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A close-up photograph of several green pine needles. Each needle is covered with a clear, glistening water droplet. The background is a soft, out-of-focus light blue and white, suggesting a misty or rainy atmosphere. The lighting is bright, highlighting the texture of the needles and the clarity of the water.

Societal impact of
Novo Nordisk Foundation
Grants 2017





Societal impact of Novo Nordisk Foundation Grants 2017



The Novo Nordisk Foundation
The headquarters in Hellerup



Contents

Introduction	7
--------------	---

Part 1

Funding and production of knowledge	14
--	----

Part 2

Dissemination and use of knowledge within academia	34
---	----

Part 3

Dissemination and use of knowledge within the public sector	64
--	----

Part 4

Dissemination and use of knowledge within the private sector	114
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Introduction

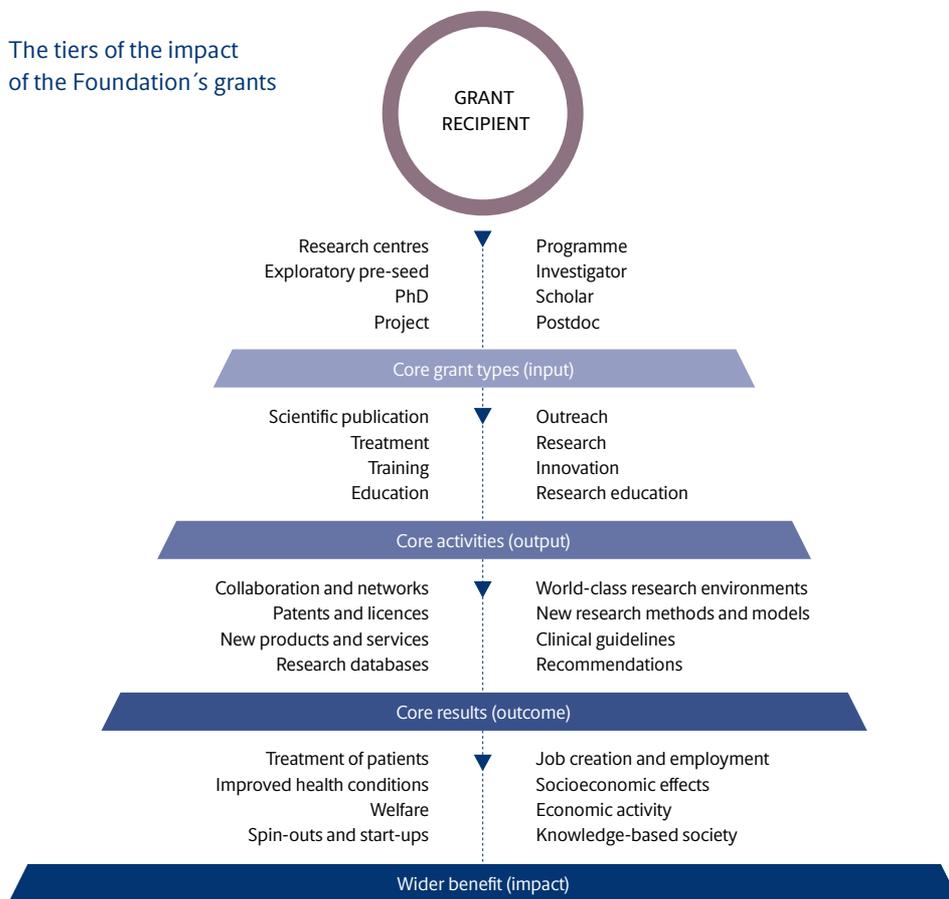
Since 1927, the Novo Nordisk Foundation has awarded grants to research and other scientific purposes at universities and hospitals in Denmark and the other Nordic countries. Today, the Foundation awards grants for research within biomedicine, biotechnology, general practice and family medicine, nursing and art history at public research institutions.

The purpose of the 2017 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 health and welfare of people. It documents the Foundation's input of resources to the scientific communities and the subsequent effects on research-, education-, and health outputs, and collaboration activities between research and industry.

THE ECOSYSTEM FOR THE IMPACT

Core grant types, activities and results represent input, output and outcome indicators that might lead to a wider benefit in the form of individual or societal impact. The following figure shows the impact channels of the Foundation's grants.

The tiers of the impact of the Foundation's grants



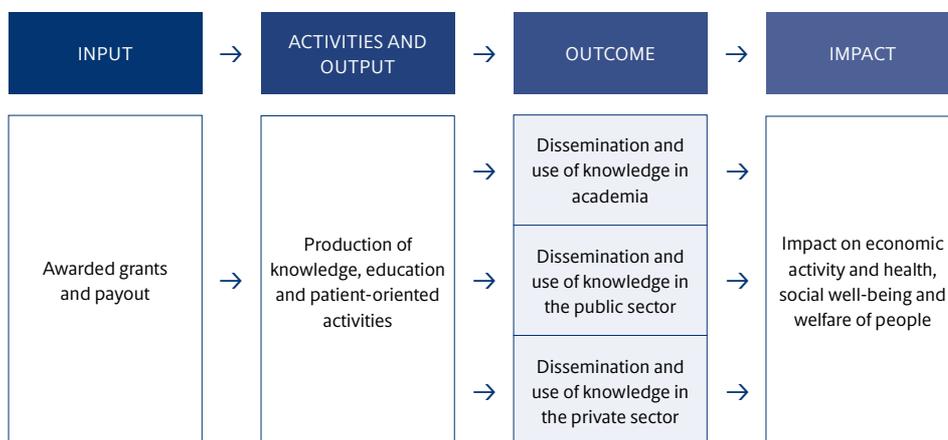
Source: Novo Nordisk Foundation.

THE IMPACT ASSESSMENT APPROACH

Science is a cornerstone in a knowledge-based society, and the focus on the “science of science” is therefore growing, with the need to understand how research works and how impacts are realized. Collecting appropriate evidence of outputs, outcomes and impacts that have arisen and assessing the impact of funding are key parts of the science-of-science agenda. The 2017 impact assessment report measures and communicates on how the Foundation’s activities affect society.

The model below illustrates the impact assessment approach applied in this report. The Foundation’s payouts for research, education, innovation and other purposes lead to the production of knowledge and other activities such as changes to clinical and treatment guidelines, interventions or the development of new research methods, diagnostic tools etc. 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 logic model of impact assessment



Source: Novo Nordisk Foundation.

THE METHOD

This report focuses on payouts, grants and recipients, the production of knowledge and the dissemination and use of knowledge reported for Novo Nordisk Foundation grants. It comprises data series of indicators that the Foundation collects and updates every year. 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 for measuring the impact of research combine quantitative and qualitative data approaches.

Since there are time lags between initiating research activities and the use and impact of research, the 2017 impact report presents trend analyses and single-period benchmark performance, which aggregate some or all the years of information. Trend analyses depict trends and correlations across certain periods of time for input (grants), output (publications and other activities) and outcome (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. The analyses also correlate input and outcome.

The Foundation's impact assessment team prepared the report supported by analytical work from the Danish Centre for Studies in Research and Research Policy, Aarhus University; consulting agency DAMVAD Analytics; the business organization Accelerace at Symbion; the Department of Economics at Copenhagen Business School; the research company Jysk Analyse A/S; and consulting group, COWI.

THE FOUNDATION'S GRANT FOCUS

The size of the Foundation's grants has developed markedly over the years. The average grant amount for a typical research project and research programme has increased more than 10 times since 2000. The Foundation has also introduced a variety of strategic funding instruments such as long-term grants for research centres, investigators and programmes.

The Foundation's Board awards grants mainly in two ways. One way is to award research and innovation grants in open competition. The application process is generally based on a fixed annual cycle in which the funding is advertised together with a call for applications before a specified deadline. These grants supplement government-funded research at universities, hospitals and other non-profit institutions with their own research staff and infrastructure.

The Foundation also awards thematic grants for which the Foundation's Board decides the overall research theme and international experts are responsible for assessing the applications. This enables the Foundation to be fully flexible and ensures that the funding is allocated to effectively support research in accordance with the aims and priorities.

All the grant-awarding methods include peers assessing the case for support. The Foundation has established 16 scientific committees with strongly qualified and internationally recognized scientific experts for assessing the quality, feasibility, novelty and potential of the proposed projects and the applicants' qualifications. Moreover, the Foundation uses international experts in assessing strategic initiatives introduced by the Board.

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. In 2017, the success rate for grants (approval rates of applications) in open competition was 17% in research programmes for Denmark and 20% in programmes for the other Nordic countries.

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 this report should not be ascribed solely to the Foundation's contribution.

Contents

Part 1

Funding and production of knowledge



Chapter 1

How the Foundation contributes to society 16

Chapter 2

Production of knowledge 19

Part 2

Dissemination and use of knowledge within academia



Chapter 3

Dissemination and use of knowledge within academia 36

Chapter 4

Interdisciplinary research collaboration, publications in cross-disciplinary journals and cross-disciplinary citations 52

Part 3

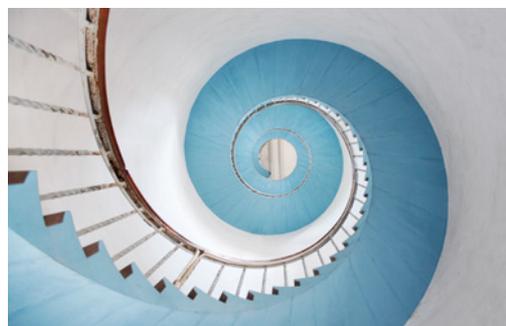
Dissemination and use of knowledge within the public sector



Chapter 5	Dissemination and use of knowledge within the public health sector	67
Chapter 6	Development of products and interventions, and patient-oriented activities	76
Chapter 7	Research-based education, training and knowledge dissemination	81
Chapter 8	Investigating the outcomes and impact of the Clinical Scientist Fellowship	96

Part 4

Dissemination and use of knowledge within the private sector



Chapter 9	Dissemination and use of knowledge in companies collaborating with the recipients of Foundation grants	116
Chapter 10	Dissemination and use of public research in patents	126
Chapter 11	Factors motivating research-active companies to collaborate with grant recipients of the Foundation	133
Chapter 12	Nordic Mentor Network for Entrepreneurship	141

KEY FINDINGS IN PART 1

- In 2017, the Foundation's grants and payouts were the largest in its history, with DKK 5.8 billion awarded in grants and DKK 1.3 billion paid out
- In 2017, almost 2,800 people were supported by Foundation grants (either fully or partly funded)
- More than 7,800 publications arising from research funded by the Foundation were published in 2014–2017. 80% were published in research journals
- The share of publications by grant recipients funded by the Foundation published in journals covering endocrinology and metabolism was 22% in 2008–2012 and 18% in 2013–2017
- More than 70% of the journal articles are co-authored with researchers from other academic institutions; 50% have international academic co-authors and 12% are co-authored with researchers from industry
- The recipients of Foundation grants published about 8% of the total publications with Danish authors in 2016
- 74% of completed research grants reported publications, 55% reported impact on research employment (including PhD students and postdoctoral fellows) and 7% reported creation of products, interventions and clinical trials

Part 1

Funding and production of knowledge



1. HOW THE FOUNDATION CONTRIBUTES TO SOCIETY

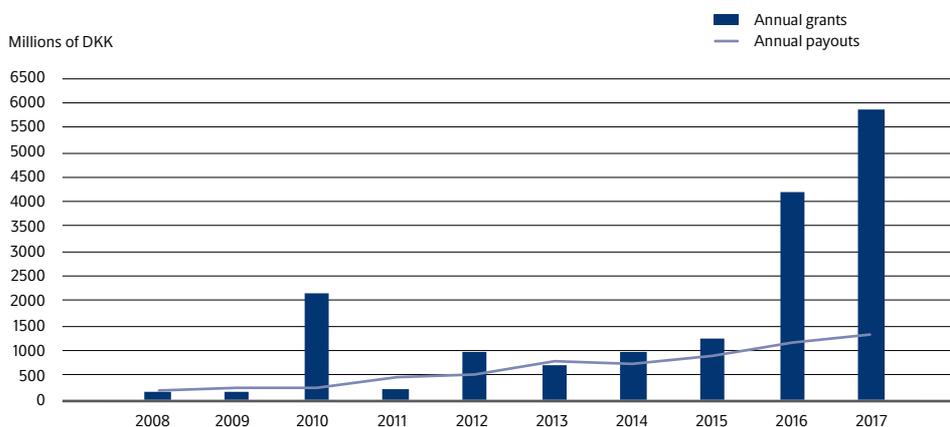
This chapter presents the Foundation's financial contribution to public research. Universities and research hospitals are the main recipients of the grant funding from the Foundation.

1.1 The Foundation's grants and payouts from 2008 to 2017

The Foundation awarded DKK 5.8 billion in grants in 2017 and made payouts of DKK 1.3 billion (Figure 1.1).

Figure 1.1

The Foundation's annual grants and payouts, 2008–2017



Source: Novo Nordisk Foundation.

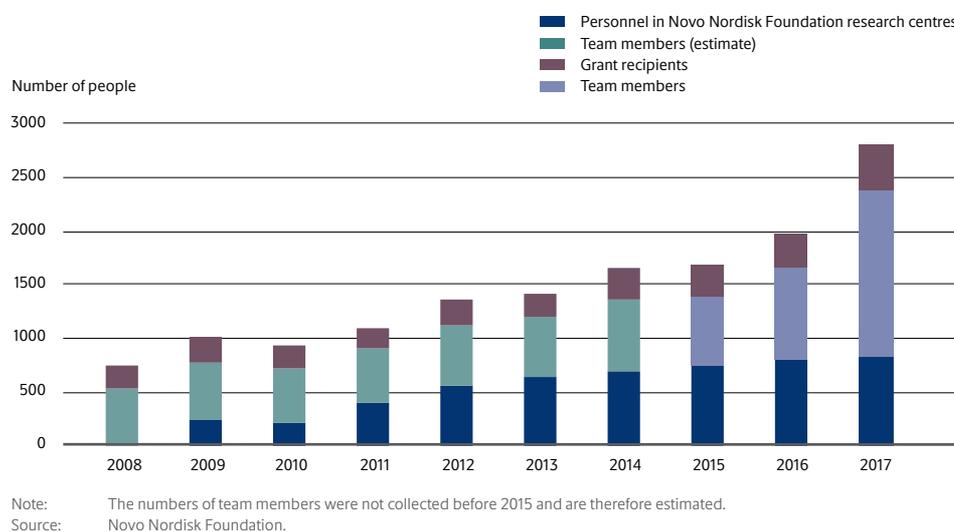
The Foundation awarded 432 grants in 2017. The length and the size of the grants vary. Grant durations vary from a few months (symposia and scholarships) to 6-7 years for research programmes and 10-13 years for large research centres. A few grants comprise a large part of the amount awarded. Grants covered in 2017 span small grants from DKK 40,000 to the largest grant of DKK 1.4 billion. Figure 1.1 covers all grants regardless of duration and size.

1.2 How many people are involved in activities funded by the Foundation?

During 2017, almost 2,800 people were involved in research activities funded by the Foundation grants either fully or partly financed (Figure 1.2). The increase in the number of individuals from 2016 to 2017 comprised some 800 individuals which is substantially more than the steady increase in previous years.

Figure 1.2

Number of people either fully or partly financed by Foundation grants, 2008–2017



1.3 Employment at the Foundation's research centres

In 2017, the Foundation's four research centres employed 814 people of which 529, or 65%, were research personnel and 285, or 35%, were technical and administrative personnel (see upper panel of Figure 1.3).

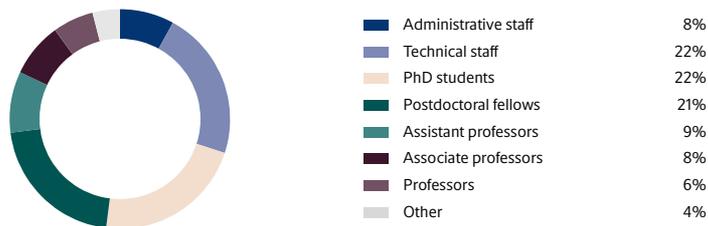
Of the research personnel employed at the Foundation's four research centres, 64% in total were recruited outside Denmark and about 28% were recruited outside the European Union (EU) (Figure 1.3).

Figure 1.3 also shows that PhD students and technical staff comprise the largest personnel group at the Foundation's research centres, followed by postdoctoral fellows and assistant professors.

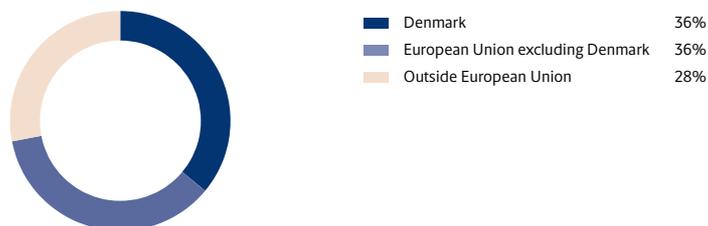
Figure 1.3

All personnel at the Foundation's four research centres and recruitment region for research personnel, 2017

All personnel



Region of recruitment for research staff



Note: Research staff includes: PhD student, Post-doctoral fellow, Assistant professor, Associate professor and Professor.

Source: Novo Nordisk Foundation.

2. PRODUCTION OF KNOWLEDGE

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, with some additional information on the development of new research methods and research databases.

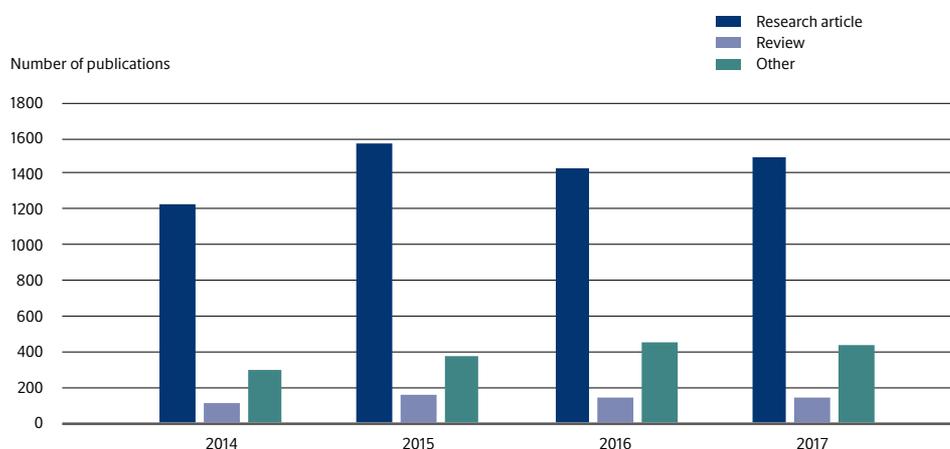
2.1 Production of publications

Since 1927, the recipients of Foundation grants have contributed to the production of more than 20,000 publications; 18,149 have been published since 2000, and 14,429 are journal articles. Since grant recipients typically obtain additional funding, and multiple authors typically contribute to a publication, the Foundation does not exclusively fund all these publications.

Researchers supported by the Foundation are required to report annually on the outputs and outcomes that have arisen from the funded research. They reported 7,840 publications for the period 2014–2017, including 6,283 journal articles (Figure 2.1).

Figure 2.1

Number of publications published by recipients of Foundation grants, 2014–2017



Note: Journal articles comprise research articles and reviews. "Other" comprises policy papers, book chapters, technical reports, letters etc.

Source: Novo Nordisk Foundation/researchfish*.

Of the publications arising from Foundation grants and published from 2014 to 2017, around 80% were journal articles and 20% were other types of publications, such as policy papers, technical reports, letters and book chapters.

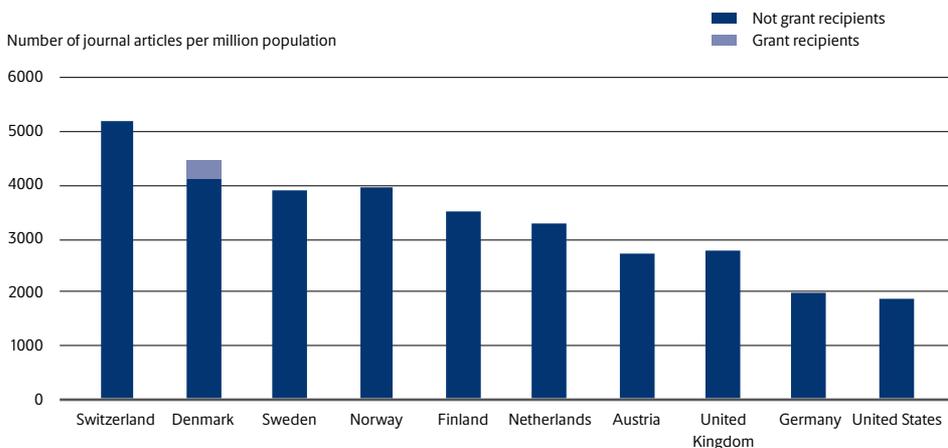
2.2 International benchmark – number of publications per million population

Researchers in Denmark publish more journal articles per million population than researchers do in the United States, United Kingdom, Germany, Finland, Sweden, Norway and most other European countries. Researchers in Switzerland published 5,184 publications per million population compared with 4,493 for Denmark in 2016. The recipients of Foundation grants published what is equivalent to 352 publications per million population, or almost 8% of the total publications from Denmark in 2016.

Denmark produces a high number of publications 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 2.2 benchmarks the number of publications per million population against peer countries. It also shows the share of publications published by the recipients of Foundation grants.

Figure 2.2

Number of publications per million population by country of origin, 2016



Sources: Novo Nordisk Foundation/researchfish® and Scimago Journal and Country Rank.

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

2.3 The 15 most common subject categories for journal articles

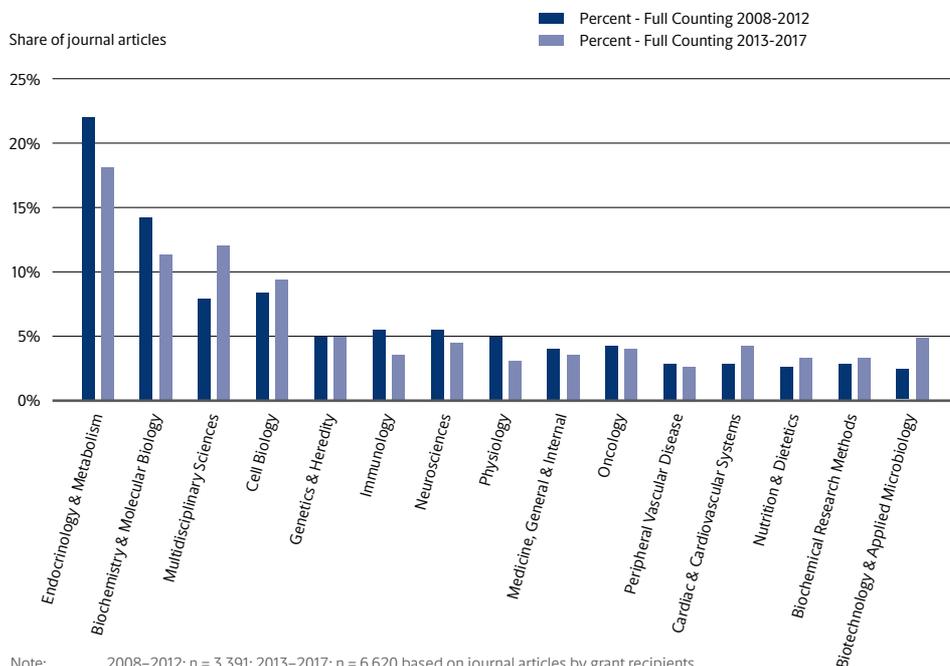
Journal articles are registered in Web of Science according to the subject category assigned to the journal of publication. Figure 2.3 shows the 15 most common subject categories within which the recipients of Foundation grants publish. These most common subject categories include scientific fields mostly within the health and medical sciences, natural sciences and technical sciences.

For the period 2013–2017, the most common journal subject category for grant recipient journal articles is endocrinology & metabolism, with 18% of all journal articles by grant recipients, followed by 13% articles published in journals within multidisciplinary sciences. The multidisciplinary sciences journal articles have thus increased their share by 5 percentage points from 8% in 2008–2012.

Journal articles within multidisciplinary science journals have just surpassed biochemistry & molecular biology in second place from the period 2008–2012 to the period 2013–2017. In the period 2008–2012, journal articles by grant recipients within endocrinology & metabolism and biochemistry & molecular biology comprised 36% of journal articles by grant recipients. In the period 2013–2017, that combined share declined to 30%.

Figure 2.3

Distribution of journal articles by grant recipients published in the 15 most common subject categories, 2008–2012 and 2013–2017



Note: 2008–2012: n = 3,391; 2013–2017: n = 6,620 based on journal articles by grant recipients registered in Web of Science. The figure above shows the 15 most frequently used subject categories.

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 describes the production of co-authored journal articles and the patterns of collaboration of the recipients of Foundation grants.¹

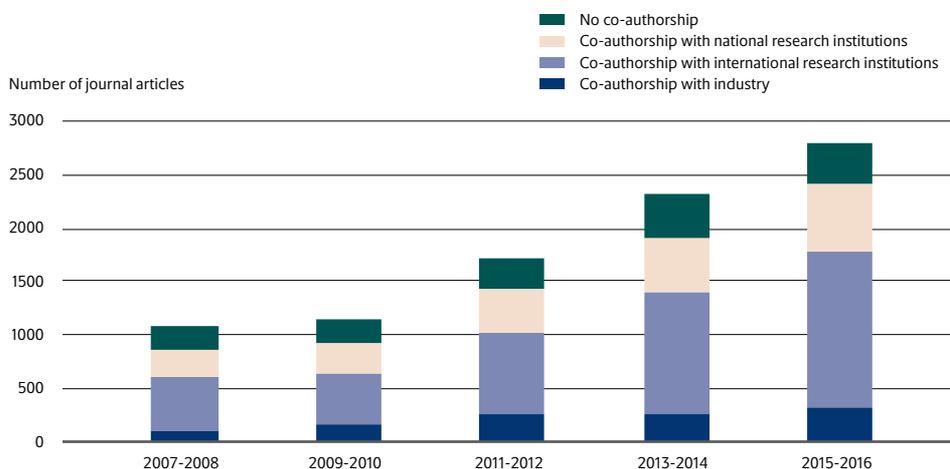
The statistics presented here are divided into three types of co-authored journal articles:

- journal articles co-authored with researchers from national research institutions (academia)
- journal articles co-authored with researchers from international research institutions (academia)
- journal articles co-authored with industrial researchers (companies)

The number of journal articles by the recipients of Foundation grants with co-authorship within academia increased from 757 in 2007–2008 to 2,093 in 2015–2016 (Figure 2.4). This shows that the recipients of Foundation grants increasingly contribute to a collaborative culture at research institutions.

Figure 2.4

Number of journal articles by co-authorship, 2007–2016



Note: The graph is based on journal articles from the Foundation's publication database validated in Web of Science.

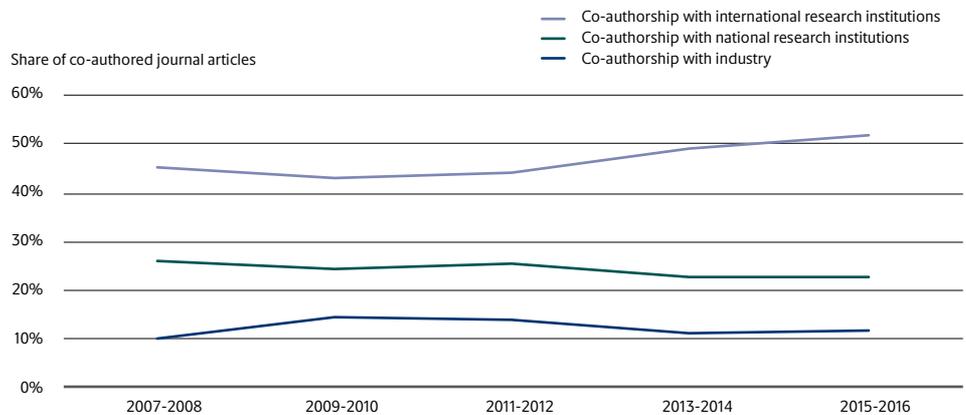
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

¹ 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. Articles in which all authors are from different departments within the same organization are registered as articles with no co-authorship.

Figure 2.5 shows that, even though the number of journal articles with national and international co-authors has increased, the share of journal articles with international co-authors has increased the most.

Figure 2.5

Share of co-authored journal articles within academia with national and international co-authors and industrial co-authors, 2007–2016



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

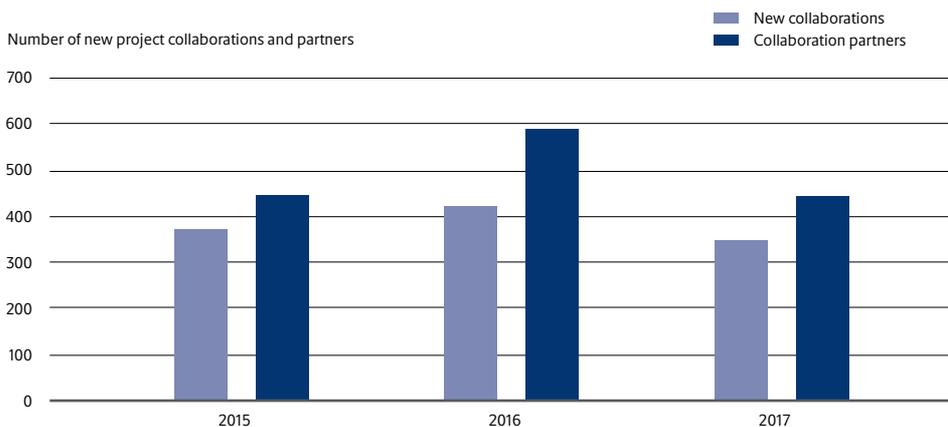
2.5 Research-to-research project collaboration and collaborators

Project collaboration can provide a variety of opportunities for research and cross-disciplinary innovation. The constellation of collaborations can be complex since a single collaboration may involve multiple collaboration partners. These partners may vary as the collaborative activity develops over time.

In 2017, grant recipients reported 348 new collaborations with 443 collaboration partners and 1,431 active collaborations with 1,939 collaboration partners. Active collaborations are defined as ongoing grants where the partnership has not been terminated. Despite of the slowdown in the flow of new collaborations in 2017 compared to the previous year, the total number of active collaborations still increased from 2016 to 2017 (Figures 2.6 and 2.7).

Figure 2.6

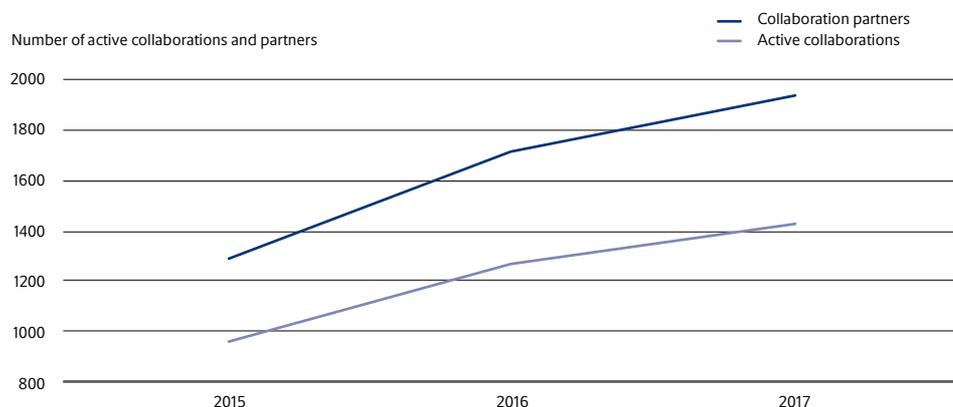
New project collaborations and new collaboration partners, 2015–2017



Source: Novo Nordisk Foundation/researchfish*.

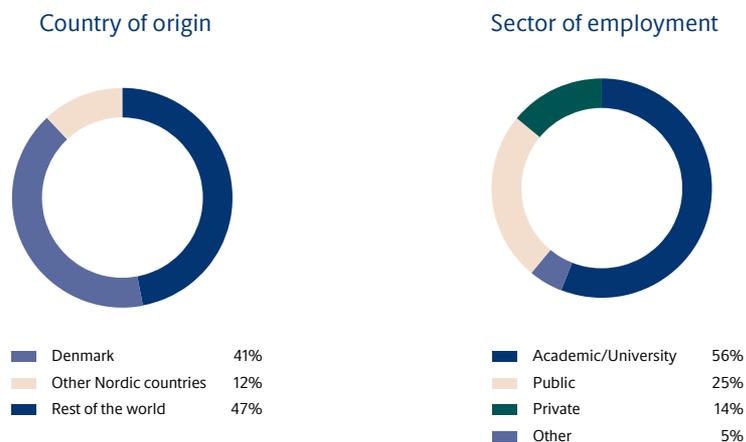
For collaboration partners by country, 41% are from Denmark, 12% from the other Nordic countries and 47% from the rest of the world (Figure 2.8). The largest share of collaboration partners, 56%, comes from the academic sector followed by other public sector institutions. The share of collaboration partners from the private sector is 14%.

Figure 2.7 Active project collaborations and collaboration partners, 2015–2017



Source: Novo Nordisk Foundation/researchfish*.

Figure 2.8 Collaboration partners within active collaborations by country of origin and sector of employment, 2015–2017



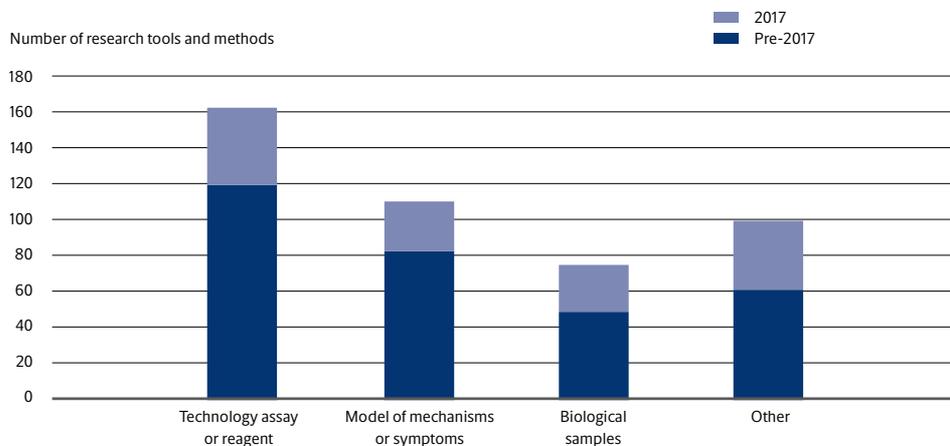
Note: "Other" includes unknown, charity or non-profit and multiple sectors, such as consortiums with partners from various sectors. Number of collaboration partners is 1,939.
 Source: Novo Nordisk Foundation/researchfish*.

2.6 Production of “research tools and methods”, and “research databases and models”

This section presents different types of research activities of the grant recipients, especially those relating to advancing research such as research tools and methods as well as research databases and models.

In 2017, the recipients of Foundation grants produced 135 research tools and methods (Figure 2.9). The main activity has been technology assays and reagents, with 43 activities reported. Assays are analytic procedures for assessing or measuring such substances as metabolites or drugs. Reagents are chemical substances that create reactions in combination with other substances. In addition, 27 models and 26 biological samples were also reported. Many recipients of Foundation grants made their research results available to other researchers. Recipients shared 41% of the research tools and methods with other researchers (Figure 2.10). Almost 55% of biological samples were shared with other researchers.

