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ANALYSING FUNDING PATTERNS AND THEIR EVOLUTION IN TWO MEDICAL RESEARCH TOPICS

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This paper analyses funding patterns and their evolution in two medical research topics: breast cancer and ovarian cancer, taking into account cross-agency and cross-national co-funding. A bibliometric analysis of 355,463 papers from *PubMed* (273,526 on breast cancer and 81,937 on ovarian cancer) brought back 91 funding agencies involved in breast cancer and 65 in ovarian cancer. Additionally, the article examined the evolution of Medical Subject Headings (MESH) funded by agencies. An analysis of patterns in funding, co-funding, MESH, and their evolution, was carried out using Social Network Analysis (SNA) methodology. The results show the importance of the National Cancer Institute (NCI) in both breast and ovarian cancer. The NCI achieves its policy goals by co-funding its programmes with both national and cross-national agencies. Moreover, the MESH that agencies co-funded in the two years studied coincided; however, it must be said that the number of agencies which participated in research funding also increased.

Keywords: co-funding research; Medical Subject Headings (MESH); cancer research; social network analysis.

1. Introduction

There are a number of open questions to be analysed regarding the role of funding agencies in the production of scientific activity. The first question concerns the role of research funding agencies in the selection and prioritisation of research topics deserving further funding. The second question concerns how funding agencies accomplish their policy objectives in tandem with other research funders. Although separate funding agencies wish to work together, obstacles occur as a result of agency preferences, national and organisational boundaries, and the nature of the funding instruments used. A third question therefore centres on the obstacles encountered by research funding agencies when funding scientific research, given the different cultures, objectives, and instruments found in cross-funding recipients.

This paper helps to address some of these questions by using funding acknowledgements from a national medical funding database. Although there is a growing availability of this data, there is still a relative lack of empirical papers which utilise this information [Vanderelst and Speybroeck (2013); Zhou and Tian (2014); Tahmooresnejad et al. (2014)]. Yet, thanks to this data we are able to investigate a number of questions, including the co-funding patterns of research agencies, and how funding differs according to topics and domains. Finally, this novel source of information enables us to dig deeper into the role of capstone funding agencies in creating a larger ecology of funders and principal investigators.

We investigated these questions and this data using two medical research topics selected from the *PubMed* database. The paper is organised as follows. Section 2 provides a short literature review of some of the key questions underlying the production of scientific knowledge through research funding and funding agencies. Section 3 provides a methodological review of specific methods used to investigate these questions. Section 4 details the data, and its cleaning and extraction. Section 5 shows the results of social network analysis and co-word analysis of the database. The paper concludes in section 6 with recommendations and topics for future research.

2. Literature Review

The processes of selecting, prioritising and funding specific areas in science are complex and varied. There are no palimpsests to be read which describe the key issues to be addressed through science, or the needs of society which might be met through scientific funding. Any effort to select topics for further funding must meet a balance of external and internal criteria [Weinberg (1963)]. External criteria include the perceived need and value of research in society. Internal criteria involve maintaining a pipeline of viable research, as well as a stable of scientific talent across the entirety of the life cycle.

Access to funding is a matter of governance, addressed like many other societal questions from the viewpoint of the use of scarce resources [Cunningham (2007)]. Direct societal and citizen input into scientific funding occurs through science advisory councils [Brickman and Rip (1979)]. Nonetheless, even this mechanism has changed over time given the general availability of funding and changing public attitudes towards public funding for science and technology. The military is a common sponsor of science in a broad range of disciplines. The specific purpose of military funding is to develop weapons, or further foreign policy objectives [Doel (2003)]. The extent to which science is funded by the state as a public good is part of a larger political agenda waged between larger, self-sufficient corporations and smaller firms with limited resources [Lassman (2005)]. A new economics of science questions the allocative efficiency of funding agencies as a means towards providing a broader, conceptual framework for analysing science and its funding [Dasgupta and David (1994)].

Science is increasingly a polycentric activity, funded by a variety of different actors for a variety of different purposes. In the developed world, national governments and their respective agencies are not necessarily the dominant source for funding science and technology. This has arisen as a result of a decline in national funding in the wake of the Cold War, as well as an increase in private-sector funding. The consequence of this is that public science is produced from an amalgam of different sources, providing funding with different purposes, different terms, and differing conditions.

Transdisciplinary research thrives in the boundaries between different organisations, as well as in the formulation and translation of research to meet the varied needs of society [Nowotny et al. (2003)]. Despite the opportunities that are created by new modes of knowledge production, care is still needed in selecting from a diverse portfolio of potential research topics [Stirling (2007)]. Explicit attention is necessary in enhancing overall participation and deliberation concerning the selection of research. An amalgamation of funding can lead to a lack of inter-agency coordination, and certainly introduces new modes of potential system failure [Negro et al. (2012)]. Overweening failure, to which even centralised agencies are subject, is a premature lock-in into undesirable or inefficient forms of technology [Cowan (1991)]. This problem is exacerbated when research funding is scarce, and scientific choice is thereby restricted.

Funding agencies face obstacles in the selection of research projects. These obstacles emerge out of hard and soft institutional rules. Epistemic boundaries on funding occur given the specific objectives of the funding agency, which may limit the kinds of science it is funding. There are also agency problems – the agency may find it difficult to effectively evaluate certain kinds of knowledge with which it is not familiar. National or geographical limits on funding can also occur given the specific mission of the

agency. Other obstacles occur because of differing incentives between the funding agency and the respective scientific organisations which receive funding. These kinds of obstacles exist between funding agencies and funded organisations, but they also manifest themselves as challenges on which funding agencies need to work together towards common interests.

The issue of funding obstacles has been addressed in part by the Dutch school of geography, which addresses and generalises the concept of proximity. Proximity entails geographical factors, but also includes epistemic and institutional factors as well [Cunningham and Werker (2012)]. These funding obstacles are partly considered within extensive literature on technology transfer. Literature highlights the many contingent factors under which funding is successful, and technological knowledge is then transferred [Bozeman (2000)]. Nonetheless, and despite these hurdles, the importance of publically funded science for the production of new technology is well documented [Narin et al. (1997)].

Despite renewed calls to set forth an agenda for research into scientific policy [Sutherland et al. (2012)], the three questions set forth here have received relatively little coherent attention in literature. There is an even greater gap when it comes to systematic and empirical evidence for how scientific networks are shaped by their funding. An exception is Lewison (1998) whose investigations centred on the diversity of research funding associated with research teams in medical research. Given this gap in the literature, an exploratory and empirical analysis of how epistemic networks are shaped by funding agencies, and how funding agencies find (or fail to find) common cause with other agencies, is of empirical and theoretical interest.

3. Methodology

Bibliometric and scientometric analysis are common in the representation of science maps in literature reviews, including medical literature reviews [Zhang et al. (2013); Ramlogan and Consoli (2014)]. Measures like co-authorship and co-word analyses are frequently used to analyse data. Moreover, the Social Network Analysis (SNA) methodology is also used to find out who the main research actors are, whether people, institutions, or countries. The technique is also used to reveal cooperation between actors, and keyword co-occurrence. This constellation of metrics is very helpful in understanding how knowledge evolves in a specific field.

