

novo nordisk
foundation

Benefitting people and society



Annual Impact Report 2022

Societal impact

of the Novo Nordisk Foundation





“Investing in research and development in society contributes to creating knowledge, employment, growth and innovation of products and services to improve people’s health and the sustainability of society and the planet.”

— Lars Rebien Sørensen
Chair, Board of Directors, Novo Nordisk Foundation



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Preface

The Novo Nordisk Foundation is an independent Danish foundation with philanthropic and corporate purposes, also called an enterprise foundation. Its vision is to improve people's health and the sustainability of society and the planet. To fulfil this vision in relation to its purposes, it pursues two three-pronged missions.

The Foundation's philanthropic mission is to:

- progress research and innovation in the prevention and treatment of cardiometabolic and infectious diseases;
- advance knowledge and solutions to support the green transition in society; and
- invest in scientific research, education and innovation to enable a world-class life science ecosystem.

The Foundation's corporate mission is to:

- be an engaged owner of Novo Nordisk A/S, Novozymes A/S and Novo Holdings A/S;
- generate attractive investment returns on the Foundation's assets; and
- make strategic investments with the main goal of supporting the Foundation's strategy.

The Foundation supports philanthropic initiatives in biomedical science, the natural and technical sciences, biotechnology, sustainability, humanities, interdisciplinary research, diabetes centres, innovation, education, and social and humanitarian causes. It focuses substantially on contributions through fundamental and translational research. In terms of its corporate activities, the Foundation contributes to the economy of society by generating jobs and advancing the development of new technologies and research. In addition, through focused investments in life sciences, it aims to improve the health

of people and accelerate the green transition of society through innovative developments in biotechnology and other technologies.

In its philanthropic focus towards 2030, the Foundation will continue to have Denmark as its centre of gravity while at the same time increasing its international reach, international collaborations and partnerships, given the interconnected, global nature of the problems it strives to solve, and thereby also strengthening the life sciences and research environments in Denmark. The corporate activities are global in scope.

We adopt a long-term perspective. Research, innovation, education and investments in companies involve trust in people and taking risks. Improving the health of people and the sustainability of society and the planet takes time. We believe that high-quality activities and interdisciplinary approaches create the ideal research environment for fulfilling a great ambition and for global scientific collaboration and new ideas to flourish. Such an environment has the potential to foster the greatest breakthroughs and find new sustainable solutions to societal challenges.

Our strategy formulates the desired contributions to society for the Foundation across its grant-awarding and commercial activities. We have established an impact framework to analyse, measure, manage and communicate our societal achievements. This impact report documents aspects of the overall contribution to the improvement of people's health and the sustainability of society and the planet provided by the Foundation's philanthropic and corporate activities. On the Foundation's website novonordiskfonden.dk, the "NNF Dashboard" provides much more information about the Foundation's contribution to society and their impact.

We hope you will enjoy reading this year's impact report.

Mads Krogsgaard Thomsen,
CEO, Novo Nordisk Foundation

Summary of the Impact Report 2022

This report links our grant-giving and commercial activities in 2022 and before to scientific achievements and societal results beyond science. The output, outcome and impact of the Foundation are structured according to our nine principles for societal impact, which help to guide the Foundation's activities.

Our results in this report are based on extensive research and build on analyses of several data sources. We track the activities from our input and assess output, outcome and impact through the systematic reporting of the grant recipients and the companies in our two reporting systems, Researchfish® and Foundgood, alongside surveys, research and other data sources. We share the results and our activities in the new NNF Dashboard.

Chapter 1 The monetary contribution to society

Chapter 1 describes the monetary flows and the capital stock of the Novo Nordisk Foundation Group and how we contribute to research investments in society. The key insights are:

- 14% of all public research and 23% of all private research in Denmark are financed by the Group. The total sum for 2022 is estimated at 0.58% of Denmark's GDP.
- An estimated 12% of corporate taxes (DKK 9 billion) and 1.3% of direct personal taxes (DKK 7 billion) in Denmark were paid by the Group and its employees.
- The Foundation's and Novo Holdings' portfolio of companies had a net worth of DKK 806 billion (EUR 108 billion) and awarded grants for a total of DKK 7.5 billion (EUR 1 billion), placing it in the world's top-three when it comes to philanthropic activities.

Chapter 2 The societal impact of philanthropic activities

Chapter 2 describes the societal impact of our grant-giving activities. Over nine sections, each devoted to a societal impact principle, we document our main imprints on society. The key results for the year 2022 are:

- 8,000 people in scientific activities and research hospitals (48% were men and 52% were women) and nearly 1,300 people in other activities have been fully or partly funded. Of the scientific personnel, 3,350 were PhD students or postdoctoral fellows.
- 8% of Danish scientific journal articles were funded by the Foundation's grants. 69% were published by international teams, and 12% with co-authors from the industry. 23% were among the 10% most cited in the world.
- In January 2023, 45 invention disclosures for 2022 were reported and of 47 invention disclosures for the period 2019–2021. Moreover, 35 patent applications and 13 new spinouts were reported by grantees for 2022.
- In 2022, more than 30,000 patients were treated at the Steno Diabetes Centers in Denmark.

Chapter 3

The societal impact of commercial activities

Chapter 3 documents the societal impact of our corporate activities. We have analysed the Novo Group and Novo Holdings' life science portfolio of companies. The key societal impacts for the year 2022 are:

- 153,000 people are employed in the Novo Group (Novo Holdings, Novo Nordisk A/S and Novozymes A/S) and the 144 other companies in the life science portfolio. This is 8,000 more than in 2021.
- Since 2018, more than 14,400 patent applications have been published and more than 3,800 patents have been granted. 20% of Danish patents are granted to the Novo Group and portfolio companies.
- In the period 2018–2022, more than 246,000 people have been successfully enrolled in 639 active clinical trials supported by the portfolio companies.
- There are 42 million users of medical products (5% increase compared to 2021), more than 40 million users of MedTech products (same as in 2021) and 500 million health tests (a 20% decrease compared to 2021).

Chapter 4

Learnings from philanthropic practice

Chapter 4 uses state-of-the-art research methods in data and analytics to analyse peer-review selection and outcome of Novo Nordisk Foundation research grants. Our analyses draw on text mining and big data analytics that, until recently, were not possible to perform without service from proprietary data owners. We investigate available reviewer data from our peer-review processes to help us understand whether the right processes and selection criteria are in place for selecting the best research projects and delivering excellent research and societal impact. Our analysis provides indicative conclusions about important aspects of the funding decisions made by the Foundation's committees:

- Applicants with a track record of high citation had a higher probability of being funded.

- Applicants with a record of more novel research articles had a lower probability of being funded.
- Applications scoring higher for novelty tended to have lower probability of being funded.
- Applications including more 'promotional language' had a higher probability of being funded and of delivering high-impact journal articles.

Our analysis also highlights the need for more detailed and structured data if we are to further understand the decision processes involved. These centre around the needs to understand if the assessment criteria support the objective of the programme, that assessment criteria are well-explained and consistently understood and used by reviewers, and how an application is read by reviewers and how different criteria are weighed to form an overall opinion. This requires improving the structure of the application form to ensure a more consistent reading and reviewing of proposals and better and more structured data on reviewer assessments and committee decisions.

Impact frameworks for research programmes can address some of these needs and facilitate development of selection criteria, and strengthen the underlying tools for selecting the best projects with the highest potential for societal impact. Better structured application forms will also allow AI-assistance to efficiently support the application and assessment processes.

We share the results and our activities in the new [NNF Dashboard](#).

The NNF Dashboard provides much more information about the Foundation's contributions to society and their impact.

[Read more](#)



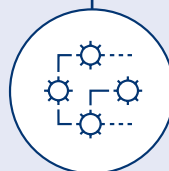
The Foundation aims to
improve people's health and
the sustainability of society
and the planet

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Output



Fostering the development of talent across different gender, life ages and scientific fields.



Supporting organisations, systems, and infrastructure to catalyse a knowledge-based societal development.



Stimulating collaboration across international borders, scientific disciplines, and sectors in society.

The societal impact principles for the Foundation

Outcome



Promoting excellent research and innovation.



Developing innovative products and solutions supporting a sustainable development.



Developing new technologies, therapies and patient-centred and research-based care and disease prevention.

Impact



Creating jobs, sustainable growth, efficient use of resources and productivity in society.



Supporting the development of world-class education at all levels and of a qualified and agile workforce.



Supporting people in difficult health, social, environmental, and humanitarian settings.

1



The monetary contribution to society

The Novo Nordisk Foundation's philanthropic and commercial activities contribute to society in many ways. It awards funds to improve people's health and the sustainability of society and the planet, pays taxes, develops solutions and employs people.

Through the Novo Group (Novo Holdings A/S, Novo Nordisk A/S and Novozymes A/S), investments in life science companies and capital investments, we contribute to private-sector research and innovation. These forms of engagement in society generate jobs, tax revenue in Denmark and abroad, and contribute to the creation of income for more than hundred thousand people.

Underpinning all these benefits is the financial resilience and scale of the Foundation and its investments, which are covered in this chapter. We outline our legal and corporate structure, before describing the economic scale of our activities.

1.1 The business model

In 2022, the Novo Nordisk Foundation Group¹ held investments in 147 life science companies and more than 200 other companies through its wholly owned subsidiary Novo Holdings A/S, a holding company and majority shareholder of Novo Nordisk A/S and Novozymes A/S. Novo Holdings manages the Foundation's commercial activities, which are primarily within the life sciences, in addition to receiving dividends from Novo Nordisk and Novozymes and returns on its own commercial and financial investments.

The Foundation receives income from Novo Holdings and awards grants to benefit society. In 2021 and 2022, the Foundation had a net worth of DKK 697 billion and DKK 806 billion, respectively, making it one of the largest financial endowments of any foundation in the world. The income and the return on the investments in Novo Holdings was DKK 3.1 billion in 2022 compared to DKK 37 billion in 2021.

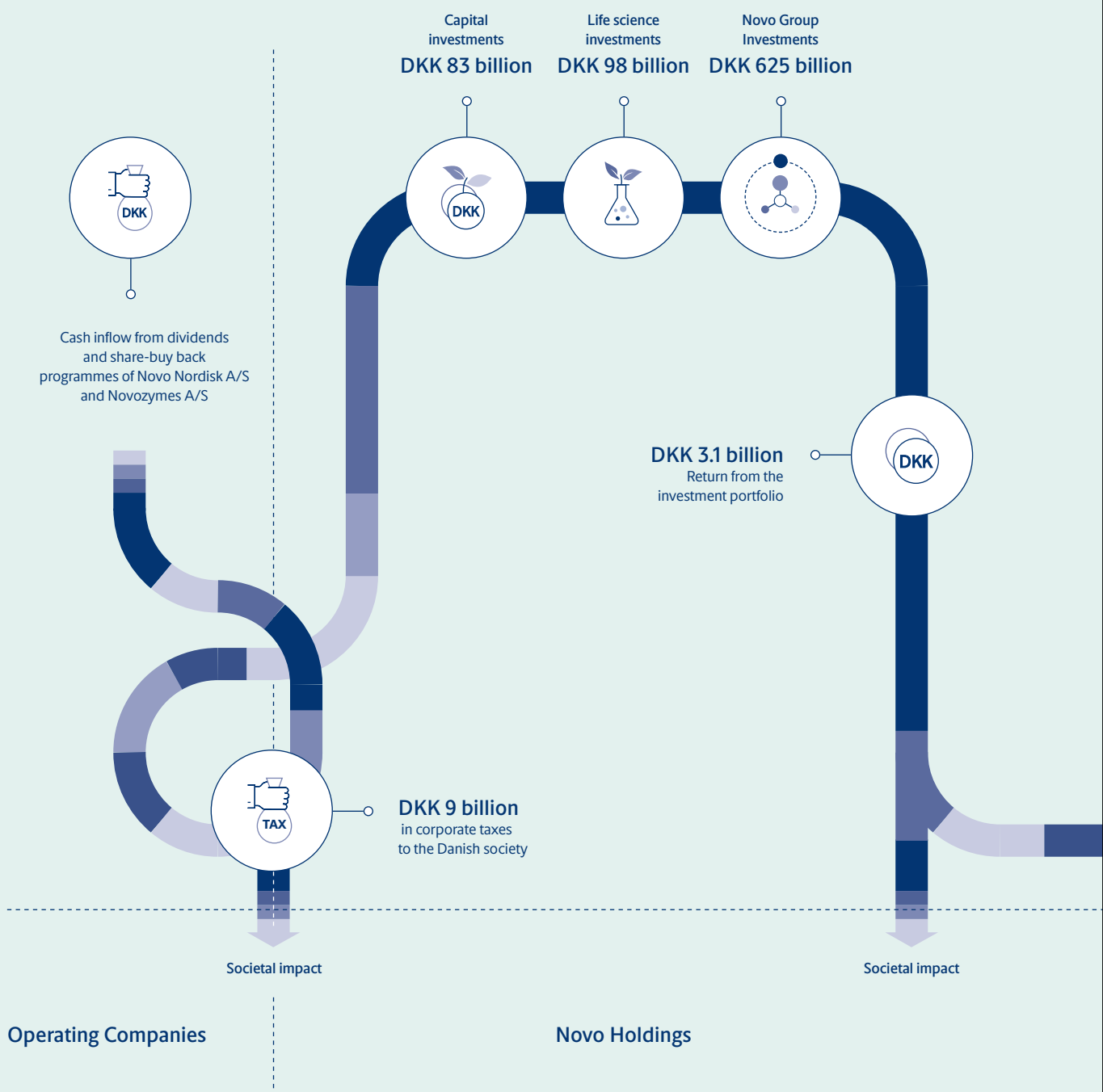


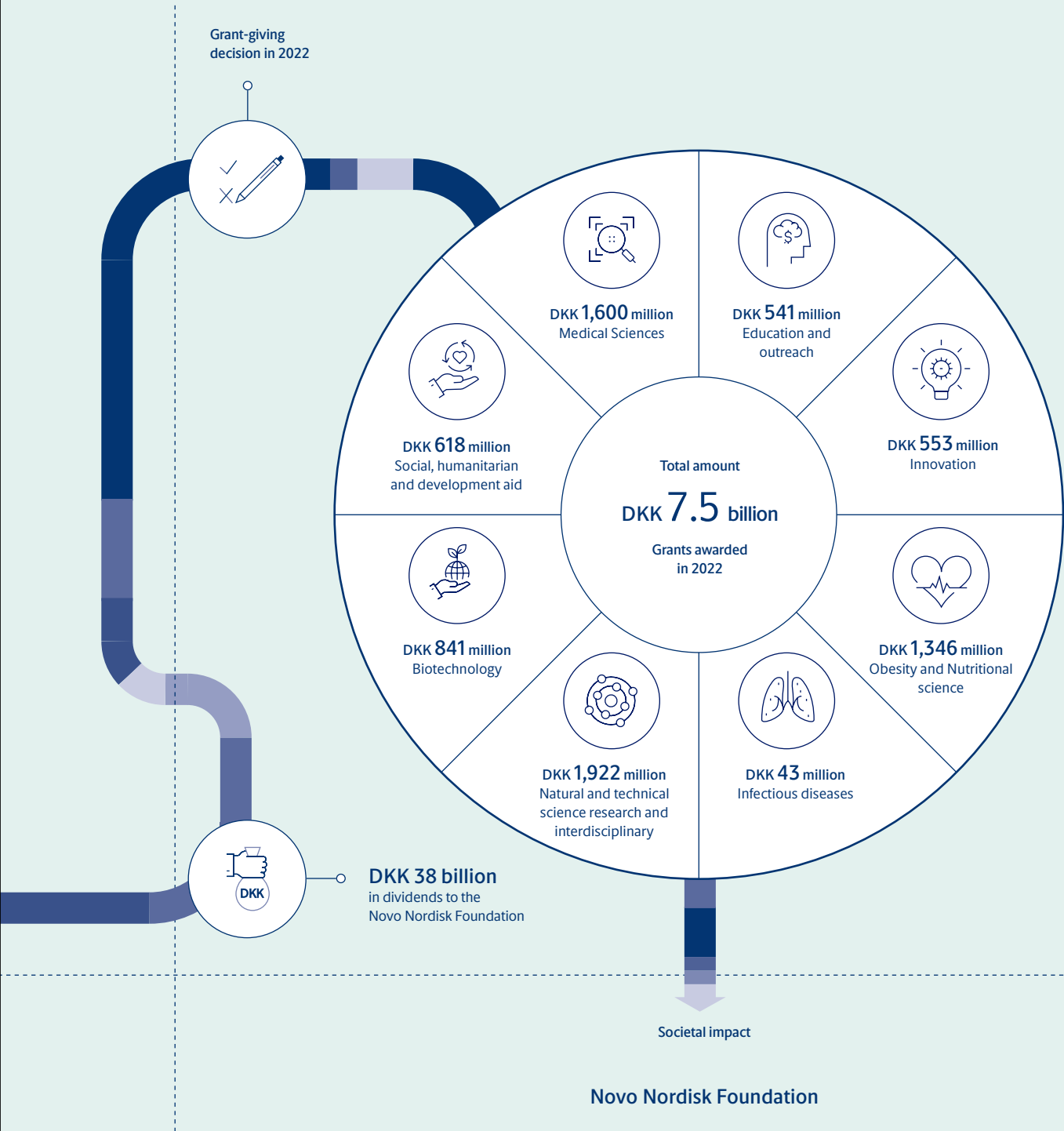
¹ Novo Nordisk Foundation Group consists of the Novo Nordisk Foundation, the Novo Group as well as Novo Holdings A/S' life science and capital investments. The Novo Group comprises Novo Nordisk A/S, Novozymes A/S and Novo Holdings A/S. Novo Holdings A/S is an investment company fully owned by the Novo Nordisk Foundation.