Figure 2.9 Research tools and methods developed by category, pre-2017–2017

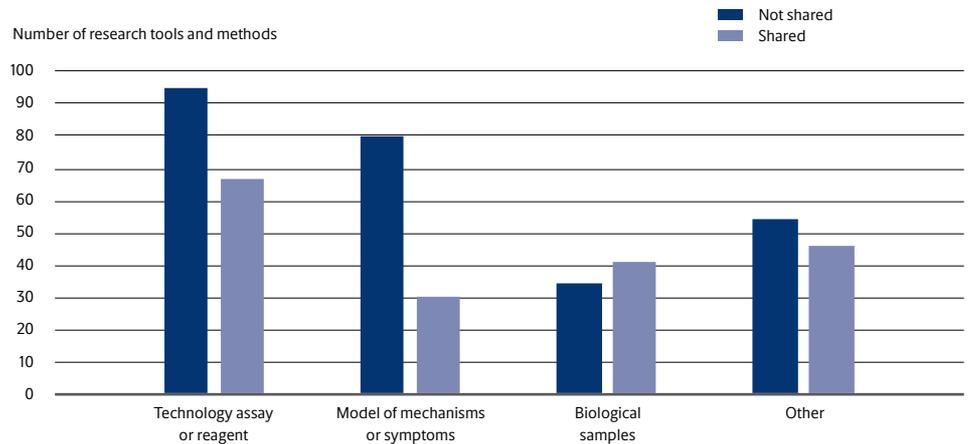


Note: “Other” includes “antibody”, “cell lines”, “improvements of research” and “physiological or outcome measure”. Total number of research tools and methods is 447.

Source: Novo Nordisk Foundation/researchfish*.

Figure 2.10

Research tools and methods shared with other researchers, pre-2017–2017



Note: "Other" includes "antibody", "cell lines", "improvements of research" and "physiological or outcome measure".
Total number of research tools and methods is 447.

Source: Novo Nordisk Foundation/researchfish*.

The following case on the classification and prognostication of colorectal cancer is one of the 27 models of mechanisms of symptoms developed in 2017. Their framework has been published and shared with other researchers, which, as shown in Figure 2.9, is only the case for 30 of the 110 models of mechanisms of symptoms developed throughout all years.

Example:**Classification and prognostification of colorectal cancer**

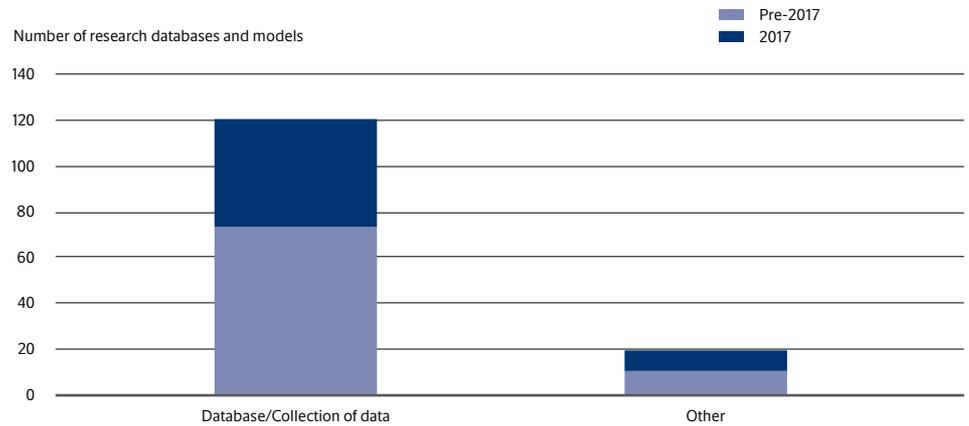
Colorectal cancer is known to have great inter-tumour diversity which means that the cells in the tumors can be very different. Tumours at the same stage can equally be very diverse and unpredictable. Due to this great diversity in colorectal cancer prognosis and response to treatment can be difficult to predict leading to both under- and overtreatment.

The research group under Jesper Bertram Bramsen has found a molecular-subtype-specific biomarker that can be used to improve the prognosis for patients with colorectal cancer. The research group has analysed 1,100 colorectal cancer samples, discovered three different cancer cells and five tumour archetypes and made it possible to find specific subtype-biomarkers. This subtyping-framework and the newly discovered biomarkers can be an important factor in improving the treatment and prognostics for colorectal patients.

There is annually 4,500 new cases and 1,900 deaths of colorectal cancer in Denmark, which accounts for 3.7% of all deaths. The findings are published and thereby other researchers can use the new subtypes-framework in their research.

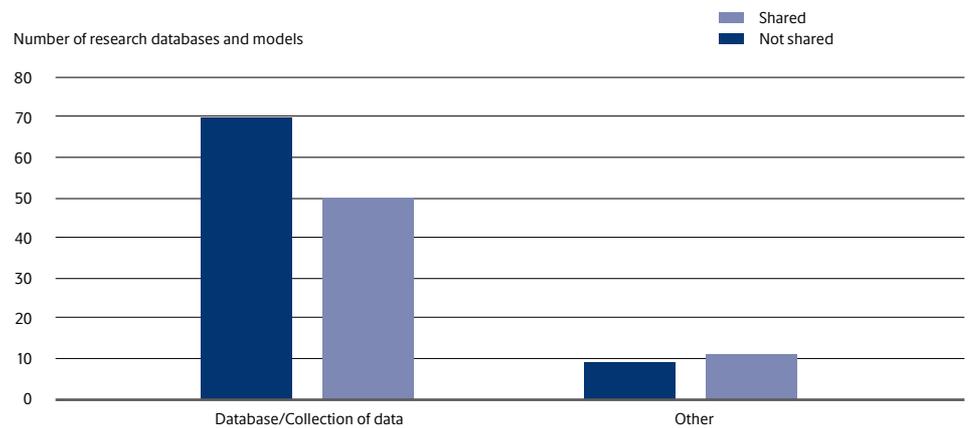
The Foundation has also collected data on activities related to creating research databases and data handling and control. Included are data processing and control systems related to data matching, monitoring, modelling, and grid infrastructure. The recipients of Foundation grants reported 56 activities in 2017; 47 were within the category database and collection of data (Figure 2.11). The databases reported covered a wide variety of subjects and purposes. Recipients shared 44% of the research databases and models with other researchers in 2017 (Figure 2.12).

Figure 2.11 Research databases and models, pre-2017–2017



Note: "Other" consists of "computer model/algorithm", "data analysis technique" and "data handling and control".
The total number of research databases and models is 140.
Source: Novo Nordisk Foundation/researchfish".

Figure 2.12 Research databases and models shared with other researchers



Note: "Other" consists of "computer model/algorithm", "data analysis technique" and "data handling and control".
The total number of research databases and models is 140.
Source: Novo Nordisk Foundation/researchfish".

Example:**A database to give children the best possible future**

The SPOR database has been developed by a grant recipient in 2017. The project has received a grant for humanitarian and social causes and is currently collecting data for the database.

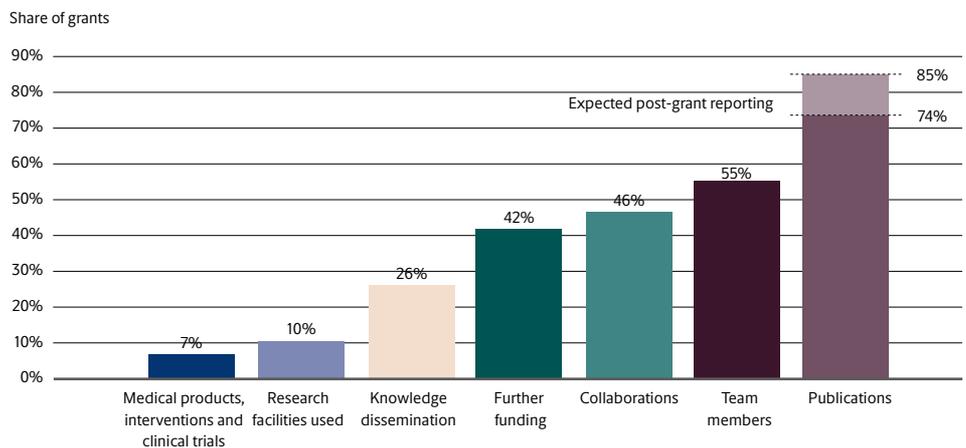
SPOR has been established to enable researchers to investigate children's development and well-being throughout their life. SPOR will connect the effects of early life circumstances on the development and long-term outcomes of 30,000 children in Denmark. The data are based on their parents' responses to a survey, with questions related to the child's socioemotional development, language and parent-child relationships. Further, the database will include information on the children's home environment, their parent's finances, social relations and mental and physical health. Combined, this survey and registry data can be used to uncover causal mechanisms, including the effects of interventions on disadvantaged groups, and thus hopefully create new knowledge that can contribute to giving children the best possible future.

2.7 Reporting of output from research grants

Share of grant recipients reporting output

The previous sections show that the research grants funded by the Foundation support many different types of output. The conventional indicators measuring the output and outcome of research are the volume of publications and the number of citations of publications. However, as shown in Figure 2.13, many grants also have other types of output than scientific articles, such as knowledge dissemination, collaborations, medical products, further funding and more (Figure 2.13).

Figure 2.13 Share of completed grants reporting on output for 2014–2016



Note: Research centre grants are not included.

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

The complementarity and substitution between the output from grants

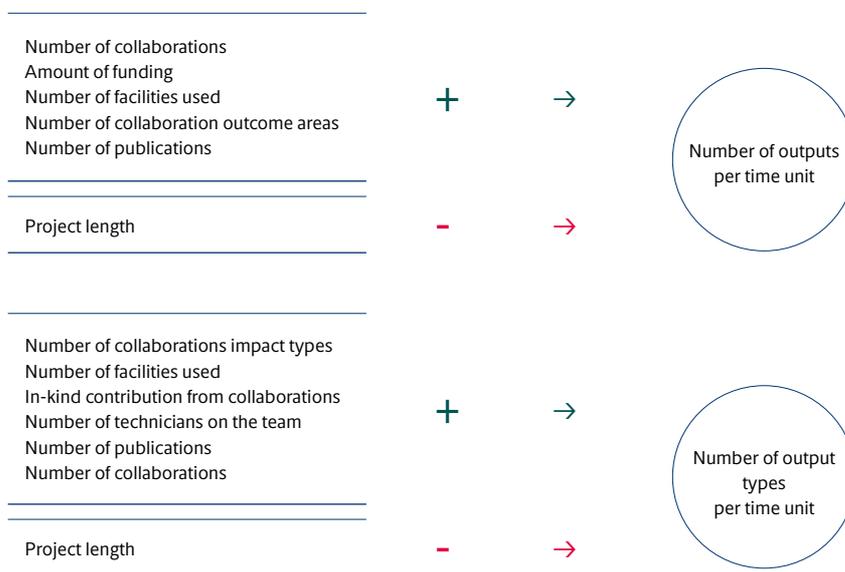
Nearly all research grants deliver scientific articles as well as other types of output. Some types of output (such as further funding) complement other types of output such as international project collaboration. To identify whether publication activity and research activity support or substitute for wider outputs, this section analyses correlations between different types of output in grants. The analysis focuses on identifying combinations of the number of outputs and number of types of outputs in completed grants.

The Foundation measures output per time unit. The overall findings show that several factors correlate positively with the number of and breadth of outputs in research projects. Figure 2.14 illustrates the factors that have a statistically significant impact on outputs.

The main results suggest the following correlations between project characteristics and the numbers of other outputs and the numbers of output types other than publications.

- The number of journal articles generated by the grants correlates positively with the total number of outputs and with the number of different output types. This is in accordance with the idea that publication activity and other types of outputs complement each other.
- The number of facilities is positively correlated with the number and types of outputs.
- Increased collaboration, by different measures, leads to a larger number of outputs and output types per time unit.
- The project length is negatively correlated with the number of outputs per time unit and with the types of output per time unit.

Figure 2.14 Factors correlating with generation of output from completed grants reporting output for 2014–2016



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

The analysis provides insight into the correlations (complementarity or substitution) between number of outputs and the number of different types of output. The analysis does not provide knowledge about the relation between the quantity and quality of the output. Further analysis should focus on a conceptual model for understanding causal or simultaneous relations and ordering the types of outputs according to, for example, closeness to the research activity, and characteristics versus the underlying substantiality of the activity leading to an observed output.

Methods and data

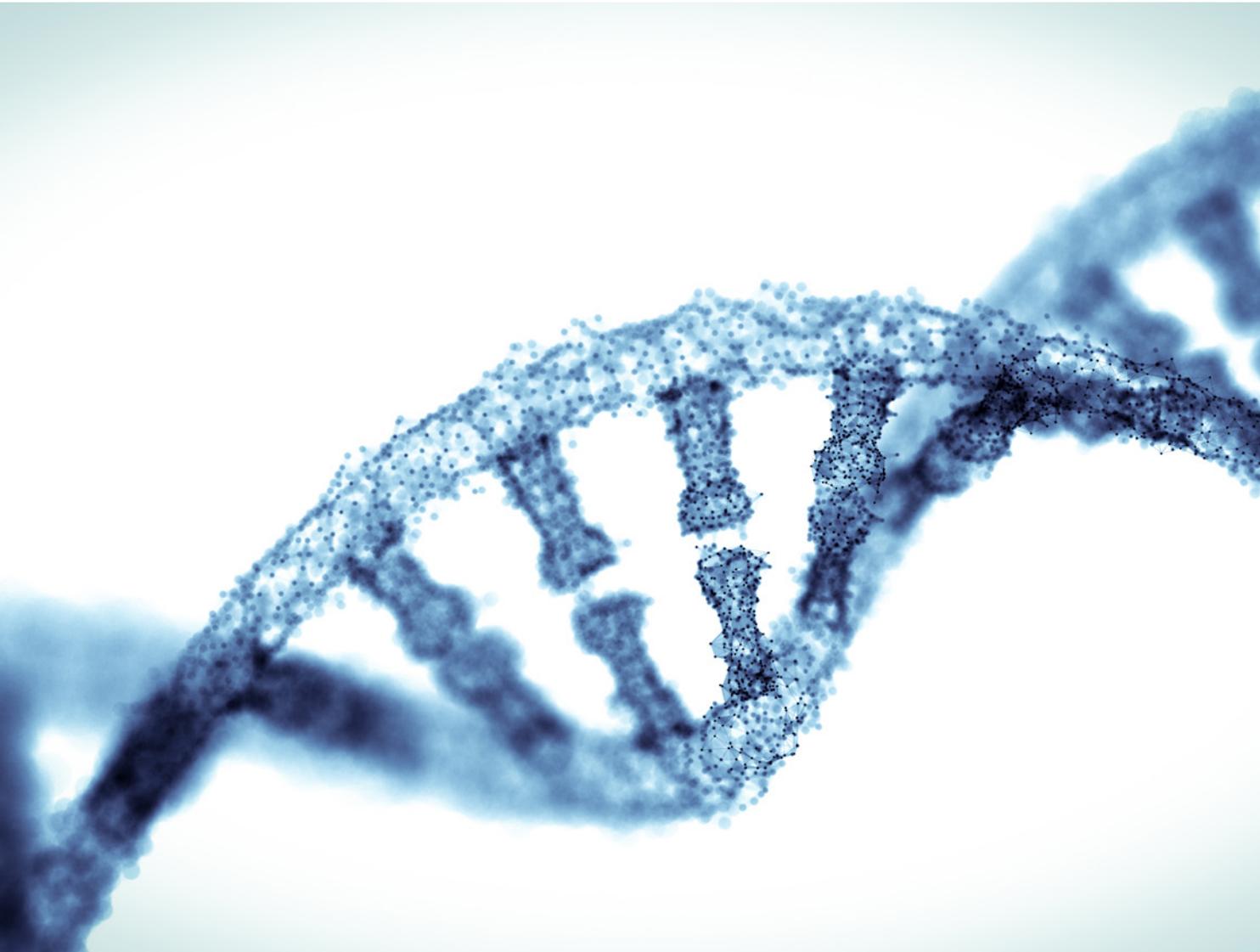
Findings are based on output data reported by the Foundation's grant recipients in the researchfish® reporting system. The data are reported output for 2014–2016 from 628 completed grants. There are more types of output than shown in Figure 2.14, but the output data from the analysed grants regarding such types as spin-outs and patents are still too sparse to draw any statistically significant conclusions. The regression model in the analysis was established through an iterative selection approach based on the Bayesian information criterion (BIC). This excludes each input variable that cannot explain enough of the remaining variance in the output variable considering the already included explanatory variables from the model. The resulting model is thus optimal with respect to the BIC and contains only the best-fitting explanatory variables, considering all the other variables.

KEY FINDINGS IN PART 2

- Distribution of journal articles reported by grant recipients according to citation impact:
 - 22% are among the 10% most frequently cited worldwide in 2013–2015
 - 3.7% are among the 1% most frequently cited worldwide in 2013–2015
- Distribution of internationally co-authored journal articles by grant recipients according to citation impact:
 - 27% are among the 10% most frequently cited worldwide in 2013–2015
- The Foundation's four research centres:
 - 36% of their journal articles are among the 10% most frequently cited worldwide in 2000–2015
 - 10% of their journal articles are among the 1% most frequently cited worldwide in 2000–2015
- Share of grants delivering articles in PP(top 10%):
 - 69% of the Foundation's open competition grants deliver at least one journal article among the most frequently cited worldwide in 2013–2015
- Interdisciplinary collaboration:
 - Two of three journal articles involve co-authors from at least two different fields of science
- Mono- and cross-disciplinary journals:
 - 20% of the journal articles by grant recipients are published in cross-disciplinary journals

Part 2

Dissemination and use of
knowledge within academia



3. DISSEMINATION AND USE OF KNOWLEDGE WITHIN ACADEMIA

This chapter focuses on disseminating and using knowledge within academia – according to the citation impact of research articles and reviews (journal articles) by the recipients of Foundation grants. The citation impact is measured by how often a researcher’s journal articles are cited. This does not necessarily measure the journal article’s quality, but a citation score indicates the relevance of a journal article to other researchers, and is therefore interpreted and used as a basis for other researchers’ work.

3.1 Trends in citation impact for journal articles reported by grant recipients within all sciences

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 2007–2015, excluding journal articles from 2016 and 2017 to allow for lag in citations, since 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 18–24 months citation lag. The analysis includes the journal articles reported by the recipients of Foundation grants that can be found in Web of Science.

The citation impact of the articles by grant recipients is well above the world average. Starting at a lower level in 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 3.5% of all journal articles are among the 1% most frequently cited journal articles for 2013–2015 (PP(top 1%)) (Figure 3.1).

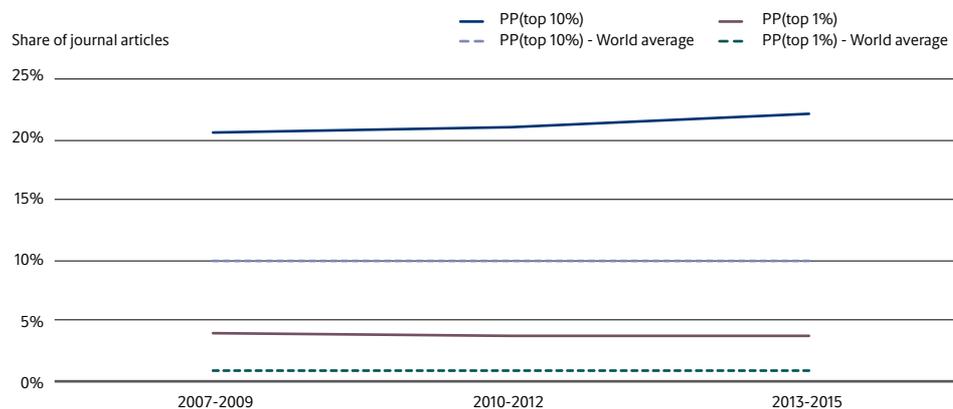
Selection bias in reported journal articles?

An analysis of journal articles by grant recipients within clinical and basic biomedical research receiving Foundation funding in 1997–2015 showed that citation impact of the journal articles reported did not exceed the citation impact of other journal articles produced by those same grant recipients.

Figure 3.1 presents the joint share of research articles and reviews among the 10% most frequently cited worldwide. However, the citation impact differs between research articles and reviews reported by grant recipients. Figure 3.2 therefore shows the shares of research articles and reviews separately. Of all reviews reported by grant recipients, 41% are among the 10% most frequently cited reviews worldwide. The share of the research articles reported by grant recipients among the 10% most frequently cited reviews worldwide is 19%. Altogether, 21% of reviews and research articles are in top 10% most frequently cited. As presented in Figure 2.1, reviews constitute a minor share of journal articles, which is why the share for journal articles (research articles and reviews combined) gravitates towards the share for research articles.

Figure 3.1

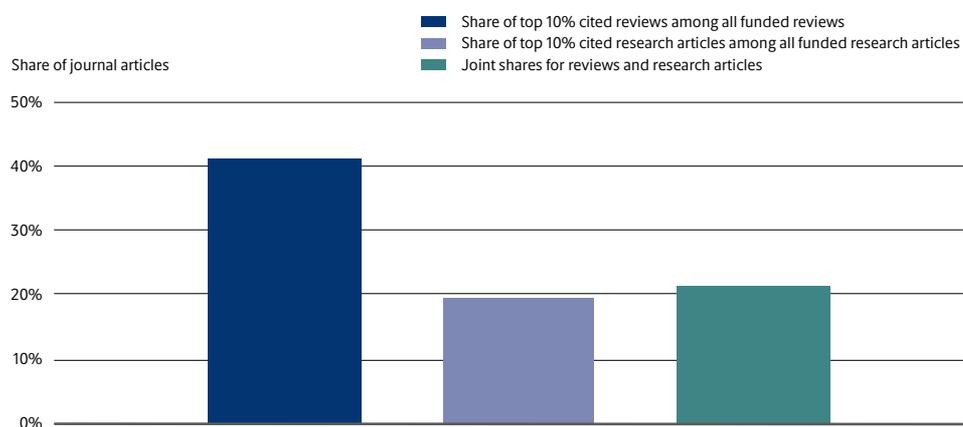
Citation impact for journal articles reported by grant recipients within all sciences – PP(top 1%) and PP(top 10%), 2007–2015



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

Figure 3.2

Comparison of the share of reviews among the 10% most frequently cited reviews worldwide and the share of research articles among the 10% most frequently cited research articles worldwide, 2009–2015



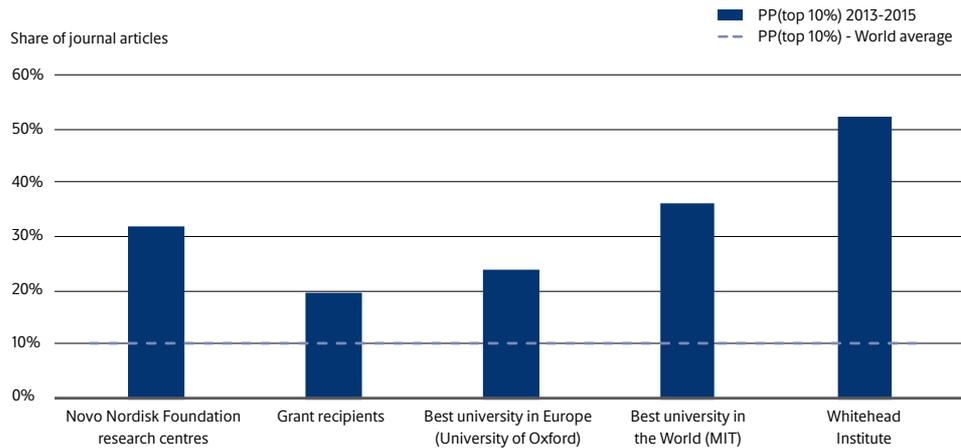
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

3.2 Impact for journal articles reported by grant recipients within biomedical and health sciences

Within biomedical and health sciences, the recipients of Foundation grants have 4 percentage points fewer journal articles among the 10% most frequently cited published in 2013–2015 than the university with the highest percentage in Europe, and the citation impact of the Foundation's four research centres is 3 percentage points lower than the university with the highest percentage in the world and about 20 percentage points lower than the Whitehead Institute, a leading independent research centre affiliated with Massachusetts Institute of Technology (MIT) (Figure 3.3).

Figure 3.3

Benchmark of the citation impact of journal articles within the biomedical and health sciences - PP(top 10%), 2013–2015

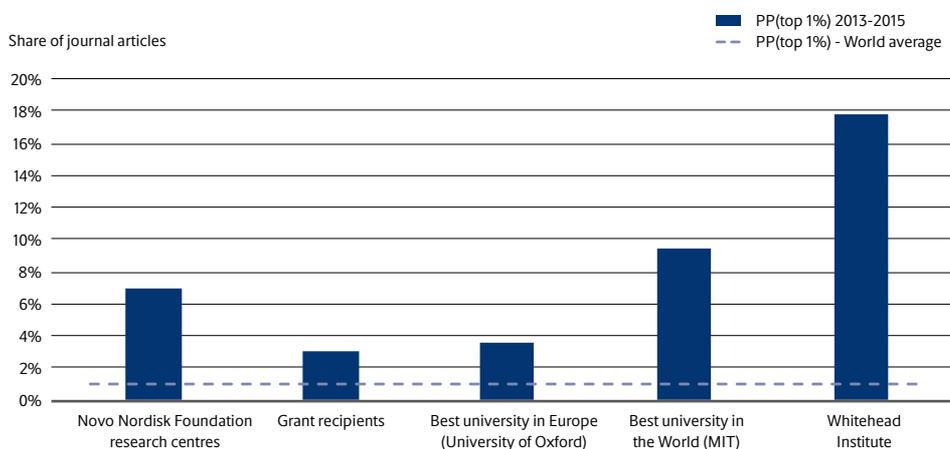


Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Within biomedical and health sciences, the recipients of Foundation grants have almost the same percentage of journal articles among the 1% most frequently cited published in 2013–2015 as the university with the highest percentage in Europe, and the Foundation's four research centres have 3 percentage points fewer journal articles among the 1% most frequently cited than the university with the highest percentage in the world and about 10 percentage points fewer than the Whitehead Institute (Figure 3.4).

Figure 3.4

Benchmark of the citation impact of journal articles within biomedical and health sciences - PP(top 1%), 2013–2015



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 latest European Innovation Scoreboard, with 13.4% of the journal articles from Denmark being among the 10% most frequently cited worldwide. The share is 22% for journal articles by recipients of Foundation grants. The top three countries are Switzerland, United Kingdom and Netherlands, ranging from 15.2% to 14.3% of journal articles among the 10% most frequently cited.¹

¹ European Innovation Scoreboard 2017, as this report also does, uses CWTS Leiden data based on Web of Science

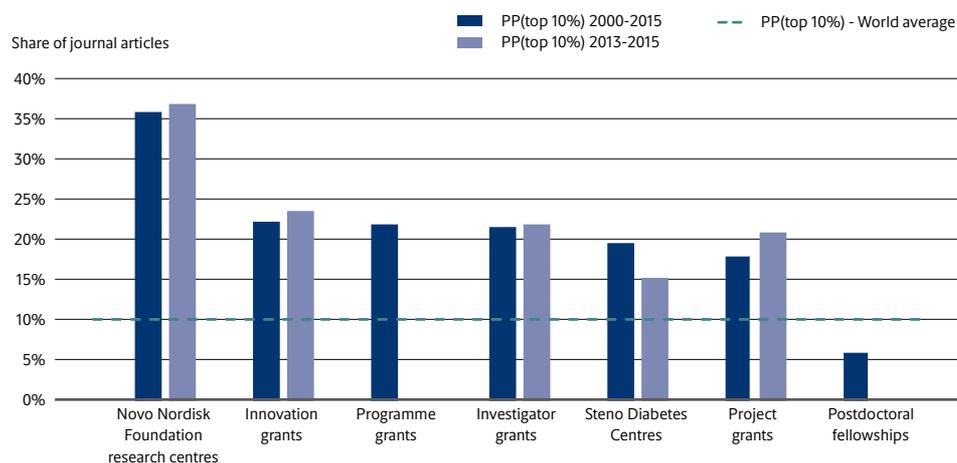
3.3 Citation impact of journal articles reported by grant recipients, by type of grant within all sciences

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

The journal articles by the recipients of different types of grants would be expected to differ in citation impact. Figures 3.5 and 3.6 confirm this. The figures show that journal articles within all subject categories based on 1 to 3-year grants (project grants and postdoctoral fellowships) have a smaller share among the 1% and 10% most frequently cited worldwide.

Figures 3.5 and 3.6 also show that a high percentage of the journal articles from the Foundation's research centres are among the world's most frequently cited; 36% are in the top 10% worldwide (Figure 3.5) and 10% are in the top 1% worldwide within all subject categories (Figure 3.6). Thus, journal articles from the Foundation's research centres are about 10 times more often among the 1% most frequently cited compared with the world average in 2000–2015.

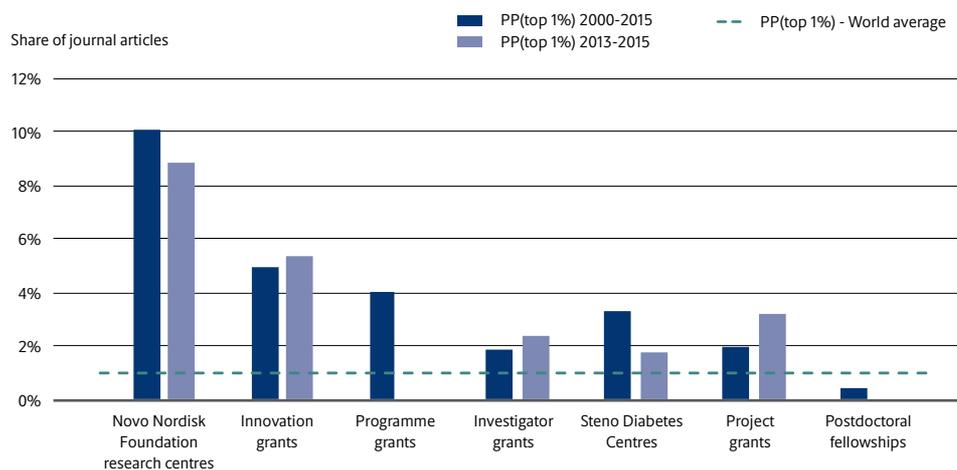
Figure 3.5 Citation impact of all journal articles reported by grant recipients, by type of grant - PP(top 10%), 2000–2015 and 2013–2015



Note: For specification of the grant types, please visit <http://novonordiskfonden.dk/en/ansogning>.
For some grant areas, there are too few publications in the period 2013-2015 to reliably calculate PP(top 10%).

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

Figure 3.6 Citation impact of all journal articles reported by grant recipients, by type of grant - PP(top 1%), 2000–2015 and 2013–2015



Note: For specification of the grant types, please visit <http://novonordiskfonden.dk/en/ansogning>.
For some grant areas, there are too few publications in the period 2013-2015 to reliably calculate PP(top 1%).

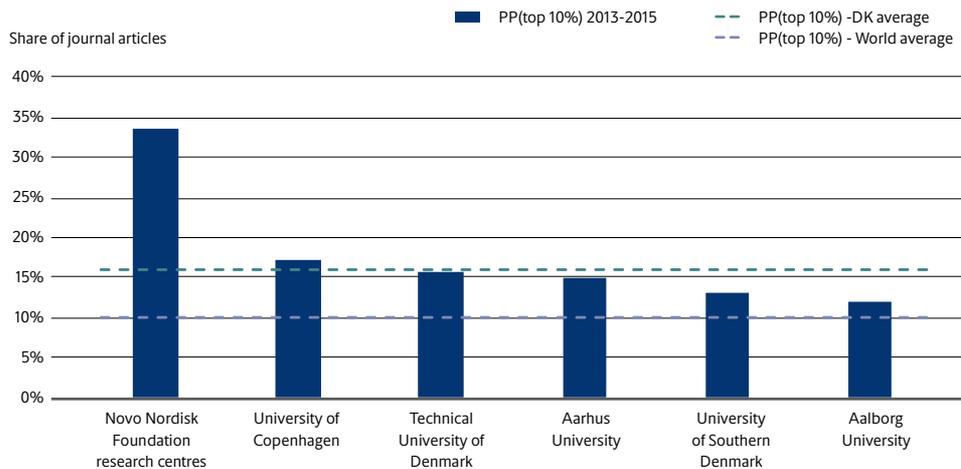
Sources: Novo Nordisk Foundation/researchfish® and Danish Centre for Studies in Research and Research Policy.

3.4 Citation impact of journal articles by the Foundation's research centres within biomedical and health sciences

The citation impact scores of the Foundation's research centres are exceptionally high by any comparison, emphasizing the likely effect of pooling high-impact researchers. Figures 3.7 and 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 (2011–2015). 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 great citation impact relative to the number of journal articles produced.

Figure 3.7

Citation impact of journal articles published in biomedical and health sciences by researchers affiliated with the Novo Nordisk Foundation research centres and universities in Denmark - PP(top 10%), 2013–2015

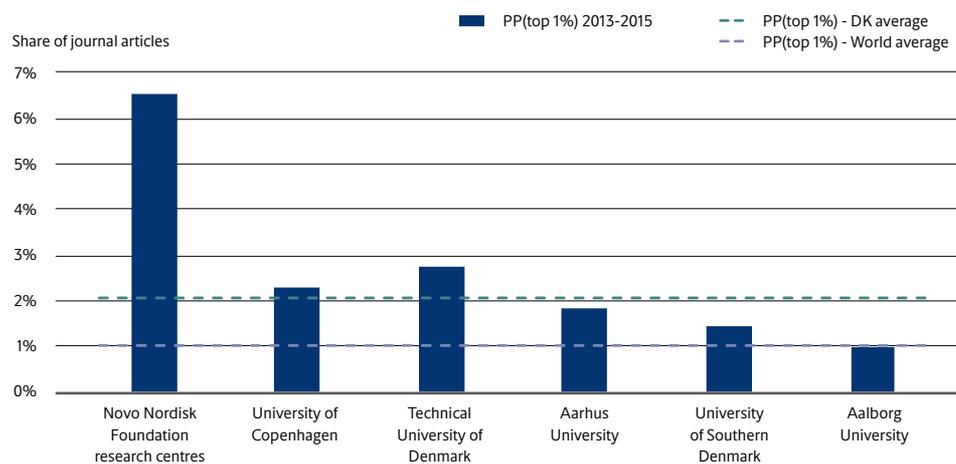


Note: All journal articles by the research centres are matched with journal articles within the biomedical and health sciences from the universities.

