هيئة تنمية البحث
والتطوير والابتكار
**Research Development
and Innovation Authority**

Clarivate™

Health and Wellness RDI National Priority in Saudi Arabia: Analytical Study

Full Study

Innovation Ecosystem in Focus

Contents

1 Introduction

The Kingdom of Saudi Arabia is undergoing a transformative journey emphasizing the importance of a knowledge-based economy as a driving force behind Saudi Vision 2030. This essential transformation is set to elevate the research, development, and innovation (RDI) landscape, positioning Saudi Arabia as a global leader within its national priorities:

- Health and Wellness

- Sustainability and Essential Needs

- Energy and Industrials

- Economies of the Future

His Royal Highness Prince Mohammed bin Salman bin Abdulaziz Al Saud has declared Saudi Arabia's goal of becoming a global frontrunner in science, technology, and innovation. The Kingdom targets investing 2.5% of its GDP in RDI by 2040. Establishing the Research, Development, and Innovation Authority (RDIA) in 2021 marked a pivotal step in steering RDI initiatives.

RDIA is dedicated to steering and executing the Kingdom's RDI strategies across the four national priorities. RDIA has led the organization of capacity-building activities, equipping Saudi leaders and practitioners with the vital skills needed for health innovation. It has crafted specialized strategies to identify numerous relevant research topics within national priorities. The authority's initiatives nurture local talent and foster global collaborations to develop an RDI infrastructure that benefits public and private sector health innovation. Strategic partnerships between universities, industries, and international institutions ensure effective alignment with global health trends to address local health challenges. These efforts by RDIA are critical to Saudi Arabia achieving global leadership in health innovation and driving economic diversification and sustainable development. By aligning research output with national health priorities, RDIA can ensure optimal return on investment, prioritize high-impact health fields, and position Saudi Arabia as a leader in global health innovation for years to come.

This study draws upon the analysis undertaken in the *Enhancing Cooperation and Partnership between Academia and Companies in Research Capacity and Technology Readiness in Saudi Arabia's Program of Work*:

1. Assessment of Academic-Corporate Partnerships in Saudi Arabia

2. Insights into Saudi Arabia's Research and Innovation Ecosystem

3. Accelerating Technology Transfer from the Lab to the Market in Saudi Arabia

This multi-part study aimed to create a comprehensive overview of the significant aspects of the research ecosystem in Saudi Arabia. This study is intended to provide a baseline dataset of the capabilities of the Saudi research ecosystem. Seven (7) discrete studies were commissioned to establish this baseline, of which this study is one part. The reader is encouraged to read this study in full and explore the other studies to understand how the research ecosystem has developed over the past decade. The deep national priority studies available under this comprehensive review are:

- Health and Wellness

- Sustainability and Essential Needs

- Energy and Industrials

- Economies of the Future

This study will highlight the significant achievements to date while offering targeted recommendations for ongoing growth, focusing on impacts within the Health and Wellness sector. It examines the foundation of research and development in the Health and Wellness sector in Saudi Arabia from 2014 through 2023. With these data in hand, RDIA will implement the mission-driven RDI strategy for the Kingdom to ensure the highest caliber outcomes and the optimal translation of that research into products and services to enhance the lives of Saudi citizens.

RDIA has engaged Clarivate, a global leader in research and intellectual property data analysis, to collect, collate, and analyze the research relationships, outcomes, and documents in Saudi Arabia and worldwide. Examining these data has identified areas of strength in Health and Wellness research and areas for improvement. This study intends to inform the reader about how these historical trends can inform the future deployment of the resources dedicated to the RDI strategy. The study is comprehensive but not exhaustive. Its data are drawn from publicly available sources at the end of the collection period. Research, particularly in Health and Wellness, often takes years before results become public either through publication in peer-reviewed journals and afterward through patent filings.

The content of this study is based on two primary sources of information:

1. Documentation published by RDIA and other agencies in Saudi Arabia concerning the national priorities themselves

2. Clarivate's technology analyst team, comprising STEM professionals with many years of experience performing innovation and technology research intelligence projects

Strategic partnerships between universities, established and emerging companies, and international collaborators ensure effective alignment with global trends, accelerating the deployment of digital health, medtech, therapeutics, and diagnostics. The Health and Wellness RDI priority provides solutions to healthcare challenges globally, while delivering local health and economic outcomes. The selected deep-dive research topics within Health and Wellness are defined as follows:

1. Cancer: Treatment, detection, and therapies related to malignant, metastatic, or abnormal tissue growth.
2. Cardiovascular Diseases: Treatment, detection, and therapies related to disorders and diseases of heart health.
3. Diabetes: Treatment, detection, and therapies related to insulin resistance leading to hyperglycemia.
4. Nutrition & Obesity: Treatment, detection and therapies related to excessive body weight and/or malnutrition.
5. Genomics: Technologies centered around evaluating genomic information on an individual or mass population scale. For example, genetic sequencing hardware and software.
6. Biopharmaceuticals: Therapies that are synthetically created from biological sources to mimic natural biological processes aimed at a target such as a condition or disease.
7. CAR-T Cell Therapy: A synthetic modification of T cells within a patient's immune system to become CAR-T cells, which attach and destroy cancer cells.
8. Stem Cell Therapy: A method of repairing specific tissues by using stem cells or derived approaches.
9. Dengue: Treatment, detection, and therapies related to the mosquito-transferred virus Dengue.
10. Vaccine: A method of proactively providing immunity to a specific disease by training an individual's immune system to a biologically similar protein to the disease's protein structure.
11. Gene/ RNA Therapy: An approach to treat, prevent or cure a condition or disease by adding or replacing genes to a patient's DNA to improve their health.

12. Antimicrobial Resistance: Treatment of and diagnosis of microorganisms using therapies or combinations of therapies where other approaches are no longer sufficient due to resistance.

The complete list of technologies that define the national priority area of Health and Wellness within this study, with global volumes across research publications and inventions, is shown in Figure 1.

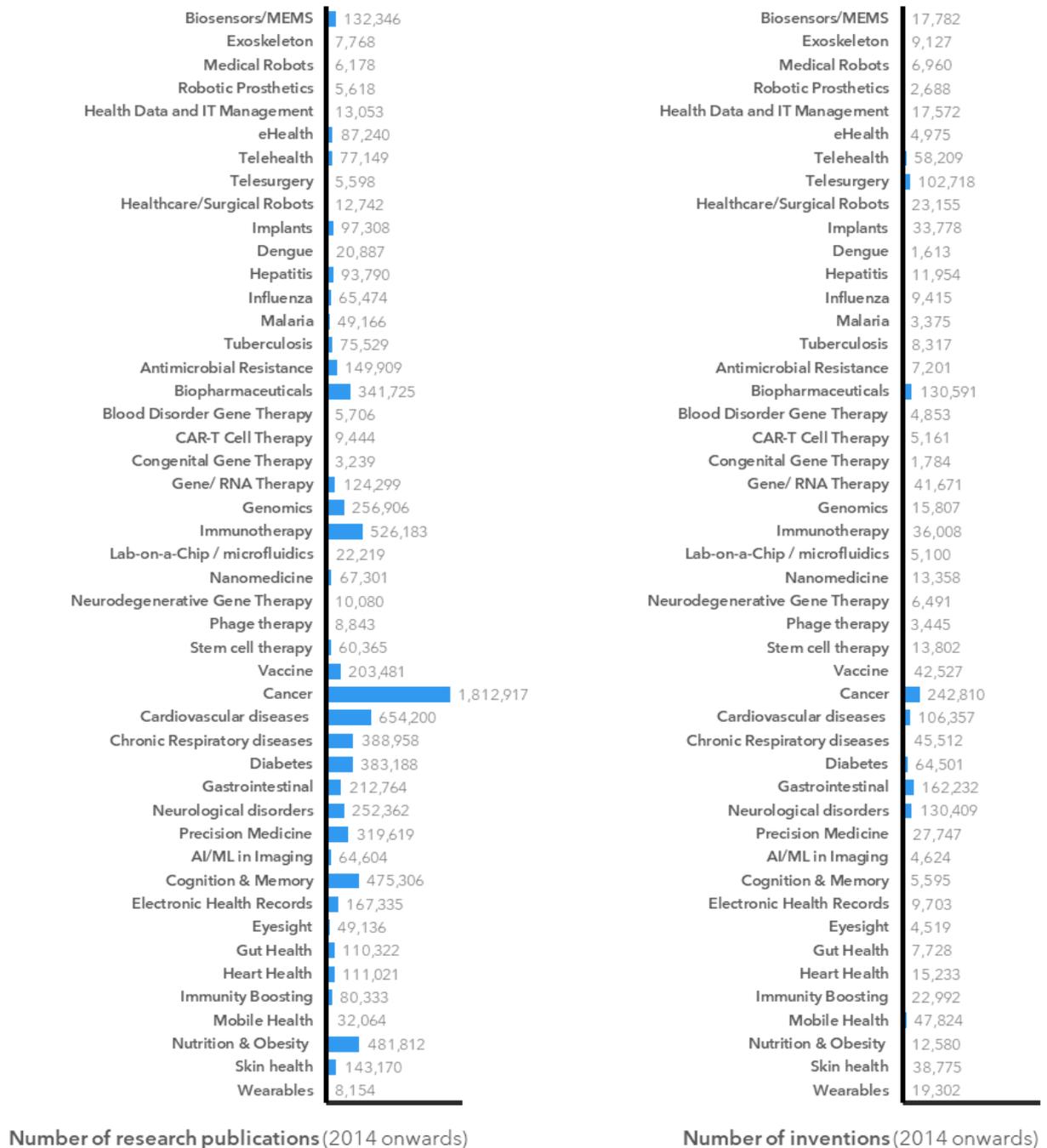| Technology	Number of research publications (2014 onwards)	Number of inventions (2014 onwards)
Biosensors/MEMS	132,346	17,782
Exoskeleton	7,768	9,127
Medical Robots	6,178	6,960
Robotic Prosthetics	5,618	2,688
Health Data and IT Management	13,053	17,572
eHealth	87,240	4,975
Telehealth	77,149	58,209
Telesurgery	5,598	102,718
Healthcare/Surgical Robots	12,742	23,155
Implants	97,308	33,778
Dengue	20,887	1,613
Hepatitis	93,790	11,954
Influenza	65,474	9,415
Malaria	49,166	3,375
Tuberculosis	75,529	8,317
Antimicrobial Resistance	149,909	7,201
Biopharmaceuticals	341,725	130,591
Blood Disorder Gene Therapy	5,706	4,853
CAR-T Cell Therapy	9,444	5,161
Congenital Gene Therapy	3,239	1,784
Gene/ RNA Therapy	124,299	41,671
Genomics	256,906	15,807
Immunotherapy	526,183	36,008
Lab-on-a-Chip / microfluidics	22,219	5,100
Nanomedicine	67,301	13,358
Neurodegenerative Gene Therapy	10,080	6,491
Phage therapy	8,843	3,445
Stem cell therapy	60,365	13,802
Vaccine	203,481	42,527
Cancer	1,812,917	242,810
Cardiovascular diseases	654,200	106,357
Chronic Respiratory diseases	388,958	45,512
Diabetes	383,188	64,501
Gastrointestinal	212,764	162,232
Neurological disorders	252,362	130,409
Precision Medicine	319,619	27,747
AI/ML in Imaging	64,604	4,624
Cognition & Memory	475,306	5,595
Electronic Health Records	167,335	9,703
Eyesight	49,136	4,519
Gut Health	110,322	7,728
Heart Health	111,021	15,233
Immunity Boosting	80,333	22,992
Mobile Health	32,064	47,824
Nutrition & Obesity	481,812	12,580
Skin health	143,170	38,775
Wearables	8,154	19,302

Figure 1: Number of research publications and inventions within Health and Wellness 2014-2023

As part of a broader effort to establish a comprehensive baseline dataset, seven discrete studies were commissioned to assess the current state and capabilities of Saudi Arabia's research ecosystem—this study being one of them. To ensure a rigorous evidence base, a total of 167 research topics were identified and analyzed. These topics were sourced from research publications (gathered from the Web of

Science) and patented inventions (sourced from the Derwent World Patents Index), using established keyword and technology classification methodologies.

The project's technology analysts conducted a multi-stage review process to validate completeness, refine topic definitions, and ensure data accuracy. Leveraging scientific and engineering expertise, the team refined and structured the data through an iterative cycle of validation and amendment. Once finalized, the records associated with each research topic were aggregated, standardized, and integrated into a project-specific data lake, forming the analytical foundation of this study. The process is illustrated in Figure 2.
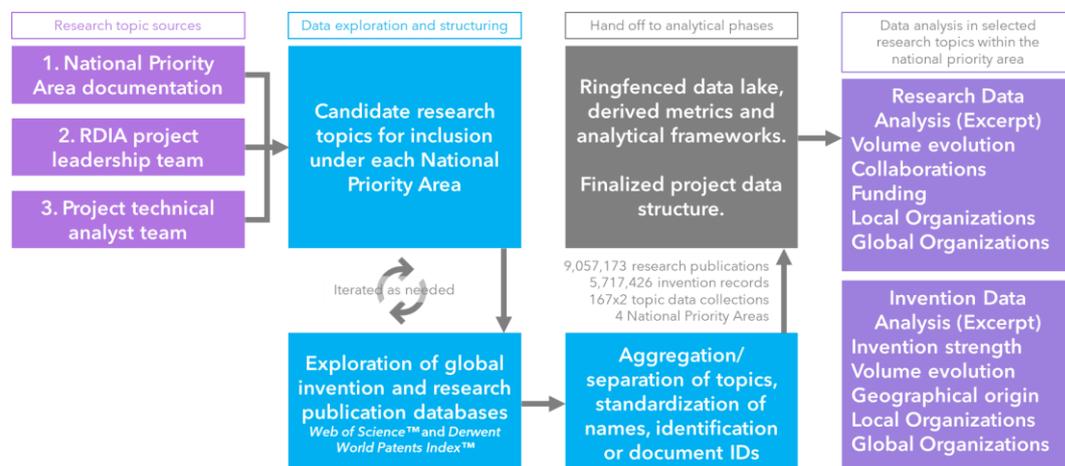
Figure 2: study data curation process

The finalized data structure includes:

- Over 9 million research publications

- Over 5.5 million patented inventions

- 167 research topic categories spanning both research publications and patented technologies

- These 167 topics define the four National Priorities

Within this broader research ecosystem, RDIA's Health and Wellness missions provide a targeted framework for advancing health innovation. This study specifically examines Missions 1.2 and 1.3, which align with the study's findings on priority health research areas.

The RDIA Health and Wellness Missions include:

- Mission 1.1: Increase healthy life expectancy by 5 years by 2040.

- Mission 1.2: Reduce the prevalence of non-communicable diseases by 50% through prevention, better management, and treatment by 2035.

- Mission 1.3: Reduce the incidence of infectious diseases significant to Saudi Arabia by 50% by 2035.

- Mission 1.4: Develop genetic therapies for at least 2 of Saudi Arabia's top 10 rare diseases by 2035.

- Mission 1.5: Ensure 40% of the population has undergone an intervention with a digital therapeutic developed by Saudi-based scientists by 2035.

2 Executive summary

2.1 Overview

The Health and Wellness priority area of RDIA represents an opportunity to transform the lives of Saudi Arabia's population and deploy applied research globally through MedTech, Digital, Surgical and Preventative research topics targeting infectious and non-infectious diseases.

There have been fluctuations in Saudi Arabia's research output on the research topics of CAR-T Cell Therapy, Stem Cell Therapies, and Dengue. Balancing research quality while continuously increasing research output is key for national priority research topics. Strategies include collaborating with identified key publishing organizations and researchers as well as collaborating with top funding organizations identified in those research topics.

Health and Wellness research topics globally have a wide range of technology maturities; however, particularly within Health and Wellness, all research topics were between Technology Readiness Level (TRL) 4-9, with no low-maturity research topics. Notably, due to long R&D cycles, regularly lasting up to 10 years, Saudi Arabia could consider the strategic allocation of resources to maximize returns on investment for research and invention protection. Many high-maturity technologies have high barriers to entry, and therefore, investments in earlier-stage technologies may bring higher chances of significant GDP addition to Saudi Arabia.

There is a tremendous opportunity for Saudi Arabia to train more Health and Wellness researchers, create jobs within Academic Institutions and the local private sector, and add significant GDP to the Saudi Arabian economy.

2.2 Key Opportunities within Health and Wellness

- **Prioritize higher performing and higher commercial potential research topics:** Four key research topics within Health and Wellness have significant commercial potential: Biopharmaceuticals, Diabetes, Cancer, and Cardiovascular Diseases. Combined, these topics have the potential to generate $2.56Bn for the Saudi Arabian economy if 6,668 inventions are protected, generating the expected yield of very high-strength inventions, and are subsequently successfully commercialized. For more details see RDIA Study: Accelerating Technology Transfer from the Lab to the Market in Saudi Arabia

- **Accelerate private organization creation through partnerships:**
  For high-maturity research topics, it may be more efficient to work directly with international corporations to reach global markets. For low and medium-maturity research topics such as Dengue, Antimicrobial Resistance and CAR-T Cell Therapy, Saudi Arabia could prioritize the spinning out, joint venture and incubator creation program to nurture high-potential specialist start-ups. These start-ups could focus first on regulatory approvals and success outside of Saudi Arabia, alongside commercializing therapies into local MENA markets.

- **Pivot funding conditions to advance from publication to protection:** Develop new funding metrics and frameworks to shift the research paper to inventions ratio within High TRL research topics to enable patent portfolio creation, licensing, and commercialization. Enhance the size and commercial acumen of Saudi Arabian technology transfer offices.

- **Leverage leading global academia through academic partnerships:**
  In addition to large corporations, stand-out invention performance is seen in international academic institutions, especially from the US, UK, and France, such as the University of Pennsylvania and Harvard University. This provides broader views on investing in Academic Partnerships.

- **Establish Academic, Corporate, Start-up infrastructure within Health and Wellness:** The creation of technology-specific hubs could also attract

international investment and the establishment of R&D facilities. Similar programs have been established in the UK, such as the Cell Therapy Catapult Centre. Suitable research areas include Biopharmaceuticals & Vaccines, Gene, RNA General Therapy and Cancer, Cardiovascular Diseases or Diabetes.

In conclusion, Saudi Arabia has a growing Health and Wellness research ecosystem. To move to the next stage in its development, further Academic-Corporate partnerships can help nurture the development of a diversified and robust private sector of organizations specializing in high-potential research topics, which can be deployed locally and internationally by producing more research and innovation.

The insight within this study provides a multi-dimensional evaluation of research topics within Health and Wellness priority area to provide key actions and options to consider, and benchmarks against global leadership. Subsequently the tailored insight, metrics and findings can enhance both the foundational research within academia, and commercially applied innovation to achieve the national missions and aspirations of Saudi Arabia.

3 Overview of research publication and patent performance in Health and Wellness

This section provides an overview of Saudi Arabia's research publication and patent performance within the Health and Wellness National Priority. This study is part of a wider program of analysis across research output, the research ecosystem and technology commercialization, and therefore the analysis presented here includes extracted data from several studies across these wider studies, now focused within this national priority area.

3.1 Overview of Performance in Research

In this section, we evaluate the research performance of Saudi Arabia in the national priority area of Health and Wellness in the period 2014-2023. The aim here is to examine the evolution as well as the status in terms of research volume and impact. For this, we start by examining the evolution of the number of papers in the priority area over this period and benchmark it with the global baseline and other countries/regions. Afterwards, we examine the citation impact. For this, we will use the Category Normalized Citation Impact (CNCI). CNCI is a valuable and unbiased indicator of impact irrespective of age, subject focus, or publication type. Therefore, it allows comparisons between entities of different sizes and different subject mixes. A CNCI value of 1 represents performance at par with the global average when considering the same publication type, year, and subject. A value above 1 reflects a performance higher than the global average, while a value below 1 reflects a performance below the global average (for more information, see Metrics). To further understand the research dynamics in the national priority area we also look at top 20 countries in terms of number of papers collaborating with Saudi Arabia and top 20 funding organizations in terms of number of papers in each of the priority areas. Looking at the top 20 funders will allow us to identify key organizations funding Saudi Arabia research in the national priority area.

We also investigate the research performance of Saudi Arabia in this national priority area with a specific focus on research performed within an industry collaboration. A paper with industry collaboration is a paper that contains two or more organizations with at least one organization listing its organization type as corporate or global corporate (see Metrics). This gives us insights into the academic-corporate partnership status currently in Saudi Arabia within this national priority area. However, it is important here to differentiate that a paper published as an output of research performed through a collaboration between academic affiliated researchers and corporations does not necessarily underpin a long-term or strategic partnership. Nevertheless, investigating papers with an industry collaboration gives insights into academic-corporate activity. To provide an overview of the academic-corporate activity in Saudi Arabia, we investigate several domains: the evolution of the percentage and number of papers with industry collaboration, funding of papers with industry collaboration, corporates collaborating with Saudi affiliated researchers and top Saudi academic institutions in terms of number of papers with industry collaboration.

Finally, we analyze the research out and impact of the priority area on a more granular level by performing a SWOT analysis of the categories constituting the national priority area. The research topics constituting the priority area are described in Program of Work. This provides an overview of research performance in the research topics constituting this area, before investigating in more detail chosen priority research topics in later sections. This also allows for classification of the underlying categories into strength, weakness, opportunity, and threat areas. Accordingly, all the above analysis will create a relatively detailed overview of Saudi Arabia research performance in the priority area.

3.1.1 Main Findings

- Over the last 10 years, Saudi Arabia's research output within the national priority area of Health and Wellness increased very rapidly, with an average annual growth rate higher than that of the comparator countries/regions considered with an average annual growth rate of ~ 20%.

- In the area of Health and Wellness, Saudi Arabia's citation impact was 19% higher than the global average but lower than several of the comparator countries/regions. This indicates that although Saudi Arabia has a relatively good citation impact performance in this area, it could be further improved as this is a national priority area.
- Although the number of Saudi Arabian papers with an industry collaboration in Health and Wellness increased between 2014 and 2023, the percentage decreased. One possible explanation for such dynamics is that the implemented efforts to increase the research output did not focus on increasing parallel academic-corporate collaborations.
- Only 2% of Saudi Arabian papers with industry collaborations are performed with a local corporation. This has the advantage of gaining international visibility and expertise from international corporations. On the other hand, having more local corporations that collaborate with Saudi-affiliated researchers would further enhance local knowledge transfer, build local expertise, and allow local corporations to receive translational research.
- The top 3 Saudi organizations in terms of the number of papers published with an industry collaboration in Health and Wellness are King Abdulaziz University, followed by King Saud University and King Faisal Specialist Hospital & Research Center.
- When investigating Saudi Arabian performance in the research topics constituting the national priority area of Health and Wellness, we noticed out of the 47 research topics, there are 23 strength research topics, 17 opportunity research topics, three weakness research topics and four threat research topics. One should focus on increasing the research output in the opportunity areas, improving the research quality in the threat areas and improving both research output and quality in weakness areas.

3.1.2 Research volume analysis

The number of Saudi Arabia papers published in the national priority area of Health and Wellness grew continuously from 2,697 papers in 2014 to 13,166 papers in 2023, as shown in Figure 3. This reflects double-digit growth for most of the considered years; for some years, the growth rate was above 30%, and there was a much higher growth rate than the global rate in the same area. It is worth highlighting that although globally, there was a negative growth rate between 2022 and 2023 (-8%), in Saudi Arabia, we still observe a growth rate of 1.3%.
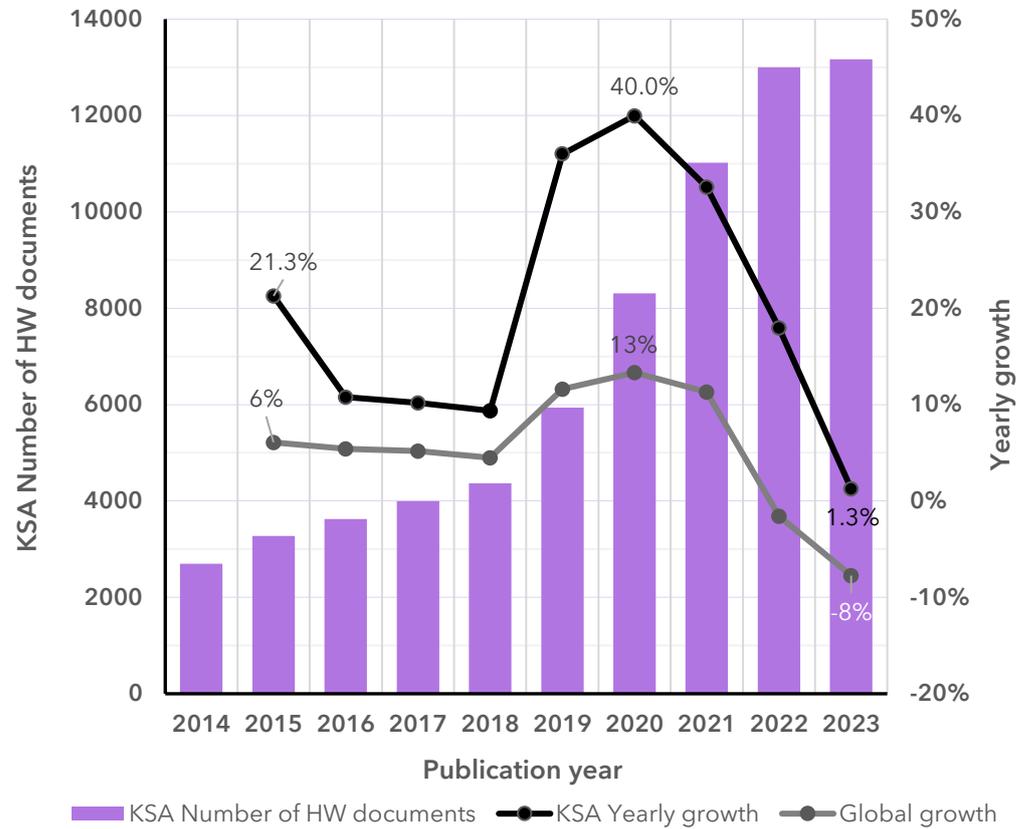
Figure 3: Saudi Arabia's number of papers and growth in the national priority area of Health and Wellness

In the considered period, Saudi Arabia had a yearly average growth rate not only almost four times the average global rate but also higher than all of the other considered benchmark countries/regions, as shown in Figure 4. It is worth mentioning that this is growth rate not only higher than countries with more almost saturated research output such as Japan, Germany, and the USA but also higher than that of countries/regions with growing research output such as Mainland China and the GCC excluding Saudi Arabia. All of the above indicates, the focus nationally of increasing the research activity in this national priority area.
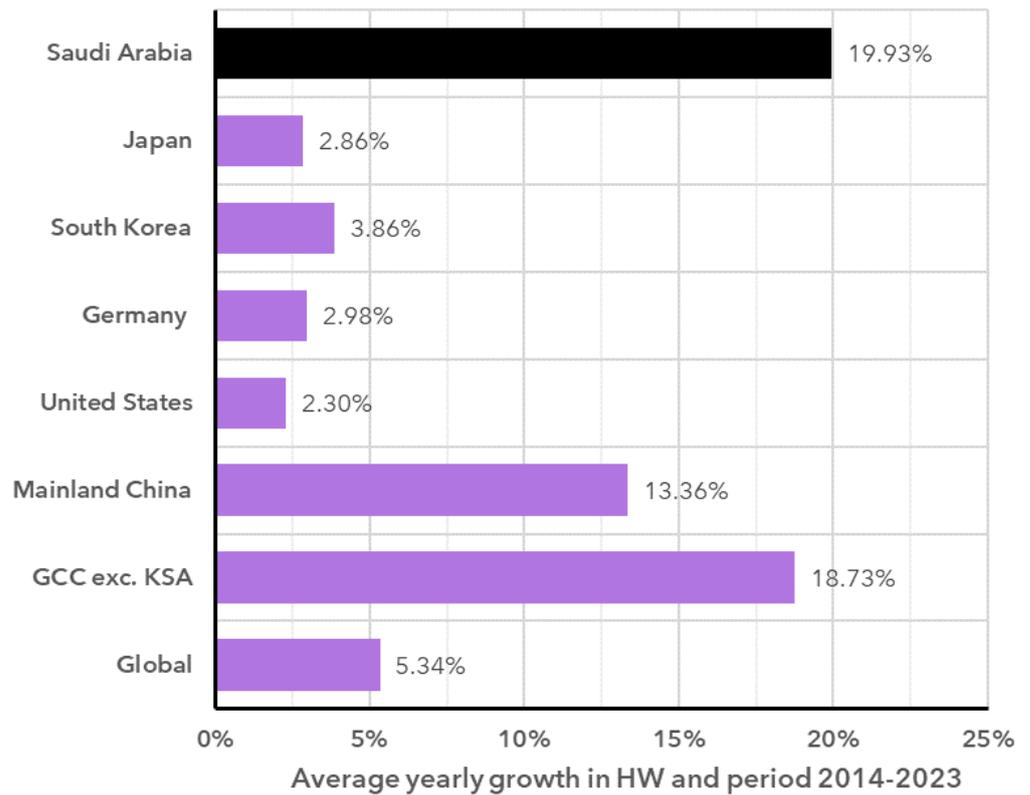
Figure 4: Average yearly growth of the number of papers in the area of Health and Wellness in the period 2014-2023

Figure 5 shows the number of active Saudi-affiliated researchers per year in the area of Health and Wellness. The number of active researchers is calculated by considering the number of unique authors of papers with an affiliation to an organization in Saudi Arabia in a certain period. For more information on the methodology used, please see the section 6.6 Metrics, Number of active researchers. It is important to note that this does not reflect the number of Full Time Equivalent (FTE) researchers but rather unique researchers appearing on papers with an affiliation to an organization in Saudi Arabia. Also, some researchers could write their names differently, or different researchers could be using the same names. To identify unique researchers, we use researcher profiles on the Web of Science platform. However, we still expect an approximate error of around ±15%.