Business model

of the Novo Nordisk Foundation 2022

Figure 1.1.1



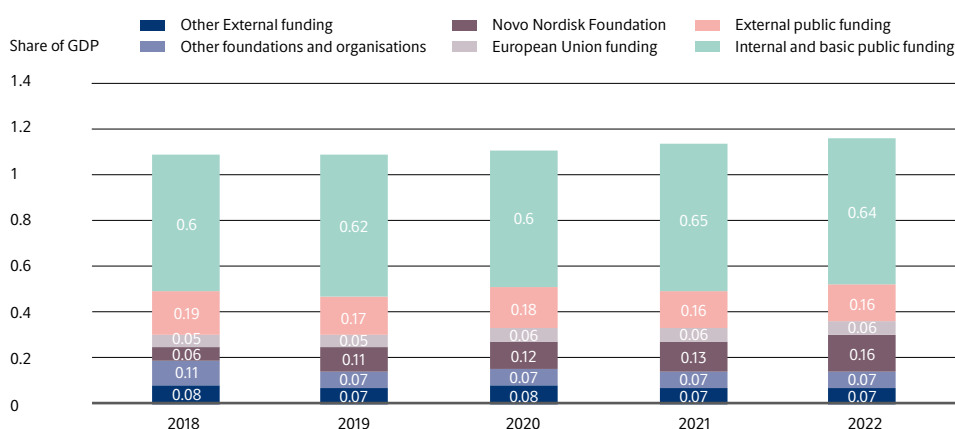


1.2 Grant-giving for scientific and non-scientific purposes

The Foundation awards grants both for scientific purposes and non-scientific purposes. In 2022, the Foundation awarded 695 new grants worth DKK 7.5 billion (€1.0 billion), while it paid out DKK 5.2 billion (€697 million) on all active grants. In 2017–2022, 80%–90% of the total payouts went directly to financing research and development in the public sector. In 2022, the direct payments to public sector research and development activities as well as to research equipment and buildings, mostly at universities and research hospitals, totalled DKK 4.6 billion (88% of total payouts). DKK 0.65 billion was paid out for non-scientific purposes.

Figure 1.2.1

Public research and development expenditure by financing source (% of GDP)



Sources: Universiteternes statistiske beredskab; Novo Nordisk Foundation.

1.3 Contribution to public and private research investments in Denmark

Public research and development

The Foundation contributed with an estimated 0.16% of GDP, equivalent to 14% of public sector research funding in Denmark in 2022 (see Figure 1.2.1 and Figure 1.3.1). The impact on funding shares within field of science is difficult to assess. The Foundation registers only the main scientific purpose of its funding, but the actual science carried out may branch out into several disciplines.

An example would be funding of research that can provide breakthroughs in health science and improve human health but builds on cell biology research rooted in natural sciences. Using the scientific purpose of funding, we estimate that the Foundation has financed 28% of public research spending in Denmark in 2022 within the medical and health sciences, 6% within the natural sciences (including agriculture), 4% within engineering/technical sciences and 2% within the humanities (the Foundation funds art research and art history research) and social sciences (incl. health economic research). If we instead use the distribution by field of subject of resulting journal articles, the numbers for the Foundation's funding of medical and health sciences would be 21% of Danish research expenditure in 2022, and 23% of natural sciences. Using journal article distribution is also imperfect as publication practices differ between fields of science.

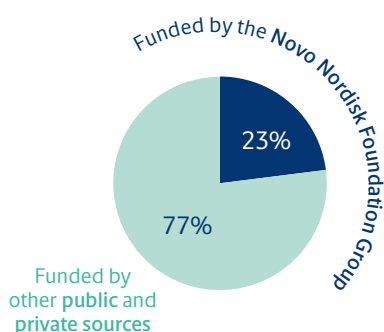
Private research and development

The share of the Novo Nordisk Foundation Group companies' expenditure for R&D in the private sector in Denmark is estimated at 23% (see Figure 1.3.1). This corresponds approximately to 0.43% of GDP. The sum of the Novo Nordisk Foundation Group's investments in R&D in the public sector as well as in the private sector is estimated at 0.58% of GDP.

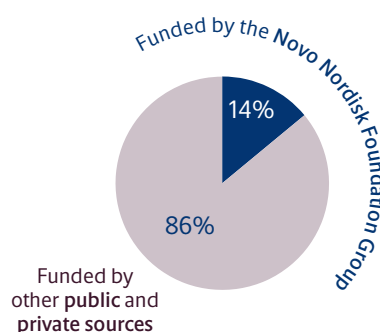
Figure 1.3.1

Research and development investments in Denmark 2022

Private research



Public research



Sources: Universiteternes Statistiske Beredskab; Novo Nordisk Foundation.

1.4 Tax payments to Danish society

Through its economic activities, the Novo Nordisk Foundation Group contributes to significant tax income. In Denmark alone, the total annual corporate tax payments amounted to DKK 10 billion in 2021 and nearly DKK 9 billion in 2022, which corresponds to approximately 14% and 12% (preliminary estimate) of Danish corporate taxes in 2021 and 2022, respectively. This is an increase compared to 2020, where the Group paid DKK 6 billion in corporate taxes in Denmark (10% of Danish corporate taxes). Furthermore, in 2021 and 2022 the Group also contributed through the Danish direct income taxes paid by the employees from the Novo Group and the life science companies where Novo Holdings' ownership share ranges between 5% and 100%. The direct tax payments of employees amounted to DKK 6 billion in 2021 and nearly DKK 7 billion (preliminary estimate) in 2022. The share of total Danish direct income taxes is approximately 1.3%.

The total sum of the Group's corporate taxes and direct taxes of the Novo Group's and the life science companies' employees in Denmark was DKK 16 billion (€2.2 billion) in 2021. For 2022, the total amount is preliminary estimated to DKK 16 billion (€2.2 billion).

In addition, the companies and employees also pay indirect taxes. On top of that, the grant-giving activities of the Foundation also generate income taxes via income for people fully or partly paid by Foundation grants and employees in spinout companies based on Foundation grants (see section 2.6).



The societal impact of philanthropic activities

This chapter surveys the societal impact of the Foundation's grant-giving activities. It does this by systematically working through the nine principles of the Foundation's societal impact model.

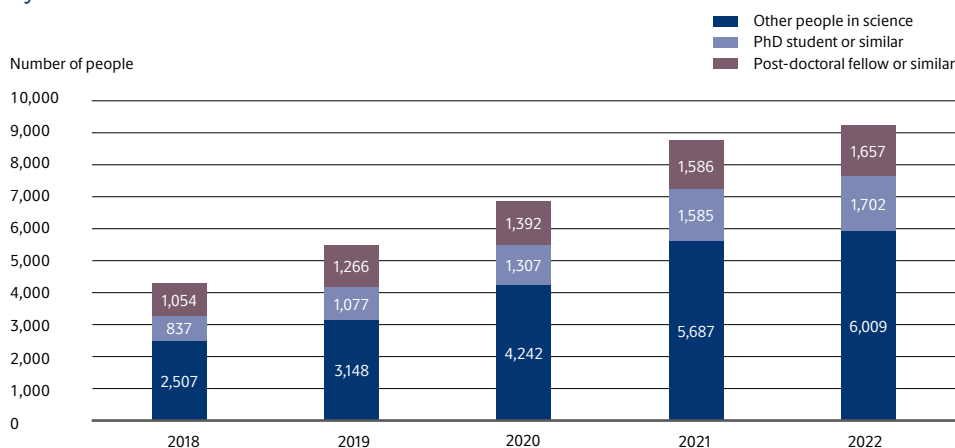
2.1 Fostering the development of diverse talent

The first societal principle in the Foundation's impact model concerns developing a talented and diverse population of researchers and helping institutions to attract talented researchers to Denmark. In 2022, the Foundation fully or partly funded approximately 8,000 people in scientific activities or research-hospital settings (see Figure 2.1.1) distributed across PhD students (18%), Postdoctoral fellows (18%) and other positions (64%) in science. This is a marked increase from previous years. The increase is in large part due to the introduction of a new reporting system (the Foundgood system) that allows for better reporting on the people associated with a grant, as well as reporting on the staff at the Novo Nordisk Foundation Center for Stem Cell Medicine, reNEW. Furthermore, efforts throughout the year to get complete and accurate reporting from grants that were identified to have reported significantly less than could be expected have resulted in more persons being reported. Finally, the increase also comes from higher payouts because of more active initiatives.

The Foundation's funding helps attract talented researchers to Denmark. This applies to almost half (45%) of the recruitments to Novo Nordisk Foundation research centres. Almost two-thirds of these (63%) are PhD students and Postdoctoral fellows, i.e. early career scientists. In addition, other Foundation funding instruments attract advanced career talent to Denmark, such as the Young Investigator Programme, RECRUIT, Start Package Grants and the Copenhagen Bioscience PhD programme for international students.

Figure 2.1.1

Number of people in scientific activities and research hospital settings fully or partly financed by the Novo Nordisk Foundation



Note: Other people in science include assistant, associate, and full professors, as well as research assistants, technical and administrative staff. The numbers of people for 2020 and 2021 are higher in this year's report compared to the previous year's reports, because many grantees have resubmitted new data on team members during 2022 and in January 2023.

Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science.

PhD students and Postdoctoral fellows

Early career researchers are the future of the research ecosystem. The number of current PhD students and Postdoctoral fellows fully or partly funded by Foundation grants has risen to more than 3,200 in 2022, up from around 1,800 in 2018 (Figure 2.1.1). The Foundation supports the research education of PhD students and Postdoctoral fellows through a variety of grant instruments, including fellowships, research centres, PhD academies and PhD programmes and team member funding through investigator grants and research projects and programmes. During 2018–2021/22, the fraction of all PhD students in Denmark fully or partly supported by the Foundation has increased from 7.4% in 2018 to approximately 12% in 2021/22.

Read more



Gender distribution among researchers supported by the Foundation

In 2022, out of the more than 8,000 people in science who were fully or partly funded by the Foundation's grants, 48% were men and 52% were women. In comparison, out of the more than 6,900 people in science who were fully or partly funded by the Foundation in 2020, 55% were men and 45% were women. The proportion of women at the lower seniority levels exceeded 50%, decreasing gradually as seniority increases. This trend reflects the situation at the universities. The Foundation has adopted a diversity policy that aims to support diversity among grant recipients and to ensure equal opportunities and treatment for all applicants (novonordiskfonden.dk/diversitetspolitik/).

2.2 Supporting organisations, systems and infrastructure

Since 2007, the Novo Nordisk Foundation has continually funded a wealth of larger initiatives designed to facilitate advancements in education, research, innovation and healthcare for the benefit of society.

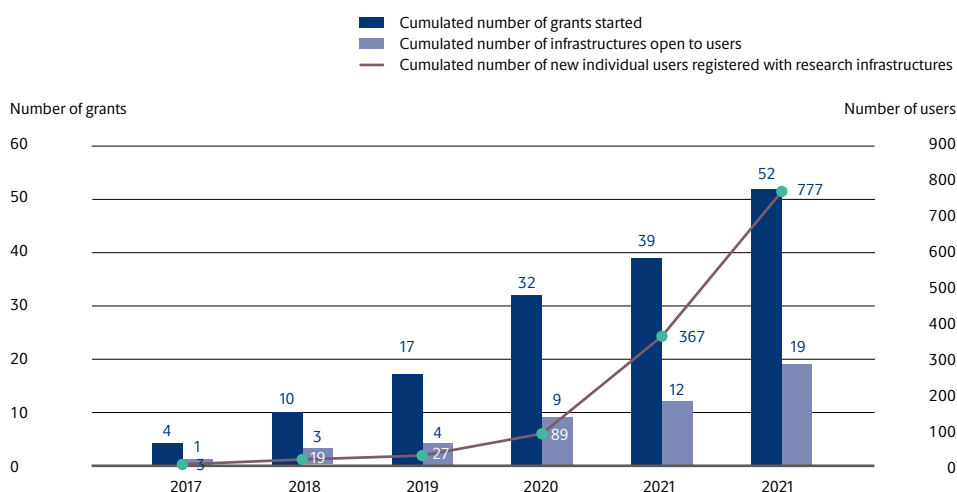
In 2022, the Foundation has awarded approximately DKK 4 billion (€ 0.5 billion) to research infrastructures, education platforms and academies, new research centres, innovation initiatives and a Steno Diabetes Center at the Faroe Islands. In 2007–2021, the Foundation awarded DKK 23.5 billion (€3.3 billion) to organisations, systems and infrastructure initiatives. The Annual Impact Report 2020 and 2021 show more details of the activities of the many different types of organisations, systems and infrastructure initiatives supported.

Research infrastructure grants

Research infrastructure grants differ from research grants and research centre grants as they are focused on giving researchers open access to large equipment and state-of-the-art research infrastructure needed to achieve excellence in research and innovation. Applicants can apply for fully funded research infrastructure projects, including procurement and instalment of equipment, building or developing facilities, as well as hiring and training of technical specialist teams to best service the infrastructure and its users.

Figure 2.1.2

Development in the number of research infrastructure grants and availability for users



Sources: Novo Nordisk Foundation/Foundgood/Infrastructure Reporting/Impact-of-Science.

In the period 2016–2022, the Foundation awarded more than DKK 1.2 billion (EUR 230 million) to 52 research infrastructures projects. These are all sizeable projects, typically with a one to three-year implementation phase during a five-year project period. This can be seen in Figure 2.2.1, which shows that the number of infrastructures open for use trail behind the number of granted infrastructures. The number of users benefitting from the availability grows fast, as more infrastructures open and in their second year reach more users. Users are the individuals that the infrastructures directly service but more than just the direct users benefit. Behind each user is a team of researchers that depend on the results from access to the infrastructures, increasing the impact beyond the mere count of users. By 2022, 777 users were reported to have registered research projects with the infrastructures. In 2021, there were 367 users.

2.3 Stimulating collaboration

In our philanthropic activities, we wish to stimulate collaborations. Collaboration strengthens the life-science ecosystem, supports the development of research talent, organisations and institutions and delivers excellent research and innovation. This section details the collaborative nature of the research supported by the Foundation. Collaborations can transcend geographical borders, involve both public and private researchers and build bridges between disciplines and genders. The data shows that researchers supported by the Foundation are involved in more international and industry collaborations than other researchers in Denmark. In addition, the level of interdisciplinary co-authorship in Foundation-funded articles is high.

Collaboration projects in Foundation-funded grants

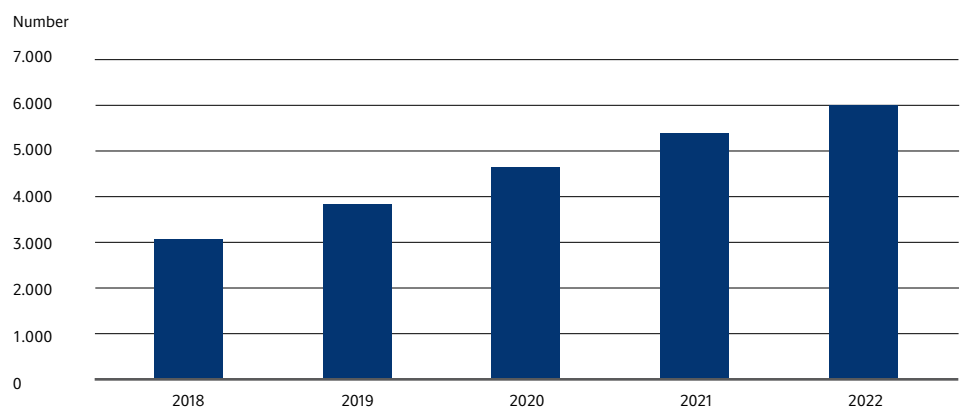
The grantees each year report active collaboration projects based on the Foundation's grant-giving activities. In the period 2016–2022, the Foundation has awarded 3,900 grants. In the following period, based on the active grants grantees have reported a steadily increasing number of active collaboration projects, rising from 3,074 in 2018 to 5,982 in 2022 (see Figure 2.3.1). The NNF Dashboard [novonordiskfonden.dk /Facts and figures](https://novonordiskfonden.dk/Facts-and-figures) provide more details regarding the type of collaborations and collaboration partners.

Read more



Figure 2.3.1

Number of active project collaborations reported by grantees



Sources: Novo Nordisk Foundation/Researchfish, Foundgood/Impact-of-Science.

Read more



National and international co-authorship in academia

In the period 2018–2022, 69% of articles authored by Foundation-supported researchers are co-authored with international researchers. This is slightly higher than the 62% share of international co-authorship among all Danish articles published between 2016 and 2020 (the most recent data available www.leidenranking.com). The rate of international co-authorship has been steadily increasing from approx. 50% in 2007–2012, but has recently plateaued.

Table 2.3.1 Number of Foundation-funded journal articles with co-authorship, 2018–2022

Academic co-authorship	Number of journal articles	% of journal articles
With international research institutions	10,039	69%
With no international research institutions	4,596	31%
Total	14,635	100%
Co-authorship with industry	1,756	12%

Note: The articles categorised as 'co-authored' in Dimensions include: 1) articles co-authored with researchers from two or more national research institutions only, and 2) articles co-authored with researchers from international, academic research institutions.

Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science, Digital Science Dimensions and DAMVAD Analytics.

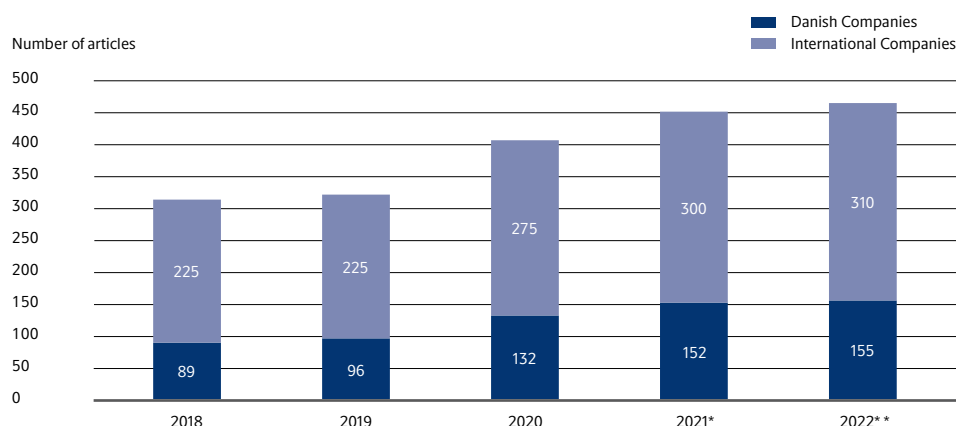
Research co-authorship with industry

Collaboration across national boundaries is often seen as a measure of success. Similarly, co-authorship between academic researchers and those based in industry is valuable, as it points towards collaborations that may translate new knowledge into commercial application. Of the Foundation-supported journal articles published by grant recipients between 2018 and 2022, 12% (1,756 articles) were co-authored with industrial researchers. The share is above the average share (9%) for all Danish journal articles published between 2017–2020 (www.leidenranking.com). 60% of the articles concerned medical and health sciences, while one third of the articles co-authored with industry researchers were within the chemical and biological sciences.