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

Figure 3.8

Citation impact of journal articles published in biomedical and health sciences by researchers affiliated with the Novo Nordisk Foundation research centres and universities in Denmark - PP(top 1%), 2013–2015



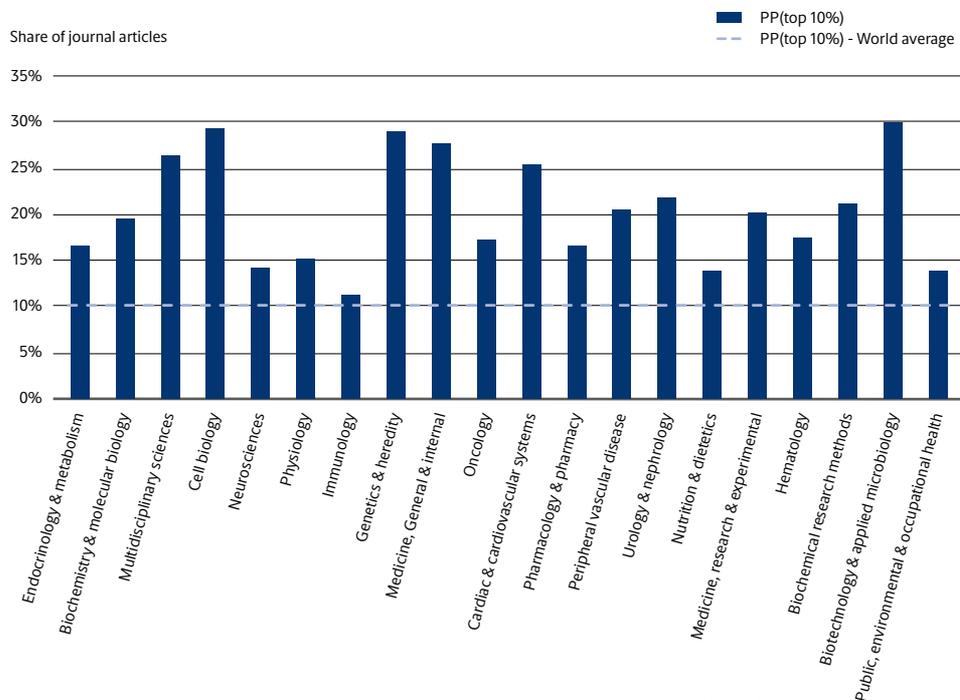
Note: All journal articles by the research centres are matched with journal articles within the biomedical and health sciences from the universities.

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

3.5 Citation impact of journal articles by journal subject category within all sciences

This section divides citation impact by journal subject category as defined by Web of Science. The journal subject category assigned to an article follows the journal of publication. The category of multidisciplinary sciences tends to be a catch-all category for journals accepting submissions from a range of scientific fields. 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 Citation impact of journal articles by journal subject category - PP(top 10%)



Note: The journal subject categories are sorted according to journal article volume, descending from left to right. Time period: 2000-2015.

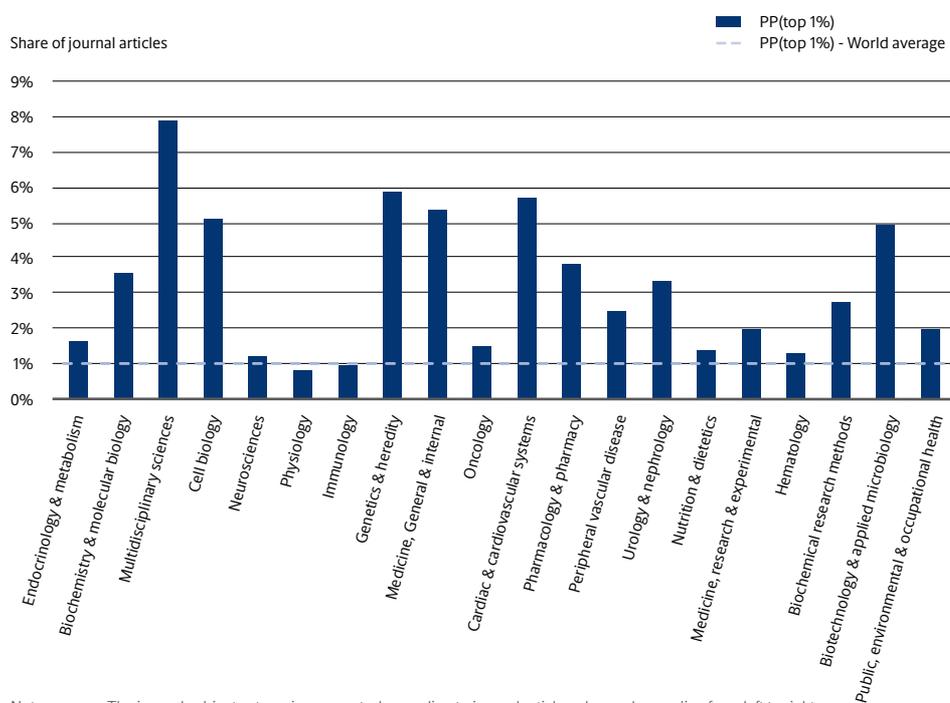
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Figures 3.9 and 3.10 show 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 in the top 1% most frequently cited worldwide within their respective research fields. Citation impact scores are normalized by journal subject category to enable citation impact to be compared across journal subject categories. The journal subject categories in Figures 3.9 and 3.10 are sorted from the left according to the number of journal articles. About 20% of the journal articles by recipients of Foundation grants published in 2000–2015 were within endocrinology & metabolism.

Of the articles in journals within endocrinology & metabolism, 16% are among the 10% most frequently cited (Figure 3.9), and 1.6% are in the top 1% most frequently cited worldwide (Figure 3.10).

In multidisciplinary sciences, 26% of the journal articles by recipients of Foundation grants are in the top 10%, and 8% are in the top 1%. In general & internal medicine, 27% of the journal articles by recipients of Foundation grants are among the top 10% most frequently cited worldwide within their field, and more than 5% are among the 1% most frequently cited (Figures 3.9 and 3.10).

Figure 3.10 Citation impact of journal articles by journal subject category - PP(top 1%)



Note: The journal subject categories are sorted according to journal article volume, descending from left to right. Time period: 2000-2015.

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

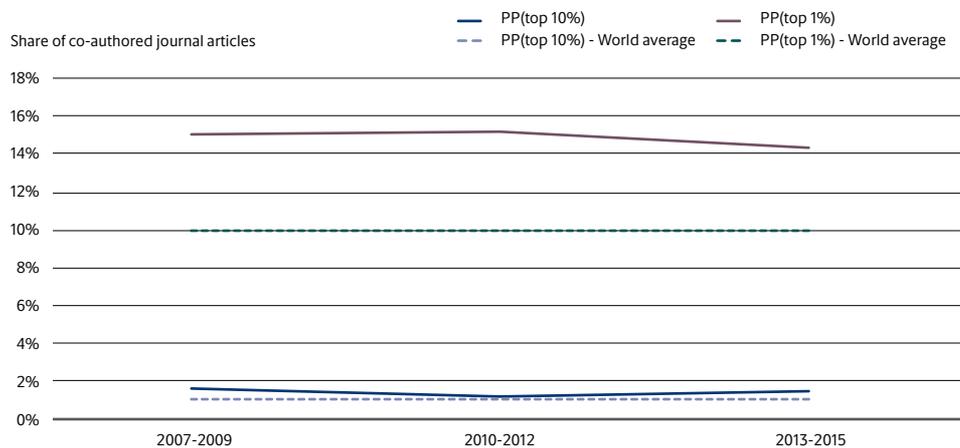
3.6 Citation impact of co-authored journal articles reported by grant recipients within all sciences

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

Collaboration with researchers from institutions within and outside Denmark can enhance knowledge of the research outside the research institution's own walls. Journal articles produced by recipients of Foundation grants in collaboration with international co-authors have a greater citation impact than those produced with national co-authors. In 2013–2015, grant recipients with international co-authors had 12 percentage points more journal articles among the 10% most frequently cited and 4 percentage points more among the 1% most frequently cited than those with only national co-authorship (Figures 3.11 and 3.12).

Figure 3.11

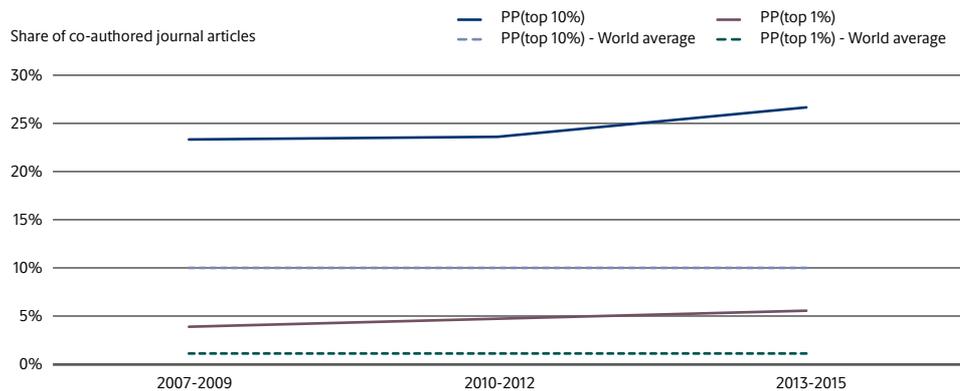
Citation impact of nationally co-authored journal articles within academia with all sciences - PP(top 1%), PP(top 10%), 2007–2015



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

Figure 3.12

Citation impact of internationally co-authored journal articles within academia within all sciences - PP(top 1%), PP(top 10%), 2007–2015



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

3.7 Citation score dynamics in journal articles

The share of journal articles by the recipients of Foundation grants among the 10% most frequently cited worldwide is twice the world average and at the same level as the universities with the highest scores in Europe. Citation analysis in general shows that most journal articles are rarely cited, a few are relatively frequently cited and a few of the frequently cited journal articles are disproportionately highly cited.

What the citation impact results in the previous sections do not reveal is how the various journal articles linked to Foundation grants contribute to the overall distribution of all Foundation-funded journal articles. Does a subset of highly successful grants or a broad range of grants deliver high-impact journal articles? And what about infrequently cited publications? What roles do the grant recipients have in the reported journal articles? Are they the first or last author? And what applies to their team members? Answering such questions requires more informative data than those used in the previous sections. The analysis requires data that link not only grant recipients with journal articles but also members of the grant recipient's funded research team, their academic titles and how the team members are represented in the journal articles reported for a specific grant.

The analysis here uses a sample of 208 research grants out of all open competition grants with amounts between DKK 100,000 and DKK 5 million and totalling DKK 267 million. The grant recipients in this highly informative sample have reported 1,080 journal articles published by 420 researchers as the publication output of the grants.

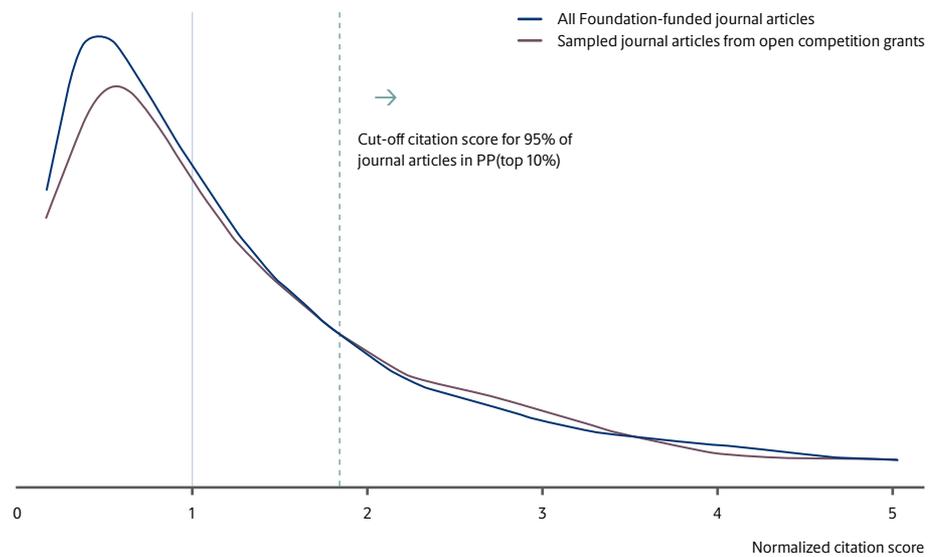
The analysis of the journal articles performed here shows that the citation scores vary substantially both across but certainly also within grants. It also shows that a small group of highly successful grant recipients produces most of the disproportionately highly cited journal articles. Further, not all grants result in frequently cited journal articles and a substantial share of grants deliver both well-cited as well as low- or uncited journal articles.

Figure 3.13 shows the skewed distribution of citation scores for all the journal articles reported by all grant recipients compared with the distribution of the citation scores of the journal articles in the highly informative sample used for analysis. In terms of the distribution of citation impact scores, the sample is representative for the citation score-distribution of all Foundation-funded journal articles.

Figure 3.13 shows the density of journal articles distributed across the normalized citation score of the articles. Most of the journal articles are to the left of the vertical line at 1, which means that most of the journal articles have a normalized citation score below the world average score (1) and are centred around 0.4 to 0.6. A total of 51% of all publications have a citation score below 1, and further, 93% of all publications have a normalized citation score below 5. Of the 208 grants analysed in the sample, 25% produced at least one journal article with zero citations.

Figure 3.13

Distribution of journal articles by normalized citation score



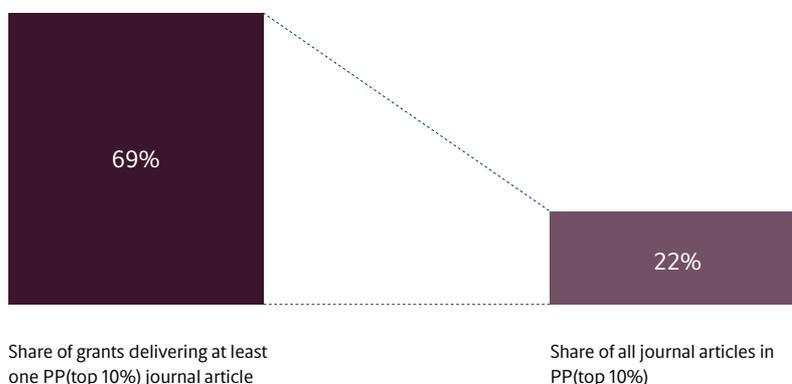
Sources: Novo Nordisk Foundation/researchfish* and Danish Centre for Studies in Research and Research Policy.

Distribution of journal articles with high citation scores

Twenty two percent of the journal articles funded by the Foundation in the subgroup of analysed open competition grants are among the 10% most frequently cited worldwide (see Figure 3.14). This PP(top 10%) share originates from 69% of the grants awarded by the Foundation. This means that 69% of the grants lead to at least one article cited among the 10% most frequently cited journal articles worldwide.

Figure 3.14

Distribution of the most frequently cited journal articles and the share of grants delivering them



Note: The results presented are based on the analyzed sample of 208 projects with 1,080 journal articles.

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

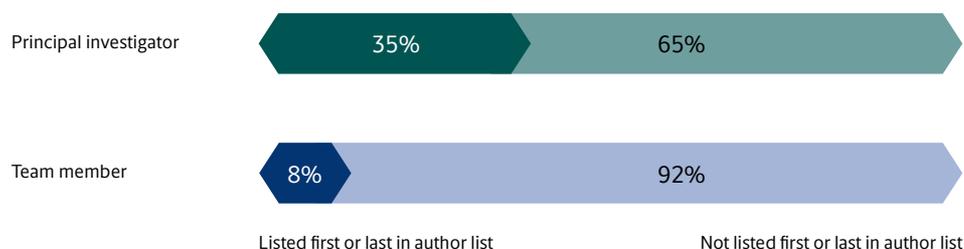
Roles of the principal investigator and team members in frequently cited journal articles

Many of the Foundation-funded journal articles are in biomedical and health sciences and natural sciences. Here author sequence matters to some extent, since the first author is usually the main author and the last author is often the head of the research activity. Figure 3.15 shows that 35% of the principal investigators (the grant recipients) are listed as the first or last author of journal articles among the 10% most cited worldwide. Other team members from 8% of the grants are also listed as the first or last author of journal articles among the 10% most frequently cited worldwide. These other team members were either postdoctoral fellows or PhD students.

Figure 3.16 compares the PP(top 10%) shares for journal articles in which the principal investigator is the first or last author, with other reported journal articles. It shows that 19% of journal articles with the principal investigator as the first or last author are among the 10% most frequently cited worldwide, whereas the corresponding number for journal articles not having the principal investigator as the first or last author is somewhat higher, at 23%.

Figure 3.15

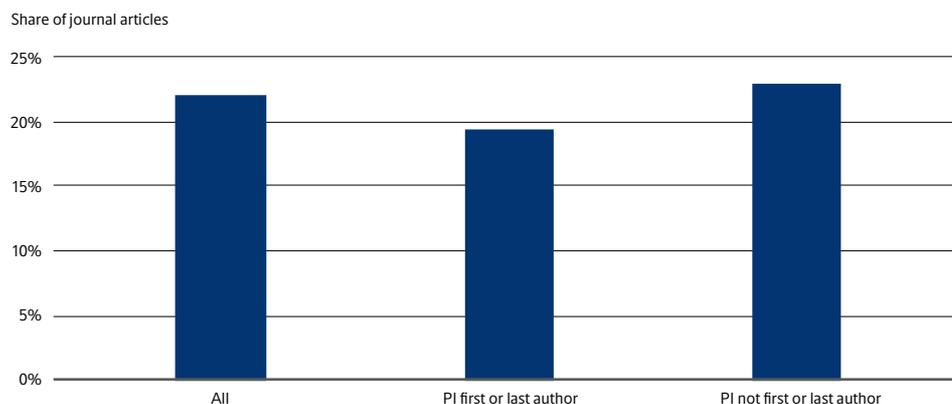
The share of principal investigators and the share of grants with team members listed as first or last author of PP(top 10%) - journal articles (open competition grants)



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

Figure 3.16

Share of journal articles in PP(top 10%) categorized according to principal investigator's position in author sequence



Note: The journal articles with the principal investigator as the first or last author constitute 21% of all reported journal articles among the 10% most frequently cited worldwide within the analysed journal articles from open competition grants.

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

These results indicate that the principal investigator tends to have a more secondary role in the research behind frequently cited publications arising from two thirds of the grants. Unfortunately, because this type of analysis requires information on who is funded how for the research conducted (grant recipient or team member), the results here cannot be compared with a well-defined benchmark. Further explorations could benchmark the results for the grant recipients against their entire publication record.

4. INTERDISCIPLINARY RESEARCH COLLABORATION, PUBLICATIONS IN CROSS-DISCIPLINARY JOURNALS AND CROSS-DISCIPLINARY CITATIONS

The Foundation has a long-term strategic goal of promoting interdisciplinary research collaboration and the potential cross-disciplinary research arising from such collaboration.

This chapter investigates interdisciplinary research collaboration by mapping researchers according to their scientific specialization, but it does not analyse whether the research carried out is cross-disciplinary. The published journal articles are mapped according to whether they were published in mono- or cross-disciplinary journals, and the citations of those journal articles by articles in journals within other disciplines are also outlined.

The focus is therefore on the researchers, whether they publish in cross-disciplinary journals, and whether articles published in journals from different fields cross-cite each other. The citation impact analysis does not benchmark cross-disciplinary research against monodisciplinary research.

4.1. Interdisciplinary research collaboration

Different specialties are imperative for cross-disciplinary research. This section identifies detailed academic specializations and broad fields of science for a sample of co-authors to reflect interdisciplinary collaboration at two different tolerance levels.

The analysed data comprise 232 articles drawn randomly from 2,320 Foundation-funded journal articles co-authored by 2,041 people and published in 2010 and 2015 (78 articles in 2010 and 154 in 2015).

Number of co-authors per journal article

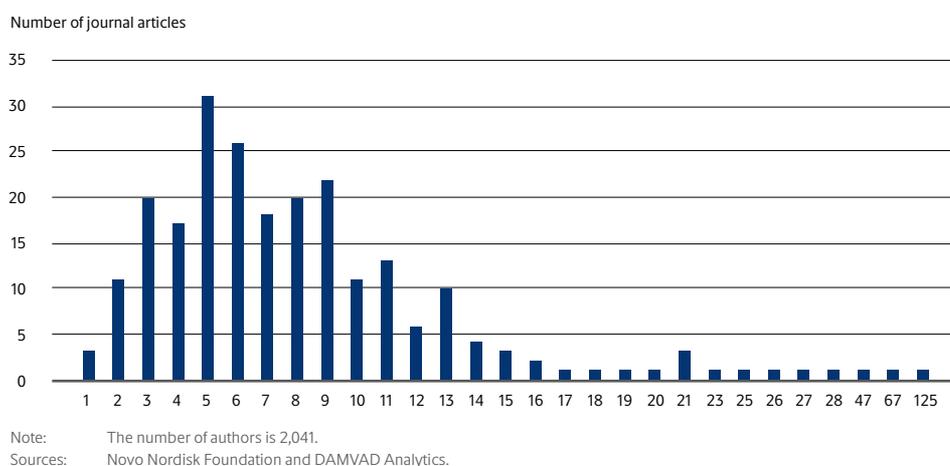
Analysing collaboration requires multiple co-authors for each journal article. The number of co-authors per journal article varies and almost all the articles have multiple authors: 31 have five co-authors and 26 have six co-authors (Figure 4.1). The average number is eight. Almost half the authors are affiliated with an institution in Denmark, and the rest are affiliated outside Denmark.

Academic specializations

An academic specialization was identified for 94% of these 2,041 co-authors. These 1,912 co-authors have a background in 106 academic specializations. The 106 specializations identified were found in an exploratory way by identifying how the researcher presented their specialization and then by harmonizing the identified specialties.

Figure 4.1

Number of journal articles by number of co-authors, 2010 and 2015

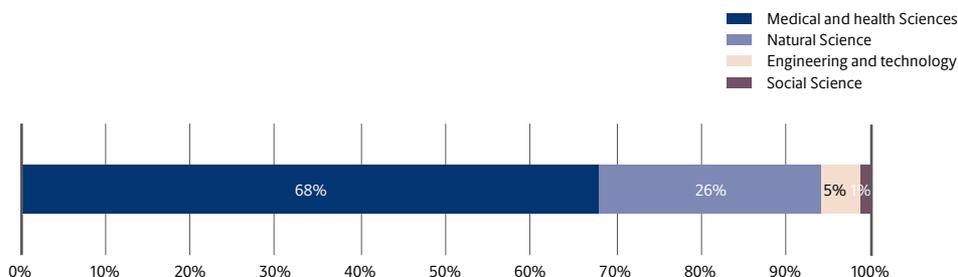


The academic specializations of grant recipients and their co-authors (and not necessarily their educational background) were used to categorize their specialization such as neurology, endocrinology, and psychology (see box: identifying academic specializations in the data set). The 106 academic specializations were further mapped into the six fields of science according to the OECD's broad classification: medical and health sciences, natural sciences, engineering and technology, agricultural sciences, social sciences and humanities. In the sample examined, no publications were published in the agricultural sciences or humanities. The two classifications, academic specialization and broad fields of science, were then used to define the two different tolerance levels for identifying interdisciplinary research collaboration:

- collaboration among researchers with different specializations between the 106 academic specializations identified among the co-authors of journal articles by grant recipients; and
- collaboration among researchers with academic specializations within the six broad fields of science defined by the OECD

A total of 68% of the authors have an academic specialization within the medical and health sciences, and 26% have an academic specialization in the natural sciences (Figure 4.2).

Figure 4.2 Distribution of the co-authors' academic specializations by scientific category, 2010 and 2015



Note: The 1,912 authors who had their academic specializations categorized are included.
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Identifying academic specializations in the data set

The academic specializations of the grant recipients' and co-authors' were identified based on three steps.

1. Basic desk research for the author's surname, initials and affiliation. This sometimes returns a faculty or LinkedIn profile with a CV that specifies the author's academic specialization and/or education.
2. If no profile is found, the search is expanded to try to find other sources that mention the author in the context of their work, such as the researcher's department, ResearchGate, publication databases, media sites or Google search results.
3. If the first two steps do not return a valid academic specialization, a search for the author's full name plus the detailed address was conducted. This often returns an academic profile or list of publications for which the author is credited. If the author has a long list of publications in the same field, this is recorded as the author's academic specialization.

Authors who could not be identified by using these approaches were recorded as missing in the dataset.

Interdisciplinary research collaboration based on 106 academic specializations

The two most common academic specializations that work together are physicians without a known academic specialization and researchers specializing in endocrinology. Table 4.1 shows the top 20 most common pairs of authors. These top 20 pairs cover 72% of all authors.

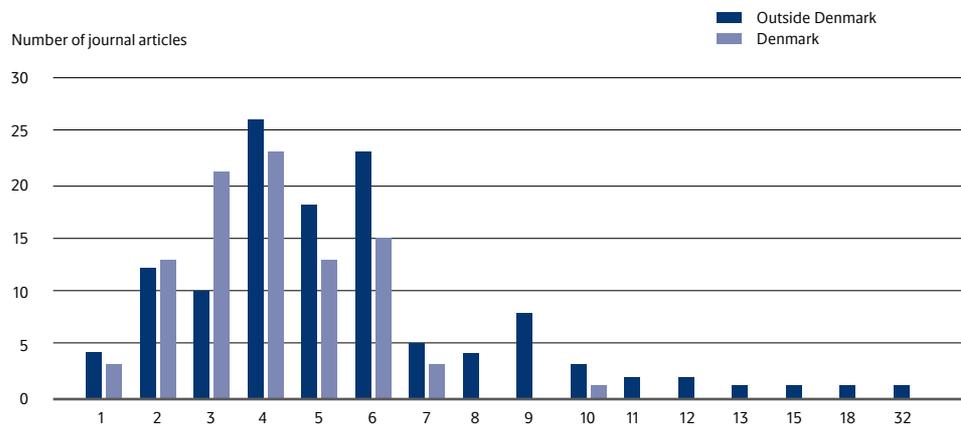
Table 4.1 Top 20 most common pairs of academic specializations collaborating, 2010 and 2015

First co-author		Second co-author		Number of publications
Academic specialization	Field of science	Academic specialization	Field of science	
Physician	Medical and health sciences	Endocrinology	Medical and health sciences	49
Physician	Medical and health sciences	Public health	Medical and health sciences	36
Physician	Medical and health sciences	Biochemistry	Natural sciences	35
Physician	Medical and health sciences	Cardiology	Natural sciences	31
Biochemistry	Natural sciences	Molecular biology	Medical and health sciences	28
Physician	Medical and health sciences	Genetics	Medical and health sciences	24
Physician	Medical and health sciences	Molecular Biology	Medical and health sciences	24
Physician	Medical and health sciences	Internal medicine	Natural sciences	20
Molecular Biology	Medical and health sciences	Genetics	Medical and health sciences	20
Endocrinology	Medical and health sciences	Public Health	Medical and health sciences	19
Biochemistry	Natural sciences	Biotechnology	Natural sciences	18
Physician	Medical and health sciences	Immunology	Natural sciences	18
Biochemistry	Natural sciences	Genetics	Medical and health sciences	17
Biochemistry	Natural sciences	Chemistry	Natural sciences	16
Biostatistics	Natural sciences	Physician	Medical and health sciences	16
Biology	Natural sciences	Biochemistry	Natural sciences	15
Chemistry	Natural sciences	Physician	Medical and health sciences	15
Epidemiology	Medical and health sciences	Public Health	Medical and health sciences	15
Physician	Medical and health sciences	Oncology	Medical and health sciences	15
Biochemistry	Natural sciences	Endocrinology	Medical and health sciences	14

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

When interdisciplinary research collaboration is defined as collaboration among co-authors from 106 academic specializations, half the journal articles are co-authored with up to four academic specializations (Figure 4.3). The share of journal articles with more than six academic specializations was 15%. The number of journal articles that have co-authors from outside Denmark (see Figure 4.3) is higher for journal articles with four specializations or more compared with journal articles with all by co-authors located in Denmark.

Figure 4.3 Number of journal articles by number of academic specializations, 2010 and 2015



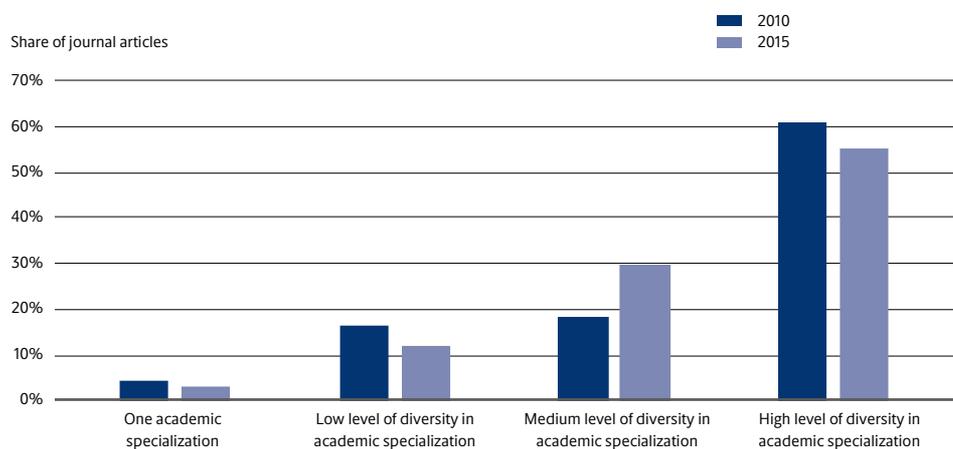
Note: The 213 journal articles in which 80% of the co-authors were categorized are included.

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 4.3 shows the number of academic specializations but does not relate this to the number of authors. Figure 4.4 categorizes the journal articles according to the number of specializations versus the number of authors as a qualified measure of diversity. The diversity of academic specializations varies among the co-authors of the 232 journal articles: 55–61% of the journal articles are co-authored by a team with many specializations, or a high level of diversity in academic specialization, whereas only 3-4% of the journal articles have co-authors with the same academic specialization. This pattern seems to be stable over time.

Figure 4.4

Co-authors' diversity in academic specialization, 2010 and 2015

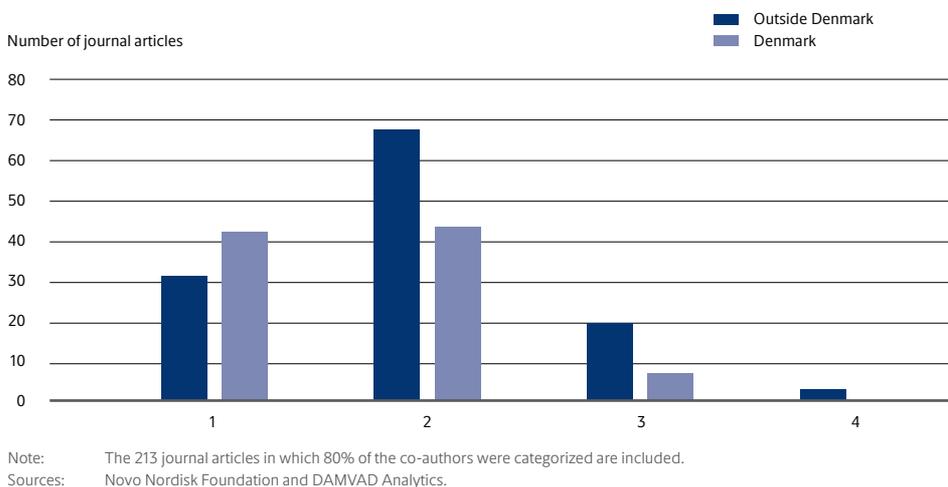


Note: The 213 journal articles in which 80% of the co-authors were categorized are included.
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Interdisciplinary research collaboration based on the six broad fields of science

Co-authors with backgrounds from more than one broad field of science as defined by the OECD (medical and health sciences, natural sciences, engineering and technology, agricultural sciences, social sciences and humanities) collaborate on most journal articles. Half the articles involve co-authors from two fields of science (Figure 4.5). About one in eight journal articles involves co-authors from three or four fields of science. This implies that two of three journal articles involve co-authors from at least two fields of science. More journal articles with at least two fields of science have co-authors from outside Denmark than co-authors in Denmark.

Figure 4.5 Number of journal articles by number of fields of science, 2010 and 2015



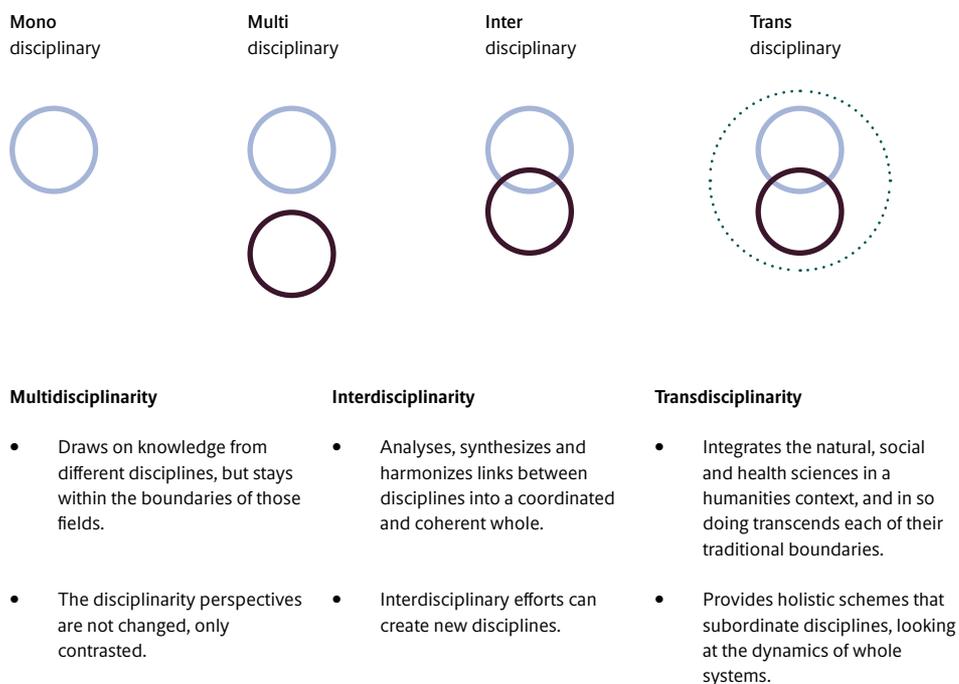
4.2 Publications in mono- and cross-disciplinary journals

When researchers have conducted their research and their articles are ready to be submitted to a scientific journal, they have thousands of journals to choose from. Some journals specialize in a single discipline (monodisciplinary journals), whereas others journals embrace more disciplines (cross-disciplinary journals).

Defining the term cross-disciplinarity

Cross-disciplinarity is a joint term for multidisciplinary, interdisciplinarity and transdisciplinarity. It relates to the nature of the research activities and output and differs from *interdisciplinary research collaboration*, discussed in section 4.1, which does not necessarily lead to multidisciplinary, interdisciplinary or transdisciplinary research outputs. Figure 4.6 shows how integrated disciplines are in the various types of cross-disciplinarity. Determining the type of cross-disciplinarity is resource intensive and not relevant for journal classification.

Figure 4.6 Monodisciplinary research and the different types of cross-disciplinary research



Source: Choi, BCK. & Pak, AWP. Multidisciplinary, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. Clin Invest Med. 2006, 29:351-64.

No single indicator can capture the full story of cross-disciplinarity. Various attempts have been done to develop an indicator that is internationally recognized and agreed on. The different aspects of cross-disciplinarity can be monitored using different approaches.

