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**Author:** Calero Medina, Clara  
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Reorganizing research with the help of bibliometric collaboration networks. Case study in a University Hospital.

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3.1 Introduction

Interdisciplinarity and collaboration

Bibliometric analyses nowadays are more and more focussed on subjects that are relevant for contemporary topics in science policy and management. One of the topics that have gained relevance in the bibliometric field in the passed years is the evaluation and study of interdisciplinary research. The growing importance of research at the boundaries of existing traditional disciplines during the last years demands for further validation of existing methods, and the development of new methods to study and evaluate interdisciplinary research fields (Rinia, 2000).

There are many different scientometric approaches to measuring interdisciplinary, each relying both on a system of disciplinary categories and a concept of interdisciplinarity (Schummer, 2004). Many approaches take papers (or patents) as the subject of study and measure interdisciplinarity in terms of the co-occurrences of what can be considered discipline specific items, such as main concepts (Borner, K., Chen C.M., & Boyack K.W., 2003, and Van Eck & Waltman, 2007), classification headings (eg. Steele & Stier, 2000, Morillo, Bordons & Gómez, 2001, and Rinia et al., 2001), authors’ affiliations (Qin, Lancaster, & Allen, 1997, and Steele & Stier, 2000), or citations (eg. Bourke & Butler, 1998, Steele & Stier, 2000, Rinia et al., 2002, and van Raan & Leeuwen, 2002).

In this study, we are interested in interdisciplinarity as a combined cognitive and social phenomenon (Schummer, 2004), which is particular important in highly interdisciplinary environments as a university hospital. Levels and types of interdisciplinary collaboration vary in different disciplines, but the general trend is toward increasing interdisciplinarity, which is particularly pronounced in biology and medical sciences (Qin, Lancaster, & Allen, 1997).

In interdisciplinary research environments, groups with in principle different research interests and backgrounds, collaborate pooling their knowledge toward a common goal (Qin, Lancaster, & Allen, 1997). This collaboration across disciplinary boundaries is a more complex form of information transfer (Pierce, 1999). Gibbons et al. (1994) have described it as a “transdisciplinary” form of collaboration with members of different disciplines working together in practical applications. The mutual, direct engagement among previously uncorrelated research topics has advantages not only for the researchers, that are able to draw from a
wider, diverse intellectual environment, but also for the nature of research performed, that is circulated, validated and enriched by contact with new research and social circles (Pierce, 1999). This is why large interdisciplinary research centers are interesting environments to study collaboration (Rodriguez & Pepe, 2008).

One way to analyze and study the ways researchers exchange and share information is through the construction of co-authorships networks (Newman, 2001; Barabási et al., 2002; Newman, 2003). Network researchers have been working during the last decade to reveal the highly clustered nature of scientific production, showing that co-authorships and citation networks are made of several dense groups of nodes, called communities (Lambiotte & Panzara, 2009). Allowing the co-publication network itself to identify communities and groups, what we call functional research groups¹ (Seglen & Aksnes, 2001; Calero et al., 2006) inside interdisciplinary research centers, may lead to a better understanding of how these complex organizations work and therefore can help research managers to reorganize the organization in a more efficient and practical way.

Main Characteristics of the Leiden University Medical Center (LUMC) in The Netherlands

The LUMC has a long tradition of pioneering medical and bio-medical research and is among the international top in this field. With its research, the LUMC wants to contribute to the prevention and solution of health problems. At the heart of their research strategy is translational research. Translational research in medicine means the effective translation of the new knowledge, mechanisms, and techniques generated by advances in basic medical research into new approaches for prevention, diagnosis, and treatment of diseases (Fontanerosa & DeAngelis, 2002; Woolf, 2008). This is a prime example of how an interdisciplinary approach can promote the use of clinical and laboratory findings in applications that are beneficial to society and citizens. The LUMC has structured its research in Departmental Programmes and Research Themes.