The number of journal articles co-published with industrial researchers has increased from 314 in 2018 to 465 in 2022. The number of different companies co-publishing with grant recipients has increased from around 200 in 2018 to nearly 300 unique companies in 2022. Figure 2.3.2 shows that the growth has largely come through co-publication with international companies. Around 80% of the collaborating companies are international, and the split remains largely the same between 2018 and 2022.

Figure 2.3.2

Number of journal articles co-authored with company-affiliated researchers distributed by origin of the company



Note: *) Distribution of Danish and international companies is likely to be different, due to publication lag.

Note: **) Preliminary estimate. The actual figure is likely to be higher, since every year in January grant recipients also report publications previously omitted.

Sources: Novo Nordisk Foundation/Impact-of-Science and DAMVAD Analytics.

In 2022, the share of articles co-authored with researchers from the life science industry was 73%. Half of the life science industry-academia articles were co-authored with industry researchers from biotechnology companies.

Interdisciplinary co-authorship

Similar to international co-authorship and co-authorship with industry, collaboration between disciplines is often valuable because scientists with different backgrounds can learn from each other and promote synergies. By examining co-authors' background, journal articles can be classified as monodisciplinary or interdisciplinary. Interdisciplinary co-authorship can link relatively closely related disciplines or reach across a wider spectrum of science. The level of interdisciplinarity used here is based on the researchers' finely grained academic specialisations, such as endocrinology, microbiology, genetics, physiology, biotechnology, physics, chemistry or bioinformatics, which are merged at the higher level of the OECD fields of science, like medical and health sciences, natural sciences, engineering and technology, or social sciences and humanities.

The analysis shows that the Foundation's dedicated interdisciplinary research grants are succeeding in promoting interdisciplinary co-authorship. Taking a random sample of 20% of the Foundation-funded journal articles for each year between 2018 and 2022, we find that 64% of the articles have been published by authors from 2–4 fields of science. In contrast, the output from our dedicated interdisciplinary grant instruments shows that 81% of the journal articles have authors from 2–4 fields of science.

Citation impact of interdisciplinary co-authorship

Citation analysis suggests that support of interdisciplinary collaboration produces high-citation research. One indicator for the impact of the journal articles by Foundation-funded researchers is that they are consistently overrepresented in the top 1% and top 10% most cited journal articles world-wide (as detailed in figure 2.3.3). The scientific literature (e.g. Lin Zhang et al., *On the relationship between interdisciplinarity and impact: Distinct effects on academic and broader impact*, Research Evaluation, 2021) suggests that a greater diversity of disciplines involved in a research project increases the likelihood of it achieving novel research findings and being highly cited.

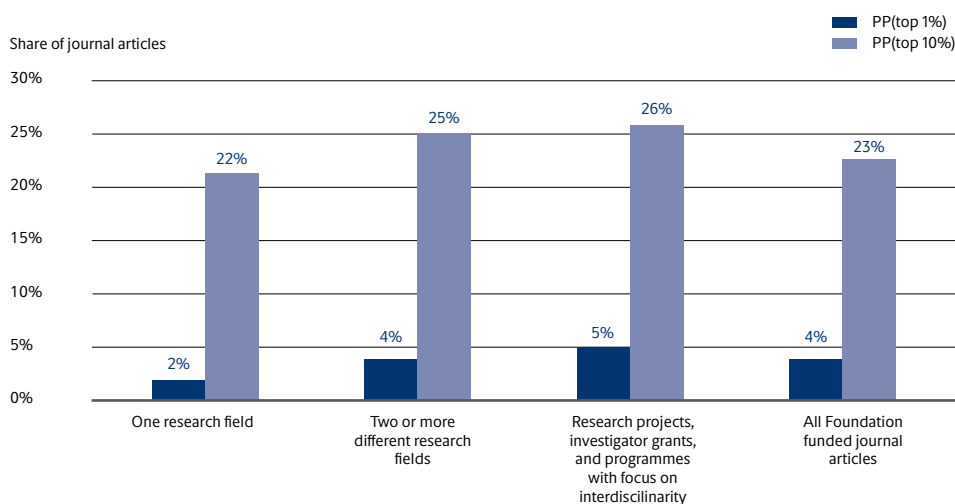
Our findings for Foundation-funded journal articles confirms that articles with authors from more than one field of science are likely to be more highly cited. Journal articles co-authored within two or more different research fields have a higher share among the top 1% or 10% most cited compared to journal articles published of authors within the same research field.

And finally, for journal articles published in conjunction with research projects and programmes with a particular focus on interdisciplinarity, the results confirm the hypothesis that a higher degree of interdisciplinarity gives a higher probability of publishing journal articles that are among the most cited in their field.

Figure 2.3.3 shows a PP(top 1%) and PP(top 10%) of 4% and 23%, respectively, for all Foundation-funded articles published in the period 2018–2021. The figure shows both the citation impact by number of fields of science of co-authors, for journal articles reported from interdisciplinary grants and for all Foundation funded articles. In comparison, PP(top 10%) for all Foundation-funded articles is two times the share for all Danish scientific journal articles.

Figure 2.3.3

PP(top 1%) and PP(top 10%) for Foundation-funded journal articles, 2018–2021



Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science, Digital Science Dimensions and DAMVAD Analytics.

2.4 Promoting excellent research and innovation

The fourth societal impact principle of the Foundation is to promote excellent research and innovation. The level of research excellence is maintained in the Foundation-funded research as the breadth and scale of the research supported increases.

Foundation-funded research published in scientific journal articles

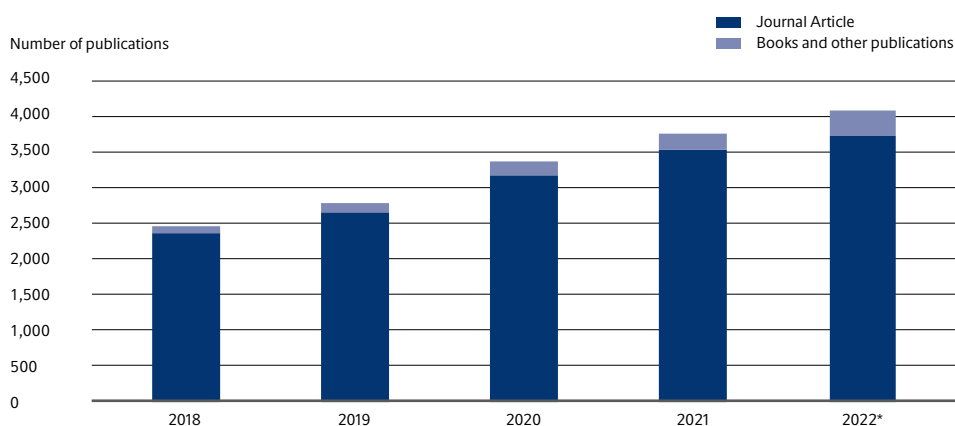
The amount of research output produced by Foundation grant recipients has continued to grow. In 2022, grant recipients reported 4,097 publications supported by the Foundation's funding. 3,728 of these were peer-reviewed journal articles, with the remaining 369 made up of a variety of other publications, including policy papers, technical reports, letters, books and book chapters (Figure 2.4.1).

Because the recipients of Foundation grants typically obtain additional funding and multiple authors contribute to a publication, most research output is supported by more than one funder or more than one funding instrument of the Foundation. In total for the period 2018–2022, the grantees have reported 14,635 journal articles plus approximately 1,400 other publications. The Foundation's grantees within the humanities delivered more than 125 journal articles plus other publications, between 2018 and 2022, and within the social sciences, the corresponding figure was more than 665 journal articles plus other publications.

In both 2021 and 2022 grant recipients contributed to 8% of the articles published in Denmark, up from 7% in 2020. In 2022, the growth rate of journal articles funded by the Foundation followed the growth in all Danish journal articles. With a delay in grantees' reporting, the share is expected to be higher next year. In addition, the Foundation grants contributed to 0.4%, 0.5% and 0.1% of the journal articles published from Sweden, Finland, and Norway, respectively.

Figure 2.4.1

Total number of publications by recipients of Foundation grants



Note: *) Preliminary estimate. The actual figure is likely to be higher, since every year in January grant recipients also report publications previously omitted.

Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science and Dimensions.

Overall citation impact of grant recipients journal articles

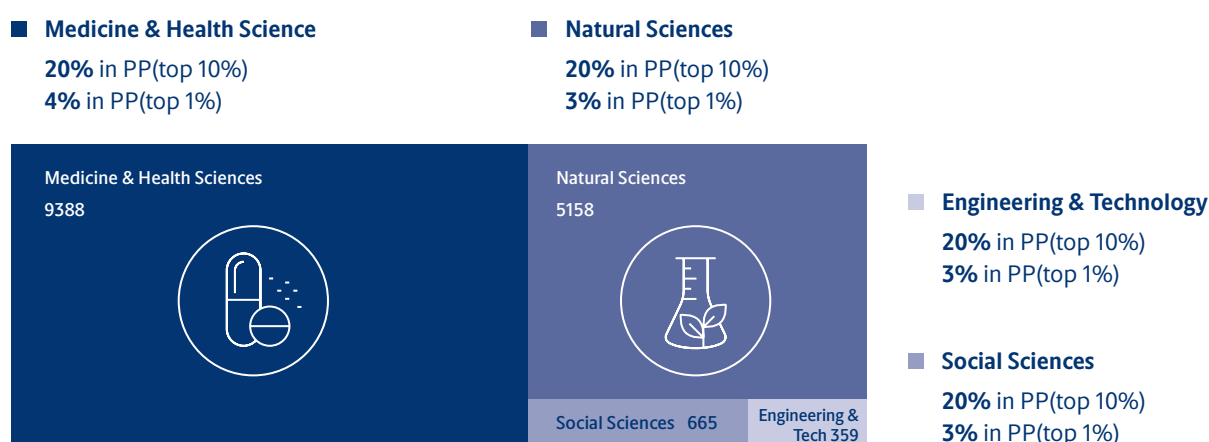
Citation levels give an indication of the rate of dissemination and use of Foundation-funded research in an academic context. For the period 2018–2021, 4% of the research was among top 1% of global research, and 23% of the journal articles are among the top 10% most frequently cited. In comparison, the fraction of all Danish journal articles among the top 10% most cited articles in the world was 12% for the same period.

The distribution of the fields in which Foundation-funded research is published are:

- 60% of the Foundation-funded journal articles refer to the medical and health sciences.
- 33% of the journal articles are within natural sciences, including e.g., cell biology and protein chemistry.
- 2% are within engineering and technology.

In 2018–2021, 8.4% of the journal articles were within Endocrinology, Diabetes & Metabolism. In the period 2013–2017, 18% of the journal articles reported by grantees were within Endocrinology, Diabetes & Metabolism. While more than 95% of the publications within medical science and natural and technical sciences are journal articles, the majority of the publications from the Foundation's grantees within the humanities (e.g. research in art and art history) are books, book chapters, dissertations and other types of publications.

Figure 2.4.2 Share of publications among the top 10% most frequently cited in the world – PP(top 10%), 2018–2021, and volume of publications, by OECD Field of Science and Technology



Note: Only includes areas with a total of 100 or more publications in the period.
Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science and Dimensions.

Overall, the Foundation grant recipients deliver high impact research within all supported fields of science (Figure 2.4.2). There are 9,388 Foundation-funded journal articles within medical and health science published during 2018–2021. 20% of the 3,138 journal articles published within Clinical Science are among the top 10% most cited in their field. 19% of the 1,909 journal articles published within the area of Biochemistry and Cell Biology are among the world's top 10% most cited in the field.

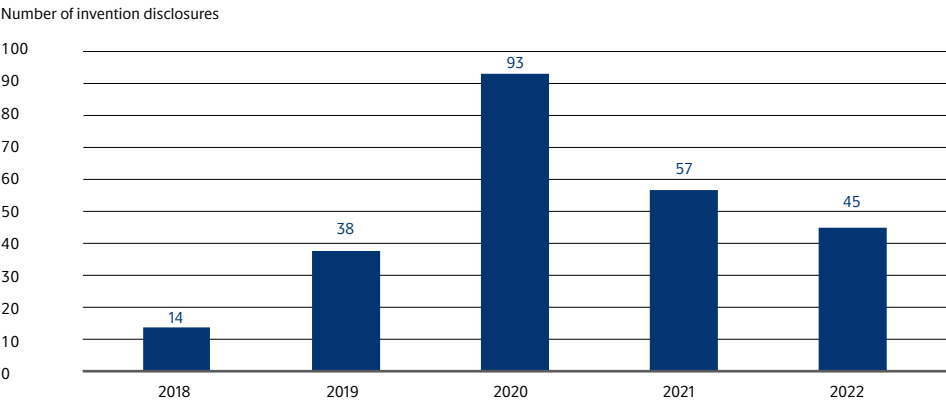
2.5 Developing innovative products and solutions

The Foundation supports innovation activities aiming for commercialisation of research discoveries within life science. Research supported also feeds into the technological and commercial innovation process.

Scientific discoveries and innovative solutions

One of the early steps on the road to commercialisation is when researchers file an ‘invention disclosure’ based on their new discovery at the research institution where they are based. Ownership and commercialisation rights for the invention are then negotiated and this allows for patent filing, which is often the next step in commercial exploitation. In January 2023, grant recipients reported 92 invention disclosures, covering novel and improved processes and products (Figure 2.5.1). 45 invention disclosures related to 2022, while 47 invention disclosures were post reporting for the period 2019–2021. For the period 2018–2022, the public research institutions have taken ownership of the invention, corresponding to 78% of the disclosures.

Figure 2.5.1 Number of invention disclosures reported by grantees



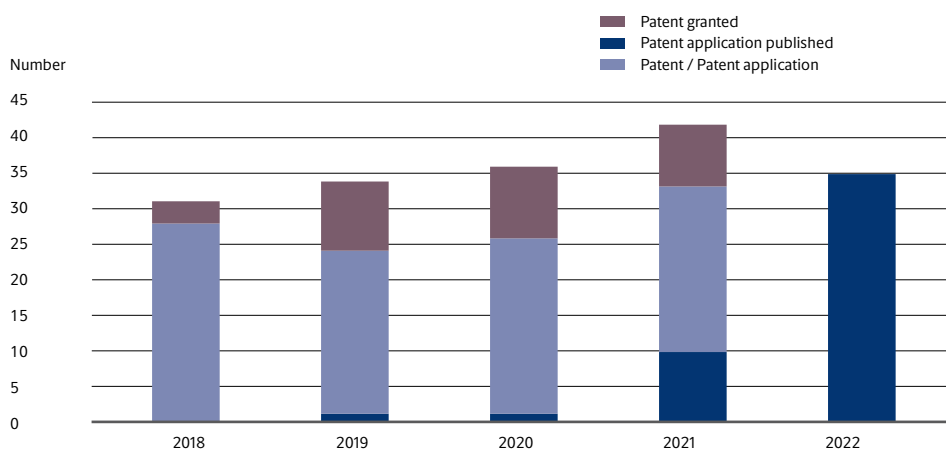
Note: Data on invention disclosures has been collected since 2020. There is an expected post reporting. In January 2023, additional 12 invention disclosures were reported for the year 2019 compared to the reporting in the previous years, additional 21 invention disclosures were reported for the year 2020, and additional 14 invention disclosures were reported for 2021. Hence, there is an expected post reporting with a delay of up to three years.

Sources: Novo Nordisk Foundation/Researchfish®.

Patent innovation activities based on Foundation-funded research

The Foundation grant recipients have reported 178 patent activities (patent applications, published patent applications or granted patents) for the period 2018–2022, including 32 granted patents. In 2022 alone, there were 35 patent applications, which is the highest application number of a single year (Figure 2.5.2). The patent activity is distributed between the BioInnovation Institute, the Novo Nordisk Foundation research centres, the Novo Nordisk Foundation open competition programmes and the Foundation's stand-alone initiatives. There is an expected post reporting with a delay of up to three years. The increased activity on reporting invention disclosures indicates an increased patent activity in the coming years.

Figure 2.5.2 Number of patent activities reported by grantees



Sources: Novo Nordisk Foundation/Researchfish*.

