivalent to that of the production by the researchers at the best universities in Europe, for example University of Oxford. The four research centres the Foundation has supported in recent years are equivalent in citation terms to the level of the best universities in the world. In 2011-2014, eight percent of the publications produced by the research centres were among the 1% most frequently cited articles in the world.

RESEARCH COLLABORATION

The researchers the Foundation supports are internationally oriented in their research activities. The recipients of Foundation grants published 53% of their articles in collaboration with researchers from research institutions in other countries.

Of the journal articles by the recipients of Foundation grants, 25% were produced in international collaboration and were among the 10% most frequently cited journal articles in the world versus 14% for collaboration with researchers at other institutions in Denmark.

HIGH-QUALITY RESEARCH IMPROVES DISEASE PREVENTION AND TREATMENT

The clinical research funded by the Foundation also contributes to development of new methods for preventing and treating disease in many places across healthcare systems in the Nordic countries and the rest of the world.

Nine percent of the Danish guidelines on treating people with cardiovascular diseases reference research published by the recipients of Foundation grants. The share is 22% for guidelines from international organizations such as the World Health Organization, European Society of Cardiology, British Cardiovascular Society and American Heart Association. In addition, since 2013, recipients of Foundation funding have contributed to the creation of 40 new medicine products and other health products.

COLLABORATION WITH COMPANIES AND NEW SPIN-OUTS

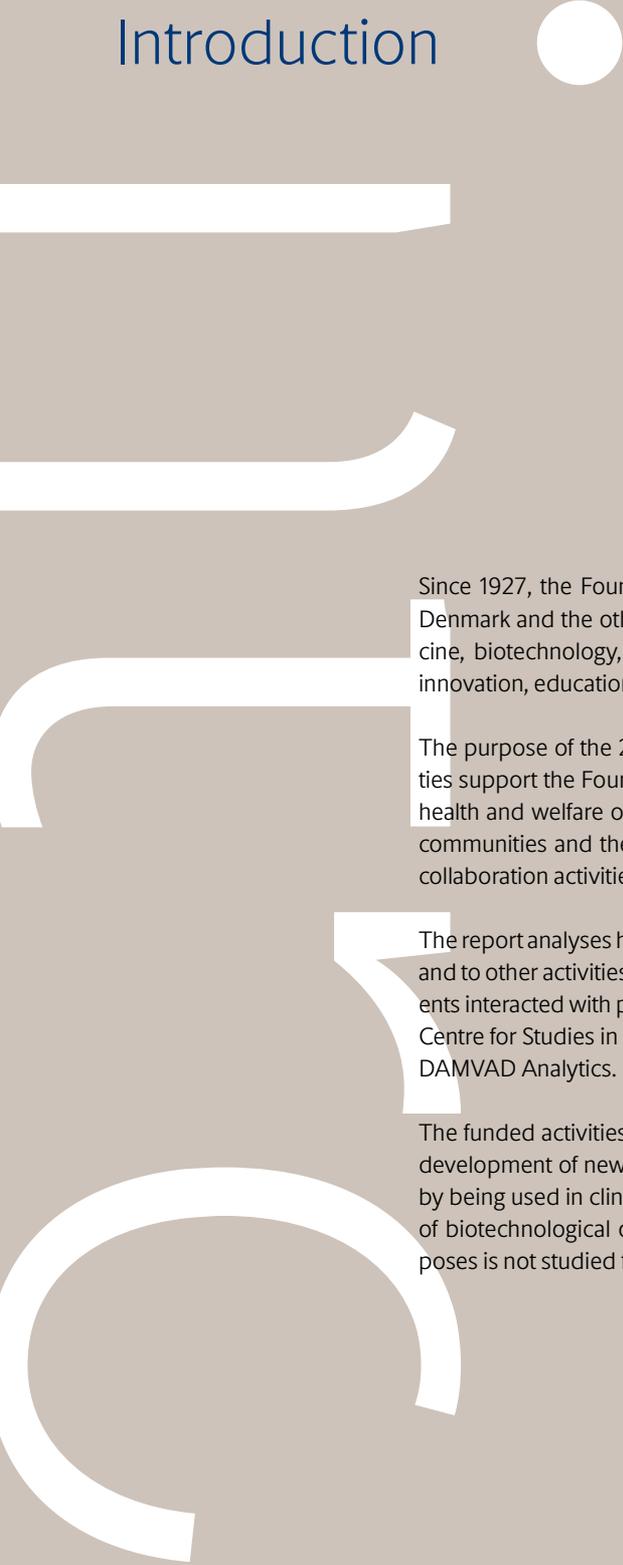
In a competitive global market, companies need access to new knowledge to be able to create new products. Many companies therefore collaborate with excellent researchers at universities and hospitals. Thus, 10% of the articles produced by the recipients of Foundation grant have researchers from companies as co-authors.

In 2015, the recipients of Foundation grants co-published journal articles with 95 companies and reported 25 public-private collaborative research projects. Of these, 60% were with companies of all sizes outside Denmark. Since 2000, the recipients of Foundation grants have collaborated with 90 small, 60 medium-sized and 88 large companies outside Denmark. The recipients of Foundation grants are also innovation-oriented and have created 23 spin-out companies.

CONCLUSION

In conclusion, the report documents that the research carried out by the recipients of Foundation grants has an impact on society, including international research communities, healthcare in the public sector, and the business sector. The recipients of Foundation grants have high citation impact, are referenced frequently in Danish and international treatment guidelines within diabetes and cardiovascular diseases, and they are engaged in public-private research collaboration, spinout activities and dissemination of new knowledge to innovative companies in Denmark and around the world.

Introduction



Since 1927, the Foundation has awarded grants to researchers at universities and hospitals in Denmark and the other Nordic countries. Today, the Foundation supports research in biomedicine, biotechnology, general practice, nursing, art history and also scientific objectives within innovation, education and outreach as well as humanitarian and social purposes.

The purpose of the 2016 impact report is to provide an overview of how grant-awarding activities support the Foundation's ambition of promoting a knowledge-based society to improve the health and welfare of people. It documents the Foundation's input of resources to the scientific communities and the subsequent effects on research, education, health, and research-industry collaboration activities.

The report analyses how the Foundation's grant-awarding activities contributed to public research and to other activities within the public sector (e.g. treatment of patients) and how the grant recipients interacted with private companies. The analyses have involved collaboration with the Danish Centre for Studies in Research and Research Policy, Aarhus University and the consulting agency DAMVAD Analytics.

The funded activities foster research leaders and facilitate world class-research that leads to the development of new products, economic growth and better treatment for patients, for example by being used in clinical guidelines and recommendations or by being used in the development of biotechnological or pharmaceutical products. The support for humanitarian and social purposes is not studied for its impacts in this report.

The Foundation's Strategic Goals

The Board of Directors of the Novo Foundation has set the following strategic goals for the Foundation:

SOCIETAL GOALS

With Denmark as the Foundation's centre of gravity, the focus is:

- To promote world-class research and innovation in the medical, biotechnological and natural sciences and help to foster a world-class education system.
- To help to develop a knowledge-based society that contributes to long-term economic activity and job creation for improving general health and welfare.

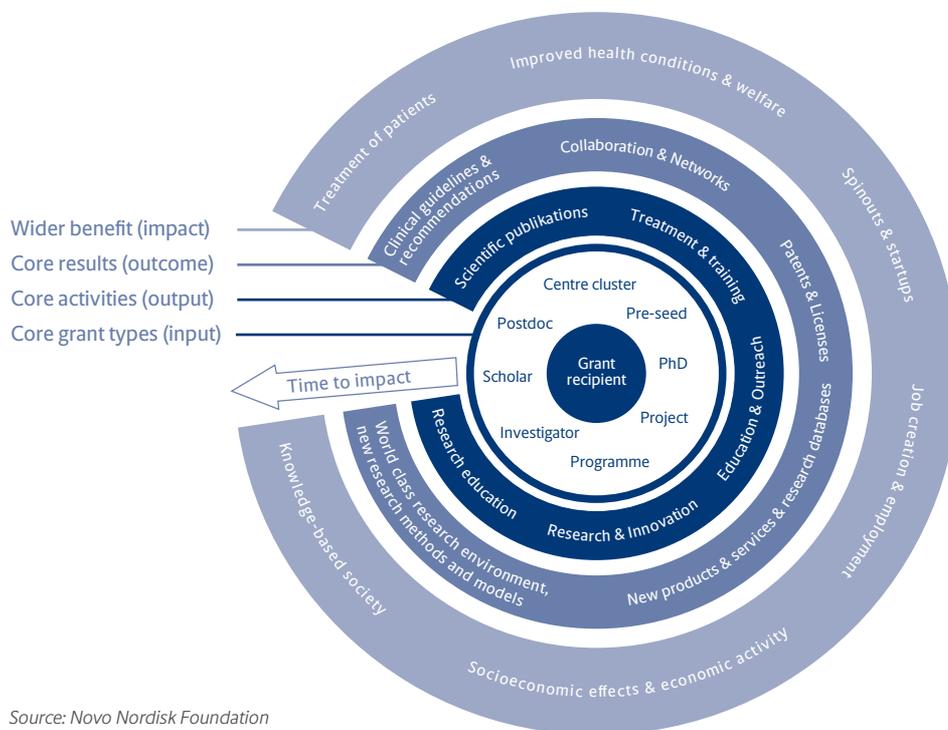
COMMERCIAL GOALS

- Be a strong owner of the companies in the Novo Group.
- Generate attractive returns for the Foundation on its financial investment portfolio.
- Make investments with the main goal of promoting knowledge and world-class research.

GOALS FOR GRANT ACTIVITIES

- Strengthen biomedical and biotechnology research in selected fields.
- Fuel cross-disciplinarity.
- Advance individual scientific excellence.
- Spur imagination, inspiration and knowledge about science and technology.
- Build bridges between scientific discoveries and their commercial applications.
- Achieve social and humanitarian impact.

The tiers of the impact of the Foundation's grants



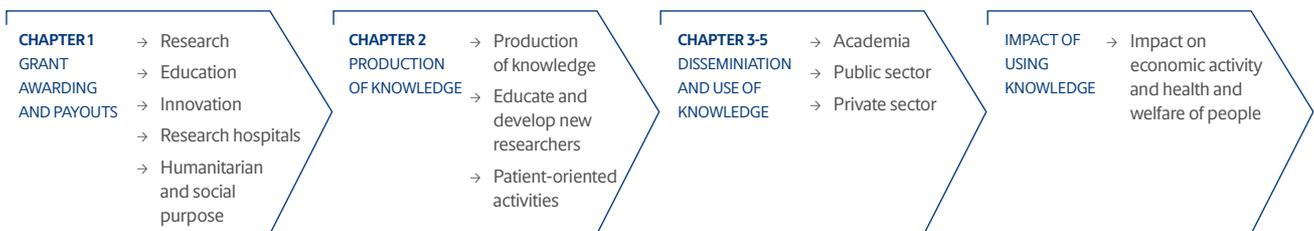
Source: Novo Nordisk Foundation

THE IMPACT ASSESSMENT APPROACH

Science is one of the cornerstones of knowledge-based societies, and therefore the focus on the “science of science” is growing, with the need to understand more about how research works and how impacts are realised. Collecting an appropriate evidence base of outputs, outcomes and impacts that have arisen, and assessing the impact of funding is a key part of this agenda. The purpose of the 2016 impact assessment report is to assess and communicate on how the Foundation’s activities affect society.

The figure below illustrates the model that forms the assessment approach applied in this report. The Foundation payouts for research, education, innovation and other purposes lead to production of knowledge and other activities such as changes to treatment guidelines or development of clinical interventions. These activities may influence other researchers, the public sector and private companies and may eventually improve economic activity and the health and welfare of people.

The model of impact assessment



THE METHOD

This report focuses on payouts and grant recipients, the production of knowledge and the dissemination and use of knowledge.¹ It comprises a series of indicators the Foundation collects and updates every year. Measuring the impact of science funding is complex. The sources of information include the Foundation’s grant administration system, the online reporting system researchfish® and external sources such as Web of Science and Scopus. The methods to measure the impact of research combines quantitative and qualitative data approaches.

Since there are time lags between initiating research activities and the use and impact of research, the 2016 impact report presents trend analyses (time series) for 2000–2016 and single-period benchmark performance which is an aggregate of some or all years of information to allow easy comparison. Trend analyses depict trends and correlations across certain periods of time for inputs (grants), outputs (publications and other activities) and outcomes (citation impact, spin-outs, patents and other results) data. Single-period statistics can provide an effective snapshot of research performance and be powerful in benchmarking, whereas time series provide insight into the changes in input, output and outcome over time. The in-depth bibliometric studies in this report provide various types of time-series analysis and benchmarking analysis. A number of correlations of input and outcome are also performed in the analyses.

THE FOUNDATION'S GRANT FOCUS

The Foundation mainly supports research at public institutions in Denmark and the other Nordic countries. Grants have been awarded within biomedicine, biotechnology, interdisciplinary research and other scientific fields. In addition, the Foundation has supported innovation, education and humanitarian and social causes. The size of the Foundation's grants has developed markedly over the years. The average grant size of a typical research project and research programme has increased more than ten times since the millennium. The Foundation has also introduced a variety of different strategic funding instruments such as long-term grants for research centres, investigators and programmes.

The Foundation's Board of Directors awards grants in two main ways. One way is to award grants through an open competition based on the Board's decisions on priorities such as particular research areas, on budgets, and based on the strength of the case for support submitted by researchers in response to calls for applications. In addition to this the Board can also decide to initiate or support one-off initiatives with or without calls for applications in accordance with the Foundation's purposes. This enables the Foundation to be fully flexible and ensures that the funding is allocated to effectively support research in line with the aims and priorities of the organization.

All of the grant awarding methods comprise assessment of the case for support by peers. The Foundation has established 15 scientific committees with internationally recognized scientific experts with strong qualifications for assessing the quality, feasibility, novelty and potential of the proposed projects and the applicants' qualifications. Moreover, the Foundation uses international experts when assessing strategic initiatives introduced by the Board. The success rate for grants (approval rates of applications) in open competition was 18% in Danish research programmes and 20% in Nordic programmes.

The Foundation funds research through a range of grant types: centre grants, programme grants, project grants, investigator grants, innovation grants, stipends for postdoctoral and PhD fellowships and research scholarships.

Grant recipients are free to decide their priorities for their research within the parameters of what was proposed as part of the application process. The researchers and the public research institutions that receive and administer Foundation grants own the results according to Danish law. Since other sources also fund these researchers, the results included in the report should not be ascribed solely to the Foundation's contribution.

Chapter 1

How the foundation contributes to society

Key findings

- In 2016, grants and payouts were the largest in the Foundation's history with DKK 4.2 billion committed in awards and DKK 1.1 billion paid out
- In Denmark, private foundations financed public research with 0.06% of GDP in 2006, increasing to 0.14% in 2016
- The Foundation contributed 0.05% of GDP in support of research in both 2015 and 2016
- In 2016, almost 2000 people were employed based on Foundation grants (either fully or partially financed)

1 HOW THE FOUNDATION CONTRIBUTES TO SOCIETY

The Foundation’s vision is to contribute significantly to research and development that aims to improve the health and welfare of people. Through its grant-awarding and commercial activities, the Foundation catalyses the creation of strong public research environments, opens a gateway to the best global scientific communities and supports collaboration links between public research and research-based companies.

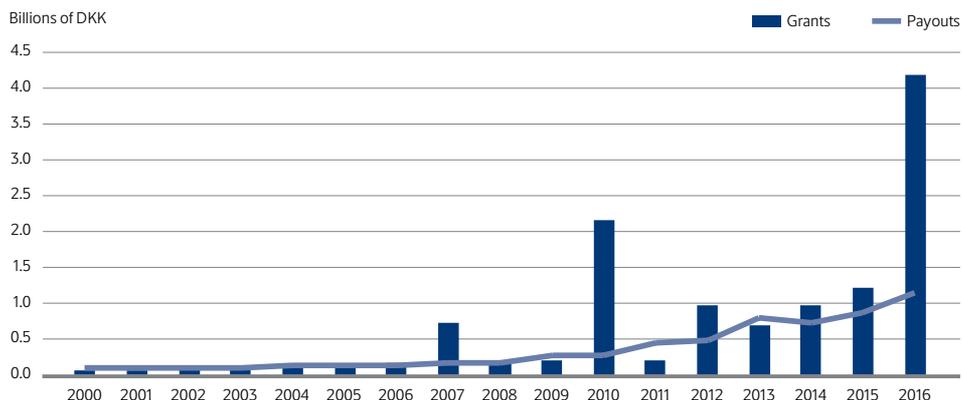
This chapter presents the Foundation’s financial contribution to public research. Researchers at universities and hospitals, and Novo Nordisk Foundation Centres based at universities are the main recipients of the grant funding from the Foundations.

1.1 THE FOUNDATION’S GRANTS AND PAYOUT FROM 2000 TO 2016

The Foundation awarded DKK 4.2 billion in grants in 2016 (Figure 1.1). The grants awarded included a DKK 2.9 billion award for the new Steno Diabetes Center Copenhagen.

Figure 1.1

The Foundation’s annual grants and payouts, 2000–2016



Source: Novo Nordisk Foundation

Figure 1.1 covers all grants regardless of length and size. For example, the grant for the Steno Diabetes Center Copenhagen covers a new building, and treatment and research activities until 2029. Grants for PhD scholarships, postdoctoral fellowships and senior researchers can last from few months to several years and typically cover salaries and running costs as well as finances for the research activities. A few grants comprise a large part of the amount awarded. 700 recipients of Foundation grants report annually on the activities and results related to their grants.

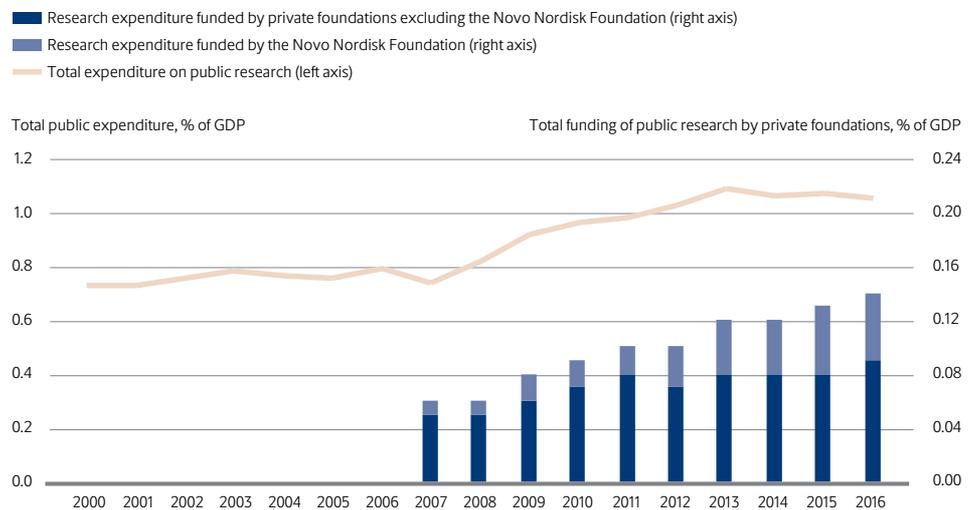
1.2 THE FOUNDATION'S INVESTMENT IN PUBLIC RESEARCH IN DENMARK FROM 2000 TO 2016

Total expenditure on public research in Denmark as a proportion of the gross domestic product (GDP) peaked in 2013 at 1.09, and is estimated to be 1.05% of GDP in 2016. Since 2007, the share of public research funded by private foundations has gradually increased over time. The share of funding of public research in Denmark by private foundations is estimated to reach 14% by the end of 2016.

Figure 1.2 shows how payout for public research by private foundations, (measured as a percentage of GDP), has contributed to public research expenditure and enabled it to remain above 1% of GDP. Private foundations, including the Novo Nordisk Foundation, have more than doubled their funding for public research in Denmark as a percentage of GDP, increasing from 0.06% of GDP in 2007 to 0.14% of GDP in 2016.

Figure 1.2

Total expenditure on public research and funding of public research by private foundations in Denmark as a percentage of GDP, 2000–2016



Note: The 2016 expenditure on public research is based on estimates. The data from before 2006 for other private foundations are not available.

Sources: Novo Nordisk Foundation and Statistics Denmark

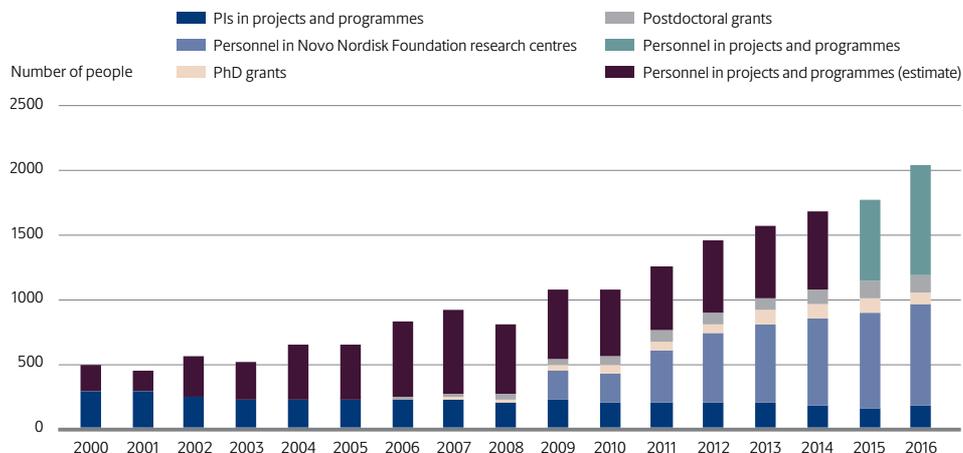
1.3 HOW MANY PEOPLE ARE INVOLVED IN ACTIVITIES FUNDED BY THE FOUNDATION?

During 2016, almost 2000 people have been involved in research activities funded by the Foundation grants either fully or partially financed (Figure 1.3). This include principal investigators on grants, PhD students, postdoctoral fellows, etc. This is an increase on the number of individuals in 2015 (1784), and in line with the steady increase seen since 2008 when there were estimated to be 750 people supported by the Foundation.

The main reason for this growth is the establishment of the four research centres between 2007 and 2010. In 2016, the research centres employ around 800 people (517 researchers and 268 technical administrative personnel – see Figure 1.4).

Figure 1.3

Number of people either full or part time financed or co-financed by Foundation grants, 2000–2016



Notes: Estimates of personnel in projects and programmes for 2000-2014 are based on reported number of personnel involved in Foundation project and programme grants for 2015-2016 relative to grants for 2000-2014.

Pls: principal investigators. Research leaders at the Foundation’s research centres are included in personnel at centres.

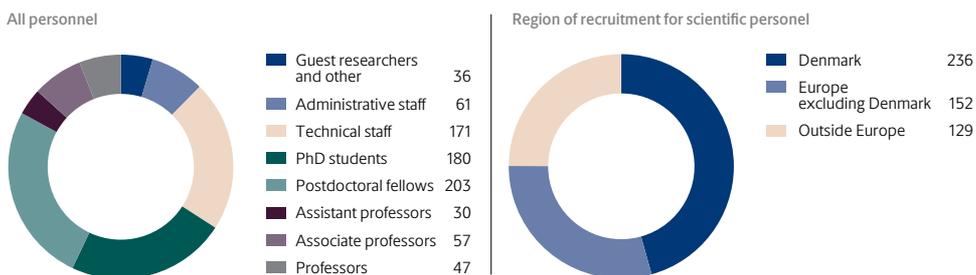
Source: Novo Nordisk Foundation/researchfish®

1.4 EMPLOYMENT AT THE FOUNDATION’S RESEARCH CENTRES

More than half of the scientific personnel at the research centres funded by the Foundation are recruited outside Denmark and about 25% are recruited outside the European Union (EU) (right panel of Figure 1.4). The left panel of Figure 1.4 shows that postdoctoral fellows comprise the largest personnel group at the Foundation’s research centres, followed by PhD students and technical personnel.