Almost all LUMC departments do conduct research in addition to their other tasks (teaching, patient care). This research is mainly structured in the form of Departmental Programmes (see Table A in the Appendix). The Departmental Programmes follow the lines of traditional research fields and there are about 150 of them. Departmental Programmes are

¹ The functional research groups are broad cooperative units of research identified through co-authorship activity, not necessarily embedded in the traditional physical groups of the organization.
representative for the scientific activities of the LUMC. But the Departmental Programmes do not stand-alone; there is a high degree of cohesion between the various programmes.

To intensify and to profile scientific collaboration in the LUMC, in 2006 a more structured approach was introduced in the form of research themes. A research theme is an intra-Departmental or cross-divisional collaborative alliance of researchers who jointly study a single topic, each of them on the basis of their own disciplines. Research themes focus on a particular illness or clinical picture. A theme is intended to promote synergy. The theme leader is accountable to a division governing board, which is ultimately responsible for the theme. The LUMC Research Themes are:

- Aging.
- Genetic Epidemiology and Bioinformatics.
- Immunotherapy of cancer.
- Infectious diseases and immunology.
- Neurosciences.
- Oncogenetics.
- Regenerative Medicine.
- Vascular Medicine.

### 3.2 Objectives of this study

In the Netherlands, research performance assessments are often extended with bibliometric analyses. In the medical sciences, the Royal Academy of Sciences (KNAW) has long been the initiator for research assessments in the field. In 2003, a new evaluation protocol, the Standard Evaluation Protocol (SEP) was implanted in the Dutch science system. In this new protocol, the responsibility and initiative for research evaluation is transferred to the individual Boards of Dutch universities.

Under this new protocol, the Board of the Leiden University Medical Center (LUMC) has initiated an annual bibliometric monitoring of the research performance of the research within the LUMC. The Board is aware of the importance for a highly interdisciplinary environment as LUMC of a proper research management to facilitate the research activities. The network of interactions (co-authorships) is considerably more complex than shown through the formal organization (Departmental Programmes and research themes). LUMC expects that the bibliometric monitoring will help them, among other issues, to change
the configuration of the Departmental Programmes orienting them towards Research Themes, in order to create as strong as possible research clusters.

In terms of policy issues, the question raised by the LUMC Board was to identify the “functional research groups” inside LUMC that could help them to re-organize their research lines (Departmental Programmes and Research Themes).

3.3 Methodology

Data

Publications from 2002 until 2006 were extracted from an in-house LUMC output registration system and matched with Web of Science (WoS). The resulting dataset, containing publications labeled with LUMC Departmental Programmes names and Research Themes names forms the basis for the first and second analysis respectively.

Departmental Programmes Analysis

For the analysis of the Departmental Programmes first the LUMC’s publication set is classified in research fields. For the most important fields in terms of number of publications, we collect which Departmental Programmes are publishing in each of the fields selected and their co-publication activity. We present a detailed explanation below.

• Inverse Research Profile

The breakdown of the LUMC output (publications) into research fields (our definition of research fields is based on the classification of scientific journals into Journal Subjects Categories developed by Thomson Reuters) is what we call research profile. The break down as such gives an impression of all fields involved in the research scope or ‘profile’ of the LUMC. This can be seen already as an indicator of interdisciplinarity (Van Raan & Van Leeuwen, 2002). Additionally, we determine the impact of the articles in these fields, so it becomes immediately visible in what fields within the ‘research profile’ the LUMC has a high (or low) performance (Moed, De Bruin & Van Leeuwen, 1995). In terms of the policy use of the profiles, the impact is compared to the mean field citation score (CPP/FCSm²).

CPP is the average number of citations per publication (excluding self-citations)
FCSm is the reference value. The average citation rate of all articles in the subfields
Having as starting point the overall ‘research profile’ of the LUMC, in which the fields are presented in such a way that the largest research fields are on top of the profile, we get a new insight in the (WoS) information available. Per research field, we have collected the ‘research profile’ information of the Departmental Programmes, and displayed the information in an inverse way: the Departmental Programmes with the largest output are on top of the profile, indicating their relative strong contribution to the field, again in combination with the impact received in that field. This is what we call ‘inverse research Departmental Programmes profiles’. Only research fields with more than 3% of all publications by the LUMC were considered. As a result, a total of 10 fields were considered and inverse research Departmental Programmes profiles were calculated for them.

