

## PAPER

# Identification of Medical Ecosystems in the Field of Mental Health and Cardiovascular Diseases at the Cologne Site

Cara Dannenberg<sup>1</sup>(✉),  
Johannes Heimann<sup>1</sup>,  
Adamantios Koumpis<sup>1</sup>,  
Oya Beyan<sup>1,2</sup>

<sup>1</sup>University Hospital Cologne,  
Cologne, Germany

<sup>2</sup>Fraunhofer Institute  
for Applied Informatics,  
St. Augustin, Germany

[cdannenb@smail.  
uni-koeln.de](mailto:cdannenb@smail.uni-koeln.de)

## ABSTRACT

As part of the Europe-wide smart health innovation hub implemented in the context of the Horizon Europe SHIFT-HUB project, our work concerns the identification of specific medical research ecosystems in the two fields, namely cardiovascular diseases and mental illness, with Cologne as the central location. To achieve this aim, the websites of involved organizations were used for data research purposes, and the members of each respective ecosystem or network were identified by acquiring information about their cooperation partners. A variety of selection criteria have been applied to filter out whether these partners were suitable to be considered as a further starting point for the research. The results indicate the existence of ecosystems in the two fields, with Cologne as the central location, in which various stakeholders, including healthcare institutions, healthcare providers, foundations, NGOs, and the business community, work closely together. Larger institutions are usually networked at an international level, while smaller institutions increasingly depend on and foster regional partnerships. This promotes cooperation and the exchange of knowledge at the regional level and facilitates direct contact with the people affected, i.e., patients' groups. Research institutions in both fields often receive financial support from commercial organizations, which highlights the importance of the business community's involvement in exploiting research results and promoting the quality of healthcare. The article highlights the complexity and interdisciplinarity of the particular ecosystems, with all the different categories of institutions comprising an indispensable position. The interaction amongst stakeholders at international, regional, and local levels can significantly help to deploy resources more effectively and improve the quality of life of people suffering from any of the two conditions.

## KEYWORDS

medical ecosystems, innovation, mental health diseases, cardiovascular diseases, stakeholder analysis, modelling

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## 1 INTRODUCTION

The SHIFT-HUB project [1] is a research action implemented as part of the Horizon Europe program aiming to establish a pan-European smart health innovation hub. Bringing together a diverse network of multidisciplinary stakeholders from business, science, politics, and society, it shall facilitate and promote the development of smart health technologies and services.

In this context, work presented concerns the identification of specific medical ecosystems in the two fields of cardiovascular and mental health diseases, with Cologne at the epicenter. The goal is to examine whether cross-network effects exist amongst stakeholders across different categories of institutions and whether these connections go beyond the regional context. All the data collected serves as information based on existing partnerships within the individual institutions. The institutions that are connected and considered members of the ecosystem are referred to as stakeholders. We used the acquired data in order to check whether large stakeholders in the network are also networked supra-regionally and whether there is any cross-networking that appears between the small and large stakeholders.

Digital business ecosystems can be regarded as an evolution or a special case of innovation ecosystems, which exhibit commonalities with general ecosystems [2]. In the latest years, with the proliferation of digital technologies and increased competition due to globalization, the importance of value co-creation has gained more significance as a success factor within ecosystems and other similar constellations. As a consequence, many approaches have emerged to model and analyze business ecosystems; we mention here a few that span between 2010 and 2020, namely [3], [4], [5], [6], [7], [8].

For the needs of the project, we study cases that can be mainly related to one of the following two ‘basic’ reference scenarios, as will be further approached in Section 3.2:

1. Supply-side-driven innovation: from the researcher and scientist to the market;
2. Demand-driven innovation: from the patients and customers back to the researcher and the scientist.

As Donaldson and Preston identified in their seminal paper, ‘[T]he stakeholder theory has been advanced and justified in the management literature on the basis of its descriptive accuracy, instrumental power, and normative validity. These three aspects of the theory, although interrelated, are quite distinct; they involve different types of evidence and argument and have different implications [9]. This is in line with the aim of the SHIFT-HUB project, according to which, by building a strong community of emerging digital technology providers and with the support of practitioners and the healthcare institutions they represent, one may better coordinate and achieve stronger cooperation amongst the various public and private stakeholders. This property of health and care ecosystems applies not only in each member country of the European Union but also at the pan-European and global levels, respectively.