The measures from Social Network Analysis usually employed in literature reviews are centrality, including degree centrality, closeness and betweenness. Moreover, statistical analyses, such as cluster detection and multidimensional scaling, are also applied to group together words, authors, and institutions. *Degree* centrality, in the case of variables organised in 1-mode matrix, represents the most important nodes in the network, that is, nodes that have the largest number of connections (links) with other nodes. *Closeness* defines the average distance between one node and other nodes [Borgatti et al. (2013)], and *betweenness* indicates whether a node is frequently located on paths between other nodes [Kolaczyk (2009)]. An additional measure for networks, which is useful in a dense network, is *clique* detection. A clique is a sub-network with three nodes or more [de Nooy et al. (2012)] in which all actors are directly connected to all others [Hanneman and Riddle (2011)].

Bibliometric and scientometric analyses and SNA are often complemented with the visualisation of networks, a tool which helps to reveal key information about the network [Ozcan and Islam (2013); Feng et al. (2015)]. Tools for visualising networks have been developed over the last few years, both in commercial and free formats [van Eck and Waltman (2010); Cobo et al. (2011); Light et al. (2014)]. These tools, like VOSViewer [van Eck and Waltman (2010)] and Gephi [Bastian et al. (2009)], also allow researchers to apply measures and models to analyse nodes and links, including centrality measures and clustering.

Collaborative network analysis has been employed to study relationships between authors and organisations in many different disciplines [Kumar and Jan (2013); Qiu et al. (2014)]. In the case of

health, there are studies in which data about collaboration comes from academic papers [Catalá-López et al. (2014); Andersen et al. (2015)], whilst in other studies these come from website inter-linkages [Barreto Lang et al. (2013)].

Co-words and co-keyword analysis are also measures used in papers where bibliometric and scientometric analyses are applied as the main methodology [Neff and Corley (2009); Yu et al. (2013)]. The analysis of words in the titles and abstracts of papers is described as a useful instrument by Leydesdorff and Zaal (1988), because authors are precise in their selection of words. In the case of keywords, authors have also stressed the use of co-word analysis as an option to display and map the literature in a particular scientific field [Zhang et al. (2012); Ravikumar et al. (2015)].

In the field of medical research, the use of MESH appears when the PubMed database is used as the source of papers that researchers use to obtain data. For example, Siqueiros-García et al. (2014) utilised network analysis to evaluate differences in the number of nodes (MESH) and edges between periods. They used 1-mode networks and calculated centrality measures, average shortest path length and number of neighbours. With these measures, they observed which MESH gained in connectivity with others over time. However, other authors like Zhang et al. (2012) preferred to make queries in the Web of Science instead of in more specialised databases, such as PubMed.

The use of information in acknowledgments is less common than the use of citations. As a consequence, there is a lack of papers examining funding agencies which appear in acknowledgements [Vanderelst and Speybroeck (2013); Zhou and Tian (2014); Tahmooresnejad et al. (2015)]. This is the reason behind this paper as it aims to cover the gap in the analysis of funding agencies through acknowledgements in papers. To achieve this, our efforts centred on finding the answers to three questions:

Q1: How did co-funding patterns differ between 2003 and 2013?

Q2: How do funding patterns differ depending on NCI involvement and cross-national co-funding?

Q3: How do funding patterns differ depending on the MESH that agencies fund?

4. Data

The *PubMed* database enabled us to obtain all the papers available in the two topics under study: ovarian cancer and breast cancer. These were analysed separately in order to find similarities and differences. The queries used are shown below:

a) Topic=("breast neoplasms"[MeSH] OR ("breast"[All Fields] AND "neoplasms"[All Fields]) OR "breast neoplasms"[All Fields] OR ("breast"[All Fields] AND "cancer"[All Fields]) OR "breast cancer"[All Fields]) AND ("2009/04/21"[PDat] : "2014/04/19"[PDat] AND cancer[sb])

b) Topic=("ovarian neoplasms"[MeSH] OR ("ovarian"[All Fields] AND "neoplasms"[All Fields]) OR "ovarian neoplasms"[All Fields] OR ("ovarian"[All Fields] AND "cancer"[All Fields]) OR "ovarian cancer"[All Fields]) AND cancer[sb]

Data on funding agencies was obtained from the acknowledgments that appeared in the papers. To obtain the names of the agencies appearing in these acknowledgements, the numbers of grants were cleaned using the software *VantagePoint* [Porter and Cunningham (2005)]. This software was also used to clean the MESH and obtain 1-mode matrixes for agency co-funding and MESH co-occurrence, and 2-mode networks for agency-by-MESH co-occurrence. *Ucinet6* software [Suominen (2014); Swar and Khan (2014); Kim et al. (2014)] was used for the Social Network Analysis.

Table 1 shows a summary of the records used in our analysis. Although information about funding depends on the period analysed (Figure 1), the database as a whole estimated that 18% of papers included information about funding agencies (Table 1). Network visualisation was carried out using Gephi

[Bastian et al. (2009)] and VOSViewer software [van Eck and Waltman (2010)], which was also utilised for clustering the MESH. A summary of the steps followed is shown below:

1. Queries made in PubMed.
2. Two files were downloaded in text format, one for each topic, imported in VantagePoint software.
3. The information in acknowledgements was cleaned to extract research agencies using VantagePoint software.
4. A sub-data set was created for the years spanning from 2003 to 2013 for each topic using VantagePoint software.
5. For each year and topic, the agencies and MESH were listed to obtain relevant records and order the relevant records by importance, using VantagePoint software.
6. The matrices for each year and topic were developed, creating agency-by-agency, MESH-by-agency and MESH-by-MESH matrices, using VantagePoint software.
7. Centrality measures were calculated using Ucinet6.
8. Networks of co-funding agencies were visualised using Gephi.
9. The MESH were clustered and networks were visualised using VOSViewer.

Table 1. Summary of data used in the analysis

	Med1 (ovarian cancer)	Med 2 (breast cancer)
Total records	81,937	273,526
Records that included funding details	14,560 (17.77%)	48,948 (17.9%)
Number of funding agencies	65	91
Funding agencies that coincide	63	63
Funding agencies that do not coincide	28	2

Source: own source from cleaned PubMed data

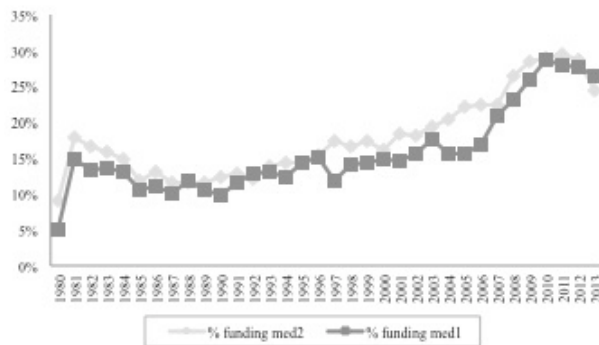


Fig. 1. Percentage of papers which give funding information by year. Source: own source from cleaned PubMed data

5. Results

Once the data had been cleaned with VantagePoint software, the first results obtained showed that the majority of funding agencies for the two topics were located in the United States (about 80%), followed by the United Kingdom, Canada, Austria, Italy, Ireland, and in other European countries represented by the European Research Council.