As we have seen earlier, the number of Saudi Arabian papers in Health and Wellness increased continuously in the last 10 years, 2014-2023 as well as the number of active researchers in this area. This reflects a 6.5x increase in this period, indicating the growing research base in this national priority area.
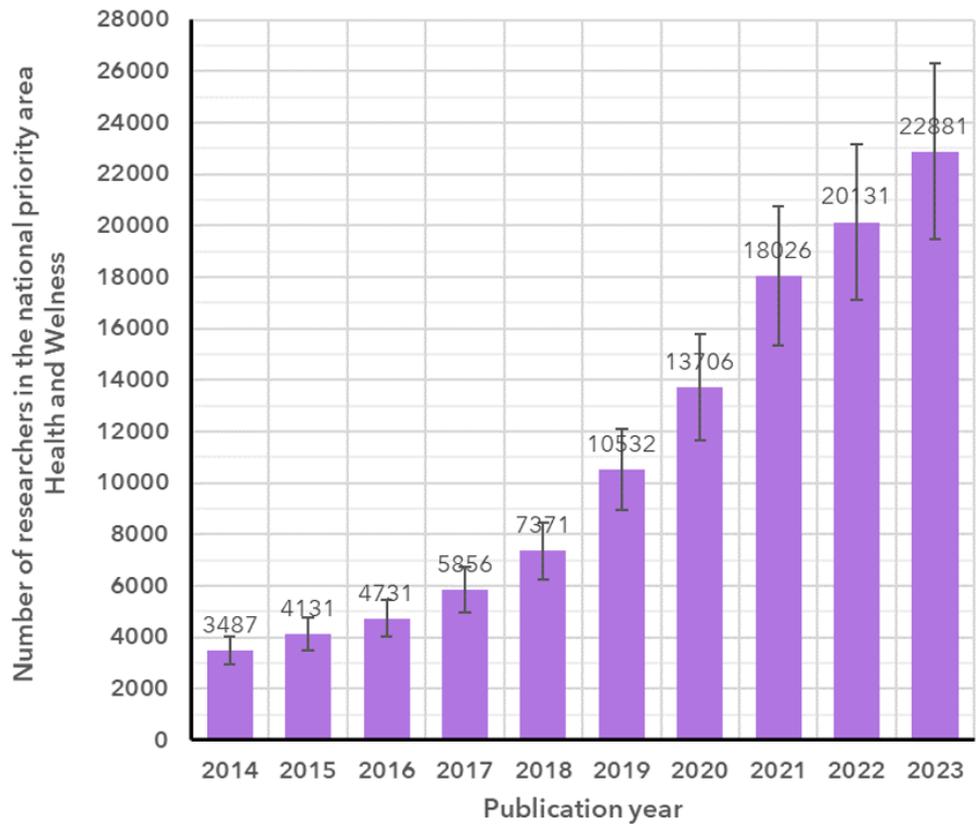
Figure 5: Number of active Saudi-affiliated researchers in the area of Health and Wellness

3.1.3 Citation impact analysis

The category normalized citation impact (CNCI) of Saudi Arabia in the period 2014-2023 was always above 1, indicating a citation impact performance at least on par with the global average, as shown in Figure 6.

The CNCI fluctuated in this period between 1.02 and 1.4. Saudi Arabia also achieved a CNCI in this period and in this area higher than that of Japan, South Korea and Mainland China but lower than that of Germany, USA and GCC excluding Saudi Arabia, as shown in Figure 7.

This indicates a relatively good citation impact footprint in this area, but it can be further improved. Usually, we notice citation impact dips in periods with high volume growth, because in such periods the knowledge and expertise are being accumulated by the expanded researcher's base.

This can be specifically seen in the years 2018-2019 in which the research output grew by 36% whereas the CNCI dropped by 20%. The CNCI recovered since then to reach 1.23 and 1.19 in 2022 and 2023, respectively.
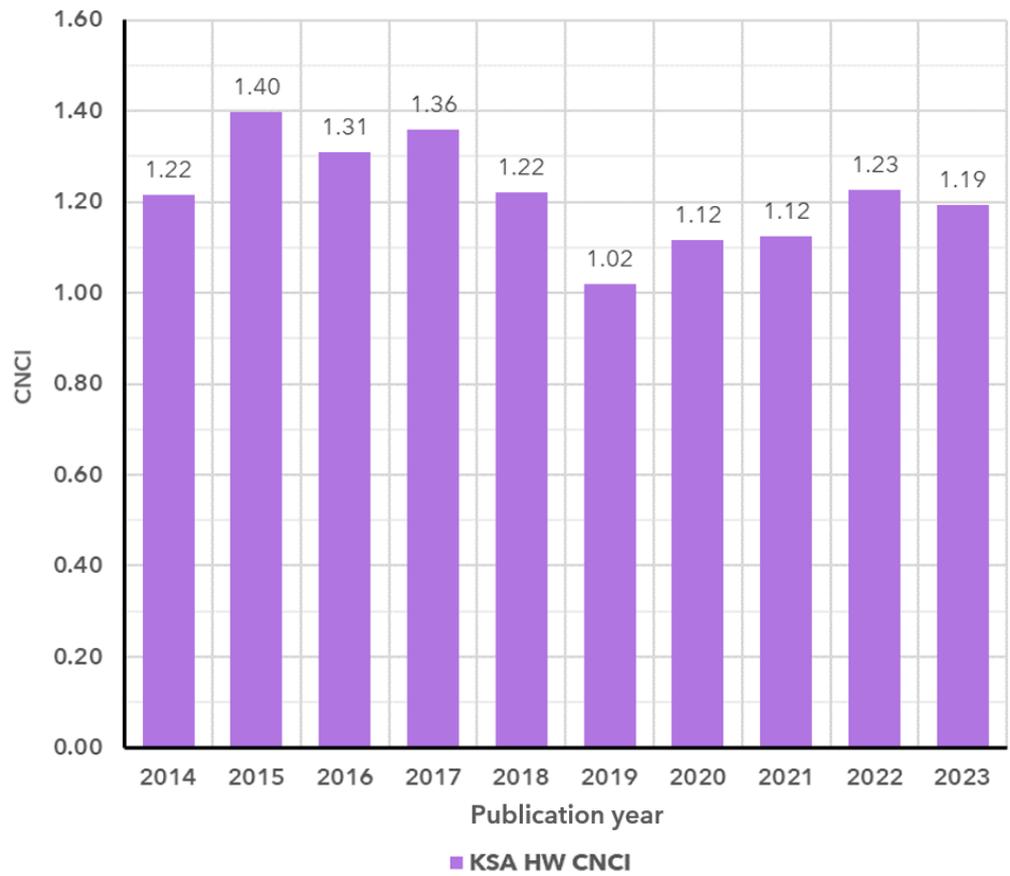
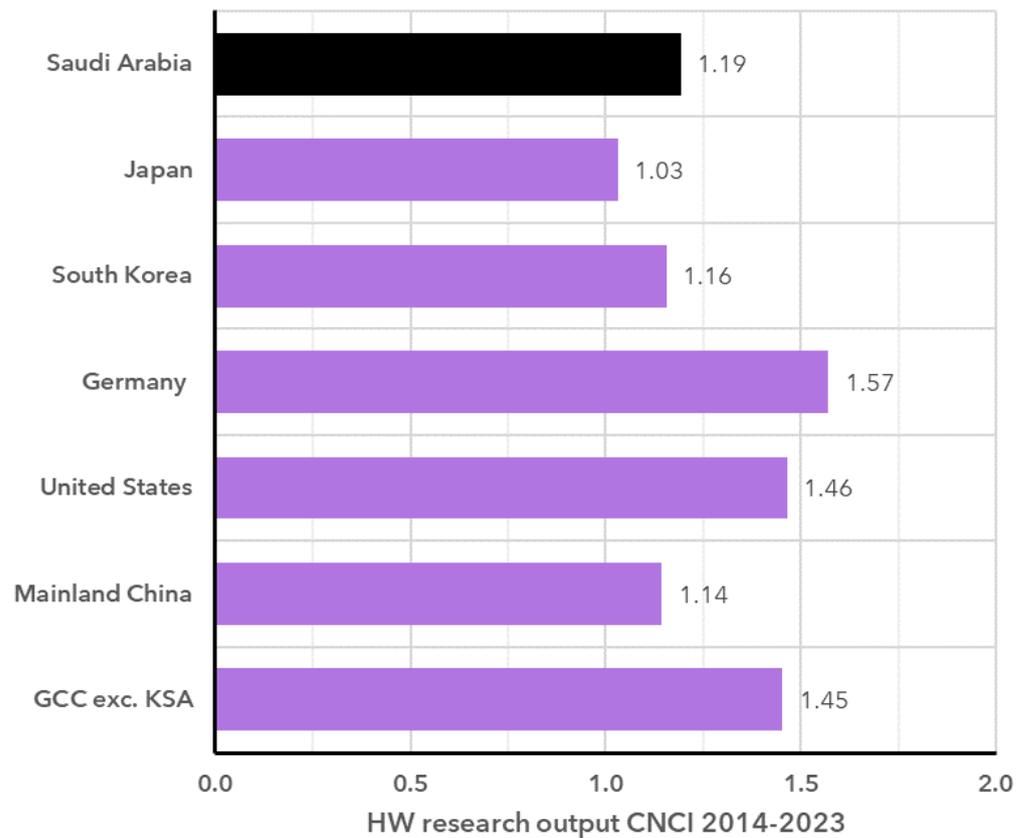Figure 6: Saudi Arabia's yearly category normalized citation impact in the area of Health and Wellness

Figure 7: Health and Wellness research output CNCI in the period 2014-2023

3.1.4 Funding dynamics analysis

The top 3 funding organizations mentioned in the funding text of Saudi Arabia publications in the area of Health and Wellness in the period 2014-2023 are King Saud University, the United States Department of Health & Human Services and the National Institutes of Health (NIH) – USA with 6,436, 1,853 and 1,823 publications respectively as shown in Figure 8.

Saudi Arabia research output in the area Health and Wellness that was funded by Medical Research Council UK (MRC) resulted in the highest citation impact measured by CNCI followed by Japan Society for the Promotion of Science and UK Research & Innovation (UKRI) with a CNCI of 9.84, 9.01 and 8.6 respectively.
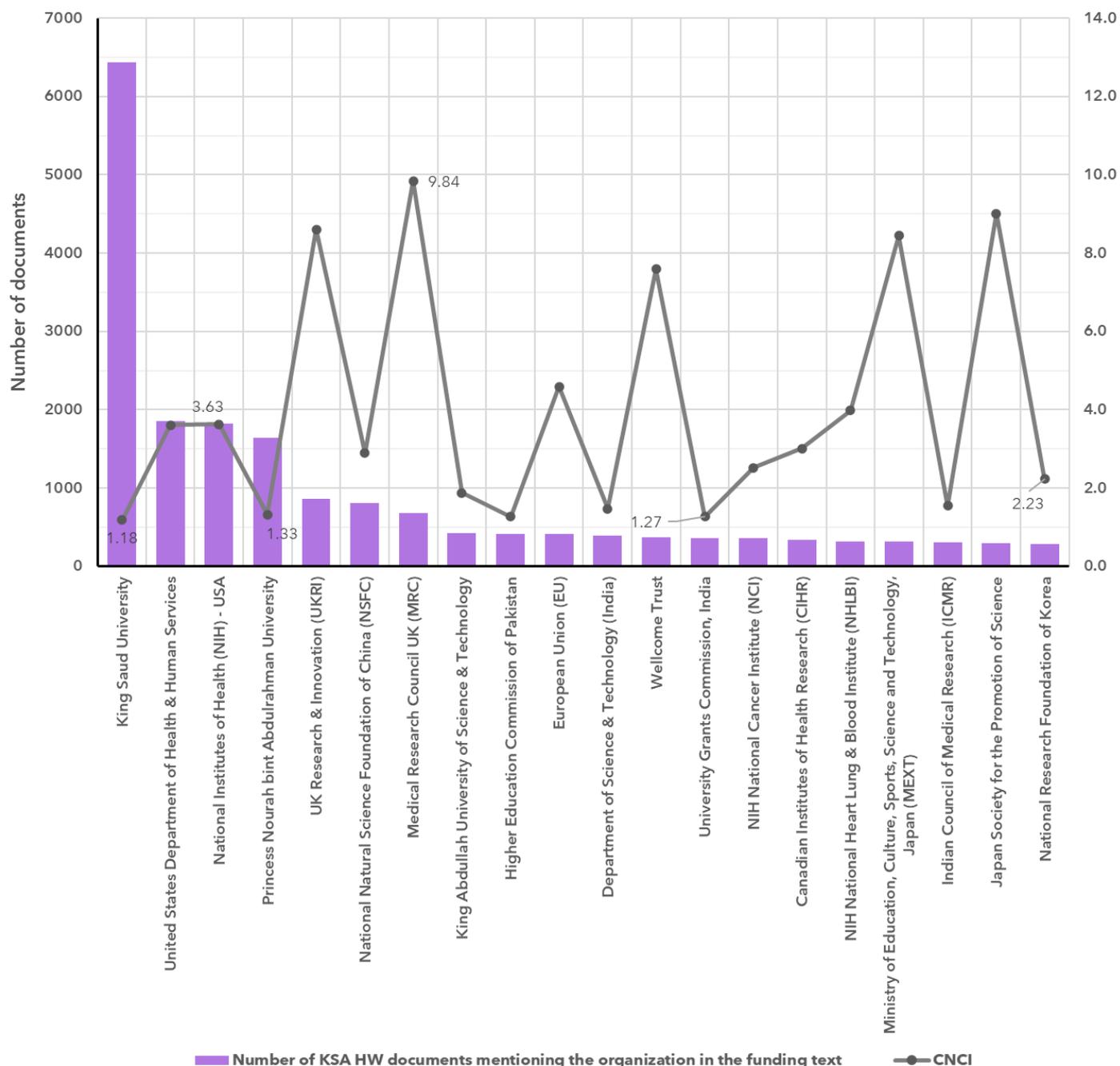
Figure 8: Top 20 funding organizations mentioned in the funding text of Saudi Arabia Health and Wellness papers in the period 2014-2023

The lowest CNCI is observed in papers funded by King Saud University, though the CNCI is still 18% higher than the global average and one should also take into consideration the high volume of funded papers relative to the other organizations. We observe that there are three funding organizations based in Saudi Arabia among the top 20.

3.1.5 Collaboration dynamics analysis

Egypt, followed by India and the USA, had the highest number of publications in collaboration with Saudi Arabia-affiliated researchers in the national priority area of Health and Wellness in the period 2014-2023, with 14,691, 10,002 and 9,700 publications, respectively, as shown in Figure 9.

In terms of citation impact measured by the category normalized citation impact, papers in collaboration with Netherlands followed by Spain and Japan with a CNCI of 7.48, 7.21 and 6.87, respectively.

Nevertheless, research with all the top 20 collaborating countries with Saudi Arabia in this area resulted in a CNCI higher than the global average performance of ~1.
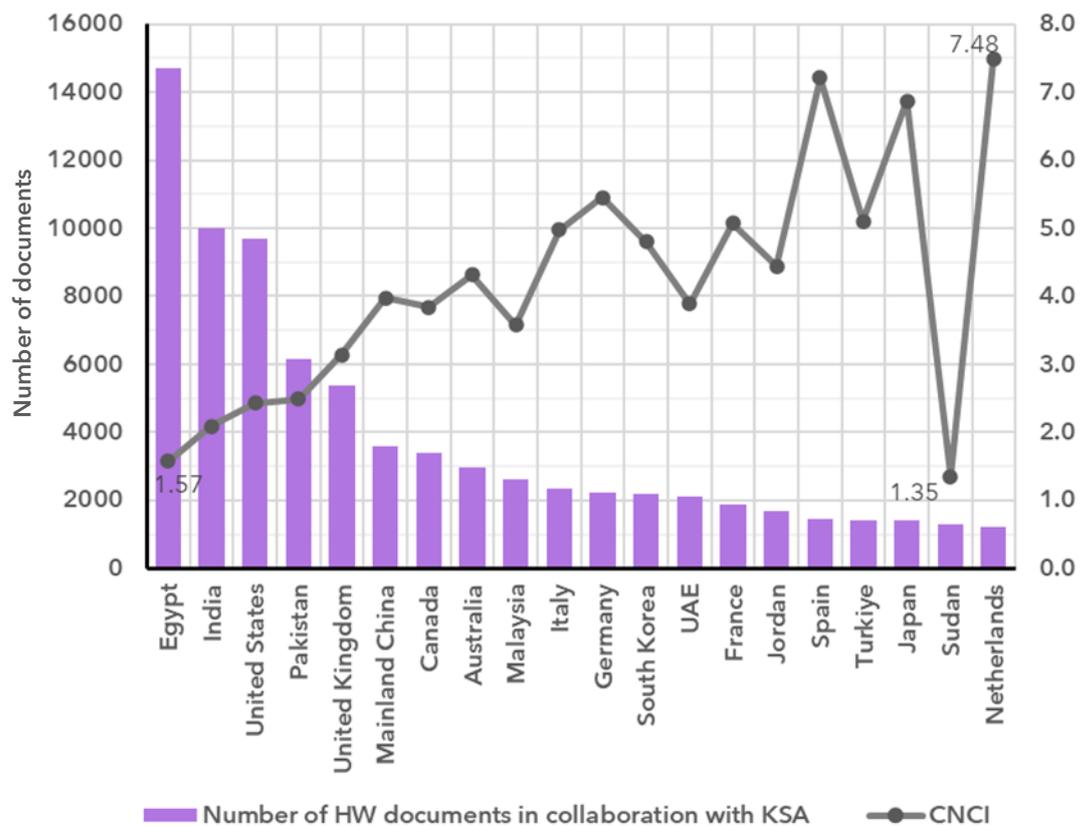

Figure 9: Top 20 collaborating countries with Saudi Arabia in the area of Health and Wellness in the period 2014-2023

3.1.6 Academic-corporate collaboration in Saudi Arabia identified from research publications in the areas of Health and Wellness

The percentage of Saudi Arabia papers with industry collaboration in the area of Health and Wellness increased from 2.2% in 2014 to 2.6% in 2017 to then decrease almost continuously to 1.1% in 2023, as shown in Figure 10.

On the other hand, the number of Saudi Arabian papers in the area of Health and Wellness with industry collaborations also increased almost continuously from 58 in 2014 to 161 in 2021 and then decreased to 144 in 2023.

The reason behind the decrease in the percentage of Saudi Arabian papers in the area of Health and Wellness is the higher growth rate of papers in the area in comparison to the growth of papers with industry collaborations.

We have noticed a similar decreasing trend when examining the percentage of papers with industry collaboration from Saudi Arabia's overall research output.

One possible explanation for such dynamics is that the implemented efforts of increasing the research output in Health and Wellness did not focus on increasing in parallel the academic-corporate collaborations via building on existing collaborations.
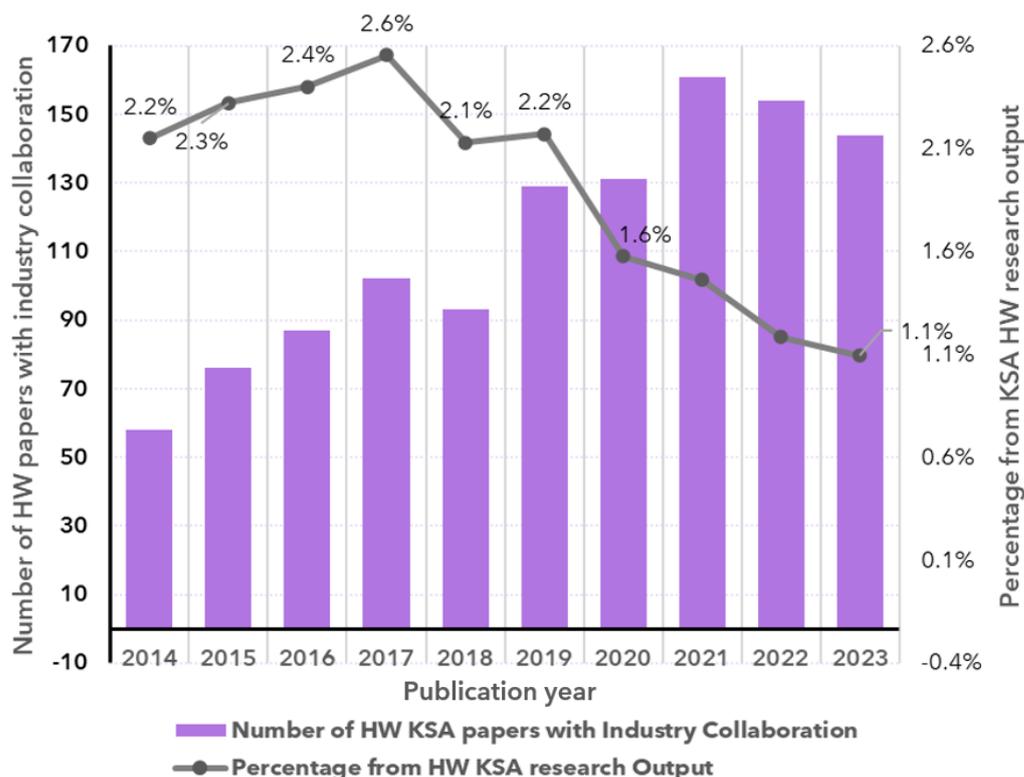

Figure 10: Number and percentage of Saudi Arabia publications that have been performed with an industry collaboration in the national priority area of Health and Wellness

When benchmarking the percentage of papers with industry collaborations in the area of Health and Wellness in the period 2014-2023 of Saudi Arabia with the considered benchmark countries, we notice that it is lower than the global baseline and than that of all considered countries/regions except than that of Mainland China as shown in Figure 11.

The highest percentage of papers with industry collaborations among the considered countries/regions is observed in Germany with ~9.81%, followed by the USA with 7.04% and the USA with 6.87%.

Considering that Health and Wellness is a national priority area, Saudi Arabia could aim as a first step achieving percentages of papers with industry collaborations close to the global baseline.
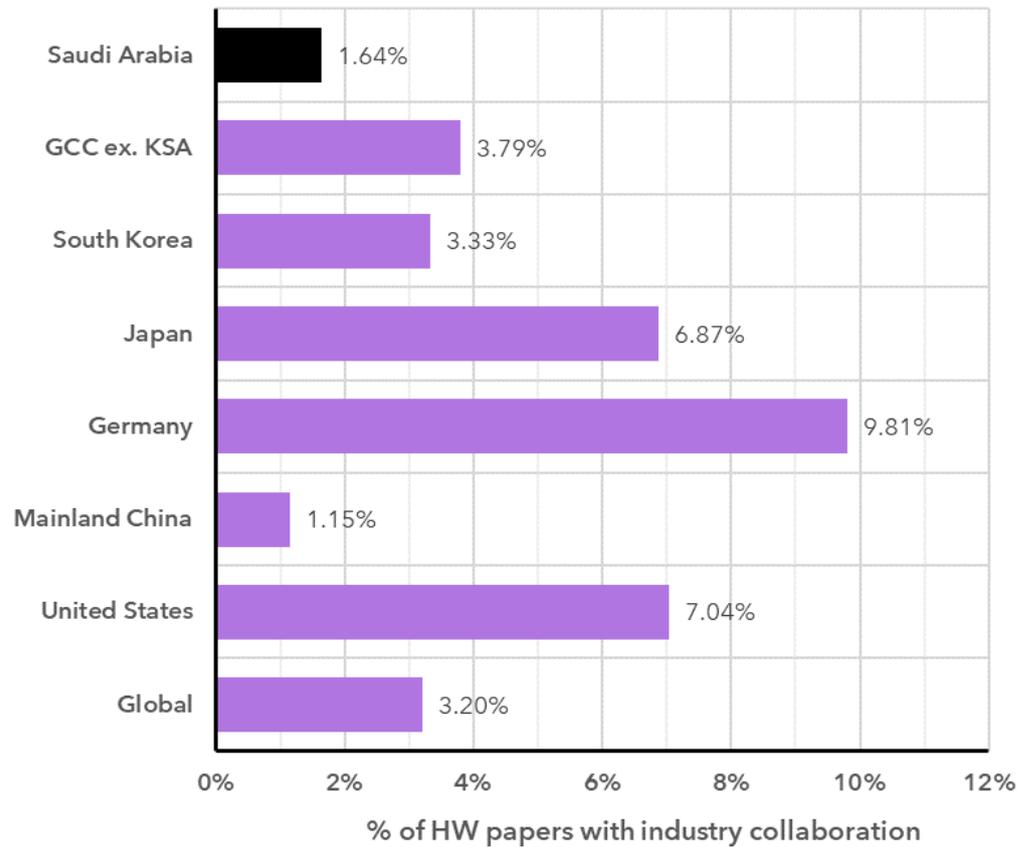
Figure 11: Percentage of papers that have been performed with an industry collaboration in the period 2014-2023 in the national priority area of Health and Wellness

In Figure 12, the top 20 funding organizations of Saudi Arabia publications with industry collaborations in the area Health and Wellness ranked by number of funded collaborations is shown.

The top 3 funding organizations are the United States Department of Health & Human Services, sharing the first position with the National Institutes of Health (NIH) – USA, followed by the UK Research & Innovation (UKRI) and the Medical Research Council UK (MRC) with 166, 131 and 119 publications, respectively. Among the top 20 funding organizations there is only one Saudi organization.

We notice a domination of international funding organizations among the top 20. This shows the ability of Saudi affiliated researchers to attract international funding and/or collaborate with corporates in an international context.
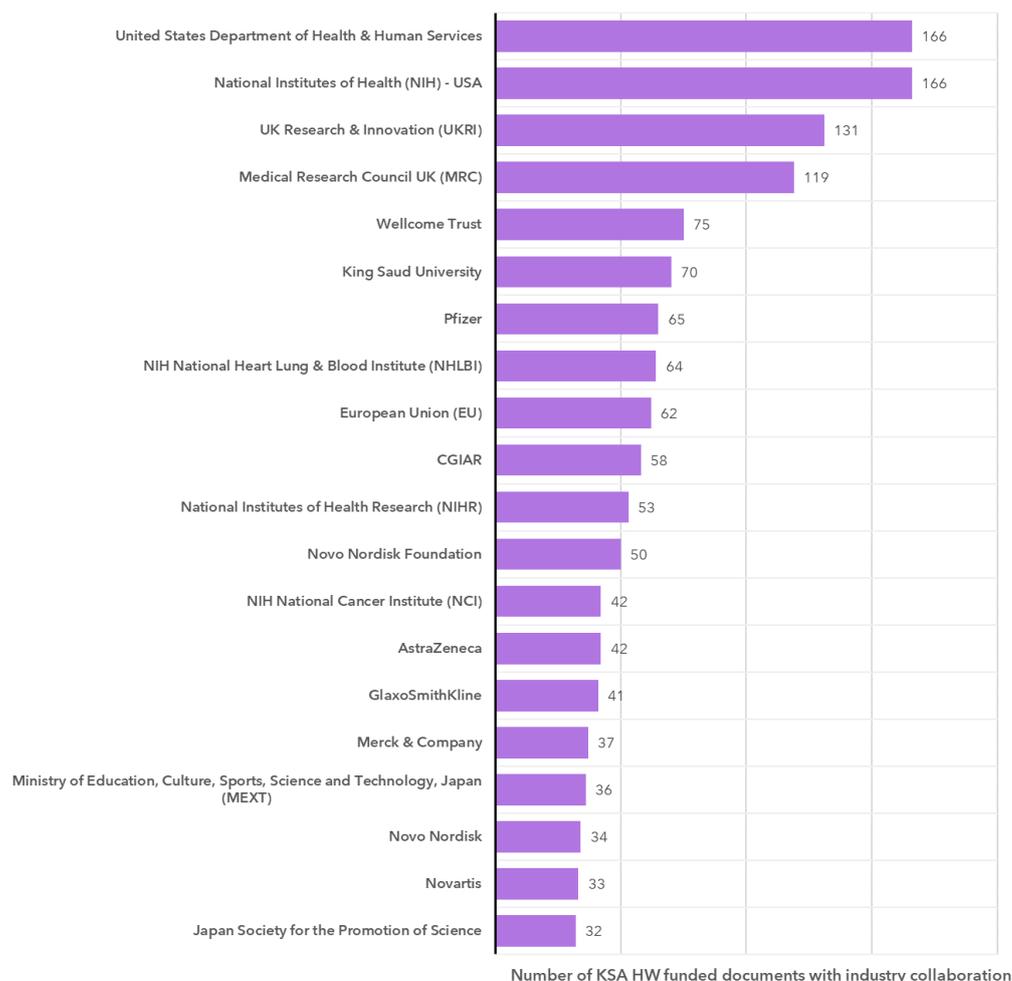
Funding Organization	Number of KSA HW funded documents with industry collaboration
United States Department of Health & Human Services	166
National Institutes of Health (NIH) - USA	166
UK Research & Innovation (UKRI)	131
Medical Research Council UK (MRC)	119
Wellcome Trust	75
King Saud University	70
Pfizer	65
NIH National Heart Lung & Blood Institute (NHLBI)	64
European Union (EU)	62
CGIAR	58
National Institutes of Health Research (NIHR)	53
Novo Nordisk Foundation	50
NIH National Cancer Institute (NCI)	42
AstraZeneca	42
GlaxoSmithKline	41
Merck & Company	37
Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT)	36
Novo Nordisk	34
Novartis	33
Japan Society for the Promotion of Science	32

Number of KSA HW funded documents with industry collaboration

Figure 12: Saudi Arabia's top 20 funding organizations of research with industry collaboration in the national priority area of Health and Wellness in terms of the number of publications and in the period 2014-2023

In Figure 13, we investigate the top 40 corporates collaborating with Saudi Arabia affiliated researchers in terms of number of publications in the area Health and Wellness.

