Present Status and Future Potential for Medical Research in the Nordic Countries

Nordic White Paper on Medical Research

NOS-M

The Joint Committee of the Nordic Medical Research Councils

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Contents

Executive Summary

The aim of the present White Paper is to identify opportunities for strengthening medical research jointly and individually amongst the Nordic countries. The paper highlights those actions that are needed in the Nordic countries to maintain a competitive position globally and respond to the scientific, healthcare and economic 'Grand Challenges' facing today's society.

Nordic co-operation has long traditions and is generally highly appreciated as being both important and influential. Within medical research, Nordic co-operation towards common goals could provide an opportunity to shape the region into a competitive environment for top-level research attracting international researchers and investors (Fig. 1). Medical research is considered strong in the Nordic countries but in today's changing society we are facing several Grand Challenges that could threaten the well-being of the citizens of the Nordic countries unless appropriate action is taken.

In order to tackle these Grand Challenges, extensive efforts in the form of strategic investment and determined research policies are required in all Nordic countries. At a national level, research policies and budgets need to support strong and independent basic research, which is the bedrock for eventual innovations and clinical applications. Unfortunately, the importance of basic research, as well as research in public health and health service systems, is often forgotten because of the increasing political pressure to show rapid payback of investment in research.

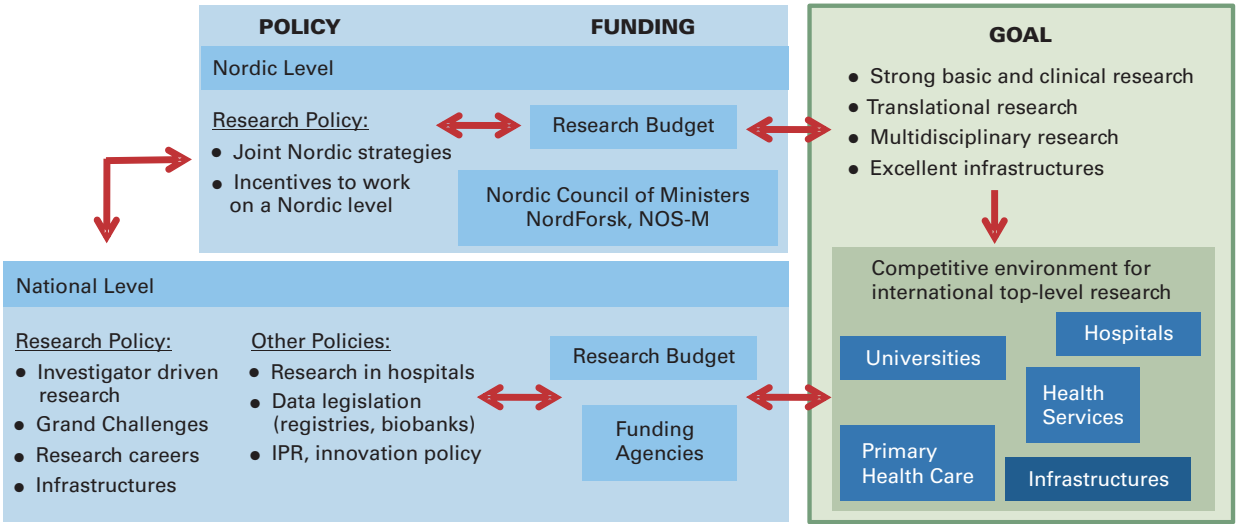

Figure 1. Summary. By establishing common goals for the future development of medical research, the Nordic countries could form a competitive environment for top-level medical research, attracting international researchers and investors. To achieve this goal, the current opportunities have to be, first and foremost, addressed at a national level, but accompanied by adequate incentives to co-operate on a Nordic level.

Excellent infrastructure, adequate economic resources and the allocation of sufficient time for clinicians to do research are prerequisites for internationally competitive medical research. Promoting the continuum from basic science through clinical research to public health and health service research could create new opportunities and innovations. Initially, medical research should be strengthened at a national level through determined action and investment by political decision makers, research funding agencies and by the universities and hospitals. National investment should be accompanied by adequate incentives for Nordic co-operation. Only joint national and Nordic efforts will make the Nordic countries a unique environment for medical research, attractive to international top-level researchers.

Box 1

The Joint Committee of the Nordic Medical Research Councils (NOS-M)

The present paper has been prepared by the Joint Committee of the Nordic Medical Research Councils (NOS-M), which is a collaborating body for the Nordic Research Councils that finance medical research. NOS-M serves as a forum and network for important information exchange of national research policies, funding and development.

The paper has been prepared based on discussions and SWOT* analyses that all national Research Councils have prepared, independently of each other. The aims were to identify strengths, weaknesses, opportunities and threats related to people (researchers), research infrastructure (research and diagnostic equipment, registries, networks, etc.), money (research funding) and society (application of research to clinical practice, decision making, etc.). The aim was also to identify opportunities for Nordic co-operation.

NOS-M is grateful to all past and present members of the national Research Councils and external experts that have contributed to this paper (Appendix 1), as well as NordForsk, the Department of Research Policy Analysis at the Swedish Research Council and the Nordic Institute for Studies in Innovation, Research and Education (NIFU STEP) for bibliometric and statistical data. The valuable contribution of Science Writer Simon Hadlington is also acknowledged.