Figure 1.4

All personnel at the Foundation’s research centres (left panel) and recruitment region for scientific personnel (right panel), 2016



Source: Novo Nordisk Foundation/researchfish®

Chapter 2

Production of knowledge and research education

- Key findings
- The number of publications that have arisen from research funded by the Foundation in 2015–2016 exceeded 4500. 90% were published in research journals
 - Approximately 20% of the publications by grant recipients funded by the Foundation are categorised under endocrinology and metabolism
 - 75% of the publications are co-authored with researchers from other academic institutions. 53% of the publications have international academic co-authors
 - Research activities currently support 1000 PhD students and postdoctoral fellows. The Foundation supports 18% of the PhD students who began their PhD study in 2013–2015 within bio-medicine in Denmark

2 PRODUCTION OF KNOWLEDGE AND RESEARCH EDUCATION

The Foundation awards grants for research programmes and projects, research centres, investigator grants, scholarships and fellowships. This chapter explores the trends in the production of knowledge from the Foundation's grants, and the knowledge being made available to other researchers, to the research environment as a whole and/or to members of the public. Research knowledge production is measured here in terms of numbers of publications, but also with some additional information on production of PhD degrees, research training, development of new research methods, and research databases.

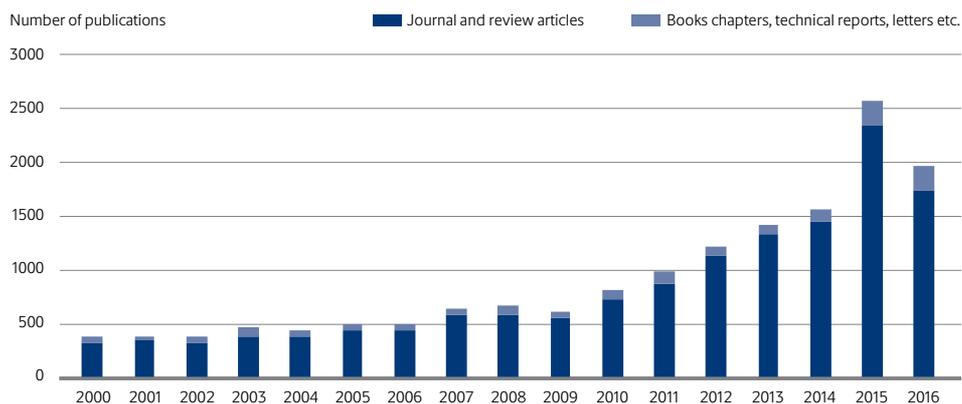
2.1 PRODUCTION OF PUBLICATIONS

Since 1927, the recipients of Foundation grants have contributed to the publication of more than 18,000 publications; 15,448 have been published since 2000, and 13,859 are journal articles.² Since grant recipients typically obtain additional funding, the Foundation does not exclusively fund all these publications. Researchers supported by the Foundation are required to report annually on the outputs and outcomes that have arisen from the funded research, registered on 4526 publications were reported for 2015–2016, this including 4065 journal articles. There has been a steady increase in the number of publications based on the Foundation's grants since 2009–2010, when grant recipients produced 1422 publications of which 1261 were journal articles (Figure 2.1).

According to Denmark's Ministry for Higher Education and Science³ researchers based in Denmark published about 97,000 articles in research journals in 2012–2015. In the same period the recipients of Foundation grants published 6207 journal articles, or 6.4% of the total for Denmark. The number of journal articles reported by the recipients of Foundation's grants increased by 63% from 2014 to 2015.⁴

Figure 2.1

Number of publications published by recipients of Foundation grants, 2000–2016



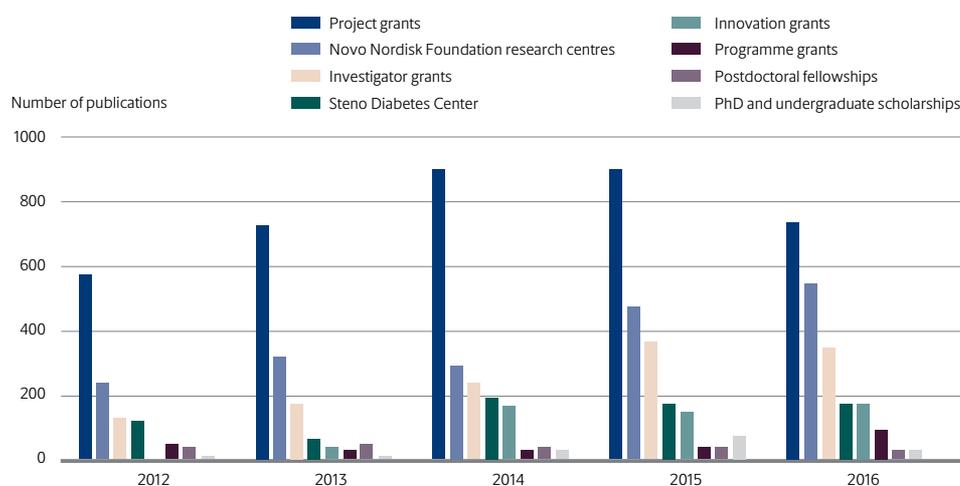
Source: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

Of the publications arising from Foundation grants and published from 2014 to 2016, 90% were journal articles and 10% were other types of publications, such as policy papers, technical reports, letters and book chapters.

The publications arising from research funded by the Foundation in research journals, book contributions, policy papers, technical reports, guidelines and the like comprise useful and consistent data sources for quantifying the research knowledge produced through support by the Foundation, as well as enabling the Foundation to understand more about the research it supports, and strategies it uses for funding.

Figure 2.2

Number of publications reported by types of grants, 2012–2016



Note: The number of publications is the number of publications reported by all recipients of Foundation grants. Several publications are co-authored with other Foundation grant recipients, so the number of reported publications is higher than the number of actual publications funded by the Foundation.

Source: Novo Nordisk Foundation/researchfish®

Figure 2.2 shows the distribution of reported publications across the eight types of grants. Project grants reported the most publications. Novo Nordisk Foundation research centres, Steno Diabetes Center, and the recipients of investigator grants, innovation grants and research programme grants report a growing number of publications.

2.2 INTERNATIONAL BENCHMARK – NUMBER OF JOURNAL ARTICLES PER MILLION POPULATION

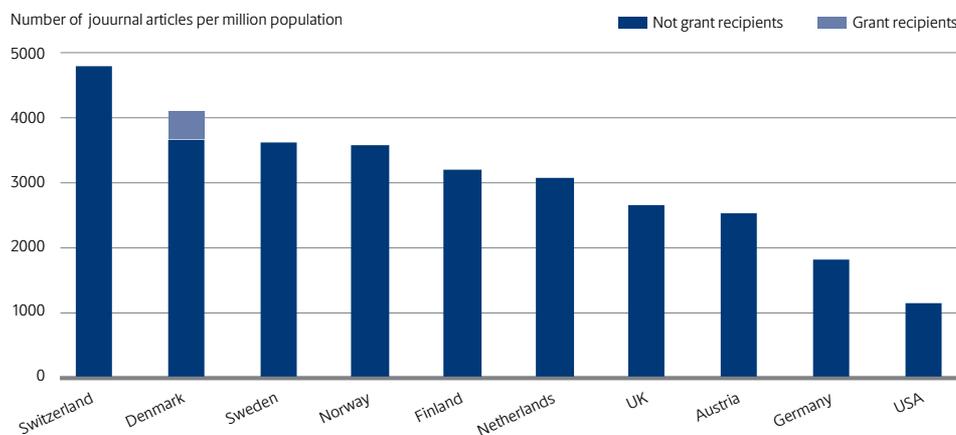
Researchers in Denmark publish more journal articles per million population than do researchers in the United States, United Kingdom, Germany, Finland, Sweden, Norway and most other European countries. Denmark ranks number 2 after Switzerland among the Organisation for Economic Co-operation and Development (OECD) countries.⁵ Researchers in Switzerland publish 4800 articles per million population compared to 4064 for Denmark. The recipients of Foundation grants published 2341 journal articles in 2015. This is equivalent to 412 articles per million population, or 10.1% of the total journal articles by researchers in Denmark during 2015.

Denmark produces a high number of journal articles per million population compared with other countries because of the high level of public research and a relatively high concentration of researchers in the population. Figure 2.3 benchmarks the number of articles per million population against peer countries. It also shows the share of journal articles published by the recipients of Foundation grants.

According to the OECD and Denmark’s Ministry of Higher Education and Science, each researcher in Denmark published 1.5 journal articles on average in 2012–2015,⁶ the same as the recipients of Foundation grants.⁷

Figure 2.3

Number of journal articles per million population by country of origin, 2015



Sources: Novo Nordisk Foundation and Scopus data.

However, the number of journal articles published does not say anything about the competence of recipients of Foundation grants, the impact of their journal articles, or the distribution of the journal articles across individual researchers or areas of research.

2.3 JOURNAL SUBJECT CATEGORIES OF PUBLICATIONS

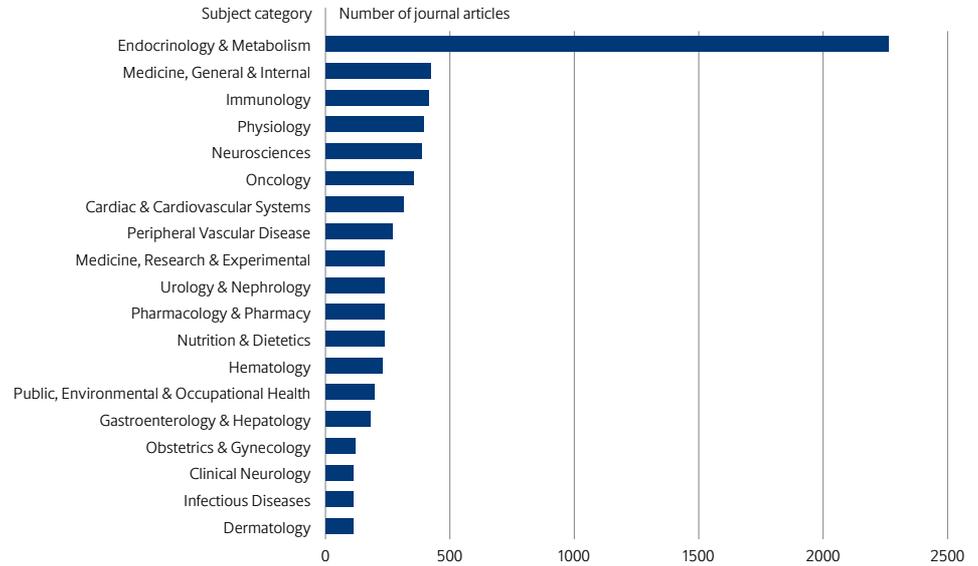
This section focuses on the publication activity by grant recipients as registered in Web of Science classified by journal subject category. The recipients of Foundation grants publish within multiple scientific fields, but mostly in the health and medical sciences, natural sciences and technical sciences. The journal of publication determines the subject categories assigned to a publication.⁸

2.3.1 HEALTH AND MEDICAL SCIENCES

Figure 2.4 shows the distribution within the 19 most frequently used subject categories in the health and medical sciences.

Figure 2.4

Journal articles within the health and medical sciences by journal subject category, 2000–2016



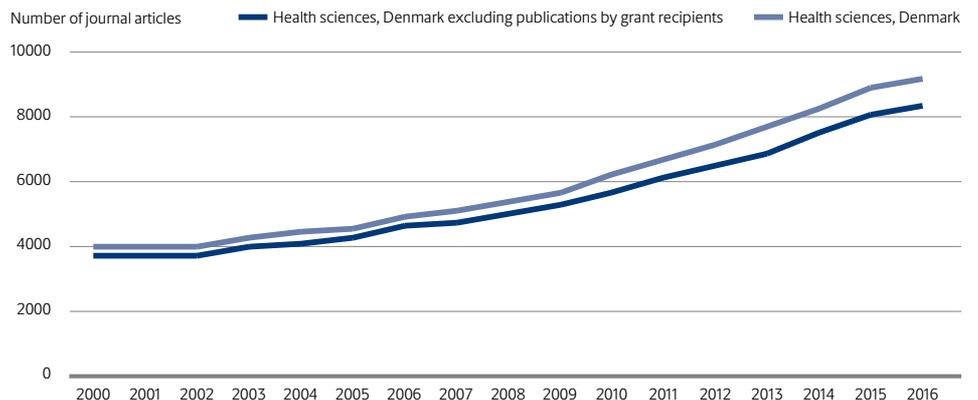
Note: The recipients of Foundation grants published 6852 journal articles in 2000–2016 primarily within the subject categories endocrinology & metabolism, immunology and physiology.

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

Figure 2.5 shows the trend in the share of journal articles within health and medical sciences in Denmark. In 2015, the number of journal articles from grant recipients corresponds to 11% of the total number of journal articles within health and medical sciences in Denmark.

Figure 2.5

Journal articles within the health and medical sciences in Denmark with and without publications from grant recipients, 2000–2016



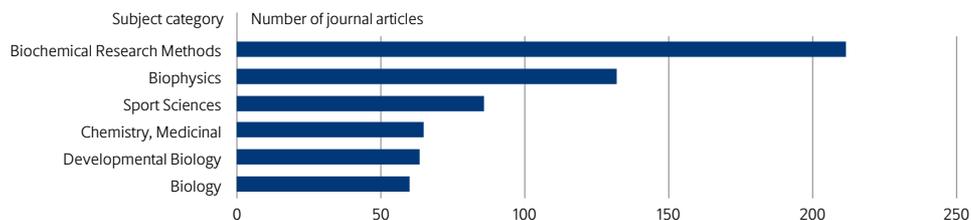
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

2.3.2 NATURAL SCIENCES

Figure 2.6 shows the distribution of journal articles by recipients of Foundation grants within the six most frequently used subject categories in natural sciences.

Figure 2.6

Journal articles within the natural sciences by journal subject category, 2000–2016



Note: The recipients of Foundation grants published 619 journal articles in 2000–2016 primarily within the subject categories biochemical research methods, biophysics, sports sciences, medicinal chemistry, developmental biology and biology.

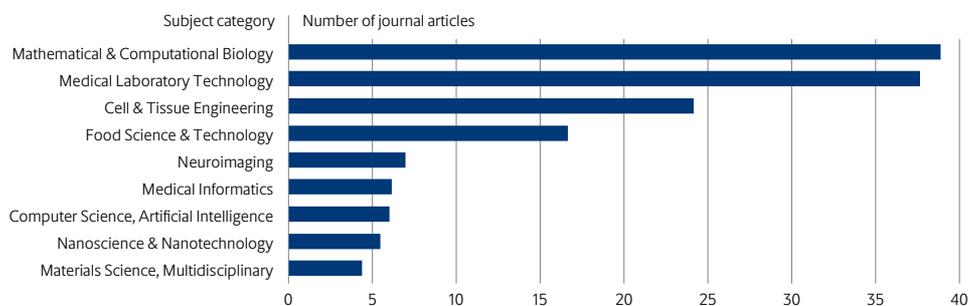
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

2.3.3 TECHNICAL SCIENCES

Figure 2.7 shows the distribution of journal articles by recipients of Foundation grants within the nine most widely used subject categories in technical sciences.

Figure 2.7

Journal articles within the technical sciences by journal subject category, 2000–2016



Note: The recipients of Foundation grants published 146 journal articles in 2000–2016 primarily within the journal subject categories mathematical & computational biology, medical laboratory technology and cell & tissue engineering.

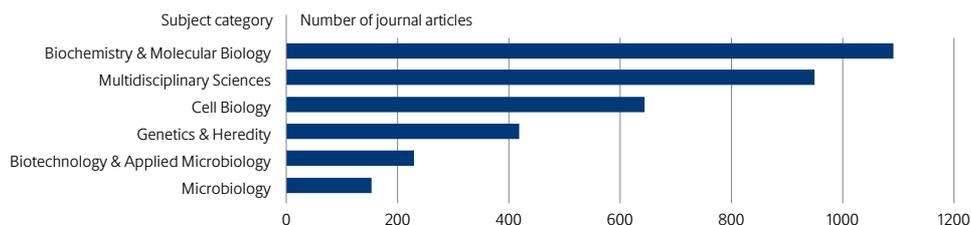
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

2.3.4 SUBJECT CATEGORIES ACROSS THE MAIN RESEARCH FIELDS: HEALTH AND MEDICAL SCIENCES, NATURAL SCIENCES AND TECHNICAL SCIENCES

Figure 2.8 shows the distribution of journal articles by recipients of Foundation grants on the shared subject categories within health and medical sciences, natural sciences and technical sciences.

Figure 2.8

Journal articles within health/medical sciences, natural sciences and technical sciences by journal subject category, 2000–2016



Note: The recipients of Foundation grants published 3482 journal articles in 2000–2016 within the six shared subject categories biochemistry & molecular biology, multidisciplinary sciences, cell biology, genetic & heredity, biotechnology & applied microbiology, and microbiology.

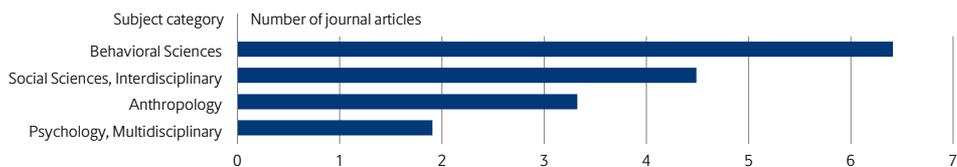
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

2.3.5 SOCIAL SCIENCES AND HUMANITIES

Figure 2.9 shows the distribution within the four most frequently used subject categories within social sciences and humanities.

Figure 2.9

Journal articles within social sciences and humanities by journal subject category, 2000–2016



Note: The recipients of Foundation grants published 16 journal articles in 2000–2016 primarily within the subject categories behavioural sciences, social sciences (interdisciplinary), anthropology, and psychology (multidisciplinary).

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

2.4 CO-AUTHORSHIP OF JOURNAL ARTICLES – COLLABORATION WITH ACADEMIA

Research is produced across national borders and across public and private organizations. Collaboration between researchers can help increase the dissemination of knowledge and collaboration can promote cross-disciplinary research and foster novel research results. This section analyses the production of co-authored journal articles and the patterns of collaboration of the recipients of Foundation grants within academia.⁹

2.4.1 TREND IN JOURNAL ARTICLES WITH AND WITHOUT CO-AUTHORSHIP

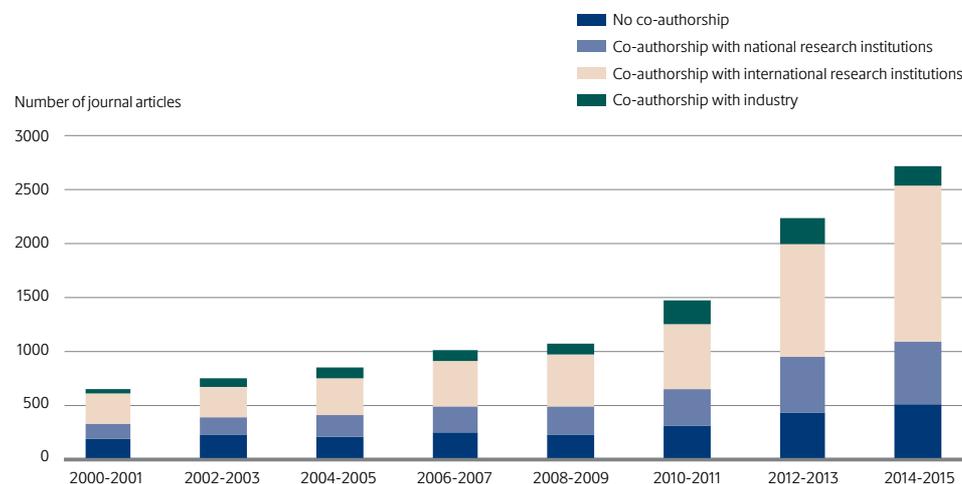
The statistics presented here are divided into three types of co-authored journal articles:

- Journal articles co-authored by researchers from national research institutions (academia),
- Journal articles co-authored by researchers from international research institutions (academia), and;
- Journal articles co-authored by industrial researchers (companies).

The number of journal articles by the recipients of Foundation grants with co-authorship within academia increased nearly five times from 2000–2001 to 2014–2015 (Figure 2.10). This shows that the recipients of Foundation grants increasingly contribute to a collaborative culture at research institutions.

Figure 2.10

Journal articles by co-authorship, 2000–2015



Note: The number of journal articles comprises articles indexed in Web of Science.

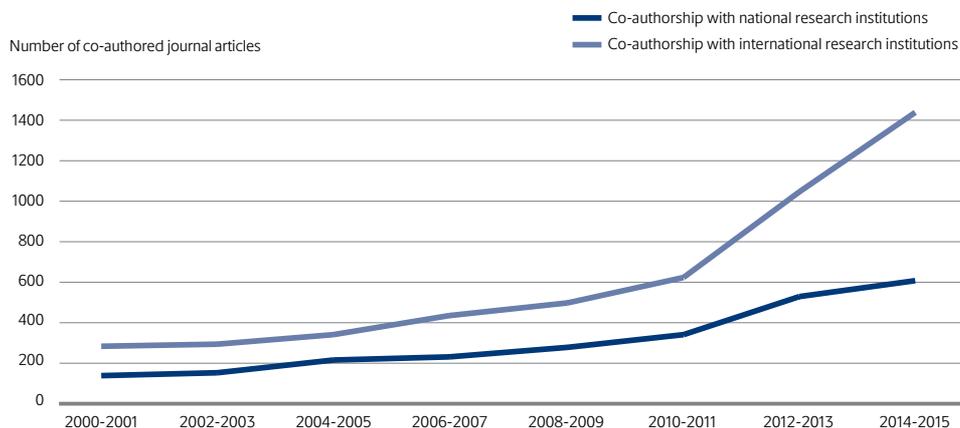
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

2.4.2 TREND IN NATIONAL AND INTERNATIONAL CO-AUTHORSHIP WITHIN ACADEMIA

The number of internationally co-authored journal articles has increased to more than twice as many as the nationally co-authored journal articles in 2014–2015 (Figure 2.11).