Specifically, the share of a specific corporation from the overall Saudi Arabia publications in Health and Wellness with industry collaborations is plotted on the y-axis. A logarithmic scale is used because of the significant difference between the top 3 and the rest of the corporates.

On the x-axis, the CNCI of those publications is plotted. Corporates that have a share above 1% of the overall Saudi Arabia papers with industry collaborations lie above null on the y-axis. Corporates that have a CNCI above 1 lie right to the dotted line, marking a citation impact higher than the global average when considering the same document type, year of publication and subject area.

Accordingly, all corporates lying in the upper quadrate are corporates that have more than 1% share of Saudi Arabia papers with industry collaborations and an impact performance higher than the global average measured by the CNCI. These corporates lie in the upper quadrate, and their output is listed in Table 1.

As these corporates are having relatively high share from Saudi Arabia overall publications with industry collaborations and their impact is higher than the global average, further developing these collaborations to partnerships could be considered. Here it is important as well to consider other criteria such as alignment

with national priorities, goals of the partnerships, etc. Such criteria can be derived from the analysis illustrated in the section Academic Corporate Partnership Models.

The top three corporates collaborating with Saudi-affiliated researchers in the period 2014-2023 in the area of Health and Wellness are the National Organization for Drug Control & Research (NODCAR), followed by Pfizer and VACSERA with ~17.53%, ~6.2% and ~5.4% from the overall Saudi Arabia publications with industry collaborations in Health and Wellness.

Among the top 40, there is only one local corporation, SABIC, and one local subsidiary of an international corporation, Pfizer - Saudi Arabia local. Actually, 98% of Saudi Arabia's Health and Wellness papers with an industry collaboration are performed with an international corporation as seen in Figure 14. Having more local corporations that collaborate with Saudi affiliated researchers would further enhance local knowledge transfer and building local expertise.
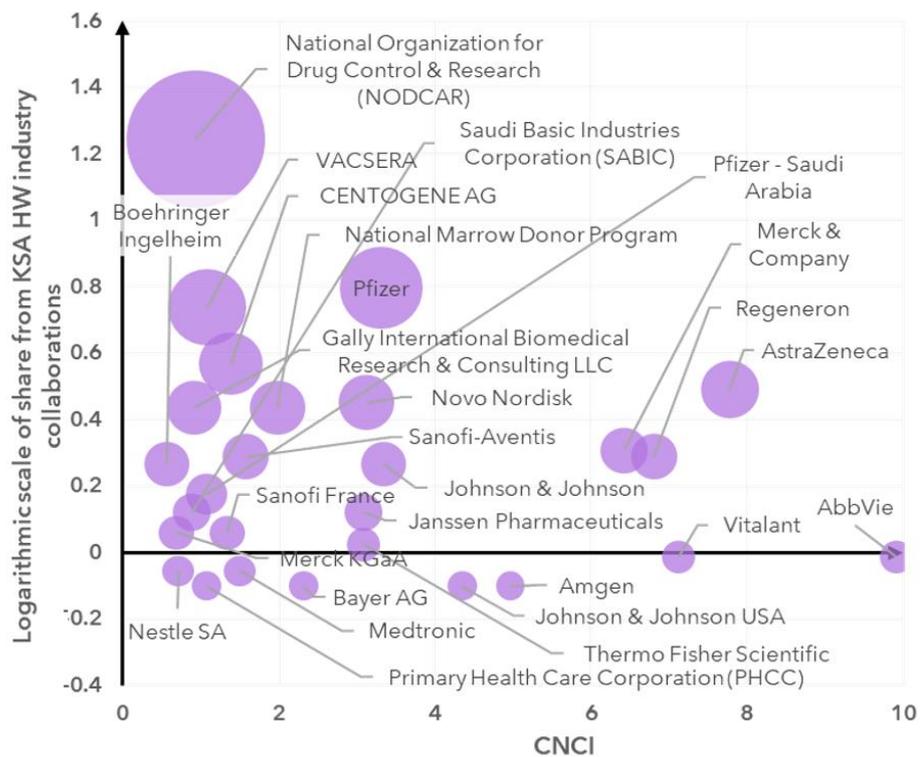

Figure 13: Top 40 corporates that have paper collaborations with Saudi-affiliated researchers in terms of the number of papers in the period 2014-2023 in the area of Health and Wellness. The figure plots the share of papers with industry collaboration in the area of Health and Wellness on a logarithmic scale.

Table 1: Corporates having at least 1% share from Saudi papers with industry collaboration in the area of Health and Wellness and have at least an impact on par with the global average (CNCI 1 or above)

Corporate	Number of papers	Share	CNCI
Pfizer	71	6.3%	3.31
VACSERA	62	5.5%	1.08
GlaxoSmithKline	56	4.9%	15.45
CENTOGENE AG	42	3.7%	1.39
AstraZeneca	35	3.1%	7.78
Novo Nordisk	32	2.8%	3.12
National Marrow Donor Program	31	2.7%	1.98
SYNLAB Group	25	2.2%	19.98
Novartis	25	2.2%	21.09
Roche Holding	25	2.2%	22.67
Merck & Company	23	2.0%	6.42
Sanofi-Aventis	22	1.9%	1.58
Regeneron	22	1.9%	6.80
Johnson & Johnson	21	1.9%	3.34
Genentech	19	1.7%	29.58
IQVIA	19	1.7%	13.45
Eli Lilly	17	1.5%	17.27
Pfizer - Saudi Arabia	17	1.5%	1.07
Janssen Pharmaceuticals	15	1.3%	3.08

Sanofi France	13	1.1%	1.34
Thermo Fisher Scientific	12	1.1%	3.08
Samsung	12	1.1%	64.79
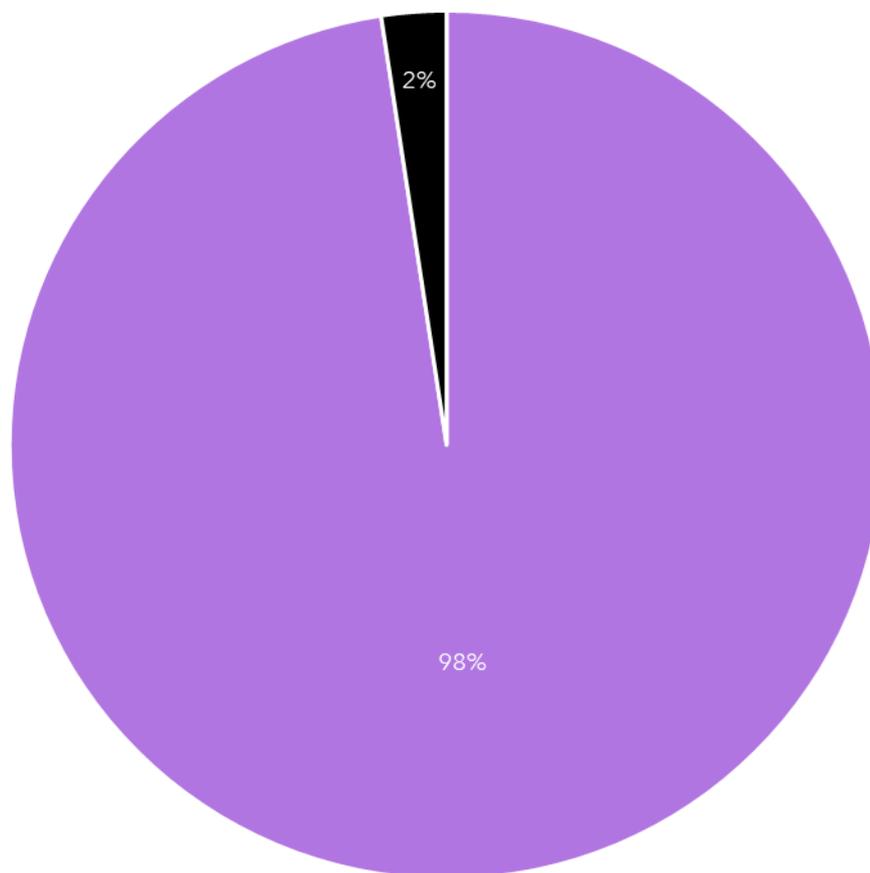
Figure 14: Percentage of Saudi Arabia Health and Wellness papers with an industry collaboration with national versus international corporates from overall papers with an industry collaboration

The top 3 Saudi academic institutions in terms of the number of papers (Figure 15) with an industry collaboration in the area of Health and Wellness in the period 2014-2023 are King Abdulaziz University, followed by King Saud University and King Faisal Specialist Hospital & Research Center with 263, 255 and 122 publications as shown in Figure 15.

When looking at the Health and Wellness papers with an industry collaboration from the overall Health and Wellness papers, Alfaisal University has the highest percentage, followed by King Fahad Medical City and King Abdullah University of Science & Technology with 4.33%, 3.85% and 3.59% respectively. It is worth noting that King Faisal Specialist Hospital & Research Center has the third highest volume of Health and Wellness papers with industry collaboration and a relatively high percentage of 3.46%, which indicates that it could be a central academic institution in Saudi Arabia for performing academic-corporate collaborations in this area.
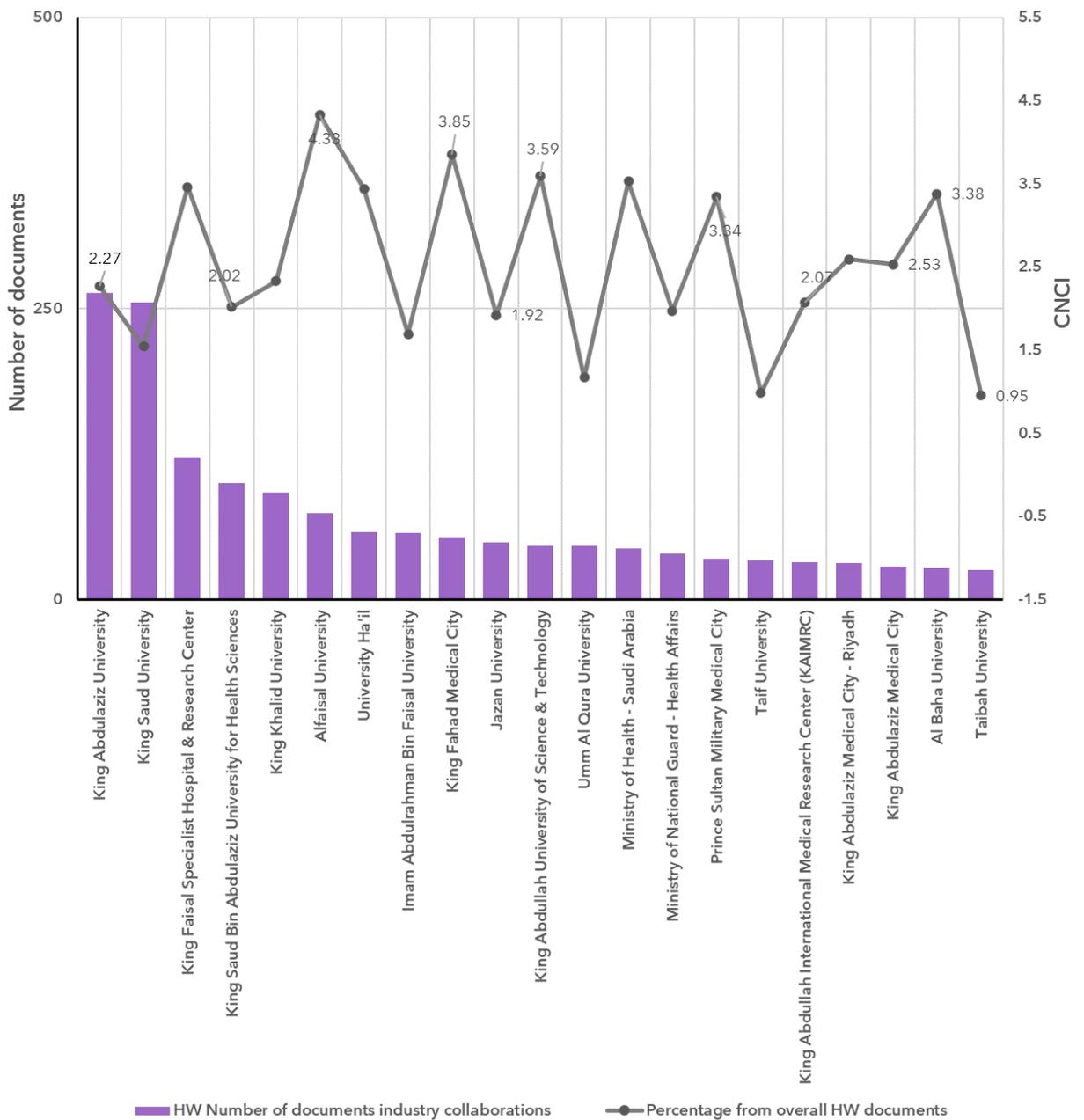
Figure 15: Number and percentage of publications with an industry collaboration in the area of Health and Wellness and in the period 2014-2023 of the top 20 Saudi academic institutions in terms of number of papers with an industry collaboration

3.1.7 SWOT Analysis of Underlying Research Topics in Health and Wellness

In this part, we examine Saudi Arabia's research performance in the underlying categories that constitute the national priority area of Health and Wellness. The research topics constituting the area and the selection of those research topics are described in the Dataset Description.

To perform this, we perform a Strength, Weakness, Opportunity, and Threat (SWOT) analysis. The analysis is based on two main metrics: productivity relative to the global productivity and impact measured by the category normalized citation impact. The productivity relative to global productivity is measured by the number of Saudi Arabian papers in a specific research topic divided by the number of global publications in the same research topic and period. This is then normalized by the share of Saudi Arabia's overall research from the global research in the same period.

Thus, a value in this indicator above 1 indicates that Saudi Arabia has a share of the global research in this research topic higher than the share of Saudi Arabia from the global research in the same period. Similarly, a CNCI above 1 indicates a citation impact footprint in the research topic higher than that of the global average. Accordingly, we can classify the research topics into four regions:

- Strength: Productivity relative to global productivity is above 1, and the CNCI is above 1

- Threat: Productivity relative to the global productivity is above 1 and CNCI less than one

- Opportunity: Productivity relative to global productivity is less than 1, but CNCI is above 1

- Weakness: both the productivity relative to the global productivity and CNCI are less than 1

SWOT Analysis
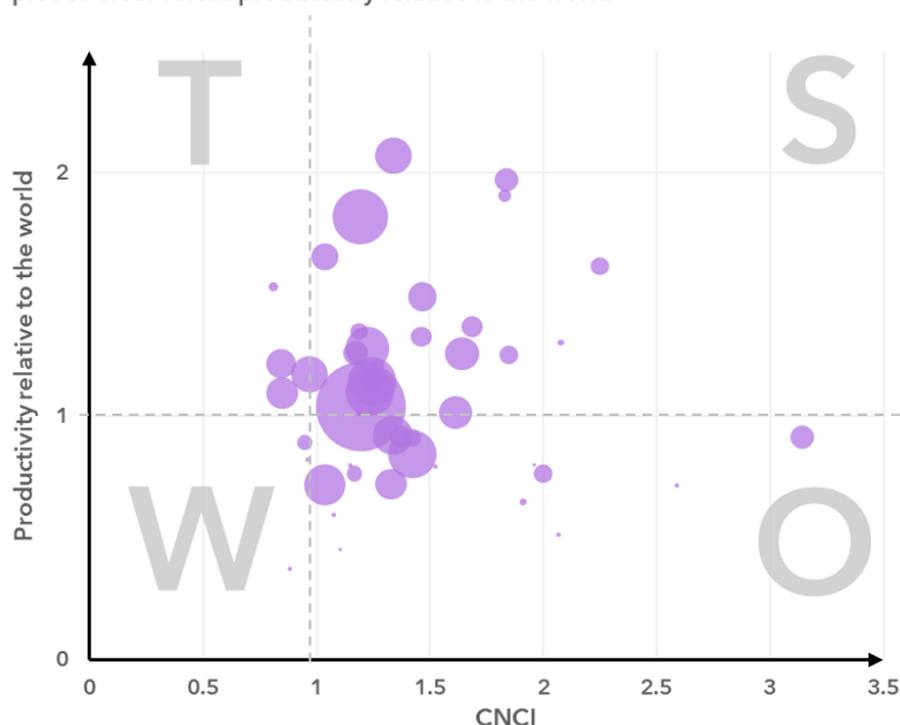plot of CNCI versus productivity relative to the world

Figure 16: SWOT analysis of the national priority area of Health and Wellness. The y-axis shows the productivity relative to the world (share of Saudi Arabia from the global productivity in the research topic normalized by Saudi Arabia's share of global productivity when considering overall research). The x-axis shows the impact relative to the world.

When investigating Saudi Arabia's performance in the research topics in the national priority area of Health and Wellness, we noticed out of the 47 research topics; there are 23 strength research topics listed in Table 2, 17 opportunity research topics listed in Table 3, three weakness research topics listed in Table 4 and four threat research topics listed in Table 5 as also shown in Figure 16.

As all of these research topics are of national priority, one should try to conserve the high performance in the strength research topics, increase the productivity in the opportunity areas by leveraging expertise that is evident with the CNCI being higher than 1, improve the quality and accordingly the citation impact in the threat categories and improve the productivity and research quality in weakness research topics.

Table 2: Saudi Arabia's strength research topics in the national priority area of Health and Wellness

Research topic	CNCI	Productivity relative to global productivity
Cancer	1.2	1.0
Nutrition & Obesity	1.2	1.1
Cognition & Memory	1.2	1.1
Diabetes	1.2	1.8
Biopharmaceuticals	1.2	1.3
Neurological	1.6	1.0
Vaccines	1.6	1.3
Antimicrobial Resistance	1.3	2.1
Biosensors/MEMS	1.5	1.5
Heart Health	1.2	1.3
Implants	1.0	1.7
Hepatitis	1.2	1.1
Telehealth	1.5	1.3
Tuberculosis	1.7	1.4
Nanomedicine	1.7	2.6
Influenza	1.8	1.3
AI/ML Imaging	1.8	2.0
Malaria	2.2	1.6
Eyesight	1.2	1.3

Mobile Health	1.3	1.2
Dengue	1.8	1.9
Neurodegenerative Gene Therapy	1.2	1.0
Wearables	2.1	1.3

Table 3: Saudi Arabia opportunity research topics in the national priority area of Health and Wellness

Research topic	CNCI	Productivity relative to global productivity
Cardiovascular Diseases	1.4	0.8
Immunotherapy	1.0	0.7
Chronic Respiratory	1.3	0.9
Precision Medicine	1.3	0.7
Skin health	3.1	0.9
Gene, RNA General Therapy	1.4	0.9
Gut Health	2.0	0.8
Digital Health - eHealth	1.4	0.9
Immunity Boosting	1.2	0.8
Lab-on-a-Chip / microfluidics	1.9	0.6
CAR-T Cell Therapy	2.1	0.5
Phage therapy	1.1	0.6
Exoskeleton	1.1	0.5
Medical Robots	1.2	0.8

Robotic Prosthetics	2.6	0.7
Telesurgery	1.5	0.8
Congenital Gene Therapy	2.0	0.8

Table 4: Saudi Arabia's weakness research topics in the national priority area of Health and Wellness

Research topic	CNCI	Productivity relative to global productivity
Stem Cell Therapy	0.9	0.9
Healthcare/Surgical Robots	0.9	0.4
Blood Disorder Gene Therapy	1.0	0.8

Table 5: Saudi Arabia threat research topics in the national priority area of Health and Wellness

Research topic	CNCI	Productivity relative to global productivity
Genomics	1.0	1.2
Gastrointestinal	0.8	1.1
Electronic Health Records	0.8	1.2
Health Data and IT Management	0.8	1.5

3.2 Overview of Performance in Patents

In this section, we summarize, and review information collated during the study: Assessment of Academic-Corporate Partnerships in Saudi Arabia of the program that is specific to the Health and Wellness National Priority.

This section concerns benchmarking invention volumes, strength, and academic-corporate partnerships in Saudi Arabia against globally relevant benchmarks.

3.2.1 Percentage of academic-corporate invention activity

Health and Wellness have seen the most consistent invention growth, and even Saudi Arabia's inventions increased by six times during the period studied. Despite this

trajectory, in Figure 17, there has been a steady decline in academic-corporate partnerships. Health and Wellness has the highest initial proportion of partnerships, with ~12% of the total invention output in 2014 involving academic-corporate partnerships. However, this has decreased sharply in 2023, top 4% in 2023, indicating a significant decline in collaboration despite an increasing volume of inventions. A rapid decline in industry-academia collaboration could be a significant challenge for the Kingdom. However, it is important to bear in mind that it could be indicative of successful partnership yield and cyclical patterns in R&D. Although this does not directly impact invention throughput, it is worth bearing in mind that of all the priority areas, Health and Wellness, is inclusive of medical devices and a wider array of therapeutic areas that typically have longer lifecycles (on average from 10 to 12 years) from discovery to market. Without strong partnerships, Saudi Arabia may struggle to sustain innovation in Health and Wellness, which could slow the sector's ability to address pressing healthcare challenges.
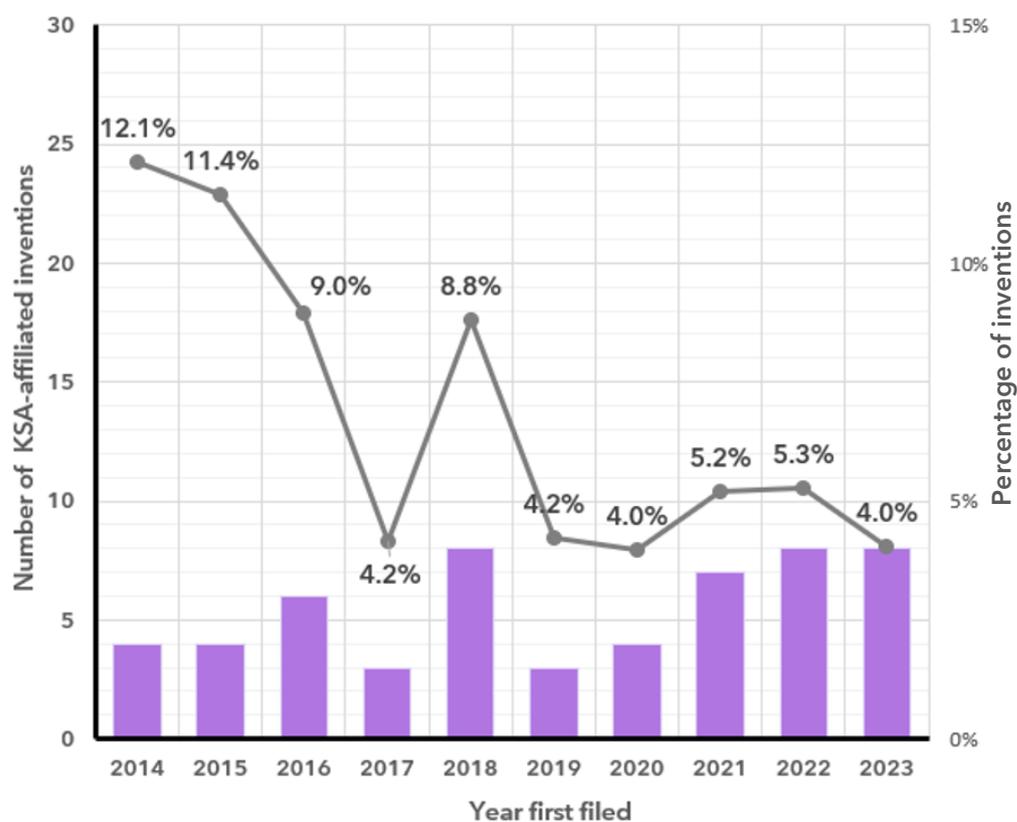
Figure 17: Timeline and trend of Saudi Arabia-affiliated inventions with industry collaboration in Health and Wellness, 2014–2023

In Figure 18 Health and Wellness, ~6% of all Saudi Arabia's invention activity (2014-2023) is linked to academic-corporate partnerships, slightly below the global average of ~8% but comparable to Mainland China (~7%). South Korea leads this sector with ~12%, followed closely by Japan at ~11%, both reflecting a strong focus on healthcare partnerships. Germany, with ~9%, also demonstrates a higher partnership rate than Saudi Arabia, while the United States aligns more closely with the global average at ~8%. Although Saudi Arabia's performance in relative terms is competitive, there is clear potential to enhance its academic-corporate partnerships in this sector to more effectively drive innovation and growth.

In Health and Wellness, the declining rate of academic-corporate partnerships in Saudi Arabia, despite significant growth in invention output, indicates a potential gap in the commercialization pipeline for healthcare technologies. Unlike other sectors,

medical research, for example, relies heavily on long-term industry collaboration to navigate the extended and complex lifecycle of innovations, from clinical trials to regulatory approvals and market entry. The drop in partnership involvement from approximately 12% to 4% over the past decade suggests that fewer projects are advancing beyond early-stage, which could limit the scalability and market potential of Saudi Arabia's healthcare innovations due to international regulatory bottlenecks.

To maintain momentum and ensure that medical discoveries reach patients and markets, Saudi Arabia needs to focus on building strong academia and industry engagement.
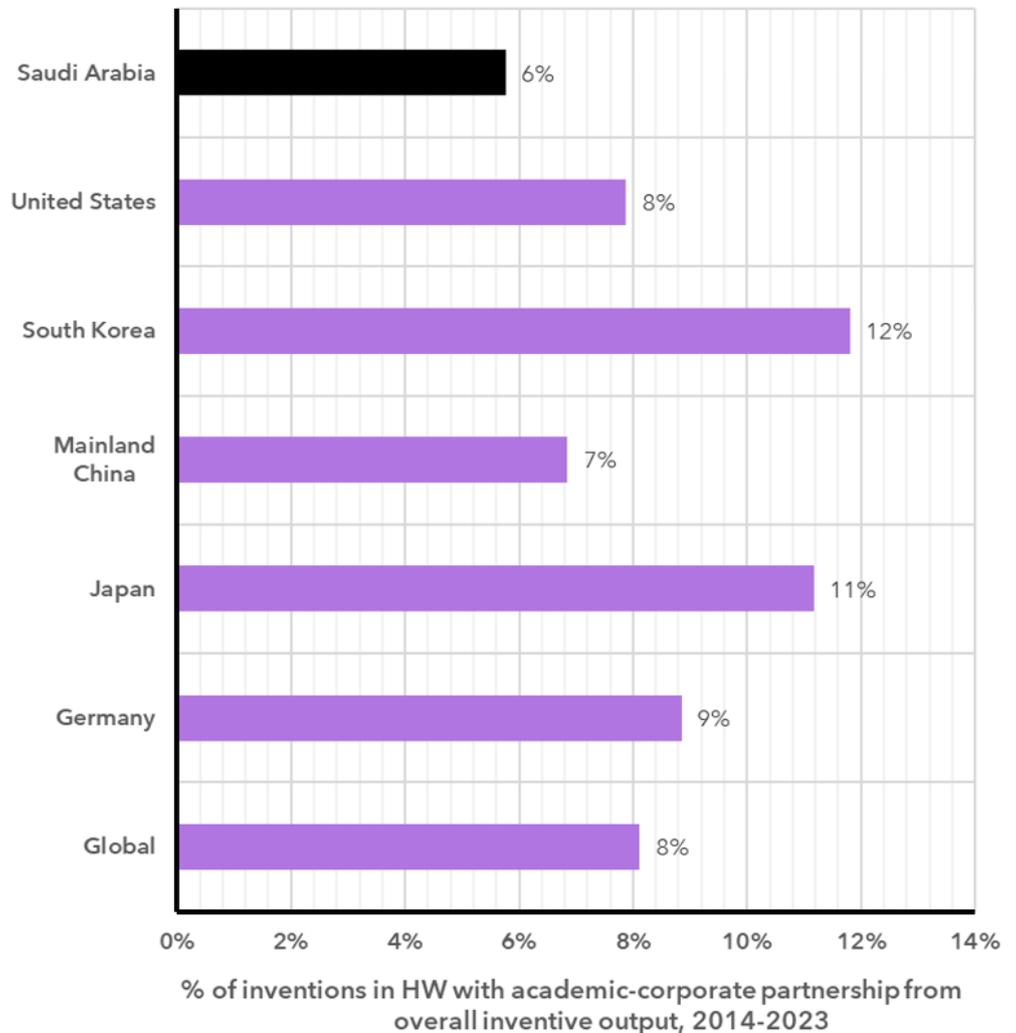
Figure 18: Academic and industry collaboration in inventions in Health and Wellness by major countries, compared to world baseline, 2014–2023

In Figure 19 Saudi Arabia's academic-corporate partnerships in Health and Wellness demonstrate a competitive invention strength of 31, comparable to Japan and Mainland China.

However, this strength should be considered Saudi Arabia's relatively low but growing activity in Health and Wellness technologies. For instance, while Saudi Arabia matches Mainland China's invention strength, Mainland China's partnerships produced nearly 50,000 inventions in this area, far outpacing Saudi Arabia's output.