- **Field collaboration Departmental Programmes: network analysis**

The various Departmental Programmes of the LUMC work together in many ways. Using each of the ‘inverse Departmental Programmes profiles’ per field, an analysis was conducted on the scientific cooperation relationships among the Departmental Programmes. Each of the 10 collaboration networks is then a set of Departmental Programmes (in network theory called nodes) linked via their co-publication activity (edges). The network is undirected which means that the edges have no direction. The edges are valued representing the strength of the co-publications activity between two Departmental Programmes. The collaboration network analysis is focused on the structures per field within which the Departmental Programmes are embedded. It is intended to create a better insight in the visibility and relatedness of the Departmental Programmes.

In network analysis there is a number of techniques to detect the cohesion and cohesive subgroups inside the network (Scott, 2000). Intuitively, cohesion means that a network contains many ties. More ties between vertices yield a tighter structure, which is, presumably, more cohesive (De Nooy, Mrvar & Batagelj, 2005). These techniques are based on the way in which vertices are interconnected, in our case in the way in which

(Thomson Reuters Journal Subject Categories) in which the research unit analyzed is active (excluding self-citations) Also indicated as the world citation average in those subfields or ‘world subfield average’. Then the CPP/FCSm is the impact of a research unit’s articles, compared to the world citation average in the subfields in which the research unit is active.
the research Programmes are interconnected in their collaboration activity. We expect that the LUMC Departmental Programmes with a common research activity will interact frequently, at least more than with other Programmes.

First we are interested in general characteristics and properties of the collaboration networks, such as:

- **Size**

  The size of the network is measured in term of the number of research Programmes involved.

- **Density and Clustering**

  The density describes the general level of linkages among the research Programmes in the collaboration network. The more the research Programmes are connected to one another, the more dense the network will. A ‘complete network’ is one in which all the research Programmes are connected to one another. The Departmental Programmes collaboration network is a valued graph. The density measure with valued graphs is complicate to calculate and interpret, especially because it is highly sensitive to the assumptions that we have made about the data (Scott, 2000). This is why we are calculating the density disregarding the values of the lines. We are aware that this involves a considerable loss of information, but at the same time it gives a first insight of the cohesion of the network. We will complement this measure with the clustering coefficient in order to get as much as information as possible.

  The maximum number of edges for a network is determined by

  \[
  E_{\text{max}} = \frac{g(g - 1)}{2}
  \]

  where \(E_{\text{max}}\) denotes the maximum number of edges for an undirected graph and \(g\) is the number of nodes (in our case Departmental Programmes). The density of a graph is simply the ratio of the edges actually present (L) to the maximum possible (Scott, 2000).

  \[
  \Delta = \frac{2L}{g(g - 1)} \quad 0 \leq \Delta \leq 1
  \]
Another insightful property of the network is the clustering or network transitivity (Watts & Strogatz, 1998; Watts, 1999). A network shows clustering if the probability of two nodes being connected by an edge is higher when the nodes in question have a common neighbor. One way of showing the existence of such a clustering in network data is to measure the fraction of “transitive triples” in a network (Wasserman & Faust, 1994), also called the clustering coefficient \( C \) (Watts & Strogatz, 1998). The Clustering Coefficient, \( C \), is the average probability that two neighbors of a given node are also neighbors of each other and can be expressed as the proportion of triples that form a triangle out of all the triples present in the network. As Eckmann and Moses (2002) showed there is a close relation between highly clustered regions of a network and the existence of communities. In this study this measure helps to determine to which level the Departmental Programmes cluster together in each of the fields.

\[
C = \frac{3 \times \text{Number of triangles}}{\text{number of connected triples}} \quad 0 \leq C \leq 1
\]

\[ \checkmark \quad K\text{-Core} \]

The additional analysis of the network was made using a technique to identify regions between the nodes called k-core. A k-core is a subgraph in which each node is connected to at least a minimum fixed number (K) of the other nodes in the subgraph (Seiman, 1983). The k-core approach allows actors to join the group if they are connected to k members, regardless of how many other members they may not be connected to (Wasserman & Faust, 1994). This resulted in network analyses on the level of these fields.