Measuring knowledge spill-over from fundamental research to private innovation using non-patent literature citations to journal articles

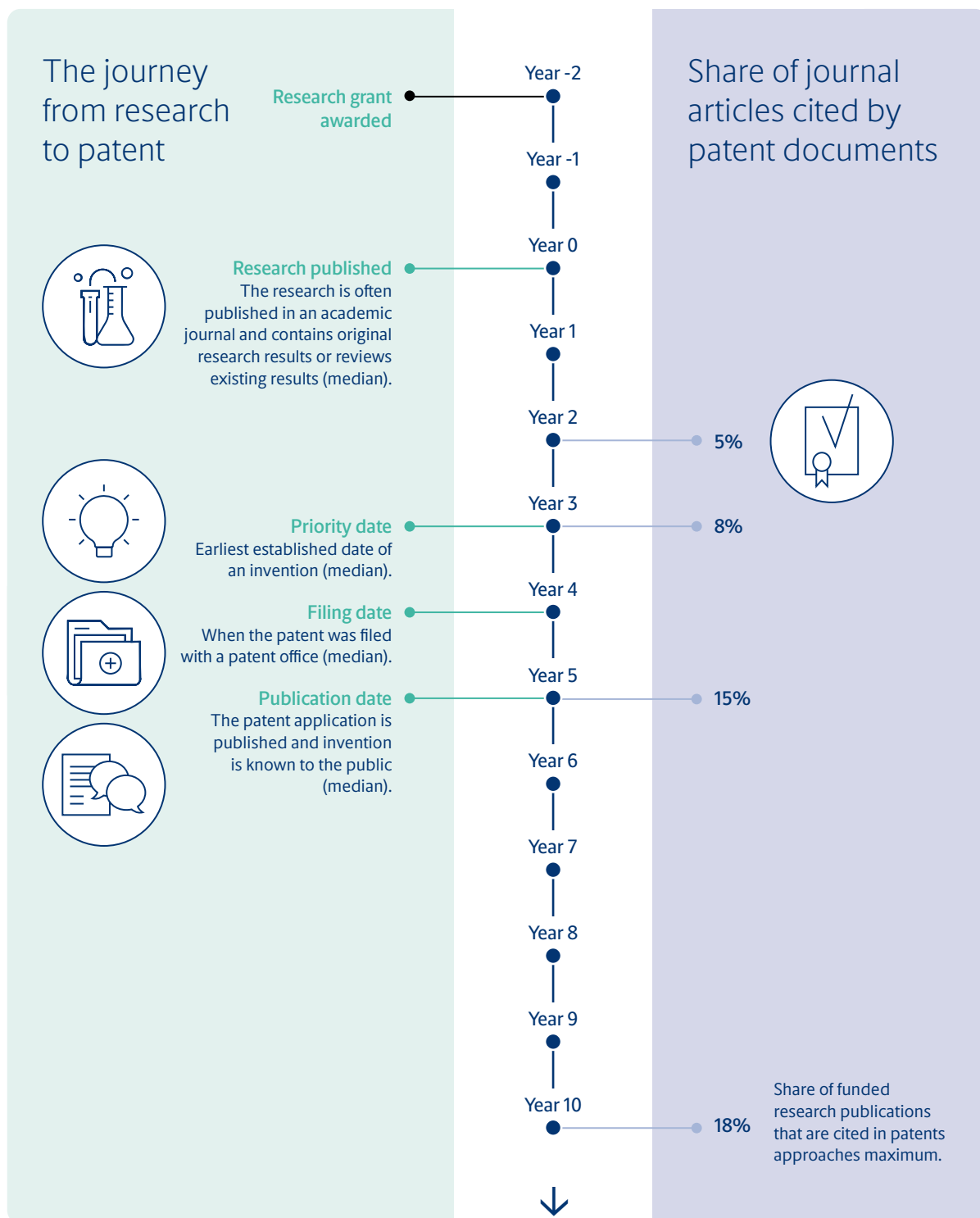
World-wide the number of journal articles now exceeds 2 million every year, and it is not always clear which ones will make a real-world impact, whether in the realm of improving treatments or supporting new research tools. Researchers and other applicants who file for patent protection of a new product or process and patent examiners make references to any existing, public knowledge (prior art, which cannot be patented), e.g. references to other patents (patents citations) or journal articles (non-patent literature citations) to demonstrate how the claimed invention is new. In this study we use non-patent literature citations to journal articles originating from Foundation-funded research to quantify the knowledge spill-over from fundamental research to private innovation.

The Dimensions tool and database has parsed non-patent literature citations in patent applications and granted patents. This allows us to easily track Foundation-funded journal articles cited in patent documents. We show that ten years after Foundation-funded journal articles are published, 18% of these articles are cited in patent documents (see Figure 2.5.3).

Observing the link between public research and private innovation takes time: First, a knowledge absorption time lag exists, measured as the time between the publication date of a journal article and the priority date of the referencing patent documents, which on average is three years. Second, a non-disclosure time lag exists because patent applications are only made public 1½ years after the date of discovery (priority date). Due to these time lags, referenced journal articles are typically observed in patent documents about five years after being published. The citation share level appears to plateau for journal articles ten years after their publication, when around 18% of Foundation-funded journal articles are cited in patent documents. This amounts to approximately 9,500 citations in patent documents.

While a project's commercialisation activity indicates the level of innovation per grant, it does not reveal the commercialisation of research results by other stakeholders, giving a more complete picture of the overall use of the research for patent activity documenting patent citation's emergence as an important indicator of science and technology interaction, also emphasising the crucial role industry plays in establishing a link between Novo Nordisk Foundation funded research and technology.

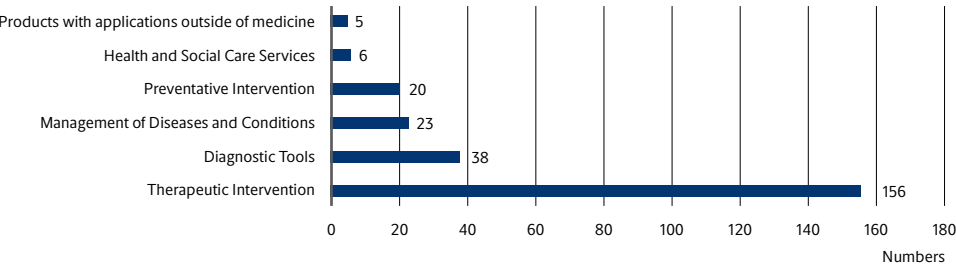
Figure 2.5.3 Patent citation timeline for public foundation-funded research



Products and interventions based on grants

Through medical interventions and products, the Foundation’s grants might have an impact on health and patient care. For the year 2022, the grant recipients have reported 82 new products and interventions. Since the beginning of the reporting in Researchfish® in 2015, the Foundation’s grant recipients have reported 298 interventions, health care services and other products. Of the interventions and products reported, 52% are therapeutic interventions that directly affect patients, 13% are new diagnostic tools, 8% are management of diseases, 7% are preventative interventions. 20% are health services, products with applications outside of medicine and other not in the reporting yet categorised products.

Figure 2.5.4 Products and interventions, 2016–2022



Source: Novo Nordisk Foundation/Researchfish®/Impact-of-Science.

2.6 Creating jobs and growth

Investments in research, innovation, education and research hospitals also have impact and provide benefit to society through the creation of companies, jobs and economic growth. This section details the direct job-generating effect of Foundation-funded activities covering spinout companies and employment through grants. The section takes its starting point in creation of spinout companies, followed by their impact on job generation, and finally assessing the impact and productivity of the companies in terms of their ability to attract additional funding.

Spinouts based on Foundation-supported research

New knowledge generated by Foundation-funded researchers can form the basis of innovation and new companies. These spinout companies are generally established by researchers based in universities or hospitals. The Foundation has had a specific stream of funding for innovation grants since 2007, which involves funding of early academic research, mentoring, proof-of concept grants, pre-seed grants, advice in commercialisation of research discoveries, follow-on investments and support for exits. The support is provided by the Foundation’s innovation initiatives, including the Foundation-funded BioInnovation Institute (BII) and pre-seed grants from Novo Seeds.

Figure 2.6.1

Spinouts and start-ups in philanthropic activities of the Novo Nordisk Foundation

Figure 2.6.1a

Reported number of new spinouts and start-ups based on Foundation grants

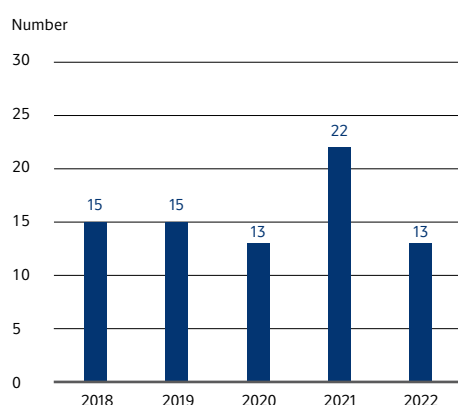
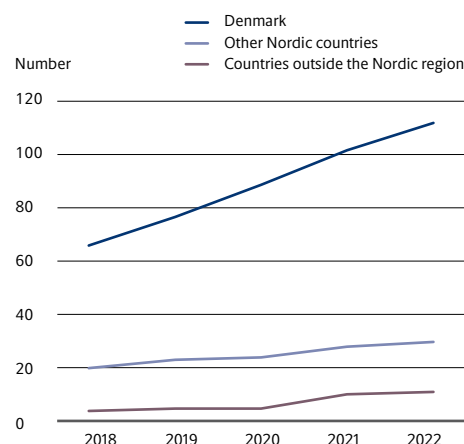


Figure 2.6.1b

Total spinouts and start-ups based on Foundation grants



Source: Novo Nordisk Foundation/Researchfish*.

For the year 2022, innovation and research grantees reported the establishment of 13 spinouts (Figure 2.6.1a), which brings the total of established spinouts and start-ups based on Foundation grants to 153. 112 spinouts were established in Denmark, 30 were established in the other Nordic countries and 11 outside the Nordics (Figure 2.6.1b).

Companies supported by Foundation-funded innovation infrastructure

At the Bioinnovation Institute another 42 start-up companies that have not been established based on Foundation grants have been supported. At the end of 2022 these start-up companies employed 131 full-time employees.

Job creation in initiatives, spinouts and start-ups based on Foundation grants

By the end of 2022, spinouts and start-ups based on Foundation-funded research accounted for around 769 full-time employees. 70% were in Denmark, 19% in the other Nordic countries and 11% in the rest of the world.

In line with the increase in the Foundation's payouts, the number of people fully or partly funded by the Foundation's grants has increased from around 3,500 in 2018 to around 9,350 in 2022. In 2022, nearly 8,000 of these people were working within science and at the Foundation-funded research hospitals.

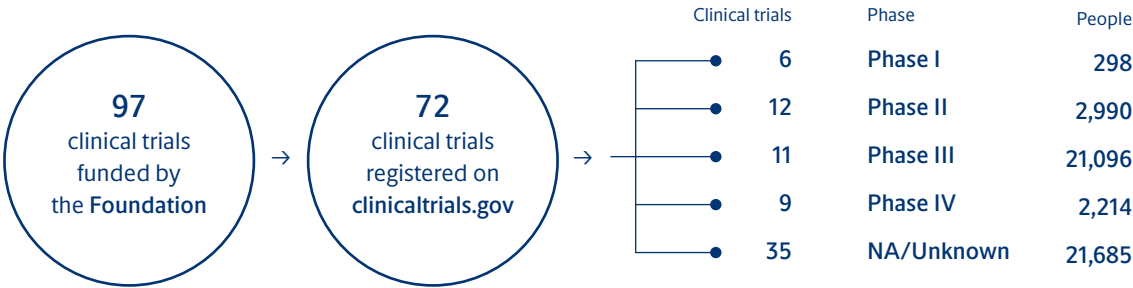
2.7 Developing new technologies, therapies and disease prevention

This section shows that Foundation-funded research contributes to clinical trials, clinical guidelines, patient care and many medical interventions and products.

Clinical trials

The Foundation funds researchers who conduct investigator-initiated clinical trials. Grant recipients have reported a total of 97 clinical trials since 2014 (Figure 2.7.1), of which 72 are registered in the US registry clinicaltrials.gov (note that not all clinical trials have to be registered, especially in the early phase I, and they might be registered in a different clinical trial registry). 82% of the 72 clinical trials were conducted in Denmark. In total, more than 48,000 people are enrolled in these trials.

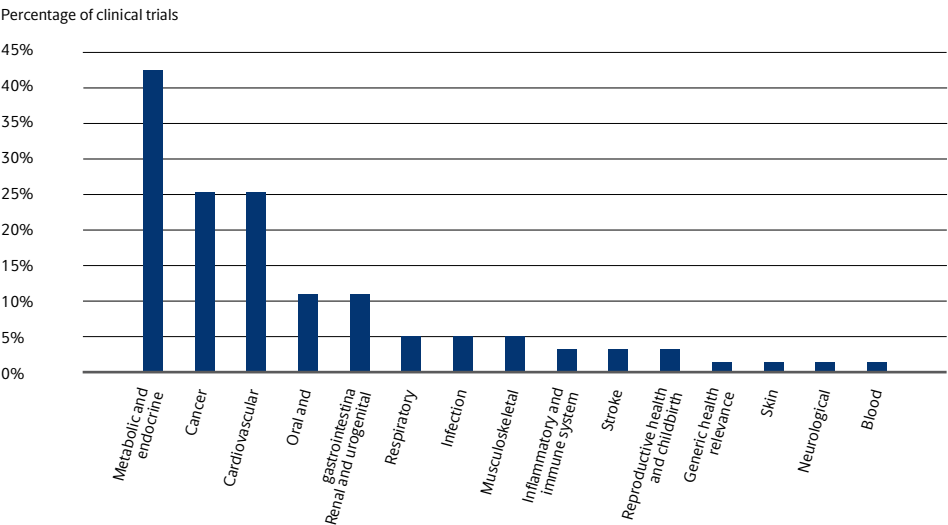
Figure 2.7.1 Clinical trials funded by the Foundation, 2014–2022



Sources: Novo Nordisk Foundation/Researchfish*/Impact-of-Science and clinicaltrials.gov.

The clinical trials reported by grant recipients are mostly within the Metabolic and Endocrine health category, which includes diabetes and obesity (Figure 2.7.2).

Figure 2.7.2 Health categories for clinical trials, 2014–2022



Sources: Novo Nordisk Foundation, ResearchFish and clinicaltrials.gov.

Clinical Guidelines

Clinical guidelines are systematically prepared scientific recommendations amalgamating evidence from clinical trials and other research that support healthcare professionals in decision-making. The extent to which clinical guidelines cite research conducted by the Foundation's grant recipients is indicative of the relevance and significance of the research for patients.

Figure 2.7.3

The 548 contributions to practice guidelines and advisory functions in 2018–2022



Source: Novo Nordisk Foundation/Researchfish*/Impact-of-Science.

Researchers contribute to improved patient care by developing and revising the clinical guidelines, drawing on their own and others' research. Grant recipients reported a total of 548 such contributions in the period 2018–2022.

In comparison, they reported 428 contributions in the period 2017–2021. Of the contributions reported, 26% concern membership of a guideline committee, while 21% relate to participation in an advisory or guideline committee. Related activities are contributions to other policy documents and supporting training of practitioners or researchers. These various activities are broken down in Figure 2.7.3.

Clinical guidelines within non-communicable diseases

Many Foundation-funded journal articles are cited in guidelines on the treatment of patients within the four non-communicable diseases (NCDs): diabetes, cardiovascular diseases, respiratory diseases and cancer. We analysed 1,164 clinical guidelines currently in use. This is nearly 200 more guidelines compared to our analysis last year. The data includes guidelines published in 2022 and earlier in Denmark, the other Nordic countries, in the United Kingdom and the United States, and by international organisations such as the European Union and the World Health Organization (WHO). Clinical guidelines and recommendations for clinicians are continually updated with the latest achievements in research and new knowledge on patient care. Some are updated annually and others every 5–10 years.

Of these 1,164 guidelines, 234 cited Foundation-funded journal articles, corresponding to 20%. In comparison, last year's analysis showed that Foundation-funded journal articles were cited in 18% of 970 guidelines. Overall, there was no substantial difference in the share of guidelines citing Foundation-funded research articles according to geographical location (Nordic countries vs the rest of the world) in the diabetes and respiratory domains. In current cancer guidelines for the Nordic countries, Foundation-funded researchers contributed to 18% compared to 8% of international guidelines. For cardiology, the corresponding shares were 17% and 25%, respectively.



Clinical guidelines within diabetes

Historically, the Foundation has focused on diabetes and its complications. The analysis of 138 current guidelines within the diabetes area showed that 55% included research published by the Foundation's grant recipients.



Clinical guidelines within cardiovascular diseases

Of the 370 current guidelines studied here, the Foundation's grant recipients contributed to 25%. The largest proportion of grant recipient contributions was seen in the most recent international guidelines (49%).



Clinical guidelines within cancer diseases

Of the 442 current guidelines analysed, Foundation-funded researchers contributed to 12%. In the most recent Nordic guidelines, contributions from grantees were seen in 18%.



Clinical guidelines within respiratory diseases

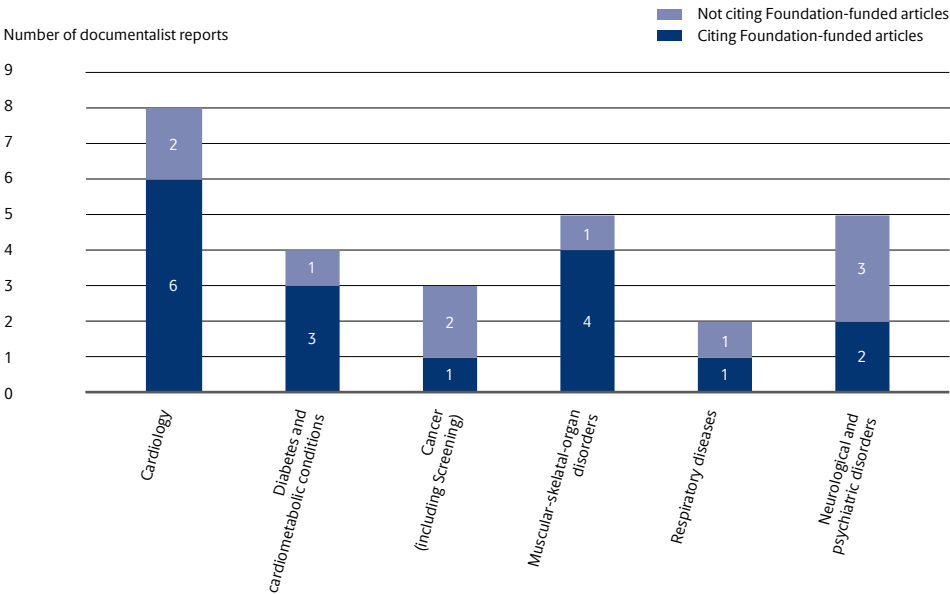
Of the 214 current guidelines within non-communicable respiratory diseases, the Foundation's grant recipients contributed to 7%. 109 guidelines were published between 2018 and 2022, and Foundation's grant recipients contributed to 10% of these, compared to 6% of the current guidelines published in 2013–2017.

Documentation in patient quality databases

The Danish Clinical Quality Program (National Clinical Registries) facilitates the development and reporting of quality indicators and standards for good clinical practice to improve the overall quality of patient treatment in the Danish hospitals and medical practices. Of the 82 Danish clinical databases, 34 reports have published documentation of the evidence in reports with references to scientific literature.

Documentation reports provide a systematic overview of the scientific evidence behind the choice of indicator variables in the patient quality database and are links between the discoveries published in scientific journals and patient treatment and outcomes. Of the 34 documentation reports in this year's analysis, 17 cite Foundation-funded journal articles. Last year's analysis found 14 documentation reports that cited Foundation-funded articles. The distribution within disease areas is shown in Figure 2.7.4.

Figure 2.7.4 Number of documentalist reports citing Foundation-funded articles as of November 2022



Source: Novo Nordisk Foundation/Researchfish*/Impact-of-Science.