This disparity underscores the opportunity for Saudi Arabia to scale its partnerships significantly to match the global presence and investment seen in countries like Japan and the United States. The United States and Germany lead with invention strength

scores of 33 and 34, respectively. South Korea marginally lags behind these strength scores in both impact and output.
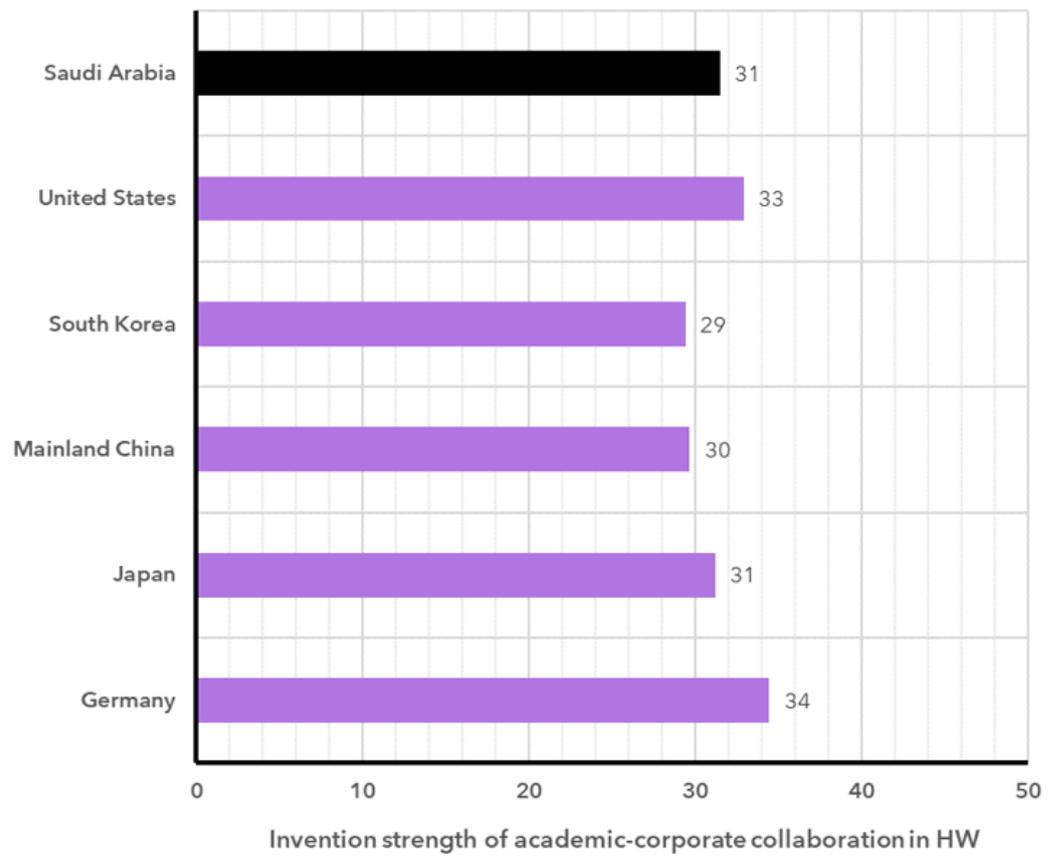

Figure 19: Strength of academic and industry collaboration inventions in Health and Wellness by major countries, 2014–2023

3.2.2 Invention impact analysis

In Figure 20 Saudi Arabia's academic-corporate partnerships in Health and Wellness exhibit greater invention strength compared to global peers like Mainland China and Japan. However, the overall volume of invention activity remains relatively modest.

This disparity underscores the opportunity for Saudi Arabia to scale its partnerships and increase invention output to match global leaders such as the US. The US benefits from a robust framework for incentivizing healthcare innovation, mainly through initiatives such as IP development.

These initiatives drive substantial collaboration in healthcare, a sector that relies heavily on long-term R&D cycles due to the regulatory complexities of bringing medical technologies to market. Despite the lower volume, Saudi Arabia's growth in Health and Wellness innovation is promising.

As Health and Wellness is still a relatively young sector in Saudi Arabia, partnerships will be crucial for driving sustained innovation and achieving competitive parity with other economies.
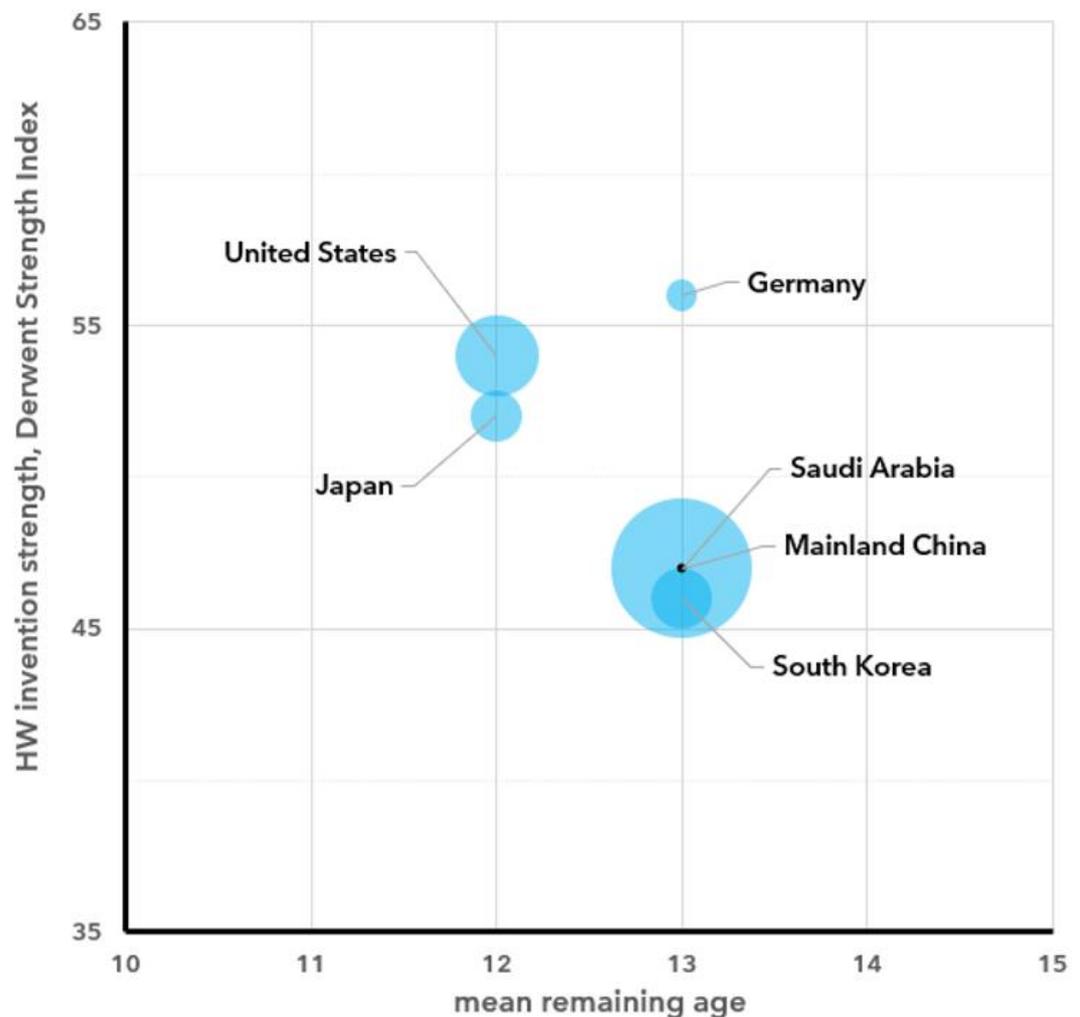

Figure 20: Invention strength dynamics of academic and industry collaboration in Health and Wellness by major countries and Saudi Arabia, 2014–2023
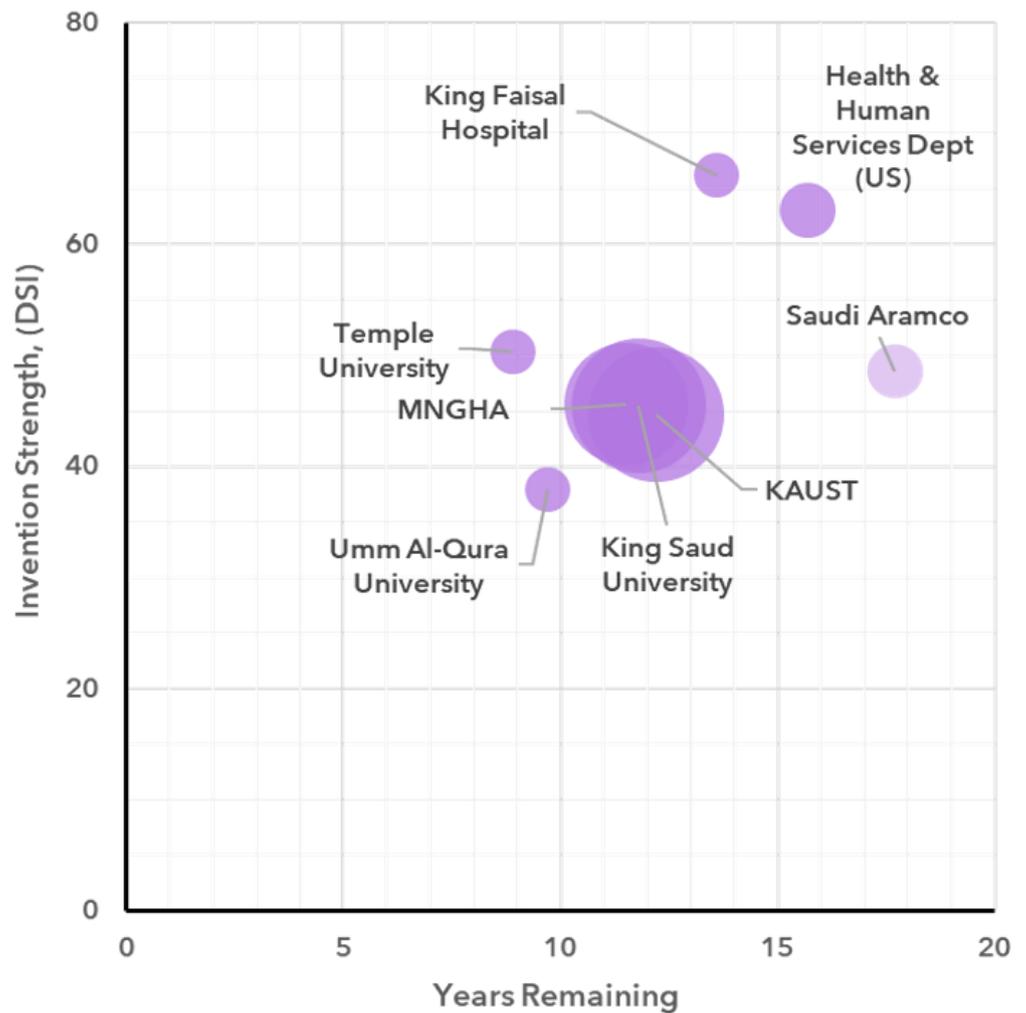
Figure 21: Invention strength dynamic of top collaborating entities in Saudi Arabia in Health and Wellness, 2014–2023

This model in Figure 21 focuses on entities engaged in academic-corporate partnerships, resulting in invention output at the entity level. In Figure 21 Specifically, we assess key collaborators in Saudi Arabia's Health and Wellness sector based on invention strength from academic-corporate partnerships (2014-2023).

Most of the entities represented are academic institutions, with King Saud University (KSU) having the largest volume of partnerships, though with relatively lower invention strength (~45). The presence of Saudi Aramco stands out with high invention strength (~70) despite its smaller involvement, indicating the significant impact of its contributions outside traditional focus areas like energy.

King Faisal Specialist Hospital and KAUST also demonstrate high invention strength, particularly KAUST, which engages in partnerships involving newer technologies.

Other notable entities include US-based Temple University and Umm Al-Qura University, both contributing smaller-scale but potentially high-impact partnerships. The involvement of international universities highlights modest global engagement, which could be expanded to enhance innovation capacity in this field.

3.3 Overview of Technology maturity, readiness, and commercialization

In this section, we summarize and review information collated during Study - Accelerating Technology Transfer from the Lab to the Market in Saudi Arabia of the program specific to the Health and Wellness National Priority.

This analysis focuses on the invention levels globally and in Saudi Arabia, specifically due to the strong link between commercial activity inherent to the patent process associated with research and well the role of patent protection in the ownership and usage of technology in commercial contracts and processes.

Inherent to this analysis in Figure 22 is a review of several key measures:

1. The evaluation of the overall technical maturity of research (on a scale of basic theory through to full market commercialization) within a specific research topic.

2. Evaluation of Saudi Arabian research commercialization activity within the National Priority, compared to global levels. This also includes an assessment of the current depth and strength of invention levels within the Saudi Research & Innovation ecosystem.

3. The future commercial potential of individual research topics within the National Priority Area

Using these criteria, we can describe research dynamics within Health and Wellness, how it meets commercial applications, where Saudi Arabia contributes today, and how future research funding policy in the National Priority can be tailored to these dynamics.

At a global level, Health and Wellness research topics trend more mature than the other National Priorities. For example, no research topic within the priority area was evaluated at TRL levels 1-3, and with three topics at TRL 9 – the highest number across the national priorities. This is most likely due to the high level of medical and pharmaceutical research that has occurred prior to the survey period of this program (2014 onwards) in combination with the higher technology demonstration requirements inherent to patient safety that occur within the health sector. This requirement for proven therapies is exhibited in the split in TRL levels itself, with high maturity in active therapies for specific disease targets versus preventative or more modern approaches involving digital health topics, which trend more immature in the analysis.
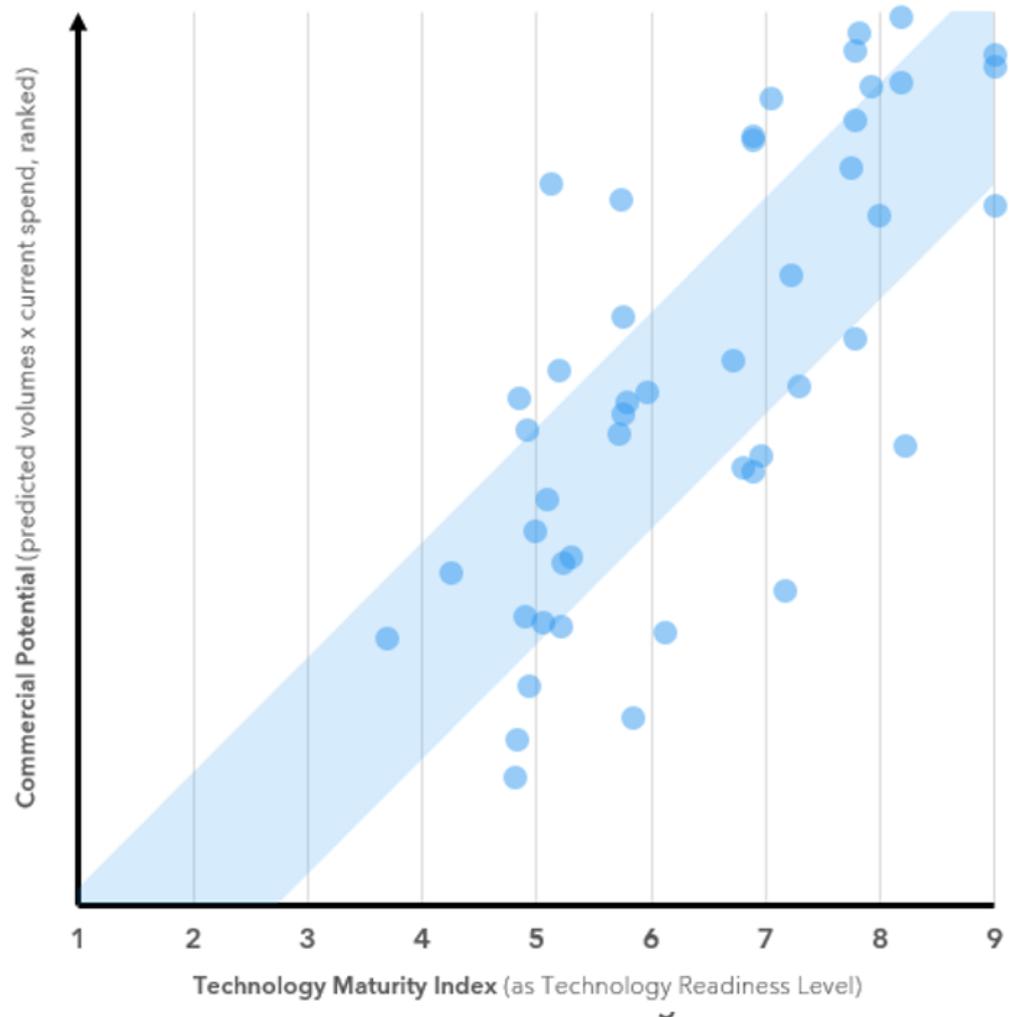
Technology Maturity Index result for research topics within the Health and Wellness National Priority Area, displayed as a stacked column chart across Technology Readiness Levels 1–9:

TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
	Exoskeleton				
	Medical Robots				
	Robotic Prosthesis				
	eHealth				
	Telehealth		Biosensors/ MEMS	Hepatitis	
	Dengue		Telesurgery	Biopharma-ceuticals	
	Antimicrobial Resistance	Health Data & IT Management	Influenza	Genomics	
	CAR-T Cell Therapy	Healthcare / Surgical Robots	Malaria	Immuno-therapy	
	Congenital Gene Therapy	Blood Disorder Gene Therapy	Tuberculosis	Cancer	
	Neuro-degenerative Gene Therapy	Lab-on-a-Chip / Microfluidics	Gena, RNA General Therapy	Chronic Respiratory	
	Phage Therapy	Nanomedicine	Stem Cell Therapy	Diabetes	
	Cognition & Memory	Precision Medicine	Vaccine	Neurological	Implants
AI/ML Imaging	Electronic Health Records	Eyesight	Obesity	Heart Health	Cardio-vascular diseases
Gut Health	Wearables	Immunity Boosting	Skin Health	Mobile Health	Gastro-intestinal

Technology Maturity Index (scaled as Technology Readiness Level)

x-axis: 1   2   3   4   5   6   7   8   9

Figure 22: Technology Maturity Index result for research topics within the Health and Wellness National Priority Area; vertical axis represents count of categories in each tier

Figure 23: Scatterplot of Technology Maturity Index for each research topic (represented on a technology readiness scale) and commercial potential (a ranked axis based on the future predicted invention volumes in each topic, multiplied by the current relative level of investment In Intellectual property protection)

Also shown in the analysis in Figure 23, and a profile that is exhibited in all four National Priorities, is a strong relationship between future commercial potential of the research topics and their evaluated TRL maturity. This is to a degree inherent in the modelling of technology maturity itself, and therefore and expected result. However, in the Health and Wellness space, there are no research topics that suggest immediate need for further, earlier research intervention.

No research topics fulfil a low maturity, high commercial potential – which would typically suggest a desire within commercial markets for rapid maturation of a technology. Within this National Priority, the analysis suggests that applied research intervention would occur at the mid-to-late TRL level.

Moving to Saudi Arabian applied research within the Health and Wellness sector, a review of predicted commercial potential versus the depth of Saudi invention levels shows a strong correlation: the Saudi research and innovation ecosystem tends to focus on research topics that are also more likely to be in demand in future years.

The very highest commercial potential fields in Health and Wellness surround disease targets, in particular infectious diseases: cancer, neurological conditions, chronic respiratory disease, diabetes, and gastrointestinal and cardiovascular interventions.
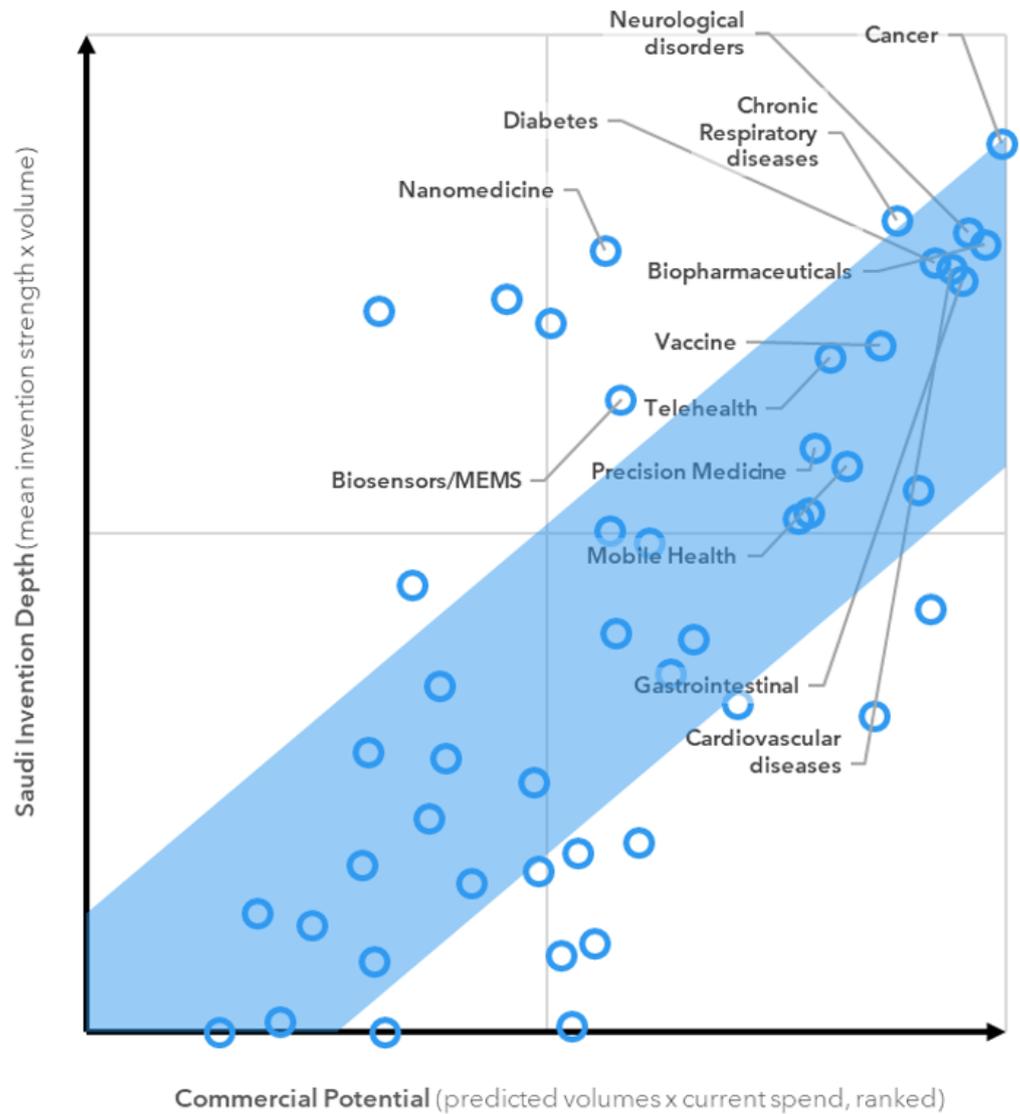
Figure 24: Views of Health and Wellness research topics arrayed by the level of Saudi Arabian research strength and depth vs the commercial potential of the research topic; high potential/high invention depth topics are labeled

The highest area of Saudi Arabian invention depth (measured as a combined measure of both the volume of inventions and their relative strength) occurs within cancer research and chronic respiratory conditions (Figure 24). A noteworthy outlier of mid-tier commercial potential and a high level of Saudi Arabian applied, patented research occurs within the nanomedicine topic.

Further summarizing the commercialization directions potentially available to the Saudi research ecosystem was performed using the Technology Maturity/Technology Readiness spectrum against a hybrid metric that distills the desirability of research itself for Saudi Arabia.

Performed as a topic recommendation score, this metric combines the predicted commercial potential measured across the topics, the depth of Saudi Arabian research today, the level of academic-corporate partnership exhibited to date from Saudi Arabian activity and finally, a check of expert opinion across the research topics.

Arraying the topic recommendation against TRL levels provides a good decision matric surrounding modes of research intervention.

For example, areas of low-level recommendation for Saudi Arabia, regardless of TRL level, can be de-prioritized for either ad hoc academic research selection or, if already highly mature, for the private sector to choose to intervene. Nonetheless due to the complex, and rapidly evolving nature of research topics such as infectious diseases;

accelerated R&D efforts may be necessary for example similar to those performed for COVID-19.

Where research topics already exhibit a track record of applied research intensity in Saudi Arabia, the TRL spread can be used to recommend either the prioritization of further academic research (for more immature topics, where research is needed to transition to more maturity), or where occurring in more mature fields, the transfer of Saudi academic research to the private sector should be strengthened.
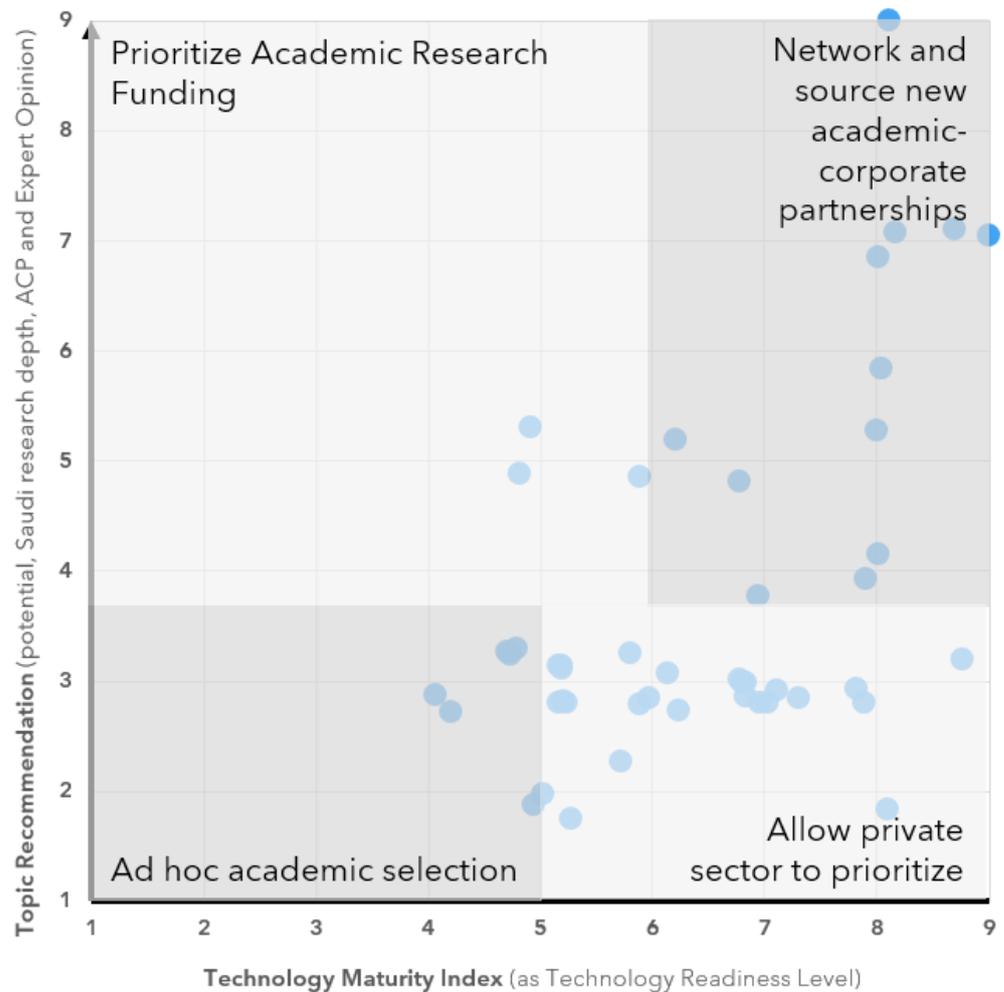

Figure 25: Summary scatterplot view of the Part 3 recommendations of research topics based on the commercial potential measure, the depth of research within Saudi Arabia, the level of academic / corporate potential, and the views of RDIA experts for interest/impact; all arrayed on the Technology Maturity Index spectrum; limited to the Health and Wellness National Priority

The view in Figure 25 is summarized here for the Health and Wellness national priority, and highlights:

1. Within earlier TRLs, a focus on applied research in telehealth and eHealth digital health topics, precision, and nanomedicine, as well as tuberculosis as a disease target.