The term ecosystem appears in the literature mainly in connection to the case of business and is usually related to some new technology, such as AI [10] or blockchain [11], related to some application area. It is also not uncommon at all to study disease categories with respect to the deployment of some technologies, such as the application of machine learning for cardiovascular diseases [12], [13], or the use of advanced technologies such as augmented reality for mental-healthcare interventions [14].

## 2 METHODOLOGY

All the data collected for the purposes of our work has been based on internet research. The information comes exclusively from the websites of the researched partners, as this appears cumulatively in the bibliography sections of [15], [16]. This ensures that only long-term partners who are listed on the website receive an entry. Short-term collaborations have therefore not been taken into account. The basic procedure started with any organization that was considered to be verifiably relevant to the research question. To ensure the latter, this was followed by a visit to the website of the same organization, where further partners were identified. Their data were collected, noted by name, and transferred to the data collection in alphabetical order.

It is important to note that only partners relating to cardiovascular and mental health diseases were documented. It should also be noted that medical practices and other very small potential stakeholders were excluded from the research in order to reduce the amount of the acquired data and focus on more significant organizations.

In order to find out whether the identified partners could be considered stakeholders, we have categorized them according to the respective research topic and therefore included the respective organization in the data set of stakeholders and then consequently explored its connections to further stakeholders. Six different categories have been used to divide our stakeholder population:

1. Firstly, the main, central location of the partner was determined.
2. Depending on the location, this was then color-coded as follows:
  - a) The color **red** indicates an entity registered in Cologne.
  - b) **Blue** was used to indicate an entity registered in Germany, though outside Cologne, and
  - c) **Green** has been used to indicate an entity registered elsewhere outside Germany.

One may regard the above as the core part of the algorithm that we have implemented that allows others to validate the repeatability of our applied methodology.

Furthermore, in order to clarify whether the partner could be considered a relevant stakeholder, an assessment has been made as to whether the particular partner's main focus is directly or indirectly related to the topics of the two diseases examined.

This distinction cannot be made accurately and with exactness and is a matter of personal judgment in cases of doubt, but it does allow the relevant stakeholders to be narrowed down in the wider context and has been considered in this respect as essential.

For example, a company that only financially supports a relevant stakeholder is a partner but is not itself a relevant stakeholder due to its fundamentally different orientation. A hospital with a department dealing with the overarching theme of cardiovascular and mental health diseases, on the other hand, is both a partner and a relevant stakeholder. Partners with stakeholder relevance located in Cologne are highlighted in **bold**; all others are not. An example of a relevant stakeholder is the University Hospital of Cologne, since its main focus is related to the topic and it is located in Cologne.

This results in the six categories we mentioned above, into which all identified partners were categorized, two for each localization and in combination with or without stakeholder relevance.

There are only four different categories in the presentation, as partners outside Cologne cannot be visually differentiated in terms of their relevance. This visualization option was chosen to focus specifically on the relevant stakeholders based in Cologne. The color coding of the individual partners indicates their localization and, thus, in the case of partners based outside Cologne, the reason why they were not considered further.

As the stakeholder relevance of these partners is not relevant to the question, it is not shown visually. If a partner was identified as a relevant stakeholder from Cologne, this served as the new starting point for the research, and the same methodology was applied to it. While it is outside the scope of the present paper, it is easy to identify the potential of reflecting lines of thought into an algorithm, which in our case relate to a finite sequence of instructions in order to perform a stakeholders' computation.

In the event that only one partner listed the other as such on its website, this was nevertheless added to the data list for the other partner, as it is assumed that the partnership is based on reciprocity and was only not documented by one partner.

In cases where several smaller institutions are part of a large institution, these were not listed separately, but were listed under the name of the larger institution, and the researched partners were noted together (e.g., as in the case of the Heart Center of the University Hospital of Cologne). Figure 1 below shows the process of information retrieval again visually.