Figures 2 to 5 show that the majority of the agencies funded breast cancer research first and then ovarian cancer research. Moreover, the number of agencies that funded research into both topics increased during the ten year period.

Table 2 features a summary of the most important results obtained from the Social Network Analysis. It is obvious that the National Cancer Institute (NCI) is the most important funding agency for the two medical topics and the two periods analysed. Degree centrality also shows the importance of the National Centre for Research Resources (NCRR) for both topics, while the National Institute of General Medical Sciences (NIGMS) was present in ovarian cancer and the Public Health Service (PHS) emerged in breast cancer. The betweenness centrality of the NCRR, NIGMS and NIMH is also important. These agencies are central nodes for those accessing the NCI. This is also the case of the WHI and NCPDCID (Figure 2). Therefore, in figures 2 to 5 we can see that the main differences between 2003 and 2013 depended on:

- a) The existence of cross-agency co-funding, and the appearance of the NCI as a co-funding agency,
- b) The existence of cross-national co-funding, and
- c) The number of participants involved in co-funding.

Table 2. Summary of Social Network Analysis. Centrality measures

	Med1 Y2003	Med1 Y2013	Med2 Y2003	Med2 Y2013
Network density	21.57%	18.5%	16.9%	23.6%
Centrality degree	NCI	NCI	NCI	NCI
	NIGMS	NCRR	NCRR	NCRR
	NCRR	NIGMS		PHS
Closeness	NCI	NCI	NCI	NCI
	NIGMS	NCRR	NCRR	NCRR
	NCRR	NIGMS		PHS
Betweenness				NIGMS
	NCI	NCI	NCI	NCI
	NCRR	NIGMS	NCRR	NIMH
				NIGMS

NCI: National Cancer Institute; NCRR: National Center for Research Resources; NIGMS: National Institute of General Medical Sciences; PHS: Public Health Service; NIMH: National Institute of Mental Health; Source: own source from cleaned PubMed data

5.1. Co-funded research into ovarian cancer

Figure 2 and Figure 3 represent the evolution in co-funded research into ovarian cancer between 2003 and 2013. It is evident that the number of agencies that funded research in this topic increased over the period, and the number of links between agencies expanded. In order to better analyse the number of links and their patterns, cliques were calculated for every network. Each participant in the clique had ties with the rest of nodes which made up the clique.

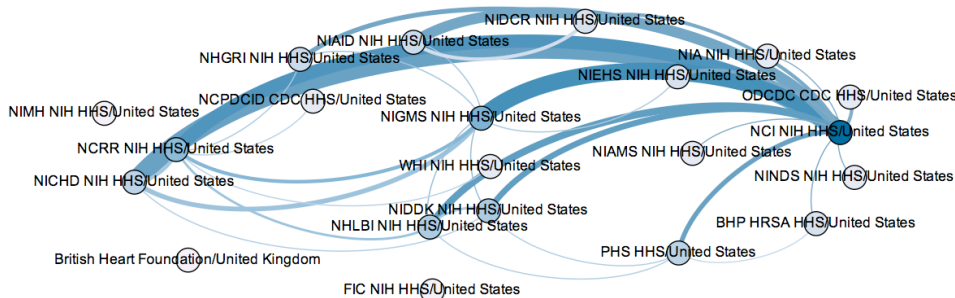


Fig. 2. Co-funded research into ovarian cancer in 2003. Visualisation using Gephi software. Nodes: 21; links: 33. Source: own source from cleaned PubMed data

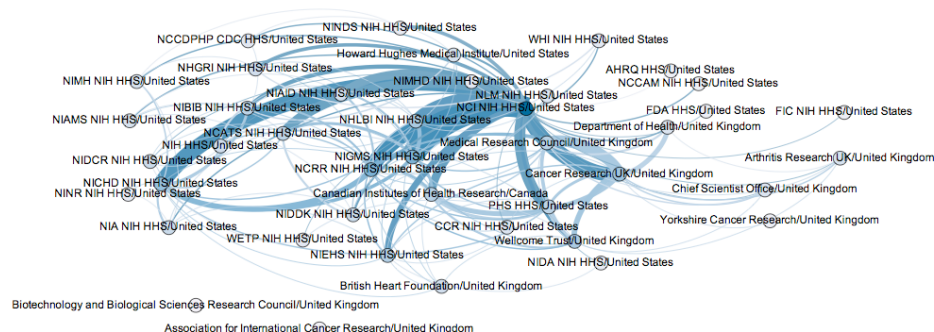


Fig.3. Co-funded research into ovarian cancer in 2013. Visualisation using Gephi software. Nodes: 42; links: 144. Source: own source from cleaned PubMed data

Next, we calculated the cliques where there were more than three funding organisations. We found 10 cliques for ovarian cancer in 2003 and 38 cliques in 2013:

1. NCI NIH HHS/United States; NICHD NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States.
2. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; NHLBI NIH HHS/United States.
3. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; NHGRI NIH HHS/United States.
4. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIAID NIH HHS/United States.
5. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NIDDK NIH HHS/United States.
6. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States.
7. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIEHS NIH HHS/United States.
8. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; PHS HHS/United States.
9. NCI NIH HHS/United States; PHS HHS/United States; BHP HRSA HHS/United States.
10. NCI NIH HHS/United States; NIAID NIH HHS/United States; NIDCR NIH HHS/United States.

We use the term clique in the strictest sense of the word, which means that each participant in the clique has ties with the rest of nodes which form the clique. When comparing the year 2003 with 2013 we can see that agencies that were not directly connected to the NCI in the network in 2003 do not appear in any clique (WHI and NCPDCID). However, while some agencies were not connected directly to the NCI in 2013, they do appear in cliques (NINR, British Heart Foundation). In addition, in 2003 the NCI was involved in every clique, while in 2013 it only appeared in 35 cliques (92% of cliques). Moreover, in 2003 all the cliques were formed by United States agencies, while in 2013 we observe that 11 cliques incorporated cross-national co-funding (28.9% of cliques). The nations involved in these 11 cliques were United States, Canada and United Kingdom (these three nations appeared in four cliques, United States and United Kingdom in six cliques, and United States and Canada in one clique). We only included the

cliques where cross-nation funding appeared. The complete results about cliques can be consulted in Annex 1.