2. Within higher TRL areas, where the commercialization of existing research pathways should be prioritized via further partnership by Saudi Arabian academic researchers with private enterprises: cancer, cardiovascular, gastrointestinal, and neurological disease, diabetes, and general biopharmaceuticals. All exhibit the highest levels of topic recommendation alongside mature TRL evaluation. Combined with the general finding that

Health and Wellness topics trend mature, this finding suggests a focus on new therapies and intervention vectors or the application of existing research to specific routes to administration. The topics coincide with significant global need as the primary sources of human mortality as societies tend to age and chronic conditions such as these stretch healthcare spending.
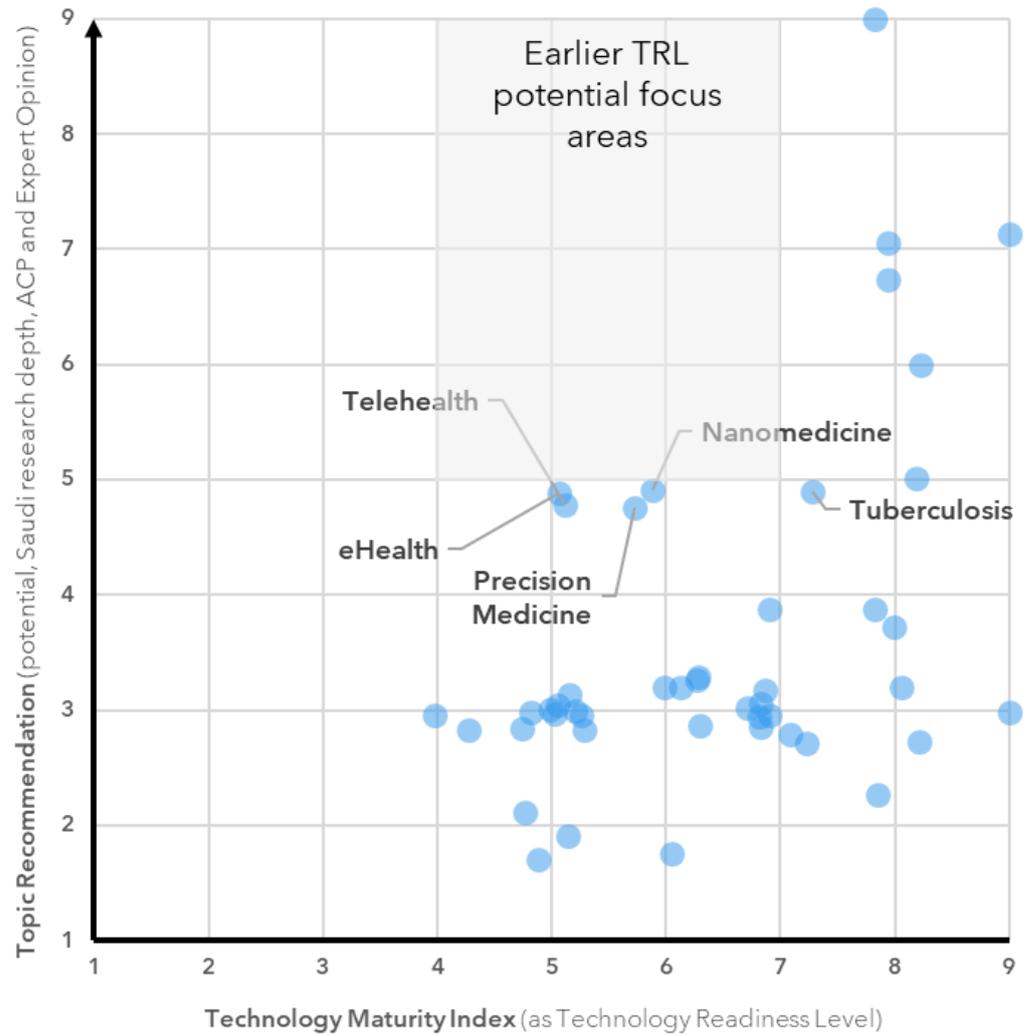

Figure 26: Scatterplot of Technical Maturity Index versus Topic Recommendation in the Health and Wellness National Priority, annotation for research topics categories of >5 in recommendation and sitting in TRLs 4 - 7.

Finally, in this section, the relative ranking and mode of research topics within the Health and Wellness National Priority is shown, ranked by the confluence of topic recommendation factors within Figure 26 and Figure 27, and by action/recommendation quadrant, they fall within based on the evaluated TRL level.
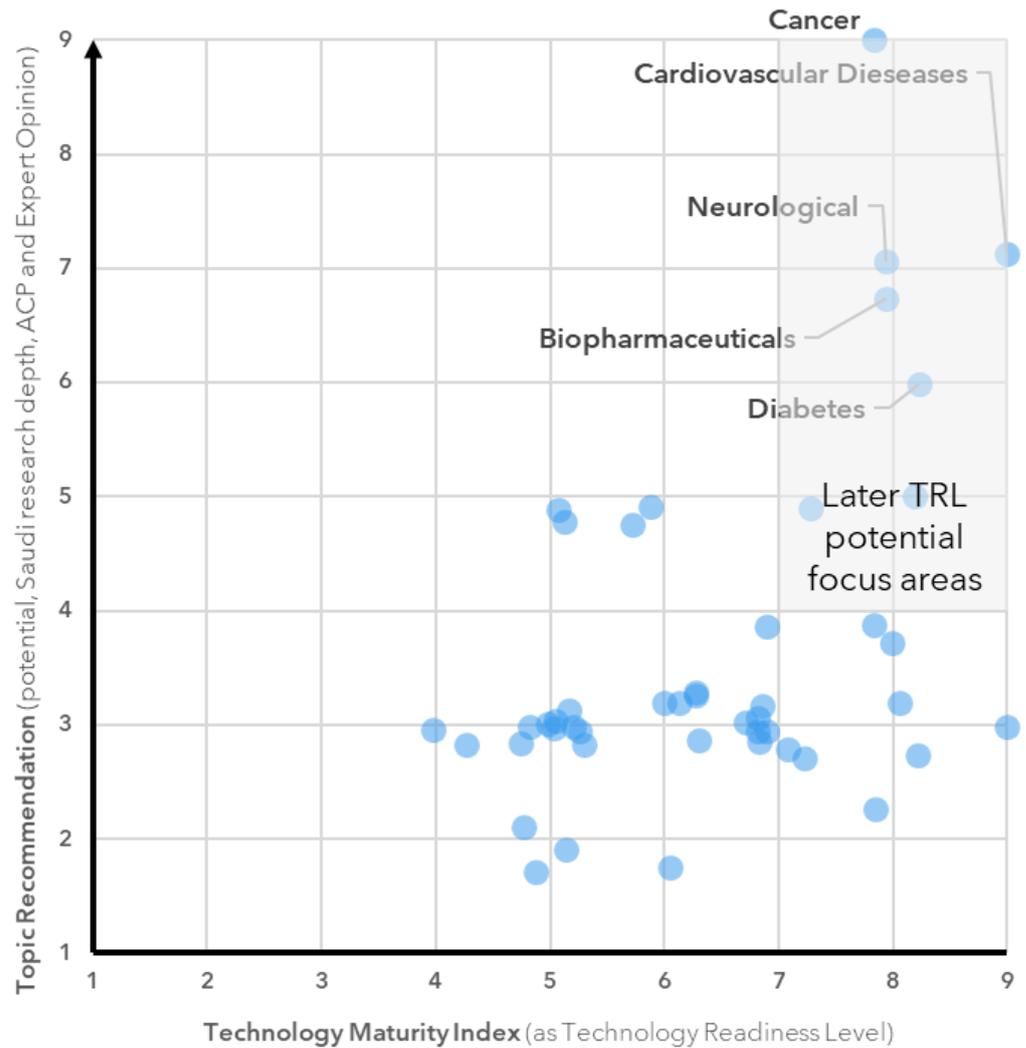
Figure 27: Scatterplot of Technical Maturity Index versus Topic Recommendation in the Health and Wellness National Priority, annotation for research topics categories of >5 in recommendation and sitting in TRLs 8 - 9

This list in Table 6 can be used to assess the specificity of research topics in the Saudi Arabian research ecosystem at present, alongside the assessed technology maturity index of the global research within that same topic. This will identify areas where Saudi Arabia can contribute further innovation that produces competitive, commercial technologies.

Table 6: outcome scorecard for Health and Wellness research topic categories, ranked by recommendation level; includes Technology Maturity Index/TRL score. Circle fill denotes a metric from highest quartile evidenced (full) to lowest quartile (single quarter).

Category	TMI as TRL	Commercial Potential	Saudi Arabia Research Depth	Level of Partnership	Expert Opinion	Recommended mode
Cancer	8					Prioritize tech transfer
Neurological disorders	8					Prioritize tech transfer
Cardiovascular diseases	9					Prioritize tech transfer
Biopharmaceuticals	8					Prioritize tech transfer
Gastrointestinal	9					Prioritize tech transfer
Diabetes	8					Prioritize tech transfer
Chronic Respiratory diseases	8					Prioritize tech transfer
Precision Medicine	6					Prioritize tech transfer
eHealth	5					Prioritize academic funding
Telehealth	5					Prioritize academic funding
Tuberculosis	7					Prioritize tech transfer
Nanomedicine	6					Prioritize tech transfer
Gene/ RNA Therapy	7					Prioritize tech transfer
Immunotherapy	8					Prioritize tech transfer
Mobile Health	8					Prioritize tech transfer
Biosensors/MEMS	7					Private sector led
Medical Robots	5					Ad hoc academic activity
Implants	9					Private sector led
Malaria	7					Private sector led
Blood Disorder Gene Therapy	6					Private sector led
Stem cell therapy	7					Private sector led
AI/ML in Imaging	4					Ad hoc academic activity
Cognition & Memory	5					Ad hoc academic activity
Electronic Health Records	5					Ad hoc academic activity
Dengue	5					Ad hoc academic activity
CAR-T Cell Therapy	5					Ad hoc academic activity
Preventative - Obesity	7					Private sector led
Antimicrobial Resistance	5				na	Ad hoc academic activity
Vaccine	7				na	Private sector led
Health Data and IT Management	6					Private sector led
Telesurgery	7					Private sector led
Skin health	7					Private sector led
Wearables	5					Ad hoc academic activity
Hepatitis	8					Private sector led
Influenza	7					Private sector led
Congenital Gene Therapy	5					Ad hoc academic activity
Lab-on-a-Chip / microfluidics	6					Private sector led
Neurodegenerative Gene Therapy	5					Ad hoc academic activity
Eyesight	6					Private sector led
Gut Health	4					Ad hoc academic activity
Heart Health	8					Private sector led
Immunity Boosting	6					Private sector led
Exoskeleton	5					Ad hoc academic activity
Robotic Prosthetics	5					Ad hoc academic activity
Healthcare/Surgical Robots	6					Private sector led
Phage therapy	5					Ad hoc academic activity
Genomics	8				na	Private sector led

4 Deep-dive into selected Health and Wellness research topics

Within this section, the following research topics, as they map to specific RDIA missions, will be explored in detail:

National Priority	Topic	1.2 Reduce the prevalence of non-communicable diseases by 50% through prevention, better management and treatment by 2035	1.3 Reduce the incidence of infectious diseases significant to KSA by 50% by 2035
Health and Wellness	Vaccine		✔
	Gene/RNA Therapy		✔
	Antimicrobial resistance		✔
	Stem cells therapy		✔
	Dengue		✔
	Biopharmaceuticals		✔
	CAR T-Cell Therapy		✔
	Cancer	✔	
	Cardiovascular diseases	✔	
	Diabetes	✔	
	Nutrition Obesity	✔	
	Genomics	✔	

4.1 Research Performance in the Selected Priority Research Topics

In this section, we investigate the research output performance in Saudi Arabia and globally for selected priority research topics. The overall dataset structure, as well as the selected priority research topics, are described in the section Program of Work.

For each selected research topic, the research output performance for Saudi Arabia is investigated. First, the share of Saudi Arabian publications from global publications published on the research topic is investigated. Investigating the share of publications shows the evolution of the number of Saudi Arabia publications relative to the global share. If the share is increasing, this means that the number of Saudi Arabia publications on the research topic is increasing at a rate higher than the global one

and vice versa. We also investigate the impact of Saudi publications on citations in the research topic by looking at the Category Normalized Citation Impact (CNCI). The metric provides information on the citation impact relative to the global average citation impact for publications of the same type, year of publication and subject area (For more information, see Metrics). A CNCI above 1.0 would generally reflect a citation impact performance above the global average.

Second, we investigate the top 10 countries collaborating with Saudi Arabia on the research topic, the top 20 funding organizations, the top 20 publishing organizations in Saudi Arabia and the top 20 researchers in terms of the number of publications on the research topic. This will provide insights about the research ecosystem in Saudi Arabia around this specific research topic. Identifying key players from this ecosystem will support deriving targeted initiatives to enhance research performance in those research topics. The indicators used are described in Metrics.

Third, we also investigate the top 10 global publishing countries, top 20 publishing entities globally, top 20 funding organizations globally and top 20 researchers globally in terms of the number of publications published in the research topic. This will provide insights into the global research ecosystem around this specific research topic. Also here, identifying key global players in the research ecosystem of a specific research topic will support enhancing Saudi Arabia's research performance by aiming to collaborate with those key players.

Finally, we identify emerging topics globally and within Saudi Arabia's research output in a specific research topic. This is identified by selecting the top topics in terms of growth in number of publications from 2014 to 2023. Although the Saudi Arabia research output within a research topic should focus on local and regional needs and priorities, it should not miss global trends that could become important in the future. Thus, we compare the emerging trends within Saudi Arabia to the global ones. Global trends provide insights to Saudi-affiliated researchers on topics that one should monitor and/or that could also be of local importance.

Main Findings

- The share of Saudi Arabia publications in each of the research topics from the global publications in the research topic increased almost continuously in all the investigated research topics except for CAR-T Cell Therapy, Stem Cell Therapy and Dengue research topics. This shows that for most of the research topics, the growth in Saudi Arabia's publications was higher than the global average.

- CAR-T Cell Therapy, Stem Cell Therapy and Dengue research topics we observe fluctuations in the research output. As these are national priority research topics, one should aim at having a continuous increase in the research output while preserving a good research quality. One possibility to perform this is by collaborating with key publishing organizations and researchers and with top funding organizations identified in those research topics.

- In all the investigated research topics, at least five of the top 10 collaborators with Saudi Arabia in terms of number of publications were also among the top 10 globally. This shows that Saudi Arabia is collaborating with key global players on the research topics.

- In almost all research topics, at least 8 of the Top 20 funders of Saudi Arabia publications in terms of number of publications are also among the top funders globally. This again shows that Saudi affiliated researchers are collaborating with key global players along the research topics and are able to attract funding from key global funders in those research topics.

- Only in the Dengue research topic, we observe among the top 20 funders of Saudi Arabia only one funding organization that is also among the top 20 global funders.

- In several of the research topics we observe King Saud University, King Abdulaziz University, King Saud Bin Abdulaziz University for Health Sciences and King Faisal Specialist Hospital & Research Center are among the top 5 publishing entities in Saudi Arbia.

- Keeping in mind that global emerging trends could be of greater importance in the future, one should monitor identified trends as well as check their relevancy for local priorities.

4.1.1 Cancer

4.1.1.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 28. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic were in all years higher than 1, indicating a citation impact performance higher than the global average.

Although the CNCI decreased from 1.5 in 2017 to 1.04 in 2018, it increased to 1.3 in 2022 and 1.25 in 2023, indicating a 25% higher citation impact performance than the global average.

Overall, Saudi Arabia publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact as measured by the CNCI.
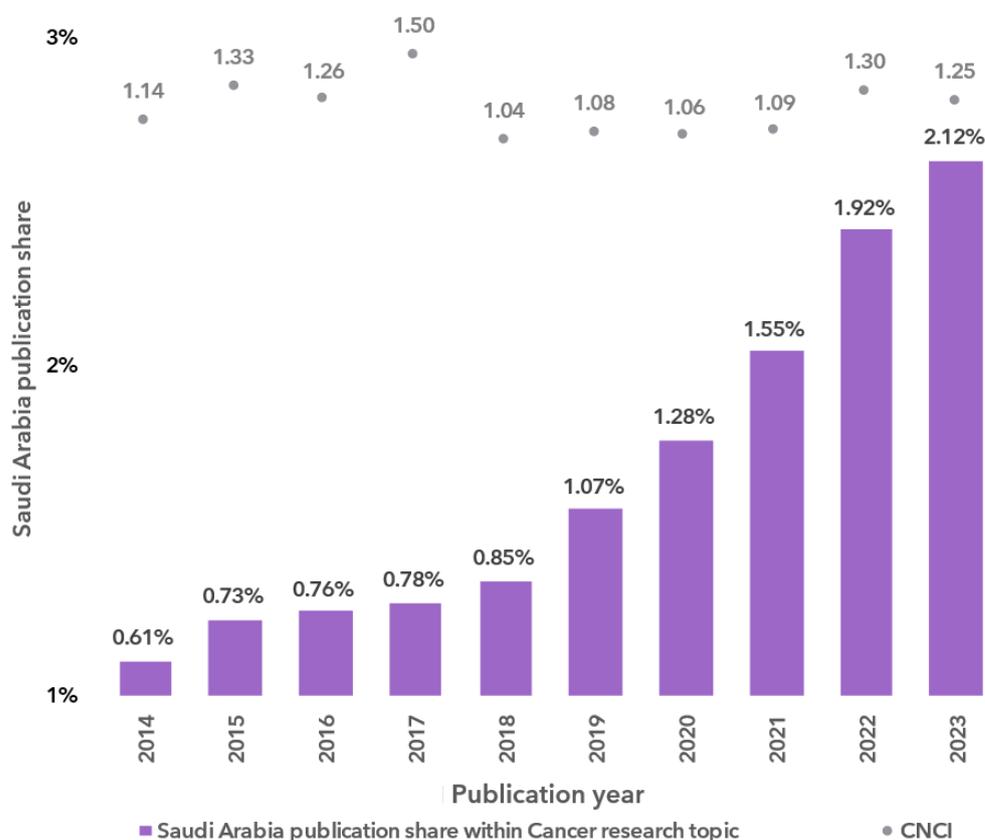
Figure 28: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.1.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is Egypt, followed by India and the United States with 5955, 3842 and 3186 publications, respectively, as shown in Figure 29.

In terms of citation impact measured by the CNCI publications published in collaboration with Australia, followed by South Korea and Mainland China, they had the highest CNCI with 3.46, 3.31 and 2.93, respectively. Nevertheless, all publications

with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
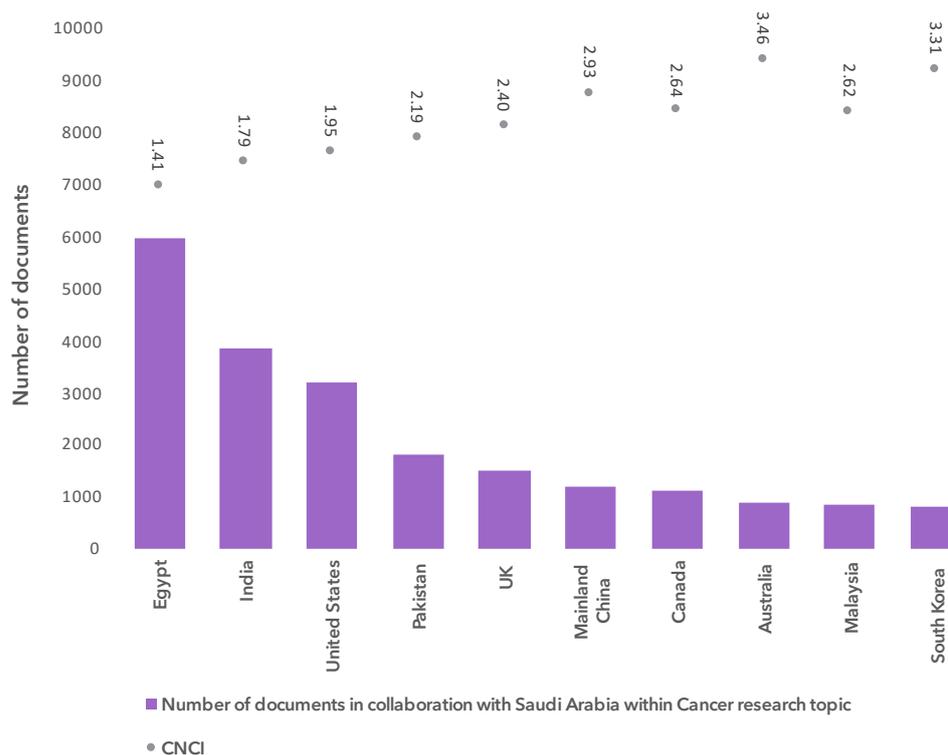
Figure 29: Top 10 collaborating countries with Saudi Arabia in terms of number of publications in the research topic Cancer in the period 2014-2023
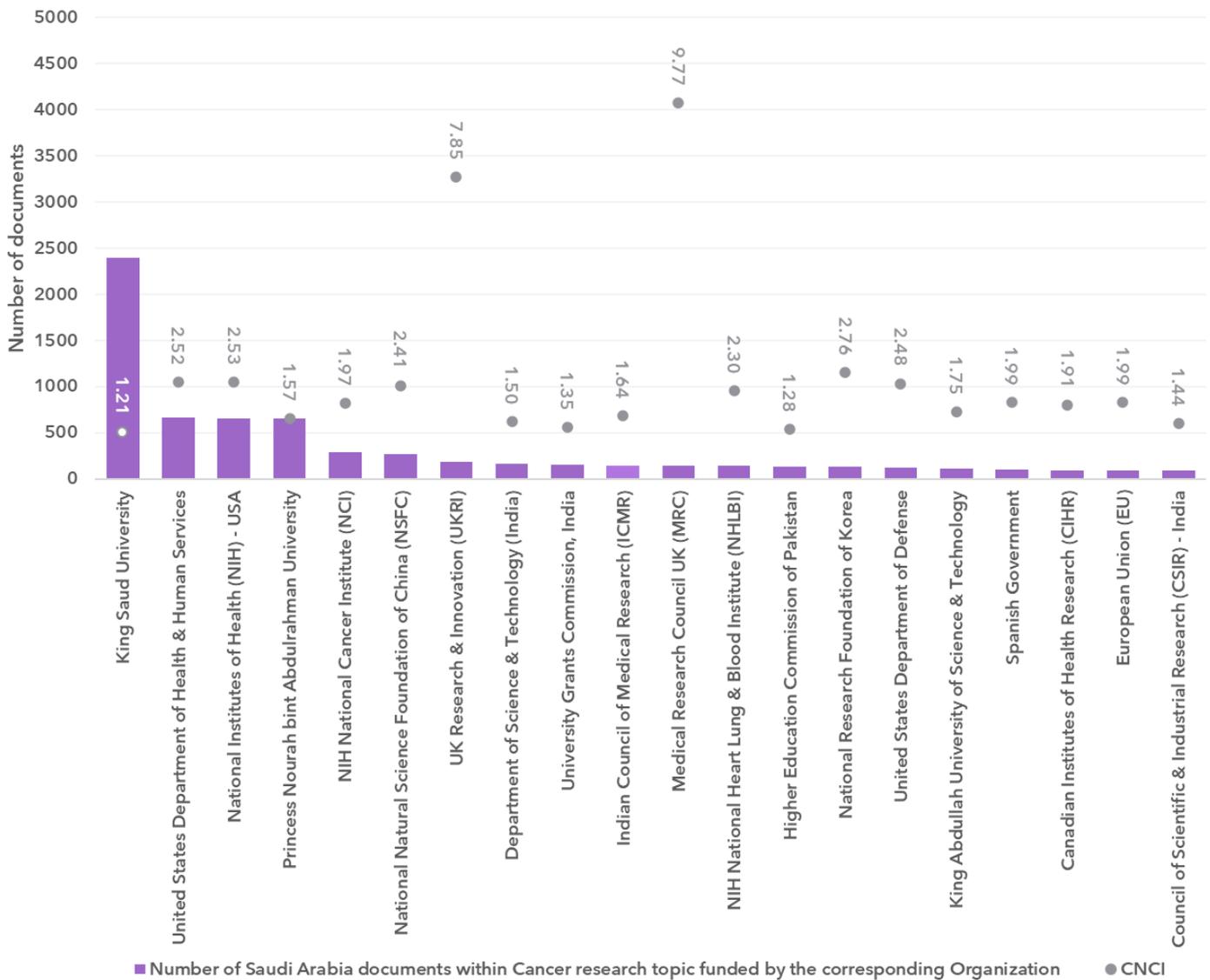
4.1.1.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by the United States Department of Health & Human Services and National Institutes of Health (NIH) – USA with 2349, 661 and 657 publications respectively as shown in Figure 30.

Publications funded by the Medical Research Council UK (MRC), followed by UK Research & Innovation (UKRI) and National Research Foundation of Korea had the highest citation impact measured by the CNCI with 9.77, 7.85 and 2.76, respectively.

Figure 30: Top 20 funding organizations of Saudi Arabia publications in the research topic Cancer in terms of number of publications in the period 2014-2023

4.1.1.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University, followed by King Abdulaziz University and Umm Al Qura University with 5539, 3707 and 1416 publications, respectively, as shown in Figure 31.

In terms of citation impact as measured by the CNCI, King Fahad Medical City, followed by Alfaisal University and University Ha'il, had the highest CNCI with 2.22, 1.79 and 1.66, respectively.

Nevertheless, all top 20 organizations, except King Faisal Specialist Hospital & Research Center and King Saud Bin Abdulaziz University for Health Sciences, had a

CNCI higher than 1, reflecting a citation impact performance higher than the global average.
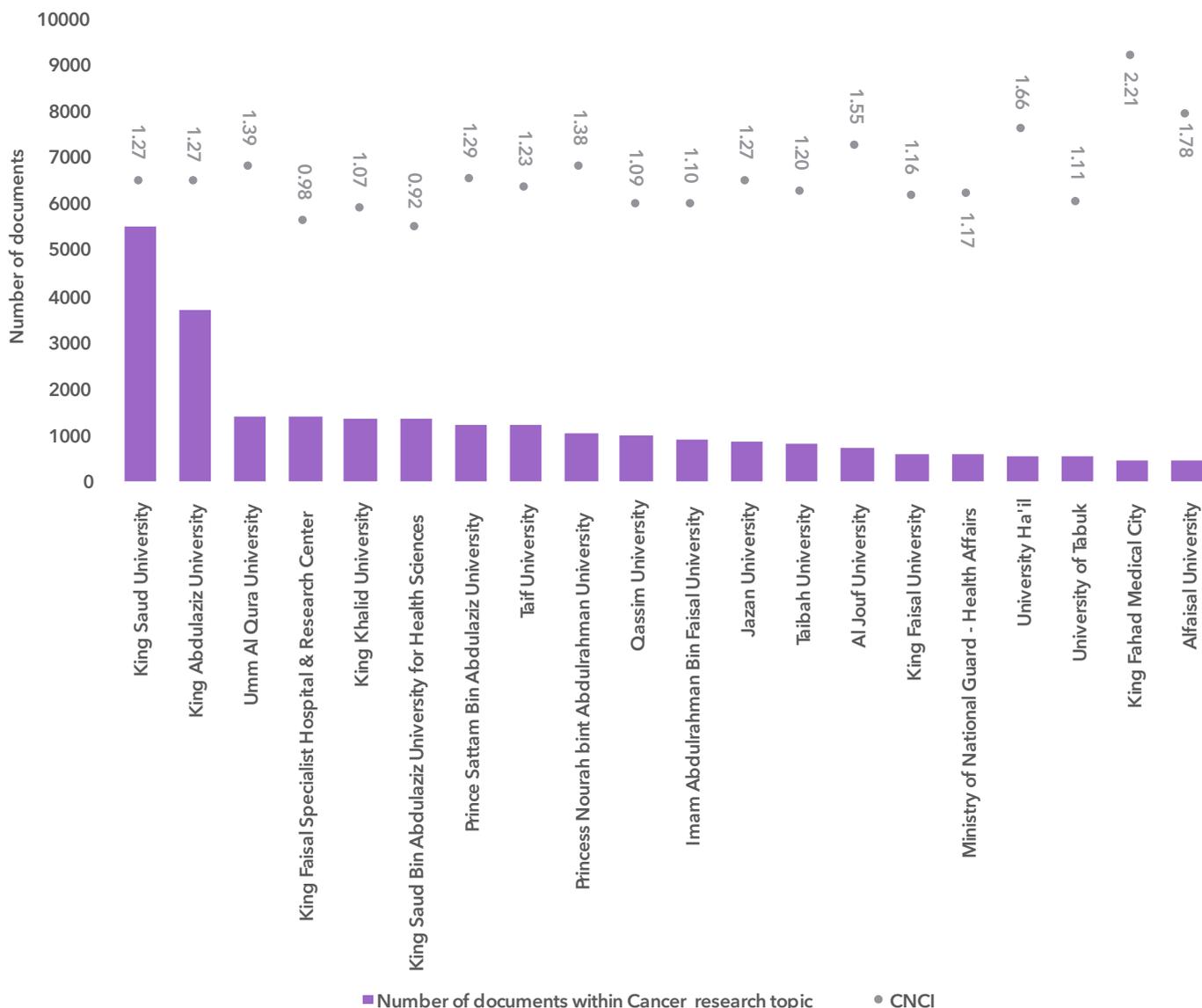
Figure 31: Top 20 Saudi organizations in terms of publications published on the research topic Cancer in the period 2014-2023 and their corresponding CNCI

4.1.1.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Shankargouda Patil, affiliated with Jazan University, followed by Mohammad Amjad Kamal, affiliated with King Abdulaziz University, and Nabil A. Alhakamy, affiliated with King Abdulaziz University with 111, 104 and 93 publications, respectively as shown in Table 7.

The highest CNCI is achieved by publications published to Imran Kazmi affiliated with King Abdulaziz University with a CNCI of 2.86 reflecting a citation impact performance 186% higher than the global average. The latter researcher has also the highest number of Top 1% and Top 10% publications.