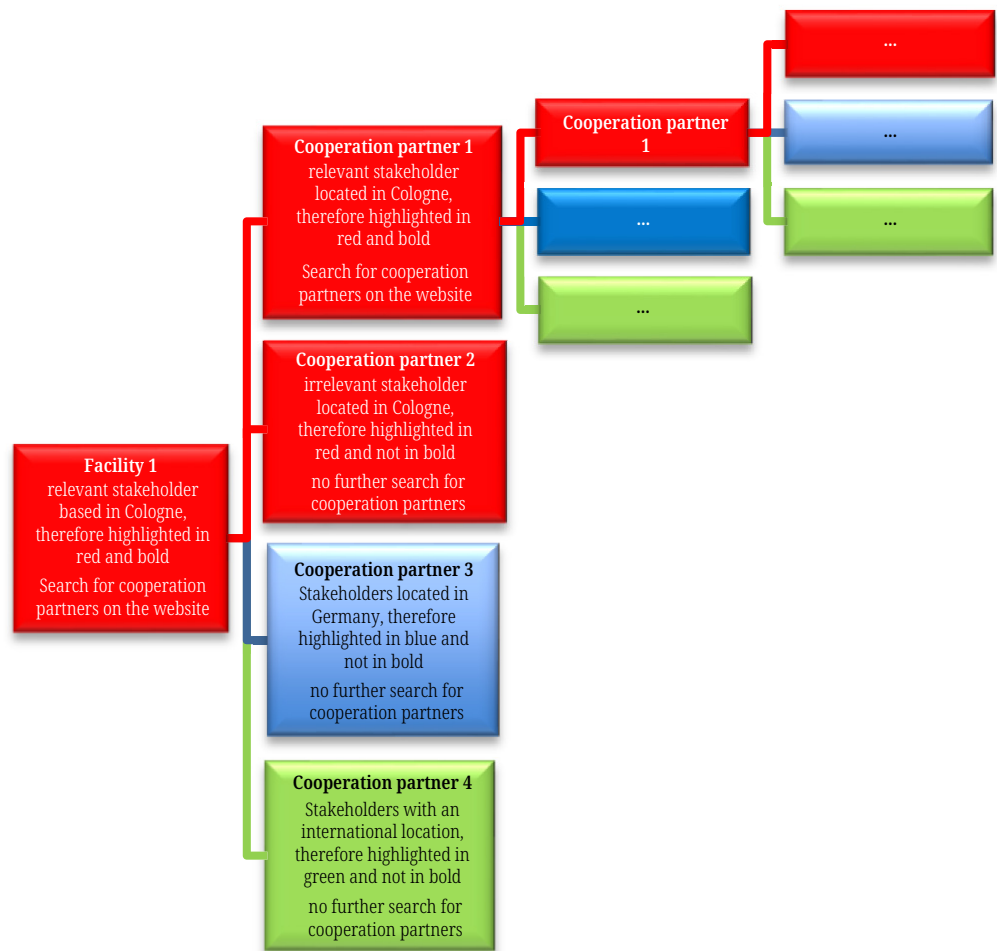


Fig. 1. Example of data research

In order to clearly present the stakeholders and partners noted on the list, the presentation of the results is divided into two different parts:

1. In the first part, the (colorless) Cologne stakeholders and the researched (colored) partners following the colon are listed in alphabetical order.
2. The second part consists of the stakeholder list, which contains all the previously mentioned stakeholders and partners.