Research theme network analysis

Our goal on this part of the study is to identify communities between the researchers working in the LUMC assigned to a research theme and through correlation techniques (assortative mixing) measure patterns in the network structure.

We analyzed the level of interaction (based on co-publications) of the researchers from a research theme. To test the methodology we focused on just one of the research themes mentioned above: Neurosciences. Since our time period of analysis is 2002-2006 and the research themes were created in 2006, we are going to be able to measure whether the
First we identify the communities and groups based on the co-publication networks and on an algorithm developed by Girvan and Newman (Girvan & Newman 2002; Newman 2004; Newman & Girvan 2004) based on the edge betweenness. Using the same idea of the node betweenness developed by Freeman (1977), the edge betweenness of an edge measures the times an edge is used in the shortest paths that connect two other nodes from the network. The edges that connect highly clustered communities have a higher betweenness so cutting these edges should separate communities. So the algorithm finds divisions of networks into closely knit groups by looking for the edges that connect groups (Lusseau & Newman, 2004).

Furthermore it is possible to measure whether the structure of the network is not randomly determined. This phenomenon is known as assortative mixing in networks (Newman, 2002; Newman, 2003; Newman & Park, 2003) in which the probability of two nodes being connected by an edge depends on some properties of those nodes. Assortative mixing on the basis of a scalar characteristic such as node degree is known as degree correlation. This measure determines whether there is preferential attachment between high-degree nodes and low-degree nodes, or whether there is preferential attachment between low and high degree nodes, referred to as disassortative mixing. Newman (2003) shows that it is possible to compute the degree correlation coefficient simply by calculating the Pearson correlation coefficient of the degrees at either ends of a link. This calculation should give a positive number for assortatively mixed networks and negative for disassortative ones. In terms of the network structure this will mean that a positive coefficient shows a core-periphery structure. The nodes with high degree are attracted with one another and as such form a core highly interconnected surrounded by a periphery of lower-degree nodes, on the other hand, negative coefficients cause the high-degree nodes to be scattered more broadly over the network.

3.4 Results

Departmental Programmes Analysis

As it was mentioned above, the overall research profile of the LUMC was used to create insight into the strength and weakness of the hospital. The standard impact of different main fields (more than 3%) of the research neurosciences research theme which was created had already a level of synergy between researchers from different departments.
profile of LUMC was measured through the field-normalized indicator CPP/FCSm.

Figure 1 shows the output and impact per field for the ten most prominent fields (accounting for at least 3% of the total of LUMC output in 1997-2006). ‘Cardiovascular’ is the most important field, including about 7% of the total output. Other three important fields are ‘Hematology’ with around 6% of the total output and ‘Cardiac & Cardiovascular Systems’ and ‘Immunology’ with almost 6%. The other important fields accounting between 5% and 3% of the total output are ‘Endocrinology & Metabolism’, ‘Radiology’, ‘Nuclear Medicine & Medical Imaging’, ‘Biochemistry & Molecular Biology’, ‘Genetics & Heredity’, ‘Rheumatology’, and ‘Medicine, General & Internal’. The impact of these fields is in all cases above world average or world average (CPP/FCSm > 1).

![Figure 1. LUMC Research Profile, 1997-2006.](image-url)
Using each of the inverse research Programmes profiles per research field, an analysis was conducted on the scientific cooperation relationships among the Departmental Programmes. Each of the 10 collaboration networks is then a set of research Programmes. The collaboration network analysis is focused on the structures per field within which the Departmental Programmes are embedded. Table 2 shows the result of the analysis where the above explained characteristics and properties of the networks are shown.