Table 7: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published in the research topic Cancer in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the Top 10%
Patil, Shankargouda	Jazan University	111	0.78	1	9
Kamal, Mohammad Amjad	King Abdulaziz University	104	1.29	2	16
Alhakamy, Nabil A.	King Abdulaziz University	93	1.48	1	17
Aljurf, Mahmoud	King Faisal Specialist Hospital & Research Center	85	1.26	2	16
Chinnathambi, Arunachalam	King Saud University	85	1.81	4	25
Alharbi, Sulaiman Ali	King Saud University	83	1.71	4	24
Kazmi, Imran	King Abdulaziz University	74	2.86	6	26
Haque, Shafiul	Jazan University	72	1.65	3	12
Choudhry, Hani	King Abdulaziz University	68	1.19	1	9
Al-Dayel, Fouad	King Faisal Specialist Hospital & Research Center	64	0.85	0	3
Alkahtani, Saad	King Saud University	63	1.16	0	6
Al-Maghrabi, Jaudah	King Abdulaziz University	61	0.59	0	2
Hussain, Afzal	King Saud University	59	1.79	2	16
Saeed, Mohd	University Ha'il	58	1.51	1	11
Adnan, Mohd	University Ha'il	56	1.94	1	21
Abdelgawad, Mohamed A.	Al Jouf University	55	1.49	1	13
Al-Abbasi, Fahad A.	King Abdulaziz University	54	1.46	1	11
Tabrez, Shams	King Abdulaziz University	52	1.74	1	13
Alarifi, Saud	King Saud University	52	1.14	1	5
Kadi, Adnan A.	King Saud University	51	0.94	0	4

4.1.1.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (469,206 publications) followed by Mainland China (466,591 publications) and Japan (114,450 publications), as shown in Figure 32.

The highest citation impact measured by the CNCI is achieved by publications published by France, United Kingdom, and Canada with a CNCI of 1.93, 1.83 and 1.77, respectively.

Five of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, South Korea, and Canada.
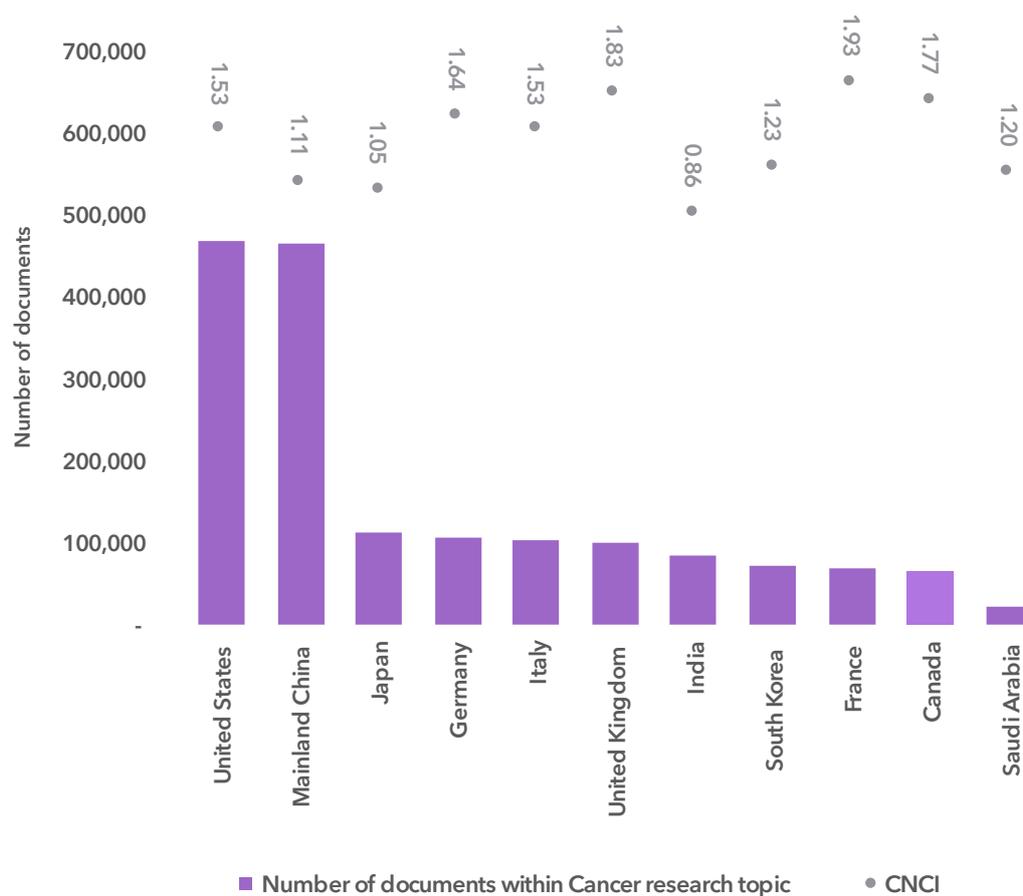
Figure 32: Top 10 countries in terms of number of publications in the research topic Cancer in the period 2014-2023 and their corresponding CNCI

4.1.1.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of the number of publications published in this research topic in the period 2014-2023 are Harvard University (48,189 publications) followed by Harvard Medical School (31,947 publications) and UTMD Anderson Cancer Center (29,540 publications) respectively, as shown in Figure 33.

In terms of citation impact measured by the CNCI, Memorial Sloan Kettering Cancer Center, followed by Harvard University and Harvard Medical School, had the highest CNCI with 3.22, 2.64 and 2.49, respectively.
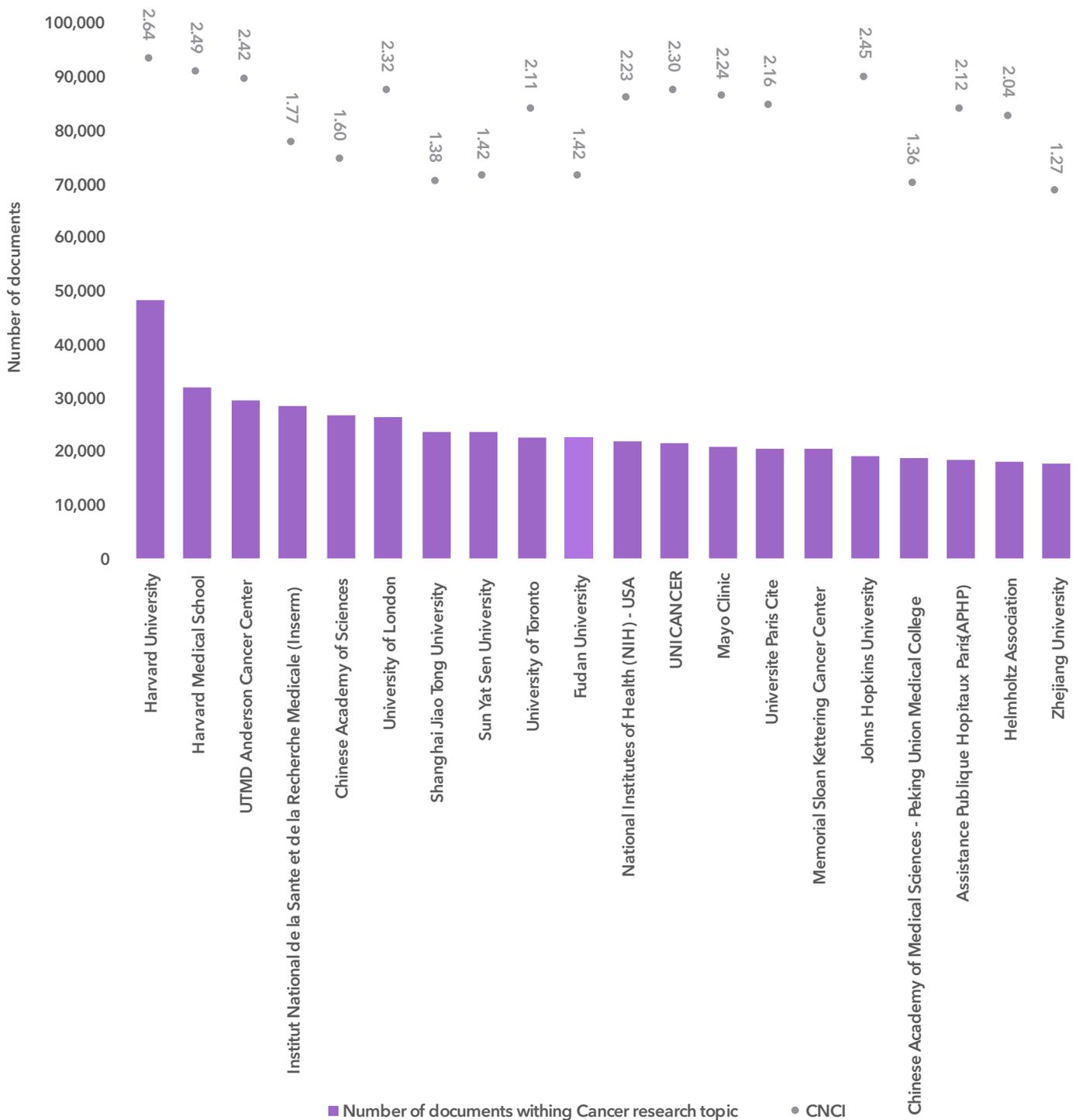
Figure 33: Top 20 organizations globally in terms of number of publications published in the research topic Cancer in the period 2014-2023 and their corresponding CNCI

4.1.1.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Shahrokh F. Shariat, affiliated to the Medical University of Vienna, with 904 publications, followed by Alberto Briganti, affiliated to Vita-Salute San Raffaele University, with 740 publications, and Hermann Brenner, affiliated to German Cancer Research Center (DKFZ) with 722 publications as shown in Table 8.

Toni K. Choueiri, affiliated with Harvard University, achieves the highest CNCI, publications in the Top 1% and publications in the Top 10% among the top 20 researchers globally.

Table 8: Top 20 researchers globally in terms of the number of publications published on the research topic Cancer in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Shariat, Shahrokh F.	Medical University of Vienna	904	1.62	15	155	Austria
Briganti, Alberto	Vita-Salute San Raffaele University	740	1.78	20	175	Italy
Brenner, Hermann	German Cancer Research Center (DKFZ)	722	3.23	44	190	Germany
Doki, Yuichiro	Osaka University	643	1.38	15	94	Japan
Baba, Hideo	Kumamoto University	639	1.29	15	106	Japan
Pawlik, Timothy M.	Ohio State University	630	1.82	19	187	USA
Montorsi, Francesco	Vita-Salute San Raffaele University	607	1.80	12	158	Italy
Scambia, Giovanni	Catholic University of the Sacred Heart	552	1.75	14	146	Italy
Oda, Yoshinao	Kyushu University	546	1.05	5	74	Japan
Saad, Fred	Universite de Montreal	526	2.08	23	114	Canada
Debus, Juergen	Ruprecht Karls University Heidelberg	475	2.00	21	91	Germany
Tian, Jie	Chinese Academy of Sciences	466	2.42	23	175	China
Giles, Graham G.	Cancer Council Victoria	463	2.13	22	130	Australia
Choueiri, Toni K.	Harvard University	458	4.20	61	214	United States
Zheng, Wei	Vanderbilt University	452	1.93	13	127	United States
Supuran, Claudiu T.	University of Florence	452	1.89	8	130	Italy
Hartmann, Arndt	University of Erlangen Nuremberg	450	2.24	22	98	Germany
Tjonneland, Anne	Danish Cancer Society	448	1.40	7	92	Denmark
Medeiros, L. Jeffrey	University of Texas System	447	1.58	6	85	United States
Zhou, Jian	Fudan University	443	2.58	32	143	Mainland China

4.1.1.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the National Natural Science Foundation of China (NSFC) with 218,272 publications, followed by the United States Department of Health & Human Services with 158,684 publications, and National Institutes of Health (NIH) – USA with 156,282 publications as shown in Figure 34.

The highest citation impact measured by the CNCI is observed in publications funded by the Medical Research Council UK (MRC), United States Department of Defense and UK Research & Innovation (UKRI) with 2.32, 2.27 and 2.12, respectively. Among the top 20 global funding organizations, 11 are also among the top 20 funding organizations of Saudi publications in this research topic.
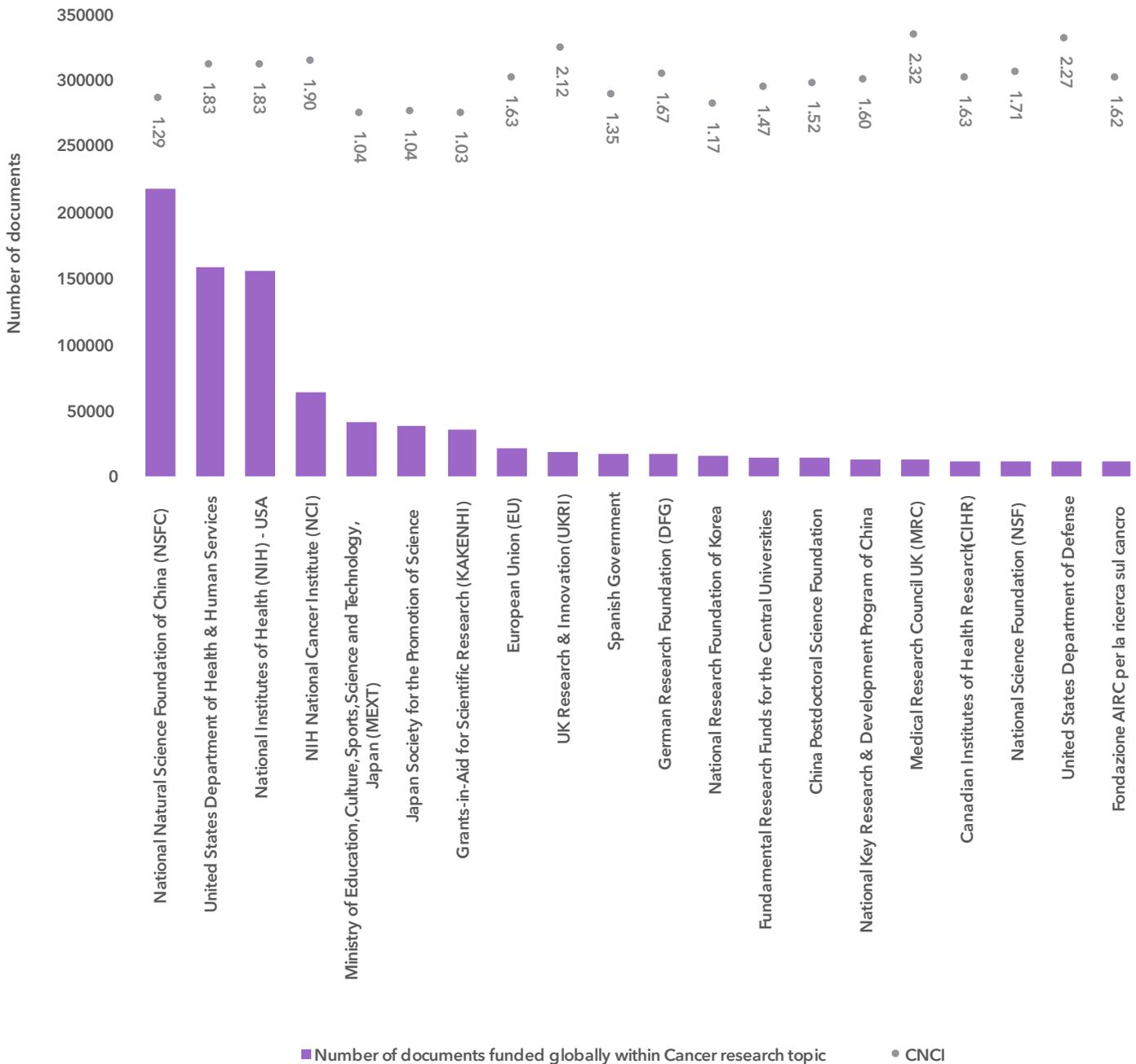
Figure 34: Top 20 funding organizations globally publications in the research topic Cancer in terms of number of publications in the period 2014-2023

4.1.1.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Cancer. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The Top 3 emerging micro-topics globally in this research topic are Molecular & Cell Biology - Genetics: RNA-Seq followed by Computer Vision & Graphics: Deep Learning and Physiology & Metals: Wilson Disease as shown in Figure 35. In Figure 36 The top 20 Saudi Arabia emerging micro-topics in this research topic are identified.
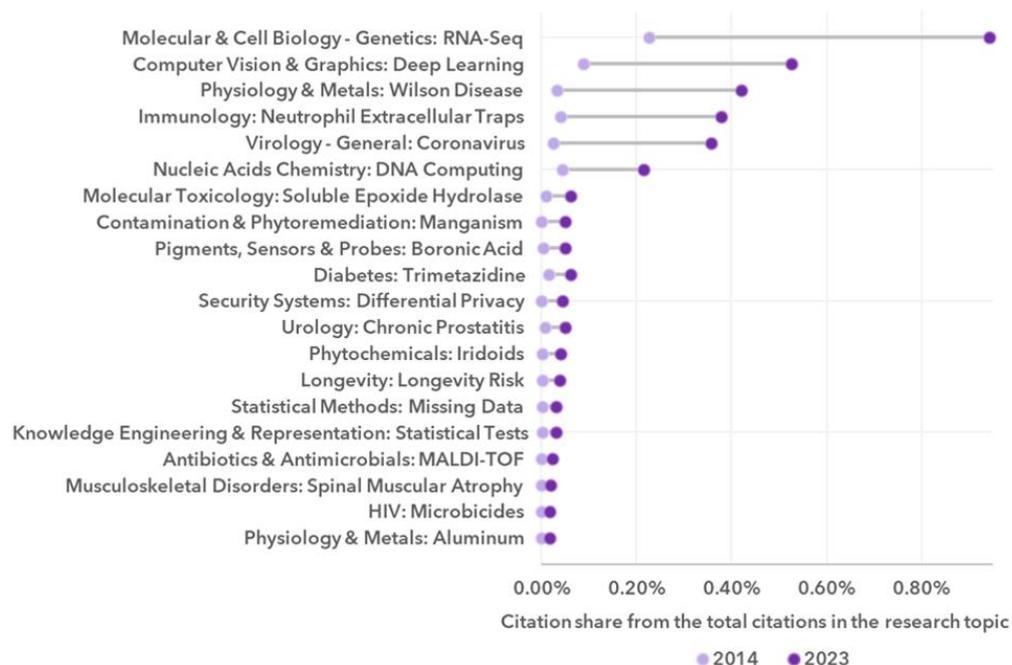
Figure 35: Top 20 emerging micro-topics globally in the research topic Cancer in the period 2014-2023
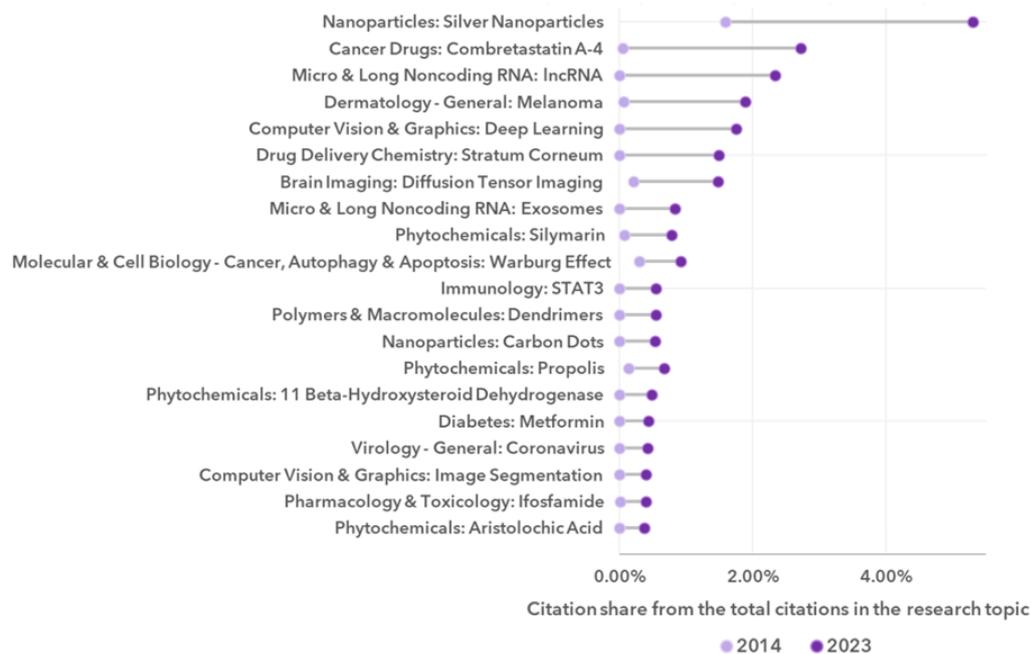
Figure 36: Top 20 emerging micro-topics in Saudi Arabia in the research topic Cancer in the period 2014-2023

The top 3 emerging topics in Saudi Arabia are Nanoparticles: Silver Nanoparticles followed by Cancer Drugs: Combretastatin A-4 and Micro & Long Noncoding RNA: lncRNA. Among Saudi Arabia top 20 emerging micro-topics there are two micro-topics that are also emerging trends globally. Specifically, Computer Vision & Graphics: Deep Learning and Virology - General: Coronavirus.

4.1.2 Cardiovascular Diseases

4.1.2.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 37. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic are growing. The CNCI of Saudi Arabia publications in this research topic were in all years higher than 1, indicating a citation impact performance higher than the global average.

On the other hand, the CNCI decreased from 2.65 in 2014 to 1.11 in 2023, still indicating an 11% higher citation impact performance than the global average. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the impact of citations.
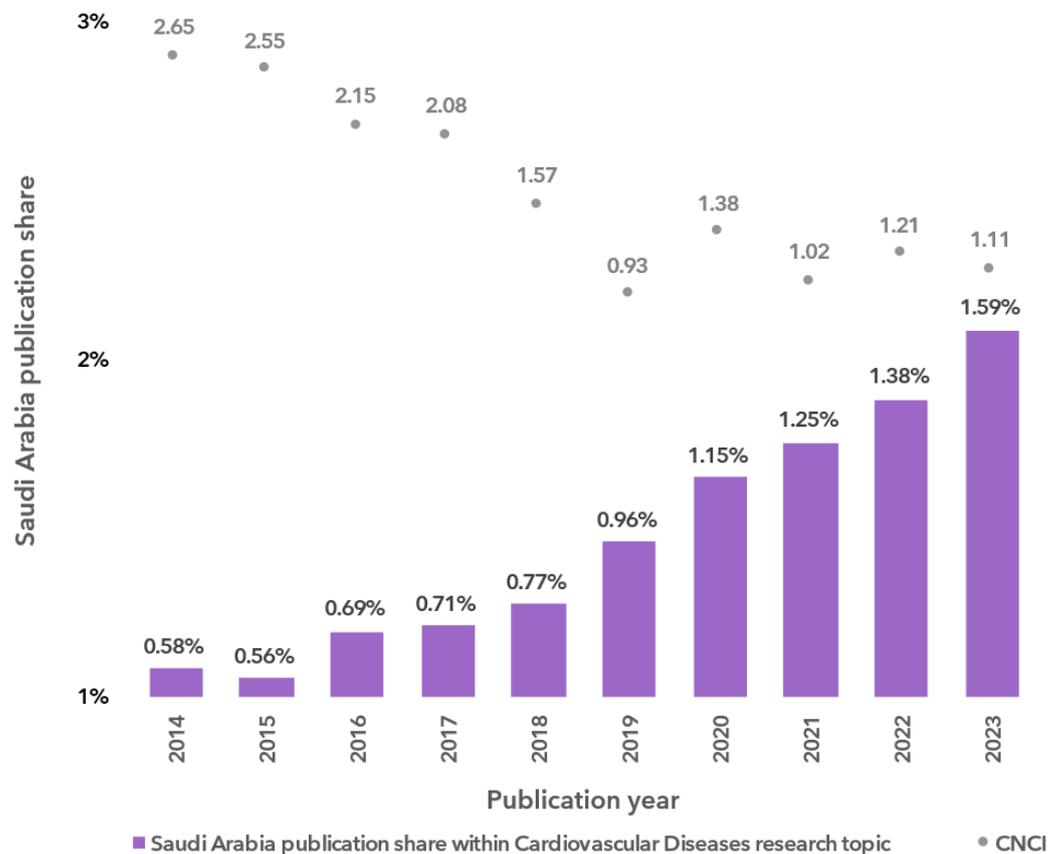
Figure 37: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.2.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is the United States, followed by Egypt and India with 1204, 1147 and 767 publications, respectively as shown in Figure 38.

In terms of citation impact measured by the CNCI publications published in collaboration with Germany, followed by Mainland China, Italy had the highest CNCI

with 10.59, 10.51 and 9.06, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
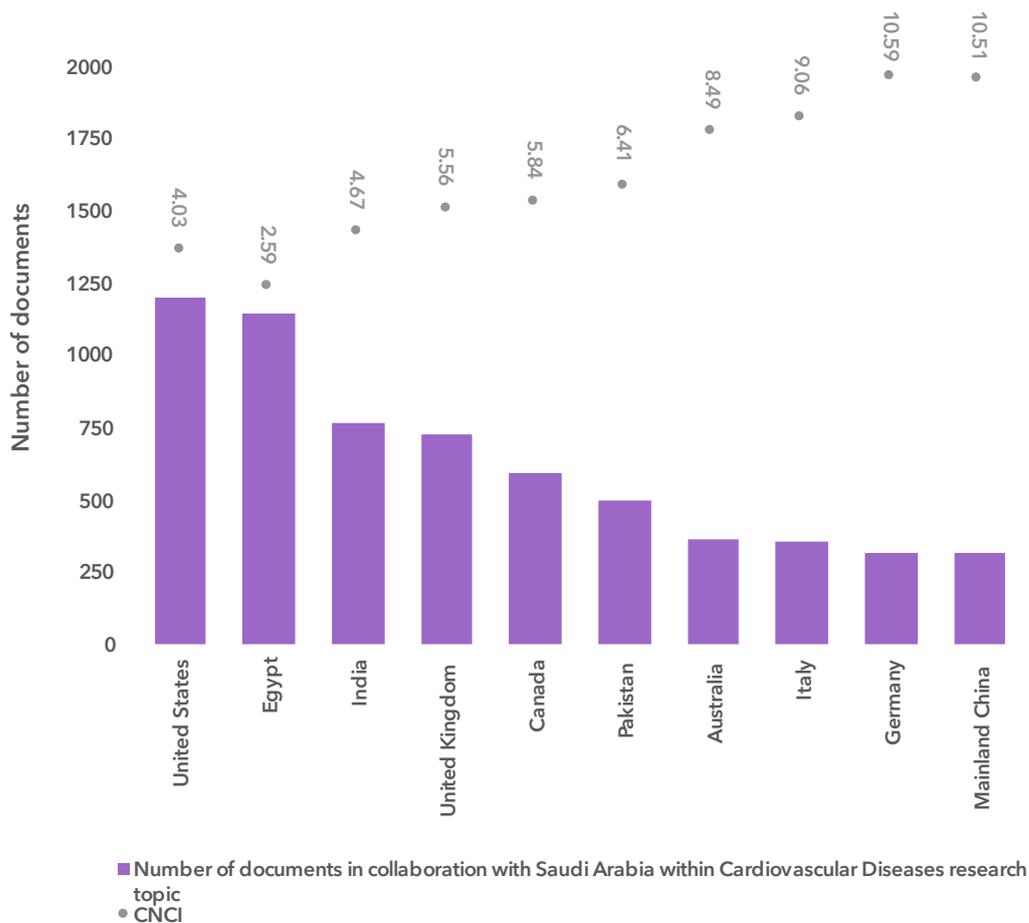

Figure 38: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Cardiovascular Diseases in the period 2014-2023

4.1.2.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by the United States Department of Health & Human Services and National Institutes of Health (NIH) – USA with 346, 240 and 239 publications respectively as shown in Figure 39.

