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Research Impact of the Dutch University Medical Centres

Bibliometric analyses of the scientific and societal impact, by CWTS and NFU

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ANALYSIS OF THE SCIENTIFIC OUTPUT OF THE UMCS CAN BEST BE PERFORMED IN RELATION TO ALL THE (BIO)MEDICAL AND HEALTHCARE RESEARCH IN THE NETHERLANDS, EUROPE AND THE REST OF THE WORLD

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AND WE NEED TO CONTINUE TO *STRENGTHEN OUR ABILITIES* TO COLLABORATE

NFU Preface

At the university medical centres of the Netherlands, we keep working towards better health for everyone. This is made possible by our unique linking of research with education and care, and the extensive support provided by regional, national and international partnerships. The 'Research Impact of the Dutch University Medical Centres' report reveals that the scientific impact of the umc's is in the same league as that of the top international institutions. But more importantly, it shows that the umcs' research has had an impact on society as a whole in a multitude of ways.

The umc's are active in a large number of collaborations. They are the 'academic driver' in their own region, foster a culture of mutual support and work together with many institutions in Europe and the rest of the world. Each umc has a prominent role in research. Altogether, our umc's cover a wide range of topics in the (bio)medical and health sciences fields along with public health. They each have their own focus and area of expertise. Thus, they complement each other in their diversity.

We share our knowledge efficiently and readily. One particular goal we strive for is Open Science, which means free access to research results and optimal reuse of research data. Already, 70% of the umcs' scientific publications was accessible online in 2018. We aim together with the universities to make even more publications accessible earlier and more easily, and we are working hard on this goal with them.

The umcs' research inspires technological innovations and tests them in practice. It contributes to the general knowledge about healthy living and provides input for the government's decisions. This is highly visible at the moment in the current COVID-19 crisis: our scientists have important roles to play in, for example, the Outbreak Management Team.
This knowledge is meant to make important contributions to clinical guidelines and treatment protocols both inside and outside hospitals. Last but not least, it is important to us that society can utilise our knowledge. That is why in this analysis we looked at the actual impact of our scientific knowledge in specific guidelines, policy documents and news media.

On behalf of the NFU, I warmly invite you to employ this analysis to seize opportunities for new collaborations and innovations. For the health of tomorrow.

Prof. Margriet Schneider
Chair of NFU

Management summary

This report marks the start of a new approach to visualize and interpret the research impact of the Dutch University Medical Centres (UMCs). Research impact has not only a scientific aspect (in which scientific journal you publish or how often your articles are cited), it also concerns, more importantly, which target audiences you reach, how you reach them, and with whom you collaborate. These dimensions of both scientific and societal impact are covered in this report. The basis for this report is the scientific publications of the Dutch UMCs; bibliometric data and maps are used to visualize our scientific and societal impact.

There are four main conclusions we can draw based upon the visualizations and our interpretations of the maps provided in this report.

1 The first is what we call ***complementarity in our diversity***. The research of the Dutch UMCs covers a very broad range of topics, highlighting the richness and diversity of our national biomedical landscape. While sometimes the individual UMCs may be active in the same general research fields, we specialize in topics which are very often complementary to each other. On these specific topics we collaborate to create mass and impact in the international scientific world, and to optimize the translation of our findings into clinical care.

2 The second conclusion is our stance towards ***practising open science.*** It is our national mission to strive towards a high level of open access to our scientific publications. The Dutch UMCs have taken this message to heart, and even in 2018, some 70% of our research papers could be accessed openly and freely by anyone. We believe that researchers around the world, health care practitioners and the general public should benefit directly from our research, especially if it was government-funded. Society should be able to reapply this knowledge in their own research or practice in order to speed up developments in medical research and health care.

3 Analyses further show that the Dutch UMCs operate on a world-class level, collaborating in research with top institutions around the globe. Our research scores at the international top, in terms of both volume and citation impact. With limited expenditure we publish many papers that are valued by our peers. In other words, ***our research can be stated as being of the highest level worldwide.***

4 In addition to our prominent and leading role in the international research landscape, the Dutch UMCs are the scientific driver of biomedical research in the Netherlands (nationally and regionally). Each UMC has a distinct national collaboration network, including universities of course, but also scientific organizations, regional hospitals and industry partners. Each UMC plays a leading and coordinating role in research with these regional partners. This is a symbiotic relationship in which all partners have their unique role, and in which knowledge and expertise are exchanged. This fourth and final conclusion we call ***our strong culture of collaboration.***

It is our national mission to strive towards a high level of open access to our scientific publications. The Dutch UMCs have taken this message to heart, and even in 2018, some 70% of our research papers could be accessed openly and freely by anyone.

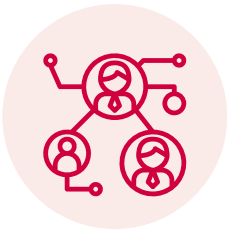
WITH THE *RESEARCH IMPACT MAPS* WE GIVE INSIGHT INTO THE VARIETY OF RESEARCH ENVIRONMENTS THAT THE UMCS ARE SPECIALIZED IN

Introduction

The landscape of medical care and research in which the Dutch UMCs operate is changing. The supply and demand of care continuously shift, we are in a transition towards open and team science, and we are strengthening our role as a regional academic driver coordinating research with other hospitals in our region. This is exemplified by the prominent role of the UMCs in the COVID-19 pandemic. And these are just a few of the changes happening right now. In this shifting landscape the UMCs occupy a unique and distinctive position because of the integration of our medical faculties within them. Their three core tasks are delivering top referral patient care, performing excellent (bio)medical research, and offering education and training for medical students and health care professionals. Together, our UMCs provide a wealth of knowledge to individual students, doctors and patients and to our society as a whole. Our scientific knowledge is shared through scientific publications. This societal impact is achieved by translating our scientific knowledge into innovations in the health care practice.

Together for the health of tomorrow

Knowledge enhancement and performing top-notch research cannot be done alone. Our UMCs are uniquely positioned to operate in a national and international context. We perform our core task of excellent (bio)medical research together, within and between the UMCs, but also with citizens, patients, and international, national and regional care and knowledge institutions. To be able to do so, open science and team science are crucially important.



Our regional, national and international impact

Benchmarking UMCs relative to each other no longer fits in the changing medical care and research landscape. Analysis of the scientific output of the UMCs can best be performed in relation to all the (bio)medical and healthcare research in the Netherlands, Europe and the rest of the world. Bibliometric analyses can support this goal. These analyses provide insight into the scientific and societal impact of our research and can be used to visualize our collaborations with national and international, regional and private partners, and can help to identify potential collaboration partners. The UMCs can use bibliometric analyses in their strategic research policy, taking into account the major changes that are taking place and the challenges we are facing.

Research Impact Maps

This report is truly unique. The different maps and visualizations show our joint and individual scientific and societal force and impact. At the same time they uncover opportunities to enhance our impact even further and to create new collaborations.

This report is structured in the following manner. Chapter 1 contains an introduction and background to the selected bibliometric analyses. Which data are used, how do the analyses work, and how are the generated figures to be understood? Explaining the methodology is outside the scope of this report, but is available as a separate document for anyone who is interested. Chapter 2 sheds light on the research landscape in which the UMCs operate, publish open access and generate societal impact. In chapter 3, the international and national scientific networks in which the UMCs operate are visualized. Finally, in chapter 4, bibliometric indicators and core data are presented that attest to the scientific impact of the UMCs, and how it relates to the top institutions in Europe.

The analyses in this report were performed in 2020, on publication data up to and including 2018, and citation data up to and including 2019. In this way publications have at least one year to get cited, which is common practice in bibliometric analyses.

The NFU invites everyone to discuss the analyses and their interpretation in this report. Are there other ways to increase the scientific and societal impact? What opportunities are there to collaborate more intensively in research? Together for the health of tomorrow; not just a motto, but our mission.

1 Background to the bibliometric analyses

This chapter provides a short introduction and background to the bibliometric analyses. Detailed descriptions of the methodology are not included in this report but can be accessed in a separate document.

Bibliometry implies the analysis of bibliometric metadata from scientific publications. Researchers from the UMCs are obliged and encouraged to make their clinical and other research findings public, most commonly done through scientific publications, but also through their inclusion in policy documents, clinical guidelines and/or through coverage in the general press and media. The UMCs together published 66,938 scientific peer-reviewed articles between 2015 and 2018. Approximately 18,000 articles appeared in 2018 for the UMCs combined. The bibliometric analyses based on these publications that indicate the scientific impact can be, for instance, the number of citations relative to other publications on the same topic. In addition, collaborations based on co-authorships or term mapping from titles and abstracts derived from the UMC publications can be used. Other, more societal impact-oriented analyses include the accessibility of publications based on open access data and the uptake of publications in societally relevant sources such as news media, guidelines and policy documents. The outcomes of these analyses can be visualized in graphs and in tables using network mapping software.

The network mapping software used in these analyses is VOSviewer. In the visualizations the size of the sphere represents the number of publications by an institution, or the number of times a term occurs in either a title or abstract. Lines between institutions reflect collaboration based on co-authorship of the same publications. The color and position of a term or institution are determined by the relatedness to other terms or institutions on the map. If terms occur frequently on the same publications, they will have a higher level of attraction towards each other and will be located closer to each other on the map. If institutions collaborate on the same publications, they will be placed together on the map in the same manner. A cluster of frequently co-occurring terms can be labeled with the same color and is a proxy for a bigger topic of research. For instance, oncology research includes terms about treatment such as chemotherapy, but also terms that indicate fundamental research on oncogenesis.

Colors can also be used as an overlay to show other dimensions. In a term map, colors can be used as a scale to indicate the grade of open access, uptake in societally relevant sources of publications on these topics, or citation impact.

2 UMC research landscape

This first visualization shows a research landscape with frequently occurring key terms (derived from title and abstract) in the high-impact scientific publications from 2018 (most recent year available for citation analysis) of the Dutch UMCs. For this map only publications in clusters (see the separate document 'Explanation of the bibliometric methodology of CWTS') with over 15 publications in one year were selected, and clusters with a joint mean normalized citation impact score of higher than 1.5 (50% above world average). Because of these methodological choices, not every topic will be visualized of the wide variety of research areas the UMCs cover. For instance, research on rare diseases typically has a lower publication volume because of its highly specialized nature, and will therefore not be prominent in this type of visualization.

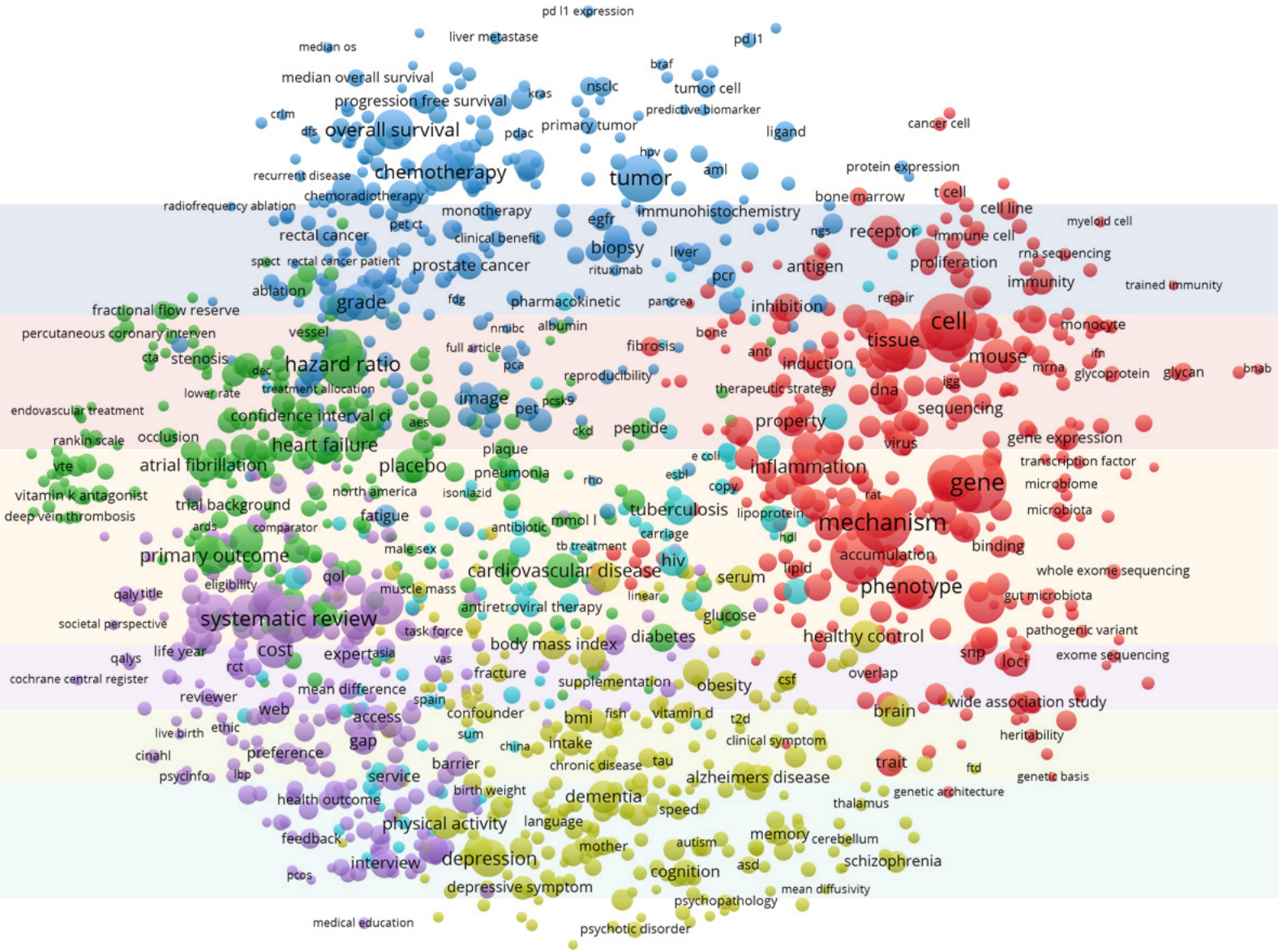


Figure 1

Map showing key terms in the high-impact scientific publications of the Dutch UMCs from 2018

The size of the spheres in Figure 1 indicates the number of occurrences of a term. The position of the terms shows their relatedness and co-occurrence on the same papers. The six colors roughly indicate major research clusters in the Dutch UMC landscape.

On the top in blue, the terms indicate oncological research, varying from more clinically oriented research on the left (treatment and diagnostics) to fundamental tumor research on the right (cellular and immunological).

The red cluster describes much of the fundamental biomedical research performed by the UMCs, such as genetics, cell biology and biochemistry. The high level of activity of the UMCs in this cluster shows the great importance of fundamental biomedical research as the foundation for more translationally oriented research.

In yellow on the bottom right, there is more fundamentally oriented neuroscientific research, and on the left psychiatric disorders are prominent. More towards the middle, we also see many lifestyle-related factors. These factors are often studied in relation to mental health, cardiovascular diseases, infectious diseases, oncology and public health. They are pulled towards different sides of the entire research spectrum and therefore are displayed in the middle of the figure.

On the bottom left in purple, public health research is indicated (quality of life and care, work-related illnesses, primary care and cost-effectiveness research).

Cardiovascular research is visible in green, ranging from very specialized treatments to broad cardiovascular risk studies centrally located in the map.

Some terms in light blue are scattered in the middle. They concern immunological and viral diseases, with both a very fundamental aspect (to the right) and a public health (spreading, prevention and modelling) and behavioral component.