Table 2. Summary results: Departmental Programmes Network Overview

<table>
<thead>
<tr>
<th>ISI Fields</th>
<th>Depart Program</th>
<th>Density</th>
<th>Clust Coeff</th>
<th>Main Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oncology</td>
<td>56</td>
<td>0.1305</td>
<td>0.371</td>
<td>7</td>
</tr>
<tr>
<td>Hematology</td>
<td>53</td>
<td>0.1183</td>
<td>0.308</td>
<td>5</td>
</tr>
<tr>
<td>Cardiac and Cardiovascular Systems</td>
<td>31</td>
<td>0.1828</td>
<td>0.416</td>
<td>5</td>
</tr>
<tr>
<td>Immunology</td>
<td>59</td>
<td>0.1081</td>
<td>0.298</td>
<td>5</td>
</tr>
<tr>
<td>Endocrinology &amp; Metabolism</td>
<td>49</td>
<td>0.1607</td>
<td>0.383</td>
<td>6</td>
</tr>
<tr>
<td>Radiology, Nuclear Medicine &amp; Medical Imaging</td>
<td>42</td>
<td>0.1173</td>
<td>0.323</td>
<td>5</td>
</tr>
<tr>
<td>Biochemistry &amp; Molecular Biology</td>
<td>45</td>
<td>0.1212</td>
<td>0.336</td>
<td>6</td>
</tr>
<tr>
<td>Genetics &amp; Heredity</td>
<td>47</td>
<td>0.1045</td>
<td>0.306</td>
<td>5</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>35</td>
<td>0.1277</td>
<td>0.333</td>
<td>4</td>
</tr>
<tr>
<td>Medicine, General &amp; Internal</td>
<td>40</td>
<td>0.0962</td>
<td>0.427</td>
<td>4</td>
</tr>
</tbody>
</table>

The number of Departmental Programmes involved in each field gives already an approximation of the level of multidisciplinarity of the field. Fields like ‘Immunology’, ‘Oncology’ and ‘Hematology’ have many Programmes involved.

The ‘Density’ measures the general level of linkage between the Programmes and the clustering coefficient the level at which the network is clustered, which means that the network contains local communities in which a higher number of nodes create closely knit groups characterized by a relative high density of ties. These two indicators are complementary, so if the network has a high density and a high clustering coefficient (i.e. ‘Cardiac and Cardiovascular Systems’) this means that a group of Programmes tends to collaborate and this can provide insight for future merging and reorganization of the Programmes.

The last column shows the Highest K-Core. As it was mentioned before a k-core is a sub-graph in which each programme is connected to at least a minimum fixed number (K) of the other nodes in the sub-graph. Table 2
shows the highest core for each of the fields. Following with the ‘Cardiac and Cardiovascular Systems’ field, the highest core is a 5. This means that there is on the collaboration network of 31 Departmental Programmes a core of programmes which collaborates with at least five of the programmes from this core. In this case the 5-core contains 15 Departmental Programmes.

**Research Theme Network analysis**

We analyzed the level of interaction (based on co-publications) of the researchers from one of the research themes, Neurosciences. Our time period of analysis was 2002-2006. The principal researchers are highlighted with a red underlined on the researcher name.

Our goal was to identify the functional groups between the researchers assigned to a research theme. Figure 2 shows the groups identified by Girvan & Newman algorithm. Nodes coloring indicates group membership. The researchers part of the same group has the same color node. Overall the algorithm has identified six groups. The experts involved in the study commented that these groups fit quite well with the organizational groups attached to the principal researchers (highlighted in Figure 2) in the Neurosciences research theme. This is confirmed by the assortative mixing coefficient that has a negative value of -0.2154. The project leaders, having a lot of co-authored papers (high degree values) are spread on the network, collaborating mainly with the members of their groups.

The research themes were created in 2006 with the objective of promoting synergies between researchers from different departments who jointly study a single topic. As the analysis shows, the groups identified by the Newman and Girvan Algorithm fits quite well the real different research groups that will take part in the Neuroscience Research Theme. This means that in terms of collaboration activity for the period 2002-2006 the future members of the Neuroscience research theme have not yet started to collaborate, or at least not in terms of scientific production. The question would be how this collaboration network is at this moment. The creation and support of this research theme is having any effect in the collaboration activity between researchers coming from different disciplines?
3.5 Conclusion

Translational research in a University Hospital is deeply embedded within daily work activities, it is not limited to a specific hierarchical or technical subset but highly distributed across the entire organization, this is why a proper management is very important to facilitate the research activities.