*Strengths, Weaknesses, Opportunities, and Threats

1 Grand Challenges

Nordic society is facing inevitable changes through ageing of the population, globalisation and climate change. These changes are accompanied by new **healthcare challenges**, with a potential to strain our healthcare systems and compromise the health of our inhabitants. Shifting demography with an ageing population leads to an increased occurrence of conditions such as Alzheimer´s disease, cancer and functional disabilities. A consequence of changing lifestyles (such as a decrease in physical activity and increasing mental distress) is altered disease patterns with a significant increase in the incidence of, for example, obesity, type 2 diabetes, depression and mental distress. Further, globalisation and climate change create challenges such as newly emerging and rapidly spreading infectious diseases and development of resistance to antibiotics. All of these alterations present new challenges both for the individual and the societies in which we live. In order to sustain the quality of life achieved in our society, it is essential that medical research is in a position to play a central role in these future confrontations.

Scientific development in areas previously not included in traditional clinical research (for example, preventive medicine and biotechnology) presents opportunities to address clinical problems from new angles and in new settings. For instance, improved computational power and increased use of data on human genomics opens the way towards personalised treatments designed for the individual patient, as well as shifting the focus from treatment to prevention of disease. Such technological advances will, however, create new **scientific challenges** raising complex ethical questions (such as those relating to privacy issues and genetic counselling) that need to be properly addressed to avoid undermining the legitimacy of medical research and detracting from the advantages that advances in research can bring to society. Further, complex issues related to prioritisation within the healthcare system will almost inevitably emerge.

Improved health creates economic benefits, but health and economy are also closely related in another way: the health of those with high socio-economic status has improved more compared to individuals with lower socio-economic status. This increasing health inequality is emerging as an important **socio-economic challenge** in the Nordic countries, as health is not equally distributed across society.

The above challenges can be defined as some of the **"Grand Challenges"** of today's society, a central new concept that is gaining increasing importance in science policy internationally. Under the Swedish EU presidency in 2009 the Grand Challenges facing the EU, and the demands they will lay on medical research in Europe, were formulated into The Lund Declaration that calls for a new research

approach to cope with these challenges (see Appendix 2) [1]. The opportunities to tackle the Grand Challenges were also acknowledged in a recent evaluation of clinical research in Finland and Sweden [2]. These EU-wide Grand Challenges are complex and battling them will require optimal development of knowledge and understanding of health and disease. The Lund declaration has been followed up at the political level in a recent EU green paper [3].

The aim of the present White Paper is to identify opportunities for strengthening medical research jointly and individually amongst the Nordic countries. The paper indicates those actions that are needed in the Nordic countries to maintain a competitive position globally and respond to the 'Nordic Grand Challenges' facing today's society. In 2008, the European Medical Research Councils (EMRC) prepared a similar White Paper concentrating on the future of medical research in Europe [4], the conclusions of which are presented in Appendix 3. This Nordic paper focuses on strengths and threats that are specific for the Nordic region. Therefore, it should be seen as complementing, not contradicting or repeating, the European paper. EMRC will continue the discussion with an updated White Paper in the autumn of 2011.

2 Medical Research in the Nordic Countries – Financial Input and Academic Output

Medical research has traditionally been seen as a priority in the Nordic countries. Figures from OECD (2007) show that there are differences in the per capita expenditure in medical research between the countries in the Nordic region, both in terms of total expenditure as well as in the contribution from private and public sectors (Fig. 2).

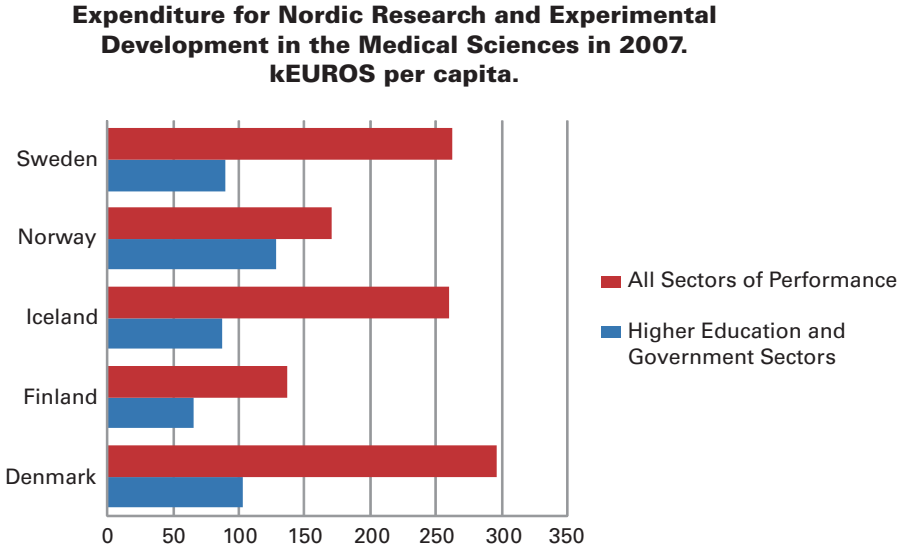

Figure 2. Expenditure (kEUR) per 1000 population for research and experimental development in the medical sciences in 2007. All sectors of performance, including Private Sectors, Higher Education and Government Sectors, indicated in blue, and total of Higher Education and Government Sectors in red. Source: OECD (2010), "Main Science and Technology Indicators", OECD Science, Technology and R&D Statistics (database), European Central Bank and Danmarks Statistik. Appendix 3, NIFU STEP.