In order to make the results clear and, if necessary, suitable for a proper visualization, each stakeholder and each partner were assigned a specific code consisting of one or more letters and a number. This promptly provides information about the type of organization. In addition, the codes have been highlighted in color as described above, to make the location of the facility clear. The letters provide a direct overview of which subgroup the stakeholder belongs to. The letter “B” stands for business support organizations, “C” for companies, “Gc” for governmental agencies and companies, “Ga” for governmental authorities, “Hcs” for healthcare schools, “H” stands for stakeholders from the subgroup hospitals and healthcare professionals, “O” for organizations founded by healthcare professionals, “Pa” for patient associations and patient advocacy groups, and “R” for research. The stakeholders were also sorted alphabetically and numbered in order in the list of stakeholders for the sake of clarity. Figure 2 shows only one possible graphical representation. The Alexianerkrankenhaus serves as an example facility from which research partners are further listed according to the coded schemes. Due to the overview and size, not all partners were listed in detail, but the graphical representation could be extended. The Alexianerkrankenhaus can be replaced by any stakeholder listed in the results list, and a new chart can be created with the corresponding partners.

All the names in this paper are not translated to English to keep the alphabetic order of their original names.

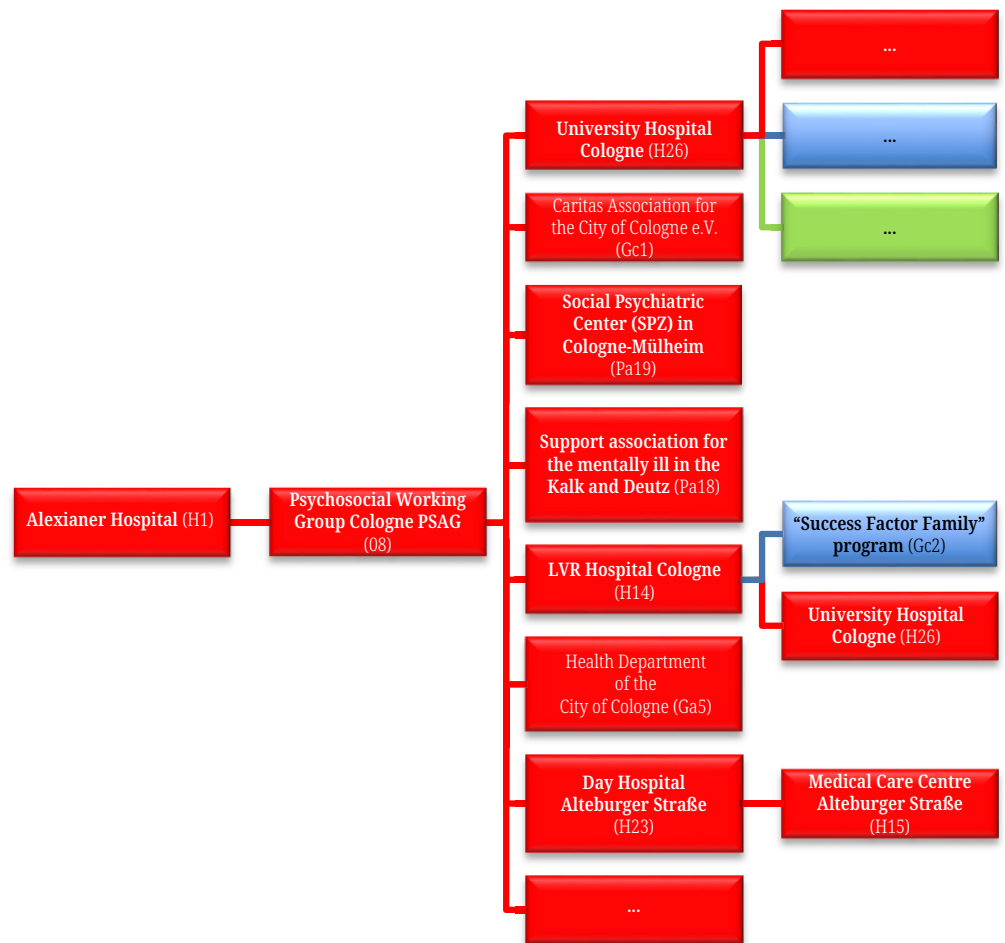


Fig. 2. Example of graphical representation for the case of mental health diseases

### 3 RESULTS

For practical reasons and the limitations in space, this paper exclusively features the stakeholders and partners outlined in the provided two examples, as these appear in the next two subsections and Tables 1–4 below. Consequently, not every category is represented, and the codes might be intricate. For a comprehensive overview, readers may refer to the publicly shared Zenodo repository lists [15], [16].