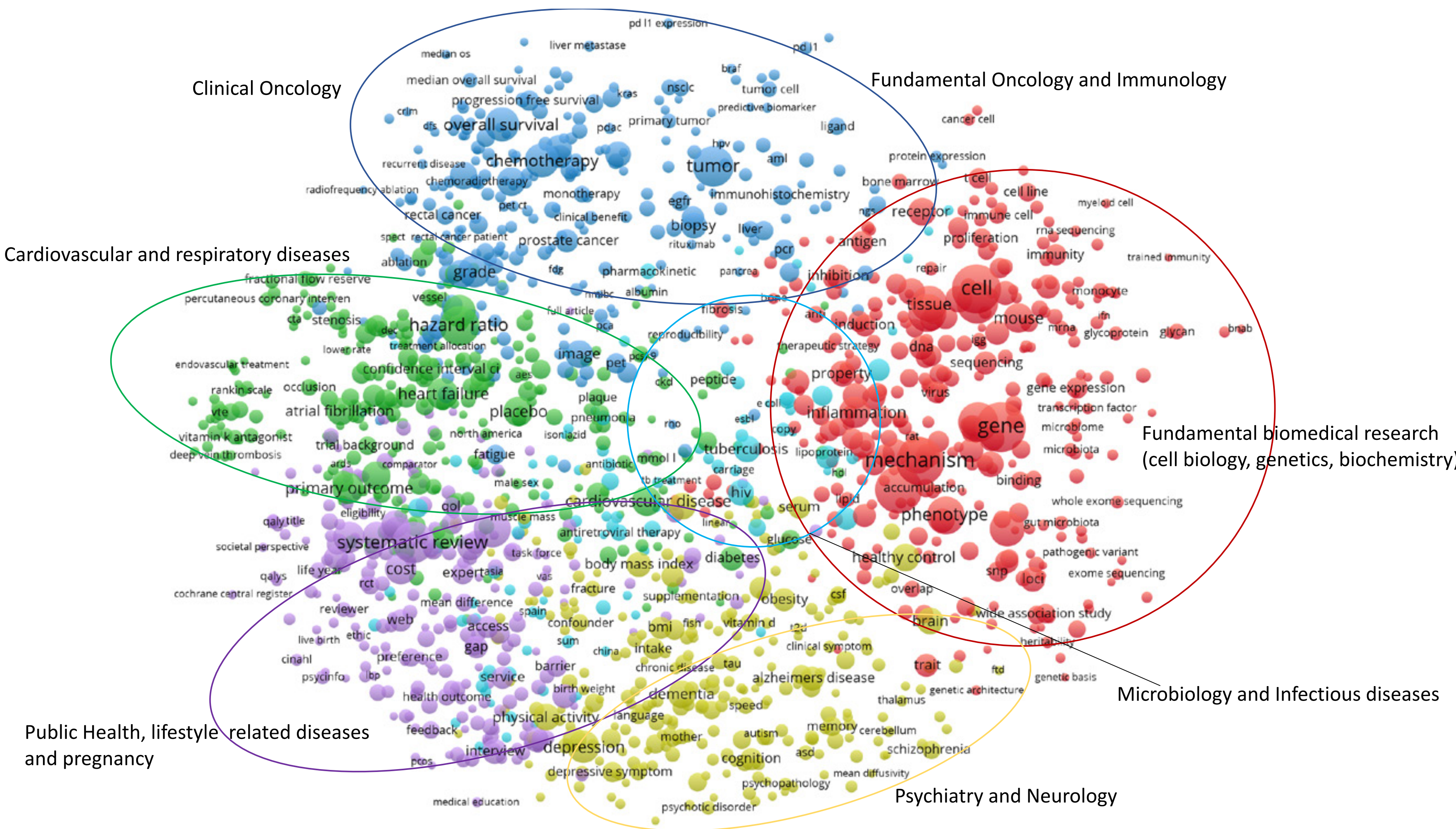


Figure 2

Annotated term map showing broad level of topic activity of the Dutch UMCs in 2018

Figure 2 shows the very broad range of high-impact (bio)medical research that is being performed in the Dutch UMCs. The colors indicate the top research clusters, their impact and relatedness. It is the same map but annotated with the previously identified broad research clusters that describe the UMC research landscape.

2.1 UMC Research landscape – Top research activity

Apart from the broad research clusters identified in the previous chapter and indicated in the term map, it is possible to indicate which very specific topics of UMC research are prominent in the international scientific community, both in volume and in citation impact[1]. The tables on the next pages show the 20 most prominent research topics, with a mean normalized citation impact of over 1.5, in which the UMCs jointly published in 2018. The topics are shown for each separate research cluster and ordered by the number of publications. For instance, in the Psychiatry and Neurology research cluster, the majority of publications are in the topic Dementia & Alzheimer's. The UMCs jointly published 184 scientific publications in this field in just one year. This can be identified as one of the absolute strengths of Dutch (bio)medical research. Though there naturally is a relation between the research clusters identified in the previous map, the terms and labels characterizing the research clusters don't overlap, because the labels are specific to a cluster and not necessarily the most frequently used terms in the publications. Note that this table only shows a very small selection of topics in which the UMCs are active and does not reflect the full scope of UMC research activity.

1 Disclaimer: the subfields are derived from the labels and connected to the research fields by the authors of this study. They are helpful in interpreting the UMC research landscape but they are subject to individual interpretation. We invite and encourage everyone to discuss the interpretation of these analyses with us.

	Research cluster	Topic	Topics described by labels
1	Cardiovascular and Respiratory diseases	Heart failure	Self-care; ivabradine; tolvaptan; sacubitril; valsartan; carvedilol
2	Cardiovascular and Respiratory diseases	Heart imaging	Image quality; coronary artery calcium; coronary CT angiography; tomography; radiation dose
3	Cardiovascular and Respiratory diseases	Venous thrombosis/Stroke/ anti-coagulant	Warfarin; stroke prevention; direct oral anticoagulant; venous thromboembolism; rivaroxaban
4	Cardiovascular and Respiratory diseases	Pulmonary embolism	Acute pulmonary embolism; inferior vena cava filter; venous thromboembolism prophylaxis; tomography; CT pulmonary angiography
5	Cardiovascular and Respiratory diseases	Treatment of thrombosis	Intravenous thrombolysis; mechanical thrombectomy; large vessel occlusion; stroke incidence

	Research cluster	Topic	Topics described by labels
1	Clinical Oncology	Immune therapy	Nivolumab; pd l1; pd l1 expression; pembrolizumab; immune checkpoint inhibitor
2	Clinical Oncology	Prostate Cancer	Prostate biopsy; active surveillance; laparoscopic radical prostatectomy; robot; prostate brachytherapy
3	Clinical Oncology	Advanced rectal cancer	Transanal endoscopic microsurgery; advanced rectal cancer; preoperative chemoradiotherapy; local excision; neoadjuvant chemoradiation
4	Clinical Oncology	Pancreatic cancer	Distal pancreatectomy; advanced pancreatic cancer; pancreatic ductal adenocarcinoma; solid pseudopapillary tumor; intraductal papillary mucinous neoplasm
5	Clinical Oncology	Glioma	Glioblastoma; high-grade glioma; gliomas; malignant glioma; central neurocytoma

	Research cluster	Topic	Topics described by labels
1	Fundamental biomedical research (cell biology, genetics, biochemistry)	Chromosomal location of disease genes/Gene mapping	Linkage analysis; chromosome; method; complex disease; power
2	Fundamental biomedical research (cell biology, genetics, biochemistry)	Next generation sequencing	Assembly; next generation sequencing; RNA seq data; annotation; genome
3	Fundamental biomedical research (cell biology, genetics, biochemistry)	Tumor suppressor, epigenetics	Hydroxymethyl cytosine; promoter hypermethylation; rassf1a; DNA methyltransferase; line
4	Fundamental biomedical research (cell biology, genetics, biochemistry)	Extracellular particles	Microparticle; extracellular vesicle; exosome; exosomes derived; vesicle
5	Fundamental biomedical research (cell biology, genetics, biochemistry)	Stem cells	Pluripotency; mouse embryonic stem cell; human pluripotent stem cell

	Research cluster	Topic	Topics described by labels
1	Microbiology and Infectious diseases	Tuberculosis	Drug-resistant tuberculosis; South Africa; interferon gamma release assay; quantiferon tb gold; tuberculin skin test
2	Microbiology and Infectious diseases	Invasive fungal infection	Invasive aspergillosis; candidemia; invasive fungal infection; candida species; mucormycosis
3	Microbiology and Infectious diseases	HIV	Antiretroviral therapy adherence; HIV stigma; HIV care; adherence; late presentation
4	Microbiology and Infectious diseases	CMV	Neutralizing antibody; T cell response; cytomegalovirus retinitis; immunogenicity; vaccine
5	Microbiology and Infectious diseases	Pneumococcal disease	Invasive pneumococcal disease; streptococcus pneumoniae; valent pneumococcal conjugate vaccine; acute otitis medium; pneumococcal vaccination

	Research cluster	Topic	Topics described by labels
1	Psychiatry & Neurosciences	Dementia & Alzheimer's	Lewy body; mini mental state examination; normative data; education; validity
2	Psychiatry & Neurosciences	Schizophrenia	Untreated psychosis; auditory hallucination; delusion schizotypy; paranoia
3	Psychiatry & Neurosciences	Multiple sclerosis	Multiple sclerosis; neuromyelitis optica; effect; interferon beta; fatigue
4	Psychiatry & Neurosciences	Depression	Unexplained symptom; late life depression; mirtazapine; treatment resistant depression; somatoform disorder
5	Psychiatry & Neurosciences	Hypoxic brain injury in neonatals	Hypoxic ischemic encephalopathy; therapeutic hypothermia; hypothermia; perinatal asphyxia; neonatal seizure

	Research cluster	Topic	Topics described by labels
1	Public Health, lifestyle-related diseases and pregnancy	Prevention by increasing physical fitness/physical activity	Sedentary time; pedometer; cardiorespiratory fitness; physical fitness; accelerometer
2	Public Health, lifestyle-related diseases and pregnancy	Relation diabetes and microbiome	Gut microbiome; obesity; diabetes; dysbiosis
3	Public Health, lifestyle-related diseases and pregnancy	High cholesterol medication	Statin use; primary care; rhabdomyolysis; pcsk9; evolocumab
4	Public Health, lifestyle-related diseases and pregnancy	Pregnancy and low back pain	Spinal manipulation; whiplash; pregnancy; pelvic girdle pain; trunk muscle
5	Public Health, lifestyle-related diseases and pregnancy	eHealth	Mobile health; text messaging; smartphone application; ecological momentary assessment; app

The UMC research landscape clusters and top activity topics illustrate what we like to call our **complementarity in our diversity**. The research performed by the Dutch UMCs covers a very broad range of topics, highlighting the richness and diversity of our national biomedical landscape. While sometimes the individual UMCs may be active in the same general research fields, we specialize in topics that very often complement each other. On these specific topics we collaborate to create mass and impact in the international scientific world, and to optimize translation of our findings into clinical care.

2.2 UMC research landscape – Open Access to publications

In line with the previous visualization, Figure 3 uses a color overlay to show the relative percentage of open access of publications on the different topics of UMC (bio)medical research in 2018. Yellow is the most open and blue, the least open.

The map shows that fundamental research (right side) is more often published open access than clinical research (top and bottom left). Also, a lot of public health research with direct societal implications is published open access (left of middle and center). An explanation for the high percentage of open access of fundamental research is that it is common in these research communities to deposit papers in public databases such as bioRxiv or pubmed central. Apart from that, more and more funding agencies stimulate or require open access to publications funded by them. In the clinical sciences a considerable part of the research is co-funded by industry, often without the incentive to publish open access, so this could explain the lower percentage of open access in these fields. Finally, a lot of effort has been put into negotiating open access deals with a large share of academic publishers, which has led to more open access to publications in recent years and will continue to do so in the future.

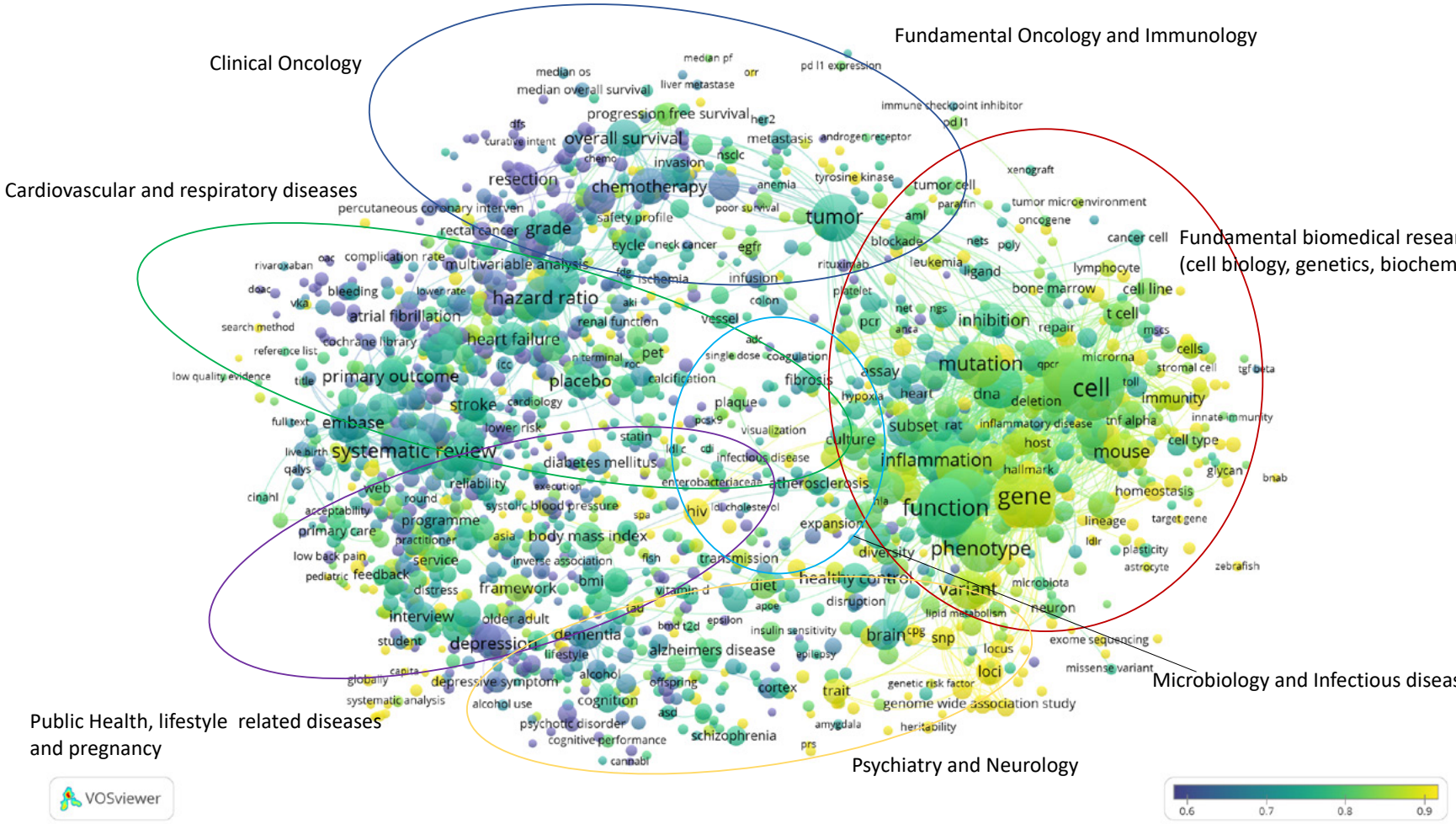


Figure 3

Term map of UMC publications in 2018, colors indicating relative open access of publications

It is our national mission to provide open access to as many scientific publications as possible, and especially to government-funded research. In total, 70% of all UMC publications in 2018 was published open access, which is above the national average. Table 1 and Figure 4 show the development of open access publications of the Dutch UMCs over time, and for the different types of open access. The totals of the different categories don't add up because Green open access regularly overlaps with the other types of open access publishing.

Open Access status	2013	2014	2015	2016	2017	2018
Closed	7447	7481	7556	6379	5683	5375
Open Access	7197	7590	9239	10740	11399	12794
Gold	2153	2427	2937	3223	3544	4032
Green	6116	6546	7931	8780	9156	10714
Hybrid	1039	1136	1700	2648	3062	3916
Bronze	2162	2172	2612	2972	2829	2680

Table 1
Development of OA publishing by all Dutch UMCs combined, 2013–2018, absolute number of publications

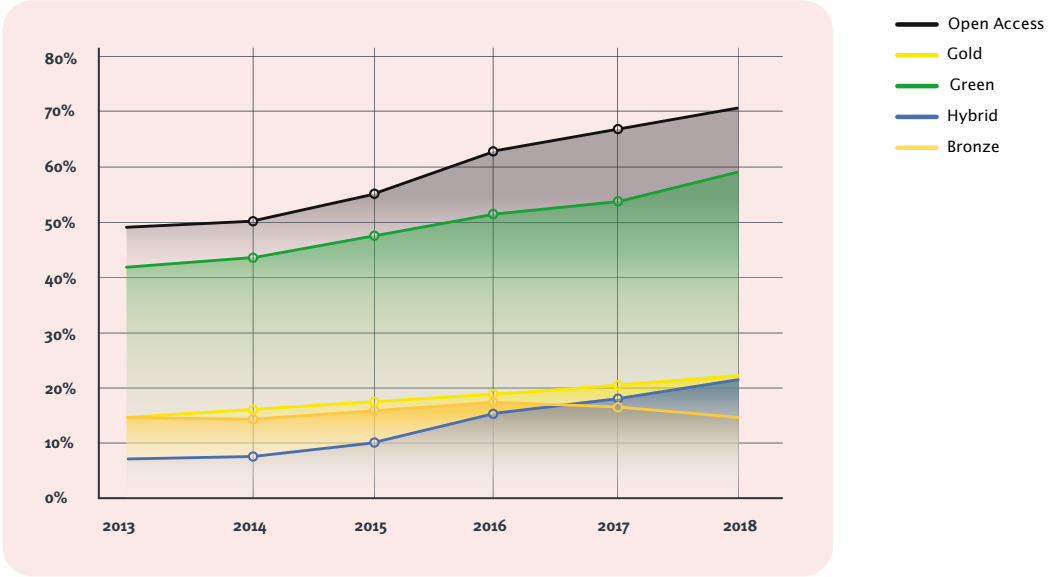


Figure 4
Relative development of OA publishing by all Dutch UMCs combined, 2013-2018

2.3 UMC research landscape – Societal impact

The following term maps (Figures 5, 6 and 7) use the same layout as before, but now the color scale indicates the uptake of UMC research publications in several societally relevant sources:

1. **(clinical) guidelines**: the translation of research into standard treatment procedures among medical practitioners;
2. **policy documents**: government documents concerning health and medicine, both national and international, and their evidence of the influence of UMC research on government strategy;
3. **news media**: an indication of topics covered in newspapers, television, radio and digital media and their evidence of the direct influence of UMC research on societal knowledge and awareness.