To estimate the long term outcomes of medical research is a challenging task, but a proxy for academic output is the production of scientific papers measured with bibliometric tools. The productivity measured as number of medical publications per capita is high in the Nordic countries as compared to EU15 and the US (Fig. 3).

When studying the development of the total publication number over a 25-year period (Fig. 4), a general increase in the number of publications per year is observed. The increase in publication volume in biomedicine, clinical medicine and health sciences has roughly been the same in the US and EU15 (Fig. 4). In the Nordic countries in general, an overall increase in the number of publications is apparent in clinical medicine and biomedicine, with some discrepancies between the individual countries. The increase has been particularly strong in the field of health sciences.

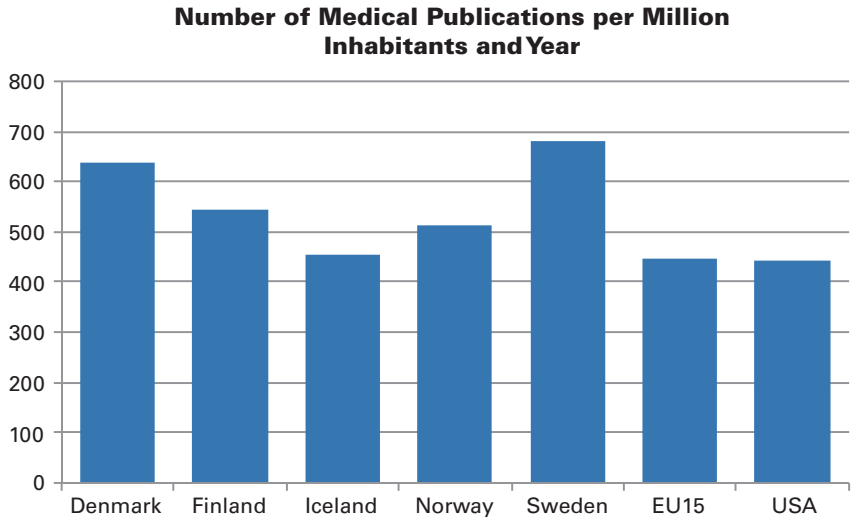

Figure 3. Per capita production of medical publications; mean number of medical publications per year 2007–2009 and million inhabitants. Population statistics from OECD.

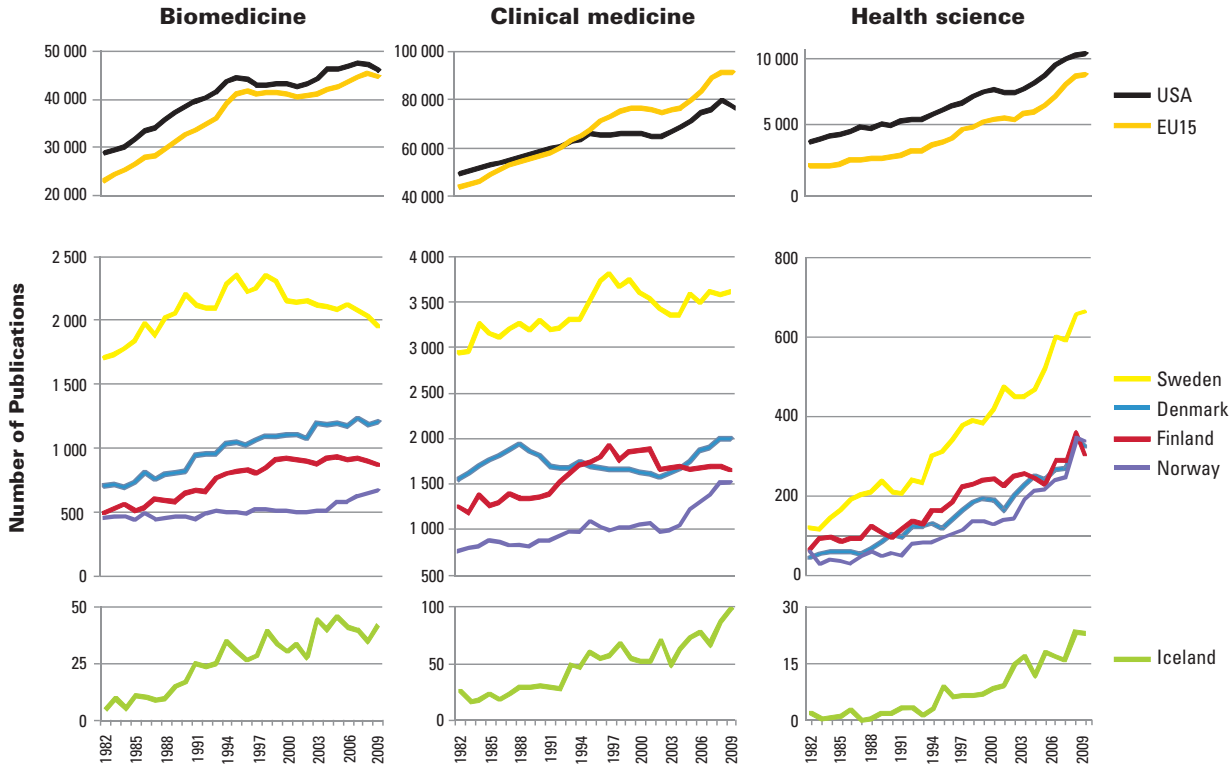

Figure 4. Number of publications in biomedicine, clinical medicine and health sciences in the Nordic countries, EU15 and United States in 1982–2009. Source: Thomson Reuters Science Citation Index Expanded[1], Swedish Research Council 2010. For details on bibliometry, see Appendix 4.