#### 3.1 The case of mental health diseases

The list of results illustrates the large number of institutions based in Cologne that deal with the topic of mental illness and maintain an effective network with each other.

The relevant organizations listed as stakeholders can be divided into five main categories. The category “hospitals and healthcare professionals” comprises fourteen stakeholders: “research,” two; “patient associations and patient advocacy groups,” five; “governmental agencies and companies,” two; “organizations founded by healthcare professionals,” three; and in the category “companies” there are two stakeholders.

Each stakeholder that is relevant to the topic has a different number of partners listed. It is worth noticing that larger institutions such as the University Hospital of Cologne list a considerable number of partners, among which there are regional, national, and international connections. In addition, these partners cover significantly more of the listed categories than partners of smaller institutions. The list shows, for example, close cooperation between research institutions and commercial enterprises.

Smaller organizations, such as the Alexian Hospital in Cologne, have fewer partners and focus more on regional networking. Many non-profit organizations and foundations are strongly networked with each other. It is also worth noticing that there are organizations that serve as stakeholders and make a targeted contribution to networking, such as the PSAG (Psychiatrie-Sozial-Arbeits-Gesellschaft), which has set itself the goal of strengthening professional cooperation between the associations, societies, and services active in the field of psychiatry by identifying deficits in psychiatric and psychosocial care in Cologne and developing solutions. (Psychosocial Working Group (PSAG) Cologne, undated).

**Table 1.** Stakeholders and their partners (Part 1)

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#### **Hospitals and healthcare professionals**

##### **Alexianer Krankenhaus Köln (H1):**

(Alexianer Köln GmbH, undated; Psychosoziale Arbeitsgemeinschaft (PSAG) Köln, 2017)

- **Psychosoziale Arbeitsgemeinschaft PSAG Köln (O8)**

##### **LVR Klinik Köln (H14):**

(LVR Klinik Köln, undated; Psychosoziale Arbeitsgemeinschaft (PSAG) Köln, 2017)

- **Deutsche Sporthochschule Köln (R7)**
- **Erfolgsfaktor Familie (Gc2)**
- **Hochschule Fresenius (R15)**
- **Psychosoziale Arbeitsgemeinschaft PSAG Köln (O8)**
- **Uniklinik Köln (H26)**

##### **Tagesklinik Alteburger Straße (H23):**

(Klinik Alteburgerstraße gGmbH, undated; Psychosoziale Arbeitsgemeinschaft (PSAG) Köln, 2017)

- **MVZ Alteburger Straße (H15)**
  - **Psychosoziale Arbeitsgemeinschaft PSAG Köln (O8)**
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(Continued)

**Table 1.** Stakeholders and their partners (Part 1) (Continued)**Organizations founded by Healthcare Professionals****Psychosoziale Arbeitsgemeinschaft PSAG Köln (O8):**

(Psychosoziale Arbeitsgemeinschaft (PSAG) Köln, 2017; Rat und Tat e.V., undated)

- **Alexianer Krankenhaus Köln (H1)**
- **Alexianer Werkstätten GmbH (C2)**
- ASB Alten- und Pflegeheime Köln GmbH (C7)
- AWO Kreisverband Köln e.V. (Pa4)
- **BTZ Berufliche Bildung Köln GmbH (C9)**
- Caritas Wertarbeit (C11)
- Caritasverband für die Stadt Köln e.V. (Gc1)
- **Der Sommerberg AWO Betriebsges. mbH (C14)**
- Diakonie Köln und Region (C15)
- DRK-Kreisverband e.V. (O6)
- **Förderverein für psychische kranke Mitbürger im Stadtbezirk Köln-Kalk (Pa18)**
- **Förderverein für psychische kranke Mitbürger im Stadtbezirk Köln-Mühlheim (Pa19)**
- **LVR Klinik (H14)**
- **Rat und Tat e.V. – Hilfsgemeinschaft für Angehörige von psychisch Kranken (Pa31)**
- SKM Köln e.V. (Pa33)
- Sozialdienst katholischer Frauen Köln e.V. (Pa34)
- Stadt Köln Gesundheitsamt (Ga5)
- Stiftung Leuchtfeuer (Pa35)
- **Tagesklinik Alteburger Straße (H23)**
- **Uniklinik Köln (H26)**