The color scale indicates the relative uptake of publications on a certain topic in the different societally relevant sources. For instance, UMC publications in the domains of public health, cardiovascular diseases, surgery and oncology find their way into (clinical) guidelines relatively often, optimizing treatment procedures based on experience, expertise and comprehensive research. Fundamental research directly translates into guidelines less often but forms the basis of understanding processes on a cellular and molecular level. Ultimately, this knowledge is of key importance for the translation to clinical practice and influences guidelines, although indirectly.

The same can roughly be said for uptake in policy documents, but here we see that across the entire map, there are more topics addressed by publications that find their way into policy documents. In fundamental research policy on lab standards, animal research and the ethics of genetics are very important, explaining the uptake of publications in policy documents in these areas. The map with the uptake of UMC publications in news media shows significant attention being paid to a lot of research topics across the entire map. In particular, research on public health, psychiatry and neurology, genetics, infectious diseases, cardiovascular diseases and lifestyle-related factors is generously covered in news media. Many of these diseases impact a large proportion of our society at some point in their lives. The research in the Dutch UMCs is aimed at solving the most complex puzzles that are fundamental in the origin of many diseases, treating them, and preventing them in the future. Communicating about our breakthroughs is anchored in our mission. This is demonstrated by the extensive coverage of our research results in the news media.

This chapter illustrates our stance towards ***practising open science*** and stimulating societal impact. It is our national mission to strive towards a high level of open access to our scientific publications. The Dutch UMCs have taken this message to heart, as already 70% of all our research papers can be accessed openly and freely by anyone. We believe that researchers around the world, health care practitioners and the general public should directly benefit from our research, especially if it is government-funded. Society should be able to reapply this knowledge in their own research or practice in order to speed up developments in medical research and health care.

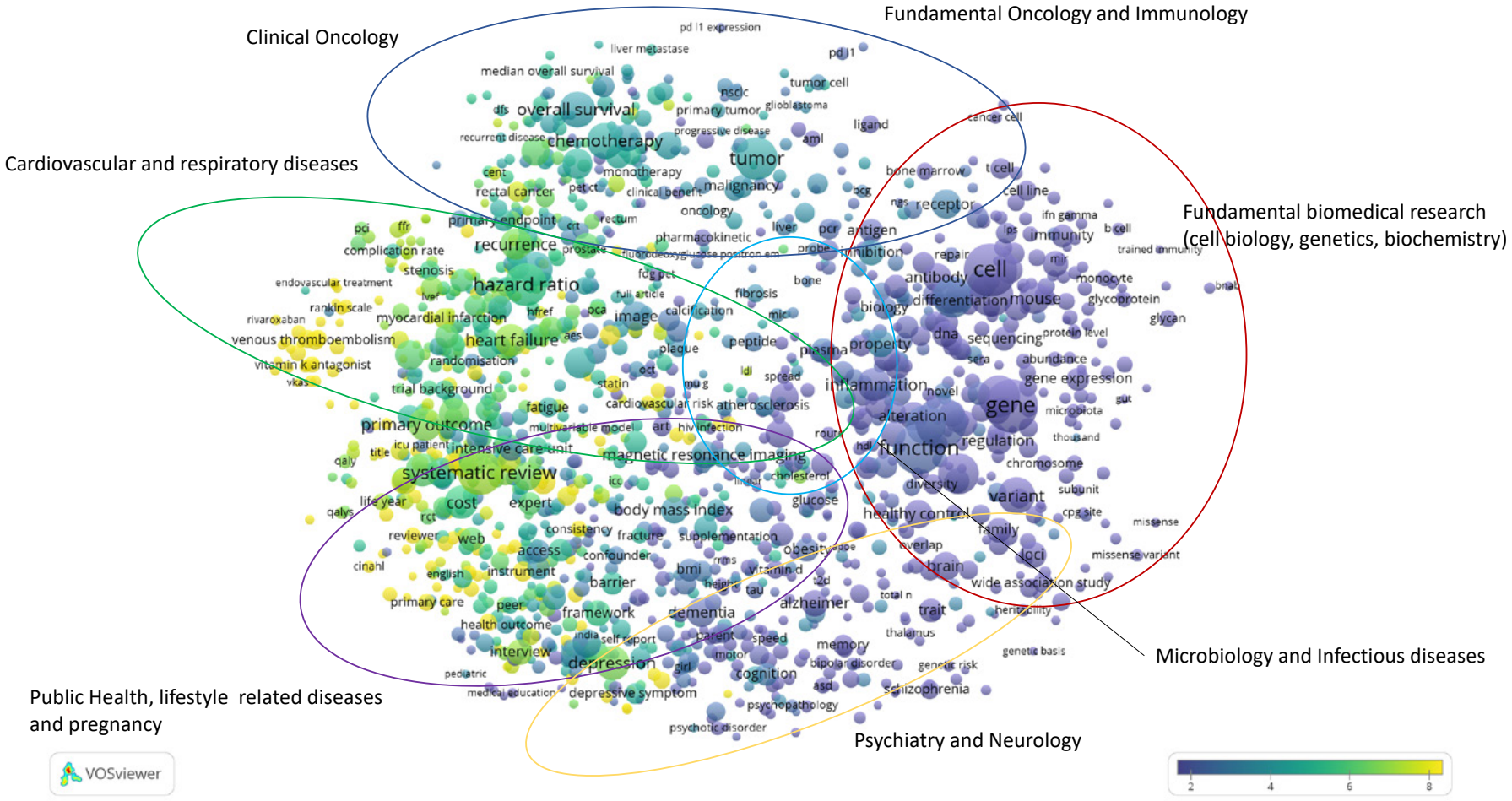


Figure 5

Term map showing relative uptake of UMC publications from 2018 in guidelines

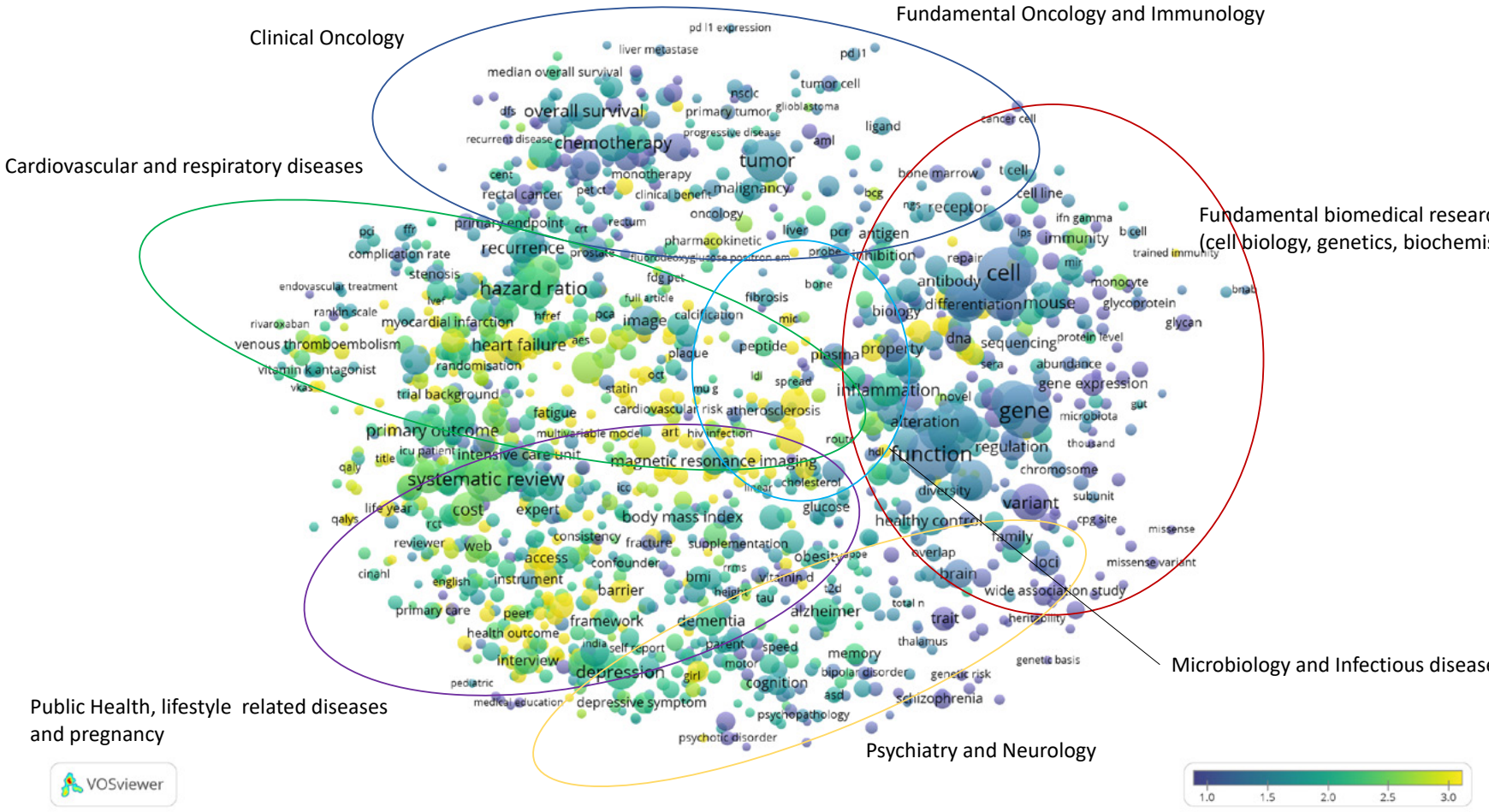


Figure 6

Term map showing relative uptake of UMC publications from 2018 in policy documents

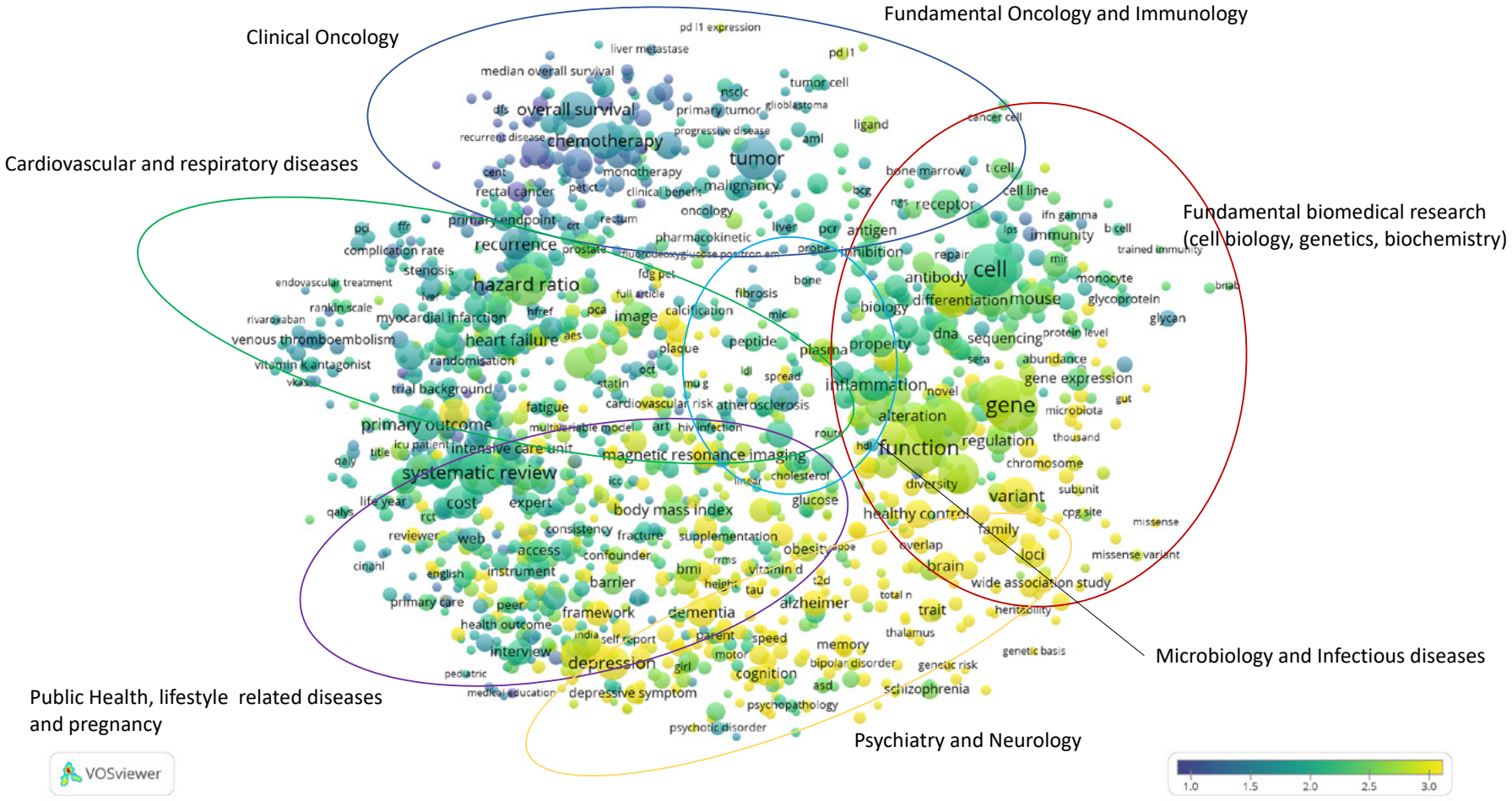
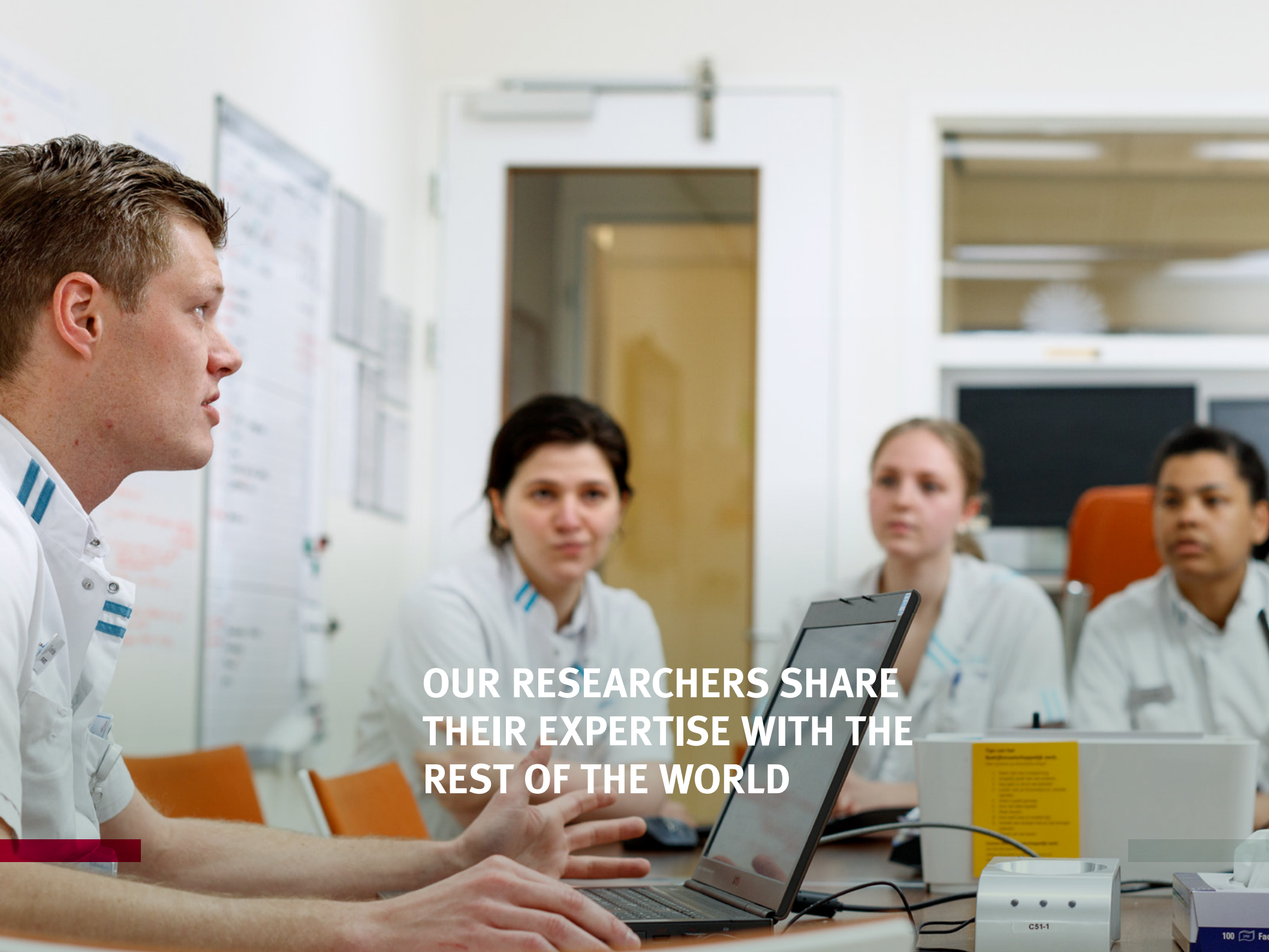


FIGURE 7

Term map showing relative uptake of UMC publications from 2018 in news media


OUR RESEARCHERS SHARE
THEIR EXPERTISE WITH THE
REST OF THE WORLD

3 UMC collaborative networks

The Dutch UMCs have extensive research networks, collaborating with many top institutions nationally and internationally. These collaborations are essential to share knowledge and expertise. They allow the researchers to compare their results in different countries, across different populations, thereby utilizing the full power of all available techniques in the most efficient way. Our researchers share their expertise with the rest of the world, but they also bring knowledge through their networks back to the Netherlands and translate this into scientific breakthroughs and clinical improvements on a national level. The UMCs, their researchers and medical specialists are the central node in national and regional health research. This is also demonstrated by the many national and regional collaborations in research shown in the maps below.