1 Any report based on these data is required to include the following statement: Certain data included herein are derived from the Science Citation Index Expanded®, Social Science Citation Index and Arts & Humanities Citation Index prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA© Copyright Thomson Reuters® 2009. All rights reserved.

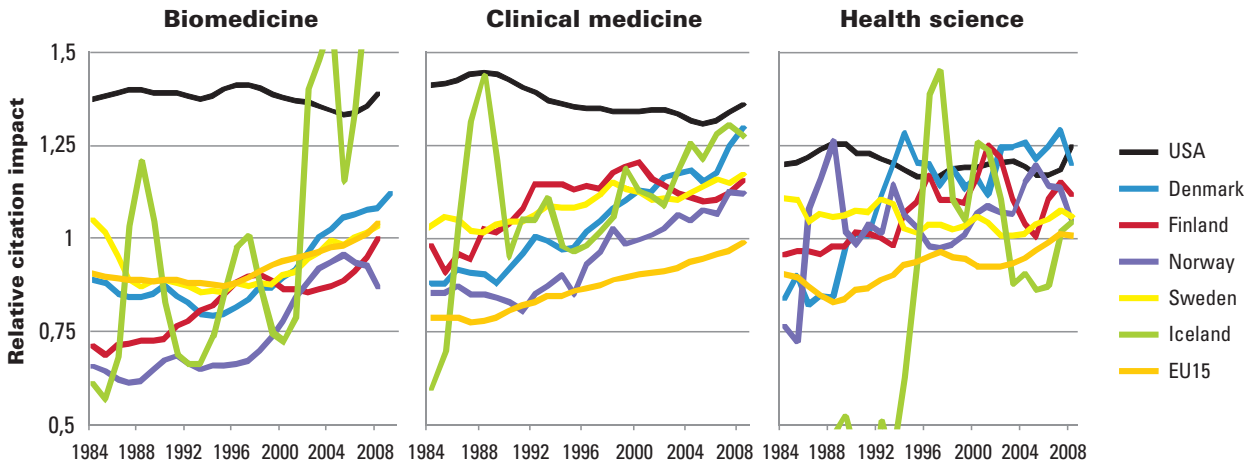

Figure 5. Field normalised citation rates in biomedicine, clinical medicine and health sciences in the Nordic countries, EU15 and the US in 1983–2009 (moving three-year averages, world average citation impact is 1). Source: Thomson Reuters Science Citation Index Expanded, Swedish Research Council 2010. For details on bibliometry, see Appendix 4.

The field normalised citation rates (Fig. 5) provide a rough measure of the scientific impact and quality of research. In biomedicine the Nordic citation impact has gradually increased, and is now at the world average. The US index for citations in biomedicine, however, remains clearly higher. In clinical medicine, the Nordic countries also display a positive development and citation rates are above the world average. The US index for citations in clinical medicine has previously been noticeably higher compared to the Nordic countries, but this gap has today nearly vanished. Interestingly, all Nordic countries perform better than the world average with a citation impact comparable to the US in health sciences.

3 Nordic Strengths, Weaknesses, Opportunities and Threats

Strengths

Nordic medical research has several clear **strengths**. A definite strength of medical research in the Nordic countries is the people behind it. The Nordic region is home to many world-leading scientists, as well as a large number of well-educated younger scientists and students. Furthermore, our national and Nordic Centres of Excellence in the medical research field are of world class.

The Nordic public healthcare system is both well organised and well equipped, holds high standards, is accessible to the entire population and employs well-educated health professionals. In general, medical research has a high standing and esteem in the Nordic countries both among politicians and the public, which translates into trust for and appreciation of research and researchers.

Of particular comparative advantage are the Nordic health registries and biobanks. In combination with the personal identification numbers commonly used in the Nordic countries, these provide an excellent research infrastructure for gene–environment research cohorts and investigator-driven clinical trials. The biobanks and health registries are, however, currently not used to their full potential and should be further exploited in the future.

An important Nordic strength is the public ownership of universities and university hospitals, which presents great possibilities for integration of research and clinical care. An additional strength is that these public resources are supplemented by substantial public and private investment in medical research in universities and in industry.

Weaknesses

Several evident, common **weaknesses** of Nordic medical research are related to medical researchers' career opportunities: it is challenging to compete with salaries in the healthcare system, research merits are not valued highly enough as part of a clinical career and there is a clear need for a defined tenure track. These disadvantages have led to decreased numbers of in particular clinical professionals engaging in research, even though basic scientists face the same problems. The decline in the number of clinical researchers, as well as the decline in the amount of clinical research that can be carried out because of constraints on time available for research, is likely to threaten the whole branch of research.

The balance of researchers in different stages of their career is not ideal, though this problem extends beyond medical research. There are presently far too many positions for doctoral students compared to postdoctoral and young investigators. Currently, Nordic research output is far too dependent on the work of doctoral

students and more attention should be paid to supporting postdoctoral and senior researchers.