- C1: NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; NIEHS NIH HHS/United States.
- C4: NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; Cancer Research UK/**United Kingdom**; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; Medical Research Council/**United Kingdom**; PHS HHS/United States; Wellcome Trust/**United Kingdom**.
- C5: NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; Cancer Research UK/**United Kingdom**; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; NIEHS NIH HHS/United States.
- C10: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; NIGMS NIH HHS/United States; NIDDK NIH HHS/United States.
- C13: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Department of Health/**United Kingdom**; Arthritis Research UK/**United Kingdom**.
- C28: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Wellcome Trust/**United Kingdom**; Chief Scientist Office/**United Kingdom**.
- C31: NCI NIH HHS/United States; Wellcome Trust/**United Kingdom**; NIDCR NIH HHS/United States; WETP NIH HHS/United States.
- C33: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Wellcome Trust/**United Kingdom**; Arthritis Research UK/**United Kingdom**.
- C35: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; CCR NIH HHS/United States.
- C36: Canadian Institutes of Health Research/**Canada**; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; British Heart Foundation/**United Kingdom**.
- C37: Canadian Institutes of Health Research/**Canada**; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; Wellcome Trust/**United Kingdom**; British Heart Foundation/**United Kingdom**.

For co-funding in ovarian cancer, we can conclude that:

- a) In 2003, the NCI was involved in every clique, while in 2013 it appeared in 35 cliques (92% of all cliques).
- b) In 2003, all of the cliques were formed by United States agencies, while in 2013 we observe that 11 cliques incorporated cross-national co-funding (28.9% of cliques).
- c) The nations involved in these 11 cliques were United States, Canada and United Kingdom. These three nations appeared in four cliques, United States and United Kingdom in six cliques, and United States and Canada in one clique.

5.2. Co-funded research into ovarian cancer

Figure 4 and Figure 5 represent the evolution in co-funded research into breast cancer between 2003 and 2013. It is clear that the number of agencies that funded research into this topic increased over the period, and that the number of links between agencies grew, as the cliques illustrate. It is important to point out that the agencies that were only related to the NCI in 2003 appeared to be connected to more agencies in 2013, demonstrating that links between agencies increased over the period. This is shown in Figures 4 and 5.

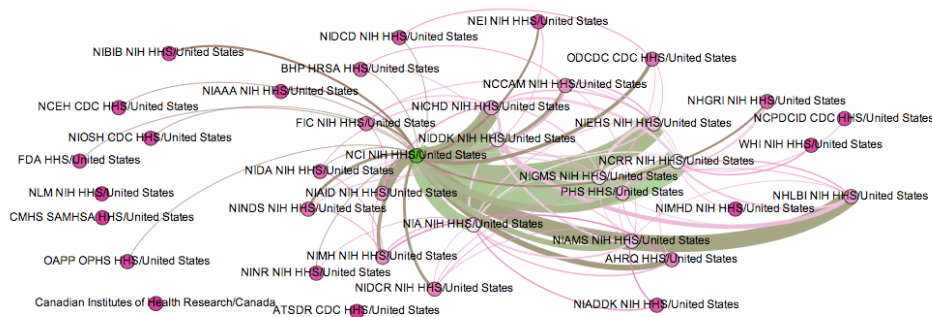


Fig.4. Co-funded research into breast cancer in 2003. Visualisation using Gephi software. Nodes: 38; links: 95. Source: own source from cleaned PubMed data

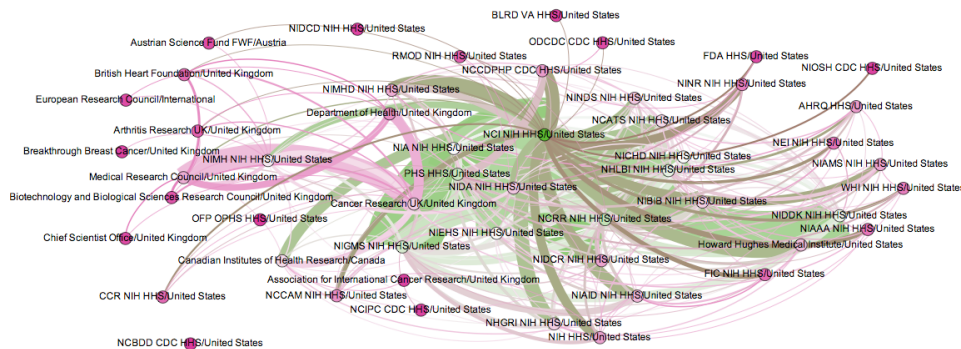


Fig.5. Co-funded research into breast cancer in 2013. Visualisation using Gephi software. Nodes: 51; links: 278. Source: own source from cleaned PubMed data

In terms of breast cancer, there were 32 cliques which featured more than three funding organisations in 2003, whilst this rose to 70 in 2013:

1. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; NIGMS NIH HHS/United States; NICHD NIH HHS/United States.
2. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; NIGMS NIH HHS/United States; NIA NIH HHS/United States.
3. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; PHS HHS/United States.
4. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; NCCAM NIH HHS/United States.
5. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; NHLBI NIH HHS/United States.
6. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; PHS HHS/United States.
7. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NIGMS NIH HHS/United States; NHLBI NIH HHS/United States; NIAMS NIH HHS/United States.
8. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NIGMS NIH HHS/United States; NIA NIH HHS/United States; NIAMS NIH HHS/United States.
9. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; PHS HHS/United States; NIAMS NIH HHS/United States.

10. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NIAMS NIH HHS/United States; NCCAM NIH HHS/United States.
11. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NEI NIH HHS/United States.
12. NCI NIH HHS/United States; NIDDK NIH HHS/United States; NCCAM NIH HHS/United States; BHP HRSA HHS/United States.
13. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NICHD NIH HHS/United States; NIAID NIH HHS/United States.
14. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIA NIH HHS/United States; NIAID NIH HHS/United States.
15. NCI NIH HHS/United States; PHS HHS/United States; NIAID NIH HHS/United States.
16. NCI NIH HHS/United States; NIA NIH HHS/United States; NIAID NIH HHS/United States; NIMH NIH HHS/United States.
17. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIAID NIH HHS/United States; FIC NIH HHS/United States.
18. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIA NIH HHS/United States; AHRQ HHS/United States.
19. NCI NIH HHS/United States; NIA NIH HHS/United States; AHRQ HHS/United States; NIMH NIH HHS/United States.
20. NCI NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; AHRQ HHS/United States.
21. NCI NIH HHS/United States; NIEHS NIH HHS/United States; NIGMS NIH HHS/United States; ODCDC CDC HHS/United States.
22. NCI NIH HHS/United States; ODCDC CDC HHS/United States; NIDCD NIH HHS/United States.
23. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; NHGRI NIH HHS/United States.
24. NCI NIH HHS/United States; NIMH NIH HHS/United States; NIDA NIH HHS/United States.
25. NCI NIH HHS/United States; NIMH NIH HHS/United States; NINDS NIH HHS/United States.
26. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIAMS NIH HHS/United States; NINDS NIH HHS/United States.
27. NCI NIH HHS/United States; NHLBI NIH HHS/United States; PHS HHS/United States; NIAMS NIH HHS/United States; NIDCR NIH HHS/United States.
28. NCI NIH HHS/United States; NIA NIH HHS/United States; NIAMS NIH HHS/United States; NIDCR NIH HHS/United States.
29. NCI NIH HHS/United States; NIEHS NIH HHS/United States; NICHD NIH HHS/United States; FIC NIH HHS/United States.
30. NCI NIH HHS/United States; NIA NIH HHS/United States; NINR NIH HHS/United States.
31. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIDA NIH HHS/United States.
32. NIA NIH HHS/United States; NIAMS NIH HHS/United States; NIADDK NIH HHS/United States.