In the last years we have observed considerable advances in the development of methods for finding communities within networks, with
an enormous number of different techniques under development (Newman, 2008). The present study shows how bibliometric analysis can benefit from these developments and complement them. The combination of bibliometric indicators and network analysis can help the research managers of such as organizations to understand the way the organization behaves in order to create as strong as possible research clusters.
References


Reorganizing research with the help of bibliometric collaboration networks


### Appendix

#### Table A. Departmental Programmes

<table>
<thead>
<tr>
<th>Department</th>
<th>Programmes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesiology</td>
<td>10100 No programme related research</td>
</tr>
<tr>
<td></td>
<td>10101 Perioperative Medicine: Efficacy, Safety and Outcome</td>
</tr>
<tr>
<td>Surgery</td>
<td>10200 Traumatologie</td>
</tr>
<tr>
<td></td>
<td>10201 Vascular Surgery</td>
</tr>
<tr>
<td></td>
<td>10202 Surgical oncology</td>
</tr>
<tr>
<td></td>
<td>10203 Transplant surgery</td>
</tr>
<tr>
<td>Orthopedic Surgery</td>
<td>10400 No programme related research</td>
</tr>
<tr>
<td></td>
<td>10401 Study of the normal and pathological locomotory system</td>
</tr>
<tr>
<td></td>
<td>10402 Diagnosis and treatment of bone and soft tissue tumours</td>
</tr>
<tr>
<td>Rehabilitation Medicine</td>
<td>10500 No programme related research</td>
</tr>
<tr>
<td></td>
<td>10501 Pathophysiological analysis of movement disorders in relation to function</td>
</tr>
<tr>
<td>Thoracic Surgery</td>
<td>10600 No programme related research</td>
</tr>
<tr>
<td>Urology</td>
<td>10700 No programme related research</td>
</tr>
<tr>
<td></td>
<td>10701 Prostatic carcinoma</td>
</tr>
<tr>
<td></td>
<td>10702 Neuro-urology: functional disorders in male and female urogenital tract</td>
</tr>
<tr>
<td>Medical Decision Making</td>
<td>10800 No programme related research</td>
</tr>
<tr>
<td></td>
<td>10801 Analysis and support of clinical decision making</td>
</tr>
<tr>
<td>Fysiotherapie</td>
<td>10900 Fysiotherapy</td>
</tr>
<tr>
<td>Endocrinology</td>
<td>20100 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20101 Bone and mineral research</td>
</tr>
<tr>
<td></td>
<td>20102 Diabetes mellitus: pathophysiological changes and therapy</td>
</tr>
<tr>
<td>General Internal Medicine</td>
<td>20201 The pathogenesis, clinical presentation and therapy of arterial and venous vascular disorders</td>
</tr>
<tr>
<td>Cardiology</td>
<td>20300 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20301 Vascular Biology and Intervention</td>
</tr>
<tr>
<td></td>
<td>20302 Cardiac Dysfunction and Arrhythmias</td>
</tr>
<tr>
<td>Pulmonology</td>
<td>20400 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20401 Pathogenesis and treatment of emphysema, other chronic obstructive pulmonary diseases and neoplasms of the lung</td>
</tr>
<tr>
<td></td>
<td>20402 Pathogenesis and treatment of asthma</td>
</tr>
<tr>
<td>Gastroenterology and Hepatology</td>
<td>20500 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20501 Cellular mechanisms in basic and clinical gastroenterology and hepatology</td>
</tr>
<tr>
<td>Nephrology</td>
<td>20600 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20601 Kidney and pancreas transplantation</td>
</tr>
<tr>
<td></td>
<td>20602 Vascular nephrology</td>
</tr>
<tr>
<td>Reumatology</td>
<td>20700 No programme related research</td>
</tr>
<tr>
<td></td>
<td>20701 Pathophysiology and treatment of rheumatic diseases</td>
</tr>
<tr>
<td>Gerontology and Geriatrics</td>
<td></td>
</tr>
</tbody>
</table>
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Radiology
- 20800: No programme related research
- 20801: Pathophysiology, epidemiology and therapy of ageing