Section 4.2 applies cross-disciplinarity (defined below) in two ways in the following two subsections:

- **journal articles in cross-disciplinary journals:** journal articles registered in journals with more than one discipline at a level of aggregation (defined further below); and
- **cross-disciplinary references to journal articles:** articles cited in journals within other disciplines

Journal articles in cross-disciplinary journals

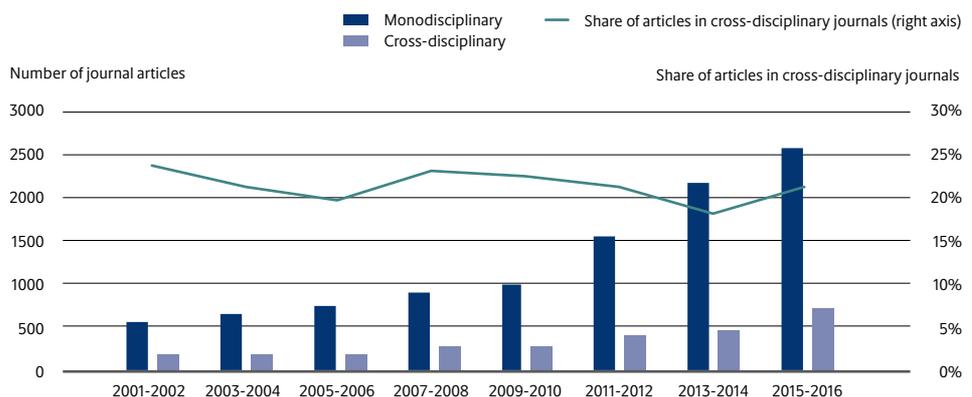
A journal is assigned at least one subject category to indicate which scientific field the journal generally covers, thereby defining the subject category of the articles in Web of Science.

The point of departure for analysing cross-disciplinarity is to define a level of aggregation. The level of disciplinarity aggregation used in analysing journal articles in cross-disciplinary journals was constructed as follows. The 252 journal subject categories were mapped into 39 scientific categories defined by the OECD, such as chemical engineering, basic medical research and mathematics.

The recipients of Foundation grants published 12,853 journal articles between 2001 and 2016 (Figure 4.7). The share of journal articles in cross-disciplinary journals is 20% and 80% in monodisciplinary journals.

Figure 4.7

Trend in number of articles published in mono- and cross-disciplinary journals, 2001-2016



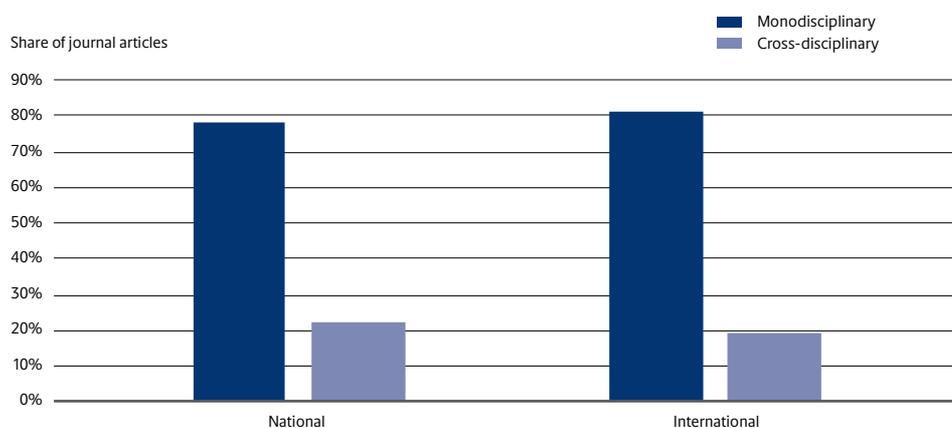
Note: Time period 2001-2016.
The number of journal articles is 12,853.

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

The same applies to articles in cross-disciplinary journals with national and international co-authors (Figure 4.8); 20% of the internationally co-authored journal articles by the recipients of Foundation grants are in cross-disciplinary journals versus 22% of the nationally co-authored journal articles.

Figure 4.8

Share of journal articles by national and international co-authorship



Note: Time period 2001–2016.
The number of journal articles is 12,853.

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

The recipients of postdoctoral fellowships and programme grants publish a higher share of journal articles in cross-disciplinary journals than the recipients of research centre grants, project grants, and PhD and undergraduate scholarships (Figure 4.9).

Figure 4.9 Share of articles in cross-disciplinary journals by types of grants

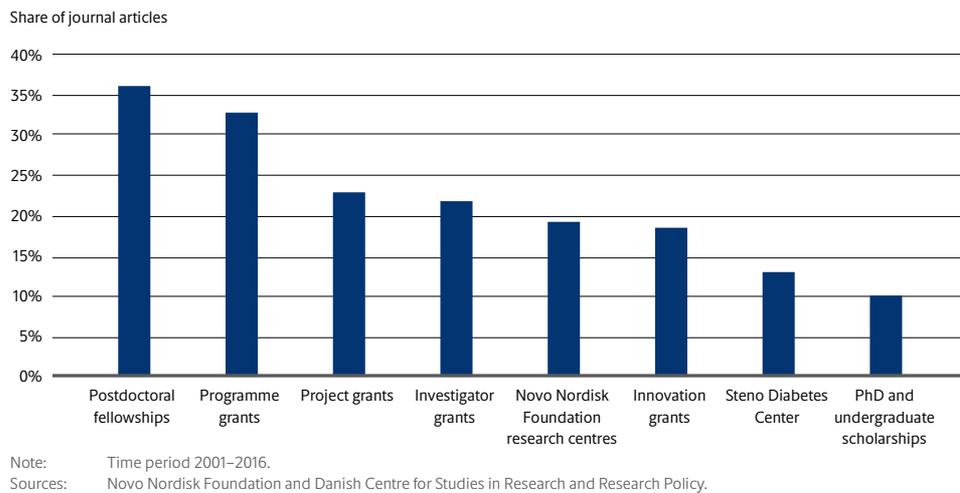
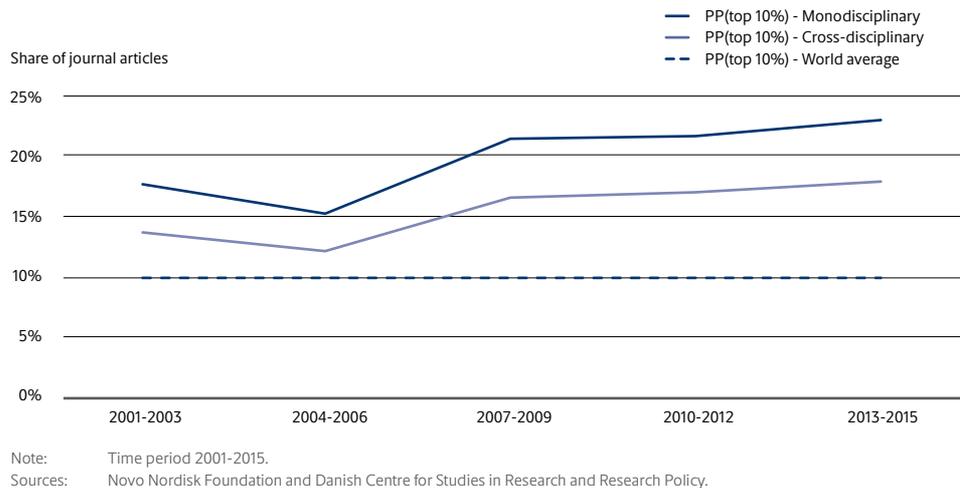


Figure 4.10 Trend in citation impact, PP(top 10%), 2001-2015



The citation impact is high for articles in both monodisciplinary and cross-disciplinary journals (Figure 4.10). In 2001–2015, about 16% of the articles in cross-disciplinary journals are among the 10% most frequently cited worldwide versus about 21% for articles in monodisciplinary journals. The citation impact increased from 2001 to 2015 for articles in cross-disciplinary journals: from 13.6% in 2001–2003 to 17.9% in 2013–2015. For articles in monodisciplinary journals, the citation impact increased from 17.6% in 2001–2003 to 22.8% in 2013–2015.

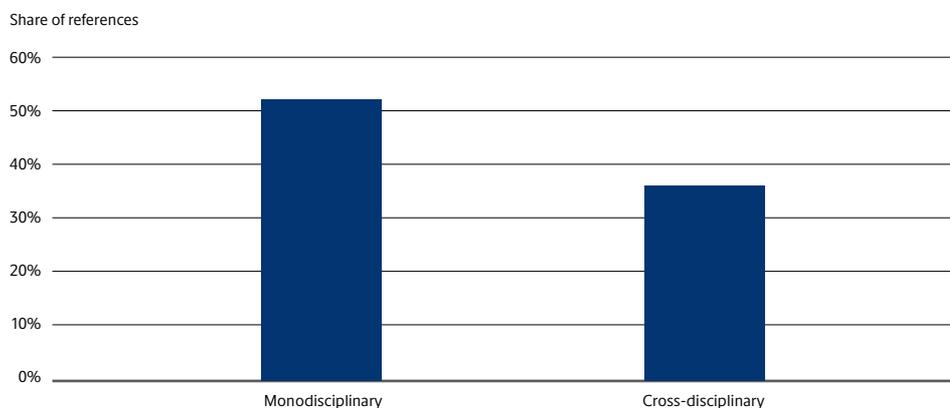
Cross-disciplinary references to journal articles

Researchers drawing on research methods and research results from disciplines outside their field may indicate cross-disciplinary research. An indicator of such sourcing of knowledge could be citations from journals in other scientific categories.

When assessing references at the journal level as cross-disciplinary at the OECD 39 level, the average share of cross-disciplinary references is 53% for articles in monodisciplinary journals and 35% for articles in cross-disciplinary journals (Figure 4.11).

Figure 4.11

Share of references outside the article's own scientific category



Note: Time period 2001–2016.
The number of references is 546,067.

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

KEY FINDINGS IN PART 3

- Grant recipients contribute to guidelines used by general practitioners:
 - Publications reported by grant recipients have contributed to 53% of the diabetes guidelines and 18% of the cardiovascular disease guidelines in Denmark and elsewhere
 - 79% of the general practitioners in Denmark acquire knowledge from the clinical guidelines
- 79 medical products, interventions and clinical trials have been reported through 2017
- Grant recipients have performed 1,780 knowledge dissemination activities targeting the public sector, of which 132 were for school audiences in 2016–2017
- Courses organized by grant recipients have reached more than 11,000 individuals, particularly healthcare professionals in 2017
- Foundation grants for research activities currently support 425 PhD students and 555 postdoctoral fellows
- Case:
Investigating the outcomes and impact of 37 completed Clinical Scientist Fellowship grants awarded to hospital physicians:
 - Of 37 fellows, 33 were survey interviewed:
 - 22 fellows earned a professorship during their fellowship and 31 including the post-fellowship period. More than 80% of the fellows indicate fellowship influence
 - 80% used research output for education and training of staff in their clinic. Research was transformed into improved treatment and diagnostics
 - The share of journal articles in PP(top 10%) produced during the fellowships was 18.3% compared to 16.2% before their fellowships began

Part 3

Dissemination and use of
knowledge within the public sector



The Foundation's
vision is to contribute
significantly to
research and
development that
improves the
health and welfare
of people

5. DISSEMINATION AND USE OF KNOWLEDGE WITHIN THE PUBLIC HEALTH SECTOR

This chapter focuses on how grant recipients contribute to improvements of the treatment of patients; how clinical guidelines and recommendations cite their journal articles and how these clinical guidelines and recommendations are used to improve treatment and make it more uniform.

5.1 Contributions by grant recipients to practice, guidelines and advisory functions

Some recipients of Foundation grants act as experts to give advice or present evidence to government institutions and other authorities because they are engaged in research activities and provide new knowledge. They contribute to the training of practitioners and researchers and they contribute in developing and revising clinical guidelines with recommendations for clinicians on diagnostics, treatment and management of diseases.

Of the reported contributions, 36% 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 5.1).

Figure 5.1

Contributions by grant recipients to practice, guidelines and advisory functions, 2016–2017



Note: The number of reported contributions is 98. Percentages do not sum to 100% due to rounding.

Source: Novo Nordisk Foundation/researchfish*.

5.2 Use of journal articles by grant recipients in clinical guidelines and recommendations

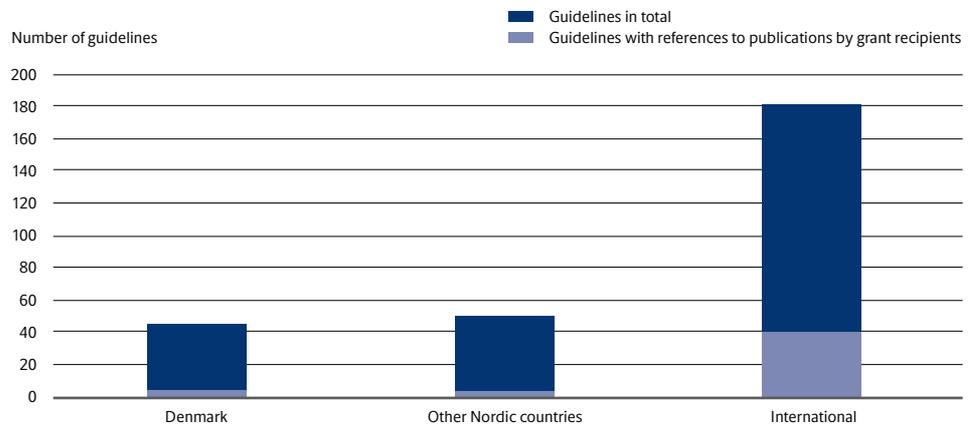
Clinical guidelines are systematically prepared scientific recommendations aiming to guide and support healthcare professionals in decision-making. The general perception of journal articles being referenced in guidelines is that the research behind the publication is likely to influence the treatment of patients.

The Foundation has documented the use of research by grant recipients in the public health-care system by analysing references in clinical guidelines and recommendations covering the specific disease fields of diabetes and cardiovascular diseases.

The analysis covered 276 guidelines on cardiovascular diseases guidelines and 100 guidelines on diabetes in Denmark and other countries published between 2000 and 2016. The analysis showed that journal articles reported the grant recipients contributed to 49 (18%) of the cardiovascular disease guidelines (Figure 5.2) and 53 (53%) of the diabetes guidelines (Figure 5.3) published in Denmark, the other Nordic countries and in guidelines in the United Kingdom and the United States and by international organizations.

Figure 5.2

Guidelines on cardiovascular diseases

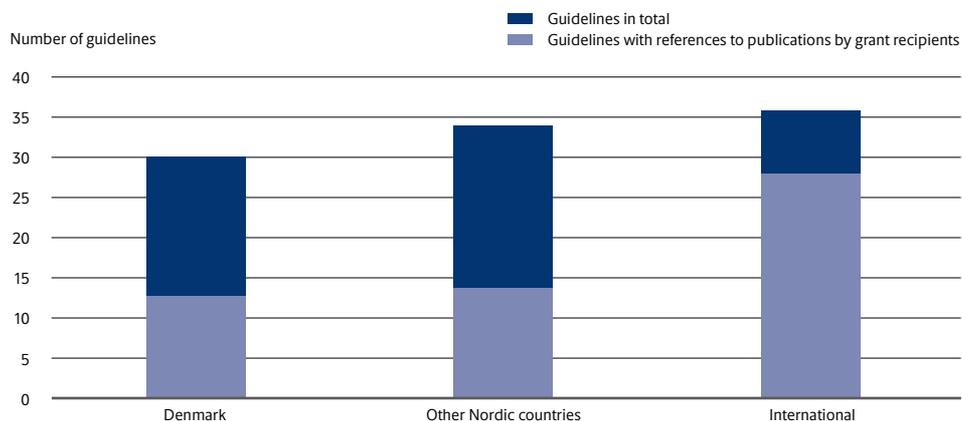


Note: International publishers of guidelines include the World Health Organization (WHO), National Institute for Health and Care Excellence (NICE), European Society of Cardiology (ESC), British Cardiovascular Society (BCS) and American Heart Association (AHA).

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 5.3

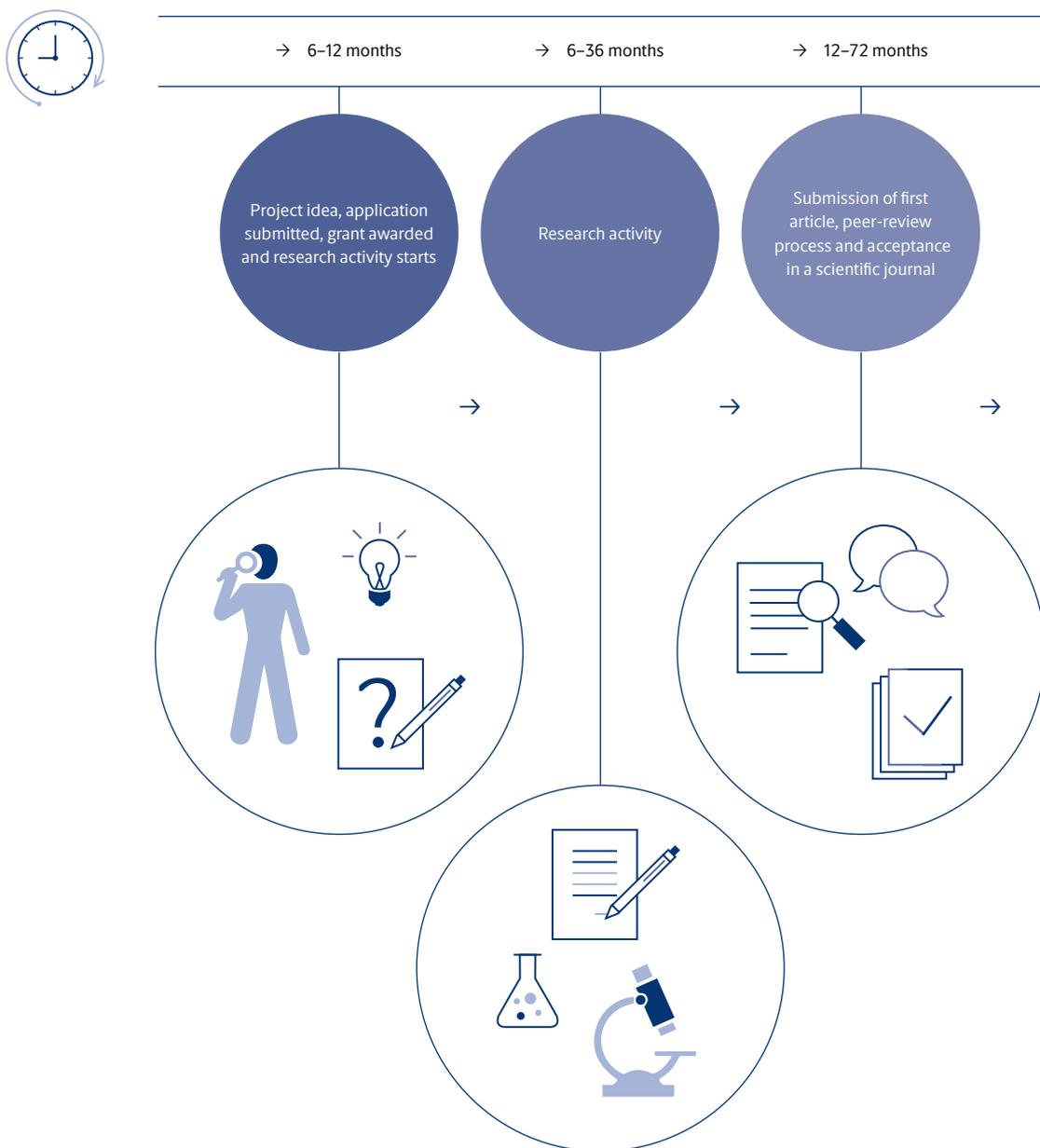
Guidelines on diabetes



Note: International publishers of guidelines include the World Health Organization (WHO), National Institute for Health and Care Excellence (NICE), European Society of Cardiology (ESC), British Cardiovascular Society (BCS) and American Heart Association (AHA).
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 5.4 shows the transmission phases from application to awarding grants and onward through research activities, grant recipients publishing journal articles, guidelines citing the articles and general practitioners using guidelines.

Figure 5.4 The transmission phases from project idea via journal articles to impact on treatment of patients



→ 24-120 months

→ 96-142 months

→ —

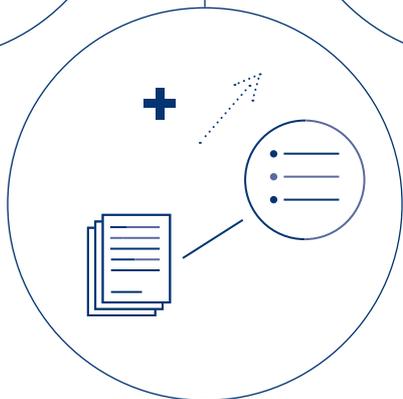
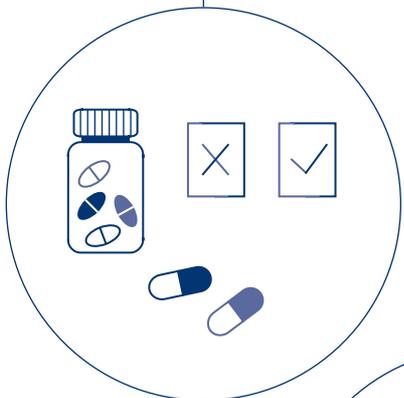
→ —

New or changed medical products and treatment methods influence therapy

Guidelines refer to journal articles

General practitioners become aware of journal articles and guidelines

General practitioners use journal articles and guidelines to improve therapy



5.3 General practitioners acquire knowledge on treating cardiovascular diseases and diabetes

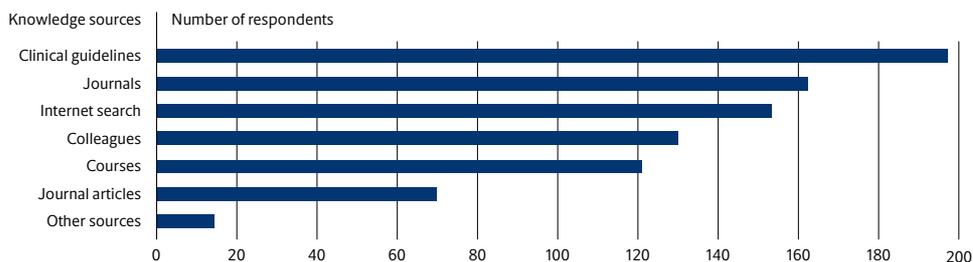
To analyse the importance of contributions to clinical guidelines and how guidelines are disseminated to and used by general practitioners the Foundation has conducted a survey among 251 general practitioners in Denmark. The general practitioners work within selected disease areas and the survey has been followed up by interviews.

General practitioners continuously update their knowledge from multiple sources. The survey shows that clinical guidelines are the most important source for acquiring knowledge.

Of the 251 general practitioners, 197 (79%) acquire knowledge about treatment from clinical guidelines (Figure 5.5), 162 (65%) acquire knowledge from journals and 70 (30%) acquire knowledge directly from journal articles.

Figure 5.5

Where do you acquire knowledge about the treatment of cardiovascular diseases and diabetes?



Note: The number of respondents was 251 (16% of the general practitioners in Denmark, who received the survey).

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

5.4 General practitioners' use of guidelines for treatment

Of the responding general practitioners who are familiar with the relevant clinical guidelines, 88% use the guidelines in their clinic for treatment (Figure 5.6 and 5.7). The share of general practitioners using the guidelines is the same for cardiovascular diseases as for diabetes.

Figure 5.6

Have you used the guidelines on cardiovascular diseases in the treatment of your patients?



Note: The number of respondents is 177.

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 5.7

Have you used the guidelines in the diabetes area in the treatment of your patients?



Note: The number of responses is 152.

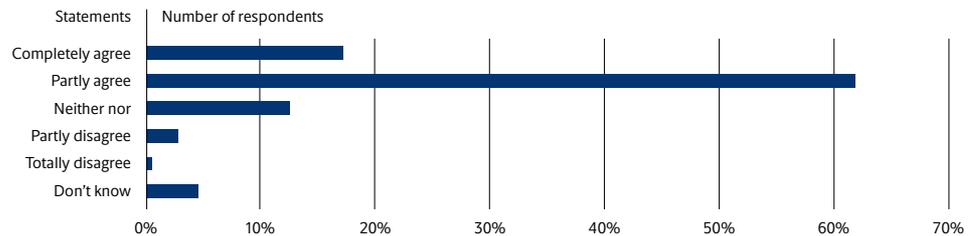
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

5.5 General practitioners say that using clinical guidelines is easy

A total of 79% of the responding general practitioners say that translating knowledge in the guidelines into actual treatment to benefit their patients is relatively easy (Figure 5.8).

Figure 5.8

To what extent do you agree with the following: “It is easy for me to translate knowledge from guidelines for cardiovascular diseases and diabetes to the actual treatment of my patients”?



Note: The number of respondents 173.

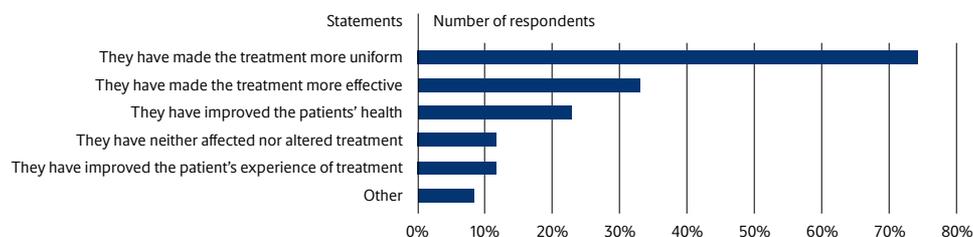
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

5.6 Guidelines have resulted in more uniform, effective and health improving treatment of patients

One of the main purposes of guidelines is to ensure uniform treatment regardless of where the patient lives. Of the general practitioners responding, 74% agree that the guidelines have resulted in more uniform treatment of their patients. Further, almost one third of the general practitioners state that the guidelines have made the treatment more effective, and one fourth state that the guidelines have improved the patients' health (Figure 5.9).

Figure 5.9

How have the guidelines for cardiovascular diseases and diabetes affected the treatment of your patients?



Note: The number of respondents is 191.

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Summary of the analysis

General practitioners report that guidelines:

- ensure uniform treatment
- provide a safer basis, ensuring that nothing is left out or overlooked
- enable them to provide the optimal treatment
- give weight to patient recommendations – a tool to support treatment
- are used for internal training and local instructions for handling patients

The general practitioners seem to know the more general guidelines such as the clinical guidelines for preventing cardiovascular diseases in Denmark and the pharmaceutical treatment guidelines for type 2 diabetes. This indicates that general practitioners do not get the full potential benefit from the research-based knowledge distributed through guidelines.

6. DEVELOPMENT OF PRODUCTS AND INTERVENTIONS, AND PATIENT-ORIENTED ACTIVITIES

Public research in the health sciences, natural sciences and technical sciences promotes the development and renewal of treatment of patients and disease prevention measures in the public health care system. It also stimulates innovation and the discoveries of diagnostic tools, medical products, clinical trials and health interventions.

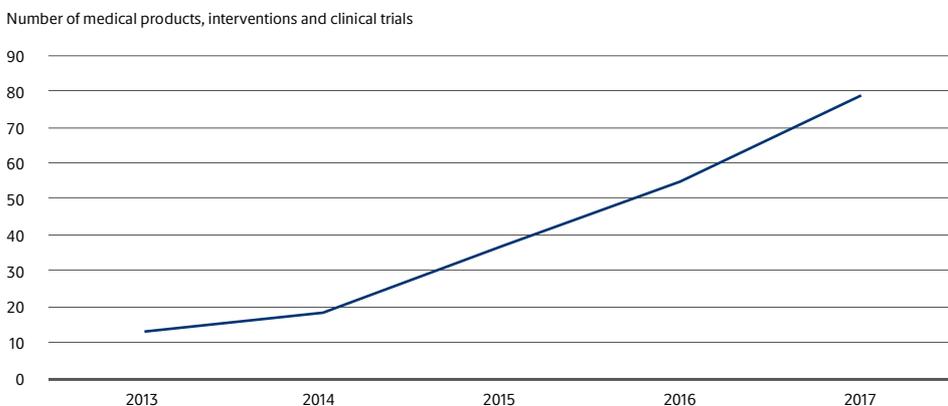
6.1 Development of products and interventions by grant recipients

The recipients of Foundation grants have reported on many new medical products, interventions and clinical trials including the development of drugs, medical devices, vaccines, diagnostic tools etc.

The recipients of Foundation grants have reported 79 medical products, interventions and clinical trials based on Foundation grants between 2013 and 2017 (Figure 6.1).

Figure 6.1

Medical products, interventions and clinical trials reported by grant recipients. Cumulative, 2013–2017



Note: The number of medical products, interventions and clinical trials is 79.
Source: Novo Nordisk Foundation/researchfish®.

6.2 Distribution of product and intervention outcomes

Therapeutic interventions comprise 69% of the medical products, interventions and clinical trials, and diagnostic tools comprise 17%. About 43% of the reported diagnostic tools are imaging tools, which include techniques or processes creating a visual representation of the interior of the body (Figure 6.2).

Figure 6.2

Diagnostic tools, interventions and other activities developed by grant recipients, 2016–2017



Note: The number of diagnostic tools, interventions and other activities is 42. Percentages do not sum to 100% due to rounding.

Sources: Novo Nordisk Foundation/researchfish*.

6.3 Examples of products and intervention outcomes

The following examples show therapeutic interventions, diagnostic tools and management of diseases and conditions that grant recipients developed in 2017. The first two examples have been awarded an Exploratory Pre-seed Grant, which funds exploration of research findings and stimulates entrepreneurship. The third example comes from a Challenge Grant, which aims to encourage and facilitate world-class research focusing on finding answers to challenges in global technology or health, and the fourth example is a nursing research grant.

Example 1

3D printed, patient-fitted, resorbable bone implants

Associate Professor Morten Østergaard Andersen and his team have developed a new method and biomaterial for creating 3D-printed implants for replacement of resected or destroyed bones. The method involves designing a 3D model of the bone-implant from a computed tomography (CT) or magnetic resonance imaging (MR) scan of the patient. Based on the 3D model, the specific bone for the patient can be 3D-printed. The bone is printed in a structure that allows room for blood vessels, nerves and bone marrow that are essential for the bone to function. The biomaterial is resorbable in the body, and the 3D bone will degrade slowly and be replaced by natural living bone.

This invention is expected to reduce the rate of complications and pain related to bone implants and reduce healthcare expenditure. The Exploratory Pre-seed Grant from the Foundation has funded a clinical trial on pigs. If the results are positive, the next step is to provide the first implants for human patients. The team has created the start-up company Particle 3D to continue the development of the technology, and Martin Bonde Jensen, another founder of the start-up, has been recognized by *Forbes magazine* for his work as a leading talent under 30 years old within science and healthcare.

Example 2

Promising treatment for nerve pain

Burning sensations, numbness, sensation of needles and problems with correctly sensing temperatures and touching. The symptoms of neuropathic pain are many. The pain can arise by damage to the nervous system caused by a disease or an accident. Current medication can only ease the experienced pain in a subset of patients, and medication has considerable side-effects.

Associate Professor Kenneth Madsen and his team have discovered mechanisms of key importance for neuronal signalling. They identified the PICK1 protein as a promising target for the development of a new therapeutic drug and developed a peptide inhibitor of PICK1: TAT-PEG4-di-DATC5 (TPD5). This invention can be a new mechanism to relieve pain without serious side-effects for patients with neuropathic pain.

The drug has proved highly efficacious in animal-trials, and the pain-relieving effect is surprisingly long-lasting. The Exploratory Pre-seed Grant has been awarded to the team to continue the development of this invention, which hopefully can lead to better and more effective treatment for people with neuropathic pain.

Example 3**Preventing damage from diabetes**

Blood vessels have a protective layer on the inside of the membrane called the glycocalyx. High blood glucose, which is common among patients with diabetes, can affect the glycocalyx and lead to damage of the small blood vessels. Changes in the composition or loss of the glycocalyx can be an early indicator of damage to the heart and kidney. The monitoring of the glycocalyx is therefore an important preventive measure for people with diabetes.

Invasive methods were the only way to measure glycocalyx integrity until recently. With the newly developed camera and software (GlycoCheck™), the thickness of the glycocalyx layer can be measured non-invasively from the small blood vessels underneath the patients' tongue.

A team led by Peter Rossing at Steno Diabetes Center Copenhagen is now assessing the camera in a trial on healthy volunteers to investigate the reproducibility and the influence of daily living conditions such as smoking and eating.

Example 4**Improved head and neck cancer rehabilitation**

Treating people with head and neck cancer involves head or neck surgery, radiotherapy and chemotherapy. Because of the site of the cancer, the treatments can affect physical and mental health and well-being as well as social functioning after treatment. An instrument is needed to support healthcare professionals in assessing people's needs to help them reduce their burden of symptoms and regain their ability to live a normal life.

Mary Jarden and her team at Dept. of Otorhinolaryngology, Head and Neck Surgery and Audiology at Rigshospitalet in Copenhagen have linguistically validated the Patient Concerns Inventory instrument developed for people with head and neck cancer in Liverpool, United Kingdom and are developing an information technology solution that is applicable to clinical practice. Further, the team is assessing the usefulness of the tool in a randomized controlled trial.

Denmark has 1,300 new cases of head and neck cancer each year, and only 68% of these people are alive 5 years after diagnosis. The project has already heightened the awareness of the complexity of the short and long-term struggles in rehabilitating people with head and neck cancer. The Foundation is supporting the project through a nursing research grant.

6.4 Activities oriented towards people with diabetes at Steno Diabetes Center Copenhagen

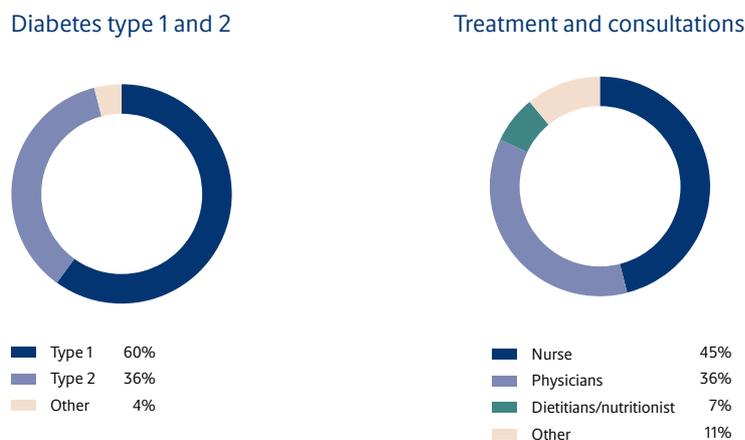
Steno Diabetes Center Copenhagen (SDCC) specializes in treating people with diabetes. The activities include endocrinological examination and diagnosis, treatment of diabetes, eye scanning and examination, podiatry, dietary guidance and courses in a food laboratory. Moreover the Center conducts substantial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

The Center was established in 2017. Until 2016, the Foundation supported Steno Diabetes Center, which treated 5,500 patients in 2016 and 5,400 in 2015.

In 2017, the Center treated 6,503 people with diabetes: 60% with type 1-diabetes and 36% with type 2-diabetes (Figure 6.3). The Center carried out 31,916 treatments and consultations in 2017. Physicians carried out 36% of the treatments and consultations and nurses 45% (Figure 6.3).

Figure 6.3

SDCC activities oriented towards people with diabetes, 2017



Note: The number of individuals with diabetes is 6,503, and the number of treatment and consultations is 31,916. Percentages do not sum to 100% due to rounding.

Source: Steno Diabetes Center Copenhagen.