A comparison of 2003 and 2013 reveals the importance of the NCI, which appeared in 31 cliques in 2003 and in 67 in 2013. Moreover, in 2003 all the cliques were formed by United States agencies, while in 2013 we can see that 25 cliques incorporated cross-national co-funding (36% of cliques). The nations involved in these 25 cliques were United States, Canada, United Kingdom, Austria and the European Research Council (United States and Canada appeared in 12 cliques; United States and United Kingdom in seven cliques; United States, United Kingdom and Canada in four cliques; United States and Austria in one clique; and United States, United Kingdom and the European Research Council in one clique). We only included the cliques where cross-national funding appeared. The complete results about cliques can be consulted in Annex 2.

- C11: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NIAID NIH HHS/United States.
- C12: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NIDCR NIH HHS/United States.
- C13: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NCCAM NIH HHS/United States.
- C14: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NHGRI NIH HHS/United States.
- C15: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NCCAM NIH HHS/United States.
- C16: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NHGRI NIH HHS/United States; NIAID NIH HHS/United States.
- C22: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; Cancer Research UK/**United Kingdom**; NIEHS NIH HHS/United States.

- C23: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; Cancer Research UK/**United Kingdom**; NIA NIH HHS/United States.
- C24: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; Cancer Research UK/**United Kingdom**; Howard Hughes Medical Institute/United States.
- C25: NCI NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; Cancer Research UK/**United Kingdom**; NIEHS NIH HHS/United States; CCR NIH HHS/United States.
- C38: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIA NIH HHS/United States; NIAID NIH HHS/United States; NIDA NIH HHS/United States.
- C39: NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIEHS NIH HHS/United States; NIDA NIH HHS/United States.
- C44: NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; Cancer Research UK/**United Kingdom**; NIA NIH HHS/United States; Medical Research Council/**United Kingdom**.
- C45: NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; Cancer Research UK/**United Kingdom**; NIA NIH HHS/United States; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States.
- C46: NCI NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Department of Health/**United Kingdom**.
- C47: NCI NIH HHS/United States; NIGMS NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States; Department of Health/**United Kingdom**.
- C48: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States; Department of Health/**United Kingdom**; British Heart Foundation/**United Kingdom**.
- C49: NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Department of Health/**United Kingdom**; Arthritis Research UK/**United Kingdom**.
- C53: NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIA NIH HHS/United States; NIMH NIH HHS/United States; NIDA NIH HHS/United States.
- C57: NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIMH NIH HHS/United States; NHGRI NIH HHS/United States.
- C58: NCI NIH HHS/United States; NIMH NIH HHS/United States; Austrian Science Fund FWF/**Austria**.
- C61: NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NCCDPHP CDC HHS/United States.
- C63: NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NCCDPHP CDC HHS/United States.
- C68: Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States; Biotechnology and Biological Sciences Research Council/**United Kingdom**.
- C69: Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Chief Scientist Office/**United Kingdom**.
- C70: NIMH NIH HHS/United States; Department of Health/**United Kingdom**; **European Research Council**/International.

For co-funding in breast cancer, we can conclude that:

- a) The NCI is important, as it appeared in 31 cliques in 2003 and in 67 in 2013.
- b) In 2003, all of the cliques were formed by United States agencies, while in 2013 we observe that 25 cliques incorporated cross-national co-funding (36% of cliques).
- c) The nations involved in these 25 cliques were United States, Canada, United Kingdom, Austria and the European Research Council. United States and Canada appeared in 12 cliques; United States and United Kingdom in seven cliques; United States, United Kingdom and Canada in four cliques; United States and Austria in one clique; United States, United Kingdom and the European Research Council in one clique.

Table 3 summarises the main results for both types of cancer, indicating that the NCI is the most important agency in both cases; this has also been demonstrated with cliques. An important difference found between ovarian and breast cancer research is that in ovarian research cross-national co-funding between the United States and United Kingdom prevailed (6 cliques), while in breast research the dominant linkage occurred between United States and Canada (12 cliques).

Table 3. Summary of co-funded research patterns

	Med1 Y2003	Med1 Y2013	Med2 Y2003	Med2 Y2013
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Non co-funding agencies (isolated in network)	3	2	4	2
Cross-agency with NCI (number of cliques)	10/10	35/38	31/32	67/70
Cross-agency without NCI (number of cliques)	0	3	1	3
Cross-national co-funding (number of cliques)	0	11/38 (29%)	0	25/70 (36%)
		United States, Canada, United Kingdom		United States, Canada, United Kingdom, Austria, European Research Council

Source: own source from cleaned PubMed data

3.3. Evolution in the funding of MESH

This section analyses the most important medical subject headings (MESH) funded and the evolution of these terms in the two medical research fields under study. It then explores the headings which were most significant depending on the respective funding agency. In all the cases, only the terms with 50 records or more were selected.

The MESH that appeared in papers in which acknowledgments included agencies supporting research are shown in Tables 3 and 4. As there were too many terms, the tables only included the first 30 headings (by order of importance). In Table 3, the MESH for ovarian cancer research indicate that the five most common terms were the same for the two years analysed: “humans”, “female”, “middle-aged”, “adult”, and “aged”. However, if we compare 2013 to 2003, we can see that terms like “cell line, tumour”, “gene expression regulation”, and “cell proliferation” increased in importance over the period. However, terms like “male” and “immunohistochemistry” were less important in 2013 than in 2003. Table 4 shows that the five most important terms in breast cancer did not change between 2003 and 2013. These terms were “humans”, “female”, “middle-aged”, “adult” and “aged”. A comparison of the two reference years showed that the terms which became more popular in the list over the period were “cell line, tumour”, “young adult”, “cell proliferation”, “receptor, erbB-2/metabolism” and “receptors, oestrogen/metabolism”.

Table 3. Ranking of MESH for ovarian research in 2003 and 2013

Order	Records med1 Y2003	MESH	Order	Records med1 Y2013	MESH
1	2508	Humans	1	2541	Humans
2	2383	Female	2	2396	Female
3	902	Middle-Aged	3	960	Middle-Aged
4	832	Adult	4	817	Adult
5	655	Aged	5	714	Aged
19	148	Cell Line, Tumour	6	501	Cell Line, Tumour
6	356	Animals	7	430	Animals
10	230	Prognosis	8	327	Prognosis
14	188	Aged, 80 and over	9	318	Aged, 80 and over
7	286	Neoplasm Staging	10	317	Neoplasm Staging
13	199	Mice	11	289	Mice
8	280	Male	12	243	Male
16	163	Retrospective Studies	13	232	Retrospective Studies
			14	223	Young Adult
11	220	Treatment Outcome	15	203	Treatment Outcome
28	104	Gene Expression Regulation, Neoplastic	16	189	Gene Expression Regulation, Neoplastic