Figure 2.11

Number of co-authored journal articles within academia with national and international co-authors, 2000–2015

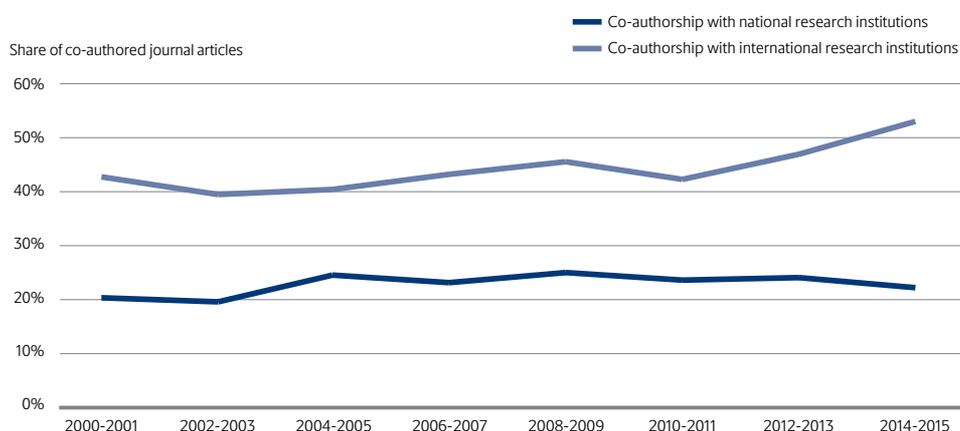


Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

The share of journal articles with national co-authorship within academia has been almost unchanged since 2000 at 20–22%, but the share of journal articles with international co-authors has increased by 10 percentage points from 2000 to 2014–2015 from 43% to 53% (Figure 2.12).

Figure 2.12

Share of co-authored journal articles within academia with national and international co-authors, 2000–2015



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

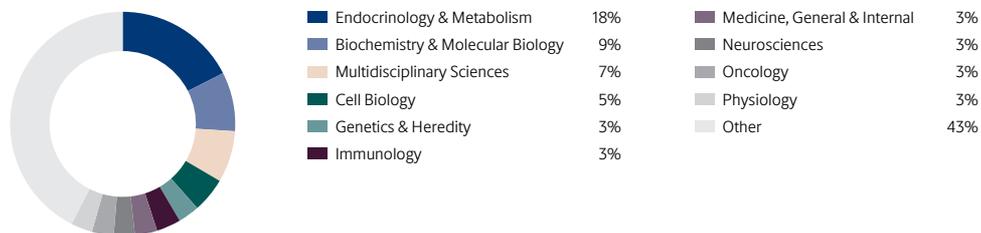
2.4.3 SUBJECT CATEGORIES FOR CO-AUTHORED JOURNAL ARTICLES WITHIN ACADEMIA

Figure 2.13 shows the 10 most frequent subject categories among grant recipient's co-authored journal articles within academia. The subject categories endocrinology & metabolism and bio-

chemistry & molecular biology have the largest share of co-authored journal articles within academia among recipients of Foundation grants.

Figure 2.13

Co-authored journal articles within academia by journal subject category, 2000–2015



Note: Other represents more than 30 subject categories.

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

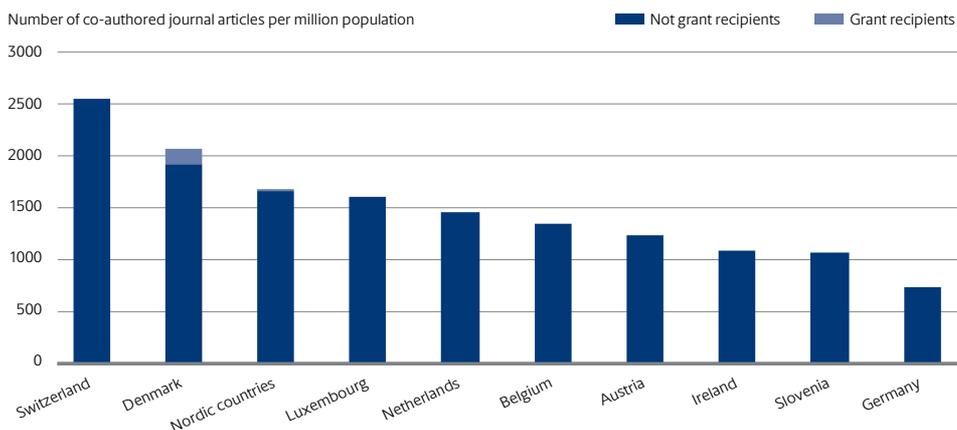
2.4.4 BENCHMARK – INTERNATIONAL CO-AUTHORED JOURNAL ARTICLES PER MILLION POPULATION

The EU's European Innovation Scoreboard estimates the number of international co-authored journal articles (academia) in Denmark for 2015 to be 2067 per million population; the number of international co-authored journal articles (academia) by the recipients of Foundation grants for the same period is 140 per million population. Hence, the recipients of Foundation grants account for 7% of all international research co-authored journal articles (across all sciences) in Denmark in 2015. Further, the grant recipients account for 0.55% of all international research co-authored journal articles in the other Nordic countries.

Figure 2.14 presents the number of journal articles per million population by country of origin that are internationally co-authored academic journal articles. It also shows the share of articles published by recipients of Foundation grants.

Figure 2.14

Internationally co-authored journal articles within academia per million population by country of origin, 2015



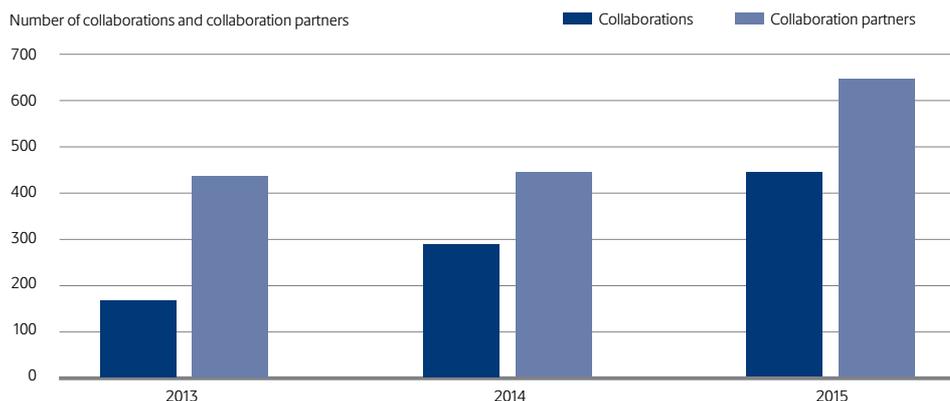
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy

2.5 RESEARCH-TO-RESEARCH PROJECT COLLABORATION AND COLLABORATORS

Collaboration can be complex, and a single collaboration can involve multiple collaboration partners, and these partners can change as the collaborative activity develops. The number of academic project collaborations reported by the recipients of Foundation grants has increased from 163 in 2013 to almost 440 in 2015. Each collaboration had on average around 1.5 collaboration partners in 2015 (Figure 2.15).¹⁰

Figure 2.15

Project collaborations and collaboration partners, 2013–2015

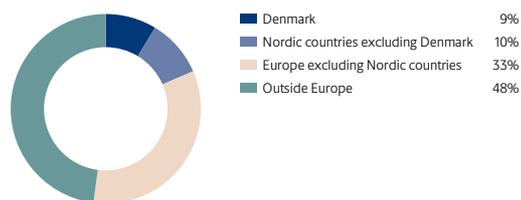


Source: Novo Nordisk Foundation/researchfish®

When looking at collaboration partners by country 10% are from the Nordic countries, 33% are from the rest of Europe, and 48% are from countries outside Europe. Nine percent of the collaboration partners come from Denmark (Figure 2.16).

Figure 2.16

Collaboration partners by country of origin, 2013–2015



Note: The number of collaboration partners is 1544.

Source: Novo Nordisk Foundation/researchfish®

2.6 RESEARCHER EDUCATION AND TRAINING

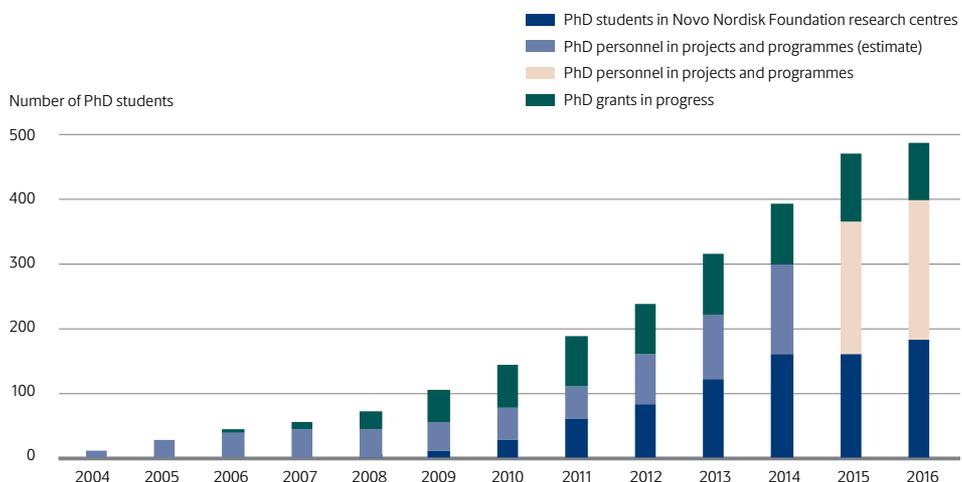
The Foundation strives to promote the development of talented researchers. The Foundation achieves this by supporting researcher education and training.

2.6.1 CURRENT PHD STUDENTS FUNDED BY FOUNDATION GRANTS

The number of current PhD students supported by Foundation grants grew from an estimated 10 in 2004 to 487 in 2016. 90 PhD students, have received a Foundation PhD fellowship, 217 are working as part of other Foundation grants, and 180 are employed across the Foundation’s four research centres. These numbers represent PhD students that are either fully funded or partially funded by the Foundation (Figure 2.17).

Figure 2.17

Current PhD students supported by Foundation grants, 2004–2016



Note: The number of PhD students based on Foundation-supported projects and programmes for 2004–2014 is estimated. Data for estimation are not available before 2004. Estimates of PhD in projects and programmes for 2000–2014 are based on the reported number of PhD students involved in Foundation project and programme grants for 2015–2016 relative to the grants for 2004–2014.

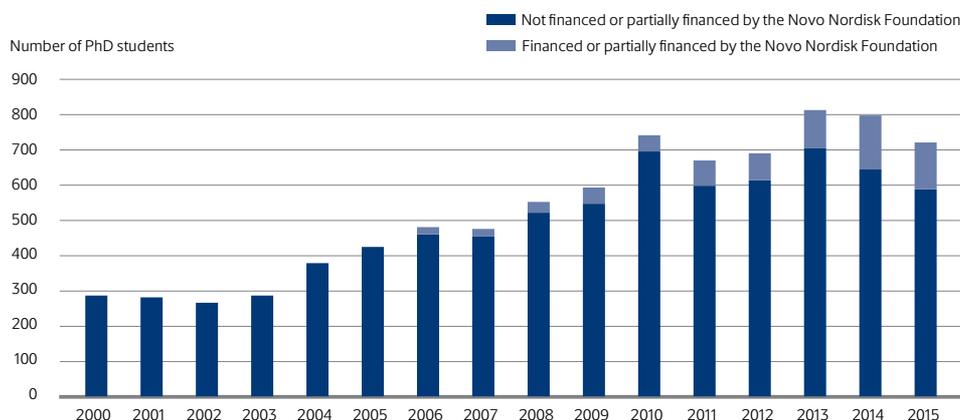
Source: Novo Nordisk Foundation/researchfish®

2.6.2 PHD STUDENTS IN THE HEALTH SCIENCES IN DENMARK

Denmark had 725 new PhD students within the health sciences in 2015. The Foundation funded or partially funded 18% of the new PhD students within the health sciences in Denmark in 2015 (Figure 2.18).

Figure 2.18

New PhD students in the health sciences in Denmark, 2000–2015



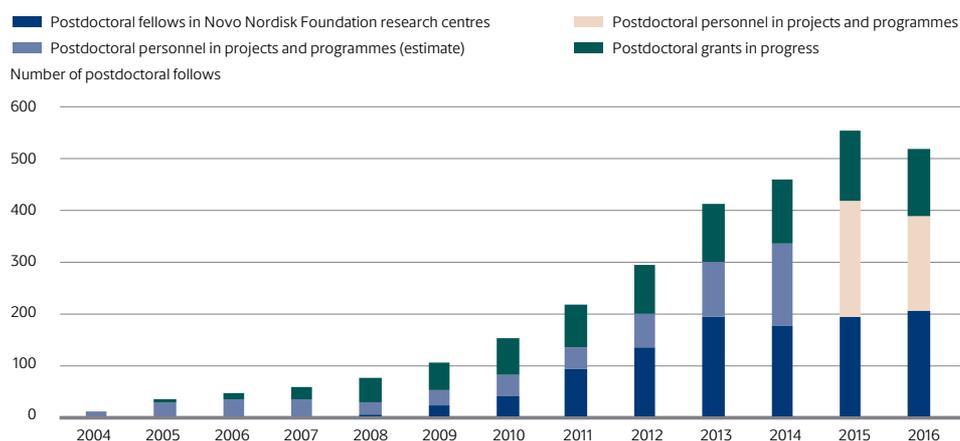
Source: Novo Nordisk Foundation and Statistics Denmark

2.6.3 CURRENT POSTDOCTORAL FELLOWS SUPPORTED BY FOUNDATION GRANTS

The number of current postdoctoral fellows (lasting typically 1–3 years) either fully or partially funded by the Foundation grew from 11 in 2004, to 514 in 2016 (Figure 2.19). A total of 127 postdoctoral fellows have received a Foundation grant, 184 work on other Foundation grants and 203 are employed at one of the Foundation's four research centres.

Figure 2.19

Current postdoctoral fellows funded by Foundation grants, 2004–2016



Notes: The number of postdoctoral fellows related to Foundation projects and programmes for 2004–2014 is estimated. Data for estimation are not available before 2004. The estimates of the number of postdoctoral fellows in projects and programmes for 2000–2014 are based on the reported number of postdoctoral fellows involved in Foundation project and programme grants for 2015–2016 relative to the grants for 2004–2014.

Source: Novo Nordisk Foundation/researchfish®

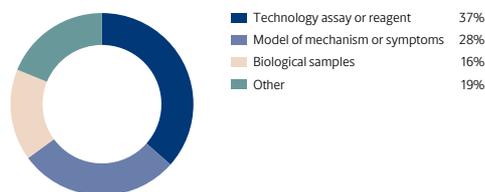
2.7 PRODUCTION OF ‘RESEARCH TOOLS AND METHODS’, AND ‘RESEARCH DATABASES AND MODELS’

This section presents other types of research activities of the grant recipients, particularly those relating to advancing research such as research tool and research methods, as well as research databases and models.

In 2015 and 2016, the recipients of Foundation grants produced 271 research tools and methods (Figure 2.20). The main activity has been in producing assays, with 99 assays and reagents being produced. Assays are analytic procedures for assessing or measuring such substances as metabolites or drugs. Reagents are chemical substances that create reactions in combinations with other substances. In addition, 77 models and a number of biological samples were also reported. Recipients of Foundation grants made their research results available to other researchers. A total of 70% of the research tools and methods were shared with other researchers.

Figure 2.20

Research tools and methods developed by category , 2015–2016 ¹¹



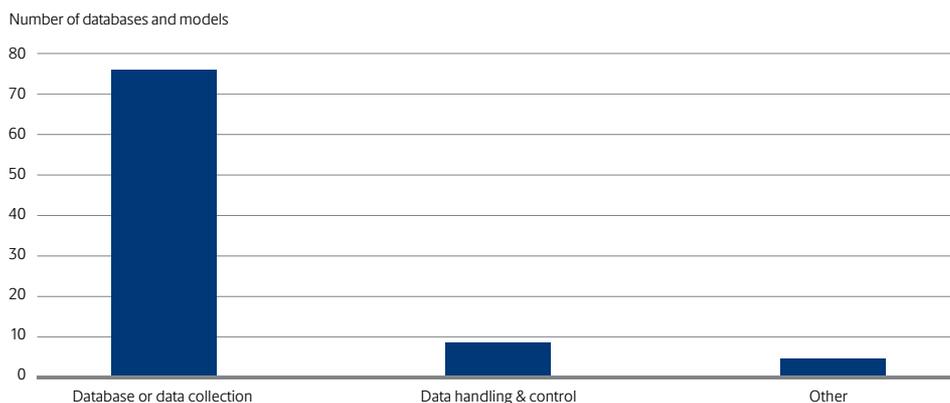
Note: 271 research tools and methods were reported.

Source: Novo Nordisk Foundation/researchfish®

The Foundation has also collected data on activities related to creation of research databases, data handling and control.¹² The recipients of Foundation grants reported 88 activities for 2015–2016, which were distributed mainly on databases, data handling and control (Figure 2.21). The databases reported covered a wide variety of subjects and purposes.

Figure 2.21

Research databases and models, 2015–2016



Note: 88 databases and models were reported.

Source: Novo Nordisk Foundation/researchfish®

Chapter 3

Dissemination and use of knowledge within academia

Key findings

- Of the journal articles by grant recipients:
 - 22% are among the 10% most cited worldwide
 - 4% are among the 1% most frequently cited worldwide
- Co-authored journal articles with researchers abroad are more cited:
 - 23% are among the 10% most frequently cited worldwide
 - The Foundations's four research centres have 9.5% of their publications among the 1% most cited worldwide

3 DISSEMINATION AND USE OF KNOWLEDGE WITHIN ACADEMIA

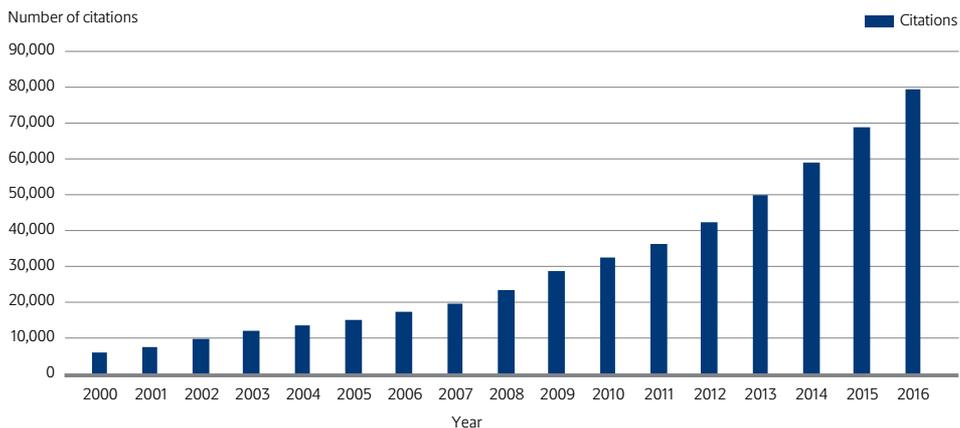
This chapter focuses on the dissemination and use of knowledge within academia – according to the “citation impact” of journal articles by the recipients as a result of Foundation grants. The citation impact is measured by how often a researchers’ journal articles are cited. This does not necessarily measure of the journal article’s quality, but a citation score indicates the relevance of a journal article for other researchers, and is therefore read and used as a basis for other researchers’ work.

3.1 KNOWLEDGE DISSEMINATION IN THE GLOBAL SCIENTIFIC COMMUNITY

The research funded by the Foundation is disseminated globally, and the articles funded by the Foundation are cited worldwide in recognized international journals. The recipients published 13,859 journal articles based on Foundation grants since 2000, which were cited a total of 66,068 times in 2015 and 76,401 times in 2016 (Figure 3.1). Each year adds citations counts to new journal articles as well as to articles published in the previous years. The total sum of citations since 2000 accumulates to 516,134 citations and the average of citations per journal article in the period 2000–2016 is 32.7.

Figure 3.1

Total number of citations on journal articles from recipients of Foundation grant, 2000-2016



Sources: Novo Nordisk Foundation

3.2 JOURNALS IN WHICH RECIPIENTS OF FOUNDATION GRANTS PUBLISH

From 2000 to 2016, recipients published their articles in 1672 research journals. These journals are based in 32 countries in Europe, Asia and North America.

As shown in Table 3.1, recipients of Foundation grants most frequently publish in *PLoS ONE*, *Diabetologia*, *Diabetes*, *Journal of Clinical Endocrinology and Metabolism* and *Journal of Biological Chemistry*. The predominant journal subject category on the list of top-10 journals is endocrinology & metabolism, which is not surprising given the amount of funding awarded to this field.¹⁵

Table 3.1

Top 10 journals in which recipients of Foundation grants most frequently publish their funded research, 2000–2016

Title	Journal subject category (Web of Science)	Number of articles 2000-2016	2016	Journal impact factor 2015
PLoS One	Multidisciplinary sciences	490	49	3.1
Diabetologia	Endocrinology & metabolism	361	32	6.2
Diabetes	Endocrinology & metabolism	310	22	8.8
Journal of Biological Chemistry	Biochemistry & molecular biology	267	15	4.6
Journal of Clinical Endocrinology & Metabolism	Endocrinology & metabolism	253	25	5.5
Diabetes Care	Endocrinology & metabolism	177	10	8.9
Proceedings of the National Academy of Sciences of the United States of America (PNAS)	Multidisciplinary sciences	163	10	9.4
American Journal of Physiology – Endocrinology and Metabolism	Endocrinology & metabolism and physiology	127	12	3.8
Diabetic Medicine	Endocrinology & metabolism	112	6	3.2
European Journal of Endocrinology	Endocrinology & metabolism	106	15	3.9

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

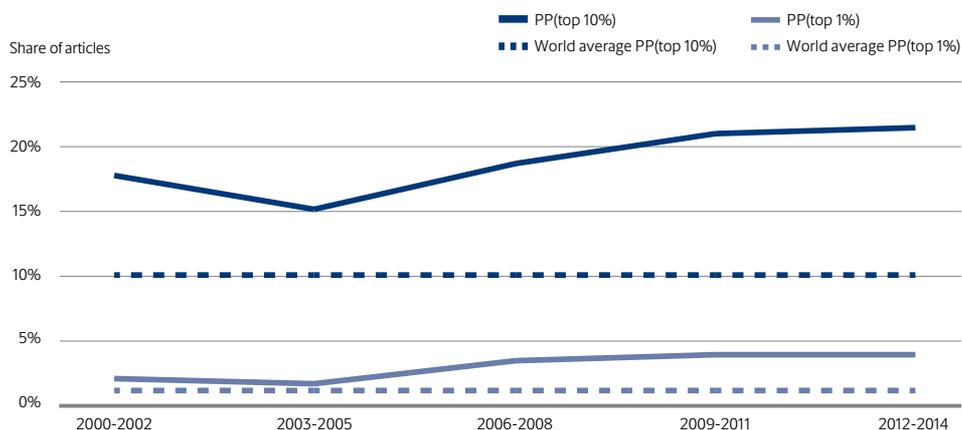
3.3 TRENDS IN CITATION IMPACT

The citation impact analysis uses various measures. Standard cut-off levels are applied: the share of journal articles among the 1% and 10% most frequently cited journal articles, respectively. The citation analysis covers 2000–2014, excluding journal articles from 2015 and 2016 to allow for lag in citations as citation impact takes time to build up and stabilize. This follows the international standard for bibliometric analysis of citation impact, which, in general, allows for 18 months to 2 years citation lag. The analysis includes the journal articles reported by recipients of Foundation grants that can be found in Web of Science.

The citation impact of the grant recipient articles is well above the world average. Starting at a lower level in 2000–2007, the share of journal articles by the recipients of Foundation grants among the world’s 10% most frequently cited journal articles (PP(top 10%)) is now at 22%, and 4% of all journal articles are among the 1% most frequently cited journal articles (PP(top 1%)) (Figure 3.2).