Number of people treated and quality of treatment at the Steno Diabetes Centers

The Steno Diabetes Centers aim to advance all aspects of diabetes care in Denmark across the lifetime of a person with diabetes through a public-private partnership model. The Foundation funds new up-to-date diabetes hospital buildings, diabetes research, education of nurses and doctors and state-of-the-art care for people with diabetes. The aim of this modernisation is to boost the development of diabetology and increase the life expectancy and quality of life for people with diabetes in the Danish Realm with an outlook to have a global impact. The Centers provide a wide range of healthcare services related to diabetes, including diagnosis, treatment, treatment and disease monitoring, screening for complications, and dietary guidance supplemented by tuition in a food laboratory.

The number of patients treated by the Steno Diabetes Centers has continued to increase with the number of centres. The total number of people treated was approximately 7,000 in 2017, and by the end of 2022 close to 30,000 adults were treated in one of the six Steno Diabetes Centers, including the newest centre in Greenland.

Certain factors are considered essential to achieving optimal patient outcomes. In diabetes, this primarily includes glycaemic control and control of blood pressure and blood lipid levels. High blood glucose levels (i.e. poor glycaemic control), high blood pressure, and high levels of LDL cholesterol are factors that increase the risk of diabetic complications and comorbidities, e.g. cardiovascular diseases, blindness, kidney disease, and amputations. As people with diabetes have an increased risk of blindness and lower limb amputations, yearly examinations of eyes and feet to prevent and treat these complications are generally recommended. However, the centres are now advancing these “one size fits all” guidelines to figure out whom to screen more or less frequently along the principles of precision medicine.

The quality of patient care is measured using these and other indicators. Using data from The Danish Clinical Quality Programme, the Steno Diabetes Centers’ patient treatment can be benchmarked against the treatment provided at other Danish hospital wards. That being said, there is an expectation that the activities at the centres will positively impact not only the quality of care at the centres themselves but benefit all people with diabetes in Denmark.

Compared to the analysis in the Foundation's Impact Report 2021, there is progress in the treatment of people with diabetes. Our analyses show that for the indicator of good glycaemic control in patients with Type 1 diabetes, the Steno Diabetes Center in Odense fares better than both the regional and national average, whereas the share of patients with good glycaemic control in the remaining Steno Diabetes Centers is close to the average of the respective regions.

For patients with Type 2 diabetes, the Steno Diabetes Center in Copenhagen fares better than the regional and national average, while the Steno Diabetes Center Odense fares better than the regional average for Southern Denmark.

The share of patients with LDL-cholesterol levels below 2.5 mM is practically identical in the different Steno Diabetes Centers, and the share matches the regional averages closely.

Regarding the share of patients that have yearly prophylactic foot examinations, the Steno Diabetes Center in Copenhagen performs better than the regional average for the Capital Region, while the Steno Diabetes Centers in Odense and Aarhus fare worse than the corresponding regional average.

2.8 Supporting the development of world-class education

It is important that every new generation receives the best education possible and that research is disseminated in education programmes and across society. This chapter investigates the outcomes of the Foundation's grant giving within education and outreach activities. It presents the number of initiatives and the reach through our different types of education grants, which target the educational system from pre-school to higher education. It also presents the results of the Foundation's support for science dissemination outside school-hours and the outreach activities indirectly funded by research grants.

Initiatives aimed at science education

The Foundation is dedicated to developing world-class education within science and technology to cultivate engagement, learning and the development of competencies of children and youth. We support STEM education in pre-school, primary and lower secondary education, youth educations (upper secondary and vocational) and higher and further education.

The Foundation's largest education initiative is LIFE, which has a ten-year budget frame of up to DKK 1.9 billion. In the period 2018–2022, LIFE has been awarded a grant amount of total DKK 1,138 million. In the period 2018–2022, the Foundation also awarded more than 170 other education grants through open calls or as stand-alone initiatives (total amount DKK 859 billion or EUR 115 million). Alone in 2022, the number of other education grants was 36 with a grant amount of DKK 164 million (EUR 22 million).

The education activities vary greatly in kind as well as reach and include visits and laboratory experiments at the LIFE campus, online materials, continued professional development of science teachers and research on science education. The reach on students from pre-school to youth education has grown since 2019 (Figure 2.8.1). In 2022, our funded education activities involved more than 240,000 participations by children and youth.

Figure 2.8.1 Reach and participation in education grants

Children and youth reached by teaching and learning activities



Sources: Novo Nordisk Foundation/Foundgood/Researchfish*.

Note: *Prognose for 2022, since several grantees have 2022-reporting deadline primo Q2 2023.

Outreach activities within natural sciences

The Foundation has open calls and stand-alone initiatives that focus specifically on providing science communication and experiences outside the educational system. The aim is to contribute to engagement and interest in natural science and technology, disseminate new knowledge on science and discoveries and to facilitate a qualified public debate on topics within natural science. Outreach activities within STEM constitute a growing field of funding for the Foundation. In the period 2018–2022 more than DKK 350 million (EUR 47 million) was awarded to outreach projects. Alone in 2022, the grant amount to outreach projects was approximately DKK 120 million (EUR 16 million).

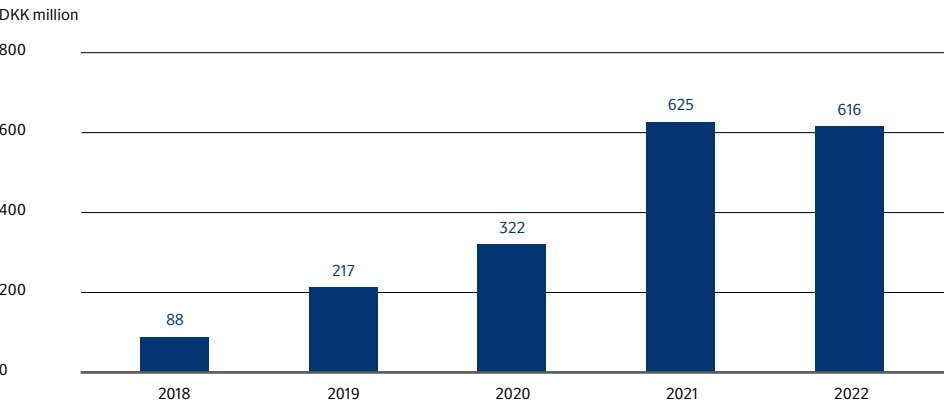
Activities on science communication and public debate include festivals, science debates (workshops, conferences, online events, podcasts etc.) and talks and presentations to the non-scientific community. Activities that provide science-based experiences outside the formal educational system include development of exhibitions at science museums, summer camps, learning games, and science clubs for children.

2.9 Supporting people in difficult social and humanitarian settings

The foundation supports social and humanitarian causes have increased during the last six year. Since 2018 the Foundation has awarded 291 grants amounting to a total of DKK 1.87 billion. 90% of the amount has been awarded to humanitarian initiatives outside Denmark.

Figure 2.9.1

Grant amount for social and humanitarian causes (DKK million)



Source: Novo Nordisk Foundation.

Supporting people in low- and middle-income countries

The Foundation's aid initiatives in low- and middle-income countries (LMICs) aim to improve the opportunities of vulnerable people affected by humanitarian crises and poverty, with a strategic focus on youth empowerment and fighting non-communicable diseases (NCDs). Through a wide range of partners such as the World Diabetes Foundation (WDF), the Red Cross, UNICEF, PlanBørnefonden and the Danish Refugee Council, the Foundation has awarded approximately DKK 1 billion (EUR 130 million) for projects in Jordan, Lebanon and several countries in Eastern Africa.

With the current strategy, the strategic programmes in LMICs will focus on fighting inequity in health. The ambition is to improve the health outcomes for patients living with diabetes and other cardiometabolic diseases by improving local capacities for NCD prevention and care. Diabetes and other NCDs are among the greatest health challenges of the 21st century, not least in LMICs, where NCDs add to the existing burden from communicable diseases, creating a double disease burden which their health systems are greatly challenged to cope with. This next section will focus on the learnings from WDF partnership programmes that were granted under the previous strategy in this field.

The World Diabetes Foundation – Novo Nordisk Foundation partnership on NCDs

Since 2018, WDF has been a strategic partner to the Foundation in fighting NCDs. Since 2020, this partnership has been governed through a Memorandum of Understanding. In the period 2018–2022, the Foundation has awarded 16 grants to WDF at a total amount of DKK 518 million, with the purpose of scaling up NCD prevention and care in countries like Tanzania, Jordan, Lebanon, and Kenya. Grants have furthermore been aimed at integrating NCD prevention and care into humanitarian response programmes in partnership with United Nations High Commissioner for Refugees (UNHCR). WDF has co-financed with a total of DKK 63 million based on its basic funding from the Novo Nordisk A/S. Further funding from other organisations amounts to DKK 199 million.

In 2022, the strategic partnership between WDF and the Foundation went through an external review process to assess its effectiveness as well as WDF's capacity to deliver on the intended outcomes, including WDF's capacity to leverage global and national partnerships and advocate for wider impact. The review concluded that WDF is considered a unique and strong global partner to the Foundation, as the two parties have a shared vision, shared ambitions and commitments.

The review highlighted WDF's credibility and ability to deliver relevant programmes focusing on diabetes while recognising the wider cardiovascular disease agenda. WDF has significant expertise in country-level NCD support programmes and a broad partnership network, including within the Foundation's geographical focus areas. The opportunity for WDF to scale up efforts has led to increased capacity as well as status amongst development partners, and thereby catalysed opportunities to mobilise additional funding sources, evidenced by the co-funding generated for specific programmes. The support for WDF has strengthened its position as a key player in the national, regional and global advocacy space.

World Diabetes Foundation - Foundation Partnership



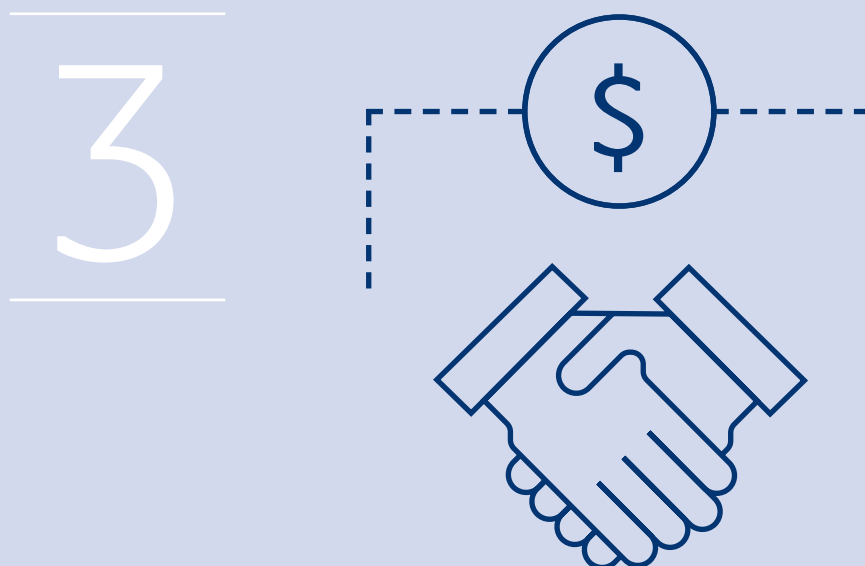
Results 2019–2022 on access to NCD prevention and care

- 725 primary healthcare clinics strengthened to provide NCD care
- Health Care Professionals trained: 3,663 (1,046 alone in 2022)
- People screened for diabetes: 97,474
- 15,958 children with Type1 Diabetes enrolled in care programmes (13,536 alone in 2022)
- 99,524 patients under treatment at supported clinics (49,000 alone in 2022)
- 79,710 children, parents and teachers trained in healthy living and prevention
- Strategic partnerships established with WHO, UNHCR, ministries of health to create policy change for improved NCD care.

Under the Diabetes Compass

A multi-year initiative to leverage technology to improve national NCD responses
- WDF collaborated with partners in Malawi, Sri Lanka and Tanzania to:

- Establish the first national NCD data warehouses to support policy, planning and quality management of NCD health services
- Design a community health platform for use by community health workers to improve early detection of diabetes and hypertension
- Create innovative digital learning experiences for health care professionals and provide them with point of care support.



The societal impact of commercial activities

The commercial purpose of the Novo Nordisk Foundation is to provide a stable basis for the commercial and research activities of the life science portfolio of companies, including Novo Nordisk A/S and Novozymes A/S, which the Foundation controls through Novo Holdings A/S or has a substantial investment in (stakeholder share).

This chapter details some of the societal impacts of these commercial activities. The impacts vary greatly, both because of the different nature of the activities and because the data related to these are very different. The societal impact of the commercial activities is also different from the impact of the philanthropic activities, as the companies controlled and invested in are already established with pipelines of products, services and clinical trials, and in some cases are mature multinational companies with high turnover and many users of products and services.

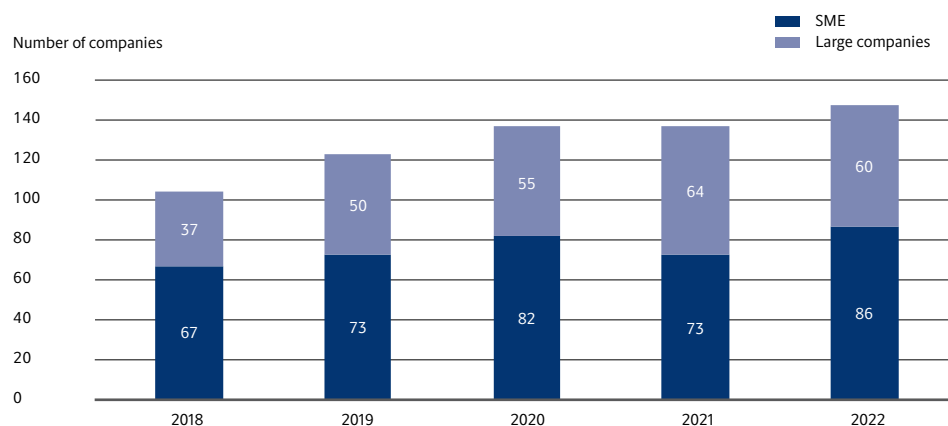
This chapter focuses on the Novo Group and equity investments in life science companies where Novo Holdings' ownership share exceeds 5%. Unless stated otherwise, the analyses include Novo Nordisk A/S, Novozymes A/S and Novo Holdings A/S.

3.1 Fostering the development of talent

The size of Novo Holdings' company portfolio has grown since 2018, both in terms of the number of companies and of employment. Since 2018, the number of companies in the portfolio has increased by 41%. It has grown from 104 companies to 147 in 2022, including Novo Nordisk A/S and Novozymes A/S (Figure 3.1.1).

Figure 3.1.1

The number of life science portfolio companies



Note: The portfolio is here defined as companies with equity investments in life science companies and includes Novo Nordisk A/S, Novozymes A/S and Novo Holdings A/S.

Sources: Novo Nordisk Foundation and Novo Holdings A/S.

A large proportion of companies in the life sciences portfolio fall within the small- and medium-sized category, including investments in startup companies with future potential for growth. The size of the SME portfolio has grown from 67 in 2018 to 86 SMEs in 2022 (Figure 3.1.1).

The company portfolio consists of very research-intensive companies, which is reflected in the research talent employed in these. Our estimates for 2022 indicate that the life sciences companies employed more than 1,350 PhDs and 200 MDs, excluding the Novo Nordisk A/S and Novozymes A/S. Novo Nordisk A/S and Novozymes A/S have a high R&D ratio, and approximately 10% of the employees are working with research and development.

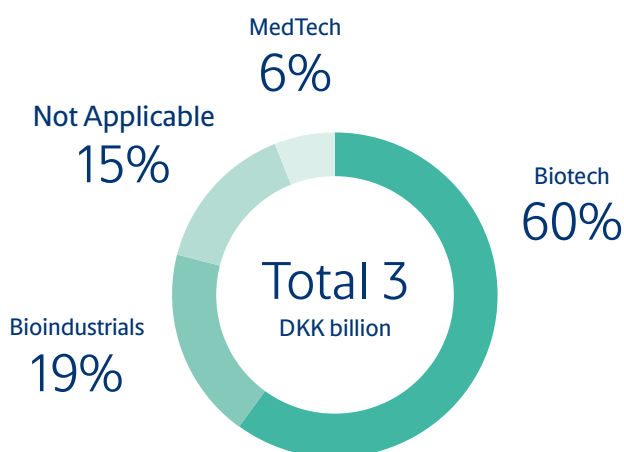
3.2 Supporting organisations, systems and infrastructure

One of the Foundation's missions is to invest in scientific research, education and innovation to enable a world-class life science ecosystem. It has been a part of the heritage of the Novo Nordisk Foundation for almost a century to support fundamental research and the development of novel technologies that have the potential to benefit people and society. Building on this legacy, the Foundation aims to increase its commercial support for building an ecosystem that is needed for excelling within the life science and sustainability areas, and to help solve some of the major challenges facing us in the future.

To promote the transition between spinouts and commercial investments, Novo Holdings A/S has established the Novo Seeds investment team, including the REPAIR Impact Fund. The allocation of funds to this part of the life science ecosystem is shown in Figure 3.2.1. The value of the Novo Seeds investment portfolio was more than six times higher in 2021 than in 2017.

Figure 3.2.1a

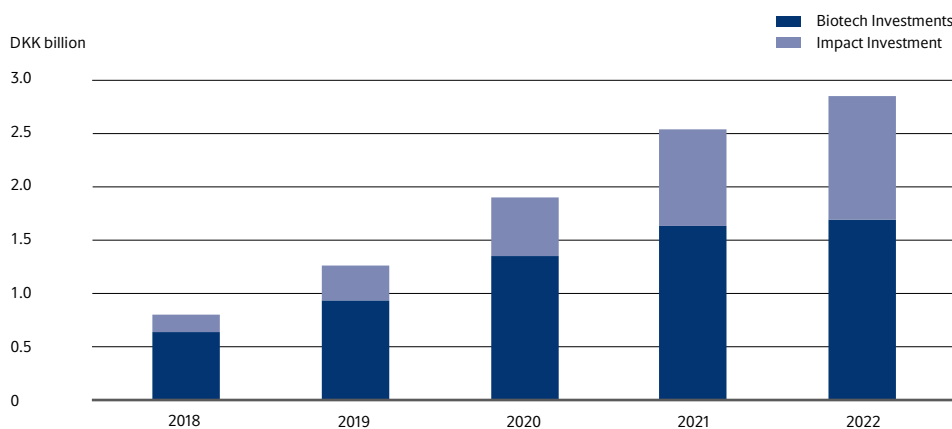
The Novo Seeds Investment portfolio by sub-sectors, end of 2022



Source: Novo Holdings A/S.