Publications funded by the Medical Research Council UK (MRC), followed by UK Research & Innovation (UKRI) and National Health & Medical Research Council (NHMRC) of Australia, had the highest citation impact measured by the CNCI with 22.07, 20.24 and 11.74, respectively.
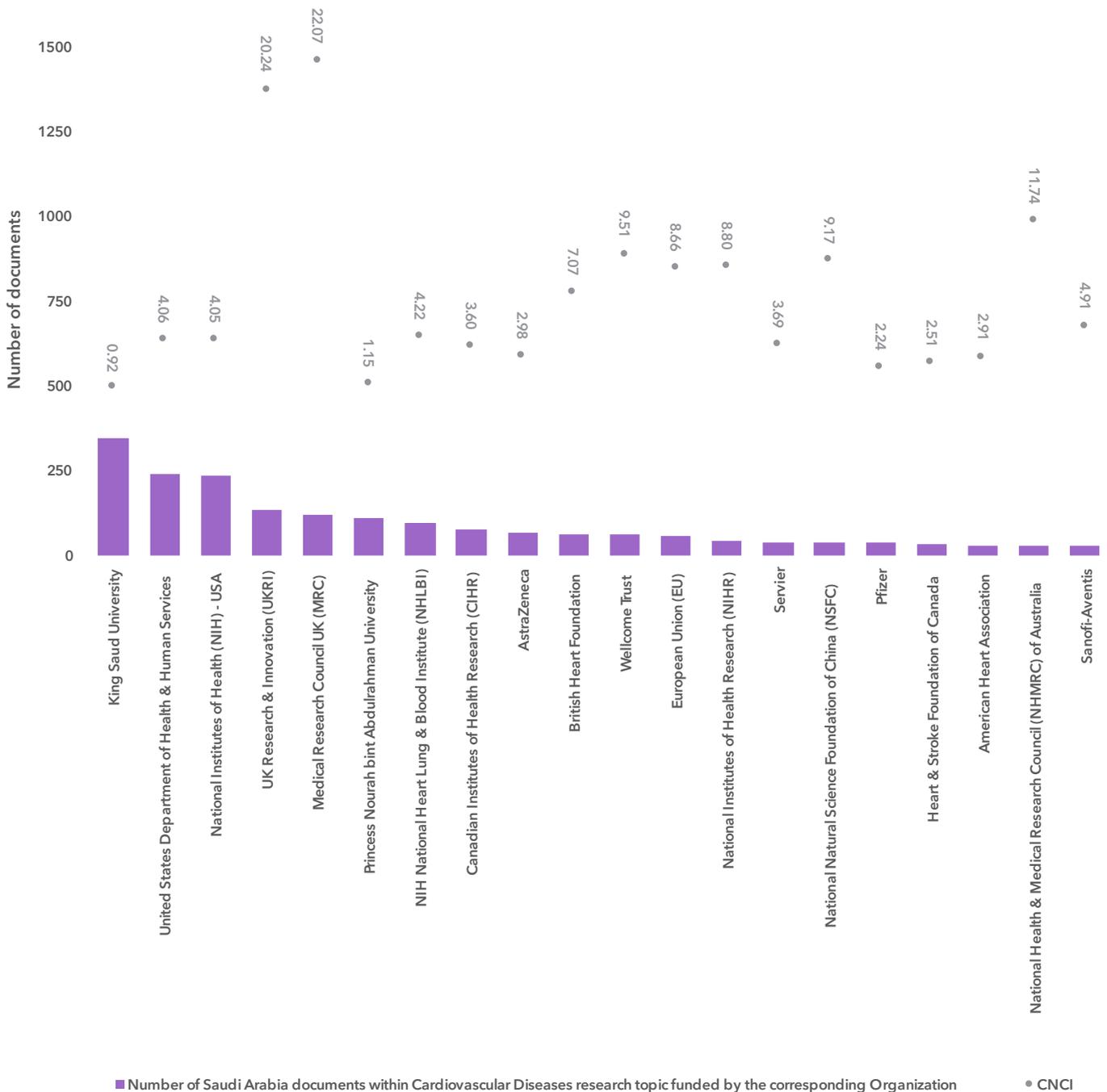
Figure 39: Top 20 funding organizations of Saudi Arabia publications in the research topic Cardiovascular Diseases in terms of number of publications in the period 2014-2023

4.1.2.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and King Saud Bin Abdulaziz University for Health Sciences, with 1368, 1114 and 769 publications, respectively as shown in Figure 40.

In terms of citation impact as measured by the CNCI, King Fahad Medical City, followed by Alfaisal University and Jazan University, had the highest CNCI with 6.10, 5.95 and 5.24, respectively.

Nevertheless, all top 20 organizations, except Prince Sattam Bin Abdulaziz University, Taif University, King Faisal University, King Khalid University and Taibah University,

had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
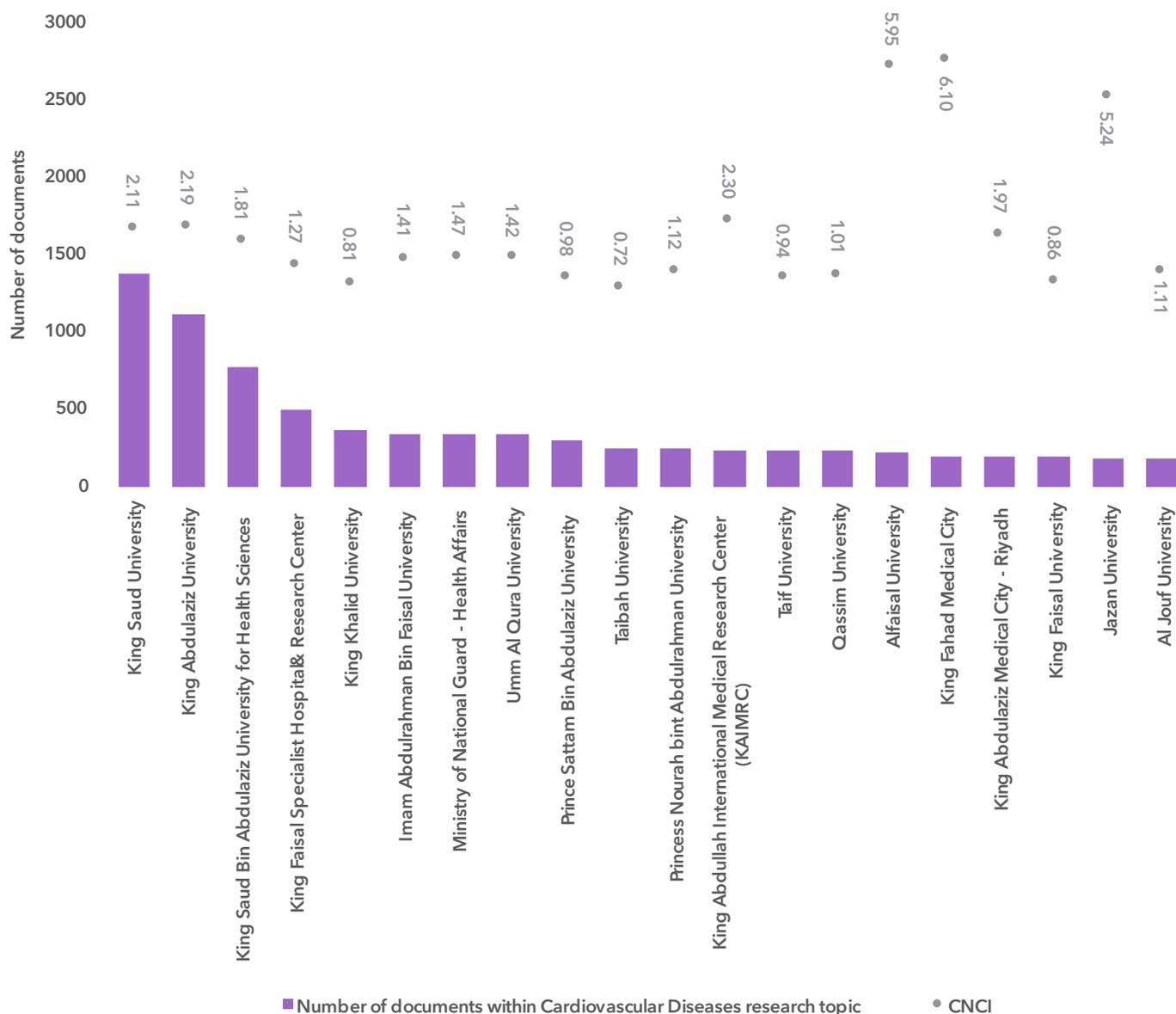
Figure 40: Top 20 Saudi organizations in terms of publications published in the research topic Cardiovascular Diseases in the period 2014-2023 and their corresponding CNCI

4.1.2.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Jaakko. Tuomilehto, affiliated with King Abdulaziz University, followed by Khalid F. AlHabib, affiliated to King Saud University and Olga Vriz, affiliated to King Faisal Specialist Hospital & Research Center, with 56, 46 and 39 publications, respectively as shown in Table 9.

The highest CNCI is achieved by publications published by Jaakko. Tuomilehto affiliated to King Abdulaziz University with a CNCI of 4.22. The latter researcher has also the highest number of Top 10% with 18 publications while Khalid F. AlHabib affiliated to King Saud University has the highest number of Top 1% publications with 6 publications.

Table 9: Top 20 researchers affiliated to Saudi organizations in terms of number of publications published in the research topic Cardiovascular Diseases in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Tuomilehto, Jaakko	King Abdulaziz University	56	4.22	5	18
AlHabib, Khalid F.	King Saud University	46	3.65	6	15
Vriz, Olga	King Faisal Specialist Hospital & Research Center	39	0.82	0	4
Hersi, Ahmad	King Saud University	27	0.70	0	2
Alasnag, Mirvat	King Fahd Armed Forces Hospital	24	2.18	1	5
Kashour, Tarek	King Saud University	24	0.60	0	1
Tabrez, Shams	King Abdulaziz University	23	0.46	0	0
Al-Daghri, Nasser M.	King Saud University	21	1.11	0	3
Fadel, Bahaa M.	King Faisal Specialist Hospital & Research Center	20	0.34	0	0
Galzerano, Domenico	King Faisal Specialist Hospital & Research Center	20	0.53	0	1
Ashraf, Ghulam Md	King Abdulaziz University	18	0.54	0	1
Kinsara, Abdulhalim J.	King Saud Bin Abdulaziz University for Health Sciences	18	0.42	0	2
Dahdouh, Ziad	King Faisal Specialist Hospital & Research Center	13	0.32	0	0
Hersi, Ahmad S.	King Saud University	11	1.13	0	1
Bakhashab, Sherin	King Abdulaziz University	11	0.77	0	0
Sakr, Sherif	King Saud Bin Abdulaziz University for Health Sciences	10	1.79	0	4
Mimish, Layth	King Abdulaziz University	10	0.41	0	0
Suliman, Ihab	King Saud Bin Abdulaziz University for Health Sciences	10	0.59	0	1
Husain, Aysha	King Faisal Specialist Hospital & Research Center	8	0.37	0	0
Khan, Mohd Faiyaz	Prince Sattam Bin Abdulaziz University	8	0.16	0	0

4.1.2.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (191,333 publications), followed by Mainland China (116,750 publications) and the United Kingdom (51,680 publications), as shown in Figure 41.

The highest citation impact measured by the CNCI is achieved by publications published by the Netherlands, United Kingdom, and France with a CNCI of 2.25, 2.07 and 2.06, respectively.

Seven of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Germany, Italy, Canada, and Australia.
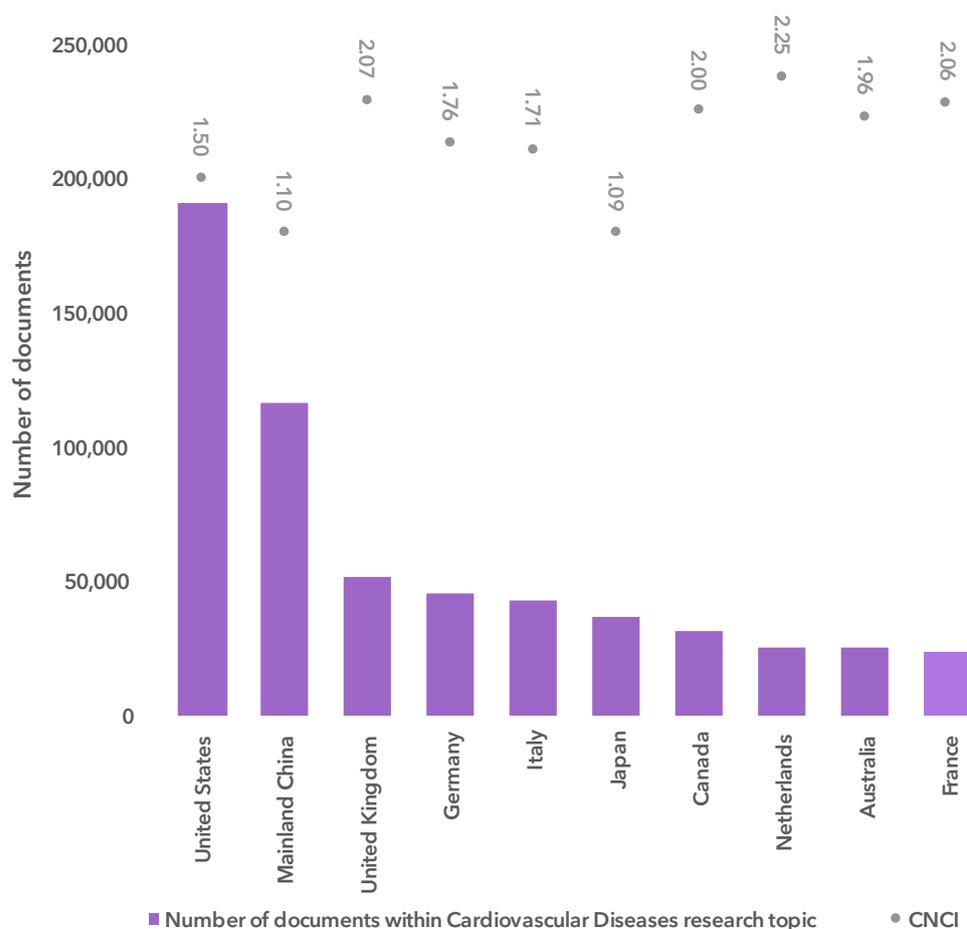
Figure 41: Top 10 countries in terms of number of publications in the research topic Cardiovascular Diseases in the period 2014-2023 and their corresponding CNCI

4.1.2.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are Harvard University (23,839 publications) followed by Harvard Medical School (16,361 publications) and the University of London (13,059 publications) shown in Figure 42.

In terms of citation impact measured by the CNCI, Imperial College London, followed by Brigham & Women's Hospital and Berlin Institute of Health, had the highest CNCI with 3.20, 3.09 and 2.75, respectively.
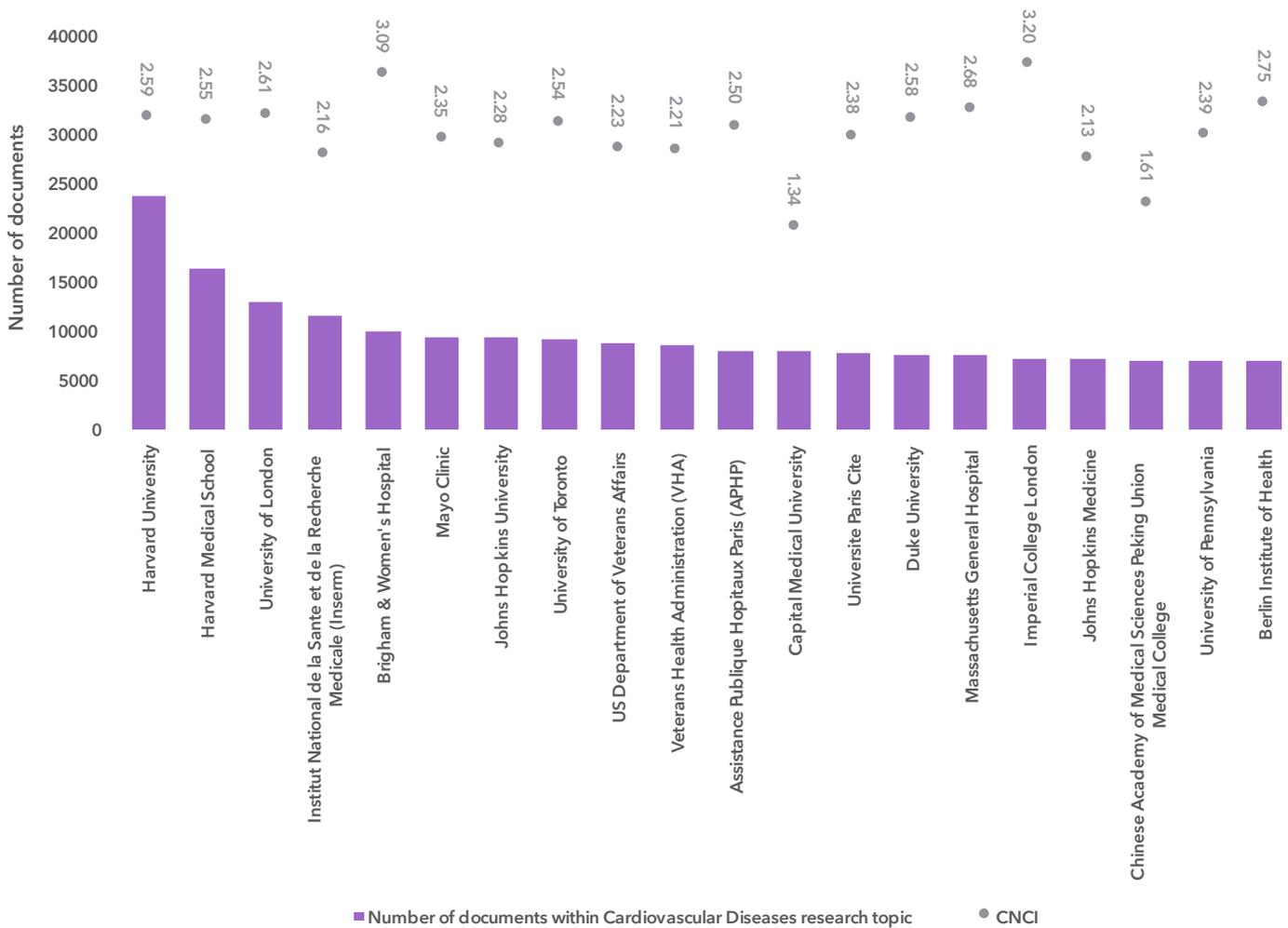
Figure 42: Top 20 organizations globally in terms of number of publications published in the research topic Cardiovascular Diseases in the period 2014-2023 and their corresponding CNCI

4.1.2.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Gregory Y. H. Lip, affiliated with Aalborg University, with 910 publications, followed by Deepak L. Bhatt, affiliated with Harvard University, with 791 publications, and Gregg C Fonarow, affiliated to University of California Los Angeles with 662 publications as shown in Table 10.

The highest CNCI is achieved by Piotr Ponikowski affiliated to Wroclaw Medical University with 5.86. The highest number of Top 1% and Top 10% publications is achieved by Scott D. Solomon affiliated to Harvard University.

Table 10: Top 20 researchers globally in terms of the number of publications published on the research topic Cardiovascular Diseases in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Lip, Gregory Y. H.	Aalborg University	910	2.21	29	226	Denmark
Bhatt, Deepak L.	Harvard University	791	3.44	53	270	United States
Fonarow, Gregg C.	University of California Los Angeles	662	2.86	24	183	United States
Kober, Lars	University of Copenhagen	633	2.20	29	178	Denmark
Solomon, Scott D.	Harvard University	576	4.36	57	307	United States
Mehran, Roxana	Icahn School of Medicine at Mount Sinai	566	2.85	41	156	United States
Ge, Junbo	Fudan University	519	1.65	17	95	Mainland China
Windecker, Stephan	University of Bern	519	2.72	26	164	Switzerland
Stone, Gregg W.	Cardiovascular Research Foundation (CRF)	491	2.75	30	154	United States
Wang, Yongjun	Capital Medical University	476	1.85	12	77	Mainland China
Metra, Marco	University of Brescia	470	3.61	30	180	Italy
Ponikowski, Piotr	Wroclaw Medical University	444	5.86	53	201	Poland
Zannad, Faiez	Universite de Lorraine	444	4.10	29	161	France
Jeong, Myung Ho	Chonnam National University	427	1.11	6	37	South Korea
Merkely, Bela	Semmelweis University	426	3.78	23	99	Hungary
Bax, Jeroen J.	Leiden University	420	2.94	18	120	Netherlands
Murohara, Toyoaki	Nagoya University	418	0.97	2	39	Japan
Katus, Hugo A.	Ruprecht Karls University Heidelberg	411	1.24	5	64	Germany
Sahebkar, Amirhossein	Mashhad University Medical Science	410	2.72	9	79	Iran
Hernandez, Adrian F.	Duke University	402	4.34	30	135	United States

4.1.2.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 156,588 publications, followed by the National Institutes of Health (NIH) - USA with 151,908 publications, and National Natural Science Foundation of China (NSFC) with 127,367 publications as shown in Figure 43.

The highest citation impact measured by the CNCI is observed in publications funded by Bristol-Myers Squibb, AstraZeneca & Medical Research Council UK (MRC), achieving the same CNCI and NIH National Cancer Institute (NCI) with 2.69, 2.49 and 2.38, respectively.

Among the top 20 global funding organizations, 12 are also among the top 20 funding organizations of Saudi publications in this research topic.
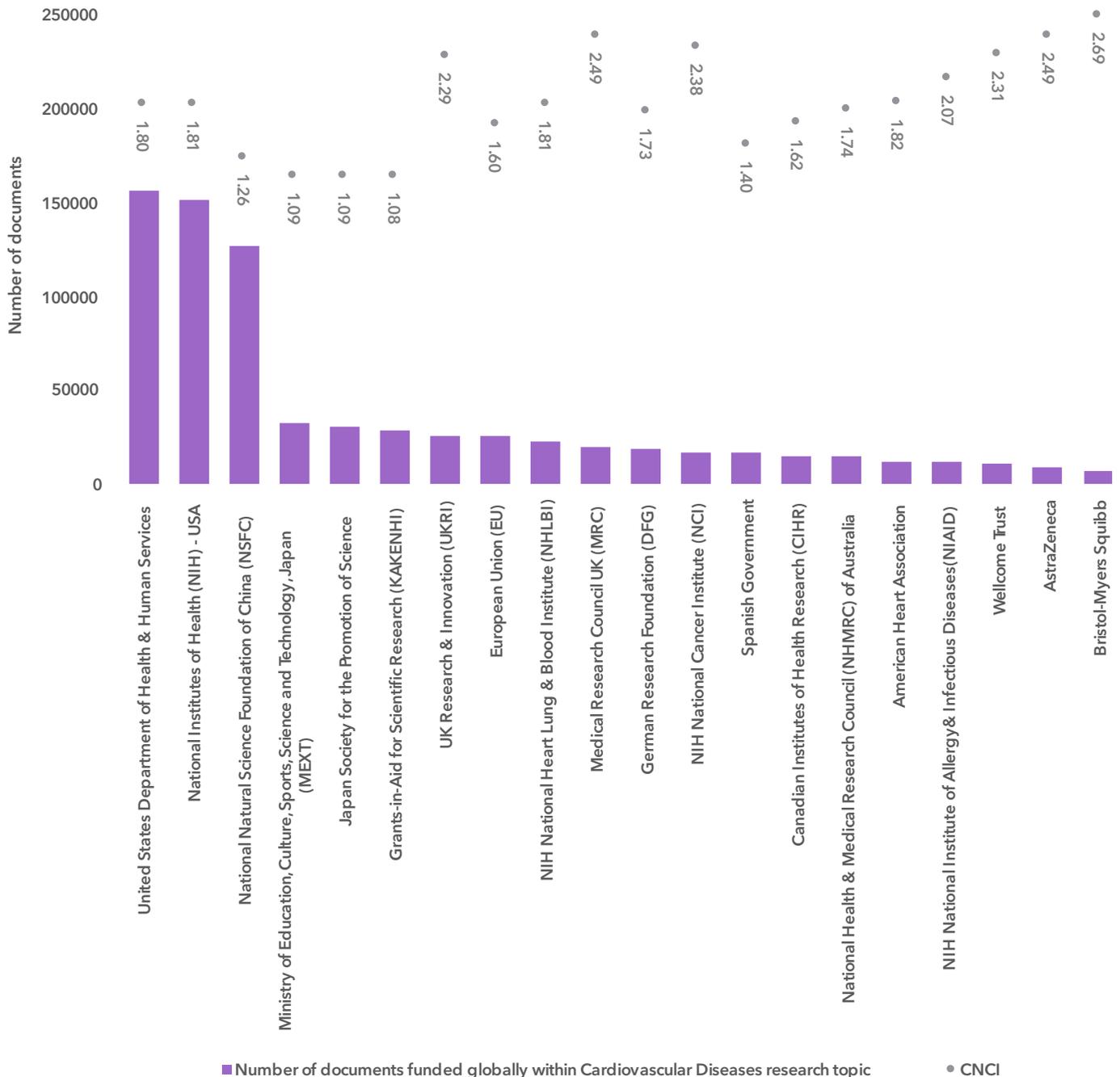
Figure 43: Top 20 funding organizations globally publications in the research topic Cardiovascular Diseases in terms of number of publications in the period 2014-2023

4.1.2.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Cardiovascular Diseases. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Molecular & Cell Biology - Cancer, Autophagy & Apoptosis: Warburg Effect followed by Virology - General: Coronavirus and Micro & Long Noncoding RNA: lncRNA as shown in Figure 44. In Figure 45 the top 20 Saudi Arabia emerging micro-topics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Cardiac Arrhythmia: ECG followed by Artificial Intelligence & Machine Learning: Feature Selection and Micro & Long Noncoding RNA: MicroRNAs. Among Saudi Arabia top 20 emerging micro-topics there is one micro-topic that is also an emerging trend globally, which is Virology - General: Coronavirus.

It is worth noting that the micro-topic Cardiology - General: Heart Failure has grown in the number of publications but had a shrinking citation share in the research topic. Accordingly, one should monitor and assess the relevance of the topic locally and globally.
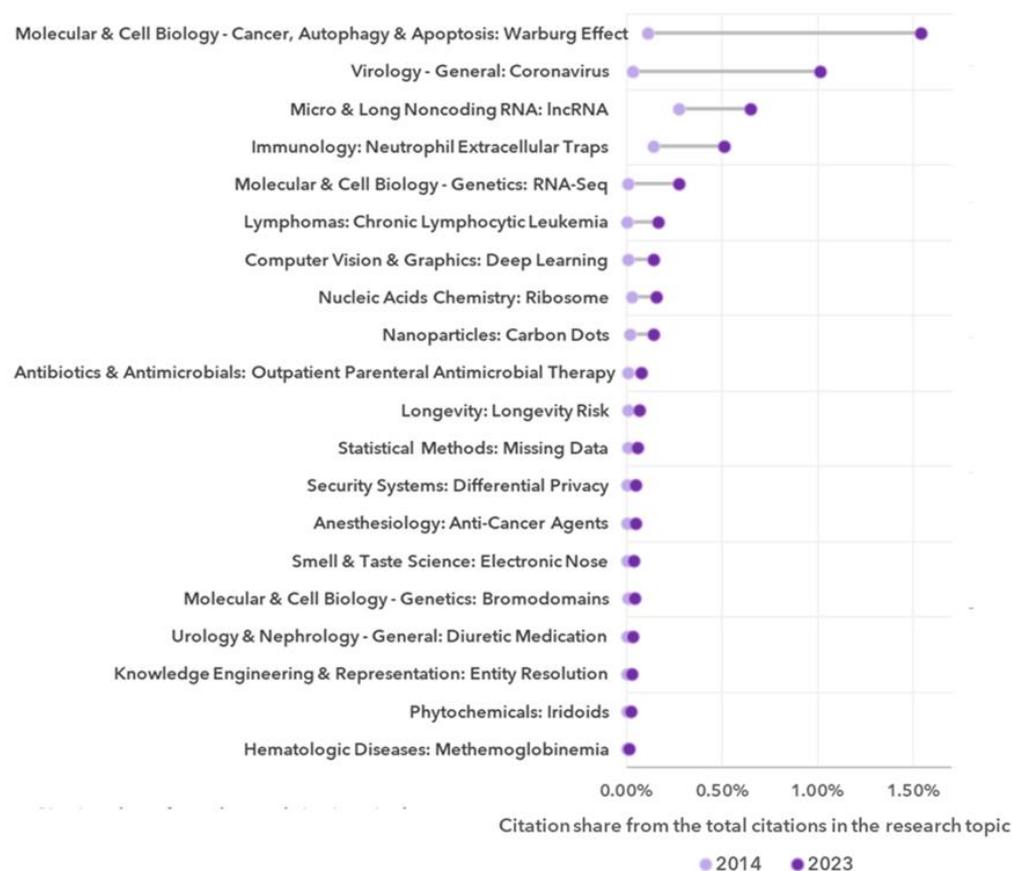
Figure 44: Top 20 emerging micro-topics globally in the research topic Cardiovascular Diseases in the period 2014-2023
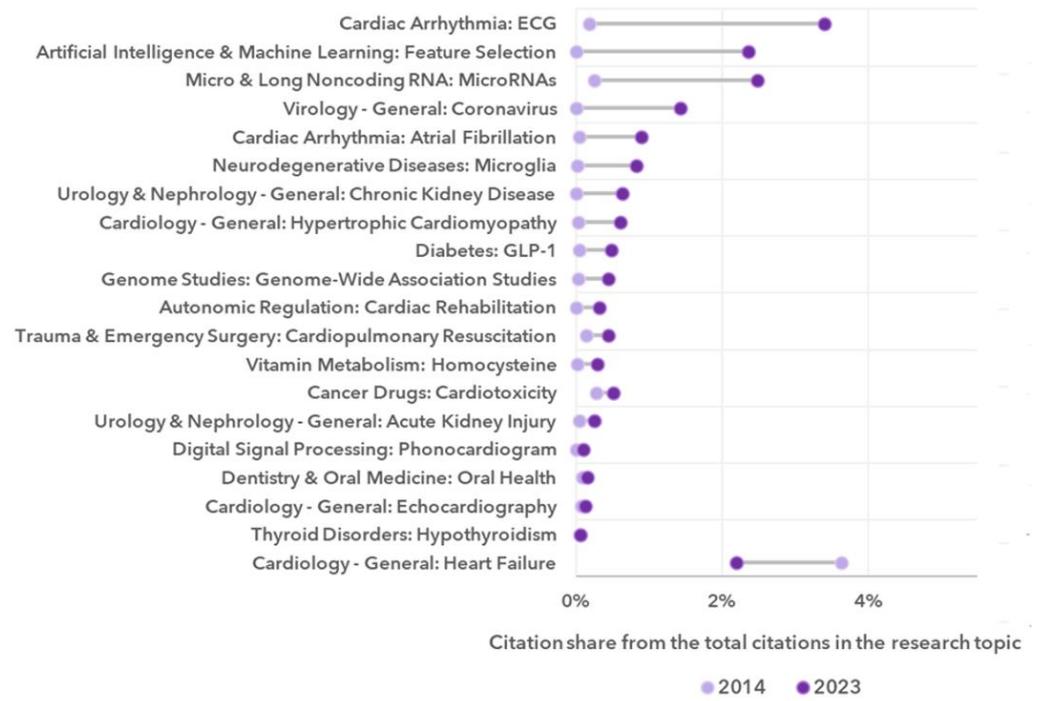
Figure 45: Top 20 emerging micro-topics in Saudi Arabia in the research topic Cardiovascular Diseases in the period 2014-2023

4.1.3 Nutrition & Obesity

4.1.3.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 46. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate. This is evident as the share of Saudi Arabia publications in the research topic are growing.