Figure 3.2

Trend in citation impact - PP(top1%) and PP(top10%), 2000–2014

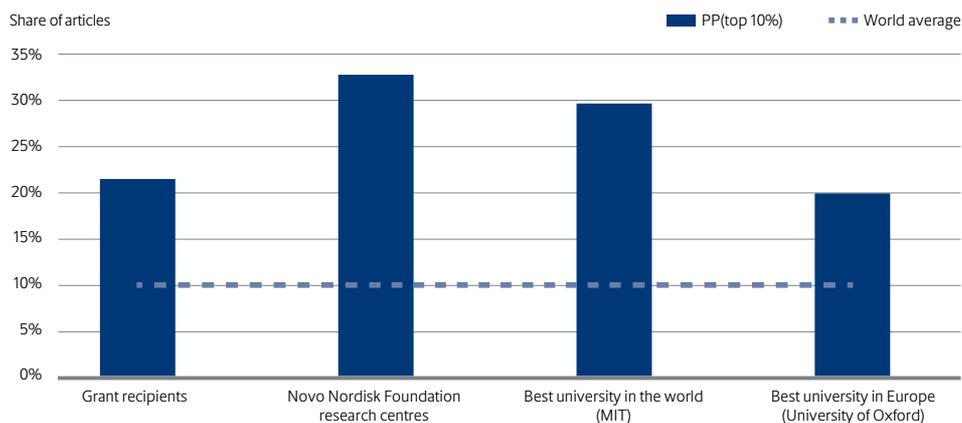


Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

The citation impact of the journal articles by the recipients of Foundation grants published in the period 2011–2014 is relatively high and equivalent to those of the best universities in Europe, such as Oxford University, and the citation impact of the Foundation’s four research centres equivalent to the best university in the world (Figure 3.3 and Figure 3.4).

Figure 3.3

Benchmark of the citation impact of journal articles categorised as biomedical and health sciences PP(top 10%), 2011–2014

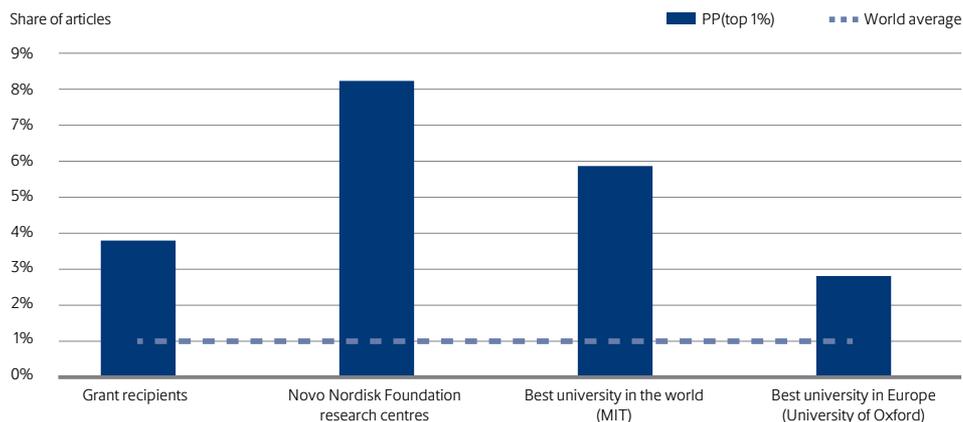


Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

Denmark ranks fourth on the citation impact of journal articles in the EU's European Innovation Scoreboard, with 13% of the journal articles from Denmark among the 10% most frequently cited worldwide. That share is 22% for articles by Foundation-supported researchers. The top three countries are Switzerland, Netherlands and the United Kingdom, ranging from 14% to 16% of journal articles among the 10% most frequently cited.

Figure 3.4

Benchmark of the citation impact of articles within the biomedical and health sciences - PP(top 1%), 2011–2014



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

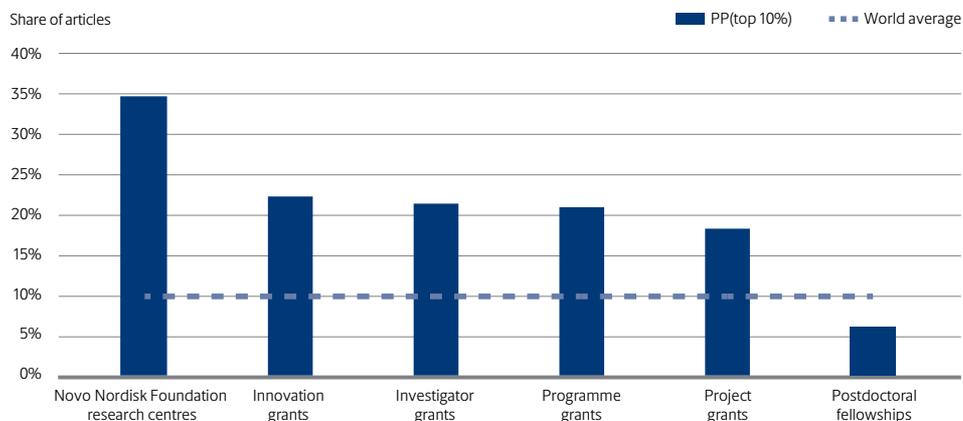
3.4 CITATION IMPACT BY TYPE OF GRANT

The types of grants the Foundation offers are specifically set up to target different groups, different purposes and different types of projects, with the aim of effectively fulfilling the strategic aims of the Foundation. Research centres are large units that attract top researchers, and can host complex and demanding research projects, and should therefore tend to have high citation impact. Research centres receive long-term grants, while research projects are smaller grants for experienced researchers who typically receive 1-3 year grants. Investigator grants target experienced and excellent individual researchers who typically receive 5-7 year grants. Research programmes target research groups. Research programme recipients typically receive 4-8 year grants to solve a difficult research challenge. Postdoctoral fellows are generally less experienced researchers conducting less complex research projects and should tend to face more difficulty in publishing high-impact research. Postdoctoral fellows typically receive support for 1-3 years. Finally, innovation grants target commercialisation of research inventions developed by experienced researchers.

Against this background it should be expected that the journal articles of the recipients of different grant types differ in citation impact. Figure 3.5 and Figure 3.6 confirm this assumption. The figures show that journal articles based on 1-3 year grants (project grants and postdoctoral fellowships) have a smaller share among the 1% most frequently cited worldwide as well as among the 10% most frequently cited.

Figure 3.5

Citation impact of journal articles by type of grant - PP(top 10%), 2000–2014



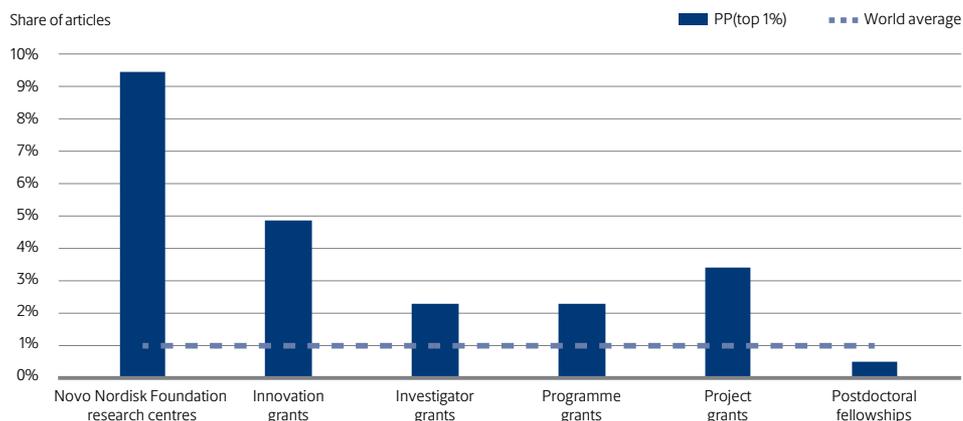
Notes: For specification of the grant types, please visit <http://novonordiskfonden.dk/en/ansogning>.

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

Figure 3.5 and Figure 3.6 also shows that the research centre journal articles are highly represented among the world’s most frequently cited journal articles. 34.5% of the journal articles fall within the top 10% worldwide, and 9.5% are in the top 1% most frequently cited worldwide – i.e. centre journal articles are about nine times more often among the 1% most frequently cited journal articles compared to the world average.

Figure 3.6

Citation impact of journal articles by type of grant - PP(top 1%), 2000–2014



Notes: For specification of the grant types, please visit <http://novonordiskfonden.dk/en/ansogning>.

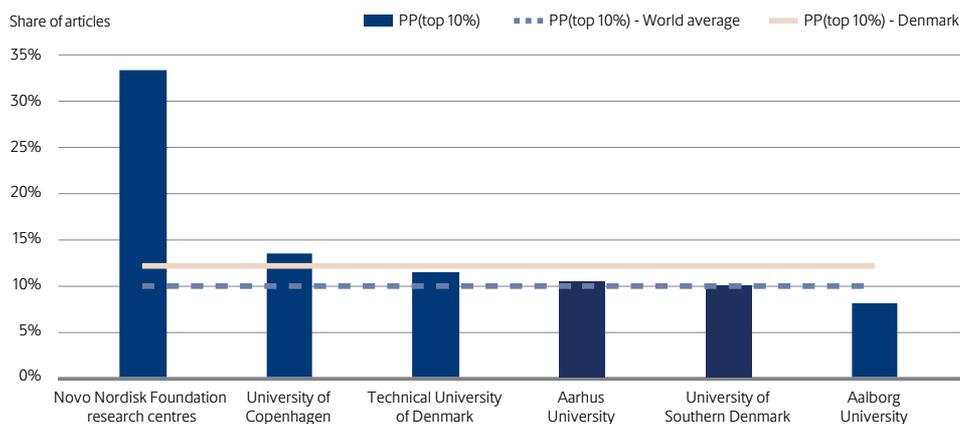
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy

3.5 CITATION IMPACT OF THE FOUNDATION'S RESEARCH CENTRES

The citation impact scores of the Foundation's research centres are exceptionally high by any comparison, underlining the likely effect of pooling high-impact researchers. Figure 3.7 and Figure 3.8 compare the performance of the research centres to that of universities in Denmark within the biomedical and health sciences, according to the CWTS Leiden Ranking (2011–2014). The research centres comprise a modest share of the total research production of their host universities, the University of Copenhagen and the Technical University of Denmark, but have a large citation impact relative to the number of journal articles produced.

Figure 3.7

Citation impact of the Novo Nordisk Foundation research centres and universities in Denmark - PP(top 10%), 2011–2014

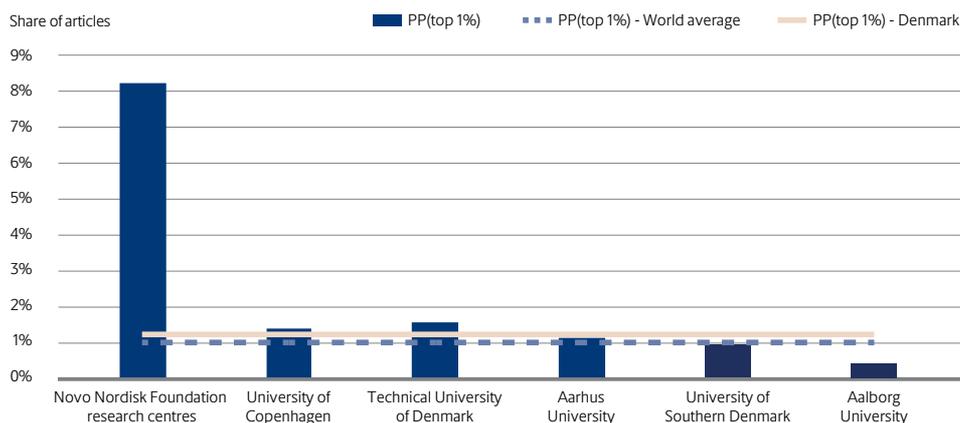


Note: All research centre journal articles are matched with journal articles within the biomedical and health sciences from the universities.

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

Figure 3.8

Citation impact of the Novo Nordisk Foundation research centres and universities in Denmark - PP(top 1%), 2011–2014



Note: All research centre journal articles are matched with journal articles within the biomedical and health sciences from the universities.

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

3.6 CITATION IMPACT BY JOURNAL SUBJECT CATEGORY

This section breaks down citation impact by the journal subject category as defined by Web of Science. The journal subject category assigned to a journal article follows the journal of publication. The category of multidisciplinary sciences tends to be a catch-all category for more general journals. These journals include high-impact journals, such as *Nature*, that attract journal articles with frontline research regardless of the detailed journal subject category.

Figure 3.9 and Figure 3.10 shows that the citation impact of journal articles by the Foundation grant recipients varies across the journal subject categories, and that this variation applies not only to the top-10% level but also to the share of the journal articles in the top 1% most frequently cited worldwide within their respective research fields. Citation impact scores are normalized by journal subject category to allow for comparison of citation impact across journal subject categories. The journal subject categories in Figure 3.9 and Figure 3.10 are sorted from the left according to the number of journal articles (see also section 2.2 in chapter 2).

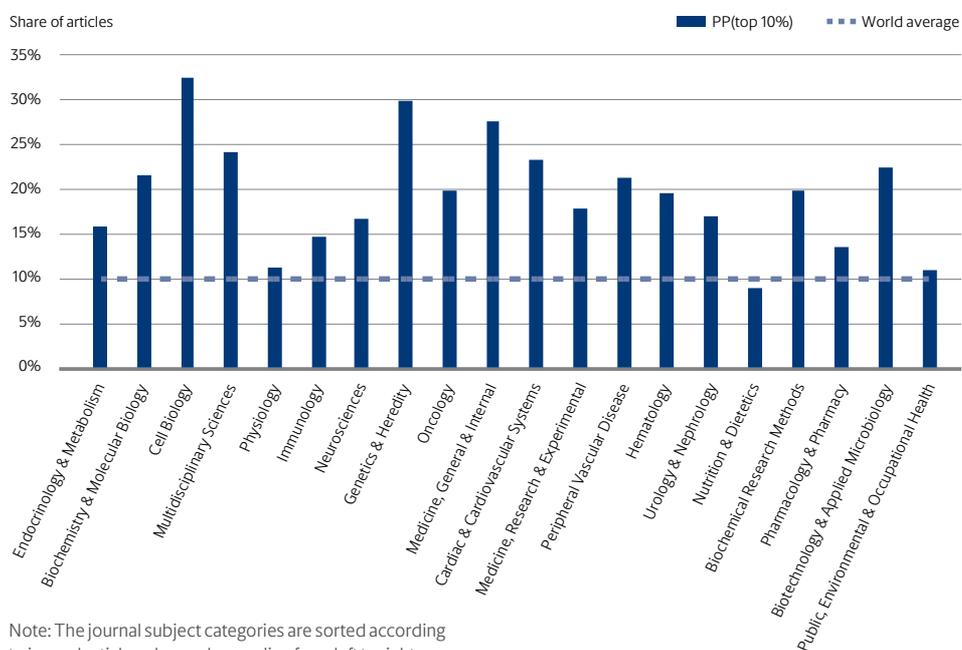
Approximately 20% of all the journal articles of recipients of Foundation grants that were published in the period 2000–2014 are within endocrinology & metabolism. Of the articles in journals within endocrinology & metabolism, 16% are among the 10% most frequently cited journal articles (see Figure 3.9), and 1% are in the top 1% most frequently cited journal articles worldwide (see Figure 3.10).

In multidisciplinary sciences, 24% of the journal articles by recipients of Foundation grants are in the top 10%, and one in four (6% of the total) of these journal articles are in the top 1%.¹⁴

In general & internal medicine, 28% of the journal articles by recipients of Foundation grants are among the top 10% most frequently cited worldwide within their field, and more than 1 in 3 of these (11% of the total) are also among the 1% most frequently cited worldwide within their field.

Figure 3.9

Citation impact of journal articles by journal subject category - PP(top 10%), 2000–2014

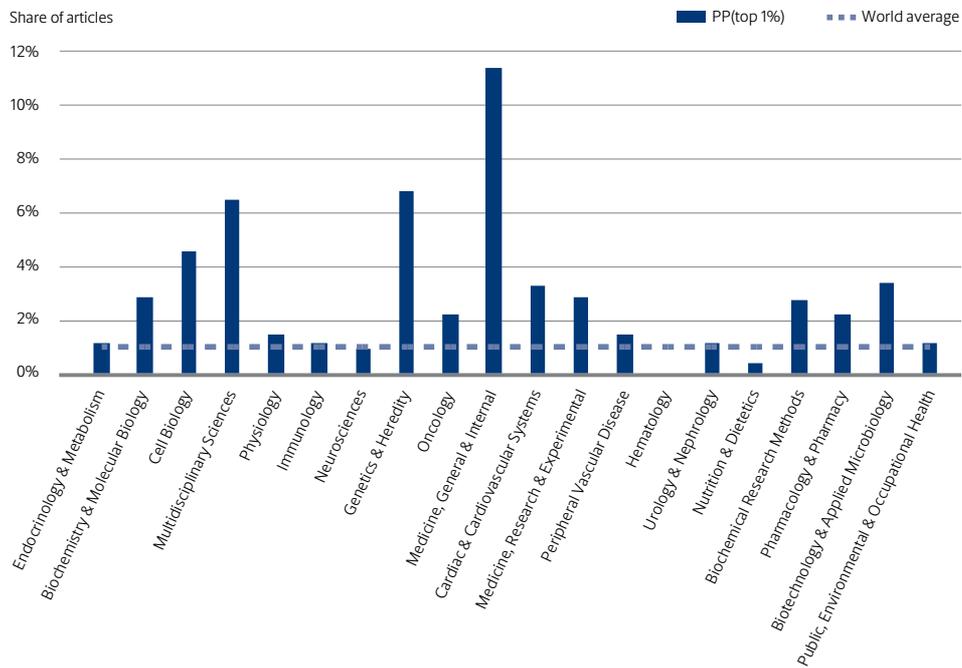


Note: The journal subject categories are sorted according to journal article volume, descending from left to right.

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

Figure 3.10

Citation impact of journal articles by journal subject category - PP(top 1%), 2000–2014



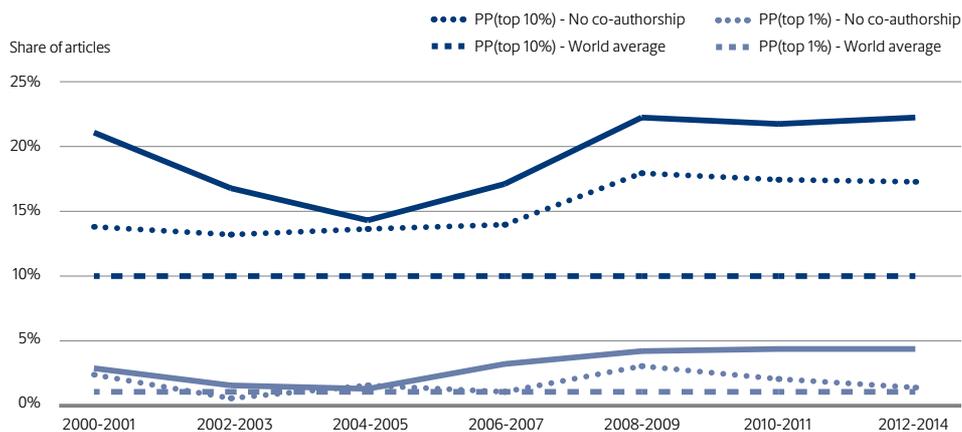
Note: The journal subject categories are sorted according to journal article volume, descending from left to right.
 Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy

3.7 CITATION IMPACT OF CO-AUTHORED JOURNAL ARTICLES

This section analyses the citation impact of journal articles produced by the recipients of Foundation grants in collaboration with other researchers from other research institutions than their own.

Figure 3.11

Trend in citation impact of co-authored journal articles within academia - PP(top10%) and PP(top10%), 2000–2014



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

Collaboration with researchers from institutions within and outside Denmark can enhance knowledge of the research outside the research institution's own walls. Co-authors of the recipients of Foundation grants are located in 120 countries and cover all continents beside Antarctica. In 2012–2014, grant recipients who had co-authors outside their own institution versus researchers without co-authors outside their own institution had 1.3 times more journal articles among the 10% most frequently cited journal articles and four times more journal articles among the 1% most frequently cited journal articles (Figure 3.11).

Journal articles produced by recipients of Foundation grants in collaboration with international co-authors have a greater citation impact than those with national co-authors. In 2012–2014, grant recipients with international co-authors had 11 percentage points more journal articles among the 10% most frequently cited and 3 percentage points more journal articles among the 1% most frequently cited co-authored journal articles in the field than those with only national co-authorship (Figure 3.12 and Figure 3.13).

Figure 3.12

Citation impact of national co-authored journal articles within academia - PP(top 1%) and PP(top 10%), 2000–2014

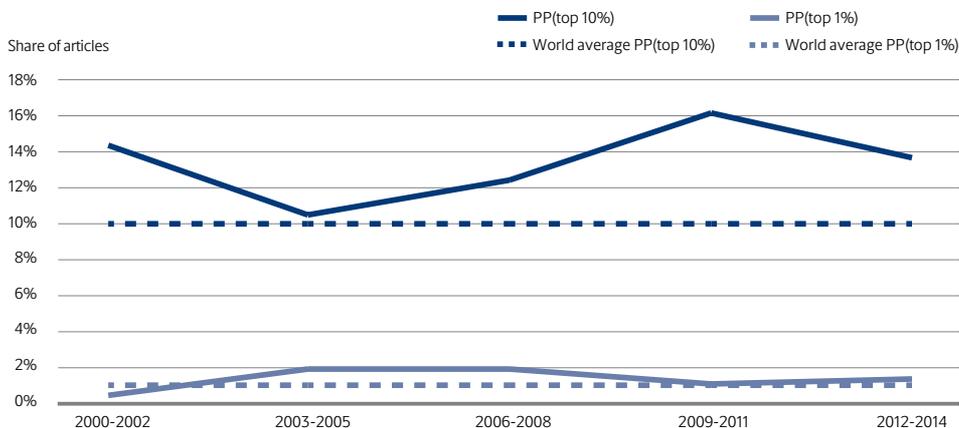
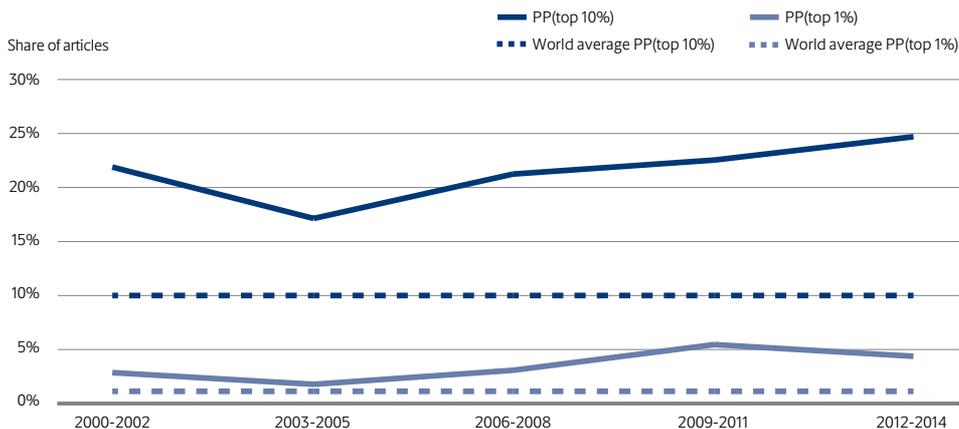


Figure 3.13

Citation impact of internationally co-authored journal articles within academia - PP(top1%) and PP(top10%), 2000–2014



Source: Novo Nordisk Foundation/researchfish®

Chapter 4

Dissemination and use of knowledge within the public sector

Key findings

- Grant recipient's publications are present in:
 - 53% of diabetes guidelines and 18% of cardiovascular disease guidelines
- References to publications by grant recipients cover:
 - 1.6% in Nordic and 1.0% in non-Nordic diabetes guidelines
 - 0.2% in cardiovascular disease guidelines in and outside the Nordic countries
- 40 medical products and interventions developed since 2013

4 DISSEMINATION AND USE OF KNOWLEDGE WITHIN THE PUBLIC SECTOR

Public research in the health, medical, natural and technical sciences promotes the development and renewal of treatment and prevention measures in the public health care system, as well as innovation in the discovery of medical products. Public research also contributes to developing the education sector, teaching and the dissemination of knowledge in society at large, not just in relation to health and medicine. Thus, public research contributes significantly to the public and society in many ways, such as improving health and welfare of people, optimising costs for public services and enabling a skilled workforce.