Figure 3.2.1b

The allocation of funds for start-up companies and impact investments in life science



Source: Novo Holdings A/S.

3.3 Stimulating collaboration

Through its holdings company Novo Holdings A/S, the Foundation owns and invests in research-intensive companies that publish journal articles. This section analyses the university-industry co-authorship patterns of these articles.

The companies in the portfolio published more than 3,593 journal articles from 2018 to 2022. 79% were published with co-authors from academia. The share of international co-authorships is high, with the proportion of international co-authorships being stable and 71% throughout the period 2018–2022.

Researchers at University of Copenhagen have published 659 journal articles with the portfolio companies since 2018. The second highest number of articles by portfolio companies co-authored with academia is with the Technical University of Denmark (238 articles). The portfolio companies publish with all top 25 highest ranked universities (measured by share of journal articles among the top 10% most cited in the field) in the world within biomedicine and health sciences. Table 3.2.1 shows the five universities with the highest number of articles co-authored with portfolio companies.

Table 3.2.1

The five universities with the highest number of articles published with portfolio companies

Institution	Number of journal articles co-authored	Leiden Ranking
University of Copenhagen	659	198
Technical University of Denmark	238	122
Medizinische Universität Graz	224	349
Universität Heidelberg	180	217
University of Oxford	137	11

Note: Novo Nordisk A/S and Novozymes A/S publish many scientific journal articles with university researchers from Denmark, Germany and the United Kingdom.

Sources: Novo Nordisk Foundation/Impact of Science, Scopus and Leiden Ranking 2022.

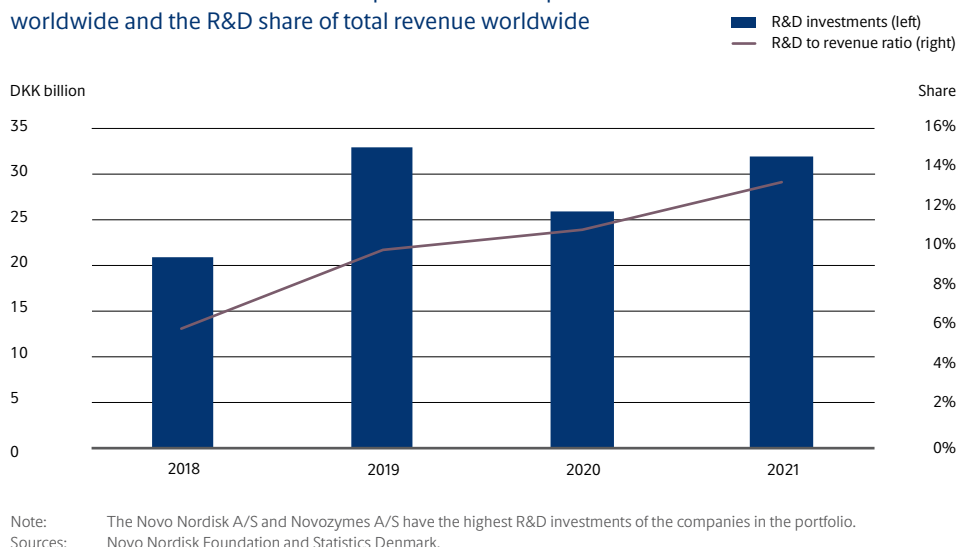
3.4 Promoting excellent research and innovation

Research and development ratio (R&D-ratio)

Many of the portfolio companies are research-active and spend a high share of their revenue in private research and development investments. Figure 3.4.1 shows the development in the R&D ratio of the companies in the portfolio. The ratio is stable and growing. Data for 2022 are not yet available.

Figure 3.4.1

The Novo Nordisk Foundation Group's investment in private R&D worldwide and the R&D share of total revenue worldwide

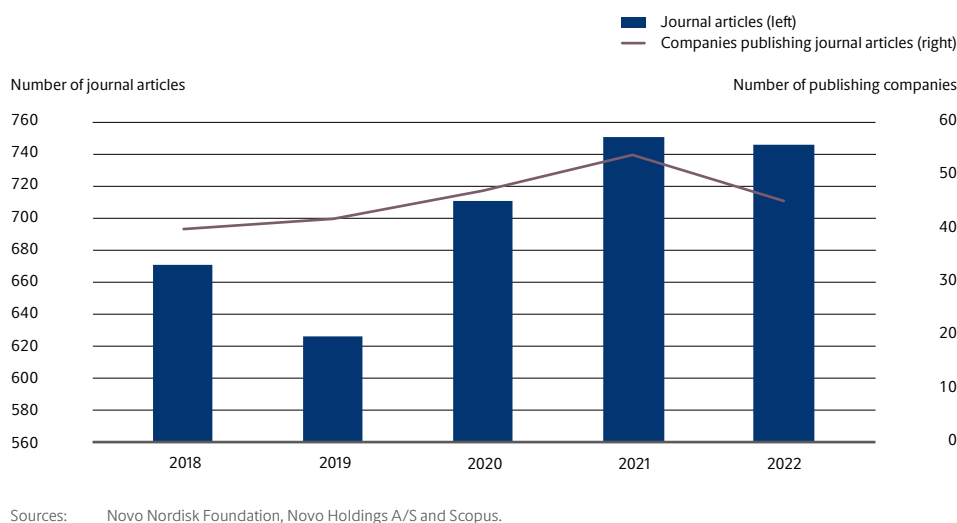


Scientific journal articles

The R&D investments result in a high output of new knowledge and ideas. The portfolio companies published 3,593 journal articles in the period 2018–2022. In 2022, 746 journal articles were published by 45 different companies (Figure 3.4.2).

Figure 3.4.2

Research active companies and journal articles



Citation impact of journal articles

Journal articles published by the portfolio companies have an impact well above the world average. Specifically, in 2020 the impact was higher than the world average, with 5% of the journal articles being ranked among the top 1% most cited, and 20% among the top 10% most cited in the world. These levels are similar to the levels for articles published by Foundation-funded researchers, suggesting the applied nature of the research does not decrease its citation impact.

Science fields of journal articles

Most articles (475 journal articles) were published by portfolio companies within endocrinology, diabetes and metabolism in the period 2017–2021, with 21% of articles among the world's 10% most cited within this field. The second highest output are within internal medicine, with 341 journal articles of which 22% is among the world's 10% most cited. The third most frequent field of science being covered in 265 journal articles by portfolio companies is endocrinology with 26% among the world's 10% most cited.

More than 200 journal articles are published within biochemistry. The 130 journal articles published by the companies within cell biology have the highest share of articles (29%) among the world's 10% most cited articles within these fields.

3.5 Developing innovative products and solutions

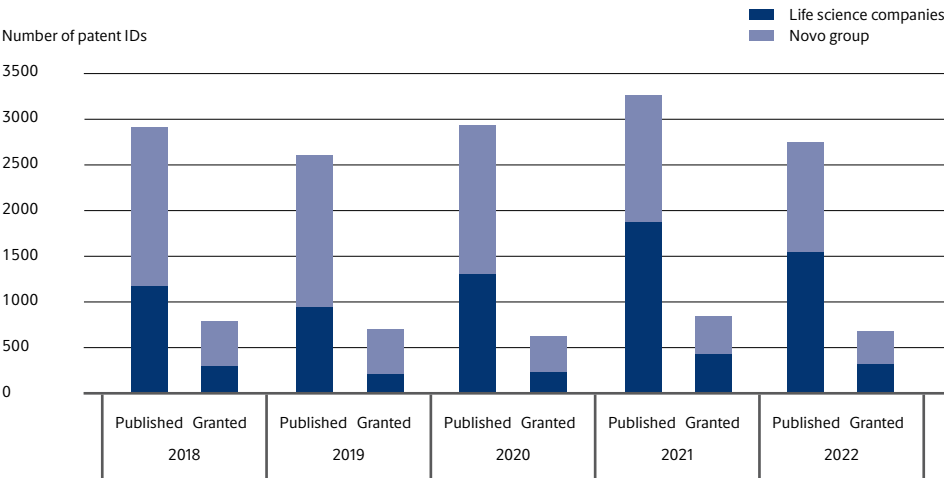
This section examines how the life science portfolio companies are contributing to development of new solutions as revealed by their product and patent activity. 74 new products were launched in 2021, of which seven were new drugs, 37 were new MedTech products and 30 were bio-industrial products.

The portfolio companies have contributed to numerous patent applications. Since 2018, more than 14,400 patent applications have been published by the portfolio of companies, and more than 3,800 patents have been granted (Figure 3.5.1). Multiple patent documents can be published for each technological innovation, as they can be patented in multiple jurisdictions. For the period 2018–2022, 6,637 technological innovations are represented in the published patent applications of the portfolio companies, and 2,687 technological innovations are represented in the granted patents. This is an increase of 27% compared to the period 2018–2021.

The number of published patent applications and granted patents in a particular year reflects the number of patents filed some years previously, as patents are not published until 18 months after filing and are granted around three and a half years later. It should also be noted that many patent applications are dropped before a patent decision is reached. In 2018–2022, portfolio companies accounted for 20% of all granted patents and 20% of all published patents in Denmark.

Figure 3.5.1

Number of patent applications and granted patents filed in the Novo Group and the life science portfolio companies across technologies



Sources: Novo Nordisk Foundation, Novo Holdings A/S and Dimensions.

3.6 Developing new technologies, therapies and disease prevention

A large proportion of the patents and products, both launched and in the pipeline of portfolio companies, are new medicines and healthcare products. These are examined further in this section.

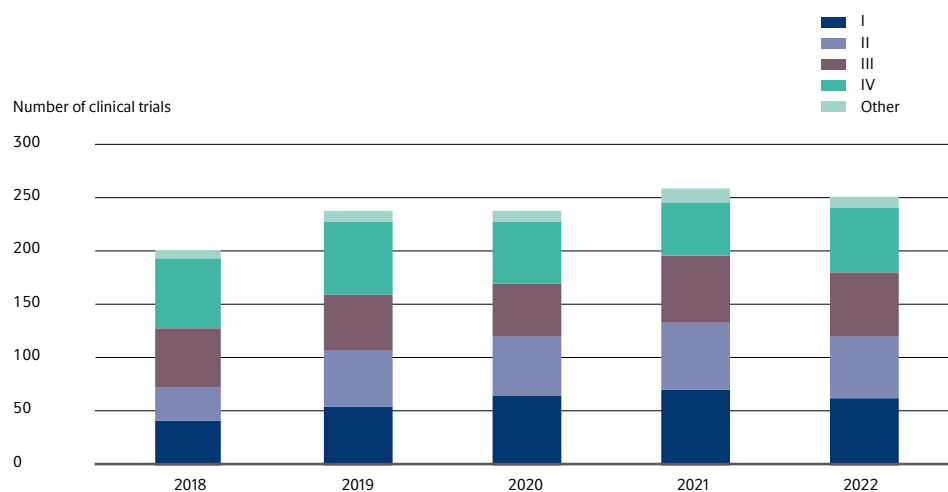
Clinical trials in companies

Before new medicines and therapeutics can be launched, they undergo vigorous testing in clinical trials. Between 2018 and 2022, 639 clinical trials were registered by portfolio companies in global clinical trial registries, making up 0.5% of all clinical trials registered during the same period (Figure 3.6.1). Compared to the period 2017–2021, this is 168 clinical trials more registered by the portfolio companies.

The clinical trials of companies tend to be associated with more advanced trials stages (phases III and IV) compared to clinical trials of public researchers. 96% are in official clinical trial phases I–IV, with 50% being in early clinical trial phases I and II, and 46% in late clinical trial phases III and IV.

Figure 3.6.1

Active clinical trials registered by the portfolio companies

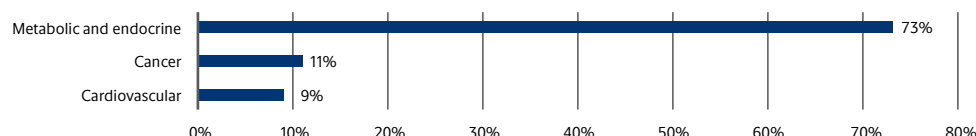


Sources: Novo Nordisk Foundation, Novo Holdings A/S and PharmaIntelligence.

Further analyses of the clinical trials show which health areas the clinical trials fall within. Most trials are in metabolic and endocrine conditions, which include diabetes (Figure 3.6.2).

Figure 3.6.2

Top three health categories of clinical trials, 2018–2022



Sources: Novo Nordisk Foundation, Novo Holdings A/S, PharmaIntelligence and Dimensions.

To ensure that new medicines and therapeutics are both safe and effective, they must be tested on numerous people. Over the past five years, more than 246,000 people have been successfully enrolled in clinical trials supported by the portfolio companies. Compared to the five-year period 2017–2021, this is 79,000 people more who have been enrolled in the clinical trials of the portfolio companies.

Globally, ensuring diversity among the participants in clinical trials has been and continues to be an issue, both in terms of biological sex and ethnic groups. If trial participants do not accurately reflect the patient population the drug aims to treat, it may not be safe to extrapolate the results of the trial to predict the benefits or adverse effects when treating the population. It was possible to find biological sex data in 17% of the clinical trials supported by portfolio companies on clinicaltrials.gov and for 30% of all people enrolled in the clinical trials. Among the clinical trials that do report on biological sex, there was an equal distribution with 49% female and 51% male participants, excluding clinical trials dealing with sex-specific illnesses such as prostate cancer.

Developing treatments for rare diseases has historically been under-prioritised, as the limited number of patients reduces the economic incentive. ‘Orphan drug’ status is one approach to addressing this, by providing incentives to companies to develop such drugs. The status is awarded to drugs aimed at rare diseases that are life-threatening or chronically debilitating, but where there is not currently any effective treatment. Thus, the orphan drug status can be used as an indicator of drugs with immense potential impact for patients living with these rare diseases.

Among the drugs in the commercially supported clinical trials, 32 of the trials have at least one orphan drug designation, with a total of 129 individual orphan drug designations (this is 13 more compared to the period 2017–2021). These designations include therapies for amyotrophic lateral sclerosis (ALS) and glioblastoma (an aggressive form of brain cancer). A parallel designation system is the FDA fast track designation, which aims to speed up clinical trial processes for drugs addressing an ‘unmet clinical need’. 18 of the drugs also have a fast-track designation indicating they have big potential to improve patients’ lives (this is eight more compared to the period 2017–2021).

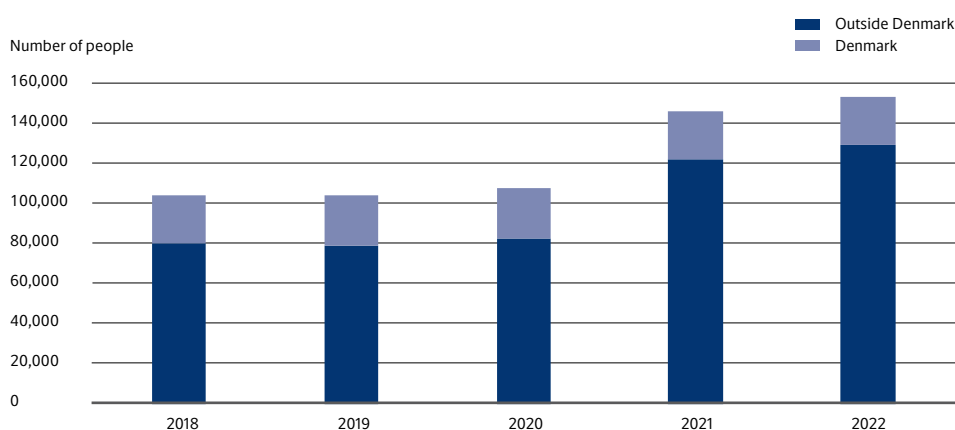


3.7 Creating jobs and growth

In 2022, the Novo Group and the life science companies employed about 153,000 people, which is approximately 8,000 more than the year before (Figure 3.7.1). Of these, almost 18% were employed in Denmark.

Figure 3.7.1

Number of people employed in Danish based an foreign based companies



Sources: Novo Nordisk Foundation, Impact-of-Science, Novo Holdings A/S and Statistics Denmark.

3.8 Supporting people in difficult settings

The products and services of the companies in the Novo Nordisk Foundation Group help millions of people every year with pharmaceutical products, medical devices and technologies, and health services, including clinical health tests.

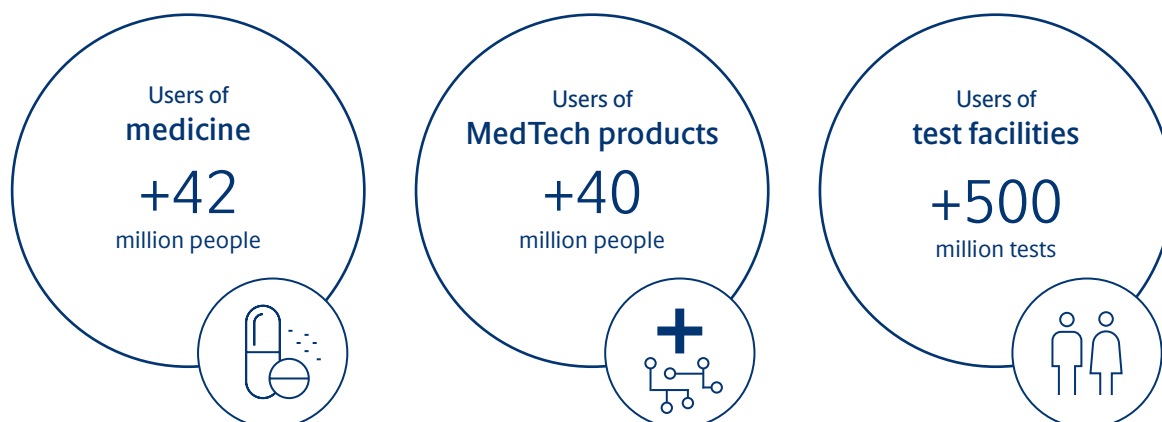
People reached with pharmaceutical products (medicine)

The Foundation is built on the success of Novo Nordisk A/S alongside other pharmaceutical companies. Today, through Novo Holdings A/S, many investments have been made in companies that develop and supply vital medicines for people all over the world. In 2022 alone, it is estimated that the portfolio of companies provided medicines to more than 42 million patients (Figure 3.8.1).