Although some excellent research infrastructures, such as registries and biobanks, are identified as strengths, the funding of infrastructures for medical research is clearly inadequate in international comparison. In addition, public financial support for investigator-driven clinical trials that are not of obvious commercial interest is too limited.

The Nordic countries have a strong tradition for collaboration but, unfortunately, specific funding for Nordic co-operation is not adequate. In contrast, collaboration among other European countries is becoming increasingly important and is better resourced.

Opportunities

A clear and important Nordic **opportunity** lies in improving the position of and possibilities open to of clinical researchers. The Nordic countries could further excel in clinical research, but the present career structure for researchers militates against this.

The Nordic countries have enormous potential for synergy if we can take advantage of our similarities. The Nordic countries have the same socio-economic background, strong healthcare registries, publicly owned universities and university hospitals and a high appreciation for medical research among the general public and politicians. The Nordic countries are small, but combining data, resources and brain power opens new possibilities [5]. Furthermore, the Nordic countries have a long tradition of strong political collaboration. A unique platform for Nordic research collaboration is provided by NordForsk, which is an organisation under the Nordic Council of Ministers that provides funding for Nordic research cooperation as well as advice and input on Nordic research policy. This collaboration is built on mutual trust and Nordic politicians are supportive of joint Nordic research activities, the current Top-level Research Initiative being an example of a joint Nordic venture originally initiated by the Nordic Prime Ministers in 2007. Another example is the Nordic collaboration project consolidating the unique Nordic biobank research infrastructure (BBMRI Nordic, Box 2).

More incentives, supported by increased funding, are needed to strengthen Nordic medical research. Improved resources, especially flexible funding opportunities to allow greater mobility among Nordic researchers, should enable strengths to be combined at both at the Nordic level and within individual countries, in order to produce synergistic effects. Researcher mobility should also be supported in a wider international perspective and emphasis should be put on attracting the best young researchers back to their home region after visits abroad. The Nordic countries could have a competitive advantage in attracting top-level researchers and companies to the region if we focus on specific research topics in which we aim to excel internationally. There is therefore room for another Nordic large-scale endeavour within the area of health research similar to the Top-level Research Initiative to tackle the Grand Challenges.

Box 2

BBMRI Nordic: A Collaboration Project Consolidating the Unique Nordic Biobank Research Infrastructure

The Nordic countries have been pioneers in establishing population-based biobanks. Specific Nordic resources such as personal identification number, national healthcare system, registers defining genetically informative populations and health outcomes make the Nordic countries uniquely suited for a successful biobanking infrastructure. The Nordic countries have recently allocated significant funding for establishing national research infrastructures on biobanks which will allow scientists to share and couple data from different biobank resources nationally.

At the European level, BBMRI (Biobanking and Biomolecular Resources Research Infrastructure) is one of the ESFRI (The European Strategy Forum on Research Infrastructures) priorities. Since coordination of the national biobanking initiatives in the Nordic countries would be hugely beneficial and ensure that the Nordic region maintains its position as a leading scientific hub of epidemiological research, NordForsk funded the Nordic network BBMRI Nordic in April 2010. The network was initiated by the Nordic scientific biobank community and has representatives from national biobanking platforms in Sweden (BBMRI.se), Finland (BBMRI.fi), Norway (BBMRI.no/Biobank Norway), Denmark (Biobank Denmark), and from Icelandic biobanking scientists. In addition, Estonia has indicated an interest in joining the Nordic initiative. The Nordic network aims to: 1) exchange experiences 2) work towards a harmonisation of the biobanking process on a Nordic level, and 3) establish a joint Nordic biobanking voice on the international research infrastructure scene. The network will bring Nordic expertise and support into the European initiative.

In order to demonstrate the viability of the joint Nordic concept and to further promote an effective harmonisation of the joint work, BBMRI Nordic recently established a joint Nordic biobank-based research project called "Joint Nordic Biobank Research Infrastructure". The overall aim of this pilot study is to start a process that will lead to a joint Nordic resource of national biobanks. Colorectal cancer has been chosen as the medical-based pilot use-case. Although colorectal cancer is one of the most frequent types of cancers and constitutes a public health problem in the Nordic countries, its incidence is still too low to allow large-scale research in one single country. Large-enough and well-validated cancer patient material can however be secured at the Nordic level – if appropriately coordinated. The suggested pilot project is divided into three phases of which NordForsk is funding the first two that will run 2011-2013.

The high-profile pilot project will optimise the scientific output from biobanks by promoting large-scale sciences. The Nordic countries will in addition have the possibility to set an international standard on how to collaborate on biobank-based research.

Threats

In a worst-case scenario, the status of clinical research will deteriorate in the Nordic countries. Growing demands for clinical specialist training, in combination with a strong focus on delivering efficient and economical healthcare services, are a severe **threat** to the position of research. The prerequisites for performing high quality medical research may become jeopardised if the importance of continued investment in basic research is not recognised by political decision makers.

The lack of researchers with clinical training is not only a threat to clinical research itself, but also to clinical practice and teaching. High quality clinical research, in combination and active partnership with strong basic research, should be seen as a prerequisite for the translation of research results into practice and good patient care.