Research transmission channels from public research to other parts of the public sector are difficult to identify and monitor, because knowledge transfer does not always leave a trail. One form of transmission channel that is useful for documenting knowledge transfer activities in the public sector is clinical guidelines and recommendations, which outlines procedures and parameters for practitioners to deal with particular conditions. Another channel is the link between researchers and the education sector covering talks, workshops, visits to research institutions etc.

The analysis in this chapter uses guidelines on diabetes and cardiovascular disease treatment and prevention to identify knowledge transfer from academia to the public sector. The analysis show that guidelines on diabetes and on cardiovascular disease worldwide cite publications that have arisen as an outcome of Foundation grants.

4.1 CONTRIBUTIONS BY GRANT RECIPIENTS TO PRACTICE, GUIDELINES AND ADVISORY FUNCTIONS

The recipients of Foundation grants act as experts to give advice or present evidence to government institutions and other authorities. They contribute to the training of practitioners and researchers, and contribute in developing and revising clinical guidelines with recommendations for clinicians on diagnosis, management and treatment of diseases. 44% of the reported contributions are related to the training of practitioners or researchers; the remaining activities cover a wide field of advisory functions, such as working as a health and scientific expert in guideline and advisory committees and national consultations (Figure 4.1).

Figure 4.1

Contributions by grant recipients to practice, guidelines and advisory functions, 2015–2016



Note: The number of reported contributions is 54.

Source: Novo Nordisk Foundation/researchfish®

4.2 USE OF RESEARCH BY GRANT RECIPIENTS IN CLINICAL GUIDELINES

The use of research by grant recipients in the public healthcare system is documented by analysing references in guidelines covering specific disease areas. In this impact report, two sets of guidelines have been selected, diabetes and cardiovascular diseases. These are fields where the Foundation supports research. The relevance of these two fields is emphasized by the fact that estimated 460,000 people in Denmark have cardiovascular diseases and 320,000 have diabetes.

The purpose of the analysis is to measure the contribution of the recipients of Foundation grants (measured in terms of the number of publications that have arisen from Foundation funding and have been cited) in guidelines from Denmark, other Nordic countries, organizations in the United Kingdom and United States and international organizations such as the World Health Organization (WHO).¹⁵

A publication being referenced in a clinical guideline or a recommendation indicates that the research behind the publication is likely to influence the treatment of patients. Clinical guidelines and recommendations gather the best and most current evidence about the prevention, diagnosis, prognosis and therapy of clinical problems. The guidelines present the evidence in a systematic review with recommendations directed at specialists as well as non-specialists.

Clinical guidelines and recommendations are treated equally, and different versions of guidelines are treated as separate guidelines as new version of guidelines are only produced when procedures described within them have been altered significantly.

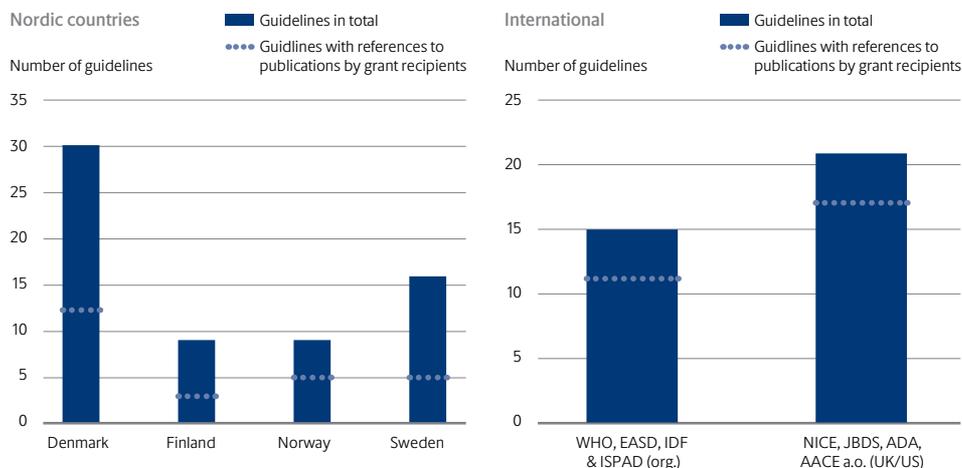
4.2.1 HOW MANY GUIDELINES HAVE BEEN IDENTIFIED?

The analysis identified 100 diabetes guidelines in Denmark and other countries that were published between 2000–2016. A total of 64% of the guidelines have been published in the Nordic countries, and 36% are from elsewhere by organisations, such as the World Health Organisation (WHO), National Institute for Health and Care Excellence (NICE) and American Diabetes Association (ADA). More than half of the diabetes guidelines (53%) examined contain references to publications published by the recipients of Foundation grants (Figure 4.2). 78% of the international diabetes guidelines and 39% of the Nordic diabetes guidelines have references to publications by the recipients of Foundation grants.

In the field of cardiovascular diseases, 276 guidelines have been identified. A total of 34% of the guidelines (95 guidelines) have been published in the Nordic countries, and 66% (181 guidelines) are from elsewhere by organisations such as World Health Organisation (WHO), European Society of Cardiology (ESC), British Cardiovascular Society (BCS) and American Heart Association (AHA). Of the 276 guidelines, 49 (18%) have references to publications by the recipients of Foundation grants (Figure 4.3). 22% of the international cardiovascular guidelines and 9% of the Nordic cardiovascular guidelines have references to publications by the recipients of Foundation grants.

A total of 61% of the diabetes guidelines are clinical guidelines published by a central authority; 39% are recommendations published by a private organization, regional authority or similar body such as the Danish Endocrine Society. For guidelines on cardiovascular diseases, 50% of the guidelines are clinical guidelines and 50% are recommendations and position papers.

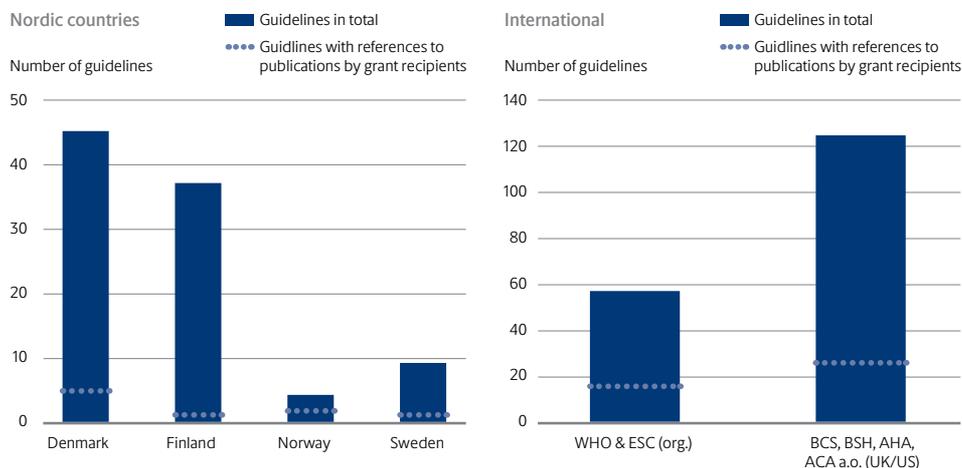
Figure 4.2 Diabetes guidelines by origin, 2000–2016



Note: WHO: World Health Organization; EASD: European Association for the Study of Diabetes; IDF: International Diabetes Federation; ISPAD: International Society for Pediatric and Adolescent Diabetes; NICE: National Institute for Health and Care Excellence; JBDS: Joint British Diabetes Societies; ADA: American Diabetes Association; AACE: American Association of Clinical Endocrinologists.

Sources: Novo Nordisk Foundation/researchfish* and DAMVAD Analytics

Figure 4.3 Cardiovascular guidelines by origin, 2000–2016



Note: WHO: World Health Organization; ESC: European Society of Cardiology; BCS: British Cardiovascular Society; BSH: British Society for Heart Failure; AHA: American Heart Association; ACA: American College of Cardiology Foundation.

Sources: Novo Nordisk Foundation/researchfish* and DAMVAD Analytics

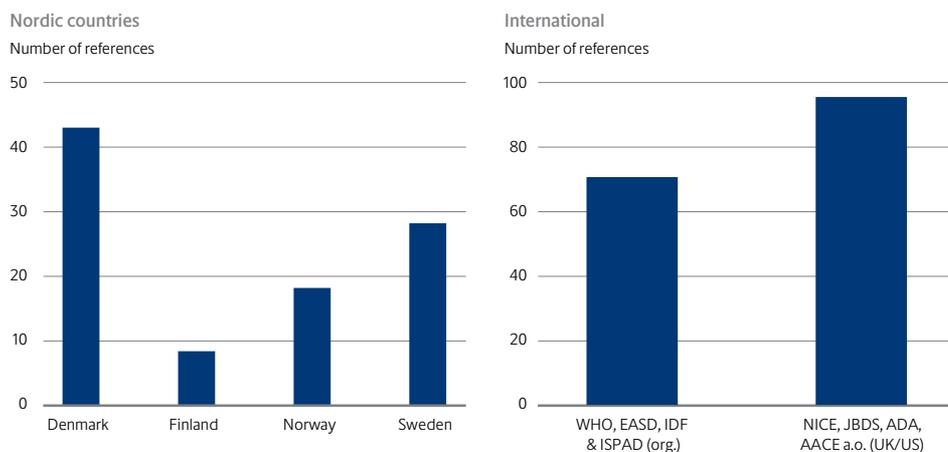
4.2.2 HOW MANY PUBLICATIONS ARE REFERENCED AND HOW OFTEN?

Across the 53 diabetes guidelines that have contributions from recipients of Foundation grants, there were 141 individual publications referenced (Figure 4.4). These publications are referenced 263 times of the 22,393 total references in all guidelines.

The cardiovascular disease guidelines show a similar pattern, of the 49 cardiovascular guidelines that have contributions from recipients of Foundation grants, there were 58 individual publications referenced (Figure 4.5). The publications are referenced 115 times of the 60,190 total references in all guidelines.

Figure 4.4

References to publications in diabetes guidelines by origin, 2000–2016



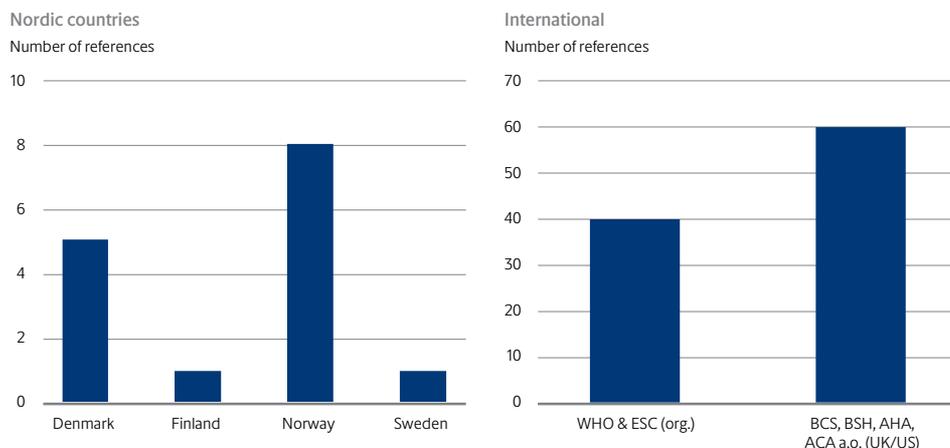
Notes: WHO: World Health Organization; EASD: European Association for the Study of Diabetes; IDF: International Diabetes Federation; ISPAD: International Society for Pediatric and Adolescent Diabetes; ADA: American Diabetes Association; NICE: National Institute for Health and Care Excellence; JBDS: Joint British Diabetes Societies; AACE: American Association of Clinical Endocrinologists.

The total number of references to recipients of Foundation grants across all Nordic countries and the international organisation is 263. The total number of references is 22,393.

Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics

Figure 4.5

References to publications in cardiovascular disease guidelines by origin, 2000–2016



Notes: WHO: World Health Organization; ESC: European Society of Cardiology; BCS: British Cardiovascular Society; BSH: British Society for Heart Failure; AHA: American Heart Association; ACA: American College of Cardiology Foundation. The total number of references to recipients of Foundation grants across all Nordic countries and the international organisations is 115. The total number of references is 60,190.

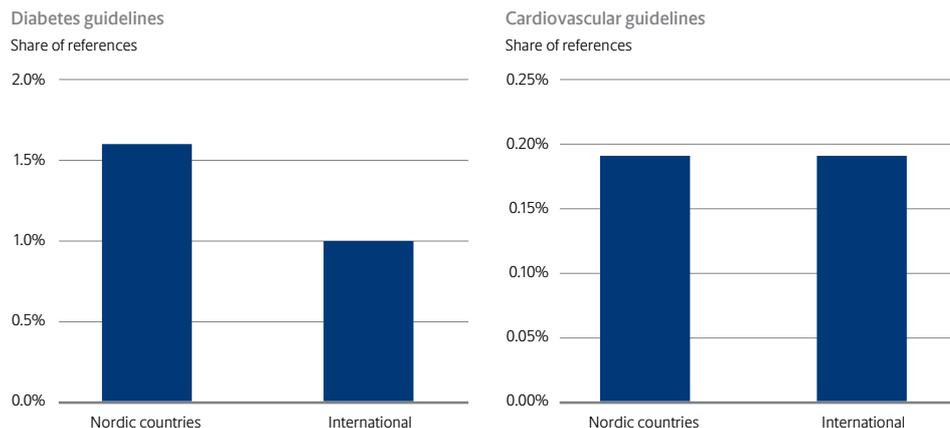
Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics

In diabetes guidelines published in the Nordic countries, 1.6% of all references are to publications by the recipients of Foundation grants, whereas publications by the recipients of Foundation grants cover 1.0% of all references in guidelines with another origin (Figure 4.6).

References to publications from the recipients of Foundation grants cover about 0.2% of all references in both the cardiovascular disease guidelines published in the Nordic countries and guidelines originating elsewhere (Figure 4.6).

Figure 4.6

Grant recipients' share of references to publications, 2000–2016



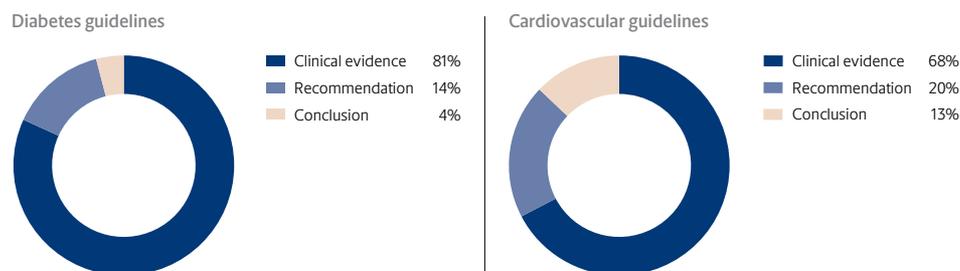
Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics

4.2.3 LOCATION OF REFERENCES IN GUIDELINES

In the guidelines, most of the references to the publications by recipients of Foundation grants are found in relation to clinical evidence. The percentage is 81% for the diabetes guidelines and 68% for the cardiovascular disease guidelines. The rest of the references are part of the recommendations or the conclusion (Figure 4.7).

Figure 4.7

Location of references to publications in guidelines, 2000–2016



Sources: Novo Nordisk Foundation/researchfish® and DAMVAD Analytics

4.2.4 TIME LAG FROM A PROJECT IDEA TO A GUIDELINE REFERENCE

In the diabetes guidelines identified, an average of 5 years has elapsed from the date of publication of the cited research article, to the date of publication of the guideline. In the cardiovascular disease guidelines, the average time lag is 2 years from the time of publication until it is referenced in a guideline. However, studies show that it might take much longer.¹⁶

When a new version of a guideline is published, some references remain. In six diabetes guidelines, 30 publications by the recipients of Foundation grants have been reused as references since 2000, whereas in two cardiovascular disease guidelines, 10 publications by the recipients of Foundation grants have been reused.

4.2.5 BENCHMARKING THE PUBLICATIONS REFERENCED IN GUIDELINES

The data in the following analyses for diabetes cover journal articles with the journal subject categories endocrinology & metabolism and general & internal medicine. These were chosen as out of the categories available they most closely represent 'diabetes' research.

The data in the following analyses for cardiovascular diseases cover journal articles with the journal subject categories cardiac & cardiovascular systems, general & internal medicine and peripheral vascular diseases. Again, these were chosen as out of the categories available they most closely represent 'cardiovascular disease' research.

The analyses are thus based on 121 journal articles of grant recipients which are referenced in the two set of guidelines.

4.2.5.1 THE PROPORTION OF JOURNAL ARTICLES REFERENCED IN THE GUIDELINES

In the diabetes guidelines, the share of total journal articles by the recipients of Foundation grants within the designated journal categories that have been referenced was 3.3% for journal articles in 1990–2014. In the cardiovascular disease guidelines, the share of total journal articles by the recipients of Foundation grants within the designated journal subject categories used as references was 4.7%.

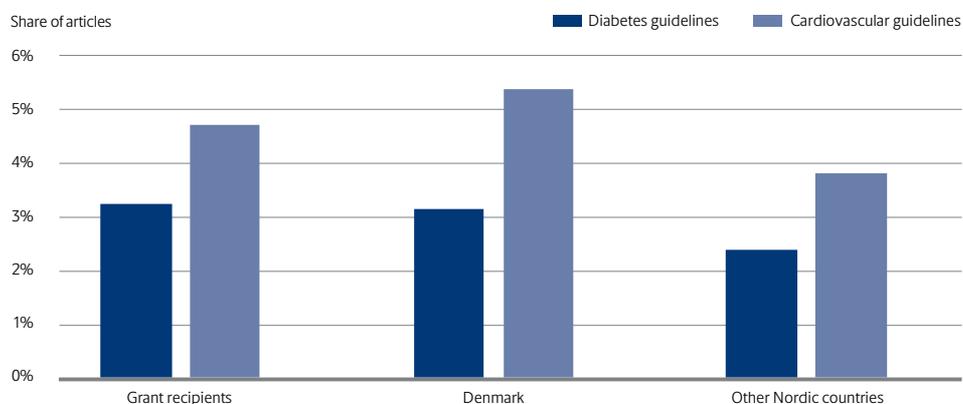
This share of journal articles referenced is higher for the recipients of Foundation grants and for the other researchers in Denmark than for other researchers in the other Nordic countries (Figure 4.8).

Time lag from a project idea to a guideline reference



Figure 4.8

Share of journal articles in guidelines by origin, 1990–2014



Note: Diabetes is covered by the journal subject categories endocrinology & metabolism and general & internal medicine and cardiovascular diseases are covered by cardiac & cardiovascular systems, general & internal medicine and peripheral vascular diseases.

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

4.2.5.2 CITATION IMPACT OF THE JOURNAL ARTICLES REFERENCED IN GUIDELINES

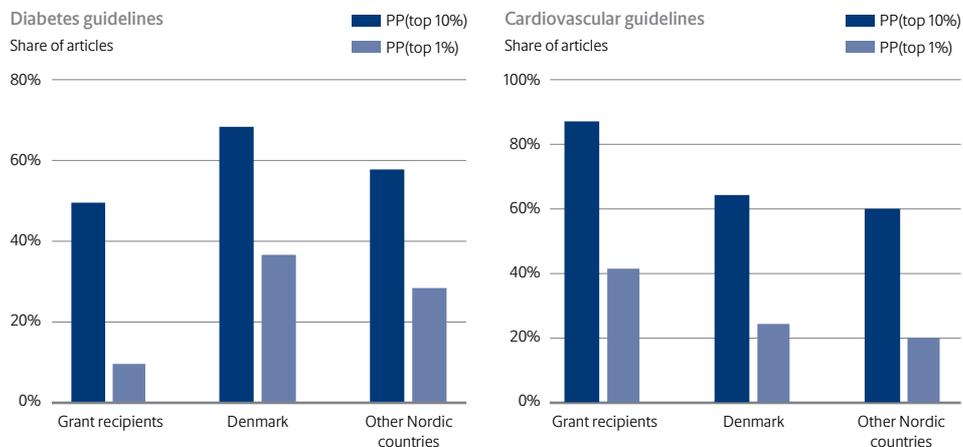
This section presents the citation impact of the journal articles referenced in guidelines. The analysis confirms that the journal articles referenced in the guidelines are high impact publications (i.e. relevant publications in the international research environments) which are generally highly cited.

For journal articles referenced in the diabetes guidelines, the PP(top 10%) for the articles of the recipients of Foundation grants was 50% in 2000–2014 and the PP(top 1%) was 9% (Figure 4.9). The citation impact for referenced journal articles by other researchers in Denmark was higher than for articles by researchers in the other Nordic countries and the recipients of Foundation grants.

For journal articles referenced in the cardiovascular disease guidelines, the PP(top 10%) for articles of the recipients of Foundation grants was 87% in 2000–2014 and the PP(top 1%) was 42% (Figure 4.9). The citation impact for journal articles by the recipients of Foundation grants was higher than for articles by researchers in Denmark or in the other Nordic countries.

Figure 4.9

Citation impact of references by origin - PP(top10%) and PP(top10%), 2000–2014



Note: The number of publications by the recipients of Foundation grants is 121. Diabetes is covered by the journal subject categories endocrinology & metabolism and general & internal medicine and cardiovascular diseases are covered by cardiac & cardiovascular systems, general & internal medicine and peripheral vascular diseases.

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

4.3 DEVELOPMENT OF PRODUCTS AND INTERVENTIONS, AND PATIENT-ORIENTED ACTIVITIES

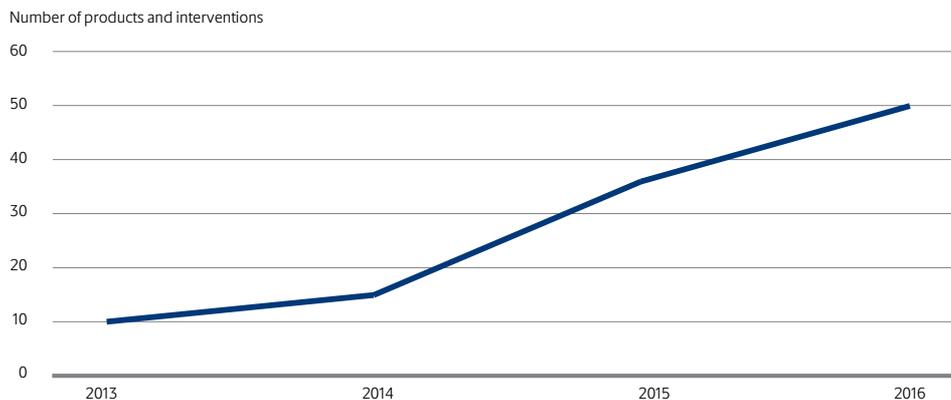
This section focuses on the development of products and engagement activities directed at a wider audience invented and created by the recipients of Foundation grants. Moreover, it focuses on the patient-oriented activities conducted at Steno Diabetes Center.