7. RESEARCH-BASED EDUCATION, TRAINING AND KNOWLEDGE DISSEMINATION

The Foundation awards research and education grants, which affect the education and training of children, students and researchers (PhD students and postdoctoral fellows). Further, the Foundation targets its grants towards training, education and mentor activities of professionals, leaders and entrepreneurs.

7.1 How the Foundation's grants affect education and training

The Foundation supports research and education activities that affect education and learning in the whole education and training system. Grants promote activities for children in primary and lower-secondary schools, upper-secondary schools, bachelor and master students at higher education institutions, PhD students and postdoctoral fellows at research institutions as well as professionals, leaders and entrepreneurs at public and private workplaces. Table 7.1 summarizes the Foundation's impact in the education and training system, showing the impact patterns of the various grant instruments.

Table 7.1 The Foundation's impact in the education and training system

Target groups: organizations	Activities and impact	Type of grants
General public	<ul style="list-style-type: none"> • Media, museums, exhibitions, articles 	<ul style="list-style-type: none"> • Education, innovation and research grants
Children at primary and lower-secondary schools and upper-secondary schools	<ul style="list-style-type: none"> • Framework conditions at schools • Natural science laboratories • Education of teachers • School books and education materials 	<ul style="list-style-type: none"> • Education and outreach grants • LIFE learning centre • Education prizes for teachers
Undergraduate and post-graduate at higher education institutions and universities	<ul style="list-style-type: none"> • Research based education (teaching and supervision of PhD students, postdoctoral fellows and professors) • Research based courses, books, articles and materials • Research-based curriculum 	<ul style="list-style-type: none"> • Research grants (research centres, projects, programmes, investigator and fellowships) • Education grants
PhD students at higher education institutions, universities and research hospitals	<ul style="list-style-type: none"> • Researcher education • Research articles, research methods and research databases 	<ul style="list-style-type: none"> • Research grants (research centres, projects, programmes, investigator and fellowships) • Symposia • Conferences
Postdoctoral fellows and young researchers at higher education institutions, universities and research hospitals	<ul style="list-style-type: none"> • Researcher training • Research articles, research methods and research data bases 	<ul style="list-style-type: none"> • Research grants (research centres, projects, programmes, investigator and fellowships) • Symposia • Conferences
Professionals (nurses, medical doctors, etc.) at higher education institutions, universities and research hospitals	<ul style="list-style-type: none"> • Training • Courses • Education materials and clinical guidelines • Research articles, research methods and research databases 	<ul style="list-style-type: none"> • Research grants (research centres, projects, programmes, investigator and fellowships) • Research prizes • Symposia and conferences
Business leaders and entrepreneurs in spin-outs, start-ups and small businesses	<ul style="list-style-type: none"> • Mentor coaching, investor meetings, commercialization courses and business-to-business collaborations 	<ul style="list-style-type: none"> • Bio Innovation Institute and innovation grants • Nordic Mentor Network for Entrepreneurship, NOME (see chapter 12)

Source: Novo Nordisk Foundation.

7.2 How research and education grants affect dissemination to a wider audience

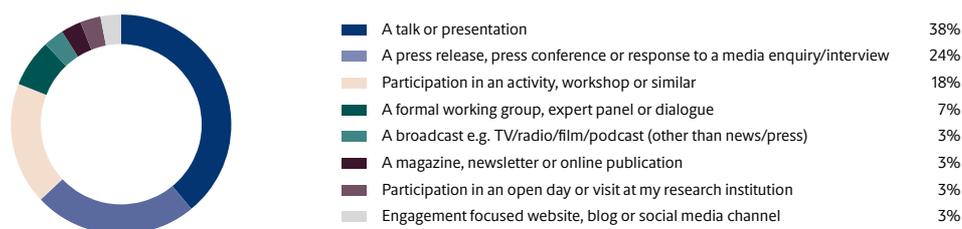
The dissemination of knowledge to a wider audience that are reported by grant recipients covers activities involving the dissemination of research results and expertise.

Figure 7.1 shows the distribution of knowledge dissemination activities in 2016 and 2017 combined. Of 1,780 activities reported in 2016 and 2017, 1,018 are from 2017. In 2016, the number of dissemination activities was 762.

Of the dissemination activities to a wider audience in 2016–2017, 38% were presentations, talks and workshops and 24% of the activities related to press releases or responding to media enquiries.

Figure 7.1

Dissemination activities to a wider audience, 2016–2017



Note: The number of dissemination activities is 1,780. Percentages do not sum to 100% due to rounding.

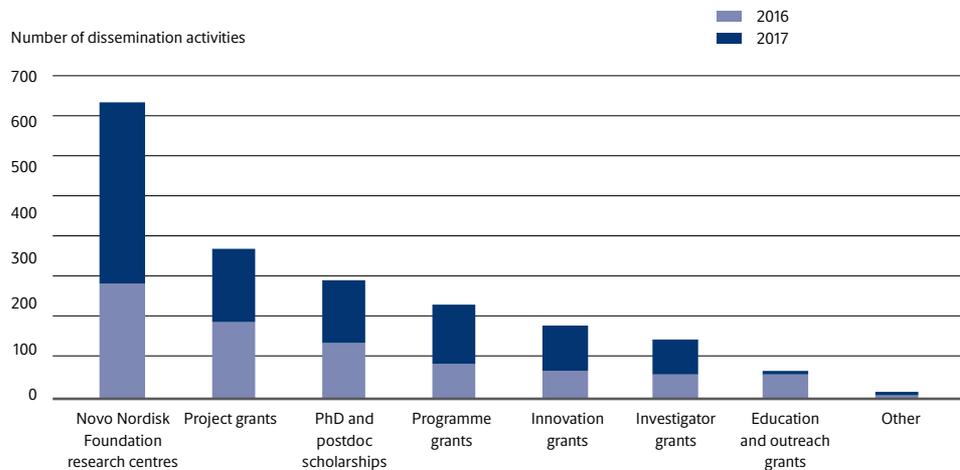
Source: Novo Nordisk Foundation/researchfish*.

7.3 The distribution of dissemination activities to a wider audience

Researchers from the Foundation's four research centres and project grants carried out 54% of all dissemination activities, with a higher proportion of the dissemination activities than all grant recipients as a whole. Both types of grants support more established researchers who are highly experienced (Figure 7.2).

Figure 7.2

Dissemination activities within the public sector by type of grants, 2016–2017



Note: The number of dissemination activities is 1,780.

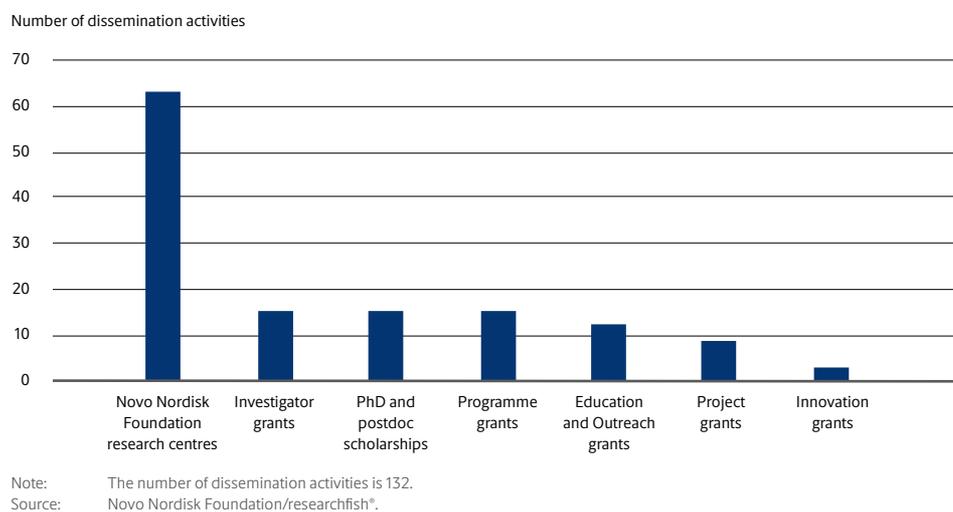
Source: Novo Nordisk Foundation/researchfish*.

7.4 Dissemination of knowledge to primary and secondary schools

About 7.5% of the total dissemination activities in 2016 and 2017 targeted primary and secondary school audiences. The distribution of activities by type resembles the distribution in the public sector in general, even though education and outreach grants are better represented than project grants and innovation grants all together.

Figure 7.3

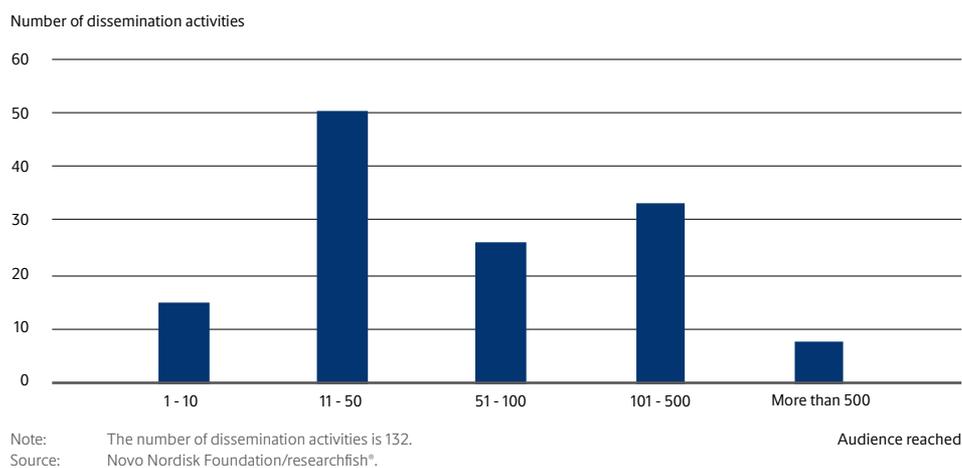
Dissemination activities to school audiences by type of grants, 2016–2017



The most common school audience for dissemination activities comprises 11–50 people, although 33 activities had 101–500 people in the audience.

Figure 7.4

Dissemination activities to school audiences by number of participants, 2016–2017



7.5 Improving framework conditions for natural science in primary and secondary schools

Grant-awarding activity targeting schools comprise support of natural science facilities at schools for children (Copenhagen International School, European School Copenhagen and Det Kgl. Vajsenhus School), the LIFE learning initiative and laboratories for children in primary schools and their teachers.

The Foundation also awards prizes to recognize and publicize extraordinary efforts in stimulating an interest in natural science for primary and secondary school audiences. The prizes include an early-childhood educator prize and four science teacher prizes: Prize for Primary Science Teachers (grades 1–6), Prize for Lower-secondary Science Teachers (grades 7–9), Prize for Upper-secondary Science Teachers (STX, HTX and HF) and Prize for Science Teachers at Teacher Colleges for educating the next generation of primary and lower-secondary schoolteachers. All prizes focus on stimulating the interest in science.

The LIFE learning initiative

In the early 2018, the Novo Nordisk Foundation established LIFE, a new major not-for-profit learning initiative, to provide science education resources free of charge to schools throughout Denmark. The Foundation aims to strengthen science learning and education in Denmark. The Foundation has awarded DKK 123 million to start the initiative in its first 2 years. Thereafter, the Foundation intends to award grants of up to a total of nearly DKK 1.6 billion to fund LIFE's activities for the following 10 years.

LIFE stands for Learn, Inspire, Fascinate and Engage. It comprises a digital platform that includes virtual laboratories and games, a building serving as a learning centre in Lyngby, and mobile laboratories designed in specially constructed semi-trailers that will travel to schools throughout Denmark. Once LIFE is fully operational, up to 100,000 children and adolescents will benefit from the mobile laboratory visits or visits to the learning centre each year. About 500,000 students are expected to be offered digital learning courses each year.

The core products and services for schools include the following:

- The learning packages include specific hands-on experiments and digital learning activities. Some also include material kits with equipment and materials that primary and lower-secondary schools and upper-secondary schools can order from LIFE free of charge. When fully operational, LIFE expects to have a portfolio of about 30 learning packages that will be continually developed, evaluated and revised or replaced with new ones.
- A digital universe comprises a web portal with access to learning material for both students and teachers and games, virtual laboratories and models that can be used in teaching.
- Ten mobile laboratories (semi-trailers) will be furnished with a laboratory staffed by LIFE employees, who will lead the experimental activity in collaboration with the class teachers. The mobile laboratories can visit all schools and municipalities, including schools that may not have modern laboratory facilities.
- A building serving as a learning centre (in Lyngby near Copenhagen) will contain modern laboratories and will serve as a visitor centre for schools. The building will be the centre of LIFE's development work and will be the physical hub for the collaboration with schools, companies, research communities and organizations disseminating science.

Target groups

- The target groups for students: grades 1–3 (primary school); grades 4–6 (primary school); grades 7–10 (primary and lower secondary school); and upper-secondary school (STX, HTX and HF).

The target groups for teachers will be those teaching the following subjects:

- Science subjects in primary and lower-secondary schools: biology, physics/chemistry, geography and mathematics.
- Natural science subjects in upper-secondary schools (STX, HTX and HF): biology, biotechnology, physics, geoscience, chemistry, mathematics and Natural geography.

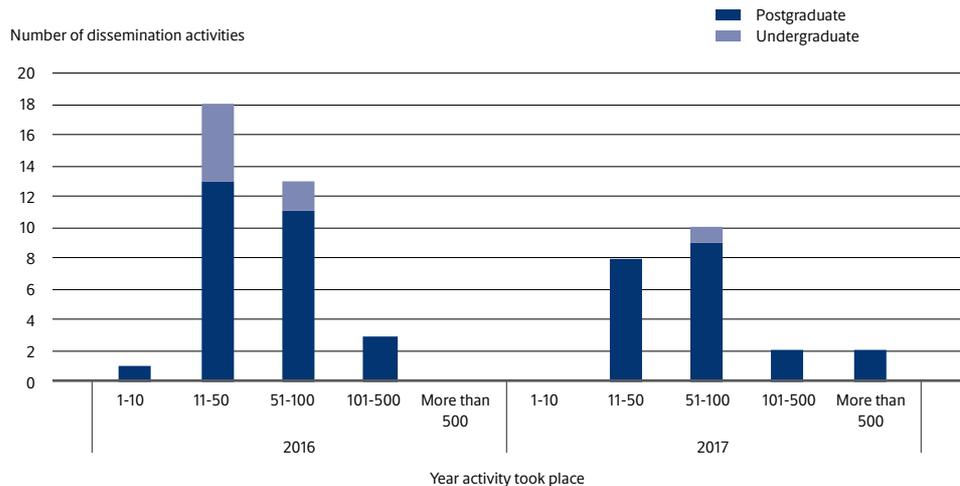
7.6 Research-based dissemination activities for undergraduates and postgraduates

Research-based dissemination targeting undergraduates and postgraduates is an important element of the impact of research in the higher education sector. These activities can be traced in both dissemination activities and courses.

Excluding courses organised by research centre scientists, the number of dissemination activities targeting undergraduates and postgraduates comprises about 3% of all the Foundation grant dissemination activities 2016-2017. In 2016, 35 dissemination activities targeted undergraduates and postgraduates, and 22 in 2017 (Figure 7.5). Most of the activities in 2016 had 11–50 participants, and most of the activities in 2017 had 51–100. Even though more activities were held in 2016, more participants were reached in 2017, with about 55–60% of the total participants in the 2 years (Figure 7.5).

Figure 7.5

Dissemination activities to undergraduate and postgraduate students, 2016-2017



Note: The number of dissemination activities is 57.
Dissemination activities does not include courses taught or organised by research centre scientists.

Source: Novo Nordisk Foundation/researchfish*.

In addition, the Foundation research centres have organised course activities for students inhouse and e-courses. The research centres have organised courses for more than 600 of their undergraduates and postgraduates, but including e-courses that are directed towards professionals as well as students, the number surpasses 11,000 for 2017.

7.7 Research-based education for PhD students

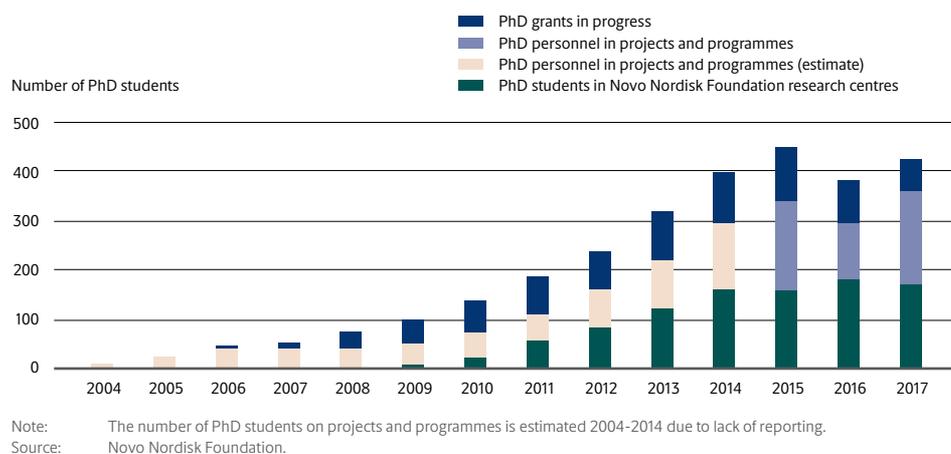
The Foundation aims to promote the development of talented researchers through various grants for research and education, such as supporting researcher education and training for PhD students and postdoctoral fellows.

Of the 743 active grants the Foundation funds, 303 (41%) supported PhD students and postdoctoral fellows working on the grants in 2017. This applies to the four Foundation research centres, research programmes and Investigator grants as well as individual PhD and postdoctoral grants.

The number of current PhD students fully or partly funded by the Foundation grants grew from an estimated 11 in 2004 to just above 100 in 2009 and further to 425 in 2017. In 2017, 63 individual PhD grants were in progress, and the Foundation's four research centres employed 171 PhD students (Figure 7.6).

Figure 7.6

Current PhD students supported by Foundation grants, 2004–2017



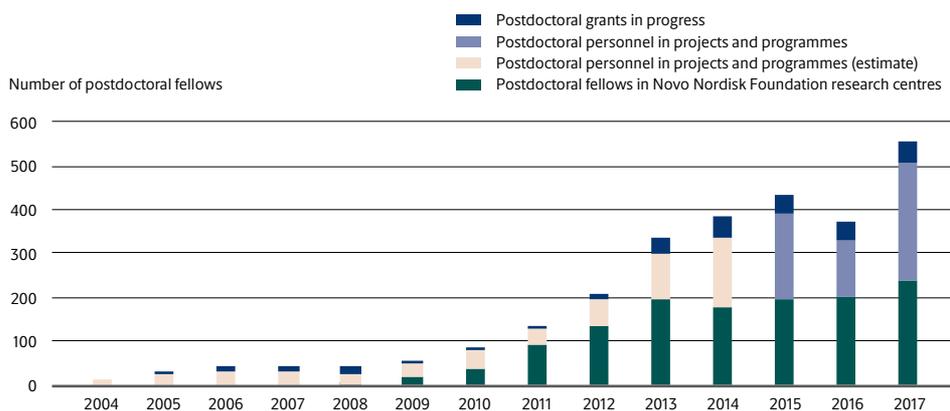
7.8 Research training for postdoctoral fellows

The number of current postdoctoral fellows (a fellowship typically lasts 1–3 years) either fully or partially funded by the Foundation grew from 11 in 2004 to 80 in 2009 and further to 555 in 2017 (Figure 7.7).

A total of 48 individual postdoctoral grants are in progress, 267 are employed full time or part time by the Foundation's project grants, programme grants or investigator grants, and the Foundation's four research centres employ 240 individuals.

Figure 7.7

Current postdoctoral fellows funded by Foundation grants, 2004–2017



Note: The number of postdoctoral fellows in projects and programmes is estimated for 2004–2014.

Source: Novo Nordisk Foundation.

Study on grants that affect and facilitate education and training of junior researchers

Foundation grants affect and facilitate training of junior researchers. Jane Bjørn Vedel, Copenhagen Business School and Andrew Webster, University of York conducted a pilot study on the Foundation's grants in 2018. The results suggest that the most significant value added of large grants derives from what these grants made possible based on the amount and duration, whereas the most important value added for co-funded PhD scholarships and postdoctoral fellowships within nursing research relates to facilitating bridge-building between nursing research and clinical practice.

Amount of the grant

The amount of grants also enables bolder research questions to be pursued, which enables the principal investigator to attract and recruit talented international candidates for PhD student and postdoctoral fellow positions. The amount of the grant enables competitive research environments to be developed, which gives the enrolled PhD students and postdoctoral fellows elite training and prepares them for future jobs.

Time horizon of grant

The time horizon (5–7 years) of the large grants enables the principal investigator to mentor PhD students and postdoctoral fellows and support them in developing their own career track. Combined with the amount of the grant, the time horizon enables projects to both investigate scientific problems in depth while also accelerate them into the clinic, which gives the enrolled PhD students and postdoctoral fellows a unique experience with different kinds of research challenges.

Flexibility of grants

The flexibility of the grant and the autonomy of the principal investigator to change directions according to what seems best means that the principal investigator can also help junior staff members to develop a balanced portfolio of research projects with a responsible risk profile, including both high-risk projects and feasible scientific problems.

Nursing research grants

The nursing research grants enable nursing researchers to develop their own research profile, establish themselves as researchers, and build bridges between new nursing research fields and clinical practices. Although these grants are small scale compared with the large research programmes, they have the potential to make significant changes in practice.

Research grants

The research grants lead to new educational practices more ways by changing curricula as a consequence of the research projects. This can involve adopting new techniques and technologies in curricula or the teaching of these by PhD students and postdoctoral fellows who are part of the research projects.

Source: Jane Bjørn Vedel and Andrew Webster 2018

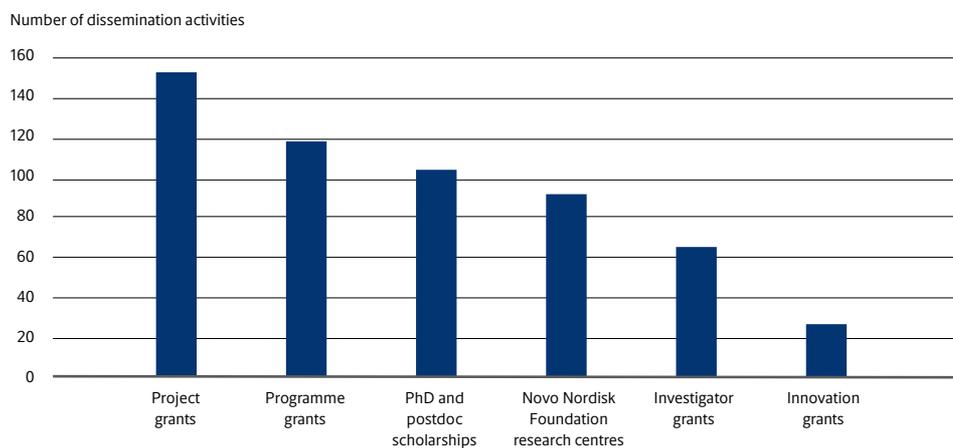
7.9 Research-based teaching activity for healthcare professionals

Research-based teaching activity for professionals is also an important part of the impact of research in the public sector, both within and beyond academia. The grant recipients of the Foundation disseminate their knowledge through courses, conferences, speeches, reports and meetings to professionals in the public sector and by contributing to training practitioners and researchers.

The Foundation's grant recipients have reported 562 dissemination activities targeting healthcare professionals. This amounts to one third of the total number of dissemination activities by the Foundation grant recipients (Figure 7.8).

Figure 7.8

Dissemination activities targeting healthcare professionals, patients, caregivers or professional practitioners, 2016–2017

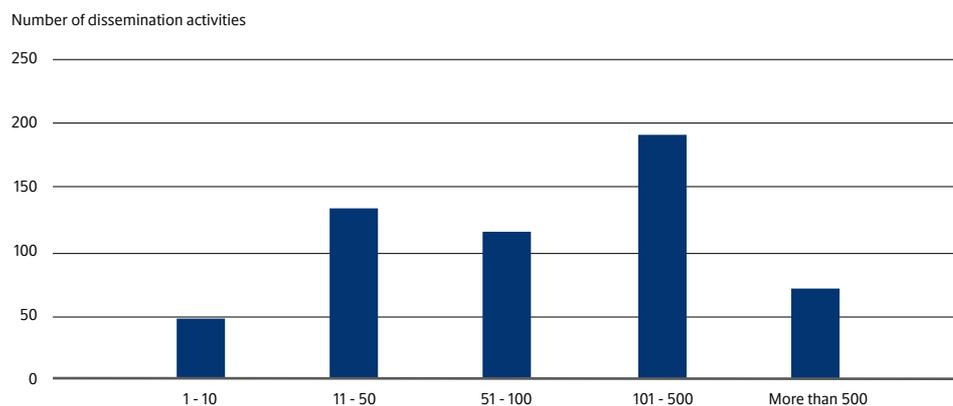


Note: The number of dissemination activities is 562.

Source: Novo Nordisk Foundation/researchfish*.

Figure 7.9

Number of participants in dissemination activities targeting healthcare professionals, patients, caregivers or professional practitioners, 2016–2017



Note: The number of dissemination activities is 562.

Source: Novo Nordisk Foundation/researchfish*.

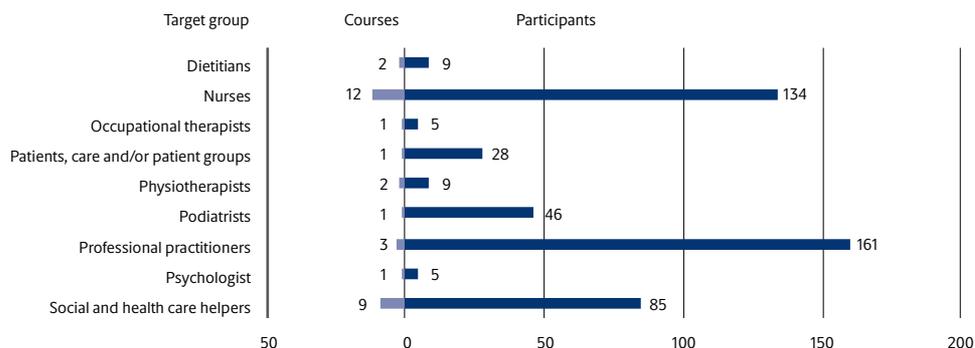
Audience reached

In Figure 5.1 (Chapter 5) it was documented that 36% of the reported contributions to practice and advisory functions are related to the training of practitioners or researchers. Both the Novo Nordisk Foundation research centres and Steno Diabetes Centers report on training as course activity for professionals.

For the research centres, e-courses organised reached almost 11,000 people in 2017. The e-course “Diabetes – a Global Challenge” organised by the Novo Nordisk Foundation Center for Basic Metabolic Research and a part of the EIT Health Campus programme had almost 4,000 people taking the course in 2017. Diabetes – a Global Challenge is a massive open on-line course. It provides the students with updated information on cutting-edge diabetes and obesity research, including biological, genetic and clinical aspects as well as prevention and epidemiology of diabetes and obesity. The course focuses on diabetes and obesity and especially target healthcare professionals such as doctors and nurses followed by BSc, MSc or PhD students.

Steno Diabetes Center Copenhagen organised several courses in 2017 for almost 500 healthcare professionals covering: dietitians, nurses, occupational therapists, caregivers and/or patients, physiotherapists, podiatrists, professional practitioners, psychologists, and social care and healthcare workers (Figure 7.10).

Figure 7.10 Courses organised for healthcare professionals by target group at SDCC, 2017



Note: If more than one target group participated in a course, the shares of participants are equally shared.

Source: Novo Nordisk Foundation/researchfish®.

REACH and STAR – education and training for professionals

The Steno Diabetes Center established the Steno Training and Application of Resources (STAR) training programme in 1999 targeting primarily physicians and nurses but also dietitians and psychologists in several low- and middle-income countries. The STAR training programme has primarily comprised theoretical symposia and, to a lesser extent, workshop-based courses in practical diabetes treatment. A total of 10,787 healthcare professionals, mostly physicians and nurses, participated in the training during the project period.

In 2013, the education portfolio was expanded with the Steno-REACH programme, which included establishing a teaching satellite in Malaysia, developing a training course with mixed learning of about 50 hours combined with workshops and clinical implementation for physicians, nurses and dietitians. The Malaysian Ministry of Health has accredited the programme, in which 143 physicians, nurses and dietitians participated.

The Steno STAR and REACH education programmes were phased out in 2016. A 2014 study evaluating the effects of the STAR programme 6 months after the training courses found that daily clinical practice reaped specific benefits associated with the training in teamwork, interaction and communication between teams and with patients.

Preliminary data from an ongoing detailed evaluation of the REACH programme show that participants increased their knowledge between 15% and 20%. The largest increase was observed among nurses. For physicians, competencies mostly improved in relation to patient communication and patient self-care as well as screening for complications. Among the nurses, competencies improved in general counselling about self-care, pharmaceutical counselling and screening for complications. Further, training participants in general have indicated that they feel better equipped to handle the treatment of people with diabetes and are better at identifying people at risk.

8. INVESTIGATING THE OUTCOMES AND IMPACT OF THE CLINICAL SCIENTIST FELLOWSHIP

The Novo Nordisk Foundation introduced the Clinical Scientist Fellowship around 2000 in response to very limited options for clinicians to perform research during regular hours by funding the hiring of a replacement physician to fill in the gap at the clinic.

Senior physicians (medical consultants) in hospital clinics who perform research differ from other public researchers. Their primary responsibility as clinicians is to diagnose and treat patients, and they have limited time to explore issues themselves or collect evidence, and to adopt new therapeutic methods. Absorbing research-based knowledge and translating that knowledge into treatment is imperative for a hospital clinic. The clinicians' own research comes second and after regular hours unless external funding can relieve the physicians from time in the clinic to work on their research.

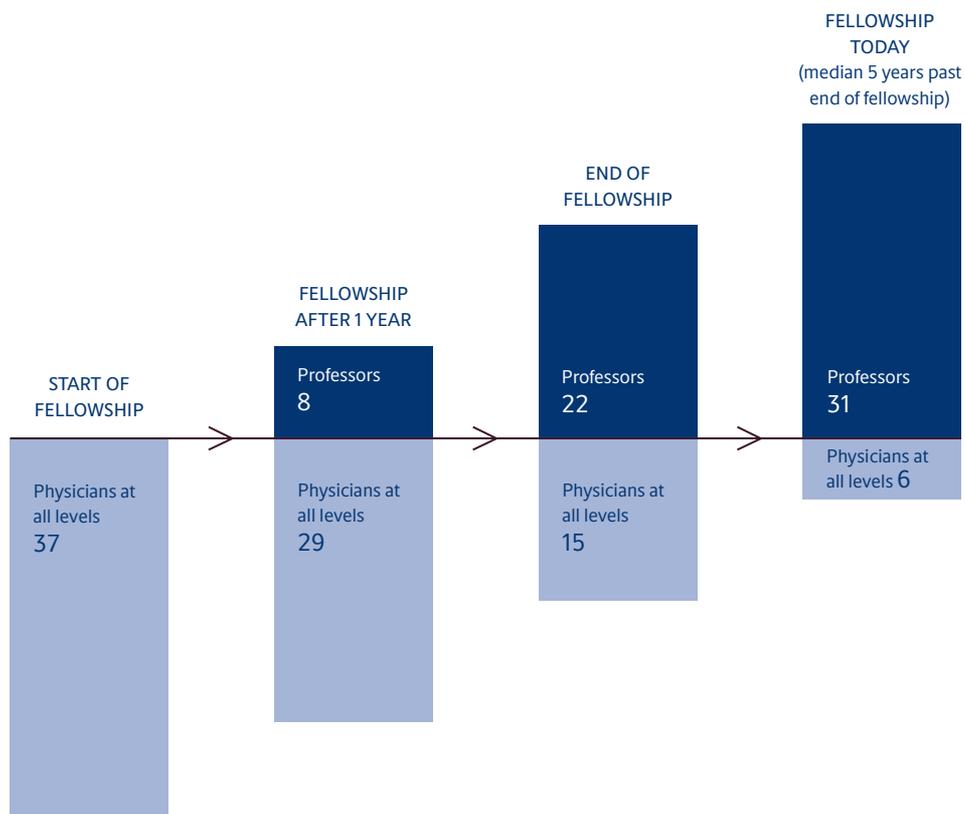
In total, the Foundation has awarded DKK 212 million for 78 fellowships in Denmark between 2000 and 2017. This chapter focuses on 37 fellows granted a 3 to 5 year fellowship between 2000 and 2012 who completed their fellowship between 2003 and 2017. The analysis demonstrates that the Clinical Scientist Fellowship programme has supported excellent researchers, many of whom earned professorships (see Figure 8.1) and carried out activities that benefited their clinic, the healthcare system and the research community.