For all UMCs two maps were generated showing:

1. the international (academic) collaboration network of all individual UMCs (Figures 8a-g)
2. the national non-university network of all individual UMCs (Figures 9a-g).

These maps are based only on joint scientific publications with international academic institutions and national non-university partners.

Each individual UMC in these maps is the centralized sphere, because the publications of this UMC are the starting point of all collaborations. The size of the other spheres is an indication of the number of co-publications that the UMC has with the other institution. Institutes of the same color and in close proximity to one another often co-publish with the UMC in the same publications.

Collaborations on scientific publications with clinicians from regional hospitals demonstrate knowledge transfer and the sharing of expertise and research infrastructures in both directions. Sometimes clinical experts in regional hospitals are also employed part-time at UMCs for this purpose or are even appointed as professors by special appointment to improve and facilitate this transfer of knowledge to their patients.

Finally, Figure 10 shows the close and intense collaborations between the different UMCs in 2018.

Amsterdam UMC

BE - Katholieke Universiteit Leuven
GB - University College London
US - Harvard University
SE - Karolinska Institutet
CA - University of Toronto
GB - Imperial College London
FR - French Institute of Health and Medical Research (INSERM)
GB - University of Oxford
BE - Ghent University
DE - Heidelberg University

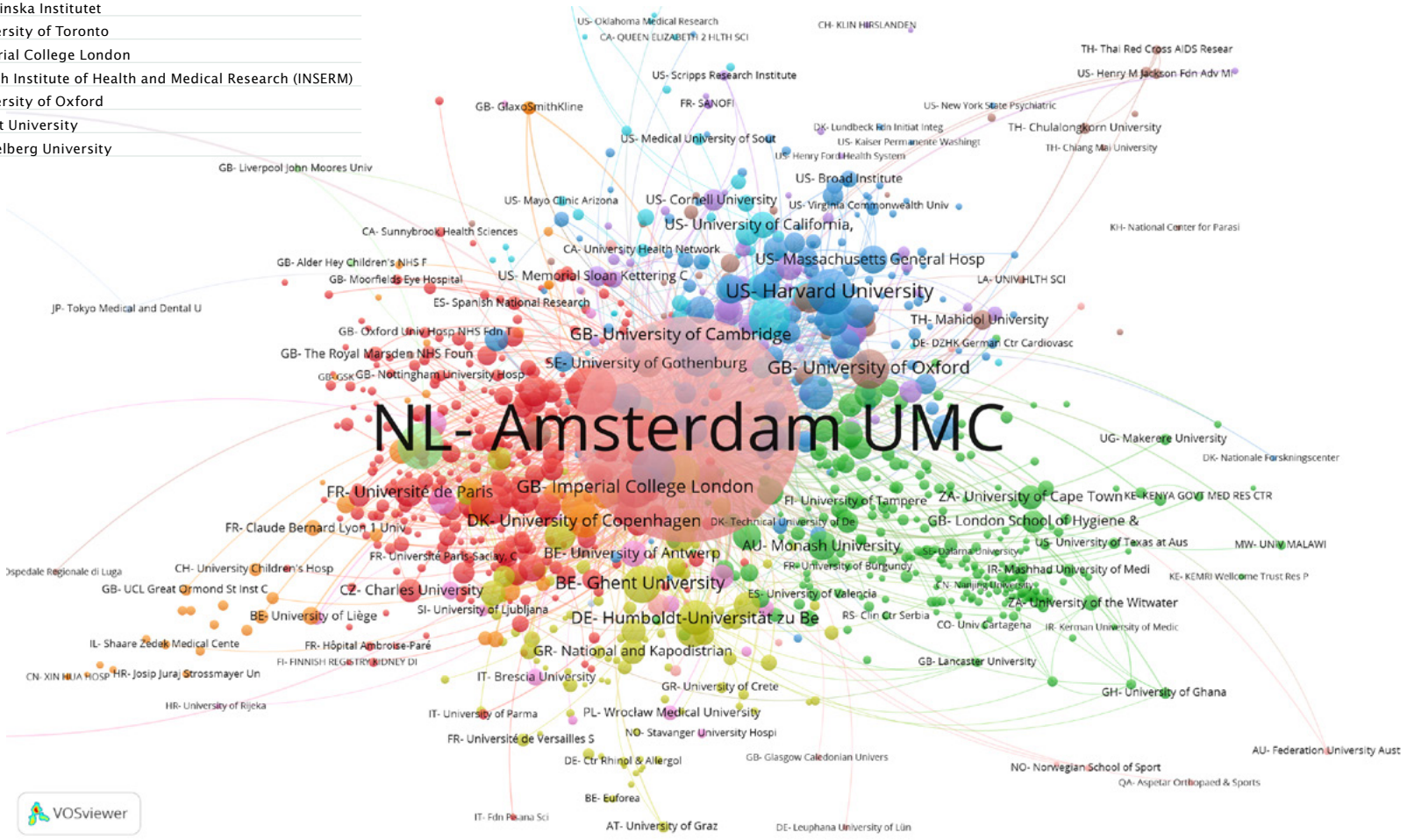


Figure 8a

Collaboration map showing the most important collaborators on scientific publications of Amsterdam UMC in 2013–2018. In the table the top 10 international collaborators.

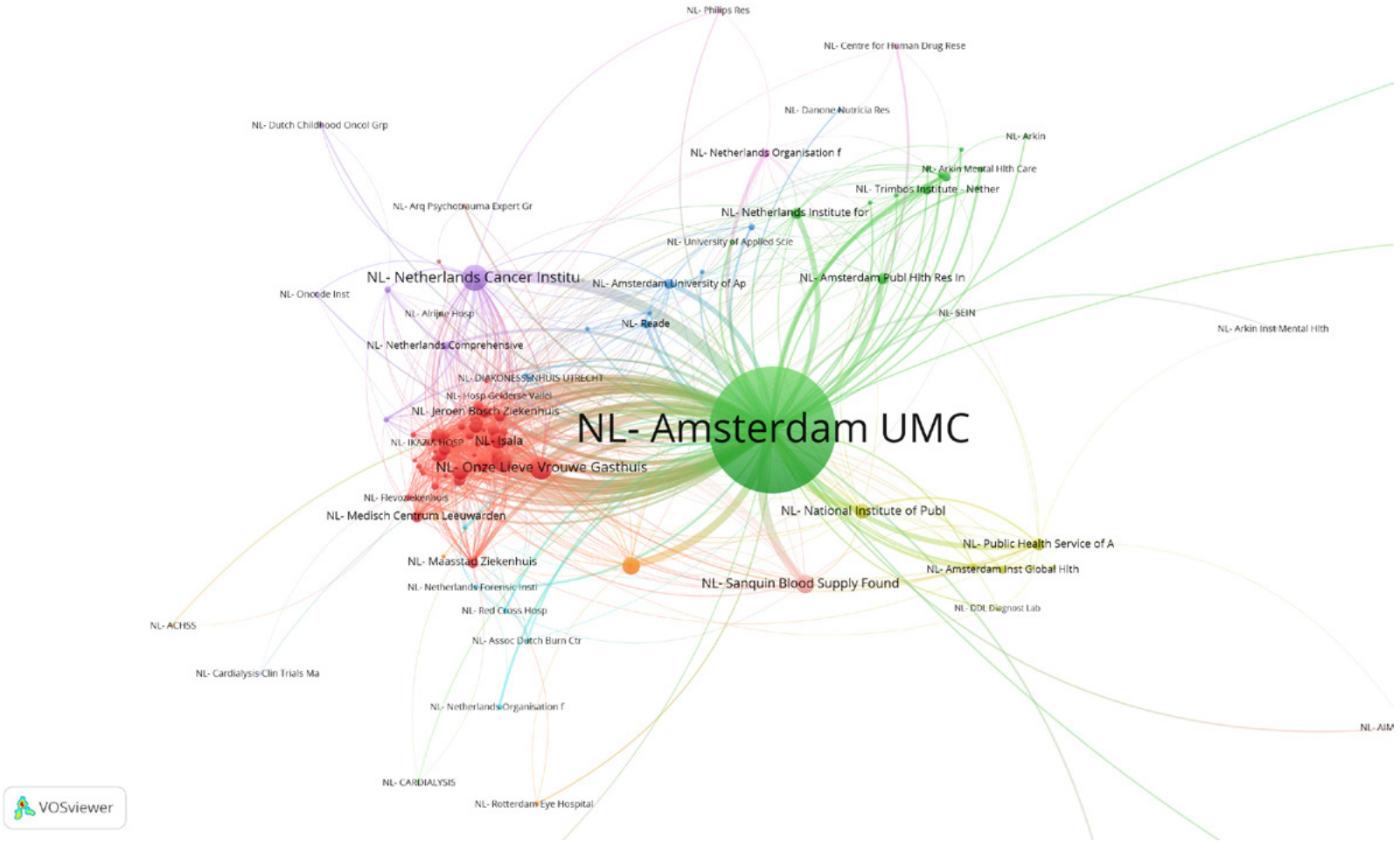


Figure 9a

Collaboration map showing collaborations with national non-university partners on scientific publications of Amsterdam UMC in 2013–2018

UMCG

US - Harvard University
SE - Karolinska Institutet
BE - Katholieke Universiteit Leuven
GB - Imperial College London
GB - University of Oxford
GB - University College London
DE - Heidelberg University
GB - King's College London
FR - French Institute of Health and Medical Research (INSERM)
US - Johns Hopkins University

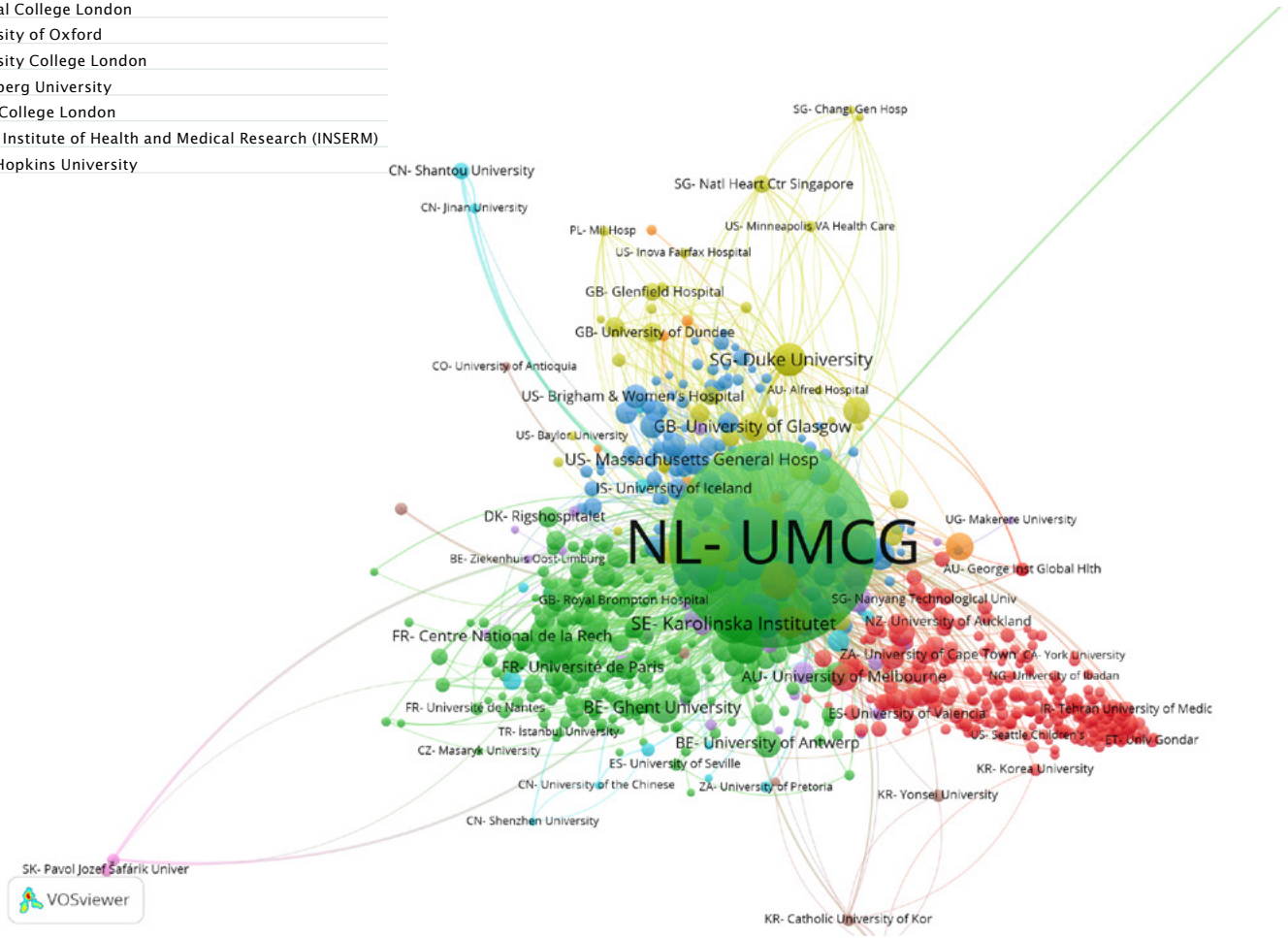


Figure 8b

Collaboration map showing the most important collaborators on scientific publications of UMCG in 2013–2018. In the table the top 10 international collaborators.

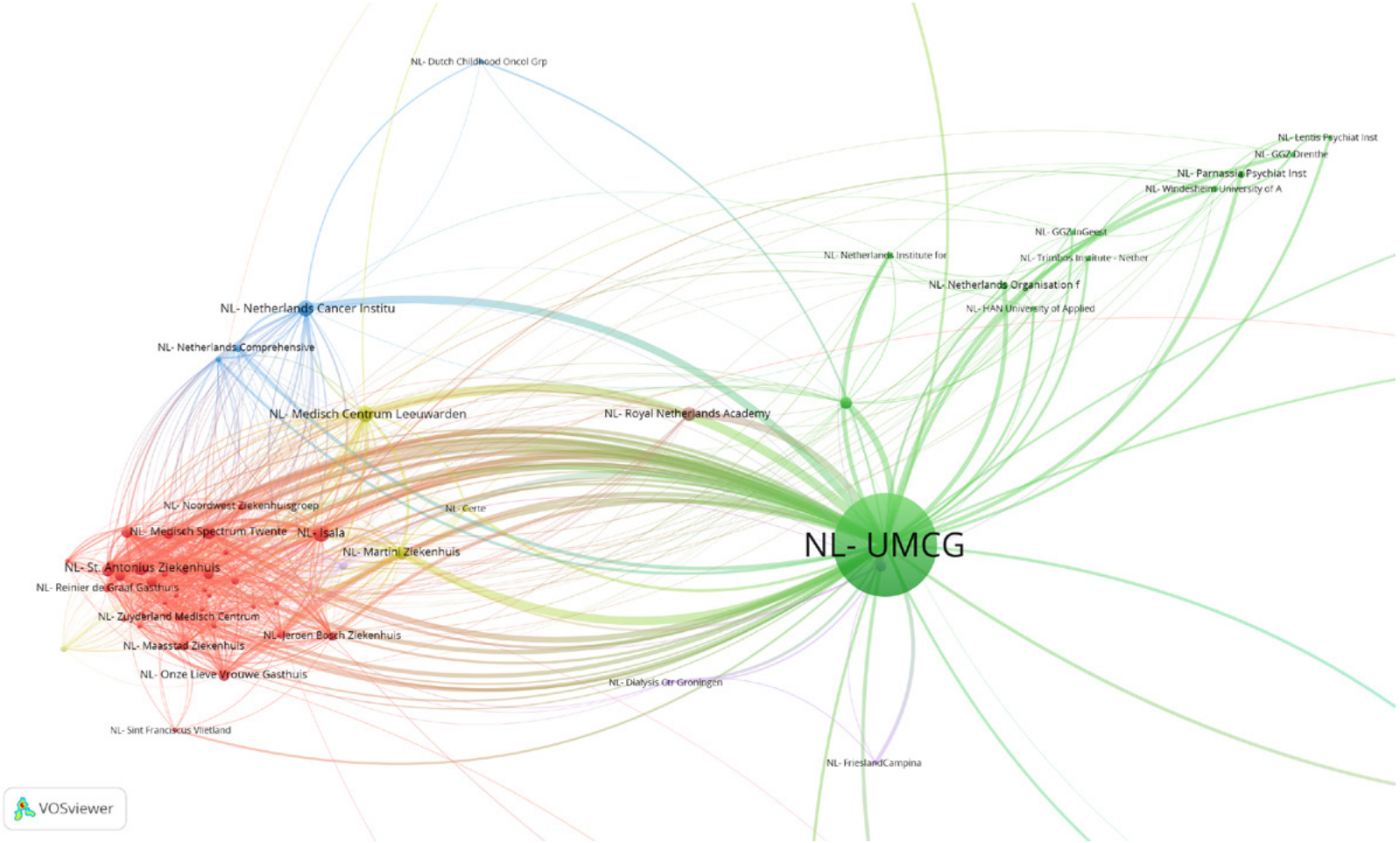


Figure 9b

Collaboration map showing collaborations with national non-university partners on scientific publications of UMCG in 2013–2018