4.3.1 DEVELOPMENT OF PRODUCTS AND INTERVENTIONS BY GRANT RECIPIENTS

The recipients of Foundation grants report development of medical products and interventions including the development of drugs, medical devices, vaccines, diagnostic tools etc., which also covers clinical trials. The recipients of Foundation grants have reported 40 medical products and interventions based on Foundation grants between 2013 and 2016 (Figure 4.10).

Figure 4.10

Medical products, clinical trials and interventions developed by grant recipients. Cumulative, 2013–2016

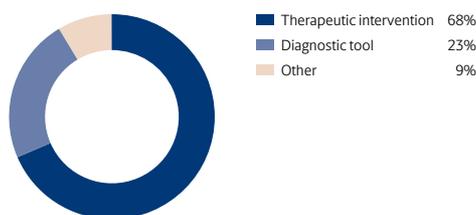


Sources: Novo Nordisk Foundation/researchfish®

Therapeutic interventions comprises 68% of the medical products, interventions and clinical trials, and diagnostic tools comprise 23%. More than 35% of the reported diagnostic tools are imaging tools, which include techniques or processes creating a visual representation of the interior of the body (Figure 4.11).

Figure 4.11

Diagnostic tools, interventions and other activities developed by grant recipients, 2015–2016



Note: The number of medical products, interventions and clinical trials is 35.

Sources: Novo Nordisk Foundation/researchfish*

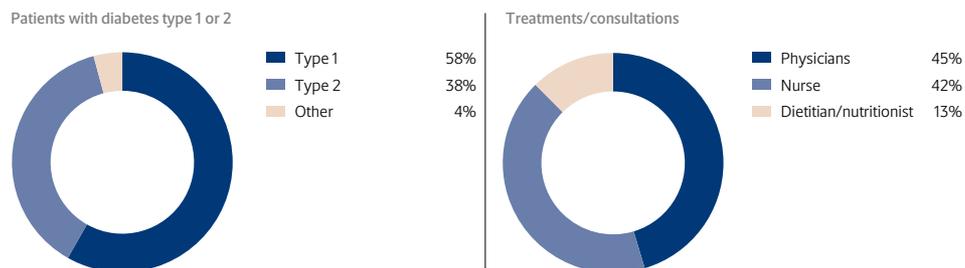
4.3.2 PATIENT-ORIENTED ACTIVITIES AT STENO DIABETES CENTER

Steno Diabetes Center specializes in treatment of diabetes. The activities include endocrinological examination and diagnosis, treatment of diabetes, eye scanning and examination, podiatry, dietary guidance and courses in a food laboratory. Moreover, the Center conducts substantial clinical research activities, health promotion and education within diabetes.

In 2016, Steno Diabetes Center treated 6025 people with diabetes: 58% with type 1 diabetes and 38% with type 2 diabetes (Figure 4.12). The number of patients was 5000–6000 in 2016, and has been at this level steadily during the preceding 10 years. Steno Diabetes Center carried out 26,578 patient consultations in 2016. Physicians carried out almost half the treatments and consultations, and nurses and dietitians the other half (Figure 4.12).

Figure 4.12

Patient-oriented activities at Steno Diabetes Center, 2016



Note: The number of patients with diabetes type 1 and 2 is 6025, and the number of treatments and consultations is 26,578.

Source: Steno Diabetes Center

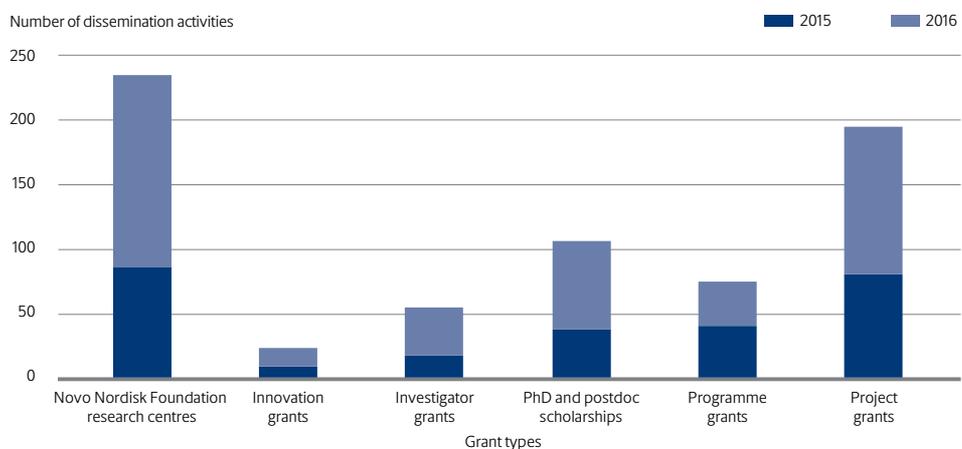
4.4 DISSEMINATION WITHIN THE PUBLIC SECTOR AND PRIMARY/SECONDARY SCHOOLS

Dissemination of knowledge to the public sector (including schools) covers activities that disseminate research results and expertise to a wider audience. The recipients of Foundation grants have conducted 274 public sector dissemination activities in 2015 and 424 in 2016.

The Foundation’s four research centres and the research project grants have reported a higher proportion of the total number of dissemination activities from all recipients. Together they are responsible for more than 62% of all dissemination activities. This high representation is to be expected given the size of the research centres and the number of recipients of Foundation research project grants. Both types of grants support more established researchers who are highly experienced (Figure 4.13).

Figure 4.13

Dissemination activities within the public sector by type of grant, 2015–2016

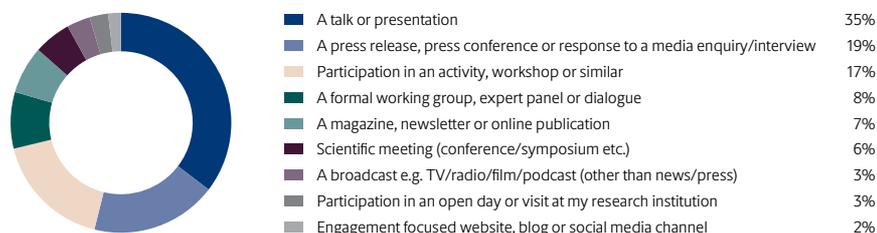


Note: The number of dissemination activities is 695 plus 3 activities not registered by a type of grant.
Sources: Novo Nordisk Foundation/researchfish®

Of the dissemination activities within the public sector in 2015–2016, 52% were presentations/talks and workshops and about 20% were related to press releases or responding to media enquiries (Figure 4.14).

Figure 4.14

Dissemination activities within the public sector, 2015–2016



Note: The number of dissemination activities is 698.
Sources: Nordisk Foundation/researchfish®

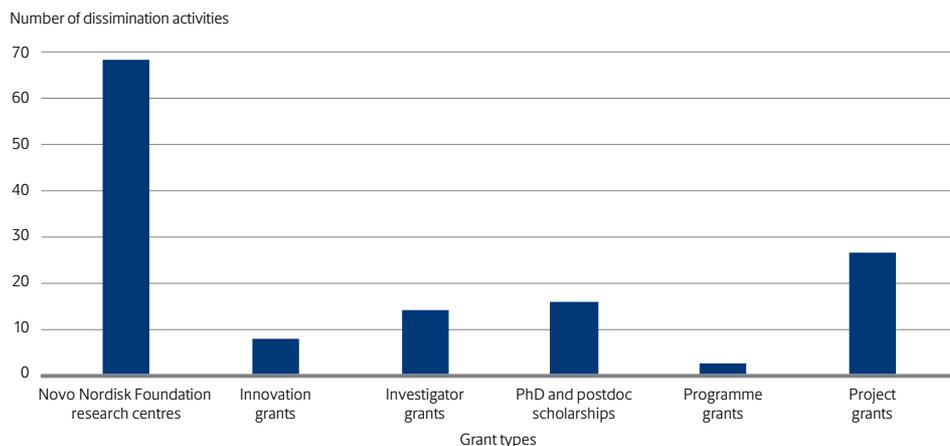
4.4.1 DISSEMINATION TO PRIMARY AND SECONDARY SCHOOL AUDIENCES

Almost 20% of the total dissemination activities in 2015 and 2016 targeted primary and secondary school audiences. The distribution of activities by the type of grant resembles the distribution in the public sector in general.

12% of the activities targeting schools are related to visiting a research institution. Research centres and the recipients of Foundation research project grants combined have more than twice as many dissemination activities as all the other types of grants combined (Figure 4.15).

Figure 4.15

Dissemination activities to school audiences by types of grants, 2015–2016



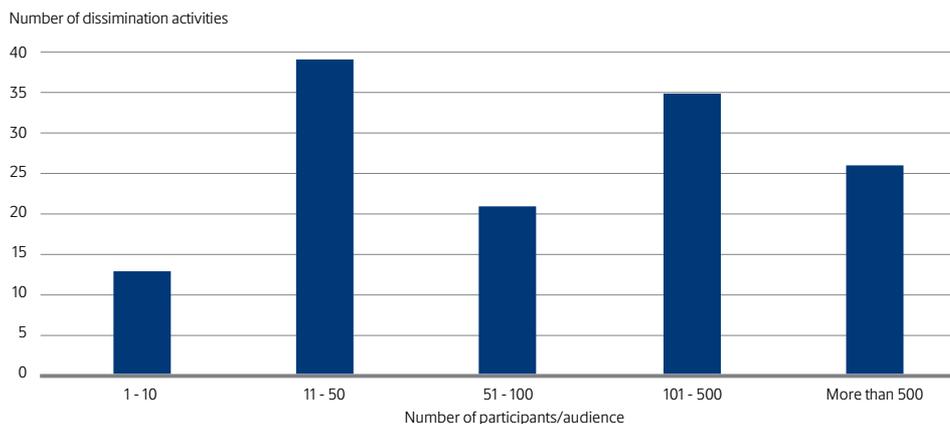
Note: The number of dissemination activities is 134.

Sources: Nordisk Foundation/researchfish®

Almost half the dissemination activities targeting a school audience had more than 100 participants per activity (Figure 4.16).

Figure 4.16

Dissemination activities to school audiences by number of participants, 2015–2016



Note: The number of dissemination activities is 134.

Sources: Nordisk Foundation/researchfish®

Chapter 5

Dissemination and use of knowledge with the private sector

Key findings

- Recipients of Foundation grants collaborated with 95 companies in 2015 compared to 11 companies in 2000
- 60% of the partner companies in research projects and journal articles are non-Nordic
- 157 companies from the biotechnology industry and 64 companies from the pharmaceutical industry collaborated with grants recipients in 2000-2015
- One in 10 journal articles were co-authored by industrial researchers
- 31% of the journal articles co-published with industrial researcher are among the 10% most cited worldwide. 8% are among the 1% most cited
- Grant recipients were part of the creation of 23 spinout companies in 2012-2016

5 DISSEMINATION AND USE OF KNOWLEDGE WITH THE PRIVATE SECTOR

Investing in public research has socioeconomic effects on society. These socioeconomic effects are transmitted through many different channels. Most important, from a societal perspective, is the lasting effect on technological progress – the source of long-term growth and prosperity. Knowledge-driven companies adopting public research produce better products more efficiently.

Academic research and innovation activities, including collaborations between academic researchers and industrial researchers, comprise channels for transmitting public research into the private sector and therefore support globally competitive companies as well as job creation. The literature on the impact of research documents how research improves company-level productivity.¹⁷

The channels through which public research is transmitted to the private sector are difficult to identify and thus analyse. One of the few channels documenting knowledge transfer activities is journal articles co-authored by academia and companies.

Hence, the analysis in this chapter uses journal articles to identify academic–industrial research collaboration where the Foundation funded the academic research activity. Another documented channel is the link between researchers and their spin-outs, which is also shown towards the end of the chapter.

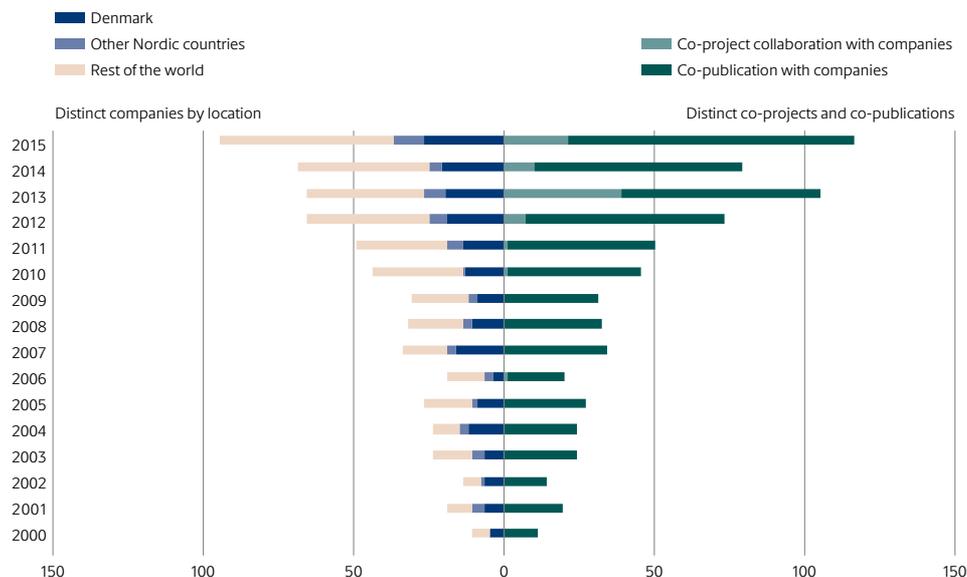
5.1 CHARACTERISTICS OF THE COLLABORATING COMPANIES

This section presents trends in the number of companies collaborating with the recipients of Foundation grants, the industries in which these companies operate, how large they are based on business registry information, and where they are located.

Figure 5.1 presents the progress in the number of companies working with grant recipients (left side), and the number of journal articles by the recipients of Foundation grants co-authored

Figure 5.1

Number of distinct companies, by location, collaborating with grant recipients, and number of distinct collaborations between companies and grant recipients, 2000-2015



Notes: From 2013 and onwards, grant recipients were asked every year to register collaboration projects with industrial partners not resulting in publication in researchfish®, the Foundation’s reporting tool. The large number of collaboration projects in 2013 partly reflects the registration of such projects initiated before 2013. 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 and DAMVAD Analytics

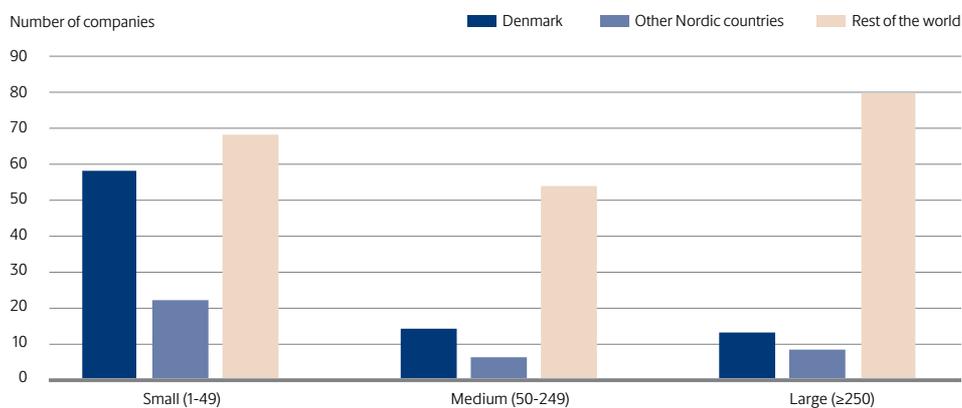
with industrial researchers and, for recent years, the number of unpublicised project-collaborations (right side), which may not develop into journal articles. The number of co-publications between grant recipients and industrial researchers from 2000 to 2015 as well as collaboration projects with private companies have grown vastly. The number of companies collaborating on publicised research increased from 11 in 2000 to 95 in 2015. The increase in collaboration is evident for both Danish companies and non-Danish companies. However, the collaboration with non-Danish companies has grown most.

5.1.1 COLLABORATING COMPANIES BY SIZE AND INDUSTRY

Grant recipients work with primarily small companies in Denmark and mostly with large companies outside of Denmark (Figure 5.2). Sixty percent of the companies involved in grant recipient research projects and co-authoring grant recipient journal articles are outside the Nordic countries.

Figure 5.2

Companies collaborating with recipients of Foundation grants by employment size and location, 2000–2015



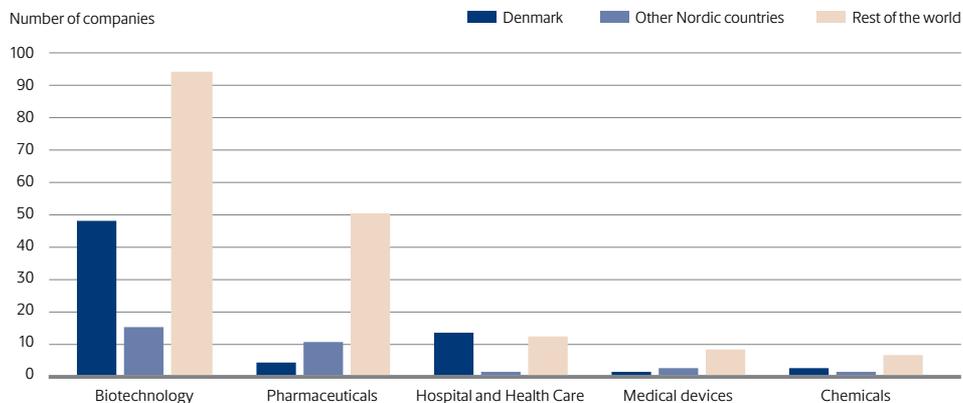
Note: Nationality of companies refers to the country in which a legal entity is registered and located regardless of the nationality of ownership. For example, Novo Nordisk A/S is Danish company, but Novo Nordisk Inc. is a United States company.

Sources: Novo Nordisk Foundation and DAMVAD Analytics

A total of 157 companies from the biotechnology industry and 64 companies from the pharmaceutical industry collaborated with grants recipients in 2000–2015 (Figure 5.3). The Danish companies are primarily within biotechnology and healthcare, and the non-Danish companies are primarily within biotechnology and pharmaceuticals, but some are within medical devices, healthcare and the chemical industry.

Figure 5.3

Companies collaborating with recipients of Foundation grants by industry, 2000–2015



Note: The categories of industries follows the international standard classifications codes.

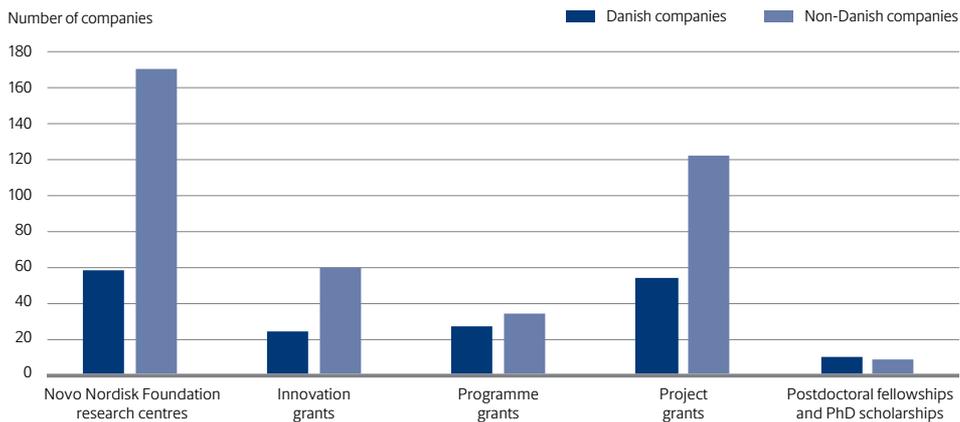
Sources: Novo Nordisk Foundation and DAMVAD Analytics

5.1.2 COLLABORATING COMPANIES BY GRANT TYPES

The Foundation’s research centers collaborate with 228 companies, and the recipients of project grants collaborate with 176 companies. These numbers are much larger than the numbers for recipients of other grant types (Figure 5.4).

Figure 5.4

Companies collaborating with recipients of Foundation grants by types of grants, 2000–2015



Sources: Novo Nordisk Foundation/researchfish®

5.2 RESEARCH PRODUCTION AND THE CITATION IMPACT OF CO-AUTHORED PUBLICATIONS

The data used for the analysis in this chapter cover publication records for grant recipients between 2000 and 2015. Table 5.1 shows that 90.1% of the publications produced are purely academic, whereas 9.9% are co-publications with companies. Slightly more than half of these co-publications were co-authored by Danish industrial researchers only.

Table 5.1

Co-authored journal articles by recipients of Foundation grants according to type of collaboration, 2000–2015

	Number of articles	Share of articles
Total articles based on the Foundation's grants	11,970	100.0%
Purely academic publications	10,783	90.1%
Articles in collaboration with one or more companies	1,187	9.9%
Articles in collaboration with Danish companies only	598	5.0%
Articles in collaboration with non-Danish companies only	518	4.3%
Articles in joint collaboration with both Danish companies and non-Danish companies	71	0.6%

Note: The total number of publications differs from section 2.1 because these data cover a different time period.

Sources: Novo Nordisk Foundation and DAMVAD Analytics

5.2.1 TREND FOR DENMARK AND GRANT RECIPIENTS AND INTERNATIONAL BENCHMARK

Figure 5.5 left panel depicts the industrial co-published journal articles trend in 2-year intervals from 2000 to 2015 for Denmark and for grant recipients. The share of articles co-authored with industrial researchers generally increased until its peak in 2010-2011. In this 2-year period, 15% of the publications by Foundation grant recipients were co-authored with industrial researchers. However, this share was smaller in 2012-2013 and 2014-2015 than in 2010-2011. This applies both to all Danish journal articles and to all journal articles based on Foundation grants, and since 2012-2013, the share has declined significantly. In 2014–2015, the share of publications by grant recipients co-authored by companies was only about 7%, half the share 4 years earlier.