The fellowship programme

The primary objective of the Clinical Scientist Fellowship is to fund clinicians to perform excellent research regardless of affiliation and field of medicine but with clear relevance to patients and human health. The Foundation states to prospective applicants that *“topics include, but are not limited to, patients and disease-related research, translational and clinical research, research in disease mechanisms, treatment methods, disease trajectories, epidemiology, diagnostic methods, public health and family medicine, intervention studies, registry-based research, proof-of concept studies, pilot projects, clinical trials and clinical testing.”*

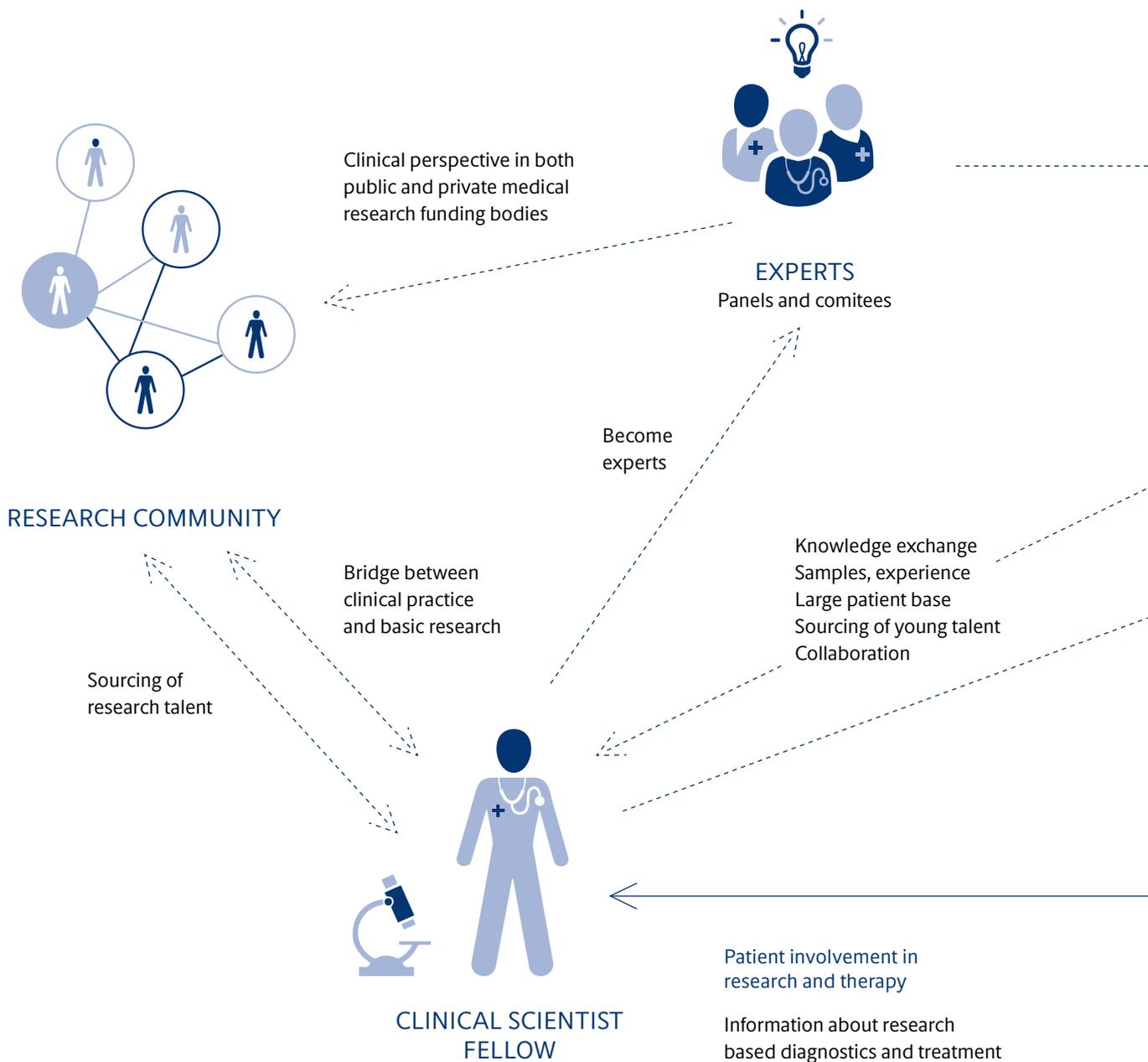
Figure 8.1

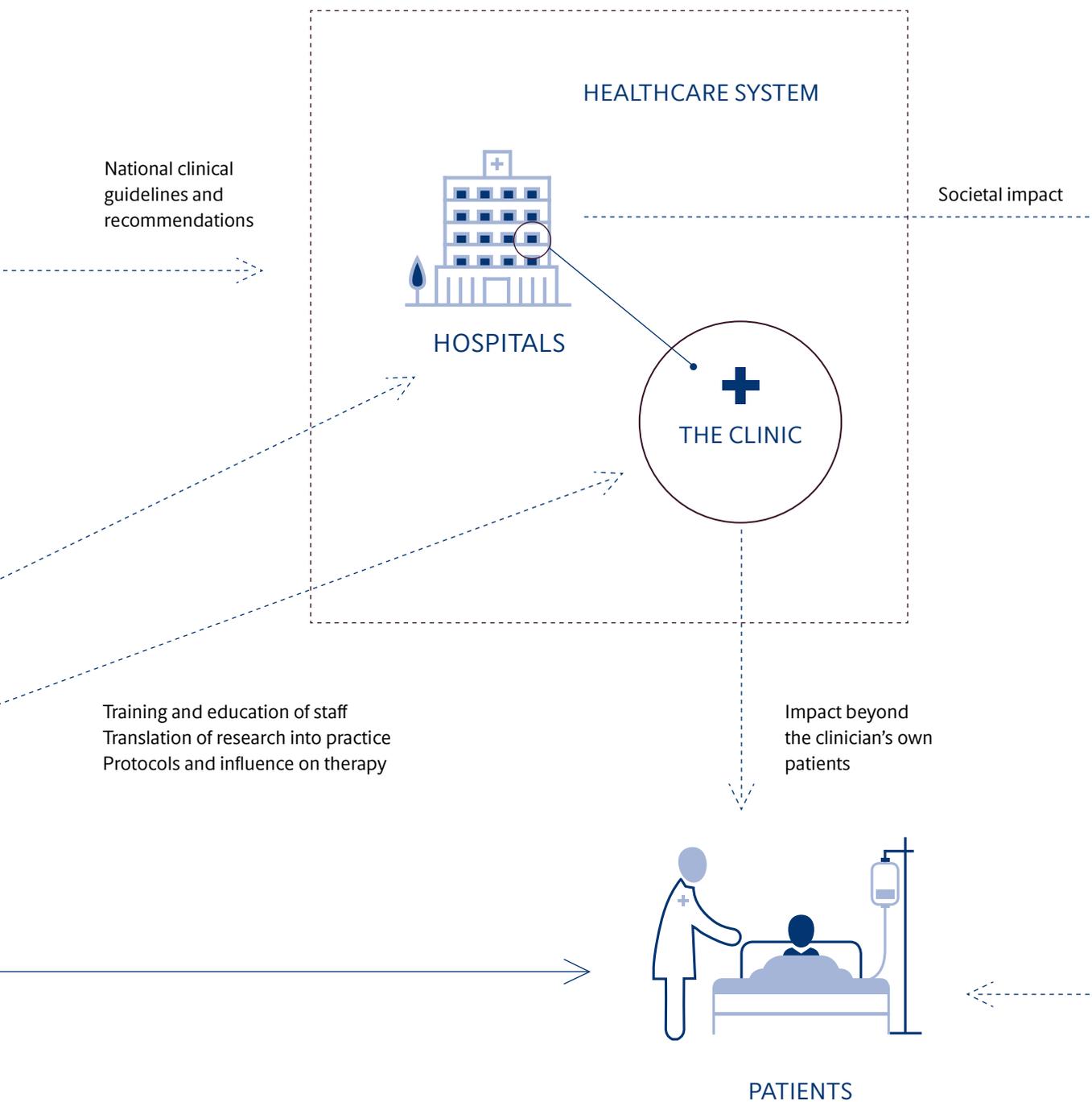
How many clinicians earned a professorship after receiving a Clinical Scientist Fellowship from the Foundation?



Note: Fellowships granted in 2000-2012 and completed in 2003-2017.
Source: Novo Nordisk Foundation.

A bridge between practice and research





8.1 The fellows and their fellowships

From 2000 to 2017, the Foundation awarded 107 fellowships to 83 researchers: 29 fellowships were awarded to researchers at Nordic host institutions outside Denmark, and 78 fellowships were awarded to researchers at Danish host institutions.

Of the 78 fellowships in Denmark, 37 have concluded their fellowships and are included in the sample analysed. The limitation ensures the conformity of the analysed fellowships. Additional information beyond compulsory project reporting and application data was included through a survey. Of the 37 fellows analysed, 33 responded to the survey. These 33 fellows and their fellowships are also representative for the 78 fellowships.

Table 8.1 Characteristics of the fellowships awarded in Denmark

	Full sample	Analysed sample	
		Finalized fellowships	Survey answers
Number of fellowships	78	37	33
Age in years: minimum (average) maximum	41 (50) 64	41 (49) 62	41 (49) 62
Women, share of fellows	24%	24%	24%
Funding range	MDKK 1 to 5	MDKK 1 to 2.5	MDKK 1 to 2.5
Funding period	3 to 5 years	3 to 5 years	3 to 5 years
Proportion with 5-year funding	82%	81%	81%

Note: A few prematurely ended fellowships in the full sample were excluded since they were too small (about DKK 200,000).

Source: Novo Nordisk Foundation.

Of the 37 fellows investigated, 30 were already chief physicians at the time the grant was awarded. During the first year of the fellowship, nine fellows earned a professorship. When the fellowship ended, 22 were professors (Figure 8.1).

The resulting topics of the successful fellowships have great diversity. The 37 fellowships had 28 different topics. Seven of the 37 fellowships covered various aspects of diabetes (Figure 8.2).

Figure 8.2

Research topics covered by the fellows

Diabetes and pregnancy Liver diseases
 Prevention of stroke Hand eczema Disease process
 DBS-treatment of Parkinson's Personalized medicine Multi-system-diseases Liver cancer
 Blood cancer diagnostics precision HIV Fat burning Diabetes Blood cancer treatment
 Cognitive impairment after surgical operations Cardiovascular diseases Migraine
 Muscle loss from aging Obesity and pregnancy Psoriasis Nerve degeneration
 Cancer Genetics of Dementia Cartilage injury HIV - quality of life Thyroid disease
 Chronic diseases and complex cardiovascular diseases Incontinence

Sources: Novo Nordisk Foundation and COWI.

During a fellowship, a research team on average involved 15 different team members, though not necessarily full time or for the entire fellowship (Table 8.2). The fellows especially attracted postdoctoral fellows and PhD-students to their research teams but also physicians specializing in a certain field and technicians.

Table 8.2

Number of team members working on fellowship-funded research (based on 37 concluded fellowships)

	Number of people
Specialised physicians	89
Other scientific personnel	52
Nurses	27
Technical staff	56
PhD students and postdoctoral fellows	148
MSc and BSc students	111
Other personnel	12
Total number of people	495
Average number per fellow	15

Sources: Novo Nordisk Foundation and COWI.

The fellowships are somewhat geographically concentrated. The *Department of Haematology* at Rigshospitalet in Copenhagen has six current or former fellows who have received eight fellowships in total from the Foundation since 2000. Other university hospitals have also benefited from several fellowships from the Foundation over the years, such as *the Department of Medicine* at Aarhus University Hospital and *the Department of Endocrinology* at Odense University Hospital.

8.2 Motivational factors for applying

Research practices at clinics both within and across hospitals in Denmark vary. In some clinics, several clinicians perform research continually, whereas in other clinics research occurs more sporadically. This could result from differences in management and individual preferences. To sort out the main drivers behind the decision to apply for a fellowship, the surveyed fellows were asked to indicate the role of their management in the application process and to indicate their personal motivation from a set of predefined options.

- **Personal motivation to apply**

The fellows were personally motivated by more time to do research (32 of 33 fellows) and the possibility to be a research leader (26). Half the surveyed fellows (17) highlight professional development as physicians as a motivating factor, whereas the possibilities of advancing within the healthcare system (10) and migrating to a research institution later on were less commonly highlighted (4). No one highlighted the pursuit of private research leader careers as a motivating factor.

- **Management was supportive but not the motivational driver**

The clinic management was generally supportive but a passive voice. Of the 33 fellows surveyed, two felt obligated to the management to apply for a fellowship. The management encouraged four to apply for a fellowship. However, the vast majority (30) of the fellows agree that they were the initiators and the decisive party in applying and the management supported their decision to apply.

8.3 Academic outcomes of fellowships

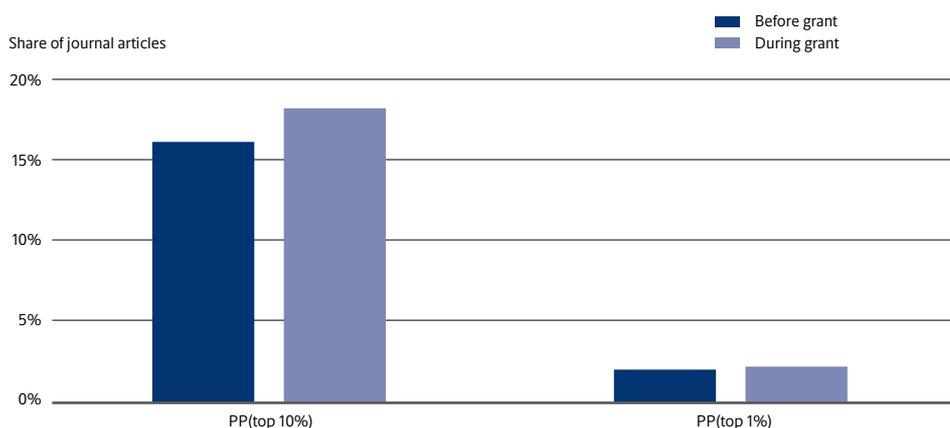
Of the 37 fellows, one was excluded because of insufficient coverage of his publication record. The other 36 fellows published 1,249 journal articles during their fellowship corresponding to 39% of their total career number of journal articles.

During their fellowship, the fellows published an average of 35 articles in 398 journals. Of these journals, the 10 most common journals contained 21% of the 1,249 journal articles. The fellows most frequently published in *Diabetes Care*, *PLoS ONE*, *Journal of Clinical Endocrinology and Metabolism*, and *AIDS*. The fellows also published articles in prestigious journals such as *Science*, *JAMA – Journal of the American Medical Association*, *The Lancet*, and *New England Journal of Medicine* with high journal citation scores, though less frequently.

Before receiving the fellowships, the fellows all had published journal articles. Of all journal articles, 16.2% were among the world's 10% most frequently cited articles within their field. During their fellowship, they increased that share to 18.3%, a statistically significant increase (Figure 8.3). Since the fellows were already experienced researchers with extensive publication records, this could indicate that offering substantial time to do research supported the further development of their research careers. The field-normalized citation scores, as used here, ensures benchmarking of the fellows against their relevant peers, implying that they improved their research publication performance.

Figure 8.3

Citation impact of journal articles before and during the grant



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

8.4 Wider impact of the fellowship

Because the fellows bridge research and clinical practice, they are in close contact with a variety of people including patients and their relatives, healthcare professionals and administrators, and the research community. Three subsections in section 8.4 highlight activities occurring during the grant, the impact on therapy (diagnostics and treatment) and short-term patient-oriented outcomes attributed to their research.

Activities during the grant

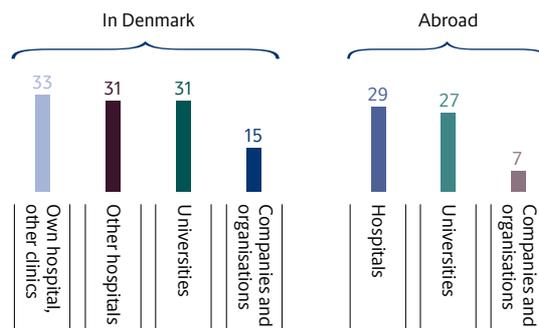
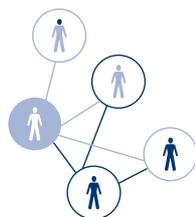
The fellowship offers the opportunity for in-depth research in a field. This induces comprehensive screening of research literature as well as exposure to and exchange of knowledge through collaborations with researchers and physicians. All fellows report that they have collaborated with other departments at their hospital, and the vast majority have collaborated with other hospitals and universities in Denmark and elsewhere (Figure 8.4).

The fellows actively disseminated the knowledge (knowledge spillover) gained from their research through presentations at department meetings and by using the knowledge for educating and training staff.

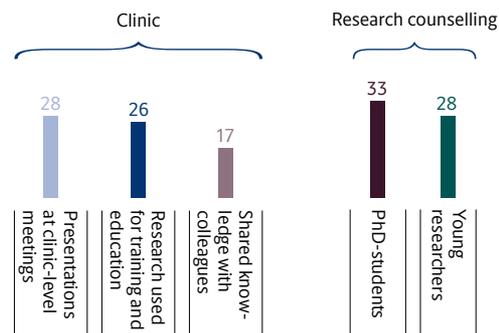
All 33 surveyed fellows report that their work was disseminated at conferences and through peer-reviewed publications, and 24 of the 33 fellows also used other types of publications than peer-reviewed publications. Half the fellows state that their publications contained best-practice advice, and 18 fellows were aware of having been cited in clinical guidelines and treatment guidelines. Finally, 20 of the 33 fellows report having debated in relevant professional or policy circles.

Figure 8.4 How many of the 33 surveyed fellows reported various types of activities?

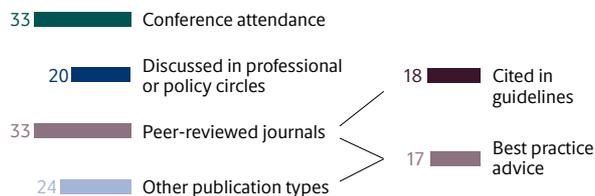
Collaborations



Local knowledge spillover



Knowledge dissemination



Impact on therapy: diagnostics and treatment

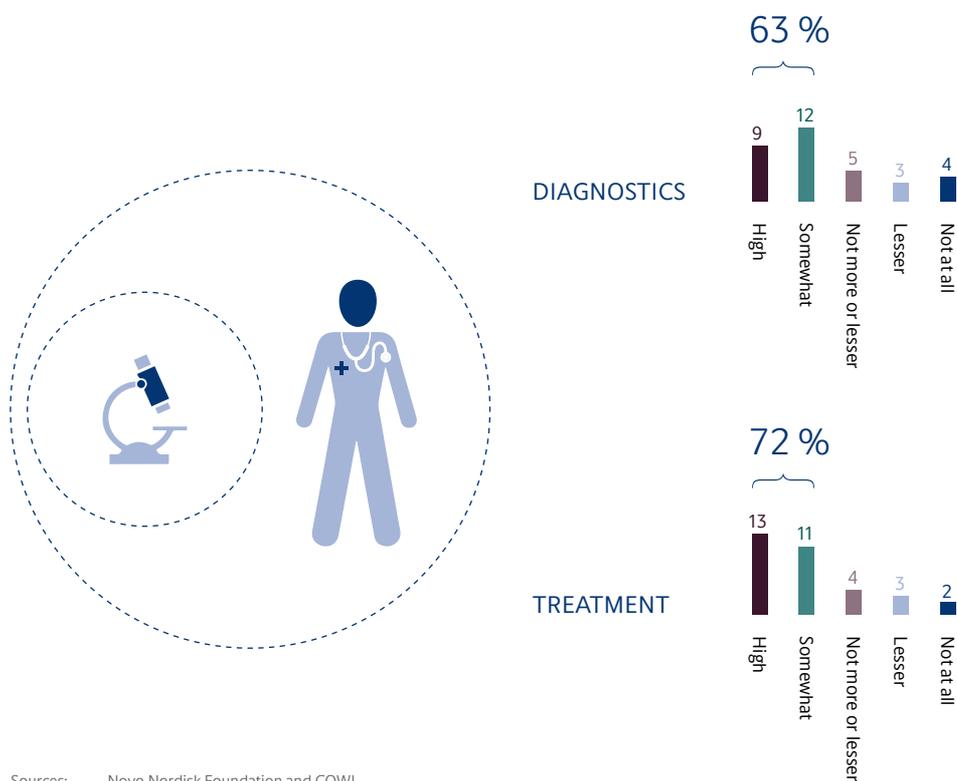
The fellows were asked to what extent they would assess that their research had been translated into stronger practice at the clinic in relation to diagnostics and treatment. Most of the fellows can assess how the research activity improves diagnostics and treatment, contrary to assessing patient-oriented outcomes (presented and discussed in the subsequent section). The key difference between assessing impact on therapy and assessing impact on patient-oriented outcomes is that assessing the impact on diagnostics and treatment decisions is observing changes in action. Patient-oriented outcomes, in contrast, are more subtle, and fewer common denominators exist across the research and fellowship activities.

Of the 33 fellows, 24 (72%) assess that their research to a high degree (13) or to some degree (11) had been translated into better treatment at their clinic. Two fellows (6%) reported impact to a minor degree and 3 fellows (9%) found no impact at all (Figure 8.5).

Clinicians devote some of their work time for screening relevant material for advances in diagnostics and treatment, and some also carry out research occasionally, but usually not at the same scale as a Clinical Scientist Fellowship would offer. Advances in treatment and diagnostics will therefore be implemented somewhat regardless of whether a fellowship is available. The results suggest that substantial funding of clinicians resulting in frequently cited research promotes advances in therapy within their clinics.

Figure 8.5

To what extent has the fellowship, in the fellow's opinion, been translated into better diagnostics and treatment?



Patient-oriented outcomes

The fellows reported that their research influenced four patient-oriented outcomes: fewer side-effects, fewer complications, improved general well-being and less hospitalization.

The responses were not uniform, especially in the implementation lag (time to achieve impact) and the degree of translation into practice.

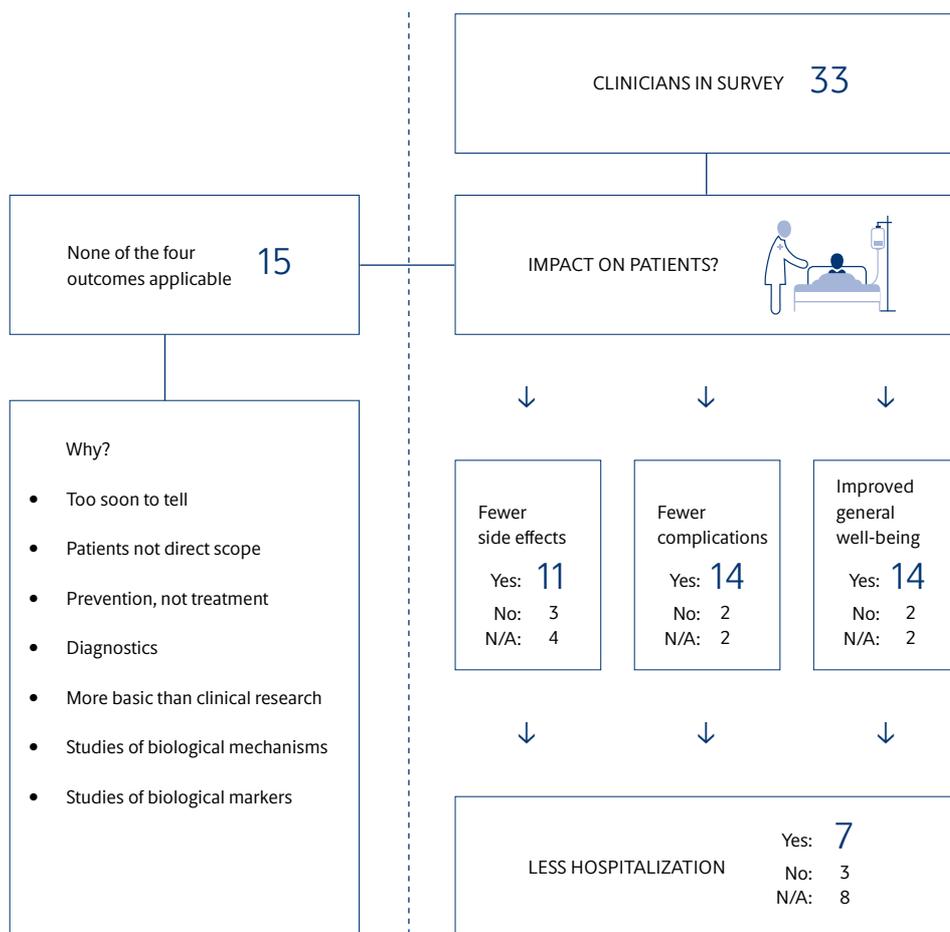
Of the 33 fellows asked, 15 replied “not relevant” to all four types of patient-oriented outcomes (Figure 8.6). One example is Professor Won Yong Ki, Aarhus University Hospital, who was a fellow in 2008–2012. He investigated the prevention of strokes caused by hardening of the neck arteries.

The remaining 18 of the 33 fellows found at least some of the four patient-oriented outcomes relevant. Hospitalization differs from the other outcomes. Professor Tove Agner, University of Copenhagen and Bispebjerg University Hospital, studied preventing and treating hand eczema as a fellow. Her studies drew attention to prevention in the field and led to national clinical guidelines, international guidelines and patient training. Side-effects and hospitalization were not relevant outcomes in this case, but less complications and improved general well-being were.

Finally, of the 18 fellows reporting impacts, 14 fellows reported patients experienced fewer complications, 14 reported improved general well-being, and 11 reported fewer side-effects. Of these seven reported less hospitalization.

Figure 8.6

Patient-oriented outcomes



Sources: Novo Nordisk Foundation and COWI.

Meet Head of Department

Lars Kjeldsen

Research attracts talent
and enriches the academic
culture at the clinic

If your primary objective is to treat patients, why say yes to research and do you try to influence the topics?

I know that many people try to exert some control over the research activity. I believe it is important for individuals to thrive. There is a sort of scouting spirit to the field of haematology. It is full of dedicated people. If they want to pursue a certain research topic for 1–2 days a week, and if they can find the funding to do part-time research, then that is okay with me.

Does the research add value to your department?

It definitely adds academic value. Years might pass between discovering something through your own research and actually implementing it in the clinic. We believe that research is important but cannot infer the quality or applicability in advance. The atmosphere and the talent that hosting research brings to the department is very valuable. Looking past disease-specific knowledge or competencies, the professional environment is at a higher level and better quality. It really adds something to the way of thinking and the way of dealing with clinical and patient-related matters.

Does a Novo Nordisk Foundation Clinical Scientist Fellowship offer you anything?

Yes, it offers a range of benefits. The new fellowship of DKK 5 million for 5 years not only pays to temporarily fill the senior physician's post but also offers DKK 2.5 million for direct operating expenses – really good! The funding of a physician to replace the fellow is not specified. Here I try to recruit young talented people who are interested

in research. We thus screen for suitable future candidates while filling in the gap in the clinic. So research fellowships benefit not only the fellow but support knowledge and recruitment channels within the department.

Are there any challenges related to receiving fellowships?

Saying yes to fellowship-funded research implies limiting the senior capacity for therapy in the department. A replacement is less experienced. We are approaching a level of research where I have to think about hiring more senior physicians without knowing whether research funding in the coming years will be as high. That adds vulnerability to the budget. Second, I also need senior physicians who want to be full time clinicians and excel in that demanding and crucial discipline.

Is external funding important for your department to conduct research?

Yes, because Rigshospitalet has limited internal funding that is mainly for young physicians for short-term projects, PhD projects and the like. Part-time research positions for long-term projects and senior physicians are limited. Everyone externally funded by fellowships or on fellowship-like terms is a senior physician. Four of them, Kirsten Grønnebæk, Henrik Sengeløv, Kim Theilgaard-Mönch and Carsten Niemann, have 5 years of funding through the Novo Nordisk Foundation, and others have about 3 years of funding from different and often multiple sources.

Were it not for the Novo Nordisk Foundation, I can only imagine that conducting continuous research at the department would be tough.



Lars Kjeldsen

- Employment:** Department of Haematology at Copenhagen University Hospital, Rigshospitalet
- Academic titles:** MD, DMSc
- Positions:** Head, Department of Haematology, 2008–
- Background:** Lars is primarily a researcher by background, growing his career under the supervision of the acclaimed researcher and haematologist, Niels Borregaard, Head of the Department of Haematology, 2001–2008. He gradually assumed managerial responsibility before replacing Niels in 2008.



Kirsten Grønbæk

Employment: Department of Haematology at Copenhagen University Hospital, Rigshospitalet

Academic titles: Professor, MD, DMSc

Positions: Chief physician at Department of Haematology
Research leader for the Grønbæk-group at Biotech Research & Innovation Centre, University of Copenhagen

**Novo Nordisk Foundation
Clinical Scientist Fellow:** 2005-2010, 2013-2018

Expertise: Myelodysplastic syndrome, epigenetics, mantle cell lymphoma biology, translational medicine

Research: Translational epigenetics in haematological cancer

Meet Clinical Scientist Fellow

Kirsten Grønbæk

Bringing together
clinical practice
and basic research

Tell us how your research career took off.

I had been a researcher with the Danish Cancer Society for 7 years when Niels Borregaard was Head of the Department of Haematology at Rigshospitalet from 1998 to 2008. He contacted me in 2003 regarding a position at his department in which I could both carry out research and work as a clinician. I was and am a physician; I am fond of both clinical work and research.

I would not, in the long term, have become a researcher had I not received the fellowship.

Why was it so important for you to obtain a fellowship and carry out research?

I wanted to perform research and I wanted to become a better clinician. Back then, we did not know as much about the molecular characteristics of most cancer diseases. I witnessed all the challenges we were facing and knew that we had to understand the biological background. I believe that thorough knowledge about the molecular mechanisms of disease is essential for improving the outcome of treatment for people with cancer.

Has your clinic benefited from your research?

I think so! I am not the only one working on genetic stratification to find markers for diseases that will probably evolve in the future in a patient. Getting involved in research brings therapy to the edge. I believe that having someone who understands both the clinic and the research is important. I use most of what I learn from research in the clinic and vice versa.

What is your strength?

Building bridges between basic research and the clinical practice. I translate basic research into treatment and diagnostics, but I also translate the needs in the clinic into the demand for new research. Cancer research often involves both basic researchers on the one side and clinicians on the other side. These are two different worlds, and I walk in both. Acknowledging the complexity and the challenges that the other part is facing is sometimes lacking, and mutual respect is needed to succeed. By understanding both sides, I hope I can facilitate the interaction between basic and clinical research to benefit the patients.

KEY FINDINGS IN PART 4

Part 4 focuses on grant recipient research that reaches the private sector and includes quantitative analysis, survey analysis, and case studies.

- Recipients of Foundation grants collaborated in 2017 with 266 companies in 351 collaborations. 74% were non-Danish companies and 26% were Danish companies

- Industrial researchers co-authored 11% of Foundation-funded journal articles

- Recipients of Foundation grants reported 115 patent applications and 13 patents between 2013 and 2017

- In the past 20 years, 980 (1 of 16) journal articles of grant recipients are cited in 2,114 distinct patent applications or patents
 - A journal article by a grant recipient takes on average 6 years (median 5 years) to be cited in a patent application and 9 years to be cited in a granted patent

- 27 of 137 surveyed Danish research-active companies have collaborated with grant recipients and have the following characteristics:
 - 85% of the companies have ongoing collaborations with public researchers for several years
 - 44% of the companies, which have collaborated with grant recipients are engaged in basic research activities, 93% in development activities, and 100% in applied research activities
 - Among the highly motivational factors for collaborating and co-publishing with public researchers are the following:
 - 50% of the companies indicate strengthening competencies through co-publishing activities
 - 44% of the companies indicate dependence on research collaboration with public researchers

Part 4

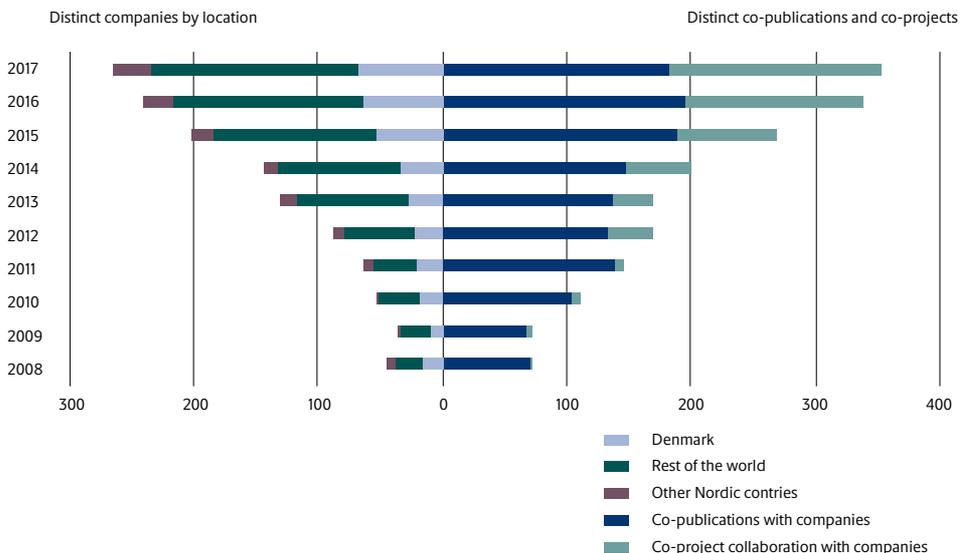
Dissemination and use of
knowledge within the private sector



9. DISSEMINATION AND USE OF KNOWLEDGE IN COMPANIES COLLABORATING WITH THE RECIPIENTS OF FOUNDATION GRANTS

Investing in public research has socioeconomic effects on society. These effects are translated through many different channels, such as collaboration between universities and companies, use of public research results in companies' patents, and spin-outs from public research. One transmission channel from public research to the private sector that can be documented is research collaboration projects. A second channel is journal articles co-authored by academia and companies. The third and fourth channels are references to journal articles in private patents, and spin-outs from public research. This chapter identifies the dissemination and use of the journal articles and other research results from recipients of Foundation grants in private companies.

Figure 9.1 Number of distinct companies, by location, company co-publications with grant recipients, and number of distinct collaborations between companies and grant recipients, 2008–2017



Note: 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 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.

9.1 Characteristics of the collaborating companies

Figure 9.1 presents the number of companies collaborating or publishing with grant recipients (left side), and the number of journal articles by the recipients of Foundation grants, co-authored with industrial researchers, and the number of active project-collaborations that have not co-published (right side).

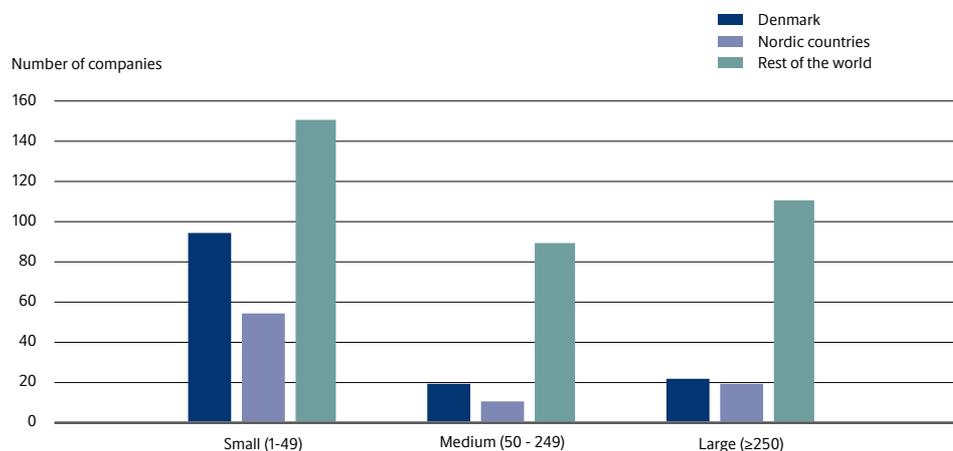
The numbers of co-publications between grant recipients and industrial researchers from 2008 to 2017 and active project-collaborations with private companies have grown vastly. The number of companies collaborating with grant recipients was 266 in 2017. The collaboration with companies outside Denmark has grown the most in recent years.

9.2 Collaborating companies by size and industry

Grant recipients primarily work with small companies within all categories (Denmark, Nordic countries and the rest of the world) measured by the number of employees. Medium and large collaborating companies are mainly located, as outside the Nordic countries (Figure 9.2).

Figure 9.2

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



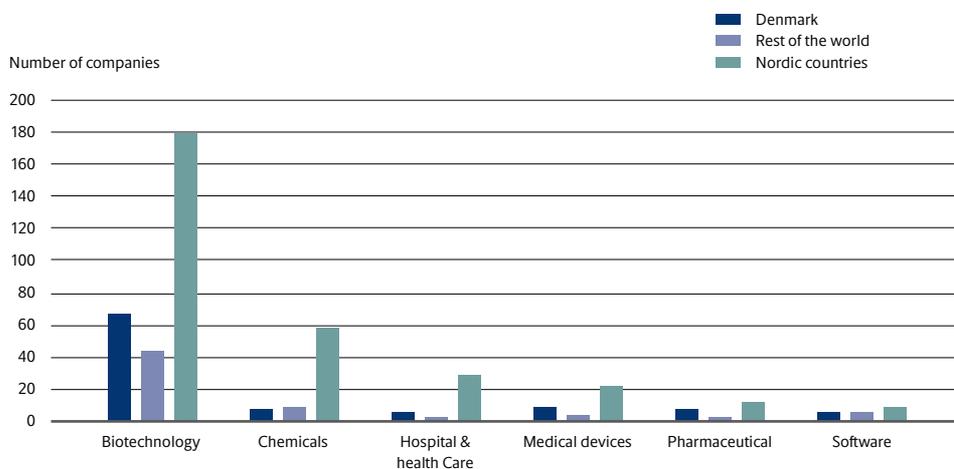
Note: Time period: 2000-2017.