LUMC

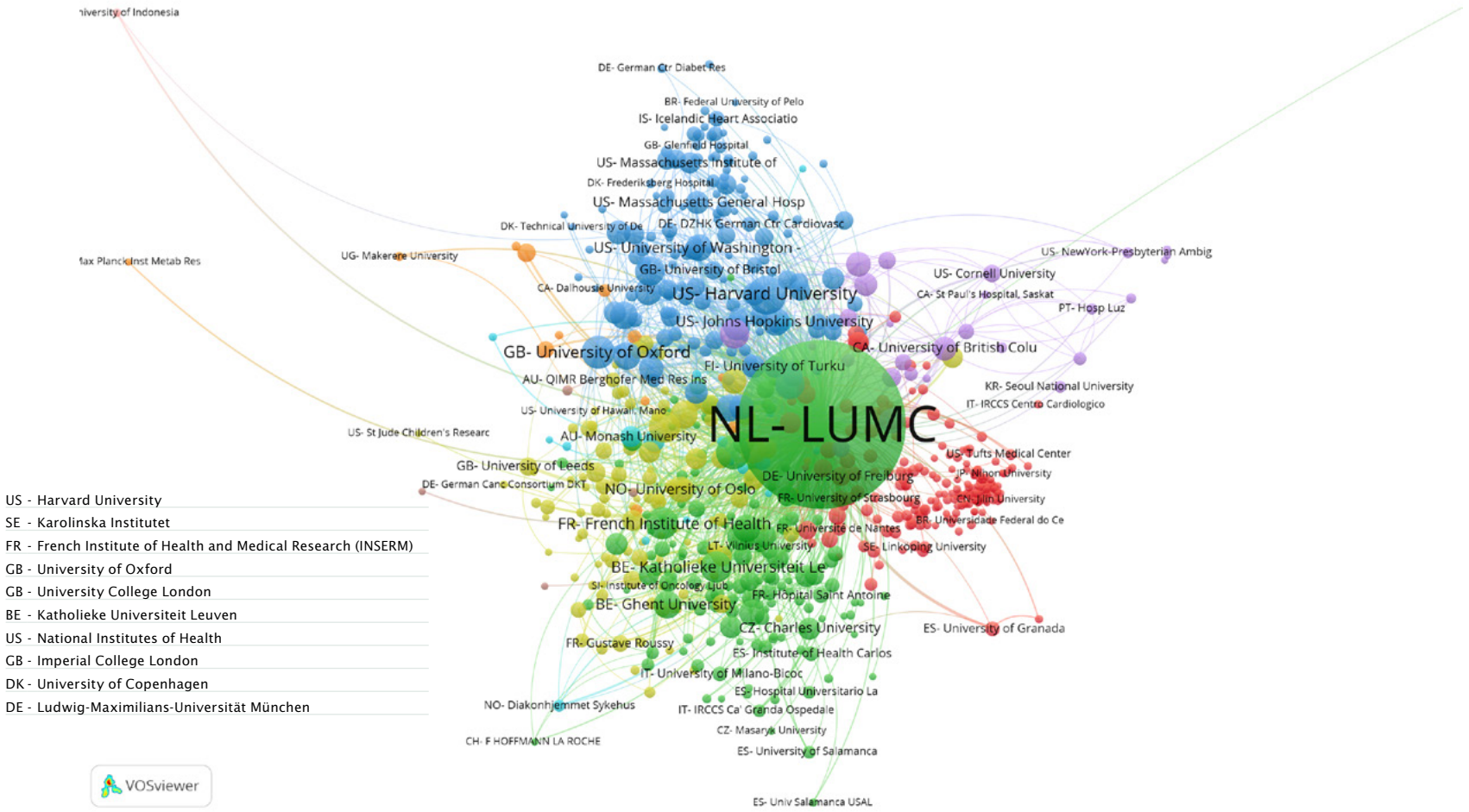


Figure 8c

Collaboration map showing the most important collaborators on scientific publications of LUMC in 2013–2018. In the table the top 10 international collaborators.

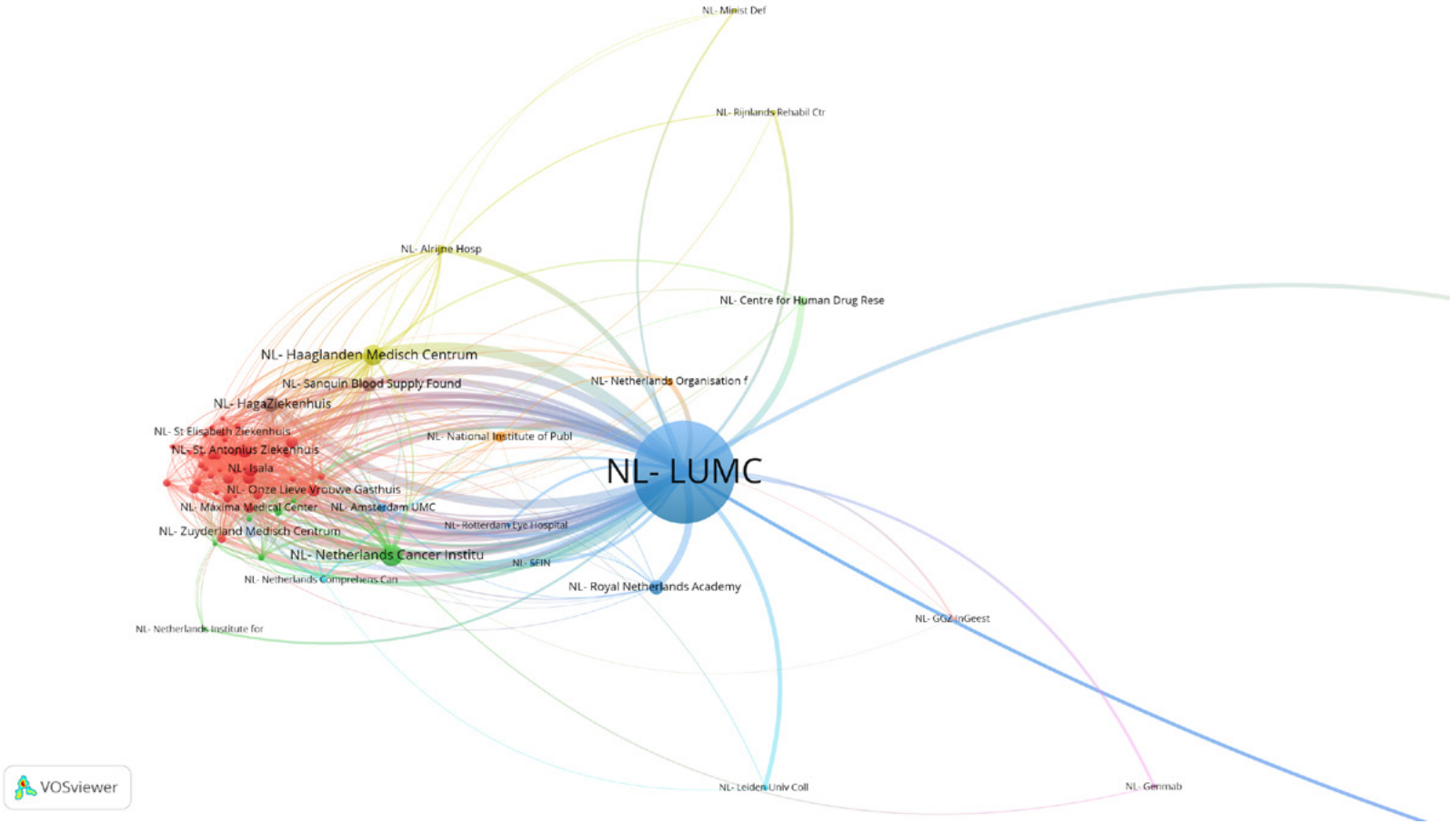


Figure 9c

Collaboration map showing collaborations with national non-university partners on scientific publications of LUMC in 2013–2018

Maastricht UMC+

BE - Katholieke Universiteit Leuven
DE - RWTH Aachen University
GB - King's College London
US - Harvard University
SE - Karolinska Institutet
FR - French Institute of Health and Medical Research (INSERM)
GB - University College London
BE - Hasselt University
BE - Ghent University
DE - Ludwig-Maximilians-Universität München

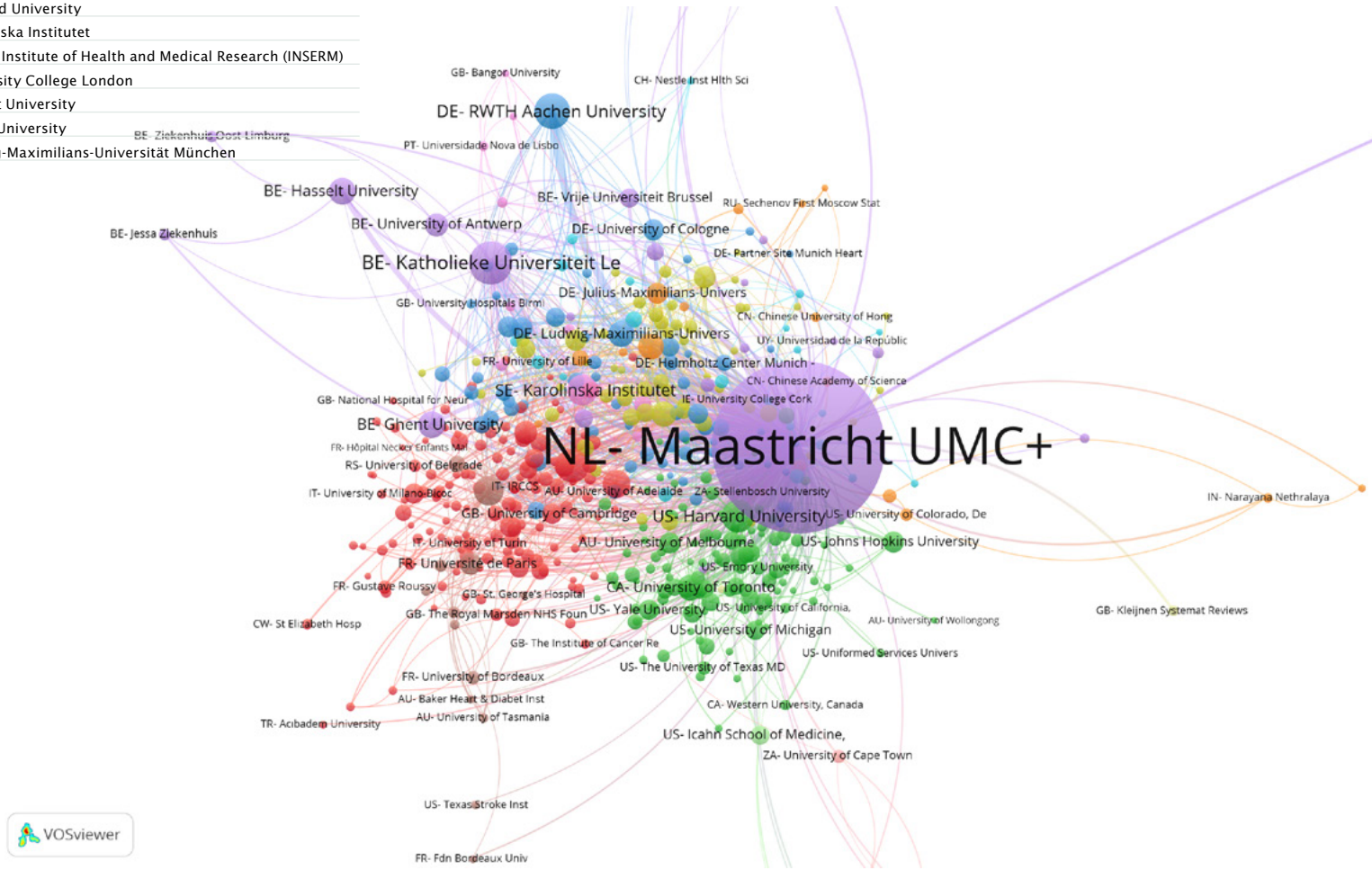


Figure 8d

Collaboration map showing the most important collaborators on scientific publications of Maastricht UMC+ in 2013–2018. In the table the top 10 international collaborators.

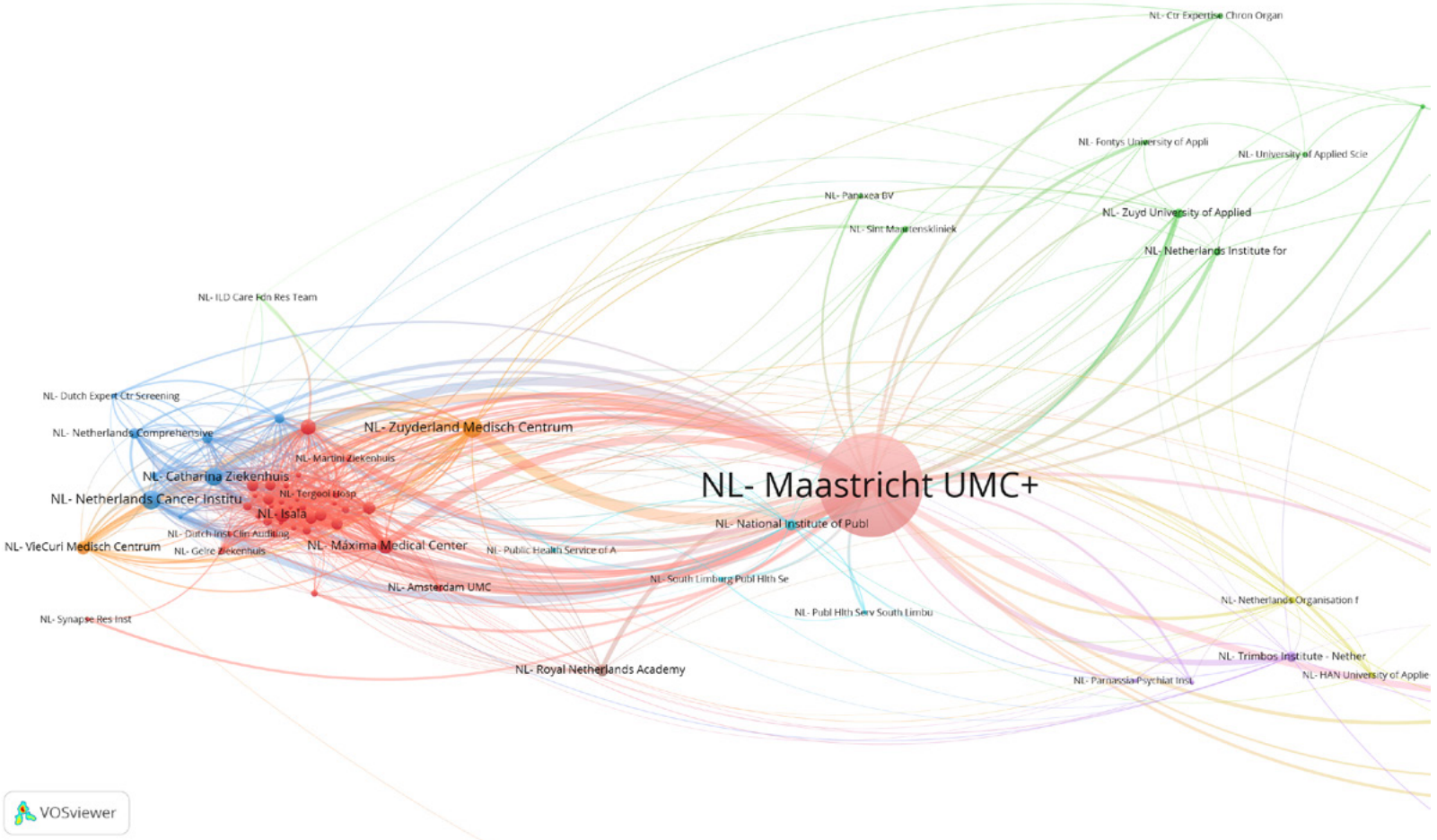


Figure 9d

Collaboration map showing collaborations with national non-university partners on scientific publications of Maastricht UMC+ in 2013–2018