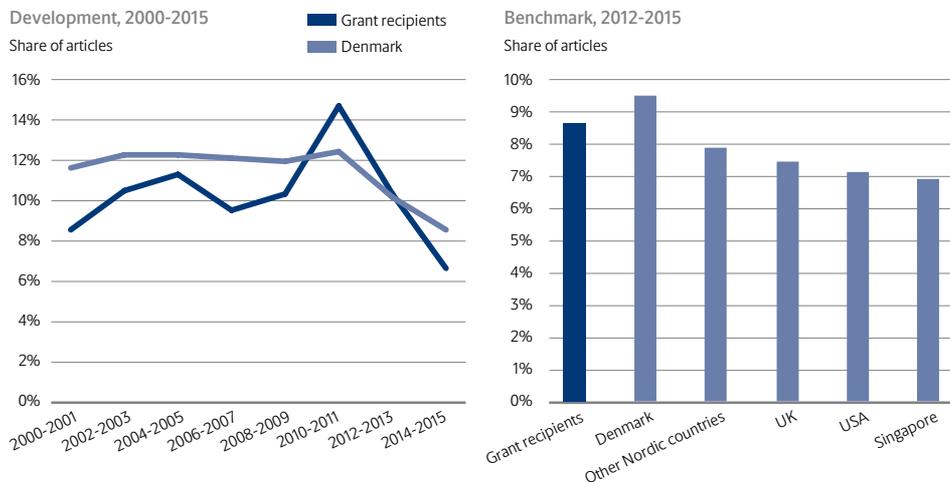
Figure 5.5 right panel shows that the share of publications co-authored with industrial researchers for Denmark is higher than for grant recipients and selected peer countries.

5.2.2 INDUSTRIAL CO-AUTHORED JOURNAL ARTICLES BY SUBJECT CATEGORY

Figure 5.6 shows the number of journal articles by recipients of Foundation grants co-authored with industrial researchers according to the top 15 journal subject categories within the life sciences. Numbers are divided according to location of industrial co-authors. Numbers for Denmark reflect publications without industrial co-authors located outside Denmark. Number for rest of the world can include industrial co-authors located in Denmark, but always include industrial co-authors located outside Denmark.

Figure 5.5

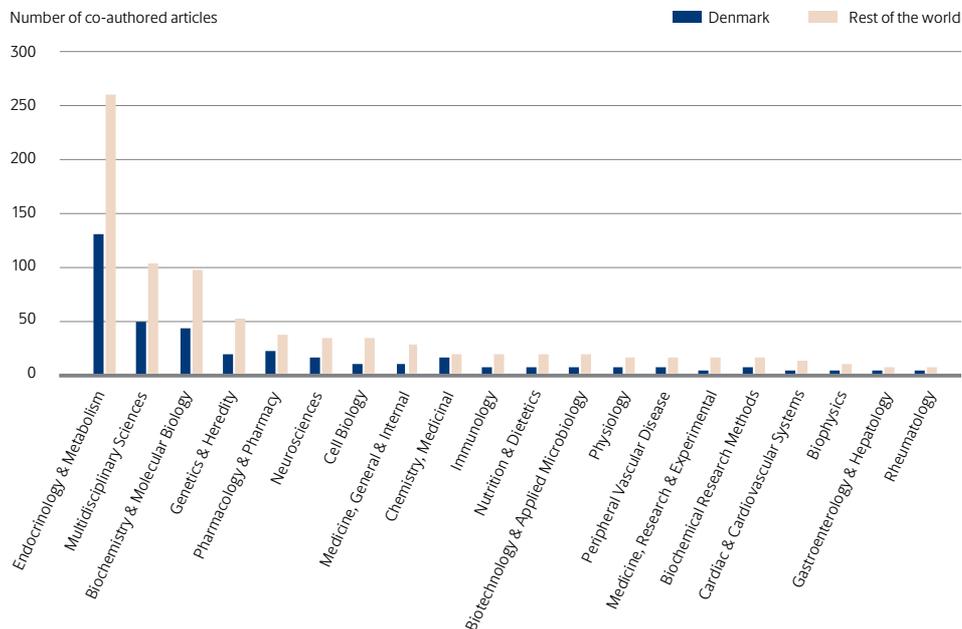
Share of journal articles by recipients of Foundation grants co-authored with industrial researchers



Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Policy

Figure 5.6

Journal articles by grant recipients co-authored with industrial researchers according to location and journal subject category, 2000–2015



Note: Top 20 journal subject categories. A few journals list more than one category.

Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Policy based on the CWTS Leiden Ranking (Web of Science)

Within endocrinology & metabolism, research and industry co-authored a total 393 journal articles distributed on 132 Danish co-publications and 261 non-Danish co-publications. Further, in total 152 articles are registered as multidisciplinary sciences, 142 articles as biochemistry & molecular biology, 70 articles as genetics & heredity and 57 articles as pharmacology & pharmacy.

5.2.3 CITATION IMPACT OF INDUSTRIAL CO-AUTHORED PUBLICATIONS

5.2.3.1 TREND IN CITATION IMPACT

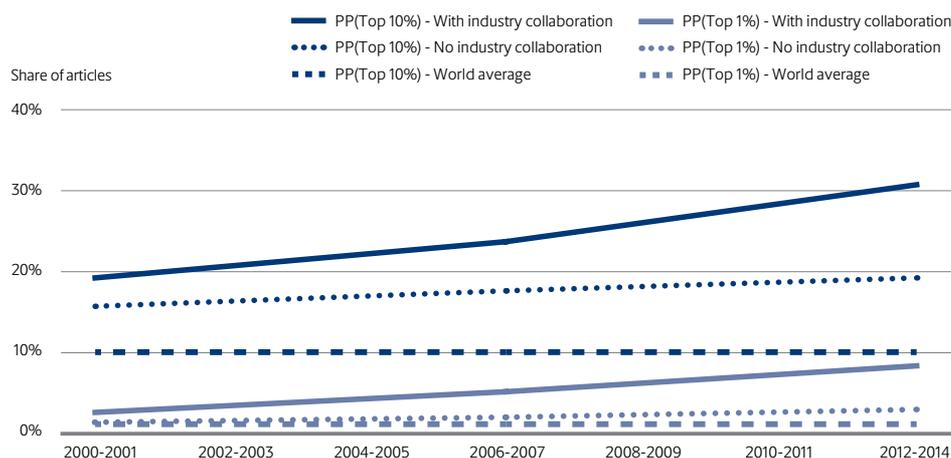
The journal articles based research funded by the Foundation are almost exclusively within life-science research. Figure 5.7 presents the citation impact for journal articles within the life sciences by the recipients of Foundation grants. Publications by grant recipients co-authored with industrial researchers perform very well in international comparison, documenting that research by grant recipients has high citation impact, and that the world-class research is likely to influence the co-authoring companies. However, it should be noted that the industrial collaboration could also increase the impact of the publications.

In 2000–2004, 19% of all co-publications with companies were among the 10% most frequently cited publications globally. That share increased to 31% in 2010–2014, implying that the share rose from a high level by international comparison to a very high level. This increase outperforms the increase for purely academic publications among the 10% most frequently cited publications globally, which grew from 16% to 19%.

Figure 5.7 shows the same pattern within the 1% most frequently cited publications. The share of very frequently cited publications with industrial co-authorship increased from 2% in 2000–2004 to 8% in 2010–2014. Again, publications by grant recipients co-authored with industrial researchers clearly outperform the articles not co-authored with industrial researchers.

Figure 5.7

Citation impact of journal articles by recipients of Foundation grants co-authored with industrial researchers



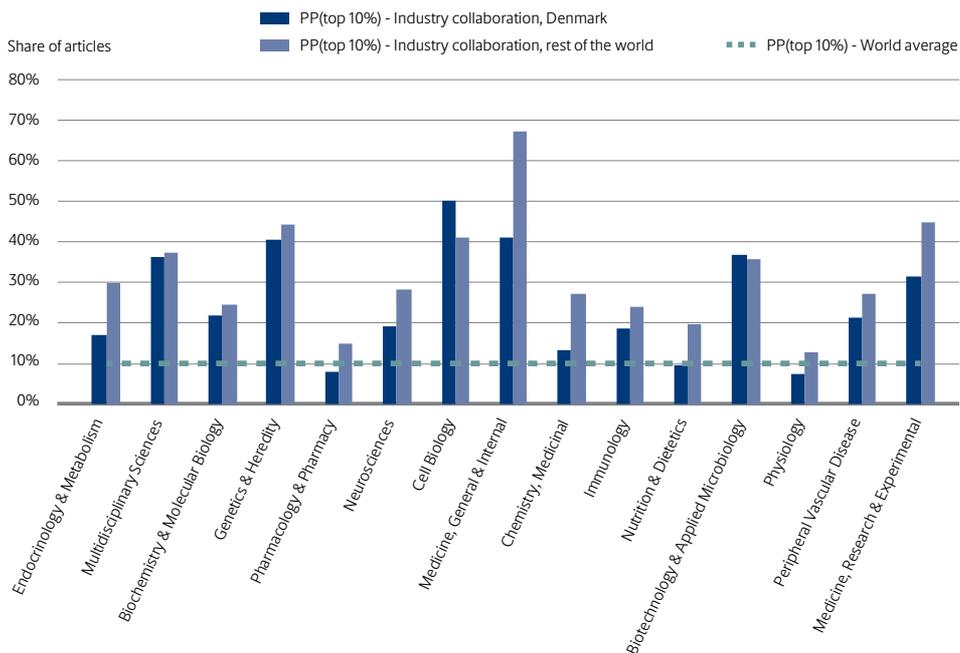
Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Polic

5.2.3.2 IMPACT BY SUBJECT CATEGORY

The citation impact of publications by the recipients of Foundation grants co-authored by industry is strong within several subject categories.¹⁸ Figure 5.8 shows the share of publications co-authored with industrial researchers that are among the 10% most frequently cited publications.

Figure 5.8

Citation impact of journal articles by recipients of Foundation grants co-authored with industrial researchers by subject category, 2000–2014



Note: Top 20 journal subject categories. A few journals list more than one category.

Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Policy based on the CWTS Leiden Ranking (Web of Science)

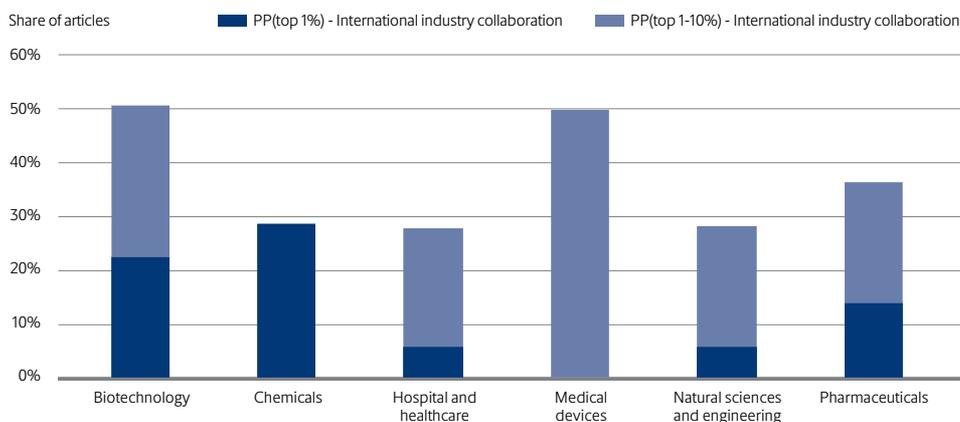
The citation impact across subject categories demonstrates that journal articles co-authored with industrial researchers outside Denmark have the strongest average impact, but collaborations with industrial researchers within Denmark also perform very well.

5.2.3.3 CITATION IMPACT FOR JOURNAL ARTICLES CO-PUBLISHED WITH COMPANIES HEADQUARTERED OUTSIDE DENMARK

The citation impact across industries is quite strong for collaborations with companies outside of Denmark. More than 20% of the journal articles are among the top 1% most frequently cited publications (Figure 5.9). In biotechnology, half the co-publications with non-Danish companies amongst the top 10%, and almost half of these are also among the top 1% most frequently cited. For the chemical industry, publications in the top 10% are exclusively in the top 1%, resulting from a few very highly cited publications.

Figure 5.9

Citation impact of publications by recipients of Foundation grants co-authored with non-Danish companies according to industry, 2000–2014



Note: The categories of industries follows Web of Science.

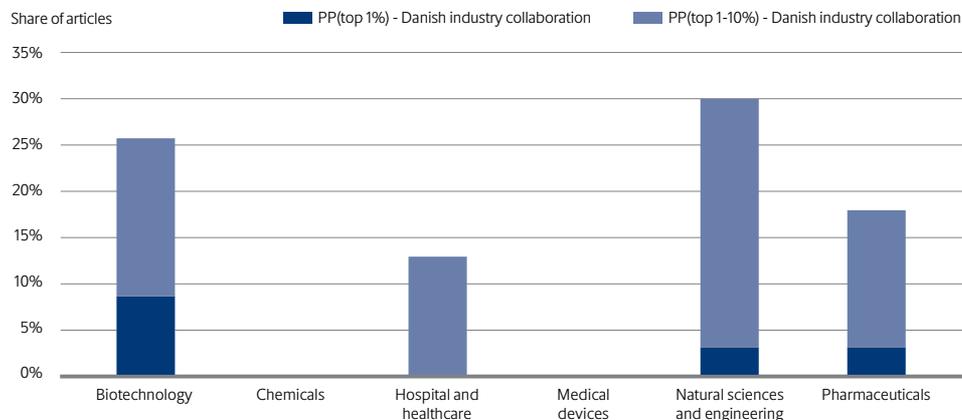
Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Policy calculations based on the CWTS Leiden Ranking (Web of Science)

5.2.3.4 CITATION IMPACT FOR JOURNAL ARTICLES CO-PUBLISHED WITH COMPANIES HEADQUARTERED IN DENMARK

Publications by recipients of Foundation grants co-authored with industrial researchers in Denmark also have high citation impact (Figure 5.10). About 25% of these biotechnology publications are in the top 10%, and 8% are in the top 1%. Within natural sciences and engineering, 30% are in the top 10%, but less than 3% are in the top 1%. About 18% of the publications co-authored with Danish pharmaceutical companies are among the 10% most frequently cited, but this percentage is even higher for non-Danish pharmaceutical companies – 36% among the top 10%.

Figure 5.10

Citation impact of journal articles by recipients of Foundation grants co-authored with Danish companies according to industry, 2000–2014



Note: The categories of industries follows Web of Science.

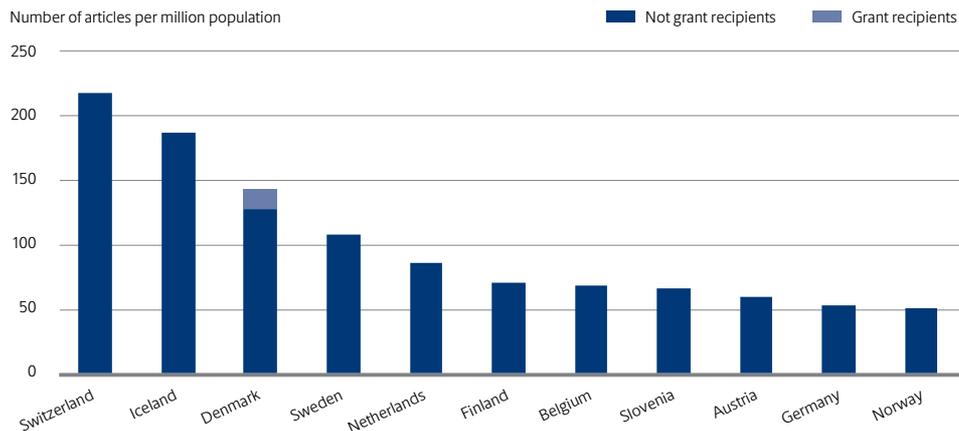
Sources: Novo Nordisk Foundation, DAMVAD Analytics and Danish Centre for Studies in Research and Research Policy calculations based on the CWTS Leiden Ranking (Web of Science)

5.3 BENCHMARK ANALYSIS – RESEARCH-INDUSTRY CO-PUBLISHED JOURNAL ARTICLES PER MILLION POPULATION AND THE CONTRIBUTION OF RECIPIENTS OF FOUNDATION GRANTS

According to the EU’s European Innovation Scoreboard (Figure 5.11), researchers in Denmark produced 143.5 journal articles co-authored with industry in 2015 per million population (including publications by the recipients of Foundation grants). Foundation-funded researchers produced 17 of these per million population. The Foundation therefore accounts for 12% of all publications co-authored with industry in Denmark in 2015.

Figure 5.11

EU’s European Innovation Scoreboard – number of industry journal articles per million population, 2015



Source: EU’s European Innovation Scoreboard

5.4 PUBLIC-PRIVATE COLLABORATION – SPIN-OUTS FROM PUBLIC RESEARCH FUNDED BY THE FOUNDATION

Spin-outs from public research benefit local economic development and create new jobs. Spin-outs often transform the technological inventions developed from public research into goods or services. They frequently lead to public–private collaboration, but these partnerships are different from partnerships with existing more mature companies as they are based on public research. Spin-outs from research institutions are thus destined to foster public–private collaboration and often with the public researcher switching sides or operating in both the private and the public sectors.

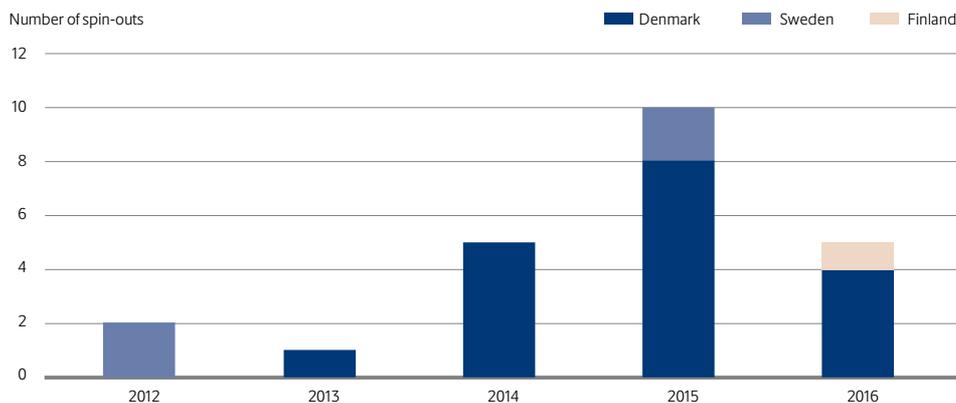
Besides spin-outs, the recipients of Foundation grants have reported the following innovation and commercialization activities having arisen between 2012 and 2016: 47 patent applications and 12 patents, which is 5% of all patents produced by research institutions in Denmark for these years.

5.4.1 SPIN-OUTS FROM PUBLIC RESEARCH FUNDED BY THE FOUNDATION

Since 2012, 23 spin-outs have been created based on research funded by the Foundation (Figure 5.12). The University of Copenhagen and the Technical University of Denmark spin-out most of these companies (Figure 5.13).

Figure 5.12

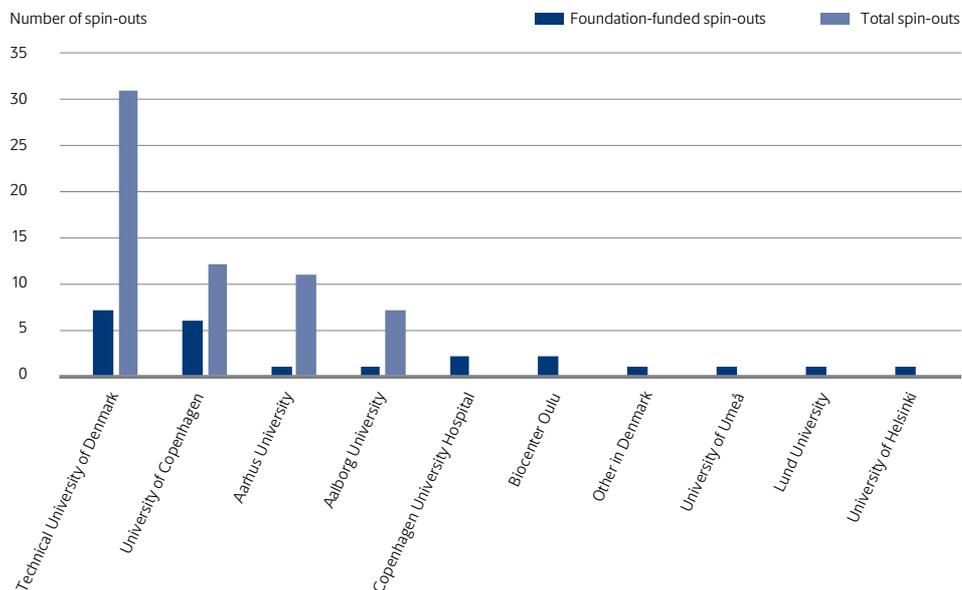
The 23 spin-outs by recipients of Foundation grants by year and country, 2012–2016



Source: Novo Nordisk Foundation

Figure 5.13

Spin-outs by recipients of Foundation grants by host institution, 2012–2016



Note: The total spin-outs were collected only for Danish universities and University hospitals through the Danish commercialization statistics from the Ministry of Higher Education and Science.

Source: Novo Nordisk Foundation and Denmark's Ministry of Higher Education and Science.

5.4.2 SPIN-OUTS IN DENMARK AND THE FOUNDATION-FUNDED SPIN-OUTS

The distribution across universities (Figure 5.13) shows that the Foundation funded research was related to one in five spin-outs at the Technical University of Denmark and 50% for the University of Copenhagen.

5.4.3 THE NOVO NORDISK FOUNDATION INNOVATION GRANTS

The Foundation provides the Nordic countries with access to Exploratory Pre-seed Grants¹⁹ and Pre-seed Grants²⁰ and aims to accelerate the commercialisation of research in biomedicine and biotechnology creating new innovative start-ups within these areas.

The Pre-seed portfolio includes 22 active Pre-seed Grants and seven of those have received investments from Novo Seed.²¹ The Exploratory Pre-seed Grants and Pre-seed Grants are described in Box 5.1.

Box 5.1

The Novo Nordisk Foundation Exploratory Pre-seed Grant and Pre-seed Grant

The Exploratory Pre-seed Grants were established to accelerate the commercialization of biomedical research findings and the development of novel technologies within the life sciences. The goal of Exploratory Pre-seed Grants is to stimulate entrepreneurship, to explore the potential of research findings at a very early stage (pre-seed) and to prepare projects for full Pre-seed Grants later.

The Exploratory Pre-seed Grants seek to support application-oriented research and to test new ideas that may lead to the development of new medical treatments, methods of preventing disease, devices and diagnostic methods as well as new industrial biotechnology. The applicants can be faculty members, researchers and students based at universities, hospitals and other research institutions in the Nordic countries.

The Pre-seed Grants support early-stage applied ground-breaking research that shows commercial potential. These grants are awarded by Novo Seed on behalf of the Novo Nordisk Foundation and given to researchers at universities or medical staff at hospitals with the aim to mature the project for a seed investment.

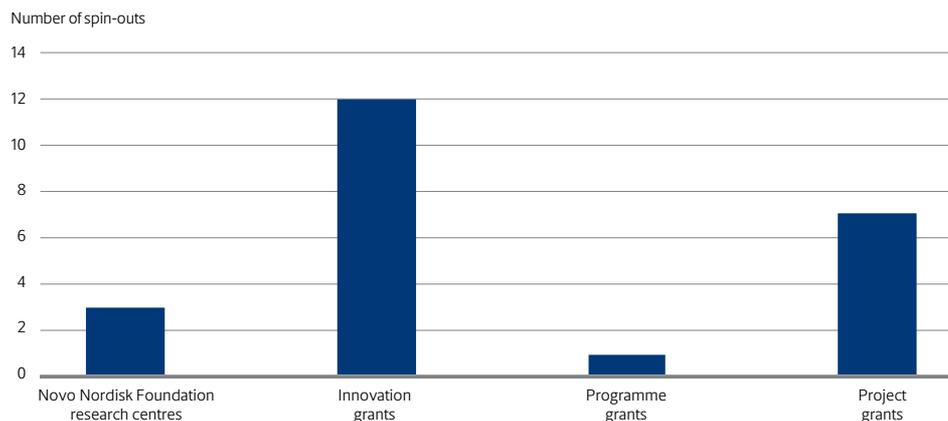
Source: Novo Nordisk Foundation

5.4.4 SPIN-OUTS BY GRANT TYPES

Figure 5.14 shows the spin-outs from grant recipients by types of grants, from 2012 to 2016. Slightly more than 50% are from the recipients of Foundation innovation grants (Exploratory Pre-seed Grant and Pre-seed Grants).