**Table 2.** Stakeholders**Companies:**

- C2: Alexianer Werkstätten GmbH**
- C7: ASB Alten- und Pflegeheime Köln GmbH
- C9: BTZ Berufliche Bildung Köln GmbH**
- C11: Caritas Wertarbeit
- C14: Der Sommerberg AWO Betriebsges. mbH**
- C15: Diakonie Köln und Region

**Governmental agencies/companies:**

- Gc1: Caritasverband für die Stadt Köln e.V.
- Gc2: Erfolgsfaktor Familie**

**Governmental authorities:**

- Ga5: Stadt Köln Gesundheitsamt

**Hospitals and Healthcare Professionals:**

- H1: Alexianer Krankenhaus Köln**
- H14: LVR Klinik Köln
- H15: MVZ Alteburger Straße
- H23: Tagesklinik Alteburger Straße**
- H26: Uniklinik Köln**

**Organizations founded by Healthcare Professionals:**

- O6: DRK-Kreisverband e.V.
- O8: Psychosoziale Arbeitsgemeinschaft PSAG Köln**

**Patient associations and patient advocacy groups:**

- Pa4: AWO Kreisverband Köln e.V.
- Pa18: Förderverein für psychische kranke Mitbürger im Stadtbezirk Köln-Kalk**
- Pa19: Förderverein für psychische kranke Mitbürger im Stadtbezirk Köln-Mühlheim**
- Pa31: Rat und Tat e.V. - Hilfsgemeinschaft für Angehörige von psychisch Kranken**
- Pa33: SKM Köln e.V.
- Pa34: Sozialdienst katholischer Frauen Köln e.V.
- Pa35: Stiftung Leuchtfeuer

**Research:**

- R7: Deutsche Sporthochschule Köln**
- R15: Hochschule Fresenius

### 3.2 The case of cardiovascular diseases

The lists of results confirm that the institutions in the Cologne ecosystem that deal with the topic of “cardiovascular diseases” are strongly networked. Overall, the relevant stakeholders in Cologne can be divided into three categories. There are 24 relevant stakeholders in the category “hospitals and healthcare professionals,” one relevant stakeholder in the category “organizations founded by healthcare professionals,” eight relevant stakeholders in the category “patient associations and patient advocacy groups,” and three relevant stakeholders in the category “research.”

All institutions relevant to the research question have at least one, often several, partner. Patterns can be recognized in this network. Large institutions, such as the University Hospital of Cologne, have many different partners, while smaller institutions, such as the PAN-Klinik am Neumarkt, tend to list fewer partners.

Many stakeholders have partners from other institution categories (e.g., hospitals that work together with companies). It should be noted that research and large institutions sometimes work together with companies, while smaller institutions tend to receive support from voluntary organizations.

There are also differences between these two groups in terms of the localization of the partners. Large organizations often have national and sometimes international partners, while smaller organizations tend to maintain regional networks. It should also be noted that several stakeholders are related to promoting networking. One such example is the case of the Kölner Infarkt Modell e.V. (Cologne Infarct Model), which is a registered association that connects all Cologne hospitals that provide internal medicine care to each other. It is also important to mention that state institutions are also part of the networks and actively cooperate with private institutions.