People reached with technology products (MedTech)

The portfolio companies own medicine devices and technology which deliver solutions to millions of people within hearing health, chronic diseases and other types of healthcare and patient care. One example is Novo Holdings A/S' 100% ownership of Sonion (since July 2014), a global leader in designing and manufacturing components and solutions for hearing instruments (hearing aids, in-ear earphones, and hearables/wearables) to improve people's quality of life all over the world. From small children to elderly people who have spent decades in silence, Sonion helps over 40 million people every year.

Figure 3.8.1 People reached, 2022



Sources: Novo Nordisk Foundation, Novo Holdings A/S, Novo Nordisk A/S, Sonion and Synlab.

People reached with test facilities and services

The life science portfolio also comprises health test and diagnostics facilities. Laboratory medicine makes a significant contribution to medical care. Around two thirds of medical diagnoses worldwide are based on or confirmed by medical laboratory tests. In February 2017, Novo Holdings A/S invested in SYNLAB, which provides modern laboratory analyses that help to confirm diagnoses, derive the right decision from them and monitor the success of therapy. SYNLAB conducted more than 500 million in 2022.

People reached with humanitarian support

In 2022, Novo Nordisk A/S awarded DKK 93 million to humanitarian and social causes via the World Diabetes Foundation (WDF). WDF is an independent fund established by Novo Nordisk in 2002 with the aim of promoting diabetes prevention and treatment in low- and middle-income countries.

Across 595 partnership projects in 119 countries, WDF's support has ensured diabetes screening of around 16 million people since its establishment. More than 8.8 million patients have received treatment at more than 24,000 clinics that have been supported by WDF. Finally, through its partnerships WDF has trained more than 3.8 million children, parents, teachers and Health Care Professionals in Diabetes care and/or prevention.

Read more



Read more at
www.worlddiabetesfoundation.org

4



Learnings from philanthropic practice

One of the hardest problems in funding scientific research is choosing which research to fund. In this chapter, we apply state-of-the-art research methods, data mining and application data to analyse the research project and investigator grants the Novo Nordisk Foundation has supported, and compare that with data on the research proposals the Foundation has rejected, to help us understand whether the criteria and processes we use to select research for funding are appropriate in order to achieve excellent research and positive societal impact.

Our ability to carry out this analysis is limited by the data we have collected in the past, which we review in Section 4.1. From this we make recommendations on what data to collect now and in the future, to pave the way for improved analyses. In section 4.2 and section 4.3, we investigate three central questions about our funding allocation process. Section 4.2 examines whether the demographic characteristics or the novelty of proposals affect the likelihood of funding research projects grants and investigator grants. Section 4.3 examines whether the use of ‘promotional language’ increases the chance of funding.

The Foundation convenes external committees of experienced researchers to make the funding decisions for its open competition programmes. Before the committees meet to discuss incoming applications, the applications are evaluated by at least two reviewers (who are often committee members). The committees are guided by the Foundation's general grant-awarding principles and by programme-specific funding criteria.

One of the advantages of submitting each proposal for multiple reviews is that it mitigates randomly deviating perceptions or mistakes, but multiple reviews are not guaranteed to highlight any biases in favour of certain types of applicants or proposals.

This type of scientific peer review is widely used for assurance of research results and selection of journal articles, as well as in scientific grant funding processes. The challenge of scientific peer review lies in focusing and codifying subjective scientific judgement, and not least prediction, on the quality and potential of the proposals while side-lining other aspects such as demographics of the investigator and the presentation of the idea. Whenever human judgement is involved, the selection mechanisms may or may not work as intended. A vast amount of literature examining both publication and application peer review has identified a variety of potential weaknesses with scientific peer review practices, including biases, such as gender bias, resume and bibliometric biases, and bias against truly novel research that sometimes also is considered high-risk research².

Our analysis provides indicative conclusions about some important aspects of the funding decisions made by the Foundation's committees:

- Applicants with track record of high citation had a higher probability of getting funding³.
- Applicants with a record of more novel research articles had a lower probability of getting funding⁴.
- Applications scoring higher for novelty had weakly significant, lower probability of getting funding.
- Applications including more 'promotional language' had a higher probability of getting funding and of delivering high-impact journal articles⁵.
- Applicant gender does not appear to affect probability of getting funding.

Read more:



² See e.g. [Nakamura et al, eLife, 2021](#), and [Stephan et al, Nature, 2017](#).

³ See section 4.2 for details of novelty measure

⁴ See section 4.3 for definition of 'promotional language'

⁵ Some newer established investigator programs have somewhat more elaborate additional assessment criteria in addition to the typical project assessment criteria (quality, novelty, feasibility + often state-of-the-art). See, e.g., [Data Science Ascending Investigator](#).

Our analysis highlights the need for more detailed and structured data if we are to further understand the decision processes involved. These centre around the needs:

- to understand if the assessment criteria support the objective of the programme;
- to document that the assessment criteria are consistently understood by reviewers; and
- to understand how information in an application is read by reviewers and how different criteria are weighed.

4.1 Guidelines and data availability

A quantitative evaluation of the grant-awarding processes requires a rigorous understanding of the grant selection process: from inviting and providing information to applicants to the decision outcome of accepting or declining incoming proposals. This section presents:

- The official information and guidelines that the Foundation provides to applicants, reviewers and committees to establish the assessment criteria.
- The content, structure and availability of data about the reviewing process and funding decisions and how this aligns with the assessment criteria.

The Foundation's reviewing process benefits from the good faith efforts of members of peer review committees and the Foundation staff who are developing programmes, reviewing, scoring, and discussing applications. As humans we have different values, and we will make good decisions as well as mistakes, consciously and subconsciously. Funding decisions are by their nature subjective and involve an aspect of predicting the future – there is plenty of scope for legitimate disagreements. The challenge in our analysis is to find ways to distinguish between reasonable and unreasonable disagreement.

Information and guidelines provided to applicants, reviewers and committee members

Programme information available to applicants details the purpose of the programme, eligibility criteria, guidance on how to apply, and the assessment criteria. Many of the assessment criteria are similar across different grants. Thus, in the application guidelines for the Foundations' classical Investigator grants⁶, the following criteria apply for grants at all levels.

Read more



⁶ Some newer established investigator programs have somewhat more elaborate additional assessment criteria in addition to the typical project assessment criteria (quality, novelty, feasibility + often state-of-the-art). See, e.g., <https://novonordiskfonden.dk/en/grant/data-science-investigator-ascending-2022/>.

“In the evaluation, the project and the applicant are weighted equally. The project is assessed based on **quality, novelty, state-of-the-art, and feasibility**.

The applicant is assessed on her/his **merits** relative to age and career stage, potential and commitment to the applied project, and contributions to the scientific community in general. [..]”

Sourced example:

[Ascending Investigator Grant 2023
Endocrinology and Metabolism
- Nordic Region](#)

Read more



How the reviewers and the committee evaluate proposals according to quality, novelty, state-of-the-art and feasibility is not outlined specifically in the programme information available to applicants. This is important because words carry different meanings to different people. In a joint research project with partners from the Research on Research Institute (RoRI)⁷, we queried funders about assessment criteria, asking them about the inclusion of originality as a criterion, which our own Foundation reported was included in the assessment, although the formal wording of the criteria rarely uses “originality”. This could suggest a common understanding that assessing quality covers originality or that novelty and originality are used interchangeably. A search in the comments made by grant reviewers also indicates that other factors beyond these four criteria, such as the research environment and budget estimate, are rightfully considered by reviewers, e.g. when judging feasibility or when forming a holistic assessment of the application.

For investigator grants, the introductory sections of the applicant guidelines provide information on the profile of the targeted investigator type (emerging, ascending, distinguished) as well as information about how applicants and their proposals are judged:

Read more



⁷ CRITERIA project eSearchonResearch.org

“The Ascending Investigator grant is for excellent and independent associate professors who have the ambition and potential to rise to the highest international level within their research fields, and who already have demonstrated their research leader potential.

Applicants should have their own research group and individual research profile and are expected to have a documented **track record of peer-reviewed research with a high impact** and must at the time of application have **senior authorships**.

Key is that the **project is novel, excellent, has the potential of high impact** and is of a character that justifies a five-year grant of this magnitude and that the applicant has momentum in the current research track.

After their PhD degree, applicants should ideally have approximately 7–18 years of subsequent research experience (parental leave excluded) but this is not a hard limit.”

Sourced example:

[Ascending Investigator Grant 2023
Endocrinology and Metabolism
- Nordic Region](#)

Read more



This text explicitly highlights the requirement of “track record of research with a high impact”. Unexplained, this potentially has different meaning to whomever reads it. The academic impact is often assessed using bibliometric measures such as citation impact or publishing in high-impact journals, which we also include in our analyses. The text also mentions “potential of high impact”, which is not explained or mentioned again as an assessment criterion⁸.

Read more



Committee members are provided with [guiding principles](#) and [mandate letters](#) on how to evaluate, score and select proposals for funding. The guiding principles outline confidentiality, objectivity, consistency, diversity, conflict of interest and the Foundation’s cornerstone values and code of conduct. A mandate letter outlines the assessment criteria of a particular grant instrument such as “Projects grants in bioscience and basic biomedicine” or “Emerging investigator in industrial biotechnology and environmental biotechnology”. The mandate letters specifically highlight the assessment criteria as well as eligibility criteria (e.g. limits in relation to co-funding). In selecting applications for project grants the same assessment criteria are used as for investigator grants. The only difference is that for project grants the project proposal assessment and the assessment of the applicant are not required to carry equal weight.

⁸ It could be thought to invite applicants to use promotional language—something which we investigate in section 4.3.



Data availability

Application data

Since 2013, all applications to the Foundation have been handled by an online grant management system. This provides access to a rich source of well-structured metadata about applications, including demographics (e.g. gender, age, institution), reviewers and scores. The data also include application titles, abstract(s), application text, literature references and shortlists of publication merits. However, the application text is not divided into standardised sections such as 'Background', 'Methods', 'Research Question' etc. While this gives the applicants freedom in how to structure the presentation and format of their proposal, it unfortunately complicates text mining when analysing application data.

Reviewer assessment and committee decisions

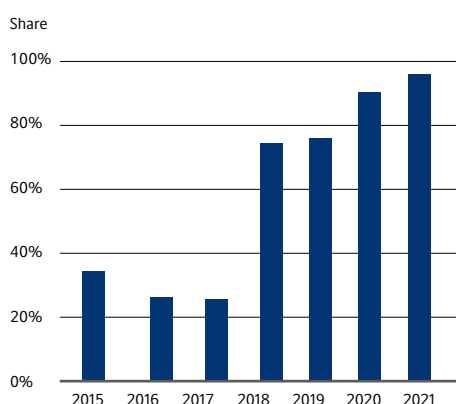
Proposals are typically evaluated by at least two reviewers. These reviewers are most often the committee members, but sometimes external reviewers are used. Reviewers/committee members give an overall score to applications using a scale from 1 to 6 – with 1 being the best score⁹. Alongside the score, reviewers can provide comments. This assessment score can be viewed as a preliminary assessment of the individual assessor prior to the committee meeting where proposals are discussed. However, applications with unanimously high scores are generally funded with little or no discussion.

It is important to note that individual assessment criteria are not scored. This makes it harder to understand which aspects of a proposal are driving the overall assessment. The only source of information about how the reviewers arrived at their overall score is by interpreting the free-text comments.

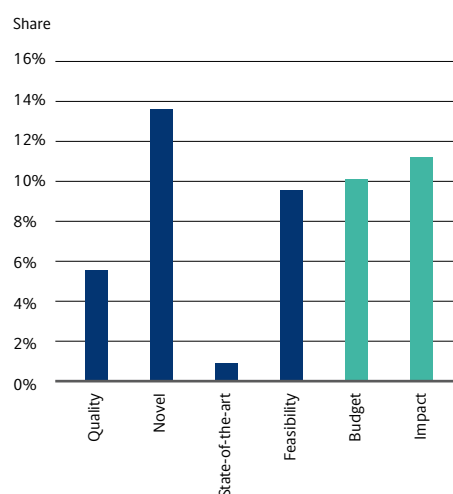
Figure 4.1.1

Assessment comments and criteria prevalence in reviews of research project grants

Panel a:
Share of assessments with
reviewer comments



Panel b:
Share of assessment comments explicitly
mentioning assessment criteria (blue),
budget or impact



Notes: Panel b shows explicit use of the naming of the criteria (blue) and mentioning of the words budget and impact in assessment comments for 955 research project grant applications in 2021.
Source: Novo Nordisk Foundation; Impact of science.

⁹ Before 2018 the scoring scale was from 1–5.

The prevalence of reviewer comments has increased substantially over the years, especially with the introduction of NORMA (the Foundation's current web-based application system, build on SmartSimple). In Figure 4.1.1, panel (a) shows the increase in the share of assessments with comments in addition to the overall score. Searching for mentions of the highlighted assessment criteria ("quality", "novelty", "state-of-the-art", and "feasibility") shows that assessors do not consistently and explicitly mention and distinguish between the criteria, and that they in fact mention other aspects of the proposal – such as budget – as often as they mention the formal criteria.

We cannot draw the conclusion that the reviewers are not scoring according to the assessment criteria, and our options for exploring the comments, analysing subjects raised related to the criteria, are limited. Examining peer review assessments from 2021, where comments were provided, 90% are shorter than 200 words (around half an A4 page), 50% not more than 55 words, and 25% not exceeding 20 words.

Challenges in evaluating the assessment of grant proposals

Instruments are designed to serve a particular purpose - objectives for a programme exist. An evaluation of whether an open competition programme fulfils its purpose must link the objective, the design of the instrument including grant-awarding conditions and the funding mechanism. We are focused on how the criteria identified as important for meeting the objectives are interpreted by committee members, reviewers, and applicants. The following circumstances about the data complicate the analysis:

- Because there is more than one criterion, committee members and reviewers must balance the criteria to come to their overall assessment. Unfortunately, this process is invisible to us as the assessment criteria are not scored individually, and the comments provided by assessors provide only glimpses of how criteria are balanced, or if reviewers make use of the criteria.
- The lack of individual scores along with the lack of a standardised structure for scientific proposals mean that we do not have well-structured information about how applications are read and how different elements of the proposal affect the overall assessment. Evidence from the National Institutes of Health has shown that different criteria carry different weight in overall scores ([Eblen et al, PLOS ONE, 2016](#)).
- The limited explanation of the assessment criteria provided to all reviewers/committees leaves open the possibility of varying interpretations among committee members and across committees.

Read more



Taken together, these aspects make it harder judge the consistency with which applications are assessed which is a guiding principle for committee members and the Foundation.

Learnings and considerations

This analysis has led us to consider the need to review both the criteria that we ask committees and reviewers to apply, and how we capture the data to understand how the criteria are being applied. The indications are that we should work with some of the following elements:

- Revisit objectives and linking to criteria that determine grant selection.
- Study international funders to gather inspiration for application templates, and revisit application fields in the grant-management system.
- Re-think scope of selection criteria to ensure that they support the purposes and objectives of the Foundation's programmes in the best possible way.
- Structure the application form to ensure a more consistent read and reviewing of proposals.
- Provide thorough descriptions of each criterion to ensure a unified understanding of the criteria. For instance, is feasibility understood in the same way and is it distinguishable from novelty; and is novelty understood correctly, or are we actually looking for originality and quality, knowing that the outcome is often incremental research and not truly novel research?
- Ensure that reviewers address the assessment criteria by scoring and commenting on each criterion, but also ask for an overall assessment score and comment/summary.
- Improve structured data access to post-assessment funding decisions (e.g. ranking) or revised overall scores at committee meetings.

The above suggested actions can substantially improve future conditions for measurement, learning and evaluation for the Foundation as well as it can allow for the implementation of AI-assisted processes, e.g. time-efficient allocation of reviewers to proposals, and will allow reviewers to focus on the text by not having to read proposals with varying structures. AI-assisted processes and analysis of the above-mentioned types of data is being implemented by other European funders. e.g. La Caixa Foundation, the Swedish Research Council, and the Swiss National Science Foundation.

4.2 Quantification of potential biases in grant awarding

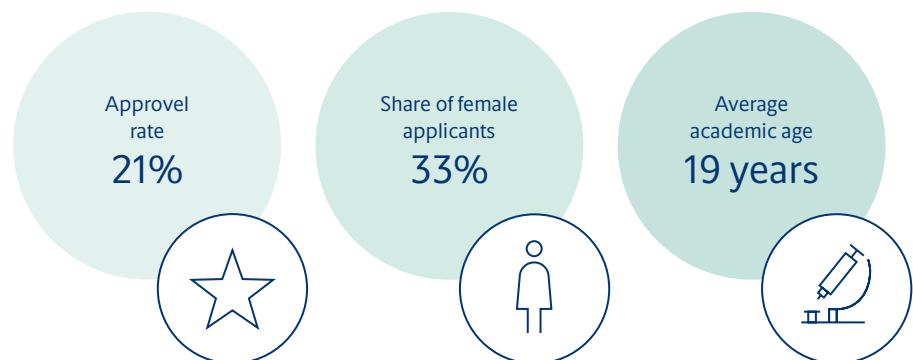
In this section, we analyse how aspects of novelty, bibliometric performance and gender relate to funding decisions within open competition projects in the Foundation. Specifically, we examine whether the likelihood of being funded is related to the applicant's personal characteristics: gender, level of experience, and/or previous publication history, either citation performance or a measure of novelty. Our findings will influence how we think about changes to our assessment processes.

Scope and data

This analysis looks at application to the Foundation's classical research programmes covering project grants and investigator grants. The number of applications to the research projects programmes and the investigator programmes of the Foundation has been steadily rising from 342 in 2012 to 1,172 in 2021. Figure 4.2.1 shows the application statistics from projects and investigators.

Figure 4.2.1

Application data from the Foundation's project grants and investigator grants (2012–2022)



Source: Novo Nordisk Foundation.