17	154	Risk Factors	17	184	Risk Factors
12	208	Immunohistochemistry	18	149	Immunohistochemistry
15	166	Adolescent	19	145	Adolescent
37	83	Disease-Free Survival	20	140	Disease-Free Survival
44	71	Follow-Up Studies	21	137	Follow-Up Studies
26	112	Mutation	22	135	Mutation
42	72	Case-Control Studies	23	125	Case-Control Studies
31	99	Survival Rate	24	125	Survival Rate
			25	123	Cell Proliferation/drug effects
			26	118	Neoplasm Grading
51	66	Mice, Nude	27	104	Mice, Nude
30	100	Drug Resistance, Neoplasm	28	102	Drug Resistance, Neoplasm
830	3	Cell Proliferation	29	101	Cell Proliferation
			30	101	Kaplan-Meier Estimate

Source: own source from cleaned PubMed data

Table 4. Ranking of MESH for ovarian research in 2003 and 2013

Order	Records med2 Y2003	MESH	Order	Records med2 Y2013	MESH
1	8810	Humans	1	8059	Humans
2	7141	Female	2	7083	Female
3	3375	Middle-aged	3	3033	Middle-aged
4	2687	Adult	4	2461	Adult
5	2463	Aged	5	2270	Aged
20	456	Cell Line, Tumour	6	1472	Cell Line, Tumour
7	1213	Animals	7	1430	Animals
6	1230	Male	8	1053	Male
12	658	Mice	9	967	Mice
9	833	Aged, 80 and over	10	935	Aged, 80 and over
11	728	Prognosis	11	876	Prognosis
10	814	Risk Factors	12	655	Risk Factors
14	552	Neoplasm Staging	13	640	Neoplasm Staging
13	598	Treatment Outcome	14	633	Treatment Outcome
19	478	Retrospective Studies	15	562	Retrospective Studies
23	362	Gene Expression Regulation, Neoplastic	16	561	Gene Expression Regulation, Neoplastic
320	3	Young Adult	17	515	Young Adult
1			18	504	MCF-7 Cells
24	347	Follow-Up Studies	19	495	Follow-Up Studies
			20	388	Cell Proliferation/drug effects
198	5	Cell Proliferation	21	357	Cell Proliferation
6					
15	550	Time Factors	22	353	Time Factors
16	538	Immunohistochemistry	23	342	Immunohistochemistry
22	373	Lymphatic Metastasis	24	341	Lymphatic Metastasis

When centrality measures were obtained, the terms with the highest degree centrality in 2003 were “humans”, “female”, “adult”, “middle-aged” and “aged”. In 2013, the terms with the highest degree were “humans”, “female”, “middle-aged”, “adult”, “cell line, tumour” and “aged”. As is the case of ovarian research, the prevalence of the term “cell line” grew in importance. Moreover, the degree centrality in agencies indicated which ones coincided in funding research in these areas. In 2003, agencies like the NCI, NIDDK, NHLBI, NIGMS, NCRR, and NIEHS coincided in the medical subject headings they funded. In 2013, concurrence occurred in the agencies NCI, NCRR, NIGMS, Canadian Institutes of Health Research, PHS and Cancer Research UK. These agencies also appeared together in the previously calculated cliques.

On the other hand, when comparing centrality measures in MESH-by-MESH networks represented in Figures 6 to 9 whose results appear in Tables 5 to 8, we can conclude that the most important terms in word co-occurrence were also those where agencies coincided most in funding.

Finally, we used VantagePoint software to obtain the MESH that were used in funded research papers in 2012 and those which started to be used in 2013. In the case of ovarian cancer, we found that terms like “cell division”, “neoplasm proteins/genetics”, “BRCA2 protein”, “tumour suppressor proteins”, “BRCA1 protein” and “receptor, erbB-2/immunology” were not included after 2012. For breast cancer, we detected this situation in terms like “tumour cell, cultured/drug effects”, BRCA2 Protein”, “Proto-Oncogen Proteins c-akt”, “Cell cycle proteins”, “aromatase proteins” and “carcinogens”. Headings first used in 2013 in ovarian cancer showed “adenocarcinoma, clear cell/ pathology”, “adenocarcinoma, mucinous/ pathology”, “cytodiagnosis”, “intestinal obstruction/ etiology/ surgery”, “laparoscopy/ adverse effects”, “ovarian neoplasms/ epidemiology/ pathology/ surgery”, “ovarian neoplasms/ pathology/ radiography/ surgery”, and “splenectomy”. In breast cancer, new MESH in year 2013 were, for example, “bone density conservation agents/ adverse effects”, “breast neoplasms, male/ diagnosis”, “breast neoplasms/ classification/ pathology/ surgery”, “genital neoplasms, female”, “mastectomy, subcutaneous/ methods”, “mastectomy/ mortality”, “muscle, skeletal/ transplantation”, and “neoplasm metastasis/ radiotherapy”.

Table 5. Ranking of MESH funded by agencies in 2003 for ovarian cancer.

NCI	NICHD	NCRR	NIGMS	NIAID
Humans (288)	Female (31)	Female (24)	Female (16)	Humans (12)
Female (267)	Humans (24)	Humans (18)	Humans (13)	Female (12)
Middle-aged (92)	Animals (14)	Animals (8)	Animals (9)	Animals (4)
Adult (80)	Mice (9)	Male (8)	Male (6)	Tumour Cells, Cultured (3)
Aged (75)	Male (6)	Middle-aged (7)	Tumour Cells, Cultured (5)	Cell Line, Tumour (3)
Animals (71)	Middle-aged (5)	Adult (7)	Mice (5)	Ovarian Neoplasms/metabolism/pathology (3)
Tumour Cells, Cultured (67)	Tumour Cells, Cultured (5)			
Mice (47)				
Male (44)				
Gene Expression Regulation, Neoplastic (29)				
Cell Line, Tumour (25)				

Source: Own source from cleaned PubMed data.

Table 6. Ranking of MESH funded by agencies in 2013 for ovarian cancer.

NCI	Canadian Institutes of Health Research	Cancer Research UK	NICHD	NIGMS	NCRR
Humans (357)	Humans (46)	Humans (45)	Female (44)	Humans (37)	Humans (34)
Female (340)	Female (45)	Female (45)	Humans (39)	Female (32)	Female (31)
Middle-aged (127)	Cell Line, Tumour (19)	Middle-aged (24)	Animals (20)	Cell Line, Tumour (17)	Cell Line, Tumour (12)
Animals (113)	Animals (16)	Aged (17)	Adult (12)	Animals (10)	Middle-aged (9)
Aged (105)	Mice (13)	Adult (15)	Mice (12)	Gene Expression Regulation, Neoplastic (9)	Animals (9)
Cell Line, Tumour (104)	Mutation (11)	Genetic Predisposition to Disease (14)	Cell Line, Tumour (8)	Mice (7)	Ovarian Neoplasms/genetics (7)
Mice (93)	Middle-aged (9)	Prognosis (9)	Risk Factors (8)	Mutation (6)	Mice (6)
Adult (85)	Genetic Predisposition to Disease (9)	Risk Factors (9)	Middle-aged (7)	Signal Transduction (6)	
Aged, 80 and over (51)	Polymorphism, Single Nucleotide (8)	Case-Control Studies (9)	Young Adult (6)		
Prognosis (49)	Gene Expression Profiling (7)	Polymorphism, Single Nucleotide (9)			
Gene Expression Regulation, Neoplastic (46)	Ovarian Neoplasms/genetics/pathology (6)	BRCA2 Protein/genetics (9)			
Male (45)	Genotype (6)				

Source: Own source from cleaned PubMed data.