Radboudumc

US - Harvard University
BE - Katholieke Universiteit Leuven
SE - Karolinska Institutet
FR - French Institute of Health and Medical Research (INSERM)
GB - University College London
DE - Heidelberg University
CA - University of Toronto
GB - University of Oxford
BE - Ghent University
US - National Institutes of Health

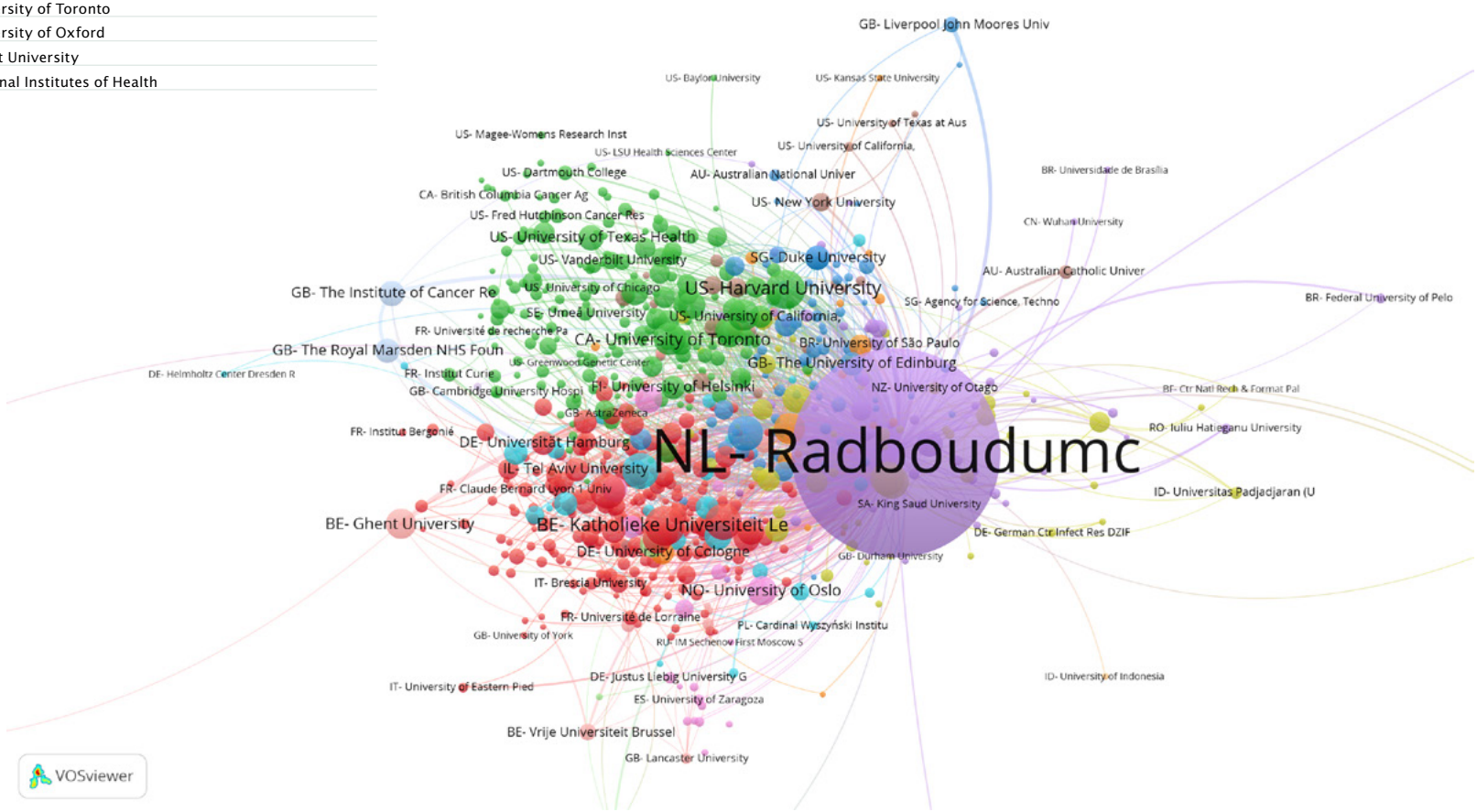


Figure 8e

Collaboration map showing the most important collaborators on scientific publications of Radboudumc in 2013–2018. In the table the top 10 international collaborators.

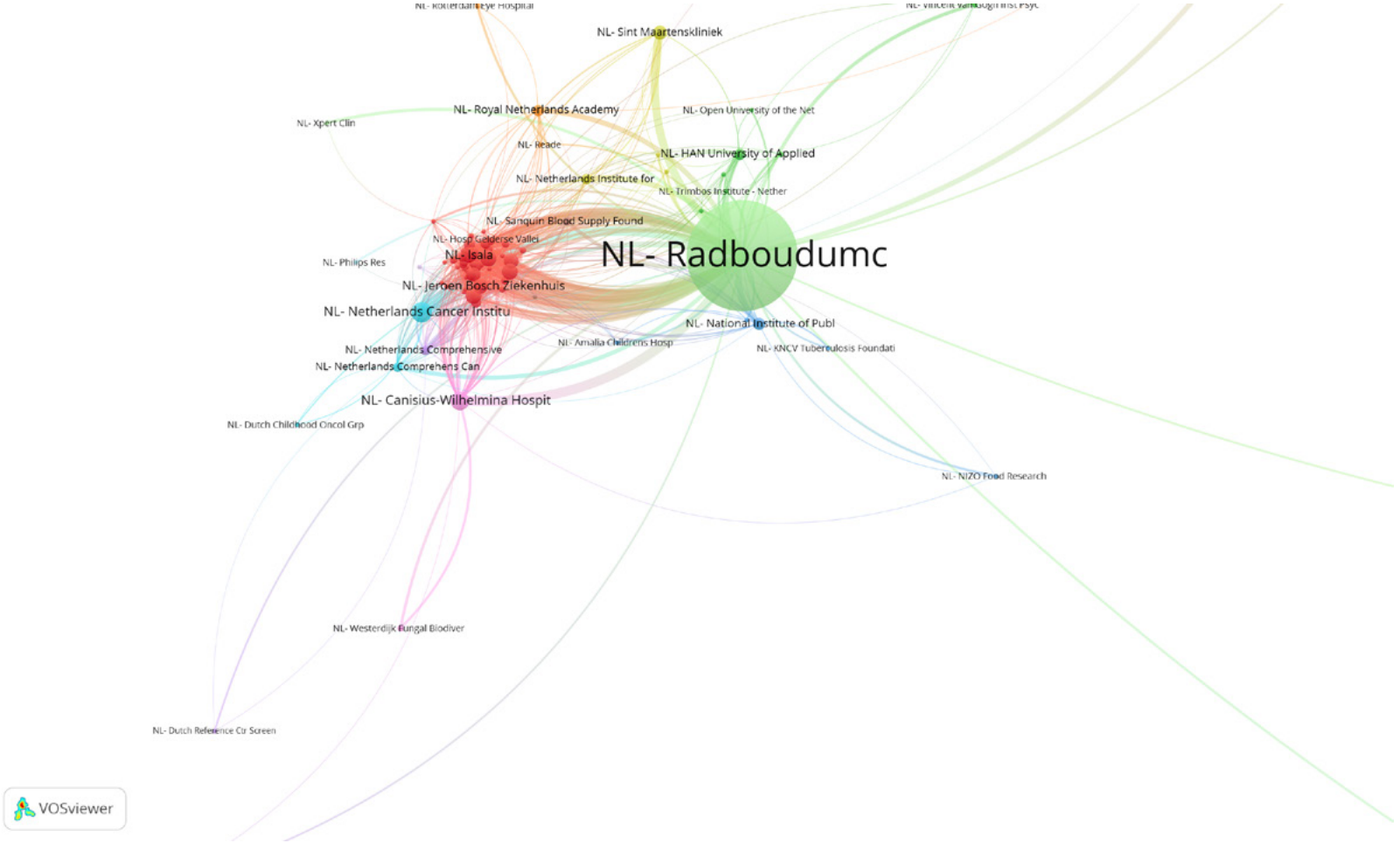


Figure 9e

Collaboration map showing collaborations with national non-university partners on scientific publications of Radboudumc in 2013–2018

Erasmus MC

US - Harvard University
BE - Katholieke Universiteit Leuven
GB - Imperial College London
GB - University College London
SE - Karolinska Institutet
US - National Institutes of Health
FR - French Institute of Health and Medical Research (INSERM)
CA - University of Toronto
BE - Ghent University
DE - Heidelberg University

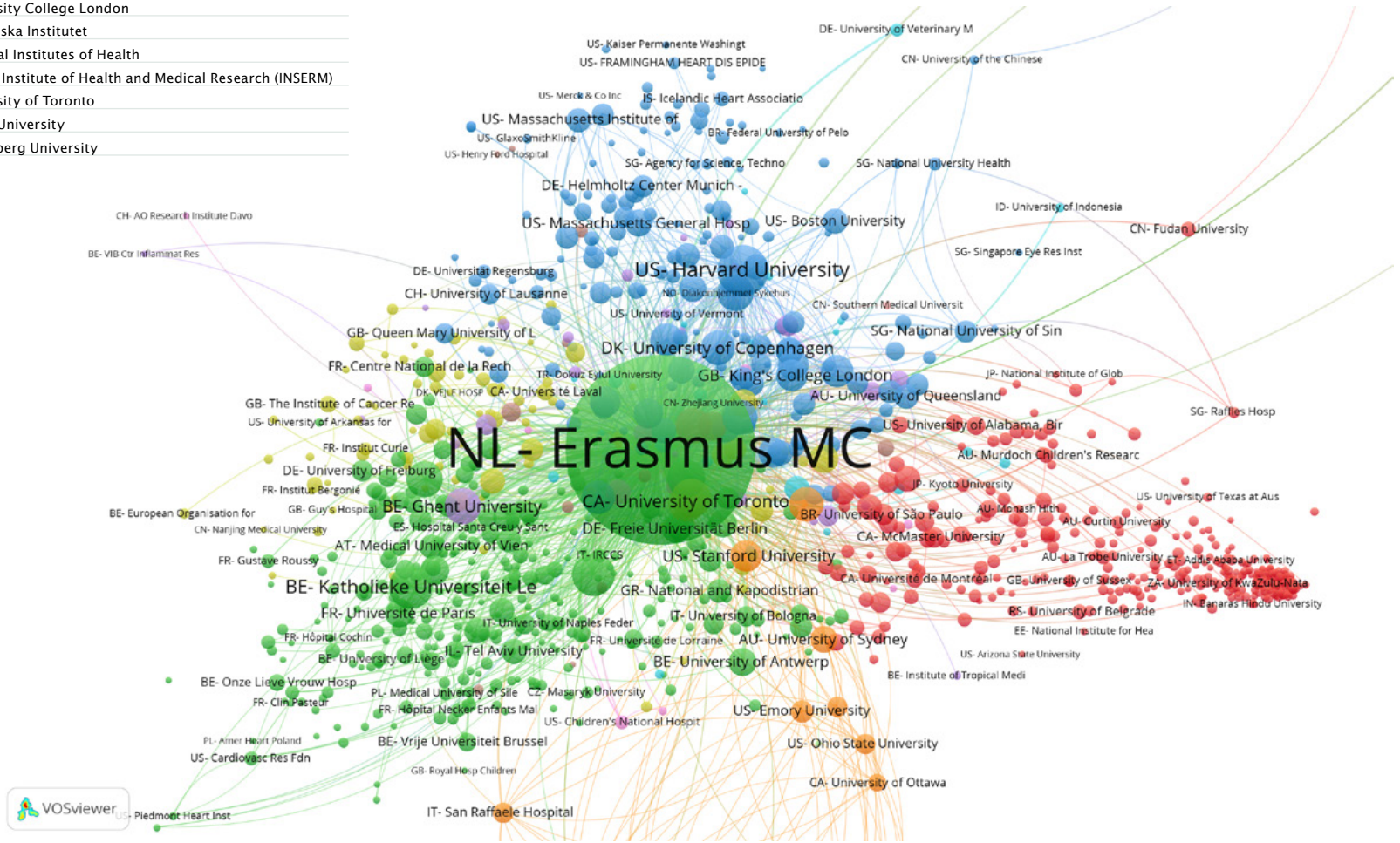


Figure 8f

Collaboration map showing the most important collaborators on scientific publications of Erasmus MC in 2013–2018. In the table the top 10 international collaborators.

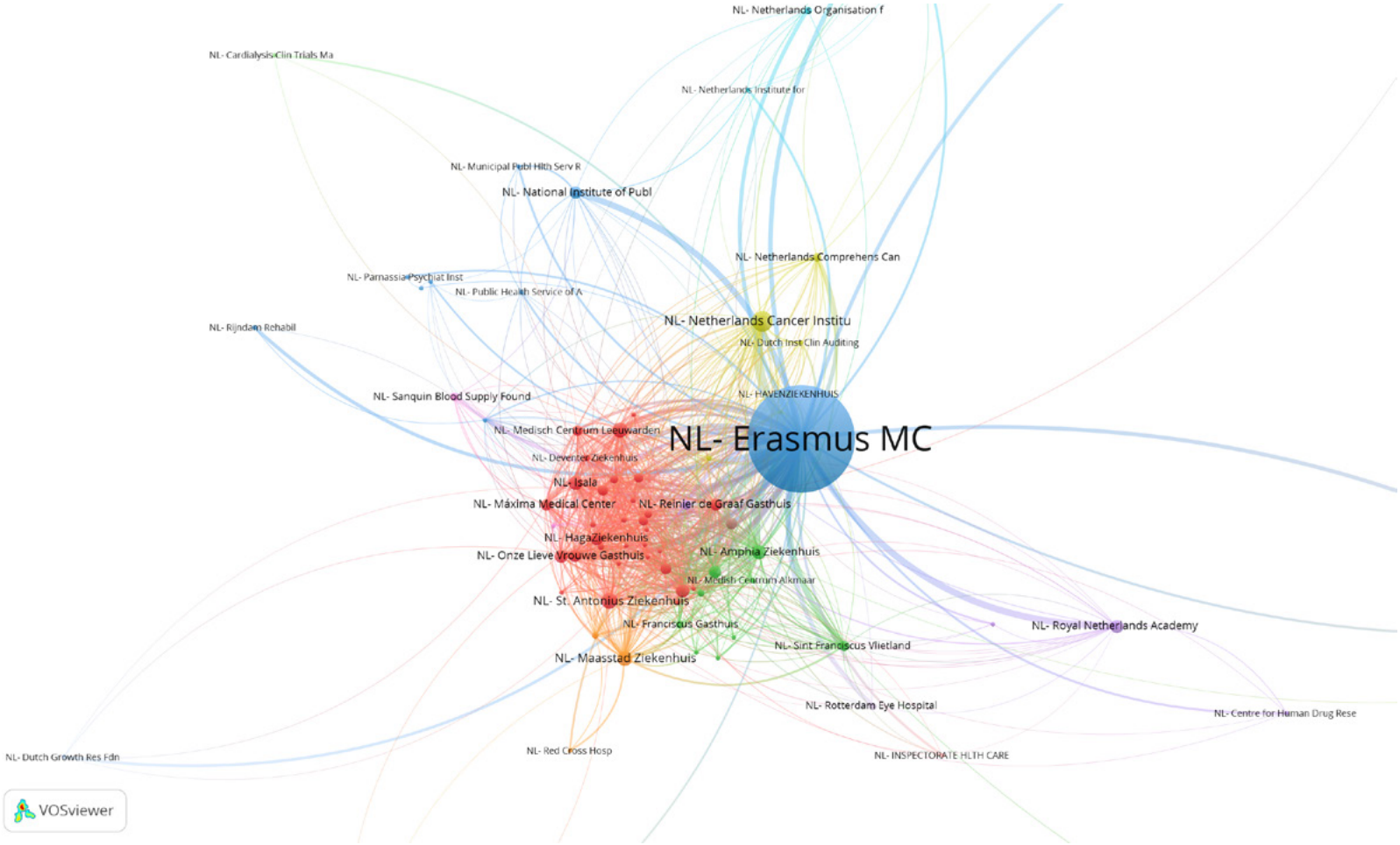


Figure 9f

Collaboration map showing collaborations with national non-university partners on scientific publications of Erasmus MC in 2013–2018

UMC Utrecht

GB - University College London
US - Harvard University
GB - University of Oxford
SE - Karolinska Institutet
GB - Imperial College London
FR - French Institute of Health and Medical Research (INSERM)
GB - King's College London
BE - Katholieke Universiteit Leuven
GB - University of Cambridge
CA - University of Toronto