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 266 biotechnology companies and 71 pharmaceutical companies collaborated with grant recipients in 2008–2017 (Figure 9.3). The Danish companies are primarily within the industries of biotechnology and hospitals and healthcare, and the non-Danish companies are primarily within the industries of biotechnology and pharmaceuticals, but some are within software and hospital & healthcare.

Figure 9.3 Companies collaborating with the recipients of Foundation grants by industry



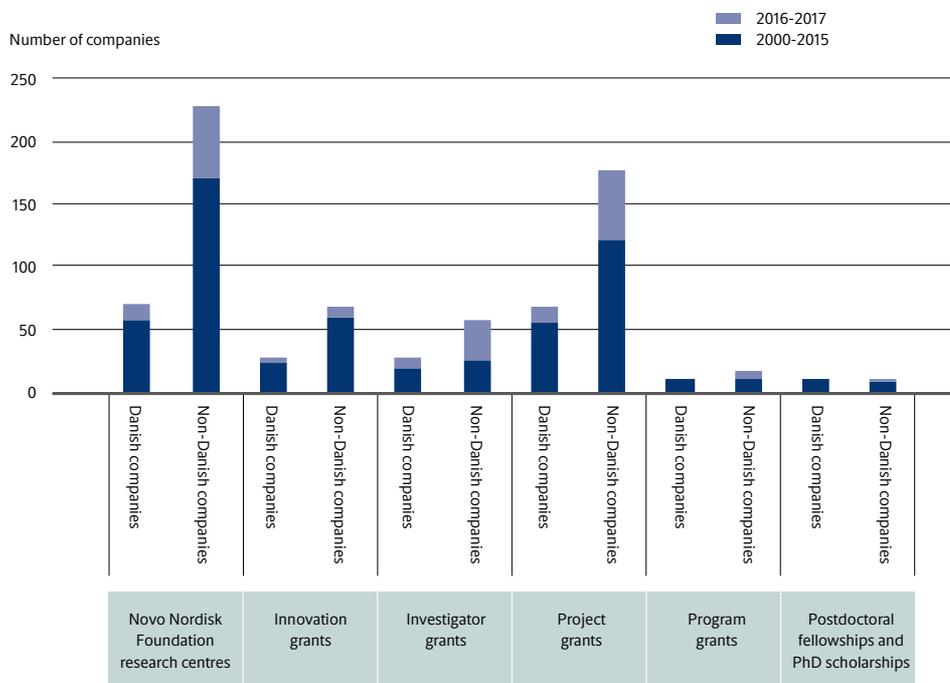
Note: Time period: 2000-2017.
The categories of industries follows the international standard classification codes.

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

9.3 Collaborating companies by types of grants

From 2000 to 2017, the Foundation's research centres have collaborated with 297 distinct companies and the recipients of project grants have collaborated with 245 distinct companies (Figure 9.4).

Figure 9.4 Companies collaborating with the recipients of Foundation grants by types of grant



Note: Time period: 2000-2017.
The number of companies are distinct for each grant.

Source: Novo Nordisk Foundation/researchfish*.

9.4 Co-authored journal articles by recipients of Foundation grants

The data used in this section cover journal articles for grant recipients between 2000 and 2017. Table 9.1 shows that 11% of the publications are co-authored with companies. About half of these co-publications were co-authored by industrial researchers in Denmark.

Table 9.1 Co-authored journal articles by the recipients of Foundation grants according to the type of collaboration

	Number of articles	Share of articles
Total articles based on the Foundation's grants	15,785	100%
Articles only co-published with academia	14,014	89%
Articles in collaboration with one or more companies	1,771	11%
Articles in collaboration with Danish companies only	838	5%
Articles in collaboration with non-Danish companies only	855	5.5%
Articles in joint collaboration with both Danish and non-Danish companies	78	0.5%

Note: Time period: 2000-2017.
The total number of publications differs from section 2.1 because these data cover a different time period.

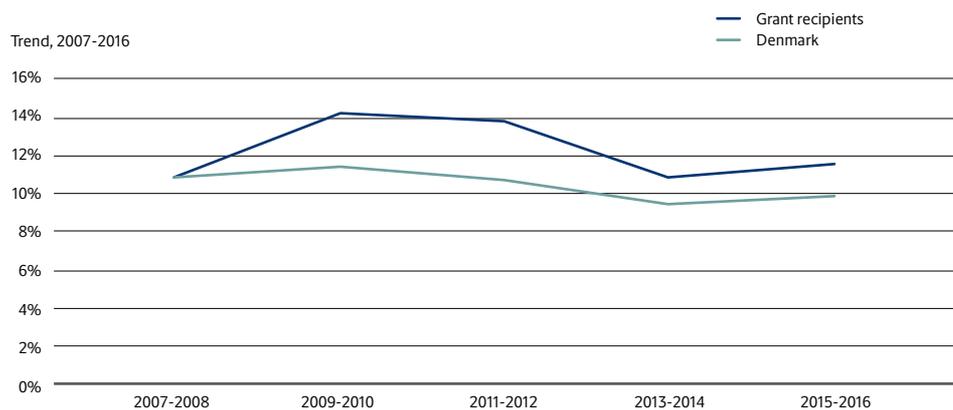
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

9.5 Trend for Denmark and grant recipients and international benchmark

Figure 9.5 presents the trend in the share of journal articles co-published with industry for the Foundation's grant recipients and for articles from Denmark as a whole. The trend is shown in 2-year intervals from 2008 to 2016. The share of articles co-authored with industrial researchers generally increased until peaking in 2009–2010. This applies both to all journal articles from Denmark and to all journal articles of the grant recipients. The share declined between 2011 and 2014 but increased again in 2015–2016.

Figure 9.5

Share of journal articles by recipients of Foundation grants co-authored with industry, 2007–2016



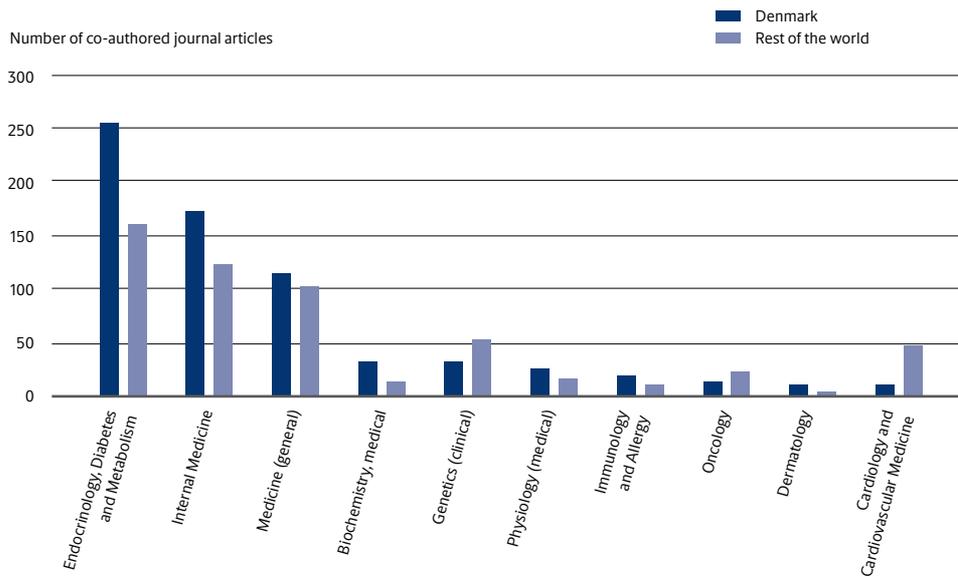
Sources: Novo Nordisk Foundation and Danish Centre for Studies in Research and Research Policy calculations based on the CWTS Leiden Ranking (Web of Science)

9.6 Journal articles co-authored with industry by subject category

Figure 9.6a. and 9.6b. show the numbers of co-authored journal articles by the recipients of Foundation grants co-authored with industrial researchers in companies in Denmark and the rest of the world across journal subject categories. The numbers are divided according to the location of the industrial co-authors. The numbers for Denmark reflect journal articles with industrial co-authors located only in Denmark. The numbers for the rest of the world always includes industrial co-authors located outside Denmark but may also include industrial co-authors located in Denmark. For the subject category endocrinology, diabetes and metabolism, the 415 co-authored journal articles include 256 co-publications from Denmark and 159 from the rest of the world.

Figure 9.6a

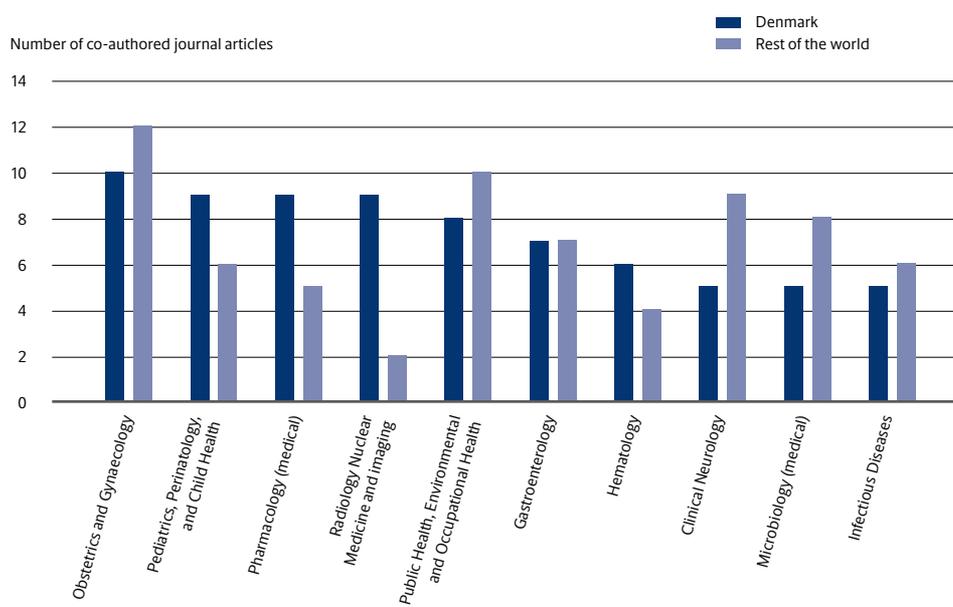
Journal articles by grant recipients co-authored with industrial researchers according to location and top 10 journal subject categories



Note: Time period: 2000-2017.
Sources: Novo Nordisk Foundation and DAMVAD Analytics.

Figure 9.6b

Journal articles by grant recipients co-authored with industrial researchers according to location and top 11-20 journal subject categories



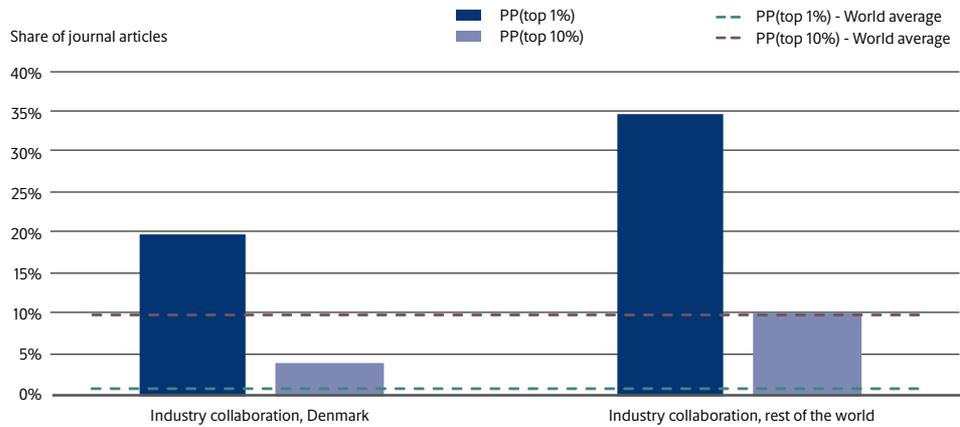
Note: Time period: 2000-2017.

Sources: Novo Nordisk Foundation and DAMVAD Analytics.

9.7 Citation impact for journal articles co-published with companies

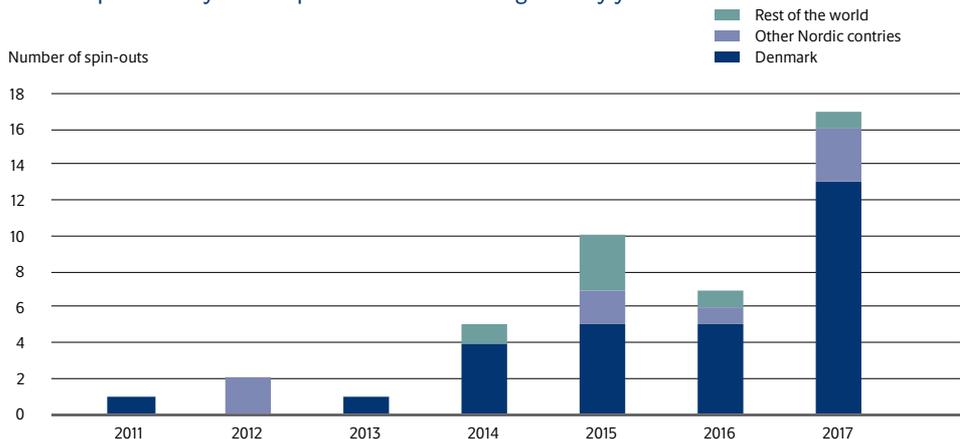
Journal articles co-authored with industrial researchers both in and outside Denmark have high citation impact. Co-authored collaborations with industrial researchers outside Denmark have the highest impact (Figure 9.7). Journal articles with co-authors outside Denmark may sometimes also include industrial co-authors located in Denmark.

Figure 9.7 Citation impact of publications by the recipients of Foundation grants co-authored with Danish and non-Danish companies



Note: Time period: 2000-2017.
 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).

Figure 9.8 The 43 spin-outs by the recipients of Foundation grants by year



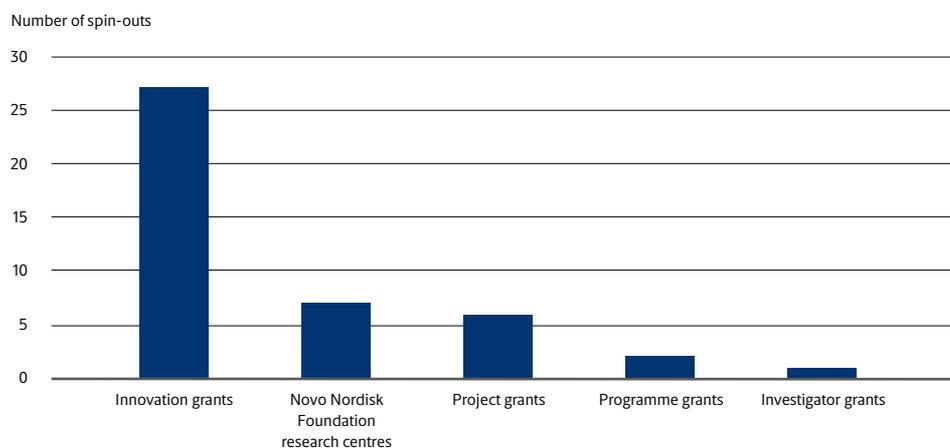
Note: Time period: 2011-2017.
 Sources: Novo Nordisk Foundation/researchfish*.

9.8 Spin-outs from public research funded by the Foundation

Spin-outs from public research often benefit local economic development and create new jobs. Since 2011, 43 spin-outs have been created based on research funded by the Foundation (Figure 9.8). From 2016 to 2017, the number of new spinouts more than doubled from 7 to 17. The number of spin-outs in Denmark has increased. Spin-outs in the rest of the world include countries such as Australia, the United States and the United Kingdom.

Figure 9.9

Number of spin-outs by recipients of Foundation grants by type of grant, 2011–2017



Note: Time period: 2011-2017.

Source: Novo Nordisk Foundation/researchfish®.

Most spin-outs are the result of the Foundation's innovation grants (Exploratory Pre-seed, Pre-seed and the Nordic Mentor Network for Entrepreneurship), the four Foundation research centres, and the project grants within biomedicine and biotechnology. The data do not yet cover the impact of the BioInnovation Institute, the Foundation's new major innovation initiative launched on January 1, 2018.

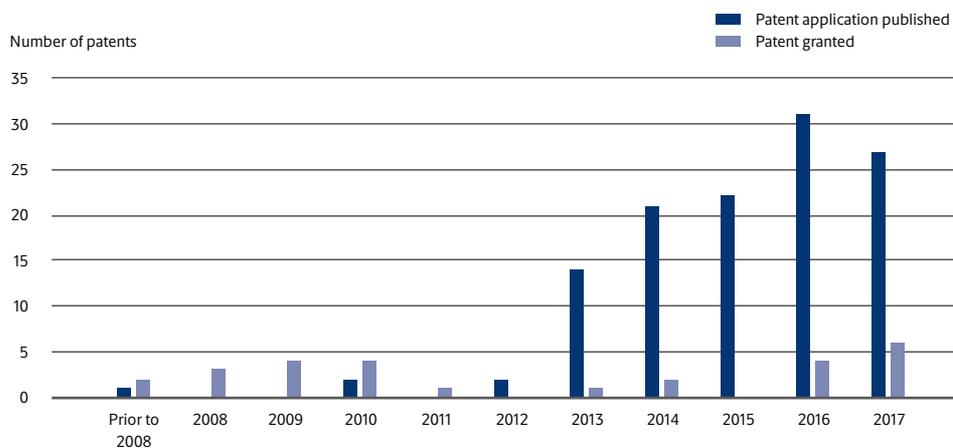
10. DISSEMINATION AND USE OF PUBLIC RESEARCH IN PATENTS

Patenting activity documents the dissemination and the potential use of research results and inventions from public research. Patents and patent applications could be the step before a given commercialization or innovation, which is why reviewing patent activities and their citation are relevant. The patent information in this chapter is from grant recipients and from worldwide patent offices.

10.1 Patent activities

The recipients of Foundation grants have reported 115 patent applications and 13 patents between 2013 and 2017, which is about 6% of the patents reported by research institutions in Denmark (Figure 10.1). The reason why the number of patents before 2013 is low due to lack of information about patents from grant recipients.

Figure 10.1 Patents applications and patents by grant recipients of Foundation grants by year, 2008–2017



Note: Before 2013, the year of application was registered as the reporting date because of lack of information.

Source: Novo Nordisk Foundation/researchfish*.

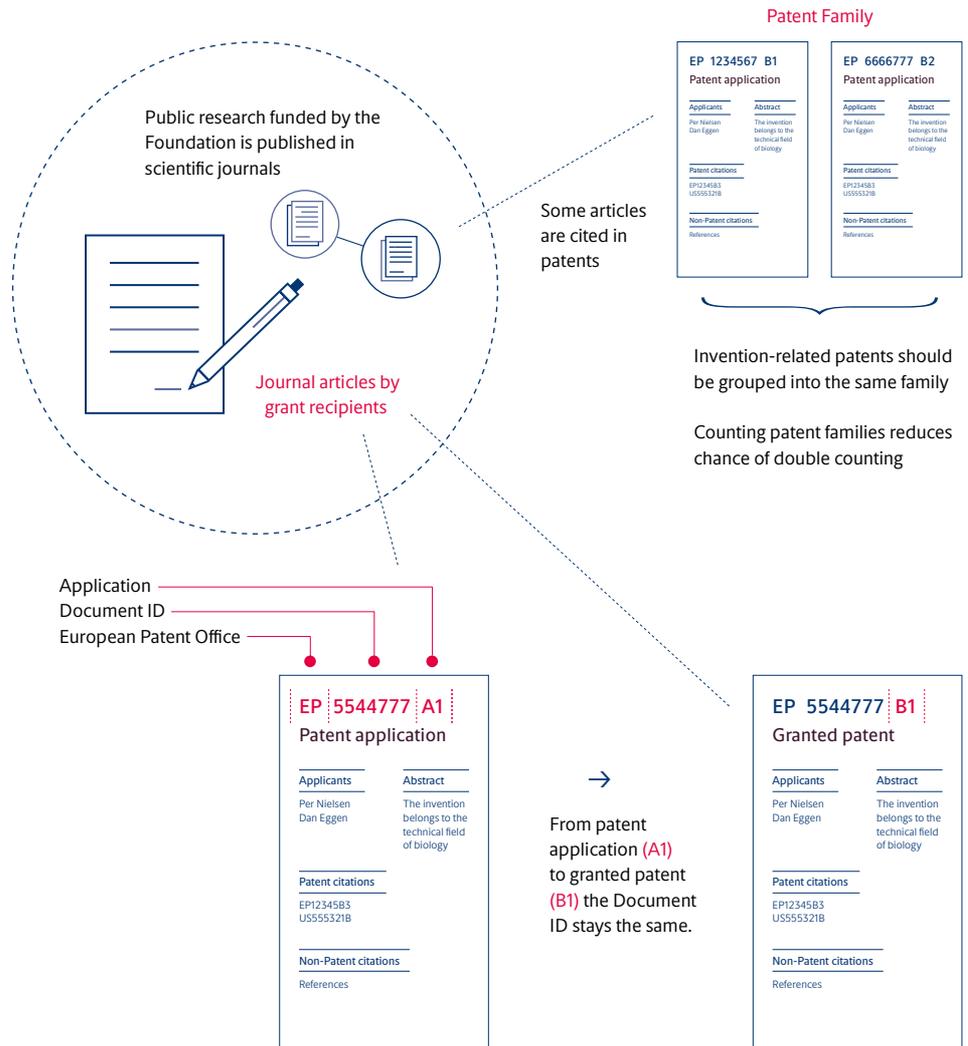
10.2 References to journal articles in patents

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

More than 25 million references to non-patent-literature publications were searched within the EPO database and matched with research publications from the Foundation's publication database, which comprises publications funded or co-funded by Foundation grants. The database holds all citations of other patents and non-patent literature such as peer-reviewed original and review journal articles, white papers, grey literature research papers, research working papers, letters, notes, books, news items, web pages etc.

In 1996–2016, 980 distinct publications from the Foundation's publication database are cited in 2,114 distinct patents or patent applications. The patent offices group patents and patent applications for similar technologies into patent families. The 980 publications of grant recipients of the Foundation are spread to more than one patent or patent family. The total distinct number of patent families is 1,606. Figure 10.2 presents an example for tracking of Foundation-funded research in patents.

Figure 10.2 Documentation of journal articles of the Foundation’s grant recipients in patenting activities

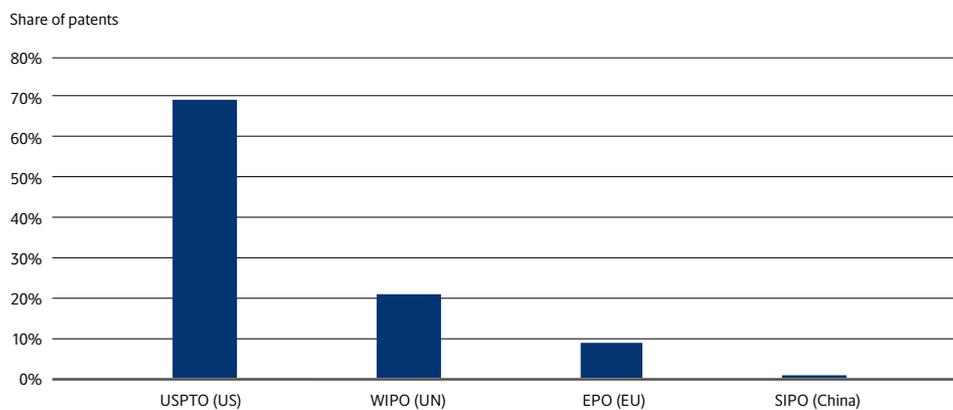


Source: Novo Nordisk Foundation.

Figure 10.3 shows the distribution among patents and patent agencies, primarily filed with the USPTO (69%), WIPO (21%) and EPO (9%).

Figure 10.3

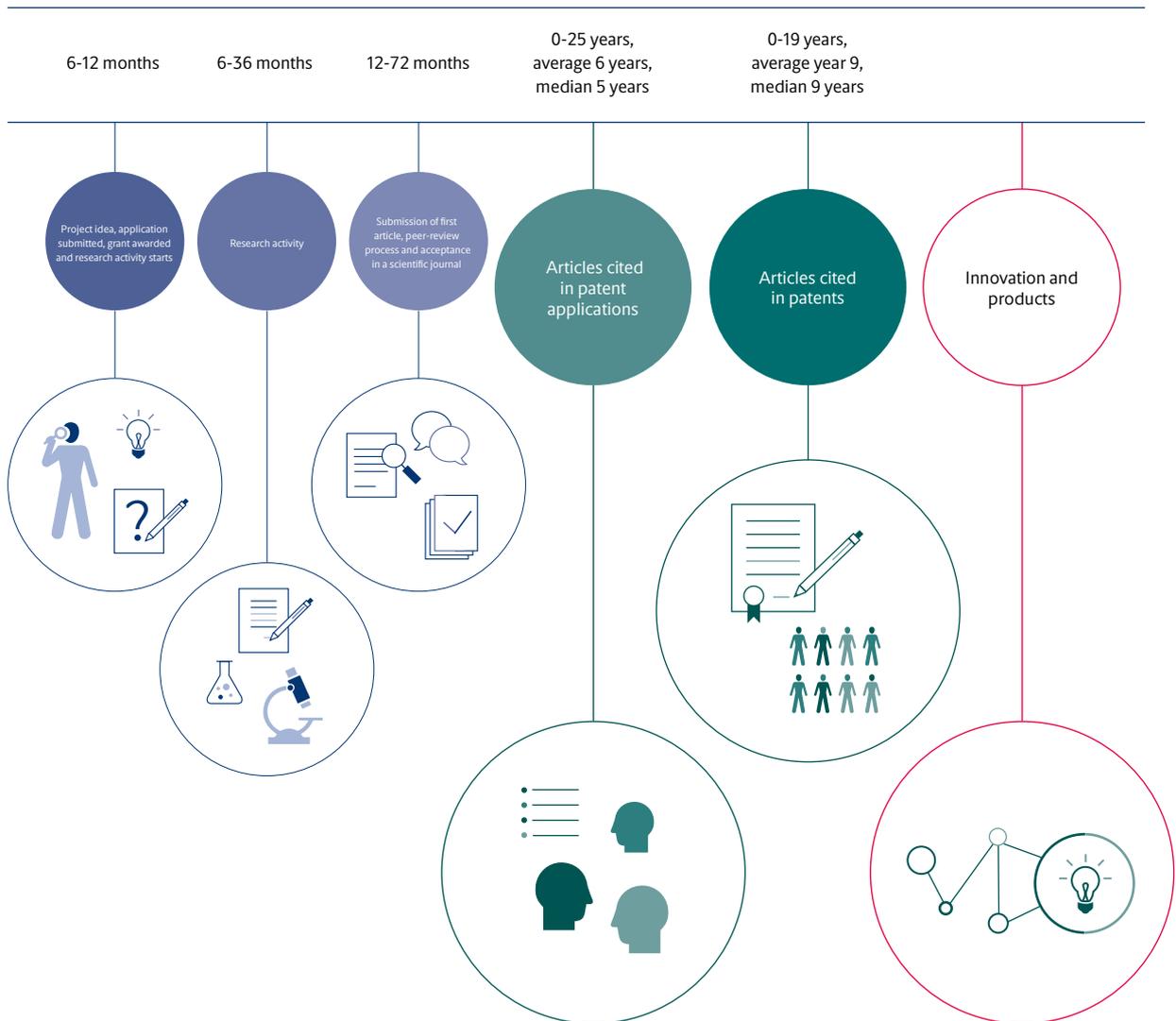
Foundation-funded publications disbursement in patent filed across patent agencies, 1996–2016



Sources: Novo Nordisk Foundation and DOCDB database.

Figure 10.4 shows that the average time period is 6 years to be cited in a patent application and 9 years for a granted patent. The time lag from project idea to publication to be cited in a patent application or a granted patent varies and the figure also shows that this might take much longer.

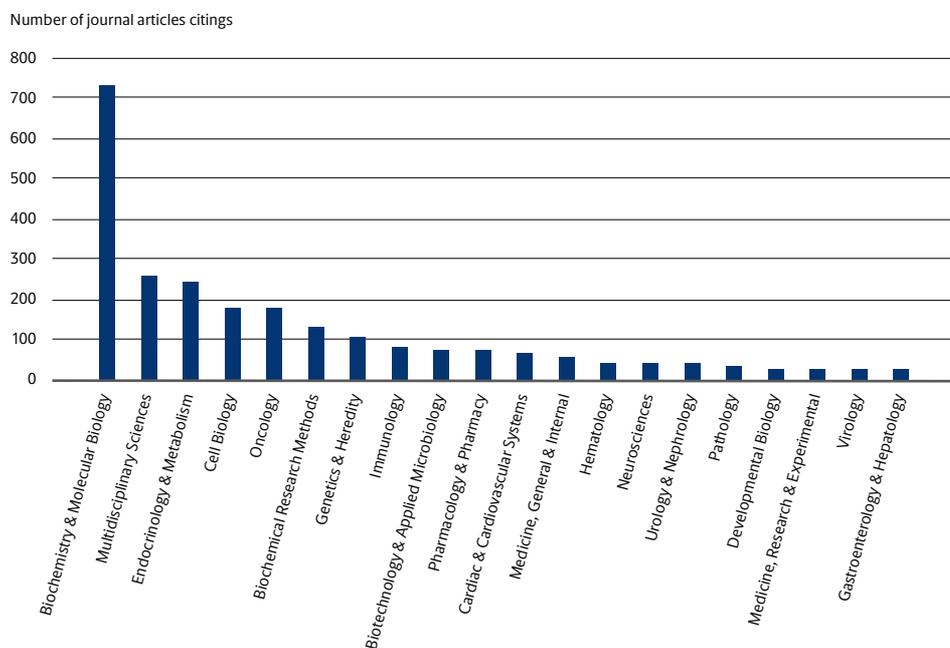
Figure 10.4 The transmission channels from project idea to citation in patents and estimated time lags



10.3 Distribution of journal articles by grant recipients that are cited in patents

Some of the 980 distinct journal articles by grant recipients that are found in patent documents (applications and granted patents) are cited multiple times. In total, these 980 distinct journal articles are cited 2,607 times. Most citing in patent documents, 726 of 2,607, occurs within biochemistry & molecular biology (Figure 10.5).

Figure 10.5 Patent document of journal articles by journal subject category, 1996–2016



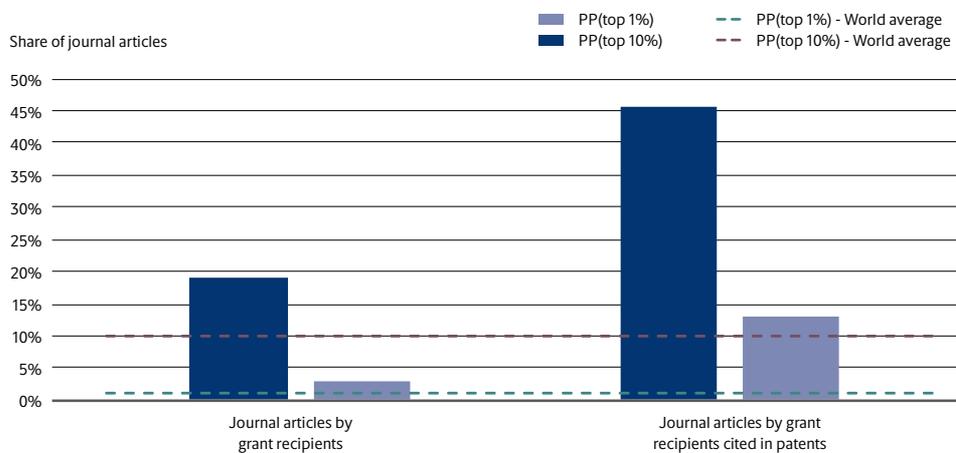
Sources: Novo Nordisk Foundation and DOCDB database.

10.4 Citation impact of the journal articles by grant recipients cited in patents

A total of 45% of the journal articles by grant recipients cited in patents are among the 10% most frequently cited articles worldwide within their scientific field and the same year. This is double of all journal articles by grant recipients (Figure 10.6).

Figure 10.6

Share of journal articles by grant recipients cited in patents within Top 10% and Top 1% frequently cited, 1996–2015



Note: For grant recipient the publications are identified 1996-2015 (and Danish publications citations are identified for the time-period 2000-2016).

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

11. FACTORS MOTIVATING RESEARCH-ACTIVE COMPANIES TO COLLABORATE WITH GRANT RECIPIENTS OF THE FOUNDATION

This chapter focuses on what types of motivational factors, incentives and values of companies influence collaboration between research-publishing companies and grant recipients. The analysis investigates the companies' experience with and motivational factors for research collaboration with grant recipients at public research institutions. Then, because research collaboration in some cases leads to joint publications between the industrial researchers and the grant recipients and other public researchers, the motivational factors for companies to co-publish with public researchers are analysed.

11.1 Descriptive statistics of the company sample

This analysis builds on survey interviews with 137 Danish research-active companies about their research collaboration culture, motivation for collaborating with public researchers and publishing research; 27 of the companies in the sample (about 20%) have collaborated with recipients of Foundation grants.

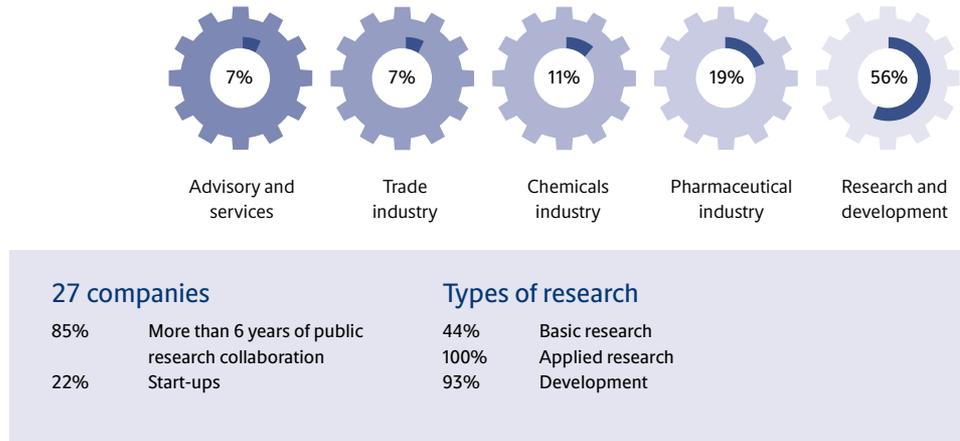
In the following sections we label the research companies collaborating with the grant recipients of the Foundation group A, and research companies not collaborating with grant recipients but potentially collaborating and co-publishing journal articles with other public researchers are labeled group B.

Among the surveyed companies, all of which publish articles in scientific journals, 85% have co-published with public researchers. Most of the companies have collaborated with public researchers for more than 6 years. For the companies that have collaborated with grant recipients (group A), 44% are engaged in basic research, 100% in applied research and 93% in development activities. Among the companies that have not collaborated with grant recipients (group B), 20% are engaged in basic research, 87% in applied research and 94% in development research (Figure 11.1 and 11.2). The variation between group A and group B is not reflected in the variation in industry allocation between the two groups. Deeper unexplored characteristics of the companies may explain the difference.