Table 7. Ranking of MESH funded by agencies in 2003 for breast cancer.

NCI	NIDDK	NCRR	NIEHS	NIGMS	NICHD
Humans (1114)	Humans (68)	Humans (55)	Humans (55)	Humans (55)	Humans (42)
Female (823)	Female (39)	Female (50)	Female (32)	Female (34)	Female (38)
Middle-aged (353)	Animals (32)	Animals (21)	Animals (21)	Animals (28)	Animals (17)
Animals (313)	Tumour Cells, Cultured (24)	Middle-aged (18)	Tumour Cells, Cultured (21)	Tumour Cells, Cultured (16)	Adult (12)
Adult (302)	Mice (19)	Adult (16)	Mice (13)	Mice (15)	Tumour Cells, Cultured (10)
Aged (265)	Transfection (14)	Aged (13)			Mice (10)
Tumour Cells, Cultured (223)	Male (13)	Tumour Cells, Cultured (13)			
Mice (220)	Molecular Sequence Data	Mice (11)			

	(10)	
Male		Male
(146)		(10)
Cell Line,		
Tumour		
(126)		
Risk Factors		
(125)		
Case-Control		
Studies		
(102)		
Time Factors		
(100)		

Source: Own source from cleaned PubMed data

Table 8. Ranking of MESH funded by agencies in 2013 for breast cancer.

NCI	NCRR	NIGMS	Canadian Inst. of Health Res.	PHS	Cancer Research UK
Humans (1164)	Humans (146)	Humans (132)	Humans (97)	Humans (98)	Humans (111)
Female (1018)	Female (130)	Female (95)	Female (80)	Female (87)	Female (102)
Animals (395)	Middle-aged (58)	Animals (61)	Animals (44)	Middle-aged (39)	Middle-aged (38)
Middle-aged (384)	Adult (50)	Cell Line, Tumour (56)	Mice (35)	Aged (39)	Aged (30)
Cell Line, Tumour (351)	Aged (48)	Mice (49)	Cell Line, Tumour (34)	Adult (35)	Adult (29)
Mice (322)	Cell Line, Tumour (39)	Gene Expression Regulation, Neoplastic (24)	Middle-aged (24)	Male (18)	Animals (22)
Adult (313)	Animals (39)		Aged (20)		Cell Line, Tumour (19)
Aged (304)	Mice (32)		Adult (18)		Mice (19)
Risk Factors (132)	Prognosis (19)		Male (18)		
Gene Expression Regulation, Neoplastic (129)	Gene Expression Regulation, Neoplastic (18)				
Male (122)					
Aged, 80 and over (117)					
Prognosis (105)					

Source: Own source from cleaned PubMed data

6. Conclusions

In this paper, we have analysed the patterns of co-funded research in two medical topics and demonstrated how this pattern varies depending on cross-agencies and cross-national collaboration in funding. Moreover, we have studied the relationship between funding agencies and the medical subject headings they set out to fund. The paper contributes, in an empirical and exploratory manner, to a growing body of knowledge concerning the production of knowledge, and how this knowledge is produced and affected by the choices and instruments of funding agencies.

Furthermore, co-funding research analysis gives researchers a thorough insight into the most important institutions that support research in a particular topic, and shows the mediator agencies to be contacted when it is difficult to achieve a direct link with a funding star --which in our analysis is the NCI. Moreover, we can also observe which countries are most directly linked to the United States, and which are better positioned, depending on the topic. For example, if we were trying to look for a mediator in ovarian cancer, we would find more opportunities in United Kingdom; if the topic were breast cancer, we would find our mediator in Canada.

In this paper, we have also detected a trend in agencies to coincide with the MESH they fund. Nonetheless, it is difficult to determine whether they fund these headings because of their importance, or if they become important because agencies fund them. This is an important area for further research. Furthermore, it is readily apparent that agencies, by and large, do not work together.

Analysing a medical bibliography involves difficulties, as we have encountered in our data processing. For example, although the *PubMed* database allowed us to download all the data quickly, cleaning the acknowledgement data took a long time. As the data included the project, the funding agencies, as well as other information, we had to delete the unnecessary data on a project-by-project basis. Another important difficulty was related to limits in working with a large amount of data with VantagePoint and Windows; fortunately we were able to solve this.

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Annex 1. Cliques in 2013 for ovarian cancer

1. NCI NIH HHS/United States; Canadian Institutes of Health Research/Canada; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; NIEHS NIH HHS/United States.
2. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NCATS NIH HHS/United States; NHLBI NIH HHS/United States.
3. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NIH HHS/United States.
4. NCI NIH HHS/United States; Canadian Institutes of Health Research/Canada; Cancer Research UK/United Kingdom; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; Medical Research Council/United Kingdom; PHS HHS/United States; Wellcome Trust/United Kingdom.
5. NCI NIH HHS/United States; Canadian Institutes of Health Research/Canada; Cancer Research UK/United Kingdom; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; PHS HHS/United States; NIEHS NIH HHS/United States.
6. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; NIAID NIH HHS/United States.
7. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; NHGRI NIH HHS/United States.
8. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; NLM NIH HHS/United States.
9. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCATS NIH HHS/United States; NHLBI NIH HHS/United States; NIDDK NIH HHS/United States.
10. NCI NIH HHS/United States; Cancer Research UK/United Kingdom; NIGMS NIH HHS/United States; NIDDK NIH HHS/United States.
11. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NHLBI NIH HHS/United States; Howard Hughes Medical Institute/United States.
12. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIMHD NIH HHS/United States.
13. NCI NIH HHS/United States; Cancer Research UK/United Kingdom; Medical Research Council/United Kingdom; Department of Health/United Kingdom; Arthritis Research UK/United Kingdom.
14. NCI NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; NIAID NIH HHS/United States; NIBIB NIH HHS/United States.
15. NCI NIH HHS/United States; NICHD NIH HHS/United States; NCRR NIH HHS/United States; NHLBI NIH HHS/United States; NIBIB NIH HHS/United States.
16. NCI NIH HHS/United States; NICHD NIH HHS/United States; NCRR NIH HHS/United States; NIBIB NIH HHS/United States; NIH HHS/United States.
17. NCI NIH HHS/United States; NHLBI NIH HHS/United States; NIBIB NIH HHS/United States; Howard Hughes Medical Institute/United States.
18. NCI NIH HHS/United States; NIBIB NIH HHS/United States; Howard Hughes Medical Institute/United States; NCCDPHP CDC HHS/United States.
19. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIBIB NIH HHS/United States; NIDCR NIH HHS/United States; NIH HHS/United States.
20. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIEHS NIH HHS/United States; NIA NIH HHS/United States.
21. NCI NIH HHS/United States; NICHD NIH HHS/United States; NCATS NIH HHS/United States; NIA NIH HHS/United States.
22. NCI NIH HHS/United States; NICHD NIH HHS/United States; NIA NIH HHS/United States; NIMH NIH HHS/United States.
23. NCI NIH HHS/United States; NCATS NIH HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States.