Epidemiology
- 20900: Onderzoeksprogramma's worden gereviseerd

Gynecology
- 30100: No programme related research
- 30101: Cervix cancer
- 30102: Technology assessment of reproductive medicine

Obstetrics
- 30200: No programme related research
- 30201: Research into fetal development and medicine

Dermatology and Venerology
- 30400: No programme related research
- 30401: Dermatology-oncology

Neurosurgery
- 30600: No programme related research
- 30601: Assessment of spine and nerve surgeries

Neurology
- 30700: No programme related research
- 30701: Pathophysiology of paroxysmal and chronic degenerative progressive disorder of the central and peripheral nervous system

Ophthalmology
- 30800: No programme related research
- 30801: Ophthalmic research

Pathology
- 30900: No programme related research
- 30901: Immunopathology of vascular and renal diseases and of organ and cell transplantations
- 30902: Molecular tumour pathology - and tumour genetics
- 30903: Tumour immunology

Psychiatry (adults)
- 31000: No programme related research
- 31001: Mood, anxiety and somatoform disorders and the HPA-axis (MASH)

Medical Psychology
- 31100: Medical Psychology

Public Health
- 31200: No programme related research
- 31201: Geriatrics in primary care

Paediatrics
- 31300: No programme related research
- 31301: Stem cell transplantation and immunomodulation
- 31302: Epidemiology in Pediatrics and Child Health
- 31303: Development

CURIAM
- 31400: No programme related research
- 31401: New methods for child psychiatric diagnosis and treatment outcome evaluation

Hematology
- 40100: No programme related research
- 40101: Trombosis and Hemostasis
- 40103: Bone marrow failure

Immunohematology and Blood Transfusion
### Infectious Diseases

- **No programme related research**
- **Tumorimmunology**
- **Transplantation and autoimmunity**
- **Stemcell biology**

### Clinical Oncology

- **No programme related research**
- **Experimental cancer immunology and therapy**
- **Biological, physical and clinical aspects of cancer treatment with ionising radiation**
- **Experimentele farmacotherapie**

### Clinical Pharmacy and Toxicology

- **No programme related research**
- **Heterogeneity of drug efficacy and toxicity in relation to individual pharmacokinetics, pharmacodynamics and pharmacogenetics**

### Medical Microbiology

- **No programme related research**
- **Molecular basis of virus replication, viral pathogenesis and antiviral strategies**
- **Molecular basis of bacterial pathogenesis, virulence factors and antibiotic resistance**

### Centraal Klinisch Chemisch Laboratorium

- **Centraal Klinisch Chemisch Laboratorium Human Genetics**
- **Mechanisms of disease, diagnostics and therapy**
- **Tumourgenetics and immunogenetics**
- **Genomics, epigenetics, population genetics and bioinformatics**

### Anatomy and Embryology

- **No programme related research**
- **Molecular cardiovascular developmental biology**

### Molecular Cell Biology

- **No programme related research**
- **Signal transduction in aging related diseases**
- **Gene regulation and cell differentiation**
- **Neurosciences in Drosophila and rodents; from genes to neuronal networks**
- **Microscopic imaging and technology**

### Parasitology

- **No programme related research**
- **Host-parasite interactions with emphasis on immunology, molecular biologie, glycobiology and epidemiology of parasitic infections**

### Toxicogenetics

- **No programme related research**
- **DNA repair mechanisms**
- **Replication associated mutagenesis**
- **Toxicogenomics and risk assessment**

### Medical Statistics and Bio Informatics

- **COMICZ**
- **Development and application of statistical models for medical scientific research**
- **Molecular Epidemiology**

### Neuro-pharmacology

- **No programme related research**
- **Stress hormones and brain function**

### Clinical Genetics
50800  No programme related research
50801  Genetics of disease, diagnosis and treatment
50802  Hereditary cancer genetics
50803  Genomics, population genetics and bioinformatics