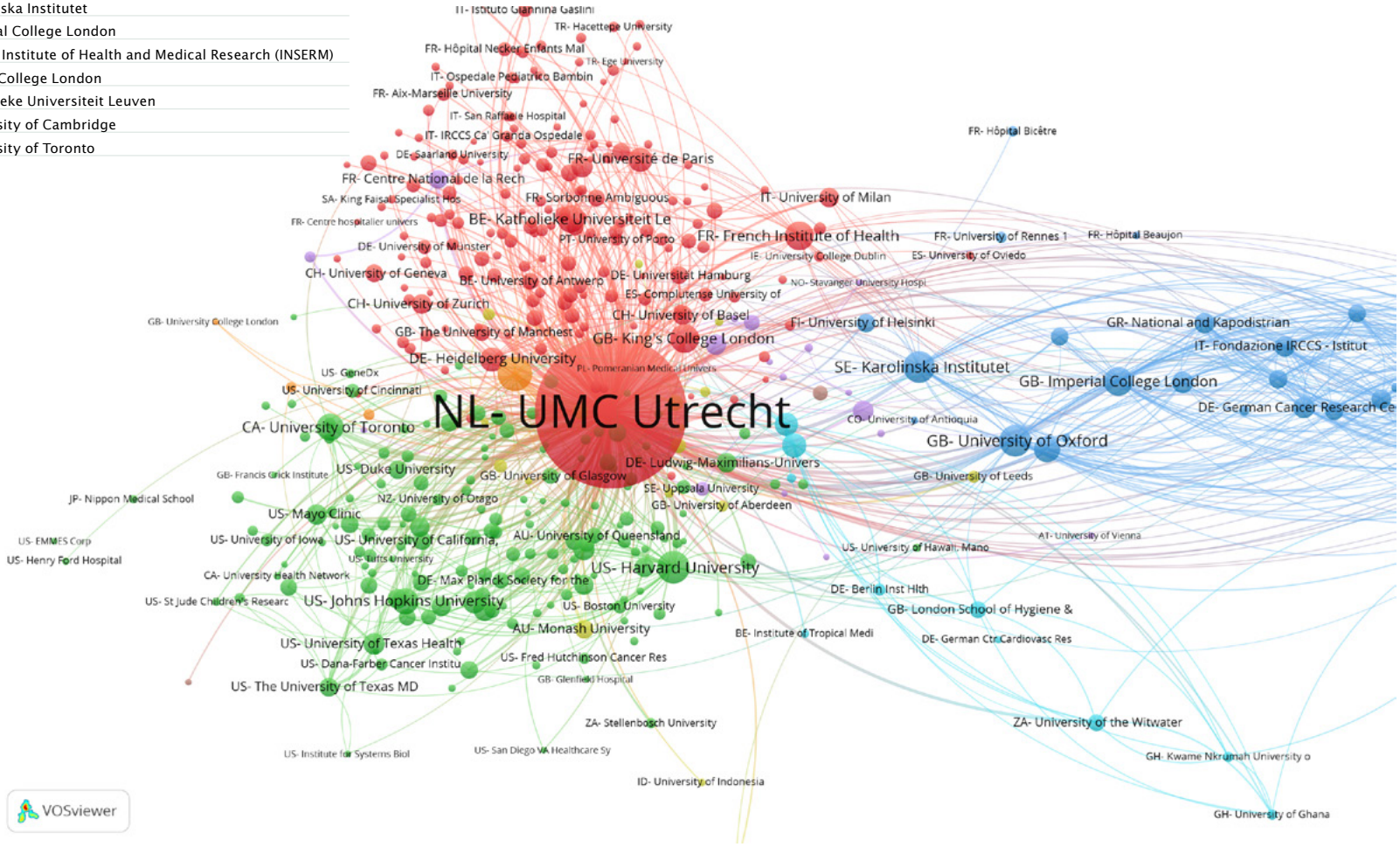


Figure 8f

Collaboration map showing the most important collaborators on scientific publications of UMC Utrecht in 2013–2018. In the table the top 10 international collaborators.

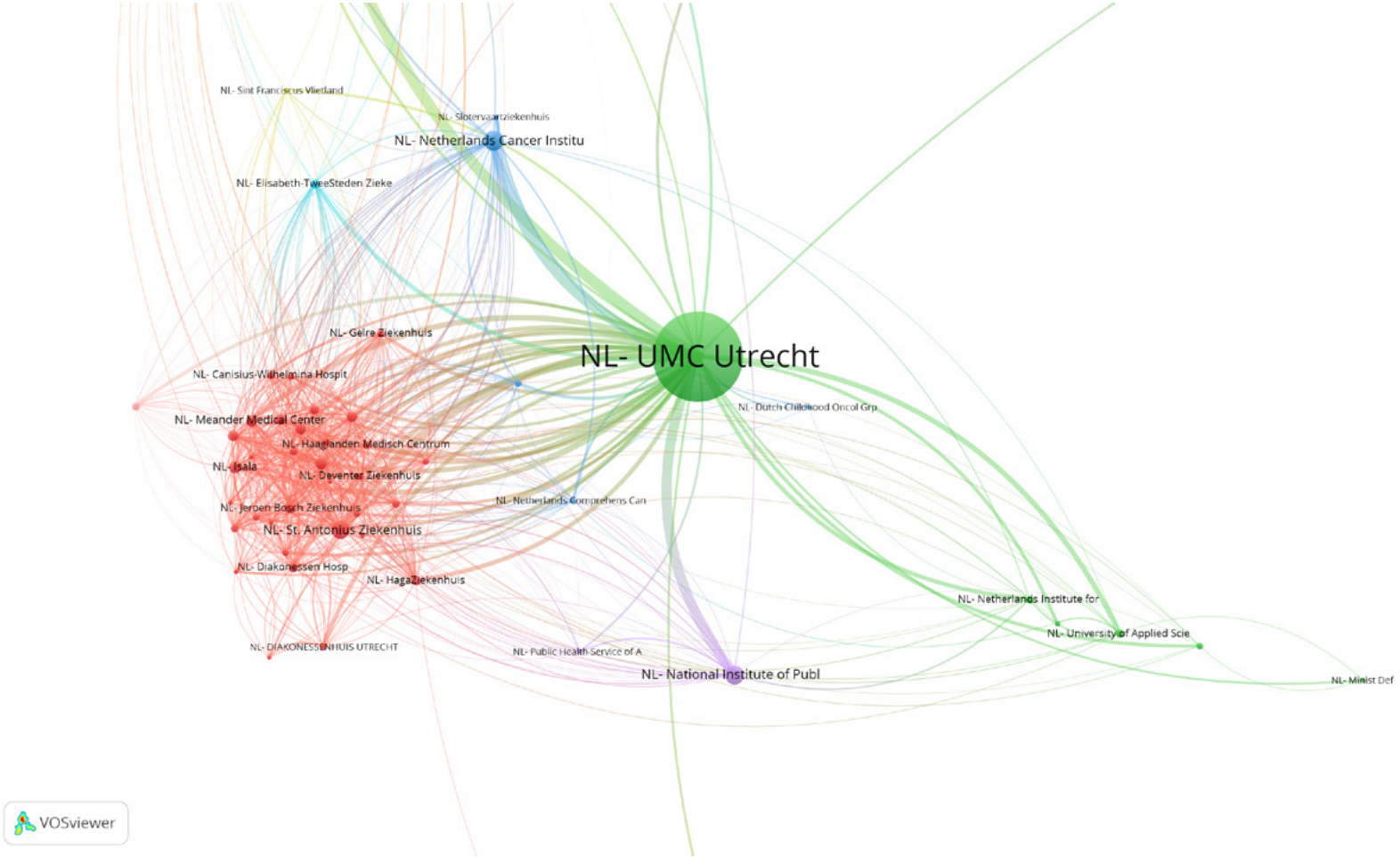


Figure 9f

Collaboration map showing collaborations with national non-university partners on scientific publications of UMC Utrecht in 2013–2018

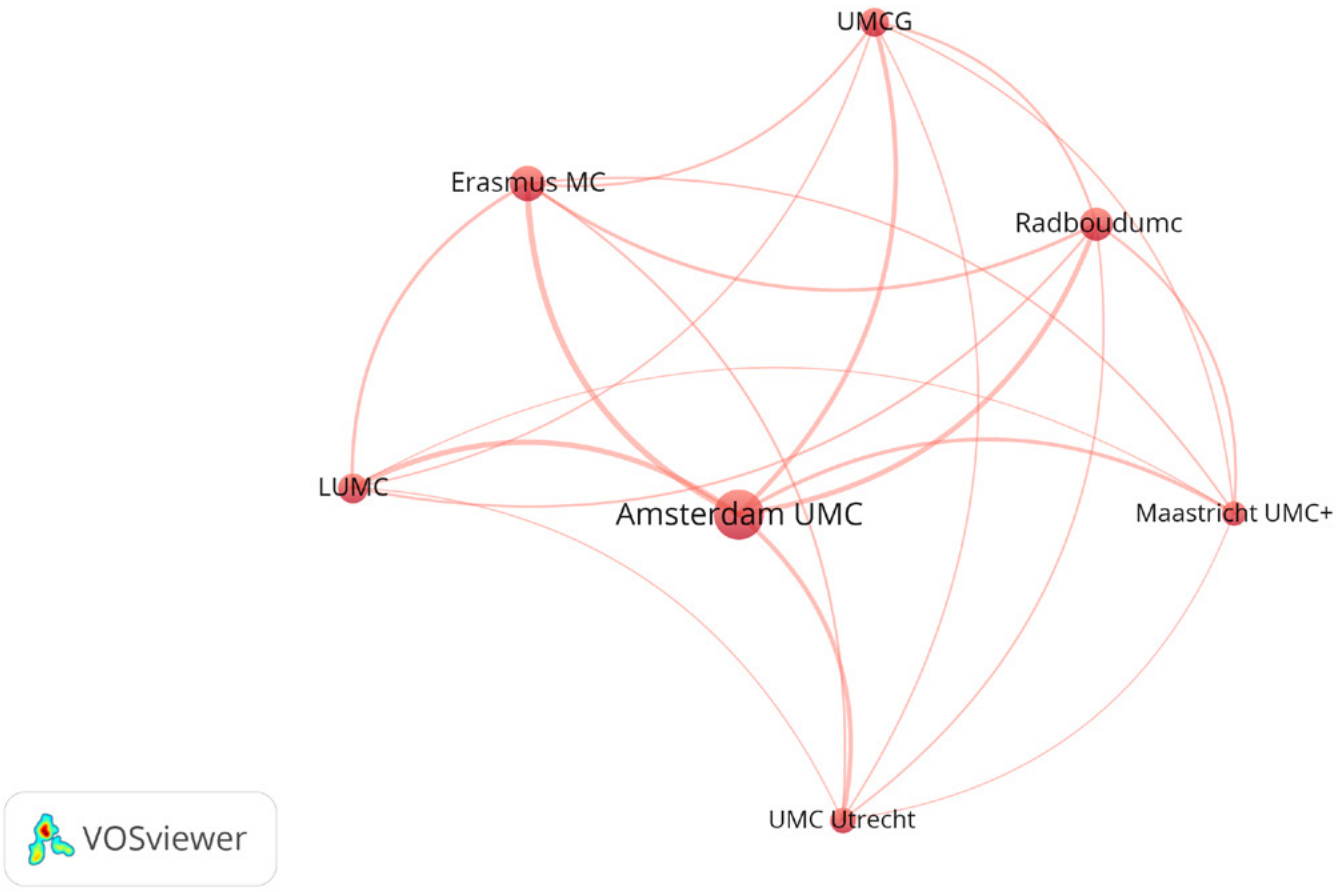
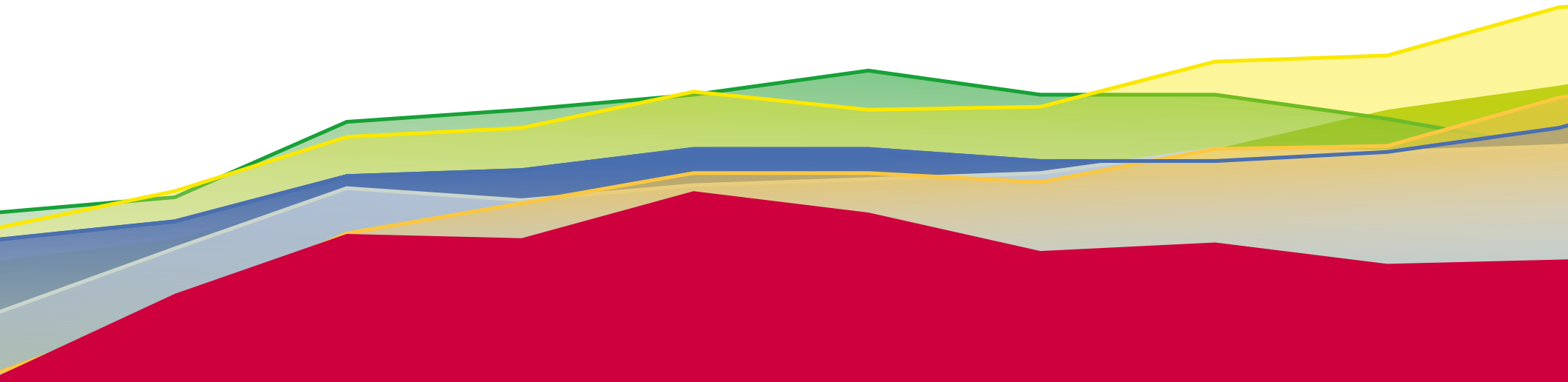


Figure 10

Collaboration map showing collaborations between the UMCs on scientific publications in 2018

THE DUTCH UMCS HAVE EXTENSIVE RESEARCH NETWORKS, COLLABORATING WITH MANY TOP INSTITUTIONS NATIONALLY AND INTERNATIONALLY



THE MNCS DEVELOPMENT OF THE UMCS TROUGH TIME

4 UMC bibliometric indicators

The figures and tables below present frequently used bibliometric indicators to measure and compare the scientific impact of publications. For more detailed information on the bibliometric methodology, see the document 'Explanation of the bibliometric methodology of CWTS'.

4.1 The impact of Dutch UMCs combined

The graph below (Figure 11) shows the development of the Mean Normalized Citation Score (MNCS) for all UMCs over time. The MNCS is the accumulated impact score of all publications of a UMC from a certain period. For each individual publication, the number of times the paper is cited is compared against the average number of citations of all publications on the same research topic from the same year. A score of 1 represents the world average. A score of 2 implies that a publication is cited 100% more often than the world average. The Dutch UMCs all have very high MNCS ratios and can compete in the absolute top in worldwide and European comparisons for medical sciences.

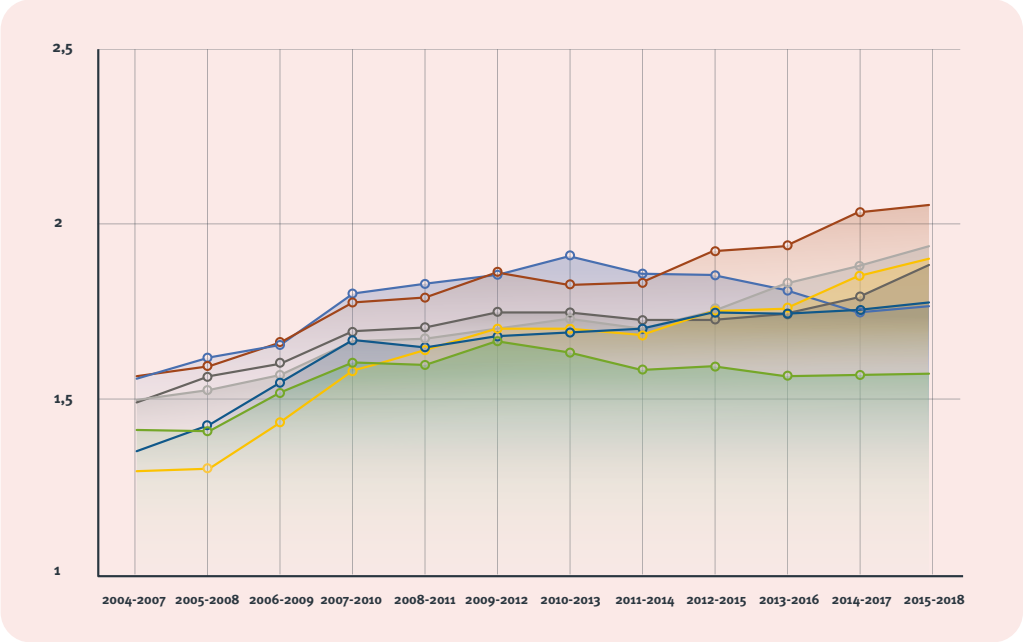


Figure 11
Graph showing the MNCS development of the UMCs over time

4.2 Scientific impact in more detail

The figures below shed light on three different types of scientific activity, and show both MNCS (on the y-axis) and PP top 10% (on the z-axis) in the same figure. The MNCS is shown in bars, and the PP top 10% with triangles. Both indicators show different aspects of the impact of the publication set of a UMC: the MNCS is an indicator based on a calculation of averages, while the PP top 10% shows the concentration of papers among the top 10% most cited papers in the research clusters they are published in.