**Table 3.** Stakeholders and their partners (part 1)

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#### Category 1: Hospitals and healthcare professionals

##### AmKaRe (H1):

(Gesundes Herz, undated)

- Deutsche Sporthochschule Köln (R4)
- Helios Kliniken (H10)
- Kölner Herzzentrum (H16)
- Krankenhaus Porz am Rhein (H20)
- Netzwerk Diabetischer Fuß Köln und Umgebung (Pa3)
- St. Vinzenzhospital (H33)
- Uniklinik Bochum Herzzentrum (H35)
- Uniklinik Bonn (H36)
- Uniklinik Freiburg Herzzentrum (H38)
- Uniklinik Köln (H39)
- Uniklinik Leipzig Herzzentrum (H40)
- Universität Witten Herdecke (R14)

##### Kooperatives Kölner Herzzentrum (H16):

(Gesundes Herz, undated, Kooperatives Kölner Herzzentrum, undated)

- AmKaRe (H1)
  - Helios Klinik Siegburg Herzzentrum (H9)
  - Krankenhaus Porz am Rhein (H20)
  - MVZ Porzer Herz und Gefäßzentrum (H22)
  - Uniklinik Bochum Herzzentrum (H35)
-



**Table 4.** Stakeholders (part 2)

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<b>Hospitals and Healthcare Professionals:</b>
<b>H1: AmKaRe</b>
H9: Helios Klinik Siegburg Herzzentrum
H10: Helios Kliniken
<b>H16: Kooperatives Kölner Herzzentrum</b>
<b>H20: Krankenhaus Porz am Rhein</b>
<b>H22: MVZ Porzer Herz und Gefäßzentrum</b>
<b>H33: St. Vinzenzhospital</b>
H35: Uniklinik Bochum Herzzentrum
H36: Uniklinik Bonn
H38: Uniklinik Freiburg Herzzentrum
<b>H39: Uniklinik Köln</b>
H40: Uniklinik Leipzig Herzzentrum
<b>Patient associations and patient advocacy groups:</b>
<b>Pa3: Netzwerk diabetischer Fuß Köln und Umgebung</b>
<b>Research:</b>
<b>R4: Deutsche Sporthochschule Köln</b>
R14: Universität Witten Herdecke

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## 4 DISCUSSION

We are convinced that the developed method of obtaining information is, in general, suitable for the context of the analysis we have performed. The chosen approach enables quite straightforward and less time-consuming data research with a good level of granularity for the acquired data.

However, there are some limitations to this method. Inaccuracies already arise in the definition of the notion of a partner. As the work relies on the information provided by the individual stakeholders, the definition of the partnership also lies with the stakeholders. As there is also no standardized information from the partners, there is a high probability that the partner list is incomplete using this research method. For example, in the study of the cardiovascular disease ecosystem, some partners, such as Cologne Sports University, have not provided their own information on partners and have therefore only made a passive appearance by being listed as partners by other stakeholders.

It is also obvious that medical practices were not included in the research. This would have meant an enormous expenditure of time with little gain in knowledge, but now leads to an incomplete overview of the ecosystem's network in Cologne. The result therefore contains part of the network. This certainly allows conclusions to be drawn on the topic, but it cannot be regarded as a complete overview.

The results of our stakeholder analysis indicate the existence of a strong ecosystem for the field of mental illness that has Cologne as its central location. The results show that various actors, including healthcare institutions, healthcare providers, foundations, and NGOs, work closely together to provide comprehensive support for people with mental illness.

The results also confirm the fact that large institutions, such as the University Hospital of Cologne in particular, play a central role as a value-added mediator between different categories of stakeholders. One reason for this could be that such institutions have the necessary resources and expertise to act as an important interface between different stakeholder categories at the regional, national, and international levels due to their number of employees and size.

Research institutions also often have close links to industry, as research and development are closely linked in many sectors. This applies in particular to the pharmaceutical industry, as the development of drugs is heavily dependent on scientific research. For example, Novartis and Janssen Pharmaceutica NV are pharmaceutical companies that are partners of the University Hospital Cologne.

Participation and support from industry in research institutions can help promote innovation. This emphasizes the need for appropriate regulation and transparency regarding the relationships between industry and other players in the ecosystem.

Smaller stakeholders focusing on regional activities may be less visible but play an important role in regional networking. These smaller actors are often highly interconnected, suggesting that there is a dense network of organizations in the region that share common interests and goals. This can promote cooperation and the exchange of knowledge, which can be important for the development and implementation of projects. In addition, the smaller organizations in particular often work together with voluntary agencies and establish direct contact with the people affected. They therefore have a very relevant position in the individual ecosystems.