Figure 5.14

Spin-outs by grant types



Source: Novo Nordisk Foundation

Case study

Case study

Hallas-Møller investigator grant recipients

The aim of the Hallas-Møller Investigator grant²² is to strengthen the development of young research leaders within the field of basic biomedical research, but also within wider natural science that are of general importance for the understanding of the human organism. The recipients undertake research at Danish research institutions, and the support from the foundation enables them to establish or expand their research group.

The selection criteria for receiving a Hallas-Møller fellowship is a documented track record as independent scientist and research of an international excellence standard. The applicant must be at the postdoctoral, senior researcher, assistant or associate professor level.

Expectations are that the award will significantly accelerate the development of young research leaders and potential research breakthroughs.

The Novo Nordisk Foundation has awarded the 5-year Hallas-Møller Investigator grant 39 times since 1985, once or twice annually, enabling young researchers to become research leaders within the biosciences and natural sciences. The average success rate since 2009 has been about 7%. So far, 25 projects have been completed, four projects have been terminated prematurely, and ten projects are still in progress.

This chapter studies the career paths and the citation impact of the Hallas-Møller Investigator grant recipients. The study investigates academic promotions within public research institutions and migration to and from the private sector. Further to this, the study examines the citation impact of the research conducted after receiving the grant and summarizes follow on activities such as patenting and entrepreneurship.

HOW MUCH DID THE HALLAS-MØLLER INVESTIGATOR GRANT INFLUENCE THE RECIPIENTS? Several factors influence career paths and choices, and the outcomes presented may not necessarily be attributed to the Hallas-Møller Investigator grant. The question asked in these types of studies of policy impact is if the recipients had not received the Hallas-Møller Investigator grant would they then have found other sources of funding to complete their projects? Another question is the extent to which the activities and outcomes after the grant ended depended on the research carried during the grant period.

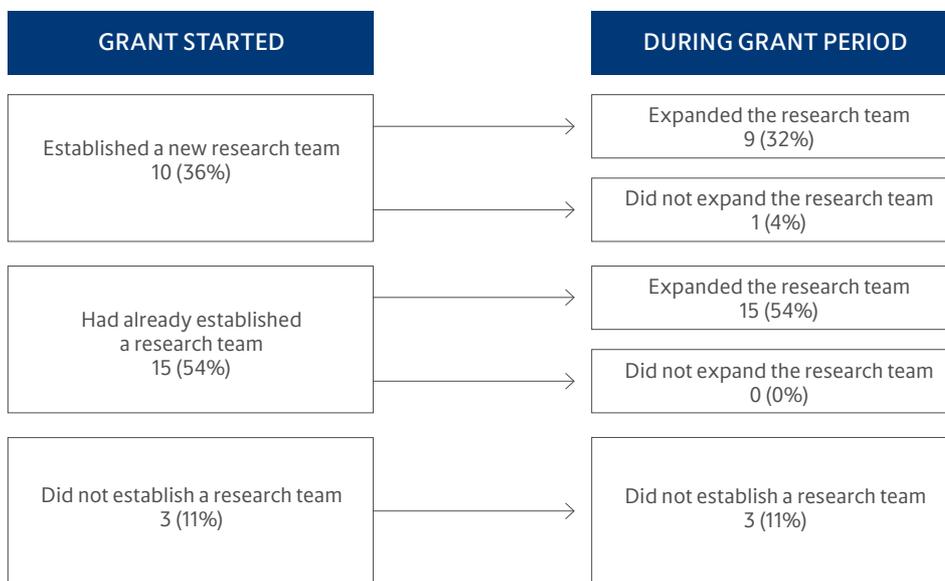
All grant recipients have been approached and asked to complete a survey related to the Hallas Møller grant to complement the already submitted reports. The grant recipients generally responded that the grant was an important or crucial determinant for continuing or establishing a research team. One respondent says:

The Hallas-Møller Investigator fellowship [in the early 2000s, ed.] was definitely a decisive factor in my career development. It provided me an opportunity for immersion without having to worry about teaching obligations or financial issues and opened many doors in academia.

One in three grant recipients established a research team after receiving the grant, and half the grant recipients had already established a research team. Only one of 28 grant recipients who established – or had already established – a research team did not subsequently expand the research team. This means that 87% of the grant recipients responding to the survey expanded their research team during the grant period (Figure 1).

Figure 1

Did recipients of Hallas-Møller Investigator grants already have a research team or did they establish one when the grant started, and did they expand their team during the grant period?



Note: The responses include grant recipients who ended their grant prematurely. One blank response was left out, giving 28 observations.

Source: Novo Nordisk Foundation

GRANT RECIPIENTS AND THEIR CAREER PATHS

Figure 2 shows the mean and range of age of grant recipients (left panel), and the recipients distributed according to job title (right panel) at the time of the award.

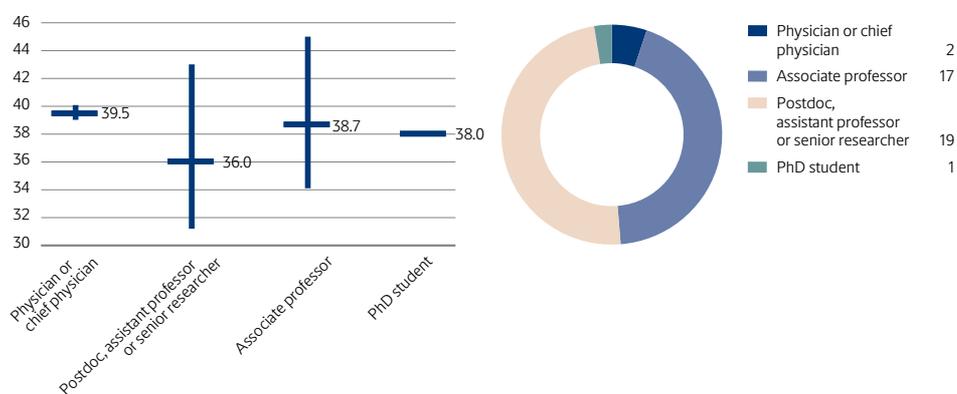
Most recipients were 35–39 years old when the grant was awarded to them. Many grant recipients were already experienced researchers – and had extensive publication records – when they received their Hallas-Møller Investigator grant. Half the recipients were in time-limited positions such as postdoctoral fellowships, assistant professorships or senior researchers; the other half were in tenured positions as associate professors or physicians (or chief physicians). Thus, most of the selected candidates were young researchers that were already independent or well-established associate professors who were granted the opportunity to establish their own research group or extend their existing group. Based on these general characteristics, these researchers would be expected to primarily proceed with academic careers.

Of the 29 projects expected to be completed, 25 have been completed. Four recipients cancelled their projects to pursue different career opportunities. Three of these four researchers went to the private sector (Novo Nordisk A/S and Lundbeck A/S), and one associate professor moved from the University of Copenhagen to pursue a professorship at the University of Southern Denmark in Odense. This promotion to professor came soon after the grant was awarded, emphasizing the quality of the grant recipient.

Six of the 29 recipients pursued private sector careers either during or after their funding period. The rest of the recipients pursued academic careers in the public sector, including two chief physicians at university hospitals, who were eventually appointed clinical professors.

Figure 2

Age and job title when the grant recipients applied for the Hallas-Møller Investigator grant



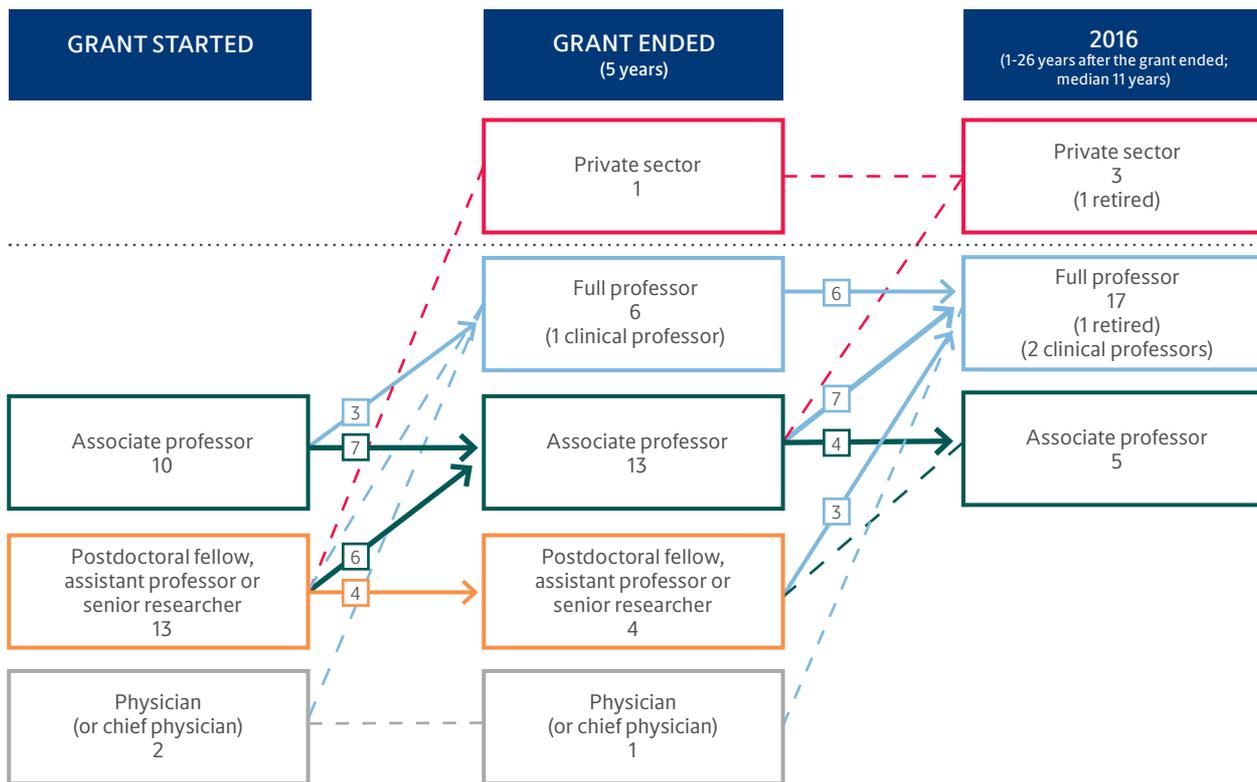
Note: Data covers all 39 grant recipients: 25 have completed their projects, four have abandoned their projects and ten still have an ongoing project.

Source: Novo Nordisk Foundation

Figure 2 (right panel) shows the distribution of 39 grant recipients when they applied for a grant.

Figure 3 then presents a flow chart of the 25 recipients who fully completed their projects. At the start of the grant, 10 recipients were associate professors, 13 assistant professors, postdoctoral fellows or senior researchers, and the last two were physicians (a senior registrar and a chief physician).

Figure 3 Career placement and job titles when the grant started, when the grant ended and in 2016 for the 25 recipients of Foundation grants who completed their grant period



Note: This includes 25 completed projects. Flows of three people or more are numbered, and dotted lines illustrate the smaller flows. Full professors include two clinical professors.

Source: Novo Nordisk Foundation

When the grants ended 5 years later, three associate professors and two assistant professors had become full professors, and a chief physician became a clinical professor.

In 2016, all recipients of completed grants were in permanent positions. As one to two grants were awarded annually since 1985, the time since project completion spans from 6 to 26 years. Three of the five associate professors funded by a Hallas-Møller Investigator grant have finished their research grant within the past 5 years and are thus still relatively young researchers; the remaining two associate professors have not yet attained a full professorship. Half of the professorships were attained 6 years after the grant was awarded.

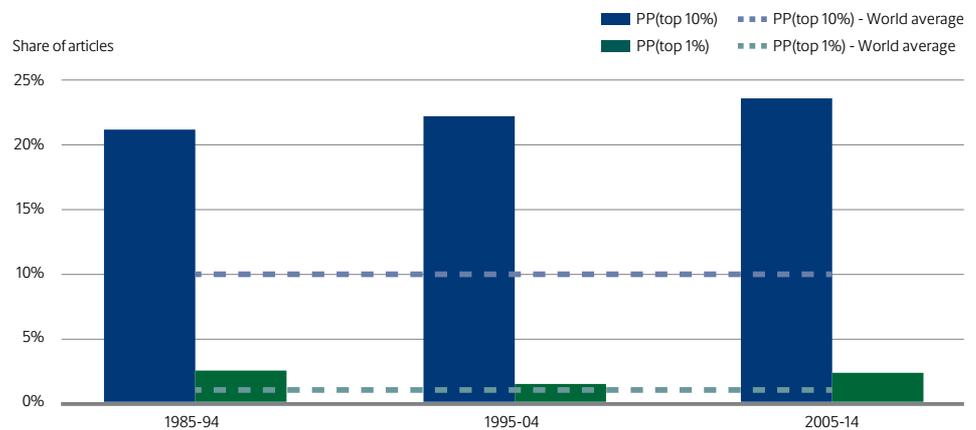
CITATION IMPACT OF THE RESEARCH PERFORMED BY RECIPIENTS OF FOUNDATION GRANTS

The assessment of the citation impact of the research is based on a sample of 1079 journal articles. These journal articles were collected in two ways. First, a sample was constructed containing complete and relevant publication records from 21 grant recipients through a survey and screening. Second, this sup-sample was supplemented with a sample for the remaining recipients by including journal articles collected solely from screening the final project reports.

Figure 4 presents the results of a citation analysis of journal articles by Hallas-Møller Investigator grant recipients. Overall, between 21% and 24% of journal articles are among the world's 10% most frequently cited in their field and 1.5% to 2.5% are among the world's 1% most frequently cited journal articles. Figure 5 shows the journals in which recipients of Hallas-Møller grants most frequent publish.

Figure 4

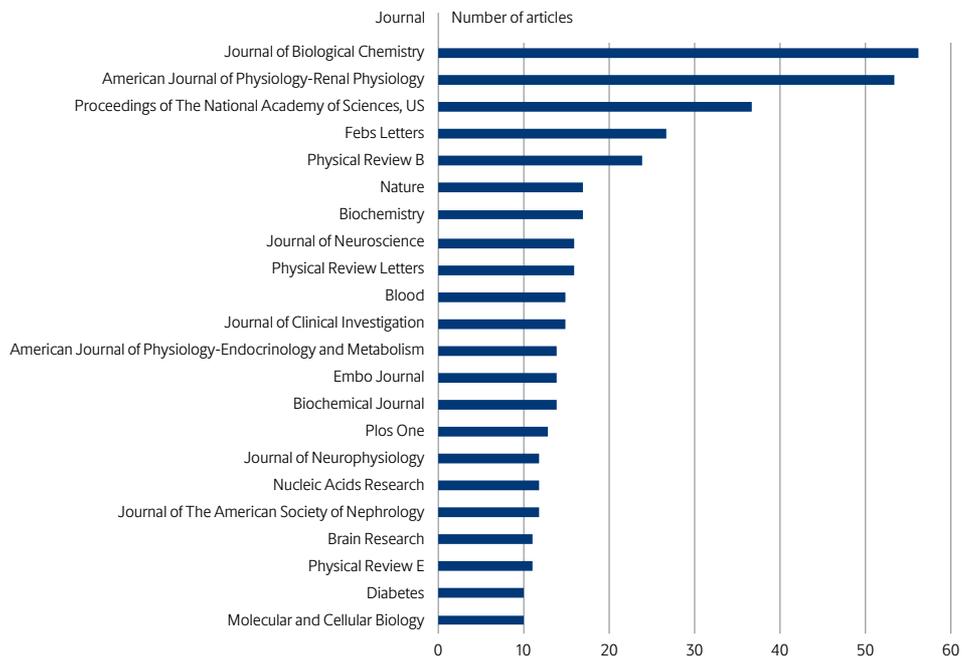
Citation impact of journal articles submitted by Hallas-Møller Investigator grant recipients



Sources: Danish Centre for Studies in Research and Research Policy and Web of Science

Figure 5

The most frequent journals in which recipients of Hallas-Møller Investigator grants publish, 1985–2016



Note: Journal articles included in the analysis have been reported by recipients of grants. For each recipient, the data include journal articles which have been published up to 7 year after start of grant.

Sources: Danish Centre for Studies in Research and Research Policy and Web of Science

COMMERCIALIZATION ACTIVITIES BASED ON HALLAS-MØLLER INVESTIGATOR GRANTS

Although most Hallas-Møller Investigator grant recipients seem to remain in the public sector and pursue academic careers, many recipients have also filed for patents or started companies based on their research. Ten grant recipients filed for patents and/or set up a spin-out after completion of grants. These grant recipients filed more than 50 patents between them.

Among the companies started by the ten grant recipients, at least 11 spin-outs were created based on research supported by the grant. Some of these companies are still active; others have been sold or liquidated for capital gains by investors (Box 1).

Box 1

Some examples of Spin-outs by recipients of a Hallas-Møller Investigator grant

Action Pharma A/S, Borean Pharma A/S, Pantheco A/S and IO Biotech are four examples of companies started by Hallas-Møller Investigator grant recipients:

Borean Pharma A/S – sold to Roche for an estimated DKK 350 million in 2008

Founded by Hans Christian Thøgersen, and one of his colleagues, under the name of Protein Engineering Technology in 1997. This was about 10 years after Hans returned home to Denmark from the United Kingdom to work on a Hallas-Møller Investigator grant which was focussed on using protein engineering technology for basic research.

Eleven years later, the essential activities of the company were sold to Roche for an estimated DKK 350 million.

Action Pharma A/S – sold to Abbot for an estimated DKK 610 million in 2012

Co-founder Søren Nielsen received the Hallas-Møller Investigator grant in 1994 as a 31-year-old assistant professor to carry out research on kidney function. He was appointed a professor at age 34 years in 1997, 2 years before finishing his grant in 1999. He then began the early stages of commercializing his research to develop a drug candidate for reducing the risk of kidney failure, eventually co-founding a company in 2002 and selling the main drug candidate to Abbot 10 years later for about DKK 610 million.

Pantheco A/S – merged with Cureon A/S and became Santaris Pharma A/S and sold to Roche

Another major sale was Pantheco A/S, a company based on PNA-technology aimed at relieving antibiotics failing with resistant bacteria, co-founded in 1998 by Hallas-Møller Investigator grant recipient Peter Eigil Nielsen. It merged with equally sized Cureon A/S in 2003 and became Santaris Pharma A/S. Roche paid DKK 1.4 billion up front for Santaris Pharma in 2014, with another DKK 1.1 billion pending based on performance. The company today is Roche Innovation Center Copenhagen A/S and has more than 50 employees.

IO Biotech – has raised nearly DKK 90 million from investors

Mads Hald Andersen co-founded IO Biotech in 2014 as a spin-out from research performed at Copenhagen University Hospital in Herlev, building on his extensive experience in both clinical cancer research and entrepreneurship. As a senior clinical researcher at the Center for Cancer Immune Therapy at Copenhagen University Hospital in Herlev, he received a Hallas-Møller Investigator grant in 2007 to perform cancer research and subsequently established a research group based on that grant. IO Biotech builds on a cancer vaccine patented and developed by Mads Hald Andersen and colleague Inge Marie Svane. The investors include Novo Seeds, Lundbeckfonden and Sunstone Capital Life Science.

Notes:

¹ The wider societal additionality (societal impact) of the use of knowledge is outside the scope of this report because in-depth analysis of the impact on individual and societal health and welfare requires longitudinal data and control groups, which are not available yet.

² The number of publications used for the analysis in Chapter 2 is 13,859 research journal articles for the period 2000–2016. Chapters 2 and 5 use 11,970 research journal articles for the period 2000–2015 in analysing co-authorship. Chapter 3 uses 9126 research journal articles for the period 2000–2014 in analysing citation impact. Journal articles comprise research journal and review articles.

³ *Forskningsbarometret 2016* [Research barometer 2016]. Copenhagen: Ministry of Higher Education and Science, Denmark; 2017.

⁴ The increase in the number of research journal articles is partly due to a change in submission procedures and reporting system.

⁵ *Forskningsbarometret 2016* [Research barometer 2016]. Copenhagen: Ministry of Higher Education and Science, Denmark; 2017.

⁶ Ibid.

⁷ Denmark ranks number 10 of 29 OECD countries in the number of peer-reviewed research publications per researcher.

⁸ Fractional counting is used to normalize for differences in number of subject categories per publication. A publication counts as one and is divided in the number of designated subject categories.

⁹ In this report, journal articles with co-authors in various national or international academic research institutions are called articles co-authored within academia. No co-authorship means articles with a single author or with authors from the same organization. Publications in which all authors are from different departments within the same organization are registered as articles with no co-authorship.

¹⁰ The recipients of Foundation grants register their activities in researchfish®. However, this registration does not necessarily comprise all collaboration activities and collaboration partners.

¹¹ Under research tools and methods, researchers report new research materials developed as part of their research. The data only capture new research materials that arise as part of the research funded by the Foundation and that make a significant difference to research.

¹² Researchers report on the production of new databases, datasets or models developed as part of their research. The data only captures new databases, datasets or models that makes a significant different to their research. Including is data processing and control systems related to data matching, monitoring, modelling, and grid infrastructure.

¹³ See “*Facts and Results 2016 The Novo Nordisk Foundation Group*”; Novo Nordisk Fonden, April 2017. Link: http://novonordiskfonden.dk/sites/default/files/facts_and_results_2016_uk_final_0.pdf

¹⁴ See section 2.1 for an overview of journal subject categories.

¹⁵ The analysis is based on the publications reported to the Foundation by its grant recipients since 1981. The analysis includes publications from Steno Diabetes Center since this organization has received grants from the Foundation. Some of the Foundations’ other grant recipients at universities or research hospitals have reported publications co-authored with researchers at Steno Diabetes Center in the period. However, a publication co-authored by a researcher from Steno Diabetes Center and by a grant recipient outside Steno Diabetes Center is only measured once in the statistics.

¹⁶ Hanney S a.o.: How long does biomecial research take? BioMed Central; 2015: <https://health-policy-systems.biomedcentral.com/articles/10.1186/1478-4505-13-1>

¹⁷ See *Analysis of the Danish research and innovation system – a compendium of excellent systemic and econometric impact assessments*, Ministry of Higher Education and Science, 2014 and *The economics of research – three socioeconomic impact analyses of investing in research in Denmark*, Novo Nordisk Foundation, 2016.

¹⁸ Publications are tagged according to the Web of Science-defined subject category/categories of the journal of publication.

¹⁹ <http://novonordiskfonden.dk/da/content/>

²⁰ <http://www.novo.dk/seeds/pre-seed-grants>

²¹ <http://www.novo.dk/seeds/about>

²² <http://novonordiskfonden.dk/en/content/hallas-møller-scholarship-denmark>



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ISBN: 978-87-994858-5-7