FIGURE 12
Graph showing both MNCS and PP top 10% indicators for all output of all UMCs in 2013-2018

FIGURE 13
Graph showing both MNCS and PP top 10% indicators for single institute publications of all UMCs in 2013-2018

The different figures show both indicators for:

- All publications of a UMC in the period 2013-2018, and citations counted up to 2019 (Figure 12)
- Papers that were published from a single institution (without collaboration) (Figure 13)
- Papers that were published in collaboration with at least one partner abroad (Figure 14)
- Papers on which an author from a UMC has a primary authorship (first, second, first to last or last author, or corresponding author) (Figure 15)

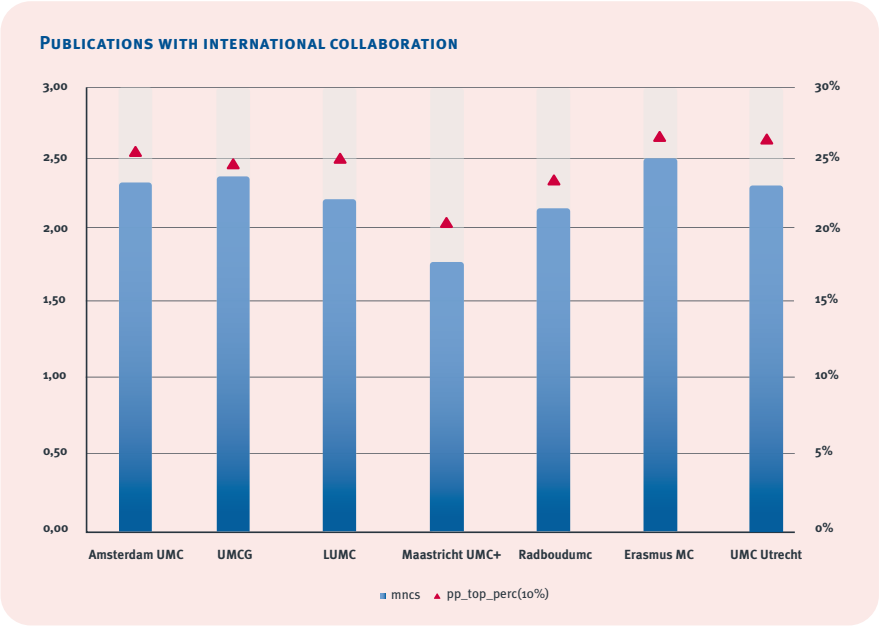


FIGURE 14
Graph showing both MNCS and PP top 10% indicators for publications with international collaboration of all UMCs in 2013-2018

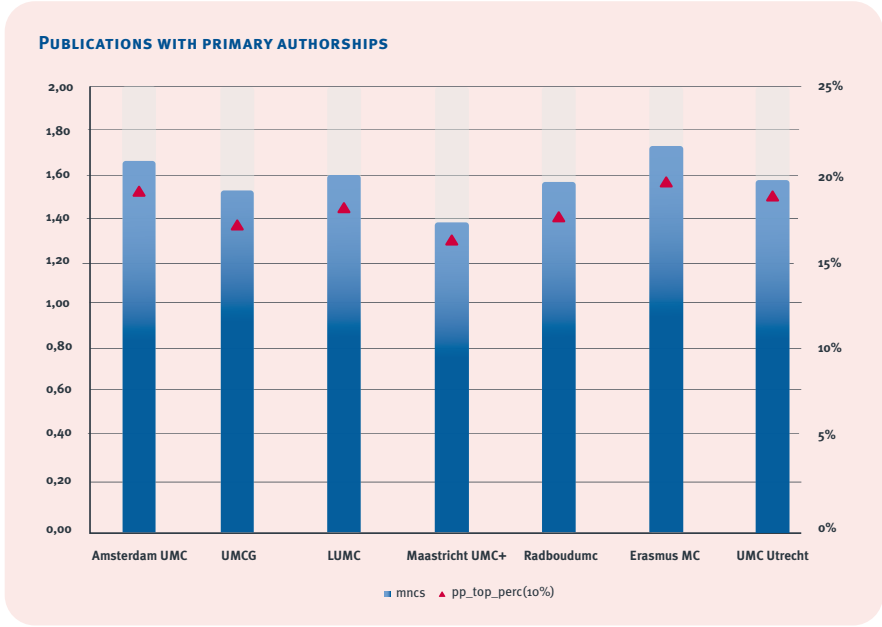


FIGURE 15
Graph showing both MNCS and PP top 10% indicators for primary authorship publications of all UMCs in 2013-2018

4.3 Scientific top research or excellence

Figure 16 shows the presence of all Dutch UMCs combined in various segments (number of papers that are among the 1% - 50% most frequently cited of all similar papers) of the global literature for the time period 2013-2018. Per category the percentage of papers of all the UMCs together is displayed (the blue bars), compared to the expected value (the orange bars). In each category there are far more UMC publications present than could be expected, indicative of the very high citation impact of UMC publications.

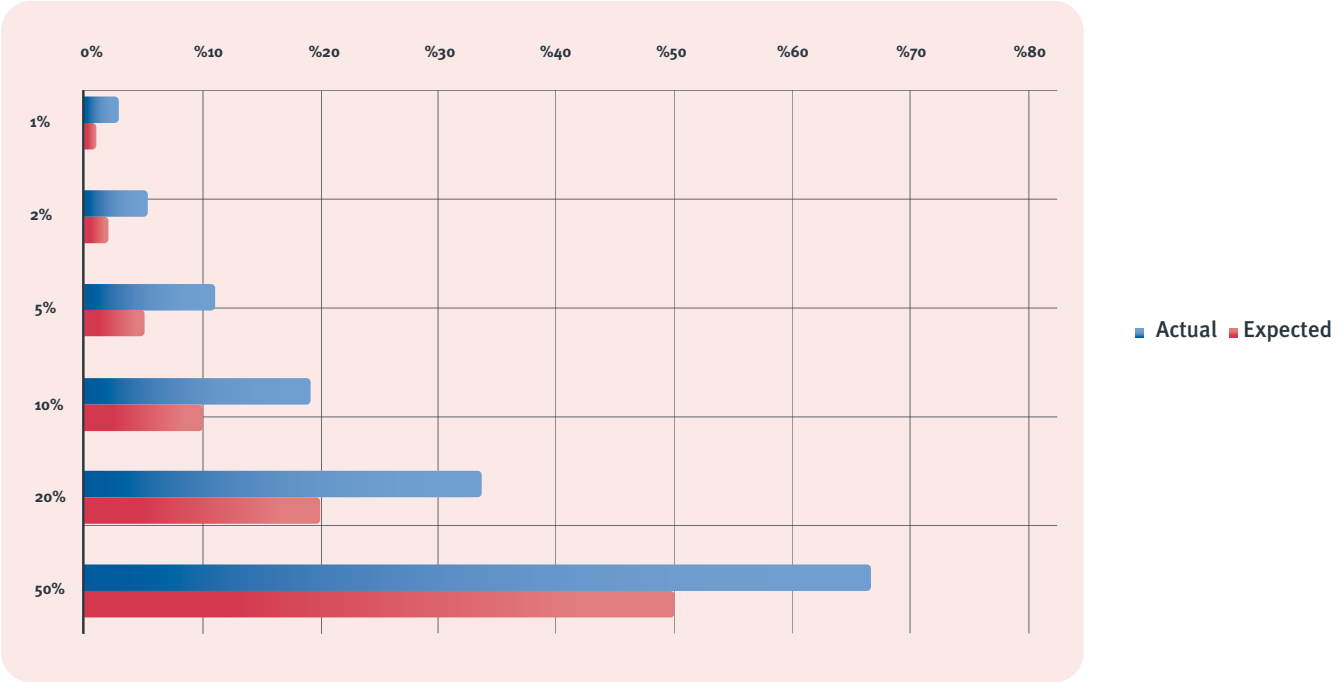


Figure 16
Graph showing presence of UMC publications in 2013-2018 per output impact category

4.4 Overview of bibliometric indicators

The tables below show the accumulated overview of bibliometric indicators for all UMCs combined (left) and separate (right) for the last time period. They indicate per time period the total number of publications (p), the total times cited (tcs), the mean number of citations per publication (mcs), the mean normalized citation score (mncs), the mean normalized journal score (mnjs), and the percentage of papers among the top 10% most cited papers in their respective clusters (pp_top_perc).

PERIOD	P	TCS	MCS	MNCS	MNJS	PP (TOP 10%)
2004–2018	191016	5832089	30,53	1,66	1,52	19%
2004–2007	36240	350857	9,68	1,44	1,36	16%
2005–2008	38281	381798	9,97	1,48	1,39	16%
2006–2009	40325	409871	10,16	1,53	1,44	17%
2007–2010	42395	449369	10,60	1,62	1,51	18%
2008–2011	45292	496473	10,96	1,64	1,53	19%
2009–2012	48879	558258	11,42	1,68	1,56	19%
2010–2013	52186	611849	11,72	1,69	1,57	19%
2011–2014	55126	630029	11,43	1,67	1,55	19%
2012–2015	58783	679439	11,56	1,69	1,55	19%
2013–2016	61515	701149	11,40	1,69	1,55	19%
2014–2017	63870	754588	11,81	1,73	1,57	19%
2015–2018	66938	837174	12,51	1,76	1,58	19%

UMC	PERIOD	P	MNCS	PP (TOP 10%)
ERASMUS MC	2015–2018	13403	2,05	21,44%
LUMC	2015–2018	8960	1,77	19,99%
RADBOUDUMC	2015–2018	11821	1,78	19,14%
MAASTRICHT UMC+	2015–2018	10009	1,58	17,50%
UMCG	2015–2018	10691	1,90	19,48%
UMC UTRECHT	2015–2018	8898	1,89	20,89%
AMSTERDAM UMC	2015–2018	22989	1,94	20,73%

4.5 International outlook

The next figures put the UMC data into international perspective. Publication and citation-impact data of the Dutch UMCs are compared to some of the top institutes in the biomedical field in Europe. For this comparison, publications from 2013-2018 were used that can be assigned to the biomedical field based on the cluster they were published in. Affiliations were subsequently used to link those publications to the correct institutions. Many institutions in Europe do not have the same organizational structure, in which the university medical center is a distinct and separated entity from the university. Therefore, we used the output of European universities active in the biomedical field as a proxy for their associated medical centres to be able to compare publication and citation-impact scores.

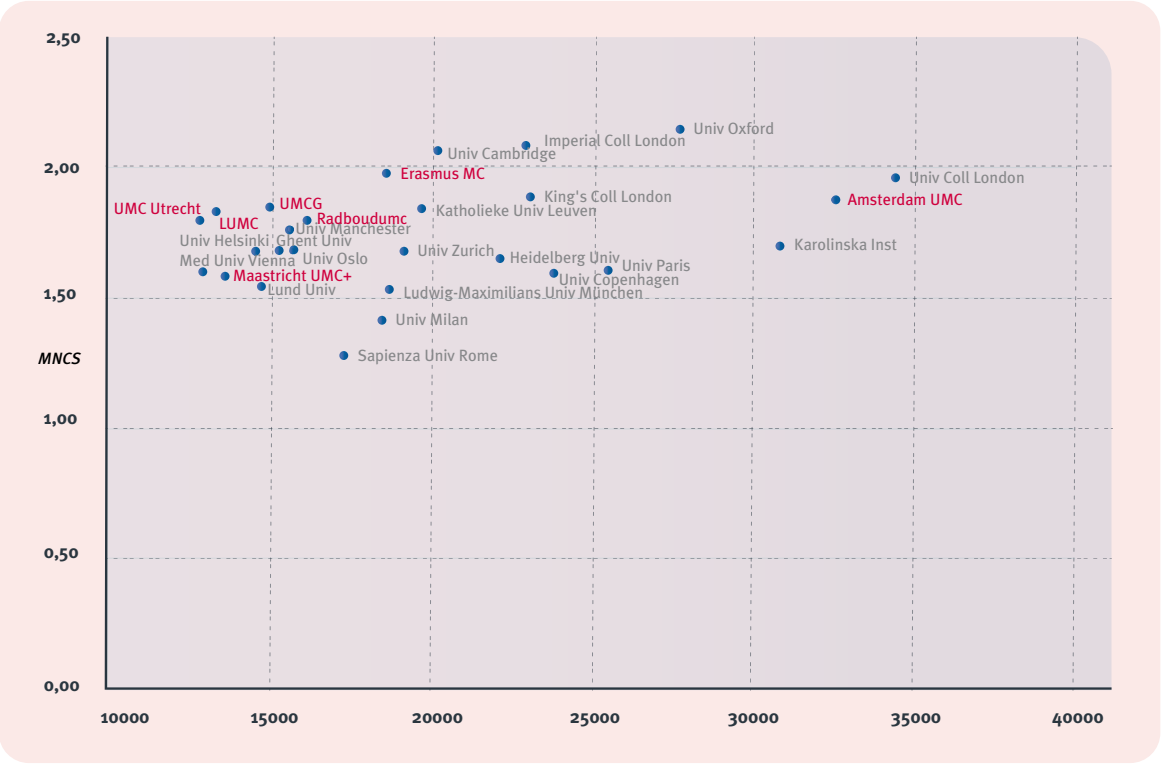


Figure 17
Output compared to impact (mncs), Dutch UMCs and the top-20 European universities in biomedicine, 2013-2018

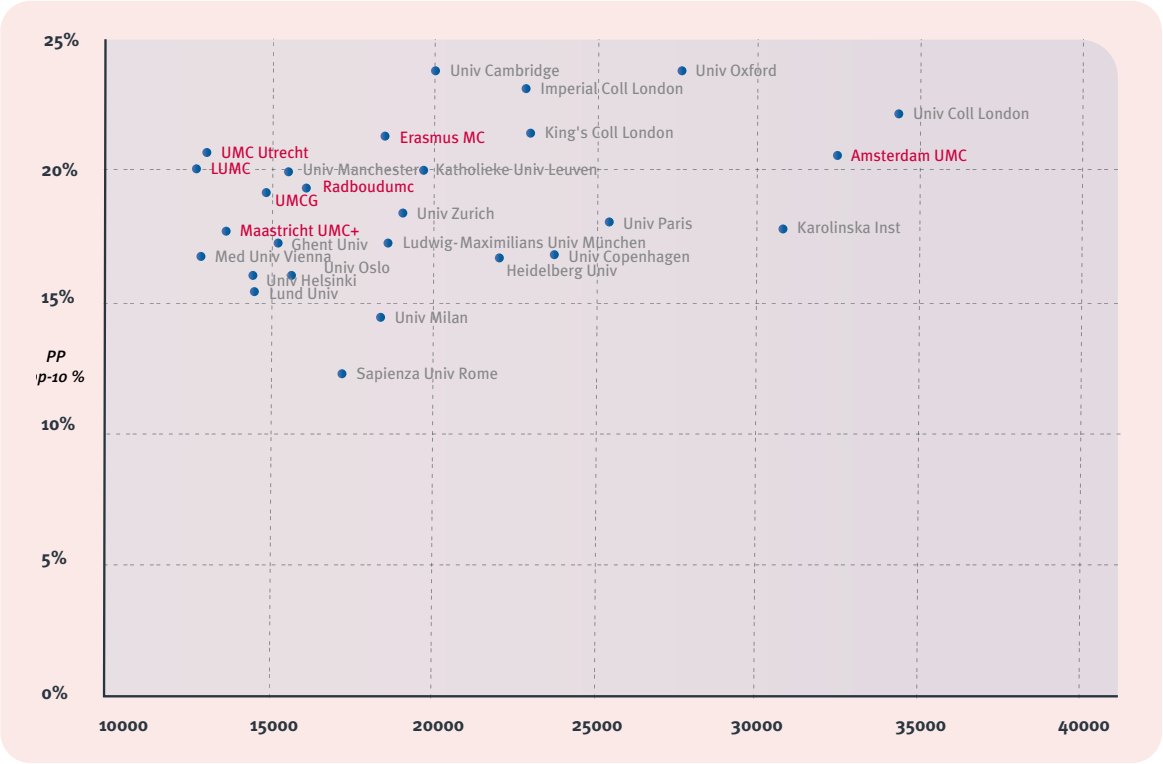


Figure 18
Output compared to impact (pp top 10%), Dutch UMCs and the top-20 European universities in biomedicine, 2013-2018

Figures 17 and 18 show the mean normalized citation score and pp top 10% of the Dutch UMCs and the top European universities in the biomedical field on the vertical axis, and the number of publications per institute on the horizontal axis. The merger of the Amsterdam University Medical Centres (AMC and VUmc) into Amsterdam UMC makes them one of the largest institutes in Europe based on volume of publications in the biomedical field in Europe. Irrespective of the volume of output, all Dutch UMCs are amongst the highest in Europe based on their scientific impact (MNCS and PPtop10%).

Chapters 3 and 4 show that our research can be compared with the top international institutions, in terms of both volume and citation impact. With relatively limited resources we publish many papers which are valued by our peers. In other words, ***our research can be stated as being of the highest level worldwide***. In addition to our prominent and leading role in the international research landscape, our Dutch UMCs are important as the national and regional scientific drivers of biomedical research. The maps above illustrate that each UMC has a distinct national collaboration network, including our universities, other scientific organizations, regional hospitals and industry partners. Each UMC plays a leading and coordinating role in research with these regional partners. This is a symbiotic relationship in which all partners have their unique role, and in which knowledge and expertise are exchanged, which shows ***our strong culture of collaboration***.

TOGETHER, OUR UMCS PROVIDE A WEALTH OF KNOWLEDGE TO INDIVIDUAL STUDENTS, DOCTORS AND PATIENTS AND TO OUR SOCIETY AS A WHOLE

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Research Impact of the Dutch University Medical Centres

Bibliometric analyses of the scientific and societal impact, by CWTS and NFU