The sample of companies was generated from a sample of 1,200 companies from Denmark's Central Business Registry, which were matched to publication data. Then 314 research companies were identified and 137 of these were interviewed (the rest were not successfully reached or did not pass the control questions).

Figure 11.1 Research companies collaborating with grant recipients (group A)

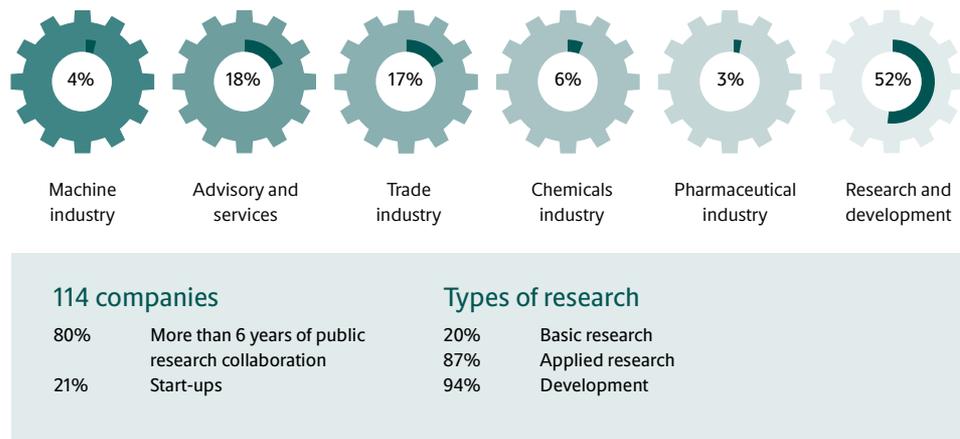
Company sample at a glance



Sources: Novo Nordisk Foundation and Jysk Analyse.

Figure 11.2 Research companies not collaborating with grant recipients (group B)

Company sample at a glance



Sources: Novo Nordisk Foundation and Jysk Analyse.

11.2 Companies' experience in research collaboration with grant recipients

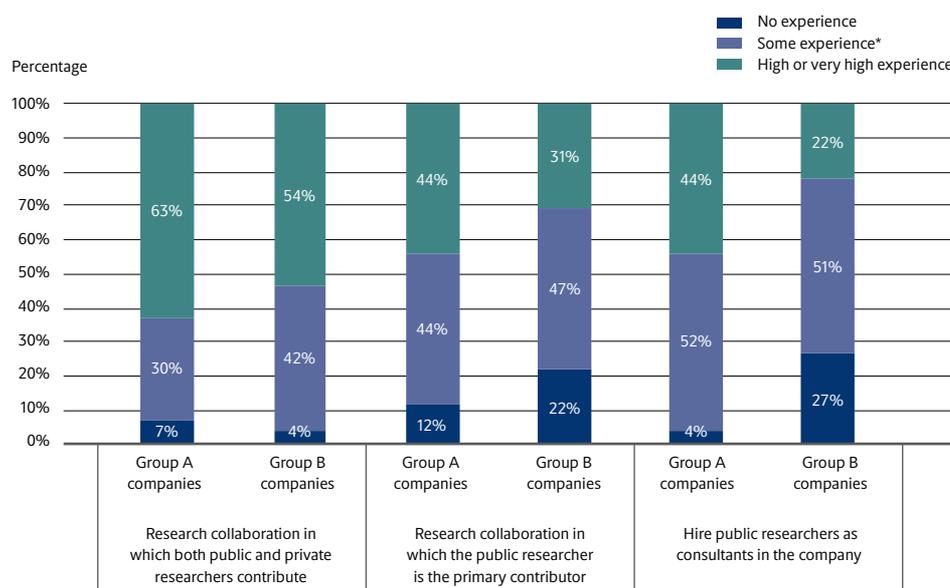
According to the research literature, companies collaborate, publish and share knowledge with public researchers for many reasons, some of which this analysis explores.

Figure 11.3 presents different forms of collaborations between public researchers and companies. It demonstrates that public research plays an important role in the companies. The following are some of the key observations:

- 63% of group A companies have high or very high experience in research collaboration in which both public and private researchers contribute. The value is 54% for other companies (group B).
- Furthermore, 44% in group A companies have high or very high experience with hiring public researchers as consultants in the company. The value is 22% for other companies (group B).

Figure 11.3

Companies' experience in collaborating with public researchers, 2018



Note: * "Some experience" means more than once.
Group A is research companies collaborating with Foundations grant recipients and Group B are research companies NOT collaborating with Foundations grant recipients.

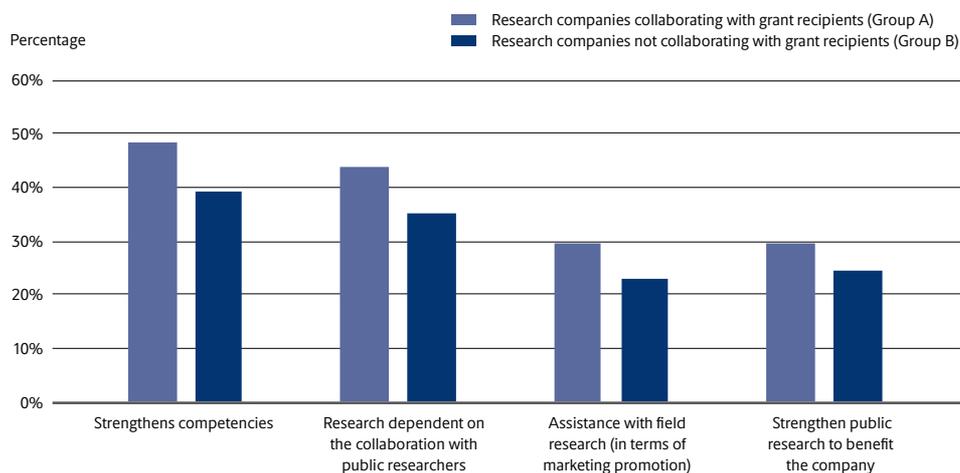
Sources: Novo Nordisk Foundation and Jysk Analyse.

11.3 Motivation for companies' collaboration with grant recipients

Figure 11.4 and 11.5 present the degree of importance of the motivational factors for collaboration between companies and public researchers. The responding companies rated the motivational factors on a scale including “not at all”, “less”, “some”, “high” or “very high”. A substantial share of the companies highlight enhancing competencies and access to applied research, research infrastructure, basic research and field research as motivational factors for collaboration.

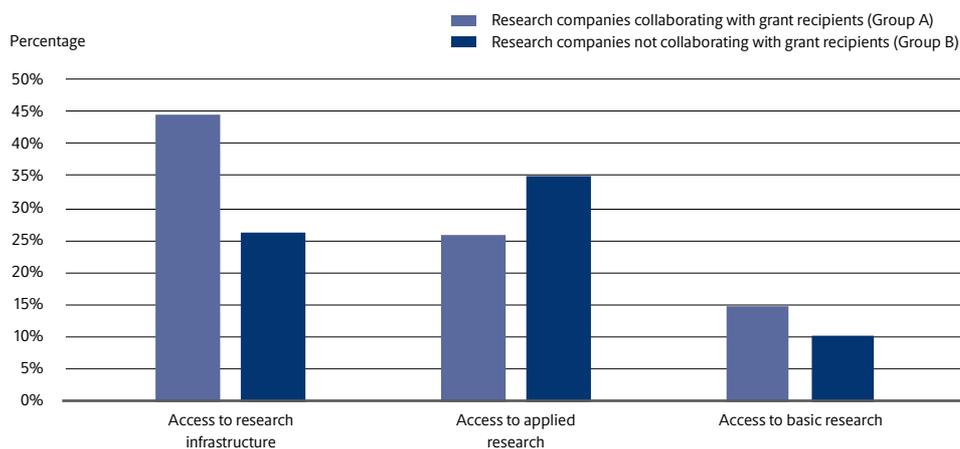
- Strengthen competencies is to a high or a very high degree a motivating factor for 48% of group A companies. The value is 39% for group B companies.
- Access to research infrastructure and applied research at public research institutions is to a high or a very high degree a motivating factor for 44% of group A-companies. The value is 26% for group B companies.
- Of the group A-companies, 44% highly or very highly depend on the research collaboration with public researchers. The value is 35% for group B-companies.

Figure 11.4 Share of companies that attribute high or very high degree of value in respect to collaboration with public research subject to different categories, 2018



Sources: Novo Nordisk Foundation and Jysk Analyse.

Figure 11.5 Share of companies that attribute high or very high degree of value in respect to collaboration with public research subject to different categories, 2018



Sources: Novo Nordisk Foundation and Jysk Analyse.

11.4 Absorbing knowledge in companies through research collaboration with co-publishing activity

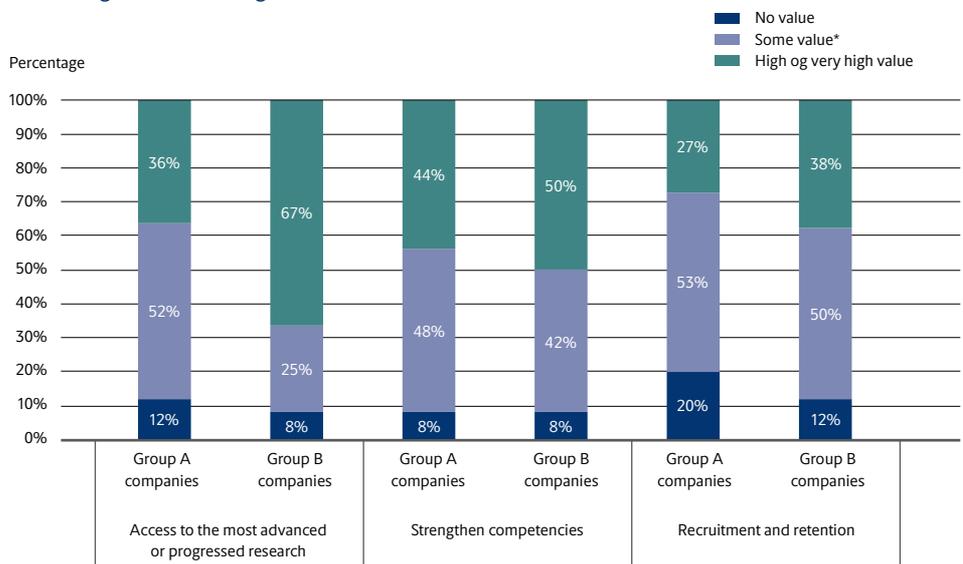
Companies use co-publishing in scientific journals with public researchers as part of their strategy to absorb new knowledge at the scientific frontlines. In that process, a substantial proportion also see possibilities in being an attractive employer to industrial researchers interested in keeping research-ties to public research.

- Of group A, 36% attach high or very high value to co-publishing because it implies access to the most advanced or progressed research. For group B-companies this applies to two out of three companies.
- Of group A, 44% attach high or very high value to co-publishing journal articles with grant recipients because it strengthens the competencies in the company. For group B, the share is 50%.
- Of group A, 27% attach high or very high value to co-publishing journal articles with grant recipients because allowing for their researchers to co-publish with public researchers improves the recruitment opportunities and supports the retention of qualified staff. For group B, the share is 38%.

Figure 11.6 compares these percentages with the same question posed to companies that co-publish with other public researchers than the recipients of Foundation grants.

Figure 11.6

The importance of co-publishing journal articles with the grant recipients for companies' absorbing new knowledge



Note: * Some value include "less value and some value".
 Group A is research companies collaborating with Foundation's grant recipients and Group B is research companies NOT collaborating with Foundations grant recipients.
 Sources: Novo Nordisk Foundation and Jysk Analyse.

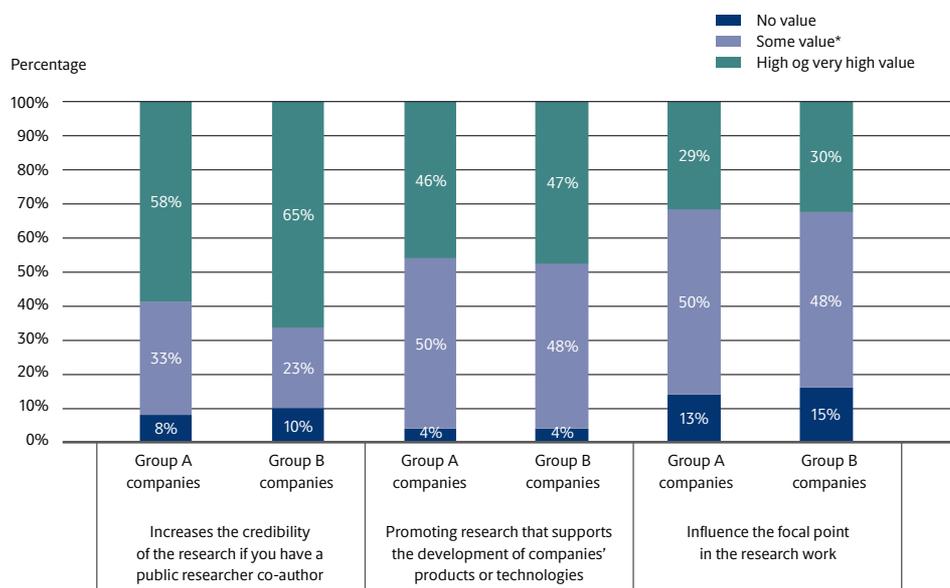
11.5 Promoting research by co-publishing with public researchers

Companies typically publish research for a reason. Co-publishing journal articles with public researchers can be used strategically to promote research and technology that is of value for the companies. Figure 11.7 highlights three motivational factors for companies to engage in co-publishing activity.

- Of group A, 58% attach high or very high value to co-publishing with public researchers because co-publishing increases the credibility of the research conducted. The share for group B is 65%.
- Of group A, 46% attach high or very high value to co-publishing with public researchers because it strengthens competencies in the company. The share for group B is 47%.
- Of group A, 29% attach high or very high value to co-publishing journal articles with public researchers because this enables them to influence the research. The share for group B is 30%.

Figure 11.7

The importance of co-publishing journal articles with grant recipients for companies' promoting research



Note: * Some value include "less value and some value".
Group A is research companies collaborating with Foundation's grant recipients and Group B is research companies NOT collaborating with Foundation's grant recipients.

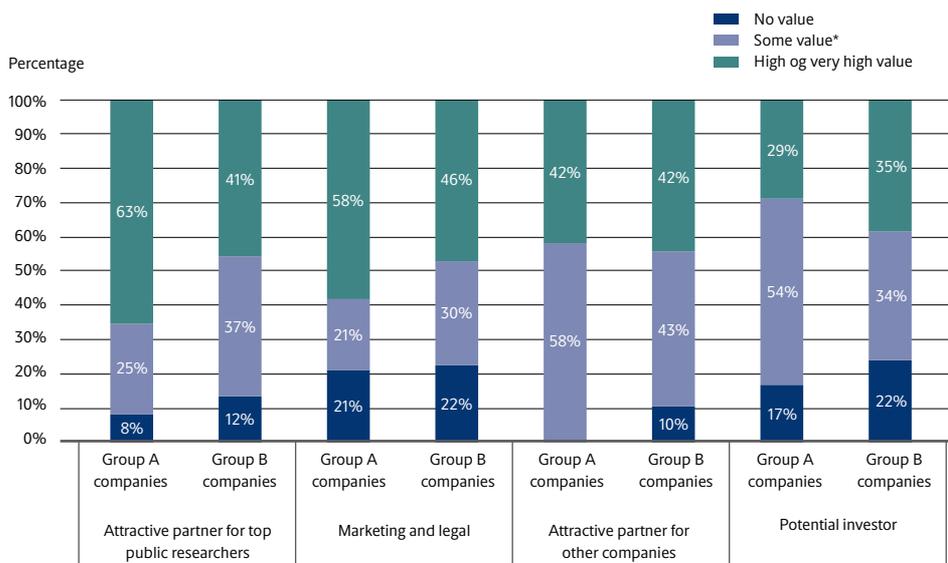
Sources: Novo Nordisk Foundation and Jysk Analyse.

11.6 Strengthening the strategic positioning of companies using co-publishing with public researchers as a signal

Companies may use co-publishing of journal articles with public researchers to strategically position their company. Figure 11.8 highlights four strategic considerations.

- Of the group A, 58% highly or very highly emphasize the importance of co-publishing with public researchers for marketing and legal purposes. For group B the share is 46%.
- Companies find that co-publishing makes them appear to be attractive partners to top public researchers (high or very high value for 63% for group A and 41% for group B) and to potential partner companies (high or very high value for 42% of group A and B).
- Of the group A, 29% emphasize that co-publishing with public researchers highly or very highly supports their appearance towards potential investors.

Figure 11.8 Importance of co-publishing journal articles with the grant recipients for companies' strategic market position



Note: *Some value include "less value and some value".
 Group A is research companies collaborating with Foundations grant recipients and Group B is research companies NOT collaborating with Foundations grant recipients.
 Sources: Novo Nordisk Foundation and Jysk Analyse.

12. NORDIC MENTOR NETWORK FOR ENTREPRENEURSHIP

This chapter investigates how the Nordic Mentor Network for Entrepreneurship (NOME) funded by the Novo Nordisk Foundation changed eight life science start-ups during their participation in NOME. Since 2016, 14 start-ups have joined NOME. The study compares the situation of start-ups before and after they joined NOME. The changes are measured in the change of each start-up's resource accumulation and composition over time.

NOME is a mentoring programme targeting promising early-stage projects and start-up companies within the life sciences in Denmark and the other Nordic countries. By matching entrepreneurs with skilled volunteer professionals, NOME aims to help to test whether the ideas of life science start-ups have international potential. The ambition is to develop a network of the highest international quality that can strengthen the position of Denmark and the other Nordic countries within the life sciences. NOME comprises 40 mentors from the life science ecosystem. They have expertise within commercialization, research and business. The mentors will help projects and start-up companies to develop and grow, establish strategies, and achieve their business targets.

The Foundation has awarded DKK 20 million to Accelerace at the research park Symbion to develop NOME from 2016 to 2020. The initiative builds on international experience and major initiatives in the United States, especially from the Massachusetts Institute of Technology (MIT). NOME provides start-ups with the opportunity to participate in the boot camp in the United States, which is specifically tailored for each selected participant and connects them with United States mentors and relevant industry contacts. Giving start-ups access to leading experts from the life science ecosystem who can share insights about technical operations and commercial activities is expected to shorten the time required to switch the mindset from academic to commercial activity.

12.1 The analysis

This analysis intends to capture the influence of the NOME project on eight start-ups that have participated for 6–8 months in NOME. Datasets specific to the start-ups were gathered in a survey. Because of the small sample size and variation in length of the participation of start-ups and the short activity period, the analysis should be interpreted as very preliminary for the outcome of NOME. Six to eight months is a short lifetime for a life science start-up, in which the market time for development of new drugs is expected to take 10–15 years.

This analysis is based on the assumption that turning an idea, invention or technology into a viable growing business is an iterative process. The iterative process comprises the business plan, designing experiments, testing assumptions, collecting data and insights for validation and turning patterns into concepts or evidence of a scalable business model. The NOME project is based on the belief that, the more iterations a start-up is able to conduct the higher the likelihood is of finding a scalable business model and validation of the commercial application of the start-up's invention or technology. The point is that, during each iteration, the start-up accumulates resources and insights based on learning. The accumulation of resources and insights over time indicates that the start-up is moving forward and may potentially be an early indicator of future success.

The following three overall indicator groups for the monitoring of start-ups have been used:

1. Human resources comprise the skills, experience and diversity within the start-up's core team, including founders, managers and employees, and the supplement team (including board members and advisers).
2. Technology resources include product maturity, intellectual property and scientific quality. Market resources cover market opportunities, the competitive landscape, and validation methods.
3. Financial resources comprise total funding, type of funding and the quality of the investors.

12.2 The influence of NOME

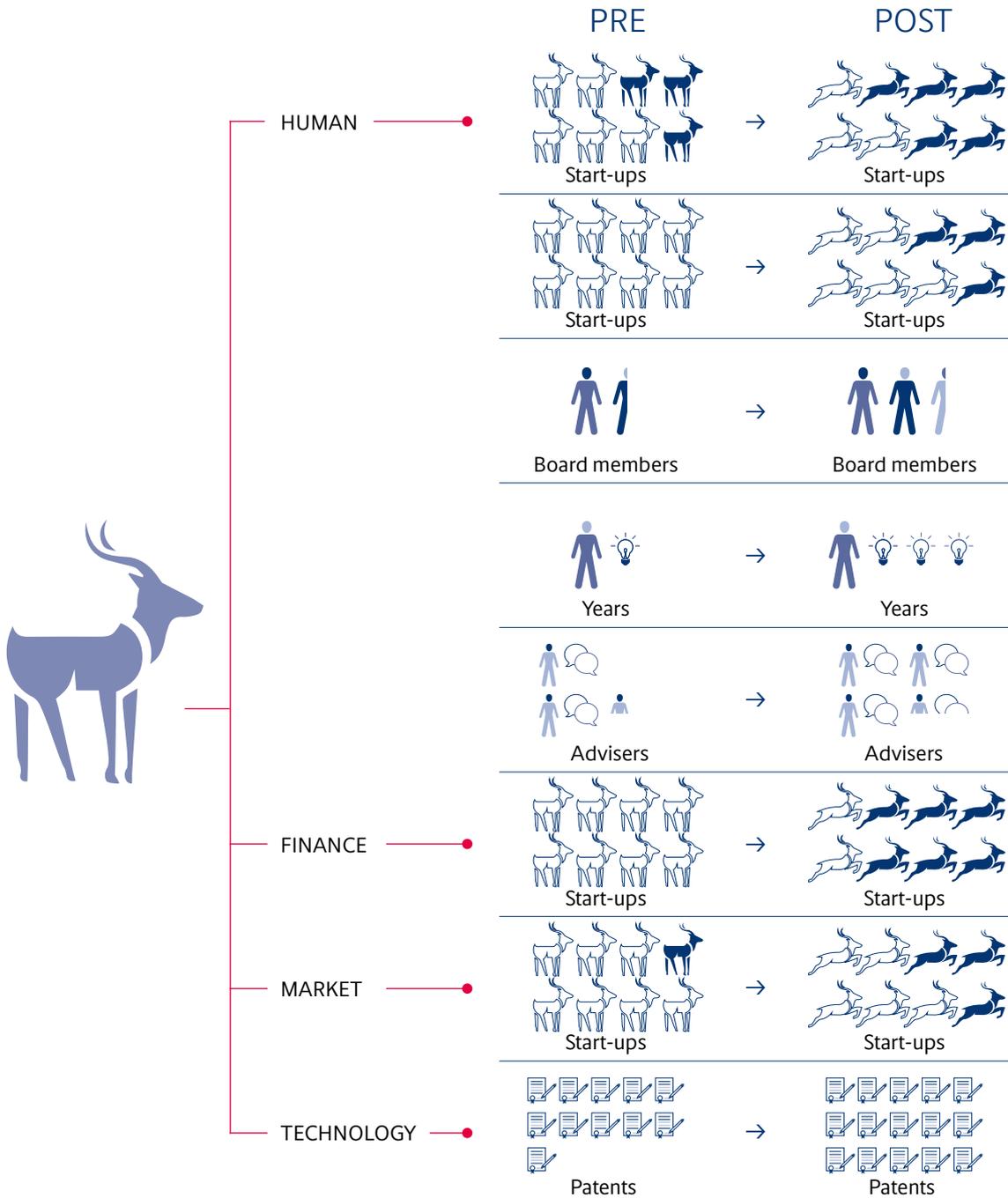
NOME succeeded in improving the human and financial resources of most start-ups across a range of measures as illustrated in Figure 12.1.

The box gives the main results and identifies the changes arising from before and after participating in NOME.

- Eight start-ups have participated in NOME for 6–8 months since 2016.
- NOME added on average 39 years of industry experience and 6 years of entrepreneurial experience per start-up.
- NOME changed the composition of the boards in 50% of the start-ups, increasing the average number of board members by 93%.
- 75% of the start-ups have raised external funding over the 6–8 months. The increased average total funding is 124% or USD 1 million per start-up.
- NOME is adding new skills such as intellectual property rights, research and development, and industry experience.
- The average number of patents increased by 36% after participating in NOME

Before start-ups participated in NOME, an experienced and diverse founder team and a mature, high-quality and intellectual property-protected technology were correlated with improved fundraising capabilities. During the NOME programme, the average years of entrepreneurial experience per board member increased by 71%, adding more practical knowledge and experience from commercializing previous start-ups in the life sciences (Figure 12.1).

Figure 12.1 Impact of the journey of a start-up in the NOME programme



2 out of 8 start-ups

established high-quality board of directors



3 out of 8 start-ups

converted NOME mentors into board members



Increased average number of board members by

93%



Increased entrepreneurial experience per board member by

71%



Increased average number of advisers by

55%



6 out of 8 start-ups

raised additional funding



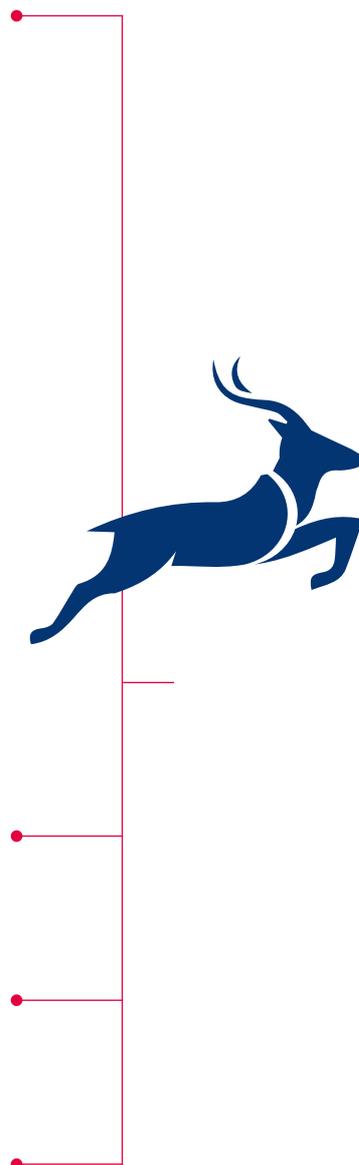
2 out of 8 start-ups

generated early revenue to validate market



Increased average number of patents by

36%



The total industry experience per start-up increased by 39 years, predominantly from adding board members with experience from executive management positions in global life science companies and advisers with specialist knowledge in finance, research and development and intellectual property rights. Adding new human resources to the start-ups increased the diversity score by 33% in the composition of board members and 16% in the role of advisers. In the short term, this is perceived as a positive outcome for the NOME programme because it demonstrates a successful match between the entrepreneur's needs and the mentors' interests. This indicates that NOME is able to identify and supply missing human resources in the participating start-ups. Table 12.1 and Figure 12.2 show the results of before and after participation in NOME.

Table 12.1 Comparison between start-ups' resources before and after participation in NOME

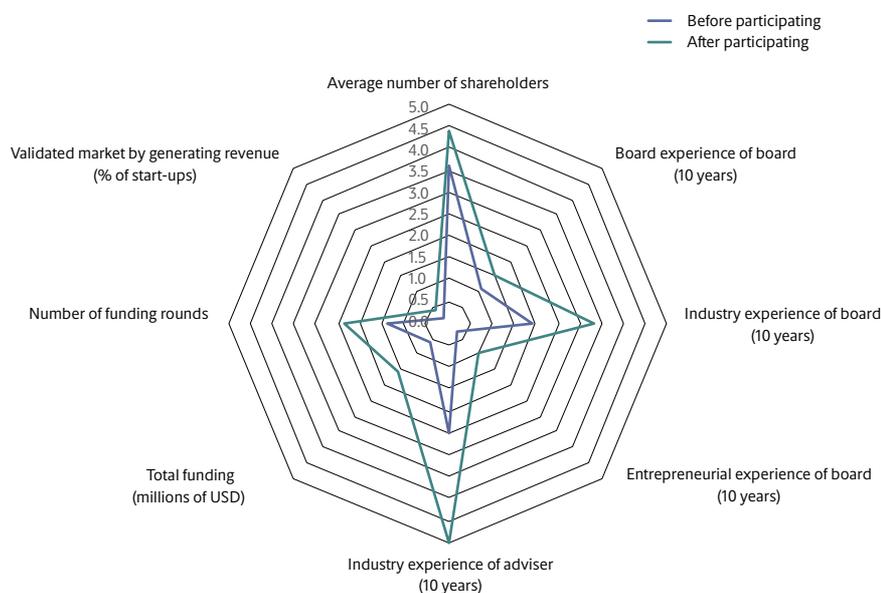
		Avg. number of shareholders	Board experience of board (10 years)	Industry experience of board (10 years)	Entrepreneurial experience of board (10 years)	Industry experience of advisor (10 years)	Total amount of funding (mill. USD)	Number of funding rounds	Validated market by generating revenue (% of start-ups)
NOME participation	Before	3.6	1.1	1.9	0.3	2.5	0.6	1.4	0.1
	After	4.4	1.5	3.3	1.0	5.0	1.6	2.4	0.4

Note: n=8 (start-up companies).

Sources: Novo Nordisk Foundation and Accelerace.

Figure 12.2

Impact of NOME based on normalized average resource scores



Note: n=8 (start-up companies).
Sources: Novo Nordisk Foundation and Accelerace.

12.3 A comparison of NOME with a public mentor programme for small businesses called ACC

This section compares NOME with a public business development programme for small businesses called the Accelerace programme (ACC), a business development organization. To participate in NOME or ACC, all start-ups underwent a rigorous selection process by life science experts, which creates a selection bias that will probably reduce the observed changes when they are compared with each other. Whereas the NOME start-ups are allocated three or more experienced and high-profile mentors from the life science ecosystem, the ACC start-ups receive 180 hours of coaching from life science consultants in ACC, who also have extensive hands-on experience from the life science sector. Both groups of start-ups participate 6–12 months in the respective programmes and were enrolled in the programmes on an ongoing basis from 2016 to 2017.

Compared with the seven ACC start-ups, the eight NOME start-ups have existed for longer (2.6 years more), raised more external funding before entering (USD 400,000 more), are based on stronger scientific quality (the chief scientific officers have 1,578 more citations on average), are protected by more patents (0.5 more patents), and are guided by more board members and advisers with more industrial experience (average 11 years per board member and 6.8 years per adviser). Further, 87.5% of the NOME start-ups are spin-outs from universities, whereas only 42.5% of the small businesses in ACC are university spin-outs.

A comparison of NOME and ACC start-ups before entering one of the programmes revealed a positive effect on the start-ups' composition of human, technology, market and financial resources. However, the influence on NOME start-ups seems to be marginally higher than that on the ACC start-ups (Table 12.2). The main differences are the following:

- The NOME start-ups raised more external funding than the ACC start-ups.
- The NOME start-ups increased human resources more than the ACC start-ups.
- The ACC start-ups developed more rapidly on technology and market compared with NOME.

This comparison should be interpreted carefully, since the ACC start-ups are on average more immature at the beginning than the NOME start-ups, which could suggest that developments in such areas as technology could be easier compared with a more advanced start-up. Table 12.2 shows the increase reported per company.

Table 12.2 Comparison between start-ups' resources before and after participation in NOME and ACC

	Change in resources by participating	Board experience of board (10 years)	Industry experience of board (10 years)	Entrepreneurial experience of board (10 years)	Industry experience of advisor (10 years)	Total amount of funding (mill. USD)	Number of funding rounds	Validated market by generating revenue (% of start-ups)
Change in resources by participating in NOME	0.8	0.4	1.4	0.7	2.5	1.0	1.0	0.3
Change in resources by participating ACC	0.6	0.02	0.8	0.0	2.5	0.5	1.1	0.1

Note: n=8 (start-up companies).

Sources: Novo Nordisk Foundation and Accelerace.

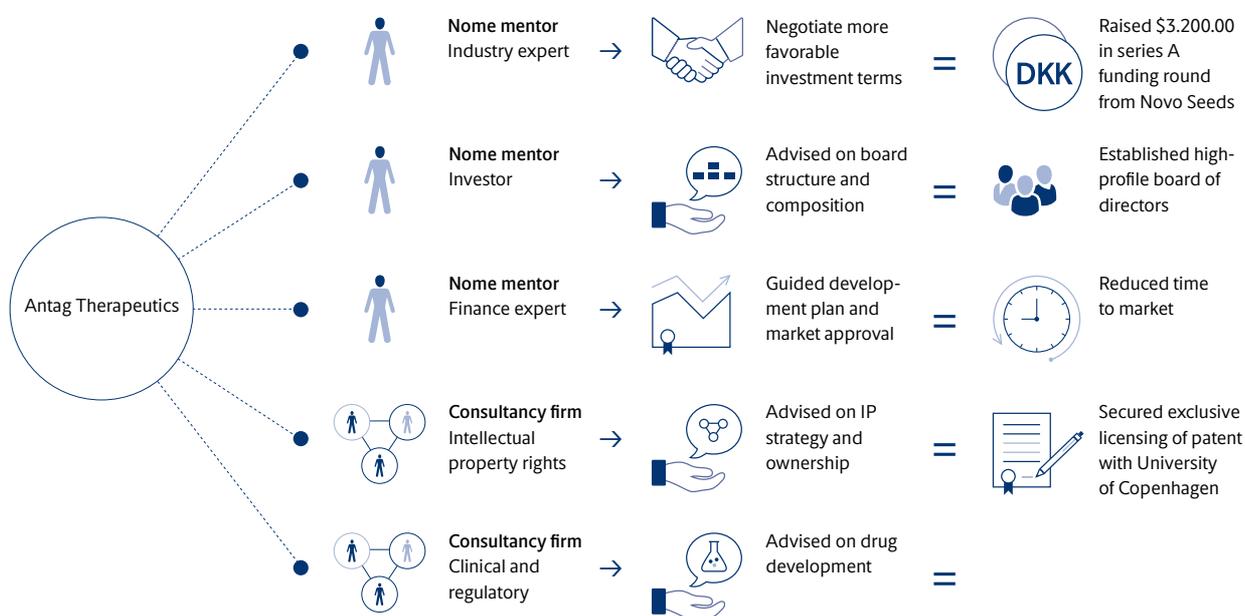
Case:

Antag Therapeutics

Before NOME, the start-up company Antag Therapeutics had the most experienced and diverse founding team and the chief scientific officer with the most publications, citations and patents among all the NOME start-ups. Antag Therapeutics had raised USD 500,000 from Novo Seeds before entering the programme. During NOME, Antag Therapeutics was introduced to three mentors with experience from executive management positions in the pharmaceutical industry, venture capital, and corporate strategy. The start-up became connected to intellectual property and regulatory consultancy firms.

The figure below shows Antag Therapeutics and their mentors. Both mentors and advisers have contributed positively to changing the resource composition of Antag Therapeutics. First, the start-up established a high-profile board of directors, including one NOME mentor with a long career building successful pharmaceutical start-ups. Second, the start-up finalized negotiations for a patent licensing deal using the intellectual property consultant to help establish the foundation for building a business based on novel treatments for dietary-related metabolic diseases. In June 2017, Antag Therapeutics raised USD 3.2 million from Novo Seeds in an equity investment, in which the NOME mentors took part in negotiations by giving strategic input on how to formulate clauses in the contract that ensure potential deal-making in a future exit strategy.

Figure 12.3

Antag Therapeutics





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ISBN: 978-87-994858-6-4

Layout: Marianne Siem
Photo: Jon Norddahl, Helga Theilgaard

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