Another clear threat concerns the development of data protection legislation. This is becoming increasingly bureaucratic, making it more difficult for researchers to perform human studies and especially to access healthcare information and data banks. This latter issue could have a clear negative impact on genetic epidemiology, which has been one of the undisputed strengths of Nordic medical research. Therefore, more attention should be paid at a political level towards solving legal and ethical hurdles to effective modern medical research.

It is important that any new funding should not be solely directed towards specific thematic areas, since solid, broad basic research is a prerequisite for medical and healthcare innovations. Top-down, theme-based funding programmes could pose a threat to basic research.

4 Nordic Potential

The identification of Grand Challenges does not mean that a majority of the research should stem from a thematic, "top-down" approach. New innovations are sought for in the medical research area, but innovations require solid and extensive basic, clinical and public health research as a source for new ideas and insights that can be translated into useful solutions in a clinical setting. Therefore, strong basic research on a broad basis, not only in areas obviously linked to the Grand Challenges, and complementing high-quality research on the health service systems will in time produce the clinical and social innovations needed in the future. Research investment at this level will eventually reap dividends, even though the time line may be longer than most political strategies demand (Box 3) [6], as exemplified by research on Alzheimer´s disease (Box 4).

The introduction and use of new knowledge and innovations are, however, often hindered by differences in "business culture" and incentives between the academic researcher on the one hand and entrepreneurs and healthcare professionals on the other. There may also be difficulties in the translation of knowledge between experimental, clinical, basic and applied research. This can present an obstacle to the optimal use of intellectual and economic investment as well as the implementation of new knowledge into practice. Ideally, basic and

Box 3

Medical Research: What's it worth?

Estimating the economic benefits from medical research in the UK

- In 2008 the results of a study into the economic benefits of the UK's public and charitable investments in medical research was published [6].
- For this purpose, a methodology to calculate the health and economic (GDP) gains from investments in cardiovascular disease (CVD) and mental health research was developed.
- The study was commissioned by the Academy of Medical Sciences, the Medical Research Council and the Welcome Trust.

Results

- The health and GDP gains derived from UK's public and charitable investments in CVD research is equivalent to an annual rate of return of around 39 % (37 % for mental health).
- This figure of 39 % includes an annual rate of return of 30 % in GDP gains (direct returns to the UK economy) and an annual rate of return of 9 % in health gains (arising from new preventive and therapeutic interventions for disease).
- The estimated time lag between research expenditure and eventual health benefits is around 17 years. Shortening this time lag would improve the rate of return still further.
- The time period studied was 1975–92. It is not obvious if the return will be the same in the future or if the same results apply to other diseases.

clinical research lines interact with research in public health and health services, leading to new knowledge and new health innovations. This requires a constant interchange of ideas and results between clinical professionals to identify needs in clinical practice, which feed into basic research from where new knowledge can be translated back into the clinical setting.

Box 4

Alzheimer's disease – an example of how basic research can lead to significant clinical outcomes

- Alzheimer's disease (AD) is a neurodegenerative disease that causes dementia. The cause of the disease is unknown but the prevalence increases drastically with increased age.
- In the Nordic countries some 350 000 people suffer from AD, about 50 000 new patients are diagnosed yearly. In Denmark, the direct and indirect costs caused by AD have been calculated to 17 500 EUR/year and patient, amounting to over 60 MEUR yearly on a Nordic level.
- With an increasing aged population, the prevalence of dementia and AD is predicted to quadruple by 2050.
- A five year delay in onset of AD would decrease AD prevalence by 50% by 2050 and accordingly reduce health care costs and increase the quality of life and productivity of affected individuals.
- Through basic research new biomarkers have been identified that can be tracked long before clinical symptoms are detected. This may allow for the development of new drugs and interventions directed towards very early disease processes.
- The Nordic countries have a strong tradition in research on Alzheimer's wdisease.

History of Alzheimer's disease:

1906	Dr. Alois Alzheimer first describes the pathology of the disease including plaques and tangles in neurons
1960s	The relationship between the number of plaques and tangles in the brain is identified
1976	A lack of function of the cholinergic system is found in AD patients
1980s	Fundamental biochemical processes responsible for the development and pathology of AD are revealed
1987	A link between AD and chromosome 21 is identified
1990s	Several risk genes and genetic mutations related to AD are described
1996	The first drug that improves symptoms comes to the market
2000s	Several drugs that target the disease process fail in clinical trials. Biomarkers that can be tracked long before the onset of disease are identified. Research is directed towards preventing or delaying the onset of disease. Life-style factors important in the onset and development of AD are recognized and subject for further research

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World Alzheimer Report 2010, http://www.alz.co.uk/research/worldreport/

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National Alzheimer's disease foundations

5 Conclusions

By analysing the present status of Nordic medical research, the following conclusions can be drawn:

Better incentives for Nordic cooperation are needed

Medical research is strong in the Nordic countries when seen from an international perspective. However, extended efforts and incentives are needed to keep our tradition, maintain our internationally esteemed position and to help solve the global Grand Challenges facing today's society. In this respect, Nordic cooperation is important and influential. Similar cultures, education systems, research traditions and healthcare systems provide a solid base upon which to expand Nordic cooperation in medical research and research policy. By working together, the Nordic countries are strong enough to be a leading force in international medical research, with a great opportunity to influence, build and lead the common European Research Area (ERA). Further, our unique research infrastructures, including population cohorts, biobanks and patient registries, are a gold mine for medical research that should be utilised to their full potential.