We collect applicants' demographic information as well as data on whether their applications were awarded from our grants application system. We then compile the publication history (volume of journal articles, citation impact, novelty) of the applicants for the five years prior to their applications¹⁰. Finally, we score the novelty aspect of the applications using the literature cited by the applicant.

¹⁰ 5 years publication history is used. Access to the Dimensions API by Google Big Query provides a large-scale access to research publications, which enrich application data.

Our novelty score is based on the combination of journal articles identified in the reference lists of the applicant's journal articles. If their journal articles reference pairs of articles from journals that have never been seen before in the same reference list, their publications are considered more novel. The applicant's novelty score is based on the novelty score of their publications. Unlike the bibliometric assessment of a publication list, the novelty score is a more subtle measure, which the reviewer is not expected to be able to infer from a publication list.

The novelty score is based on Wang et al. (2017), see Box 4.2.1, who also show that publications with a high novelty score eventually have a higher citation level although they initially score lower than conventional papers in standard citation performance (3–5 years after time of publication). In addition, Wang et al. note that the collection of novel research publications has a higher citation variance, which they suggest reflects its risky nature. We calculated novelty scores for publications published between 2000–2021¹¹.

Box 4.2.1

Definition of novelty score

It has long been suggested that research which explores uncharted waters has a high potential for major impact but also carries a higher uncertainty of having impact.

Such explorative research is often described as taking a “novel” approach. Wang et al. (2017) view scientific research as a combinatorial process and consider reference lists that contain pairs of journals never before seen in reference lists to be a marker of combinations of knowledge.

Their novelty measure counts these new pairings and weights them according to how closely linked the pair (A and B) are through third journals, i.e., how frequently A & C and B & C have been cited together.

¹¹ Using Dimensions and Google Big Query see Box 4.2.2. publications, which enrich application data.

Box 4.2.2

Preparation of the data for the novelty score estimation

We use **Dimensions** with full access to all publications through **Google Big Query**, which is extremely powerful in handling very large datasets. We pull out all publications since 1980 and create a co-citation matrix counting all pair-wise citings of any two publications over time, which we then collapse to a journal-to-journal co-citation matrix.

From here we continue in our **Azure cloud** environment to loop through each paper separately calculating a cosine similarity score for each novel journal pair which determines just how odd/novel/unlikely the combination of any two journals in a reference list are. If there are more than one new pair of journals, we sum up the cosine similarity scores to arrive at the novelty score for one paper.

We do it for every year separately, as any two journals similarity changes over time. The matrices used for each year have 150–200 million rows, which makes the calculations computationally demanding and very time consuming.

Results and discussion of the analysis

We investigate the effect of novelty, gender and bibliometric performance, on the probability of getting funding using regression models. We measure novelty bias in two different ways: directly using the novelty score of an application, and indirectly using the novelty score of the applicant. The regression results are robust, as we control for other characteristics that could influence both application writing and assessment: the volume and citation impact of past published journal articles, and academic experience. We also control for instrument-specific funding-round variation ([Bias against novelty, 2023, Novo Nordisk Foundations Working Paper Series](#)).

We find that researchers with a high share of novel research in their journal articles have a lower probability of being funded. The granted applicants have 5% points less novel journal articles than non-granted application. The regression results show that increasing the percentage of novel publications decreases success rate, see Figure 4.2.2. This could suggest that researchers with more “novel background” may write more novel research proposals.

We also find that researchers with a high share of journal articles among the world’s most cited journal articles PP(top 10%) have an increased probability of getting funding (see Figure 4.2.2). Finally, and reassuringly, we find that gender has no discernible effect on funding decision.

Read more

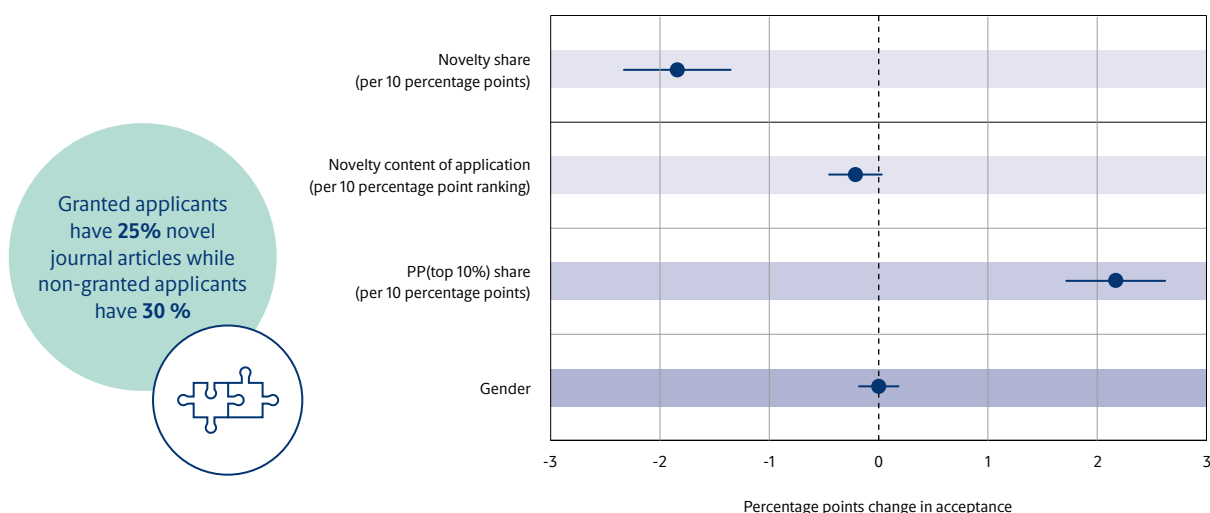


We repeated this analysis for the initial score of proposals rather than the decision to fund, looking at the same three factors (novelty, citation record, and gender) and found similar results. To further test the robustness of our results, we replicated the analysis using a novelty measure proposed by Uzzi et al. (2013). Unlike Wang et al. (2017), who only attribute positive novelty to new journal article pairs, the approach from Uzzi et al. (2013) computes a continuous measure of how atypical all journal pairs are, regardless of whether they have been paired before. The results were robust to exchanging the Wang et al. (2017) novelty score for the Uzzi et al (2013) atypicality score.

Finally, a new contribution to the literature, we attempted to score the novelty content of the proposals by utilising the journals referenced by the applicant. As Wang et al. (2017) scored journal articles using references, we treated proposals in the same way to identify uncommon pairings of journals. Only significant at the 10%-level, the results weakly indicate a two percentage point disadvantage compared to non-novel proposals.

Figure 4.2.2

Bias against novelty - analysis estimates



Notes: The lines are at 95% confidence intervals. The estimates are marginal effects from a probit regression with fixed effects and the dependent variable is whether an application is granted or not. The independent variables are share of novel research (share of publications with a novelty score > 0 for researchers) and control variables PP(top 10%), volume of publications, gender, academic age, and instrument-specific funding round fixed effects.

Sources: Novo Nordisk Foundation Impact-of-Science, Cross-ref, Dimensions via Google Big Query, Scopus, Open Alex, own calculations of Wang et al. (2017) novelty measure are following.

The results in this analysis indicate that novelty as an assessment criteria should be treated carefully and explained well, as also discussed in section 4.1. Our results indicate that applicants with a background of more novel research tend to write proposals that are judged harder than proposals of applicants with less novel research track record.

Novelty may be correlated with other characteristics and factors not included in this analysis, which we continue to explore. Further, the positive impact that past citation performance has on the chance of funding should draw attention to the role of bibliometric scoring, as it can influence perception of the proposal where not intended.

4.3 Promotional Language and Grant Application Acceptance and Impact

The analysis in this section is the first of its kind on applications to the Foundation¹², constituting a step towards a deeper and more complex exploration of the text, which we will continue to work on in the future. Using natural language processing techniques, we investigate the frequency of words that can be classified as “promotional language” and examine the link to funding success and publication outcome.

Promotional language allows application authors to highlight the merits of good ideas and draw attention to key points of discussions to the reader. Considering that reviewers are under a time constraint and read several proposals at the same time, promotional language could be helpful to the applicant and the reviewer in highlighting essential contributions. However, it may also be used to oversell ideas, overplay the potential of approaches and cloud or complicate reviewer judgements by obscuring important information. In general, an overuse of promotional language threatens to undermine the credibility of scientific results, as observed with the emerging retraction and replication crisis in later years.

Read more



[Millar et al, JAMA Open Network \(2022\)](#) shows an increase in the use of promotional language over the period 1985–2020 in abstracts among 901,717 projects funded by the National Institutes of Health. The authors raise the concern that promotional language clouds the judgement of grant applications, touching upon an overlap with buzzwords which could impose a burden for the reader and obscure important information. However, the article cannot tell if this concern holds true, because the authors have not explored the application texts, which might differ from the abstracts, just as they have not looked at declined applications. Our data set allows us to advance their work in two important ways that address questions that are important for funders:

1. Is promotional language in application texts associated with higher funding success?
2. Is promotional language a predictor of outcomes, e.g. the citation impact of the research results?

The use of promotional language is only one aspect that may reflect deeper underlying differences in the way applicants argue for their research ideas, which we have yet to explore.

¹² The results presented are a short summary and originate from an ongoing research collaboration with professor and co-director Brian Uzzi and team from The Northwestern Institute on Complex Systems at Northwestern University.

Box 4.3.1

Broad semantic categories and promotional adjectives

Importance

Compelling, critical, crucial, essential, foundational, fundamental, imperative, important, indispensable, invaluable, key, major, paramount, pivotal, significant, strategic, timely, ultimate, urgent, and vital;

Novelty

Creative, emerging, first, ground-breaking, innovative, latest, novel, revolutionary, unique, unparalleled, and unprecedented;

Rigour

Accurate, advanced, careful, cohesive, detailed, nuanced, powerful, quality, reproducible, rigorous, robust, scientific, sophisticated, strong, and systematic;

Scale

Ample, biggest, broad, comprehensive, considerable, deeper, diverse, enormous, expansive, extensive, fastest, greatest, huge, immediate, immense, interdisciplinary, international, interprofessional, largest, massive, multidisciplinary, myriad, overwhelming, substantial, top, transdisciplinary, tremendous, and vast;

Utility

Accessible, actionable, deployable, durable, easy, effective, efficacious, efficient, generalisable, ideal, impactful, intuitive, meaningful, productive, ready, relevant, rich, safer, scalable, seamless, sustainable, synergistic, tailored, tangible, transformative, and user-friendly;

Quality

Ambitious, collegial, dedicated, exceptional, experienced, intellectual, longstanding, motivated, premier, prestigious, promising, qualified, renowned, senior, skilled, stellar, successful, talented, and vibrant;

Attitude

Attractive, confident, exciting, incredible, interesting, intriguing, notable, outstanding, remarkable, and surprising; and

Problem

Alarming, daunting, desperate, devastating, dire, dismal, elusive, stark, unanswered, and unmet.

Promotional language

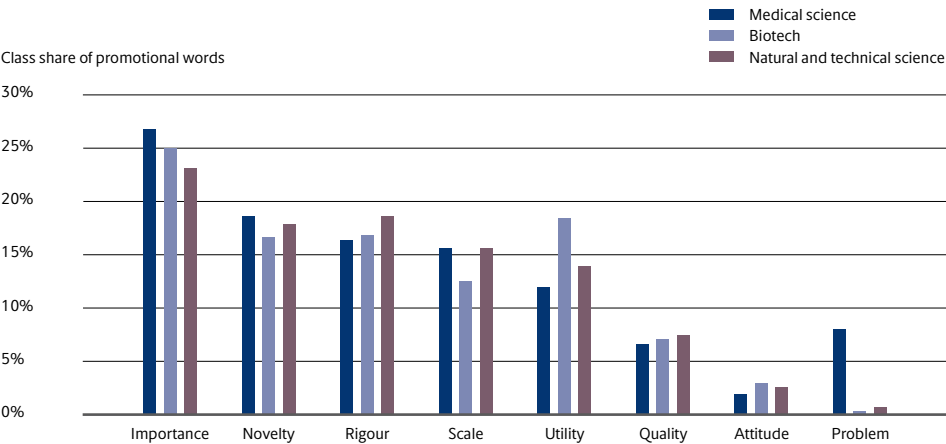
We use the dictionary of promotional language developed by Millar et al. (2022). The dictionary divides words into eight classes used to promote the message to the reader: Importance, Novelty, Rigor, Scale, Utility, Quality, Attitude, and Problem. Box 4.3.1 shows the resulting dictionary.

Millar et al. describe how different words have followed different patterns of evolution and appear at different frequencies. One group of words have shown a strong, steady increase in usage since 1985; these are the most common words in absolute terms and are primarily found within the categories of importance and novelty (e.g. “novel”, “critical”, and “innovative”). However, not all words within the categories importance and novelty have increased in usage, although still commonly used the words “important” and “major” have declined in use. Since 2010, the usage of words associated with research project’s utility and scale has grown sharply. These include “transformative”, “transdisciplinary”, “scalable”, “actionable”, and “impactful”. Although these words have emerged recently and grown sharply, they are still much less common (15–60 times less common) in absolute terms than the group of words relating to importance and novelty (such as “novel” and “critical”).

The impact of promotional language on funding success

We performed text analysis on 13,888 applications submitted to open competition research and innovation programmes in the Foundation from 2013–2022. Figure 4.3.1 shows the identified distribution of the classes of words used in the written applications within the three core scientific areas that the Foundation supports. The descriptive results reveal that within medical science, natural and technical science and biotechnology, emphasis was mostly on “importance”, followed by “novelty”, “rigour”, “scale” and “utility”. Applications within the medical science area put somewhat higher relative emphasis on “importance” than applications within natural and technical science, while applications within biotechnology put higher emphasis on utility compared to the other two areas. In absolute terms, biotech and natural and technical science applications use promotional language 36–42% more than applications within medical science.

Figure 4.3.1 Distribution use of promotional language in Foundation applications within scientific areas



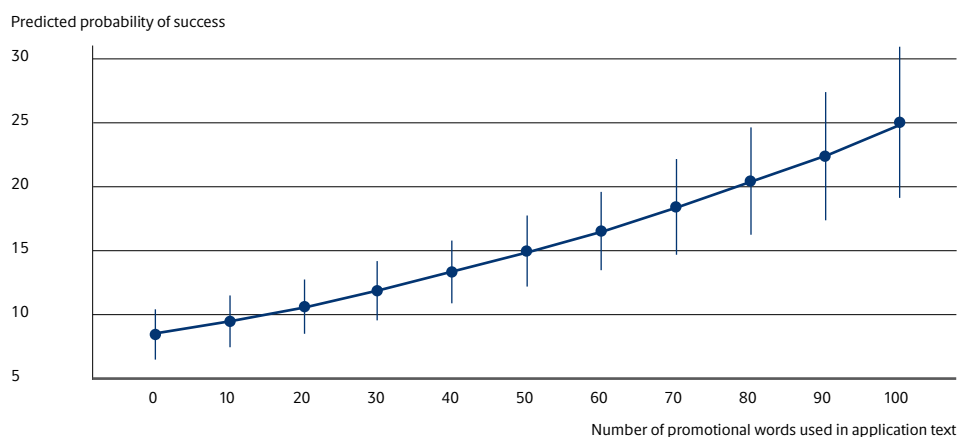
Source: Novo Nordisk Foundation.

When estimating the impact of the prevalence of promotional language, we control for area-specific and instrument-specific effect, text characteristics such as length, and person-specific characteristics. We found that both our outcome measures were associated with more extensive use of promotional words: Applications with more promotional words were more likely to be funded; and successful applications which contained more promotional words were more likely to produce articles that are published in high-impact journals¹³. This makes it hard to tell whether promotional words are having an inappropriate effect – as the increased bibliometric success of applicants who use the words could suggest that the words were being used and read appropriately in the applications. It could also suggest that applicants who effectively ‘sell’ their applications using promotional words are able to do the same with the publications that stem from their research.

Figure 4.3.2 shows the predicted chance of receiving funding by using more or less promotional words in the proposal text. Holding all other factors of the estimation model constant (including text length), the estimation results suggest that proposals that use more promotional words have higher chance of funding success.

Figure 4.3.2

Predicted chance of funding success using promotional language in proposals



Note: Calculations use controls for time, and area-specific-, instrument-specific-, application-specific-, and person-specific trends in the data as well as text score variables (number of words, Flesch reading score, positive tone, concreteness score).

Sources: Novo Nordisk Foundation Impact-of-Sciencee, Cross-ref, Dimensions, Scopus, Open Alex.

¹³ Effects estimated using a citation-based ranking of journals.

Promotional language as a predictor of highly cited journal articles

The use of promotional language could raise a concern that more modest applicants' proposals, i.e., applicants that use less promotional language, are at risk of not being funded. It could also be that the better applications are described with more promotional language because they are better. Our second analysis therefore examined the extent to which the bibliometric performance of the publications arising from the funded applications correlates with the level of promotional language used.

The comparison is not complete because we could not analyse the counterfactual outcome of not being funded. However, we are able to compare successfully funded applicants' publication citation impact and relate it to the use of promotional language to more or lesser extent. These calculations suggest that within the group of successful applications, and holding other factors constant, the use of promotional language is a predictor of a hit paper (we account for past citation performance): Compared with applications in the 20% of promotional words use (less than 17 words in total), applications in the highest quintile of promotional words (more than 45 words in total) produce journal articles that ranked considerably higher, making it the difference between publishing in an "average" journal and in a prestigious journal such as *Cell*, *Science*, *Nature*, *JAMA* or *New England Journal of Medicine*.

Discussion

Reviewing and selecting proposed research projects for funding involves predicting outcomes. In recent years, advanced text mining, beyond what we have covered here, has shown potential to assist decision making. By analysing thousands of texts, or even millions, text mining can provide us with learnings about patterns that can serve as predictors of outcome. This analysis is a first step towards reaching a deeper understanding of how applications submitted to funders convey their research ideas and argue for the quality of their approach, and importance of the projected outcomes. The results presented here suggest that wording does matter.

The bigger and more important questions to answer include: What are the deeper factors that result in the use of promotional language? and: Are applications structured in a certain way more likely to deliver the message to the reviewer? Answers to such questions can guide the Foundation towards structuring the application template in ways that avoid good research ideas being undervalued and bad research ideas being overvalued.





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