24. NCI NIH HHS/United States; NCATS NIH HHS/United States; NIDDK NIH HHS/United States; NIAMS NIH HHS/United States.
25. NCI NIH HHS/United States; NCRR NIH HHS/United States; NCATS NIH HHS/United States; NIAMS NIH HHS/United States.
26. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIAID NIH HHS/United States; NIAMS NIH HHS/United States.
27. NCI NIH HHS/United States; NINDS NIH HHS/United States; NIMH NIH HHS/United States.
28. NCI NIH HHS/United States; Cancer Research UK/United Kingdom; Medical Research Council/United Kingdom; Wellcome Trust/United Kingdom; Chief Scientist Office/United Kingdom.
29. NCI NIH HHS/United States; NIEHS NIH HHS/United States; NIDA NIH HHS/United States.
30. NCI NIH HHS/United States; NICHD NIH HHS/United States; NCATS NIH HHS/United States; NIDCR NIH HHS/United States.
31. NCI NIH HHS/United States; Wellcome Trust/United Kingdom; NIDCR NIH HHS/United States; WETP NIH HHS/United States.
32. NCI NIH HHS/United States; NHGRI NIH HHS/United States; NIMH NIH HHS/United States.
33. NCI NIH HHS/United States; Cancer Research UK/United Kingdom; Medical Research Council/United Kingdom; Wellcome Trust/United Kingdom; Arthritis Research UK/United Kingdom.
34. NCI NIH HHS/United States; NHLBI NIH HHS/United States; NHGRI NIH HHS/United States; WHI NIH HHS/United States.
35. NCI NIH HHS/United States; Cancer Research UK/United Kingdom; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; CCR NIH HHS/United States.
36. Canadian Institutes of Health Research/Canada; NICHD NIH HHS/United States; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; NIEHS NIH HHS/United States; British Heart Foundation/United Kingdom.
37. Canadian Institutes of Health Research/Canada; NIGMS NIH HHS/United States; NCRR NIH HHS/United States; Wellcome Trust/United Kingdom; British Heart Foundation/United Kingdom.
38. NICHD NIH HHS/United States; NIA NIH HHS/United States; NINR NIH HHS/United States.

Annex 2. Cliques in 2013 for breast cancer

1. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NCATS NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIMHD NIH HHS/United States.
2. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NCATS NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIDCR NIH HHS/United States.
3. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIEHS NIH HHS/United States; NCATS NIH HHS/United States; NIBIB NIH HHS/United States; NICHD NIH HHS/United States.
4. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIEHS NIH HHS/United States; NICHD NIH HHS/United States; NHGRI NIH HHS/United States.
5. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIEHS NIH HHS/United States; NIBIB NIH HHS/United States; NICHD NIH HHS/United States; NINDS NIH HHS/United States.
6. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIDCR NIH HHS/United States; NINDS NIH HHS/United States.
7. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NHGRI NIH HHS/United States; NIAID NIH HHS/United States; Howard Hughes Medical Institute/United States.
8. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIA NIH HHS/United States; NIAID NIH HHS/United States.
9. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NCATS NIH HHS/United States; NIBIB NIH HHS/United States; Howard Hughes Medical Institute/United States.
10. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIBIB NIH HHS/United States; NINDS NIH HHS/United States; Howard Hughes Medical Institute/United States.
11. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/Canada; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NIAID NIH HHS/United States.
12. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/Canada; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NIDCR NIH HHS/United States.
13. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/Canada; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NCCAM NIH HHS/United States.
14. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/Canada; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NHGRI NIH HHS/United States.
15. NCI NIH HHS/United States; NCRR NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/Canada; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NCCAM NIH HHS/United States.

48. NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States; Department of Health/**United Kingdom**; British Heart Foundation/**United Kingdom**.
49. NCI NIH HHS/United States; Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Department of Health/**United Kingdom**; Arthritis Research UK/**United Kingdom**.
50. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCATS NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States; NIMHD NIH HHS/United States.
51. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States; NIMHD NIH HHS/United States; NIDA NIH HHS/United States.
52. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States; NINDS NIH HHS/United States; NIDA NIH HHS/United States.
53. NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIA NIH HHS/United States; NIMH NIH HHS/United States; NIDA NIH HHS/United States.
54. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NIBIB NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States; NINDS NIH HHS/United States; NIDA NIH HHS/United States.
55. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NCATS NIH HHS/United States; NIBIB NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States.
56. NCI NIH HHS/United States; NIGMS NIH HHS/United States; NICHD NIH HHS/United States; NIMH NIH HHS/United States; NHGRI NIH HHS/United States.
57. NCI NIH HHS/United States; NIGMS NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; NIMH NIH HHS/United States; NHGRI NIH HHS/United States.
58. NCI NIH HHS/United States; NIMH NIH HHS/United States; Austrian Science Fund FWF/**Austria**.
59. NCI NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NCCDPHP CDC HHS/United States.
60. NCI NIH HHS/United States; PHS HHS/United States; NIA NIH HHS/United States; NICHD NIH HHS/United States; NCCDPHP CDC HHS/United States; NINR NIH HHS/United States.
61. NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIA NIH HHS/United States; NCCDPHP CDC HHS/United States.
62. NCI NIH HHS/United States; PHS HHS/United States; NIDDK NIH HHS/United States; NHLBI NIH HHS/United States; NIEHS NIH HHS/United States; NICHD NIH HHS/United States; NCCDPHP CDC HHS/United States.
63. NCI NIH HHS/United States; Canadian Institutes of Health Research/**Canada**; PHS HHS/United States; NIDDK NIH HHS/United States; NIEHS NIH HHS/United States; NCCDPHP CDC HHS/United States.
64. NCI NIH HHS/United States; NCCDPHP CDC HHS/United States; ODCDC CDC HHS/United States.
65. NCI NIH HHS/United States; PHS HHS/United States; NHLBI NIH HHS/United States; NIEHS NIH HHS/United States; NICHD NIH HHS/United States; NHGRI NIH HHS/United States; WHI NIH HHS/United States.
66. NCI NIH HHS/United States; PHS HHS/United States; NHLBI NIH HHS/United States; NIAMS NIH HHS/United States; WHI NIH HHS/United States.
67. NCI NIH HHS/United States; PHS HHS/United States; FDA HHS/United States.
68. Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; NIMH NIH HHS/United States; Biotechnology and Biological Sciences Research Council/**United Kingdom**.
69. Cancer Research UK/**United Kingdom**; Medical Research Council/**United Kingdom**; Chief Scientist Office/**United Kingdom**.
70. NIMH NIH HHS/United States; Department of Health/**United Kingdom**; **European Research Council**/International.