Innovations require good basic research

Innovations and future advances in healthcare stem from very strong and independent basic research. This is, unfortunately, often forgotten when the political pressure to show rapid payback is increasing. However, the Grand Challenges of today are so complex and multi-faceted that they cannot be solved solely through research that is thematically directed. Investigator-driven basic research is therefore always needed as an important input to more applied science. Faith and trust in basic research should be the key issue in medical research policy.

Clinical research requires increased attention

High quality clinical research is needed in order to improve the cost-efficiency of the healthcare system. Moreover, strong clinical research is a prerequisite for high-quality education of medical doctors. Unfortunately, the quality and quantity of clinical research is threatened in the Nordic countries. Better integration of medical faculties and university hospitals is needed in order to link clinical research with basic and public health research. Focus on the clinical researcher's career is essential: research output should be valued as an integral part of the clinical career – and vice versa.

6 Recommendations

- Efforts should be extended to increase and improve Nordic cooperation in medical research and research policy.
- Flexible funding opportunities should be made available to allow greater mobility among Nordic researchers.
- There needs to be a recognised career path for clinical researchers.
- There is an urgent need at the political level to solve legal and ethical hurdles that are arising in areas such as biobanking and databases that could seriously hinder effective medical research in a number of key areas.
- There needs to be greater use of the Nordic biobanks and health registries to exploit their maximum potential, including greater cooperation between these infrastructures.

To achieve these goals, the identified challenges have to be acknowledged at all levels of decision-making and must be taken into account during the preparation of research policies and budgets both at the national and the Nordic level.

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Appendices

Appendix 1. Members of the Nordic Medical Research Councils (NOS-M)

Professor *Stig Slørdahl* (chair)
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Professor *Lars Køber* (2011 ->)
Rigshospitalet, Denmark

Professor *Mads Melbye*
Statens Serum Institut, Denmark (-> 2010)

Professor *Tuula Tamminen*
University of Tampere, Finland

Professor *Mats Ulfendahl*
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Professor *Birgitta Öberg*
University of Linköping, Sweden

Administrative Representatives from:

Academy of Finland, Finland
RANNÍS – The Icelandic Centre for Research, Iceland
Swedish Research Council, Sweden
The Danish Council for Independent Research | Medical Sciences, Denmark
The Research Council of Norway, Norway
NordForsk

Appendix 2. The EU Grand Challenges

- **Global warming:** In the current changing climate, how to better manage (prevention and recovery) the consequence of natural disasters such as flooding, fire forest, hurricane, dry area extension which tend to increase in numbers but also in intensity?
- **Tightening supplies of energy, water and food:** In a constraint resource environment, how to improve the efficiency of the consumption, the recycling rate while further reducing waste?
- **Ageing societies:** As the life duration of people increases, this raises numerous issues among which economical, social inclusion, accessibility.
- **Public health:** How to provide medical care to everyone while minimising discrimination?
- **Pandemics:** With the global and fast circulation of people and animals, disease can spread fast. How to improve the prevention and recovery in case of wide spread diseases since they potentially have a huge impact to the economy but also social stability.
- **Security:** How to improve the security of European citizens and their goods within but also outside Europe?

Appendix 3. The Tool Box from the EMRC White Paper [4]

Tool Box: "Best Practice" for medical research in Europe:
EMRC White Paper: Present Status and Future Strategy for Medical Research in Europe [4]

Primary goals:

- Strong basic research
- Strong clinical research
- Strong translational research: bringing basic research knowledge into clinical practice, and vice versa

– all three of the above being facilitated by interdisciplinary research and public– private partnerships

Tools to reach these goals: ***people***

- Career track schemes with attractive possibilities for researchers taking advantage of co-funding strategy
- European Medical Scientific Training Programme (EMSTP) for physicians and scientists scaling up existing successful initiatives
- The highest level of research ethics, and no scientific misconduct

Tools to reach these goals: ***research infrastructure***

- Investment in national and European research infrastructure – covering the whole range from laboratory equipment in basic science labs and research facilities in hospitals, to the largest pan-European infrastructures, as outlined in the ESFRI Roadmap
- Launch a call for proposals to directly support on a highly competitive basis a league of top performing biomedical research centres of excellence, integrated into regional clusters
- Post-genomic clinical medicine
- Intelligent and coordinated use of Information Technology (IT)
- EC and national regulatory issues for clinical research adapted to facilitate research

Tools to reach these goals: ***research funding***

- Adequate research funding – distributed on the basis of scientific excellence and through peer review
- Common criteria and methods for the evaluation of research outcomes

Tools to reach these goals: ***societal means***

- Globalisation and collaboration: sharing of research and results
- Public engagement about medical research and its possible impacts
- Preparedness for the future

Appendix 4. Economical figures

The figures are mainly based on *OECD (2010), "Main Science and Technology Indicators", OECD Science; Technology and R&D Statistics (database)*. The numbers describe collected spending on research and development (R&D) according to the definitions of OECD. To limit the data to R&D related to medical research, the following operational definitions have been applied:

- For the Higher Education, Government, and Private Non-Profit (PNP) Sectors the data allocated under Medical Science according to OECD's division into fields of research has been used.
- For the Private Sector data from the two following industries have been included:
  - 2423 Pharmaceuticals
  - 3300 Medical, precision and optical instruments

Comment: These categories are broad and not optimal for selecting data exclusively related to Medical Science. In addition, also other industries may contain branches relevant for Medical Science. These two industries, however, cover the main part of the Private Sector in Medical Research and have been chosen to retain the comparability between the countries.