One example is Caritas Cologne, where many volunteers work. It is indirectly linked to Cologne hospitals such as the LVR Clinic or the Alexian Hospital via the PSAG as a partner. The high number of non-profit organizations indicates their important role in networking and care. This multiple networking, also with authorities and companies, emphasizes this. The results of the PSAG clearly show that there are also partners who specifically serve to link facilities.

The present results offer certain insights, but the informative value of this data collection is limited to a certain extent. The chosen method of data collection aimed to gather a large amount of information in a relatively short period of time. While this can be efficient, it does have certain limitations.

If we had opted for more in-depth research over a longer period of time and expanded the stakeholder categories, it would have been possible to collect more comprehensive and detailed data. One problem is that many stakeholders may not list all partnerships and collaborations online on their websites. This means that some important partnerships may not have been captured.

Furthermore, it can be difficult to make a clear distinction between overarching topics such as mental illness and other subject areas, as the information is not always sufficiently detailed.

To overcome these challenges, one could have considered engaging directly with stakeholders to obtain more comprehensive and accurate information. The ideal and almost flawless data collection would undoubtedly be the one based on active information from all stakeholders.

Nevertheless, it can be summarized that the results show that there are a large number of different stakeholders who deal with the topics of cardiovascular diseases and mental illness and who work together in a complex ecosystem with Cologne as the central location. The hypotheses proposed in the introduction, suggesting cross-networking between stakeholders from various organization types and regions, were supported by the results.

In our presentation, the code system provides a direct overview of localization, type of facility, and relevance as a stakeholder, but not of the size of the facility. Although this can be researched on the websites, it cannot be precisely defined and is therefore only approximately reliable.

It is also not surprising that state institutions are part of the network, as they have regulatory oversight and an interest in expanding the network to improve healthcare provision. One indication that networking is beneficial for stakeholders

overall is the existence of certain organizations that appear to serve the sole purpose of networking. Apparently, a need for connection was seen in this context for the case of the cardiovascular disease ecosystem, which is why, for example, the registered association “Kölner Infarkt Modell e.V.” was founded in the specific case, which serves the purpose of supporting hospitals in the care of the widespread disease “heart attack.” Overall, it can therefore be said that the networking of individual stakeholders is often worthwhile for a variety of reasons other than financial ones.

## 5 ACKNOWLEDGMENT

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## 6 AUTHOR CONTRIBUTION STATEMENT

Koumpis and Beyan designed the structure of the research context and the scope of the research. Dannenberg and Heimann conceived the methodology and developed the algorithm that was adopted for the presented idea. Dannenberg applied the methodology and algorithm for the field of mental health diseases and Heimann for the case of cardiovascular diseases. Both Dannenberg and Heimann carried out the quality control, and Koumpis supervised the findings of this work. All authors contributed to the interpretation of the results and the final manuscript.

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## 8 AUTHORS

**Cara Dannenberg** is a medical student at the University of Cologne. For a scientific project as part of her medical studies (E-mail: [cdannenb@smail.uni-koeln.de](mailto:cdannenb@smail.uni-koeln.de)).

**Johannes Heimann** is a medical student at the University of Cologne. For a scientific project he works at the Biomedical Informatics Institute (E-mail: [jheiman4@smail.uni-koeln.de](mailto:jheiman4@smail.uni-koeln.de)).

**Adamantios Koumpis** is research officer at the Biomedical Informatics Institute of the University Hospital Cologne and researches in the areas of medtech entrepreneurship and medical and health innovation ecosystems (E-mail: [Adamantios.koumpis@uk-koeln.de](mailto:Adamantios.koumpis@uk-koeln.de)).

**Oya Beyan** is Medical Informatics Professor at the University Hospital Cologne and the Medical Faculty of the University of Cologne. She is Founding Director of the Biomedical Informatics Institute and also the lead of the FAIR Data and Distributed Analytics Group at the Fraunhofer Institute for Applied Informatics (FIT) (E-mail: [oya.beyan@uni-koeln.de](mailto:oya.beyan@uni-koeln.de)).