Given these reservations, the confounding data is relatively comprehensive. There are, however, some circumstances that should be noticed regarding the individual countries:

Denmark:	The division into lines of business in the Private Sector is available only until 2006. The data from 2007 is based on national numbers on the web-page of Statistics Denmark, where a somewhat different categorisation is used.
Finland:	Finland does not report data from the PNP-sector.
Iceland:	The division into lines of business in the Private Sector, as well as the division in to fields of research in the Higher Education Sector is available only until 2005. As data from 2007 is not available, data from 2005 has been used.
Norway:	Norway does not report data from the PNP-sector.
Sweden:	The division into fields of research is not given for the Government Sector or the PNP-sector. Therefore, the data covers only the Higher Education Sector and the Private Sector.

Nordic Institute for Studies in Innovation, Research and Education (NIFU STEP)

Appendix 5. Information on the sources for bibliometric figures

Bibliometry

Data source

The statistics are compiled using the publications database at the Swedish Research Council (Vetenskapsrådet). This database contains all publications from international journals indexed in the following Thomson Reuters products: Science Citation Index Expanded, Social Science Citation Index and Arts & Humanities Citation Index.

Any report based on these data is required to include the following statement: Certain data included herein are derived from the Science Citation Index Expanded®, Social Science Citation Index and Arts & Humanities Citation Index prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA© Copyright Thomson Reuters® 2009. All rights reserved.

Definitions

Publication types included

All statistics are based on articles and reviews only. However, the definition of article has been expanded to include the publication types note and letter. The types note and article were merged by Thomson Reuters in 1996, but the Swedish Research Council has also merged them before this year.

All citation statistics are based on field normalised citations using a 3-year citation window (i.e. citations received during the publication year +2 following years). For the years 2008 and 2009, the 3-year citation window is not complete and therefore the statistics may change when the database is updated. Volume and citation statistics may also change concerning previous years when the database is updated, since new journals are continuously added to the database contents. Updates usually also include back issues of new journals.

Self citations are always removed based on author names. All citations where the same surname and initial(s) occur among the authors in both the citing and cited work are ignored.

Multidisciplinary publications are, whenever possible, reclassified into other subject fields based on (a) the subject profile of the reference list of each multidisciplinary publication and (b) the subject profile of the publication citing the publication. A publication remains classified as multidisciplinary only when the reclassification algorithm has failed to reclassify it. After the year 2000, approximately 10% of the publications originally classified as multidisciplinary remain in this group.

Number of (fractionalised) publications per subject field

For example, if a publication has five addresses of which two belong to Finnish organisations and the publication is assigned to two subject fields, Finland is credited 2/(5*2) = 0.2 fractionalised publications to each of the two subject fields. All statistics on number of publications are based on fractionalized numbers according to this definition.

Field normalised citation rate

The field normalised citation rate is one of what is called 'state-of-the-art' bibliometric indicators. The general idea of the indicator is to relate the number of citations made to a publication or a group of publications to average citations to a group of comparable publications of the same publication type, publication year and scientific field.

The Swedish Research Council calculates its cf indicator using a fraction-oriented method, which means that the citation rate of each subject fraction for a publication is normalised against an average citation rate for the same publication type, publication year and subject field that the fraction in question belongs to. When the average normalized citation rate for the analysed unit's publication is calculated, each publication fraction is weighted according to the inverse of the number of subject fractions, so that the resulting average is a weighted average.

Field of science	Thomson Reuters categories	
Biomedicine	Anatomy & Morphology Biochemical Research Methods Biochemistry & Molecular Biology Biophysics Biotechnology & Applied Microbiology Cell Biology Cell & Tissue engineering Chemistry, Medicinal	Cytology & Histology Genetics & Heredity Immunology Microbiology Microscopy Neurosciences Pharmacology & Pharmacy Physiology
Clinical medicine	Allergy Andrology Anesthesiology Oncology Cardiac & Cardiovascular System Critical Care Medicine Psychology, Clinical Emergency Medicine Dentistry, Oral Surgery & Medicine Dermatology Substance Abuse Endocrinology & Metabolism Gastroenterology & Hepatology Geriatrics & Gerontology Gerontology Hematology Infectious Diseases Integrative & Complementary Medicine Medical Ethics MEDICINE, LEGAL Medical Informatics Medical Laboratory Technology Medicine, General & Internal Medicine, Research & Experimental	Medicine, Miscellaneous Clinical Neurology Neuroimaging Obstetrics & Gynecology Ophthalmology Orthopedics Otorhinolaryngology Parasitiology Pathology Pediatrics Rehabilitation Psychiatry Respiratory System Rheumatology Radiology, Nuclear Medicine & Medical Imaging Surgery Toxicology Transplantation Tropical Medicine Urology & Nephrology Peripheral Vascular Disease Virology
Health sciences	Health Care Sciences & Services Public, Environmental & Occupational Health Nursing	Nutrition & Dietetics Sport Sciences

Department of Research Policy Analysis at the Swedish Research Council

Vetenskapsrådet

Ministry of Science
Technology and Innovation

The Research Council
of Norway

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