The CNCI of Saudi Arabia publications in this research topic were several years higher than 1, indicating a citation impact performance higher than the global average. The CNCI increased from 1 in 2014 to 2.18 in 2018 and then decreased to 0.89 in 2022, then recovered to 1.24 in 2023. In a high publication period, it is usually observed that the citation impact decreases, as also observed in this case.

Overall, Saudi Arabia publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a recover in 2023.
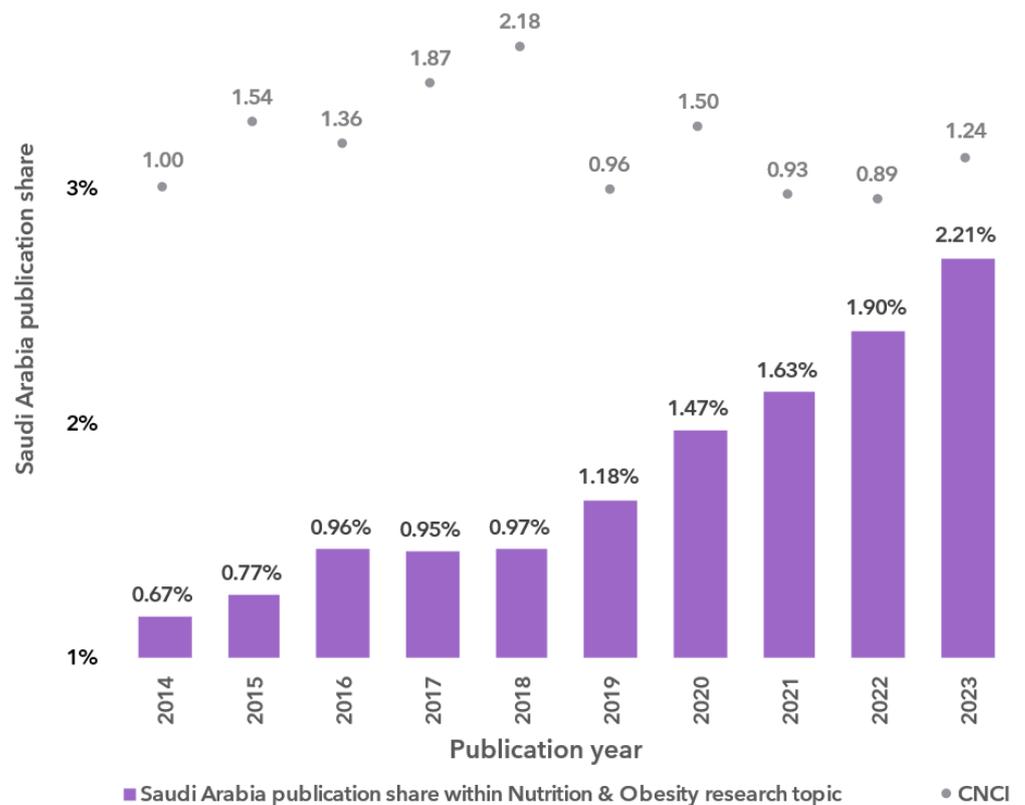

Figure 46: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.3.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 was Egypt followed by the United States and India with 1276, 797 and 623 publications, respectively, as shown in Figure 47. In terms of citation impact measured by the CNCI publications published in collaboration with Canada, Malaysia and Mainland China, they had the highest CNCI with 8.41, 8.38 and 8.25, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
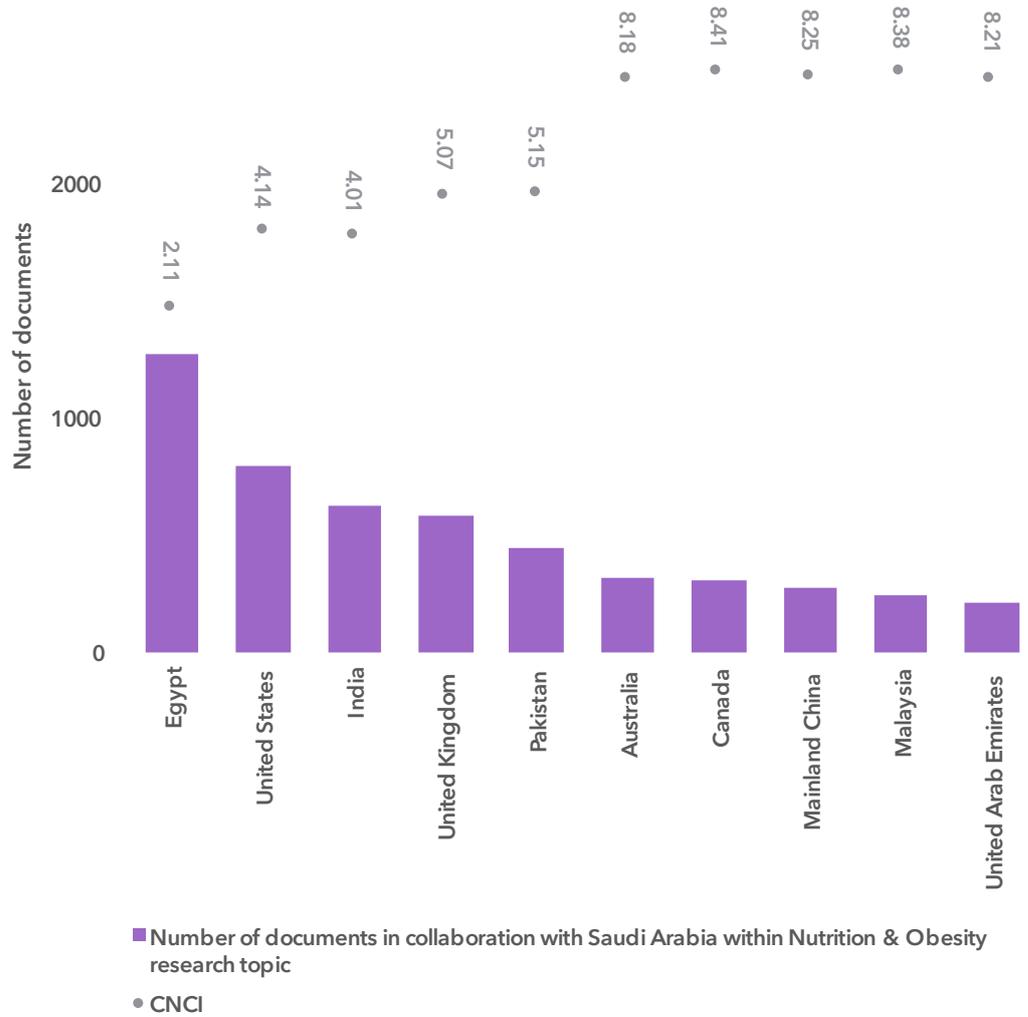
Figure 47: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Nutrition & Obesity in the period 2014-2023

4.1.3.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by Princess Nourah bint Abdulrahman University and United States Department of Health & Human Services with the same number of publications and National Institutes of Health (NIH) – USA with 491, 127 and 125 publications respectively as shown in Figure 48.

Publications funded by CGIAR, followed by Wellcome Trust and UK Research & Innovation (UKRI) had the highest citation impact measured by the CNCI with 39.19, 20.24 and 18.35, respectively.
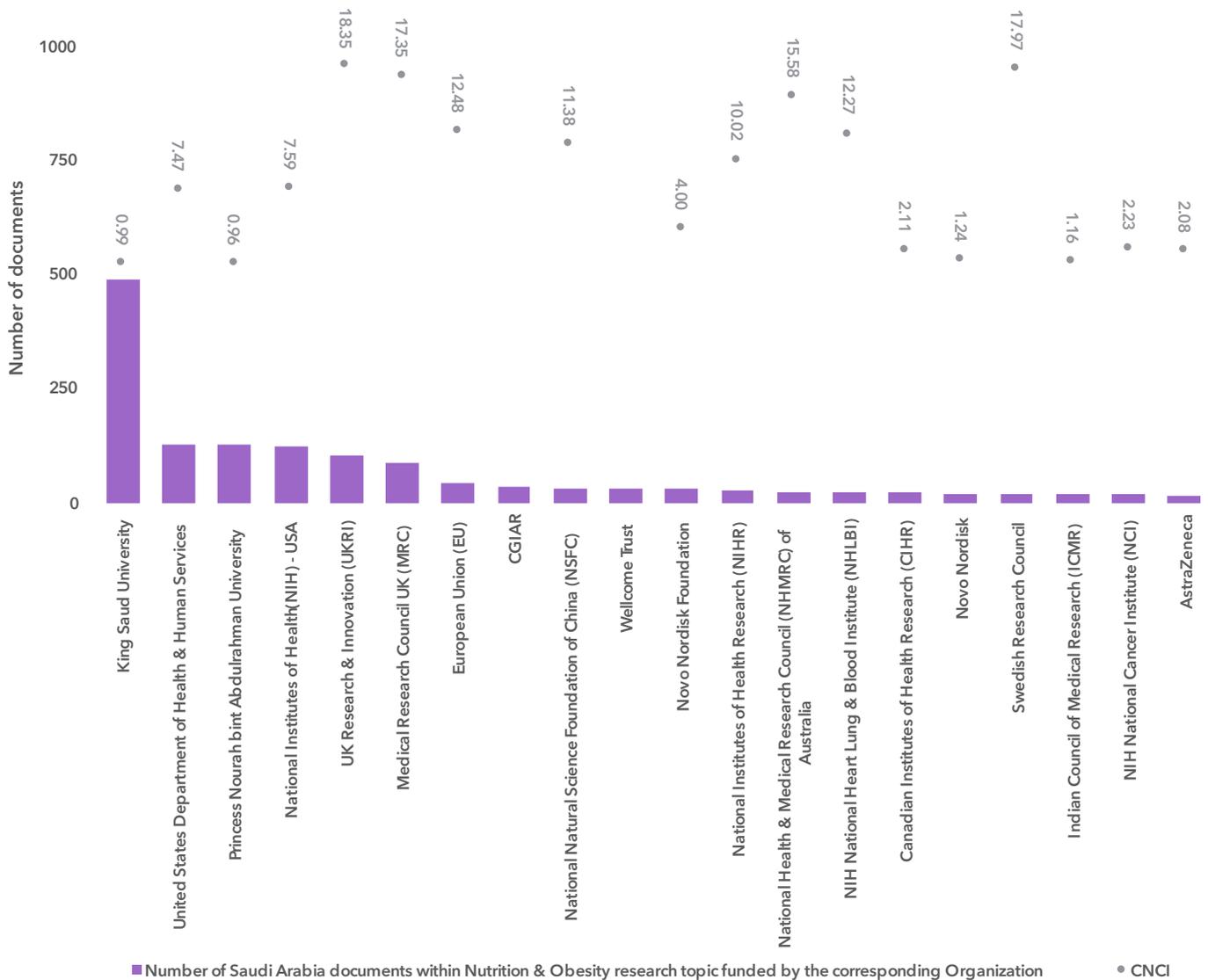
The chart shows "Number of documents" on the y-axis (0, 250, 500, 750, 1000) with the following organizations and CNCI values:

- King Saud University — 0.99
- United States Department of Health & Human Services — 7.47
- Princess Nourah bint Abdulrahman University — 0.96
- National Institutes of Health(NIH) - USA — 7.59
- UK Research & Innovation (UKRI) — 18.35
- Medical Research Council UK (MRC) — 17.35
- European Union (EU) — 12.48
- CGIAR —
- National Natural Science Foundation of China (NSFC) — 11.38
- Wellcome Trust —
- Novo Nordisk Foundation — 4.00
- National Institutes of Health Research (NIHR) — 10.02
- National Health & Medical Research Council (NHMRC) of Australia — 15.58
- NIH National Heart Lung & Blood Institute (NHLBI) — 12.27
- Canadian Institutes of Health Research (CIHR) — 2.11
- Novo Nordisk — 1.24
- Swedish Research Council — 17.97
- Indian Council of Medical Research (ICMR) — 1.16
- NIH National Cancer Institute (NCI) — 2.23
- AstraZeneca — 2.08

■ Number of Saudi Arabia documents within Nutrition & Obesity research topic funded by the corresponding Organization ● CNCI

Figure 48: Top 20 funding organizations of Saudi Arabia publications in the research topic Nutrition & Obesity in terms of number of publications in the period 2014-2023

4.1.3.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and King Saud Bin Abdulaziz University for Health Sciences with 1559, 1073 and 496 publications respectively as shown in Figure 49.

In terms of citation impact as measured by the CNCI, the Ministry of Health - Saudi Arabia, followed by University Ha'il and Jazan University, had the highest CNCI with 5.38, 5.37 and 4.24, respectively. 12 of the top 20 organizations have a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
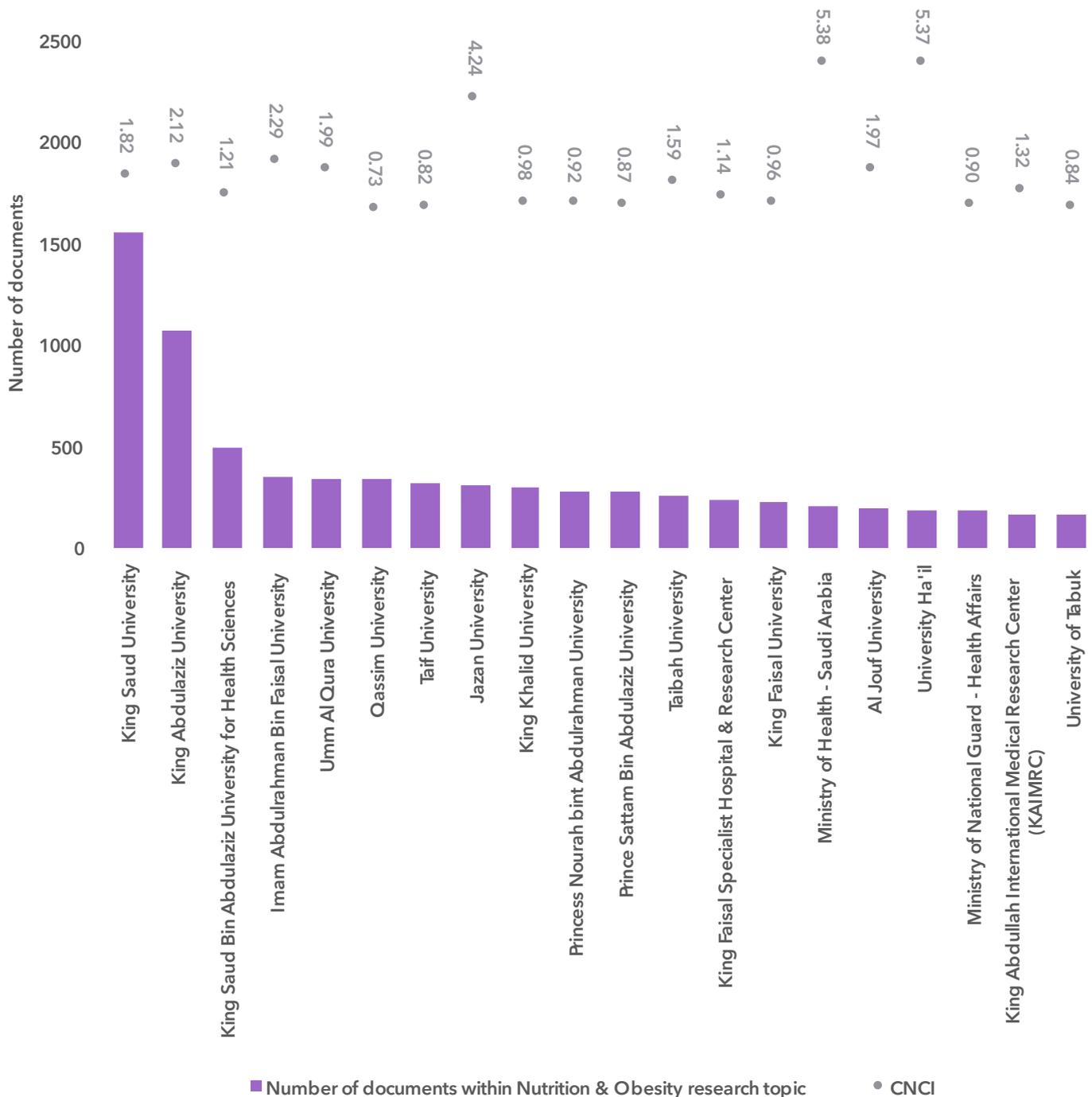
Figure 49: Top 20 Saudi organizations in terms of publications published in the research topic Nutrition & Obesity in the period 2014-2023 and their corresponding CNCI

4.1.3.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Nasser M. Al-Daghri, affiliated with King Saud University, followed by Jaakko Tuomilehto, affiliated with King Abdulaziz University, and Rashid Mir, affiliated with the University of Tabuk, with 44, 36 and 32 publications respectively as shown in Table 11.

The highest CNCI, number of Top 1% publications and number of Top 10% publications are achieved by Khalid A. Altirkawi with a CNCI of 42.89, 10 and 13 publications in Top 1% and Top 10% respectively. Jaakko Tuomilehto has also 13 publications in Top 10%.

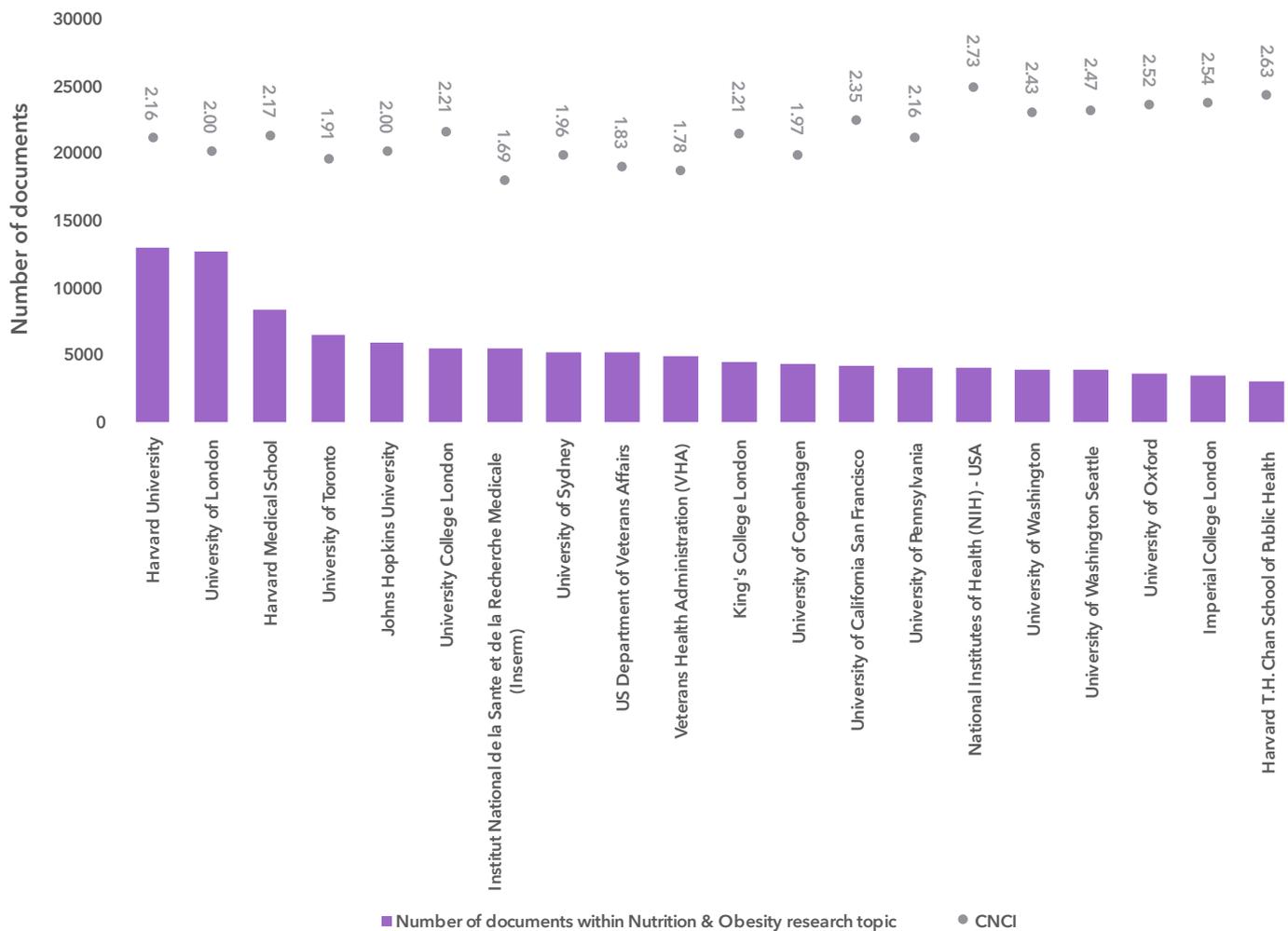Table 11: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published in the research topic Nutrition & Obesity in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Al-Daghri, Nasser M.	King Saud University	44	1.18	0	6
Tuomilehto, Jaakko	King Abdulaziz University	36	4.89	3	13
Mir, Rashid	University of Tabuk	32	0.88	0	4
Alfadda, Assim A.	King Saud University	28	1.18	0	5
El-Ansary, Afaf	King Saud University	26	1.04	0	5
Sabico, Shaun	King Saud University	20	1.52	0	4
Al-Quraishy, Saleh	King Saud University	19	0.78	0	1
Patil, Shankargouda	Jazan University	18	1.00	0	1
Adam, Ishag	Qassim University	17	0.66	0	0
Gabr, Sami A.	King Saud University	16	0.65	0	1
Naseer, Muhammad Imran	King Abdulaziz University	16	0.65	0	1
Iqbal, Muhammad Shahid	Prince Sattam Bin Abdulaziz University	14	0.24	0	0
Ahmad, Irfan	King Khalid University	14	0.77	0	1
Masood, Afshan	King Saud University	13	0.99	0	2
Tabrez, Shams	King Abdulaziz University	13	0.46	0	0
Al-Mekhlafi, Hesham M.	Jazan University	13	38.28	7	8
Househ, Mowafa	Ministry of National Guard - Health Affairs	13	1.56	0	4
Altirkawi, Khalid A.	King Saud University	13	42.89	10	13
Bindawas, Saad M.	King Saud University	12	0.71	0	0

4.1.3.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (133,316 publications), followed by Mainland China (68,663 publications) and the United Kingdom (43,419 publications) as shown in Figure 50.

The highest citation impact measured by the CNCI is achieved by publications published by United Kingdom, Italy and Canada achieving the same CNCI and Australia and Germany also achieving the same CNCI with a CNCI of 1.66, 1.56 and 1.51, respectively.

Seven of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Germany, Italy, Canada, and Australia.
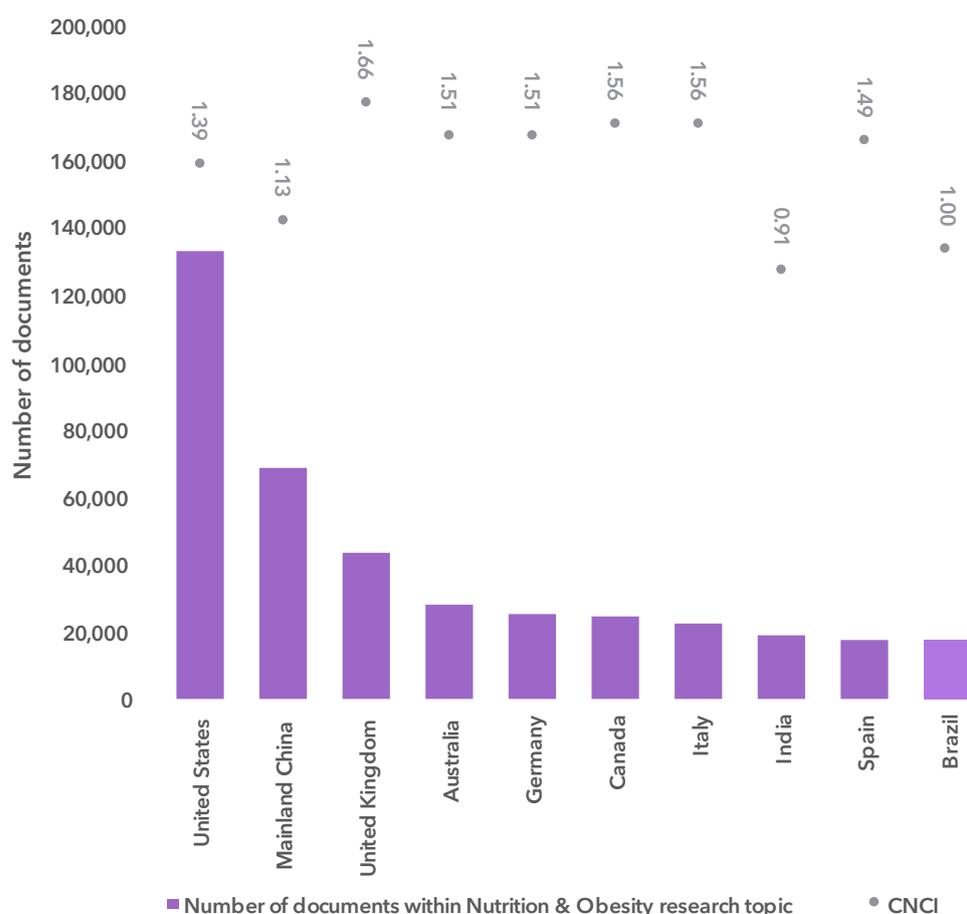
Figure 50: Top 10 countries in terms of number of publications in the research topic Nutrition & Obesity in the period 2014-2023 and their corresponding CNCI

4.1.3.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are Harvard University (12,930 publications) followed by University of London (12,625 publications) and Harvard Medical School (8,343 publications) as shown in Figure 51.

In terms of citation impact measured by the CNCI, National Institutes of Health (NIH) - USA followed by Harvard T.H. Chan School of Public Health and Imperial College London had the highest CNCI with 2.73, 2.63 and 2.54, respectively.

Figure 51: Top 20 organizations globally in terms of the number of publications published in the research topic Nutrition & Obesity in the period 2014-2023 and their corresponding CNCI

4.1.3.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications on this research topic are Qiyong. Gong affiliated with Sichuan University with 277 publications, followed by Massimo Filippi, affiliated with Vita-Salute San Raffaele University with 202 publications, and Henrik. Zetterberg is affiliated to the University of Gothenburg with 197 publications, as shown in Table 12.

The highest CNCI (10.76) and number of Top 1% publications (22) is achieved by Zulfiqar A. Bhutta affiliated to Aga Khan University. Naveed Sattar affiliated to University of Glasgow has also 22 Top 1% publications The highest number of Top 10% publications are achieved by Henrik Zetterberg affiliated to University of Gothenburg.

Table 12: Top 20 researchers globally in terms of the number of publications published in the research topic Nutrition & Obesity in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Gong, Qiyong	Sichuan University	277	1.42	5	54	Mainland China
Filippi, Massimo	Vita-Salute San Raffaele University	202	1.92	9	54	Italy
Zetterberg, Henrik	University of Gothenburg	197	2.86	17	80	Sweden
Andreassen, Ole A.	University of Oslo	160	1.72	4	34	Norway
Blennow, Kaj	University of Gothenburg	159	3.47	19	64	Sweden
Le Roux, Carel W.	University College Dublin	155	1.78	6	27	Ireland
Erel, Ozcan	Ankara Yildirim Beyazit University	148	0.55	0	5	Türkiye
Calhoun, Vince D.	Lovelace Respiratory Research Institute	136	1.69	3	40	United States
Paul, Friedemann	Free University of Berlin	136	2.03	4	40	Germany
Holst, Jens J.	University of Copenhagen	132	1.94	4	40	Denmark
Astrup, Arne	University of Copenhagen	128	2.18	6	30	Denmark
Wadden, Thomas A.	University of Pennsylvania	123	5.37	17	43	United States
Bhutta, Zulfiqar A.	Aga Khan University	122	10.76	22	47	Pakistan
Sattar, Naveed	University of Glasgow	122	5.13	22	63	Scotland
Chen, Huafu	University of Electronic Science & Technology of China	122	1.65	4	21	Mainland China
Wing, Rena R.	Brown University	121	1.33	2	19	United States
Alfredo Martinez, J.	University of Navarra	120	1.40	2	17	Spain
Shao, Yi	Nanchang University	118	0.72	0	3	Mainland China
Hu, Frank B.	Harvard University	118	5.01	20	66	United States
Guo, Wenbin	Central South University	115	1.05	0	9	Mainland China

4.1.3.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 43,243 publications, followed by the National Institutes of Health (NIH) - USA with 40,925 publications and the National Natural Science Foundation of China (NSFC) with 29,915 publications as shown in Figure 52.

The highest citation impact measured by the CNCI is observed in publications funded by Medical Research Council UK (MRC), UK Research & Innovation (UKRI) and NIH National Institute on Aging (NIA) with 2.20, 2.11 and 1.84, respectively. Among the top 20 global funding organizations, 10 are also among the top 20 funding organizations of Saudi publications in this research topic.
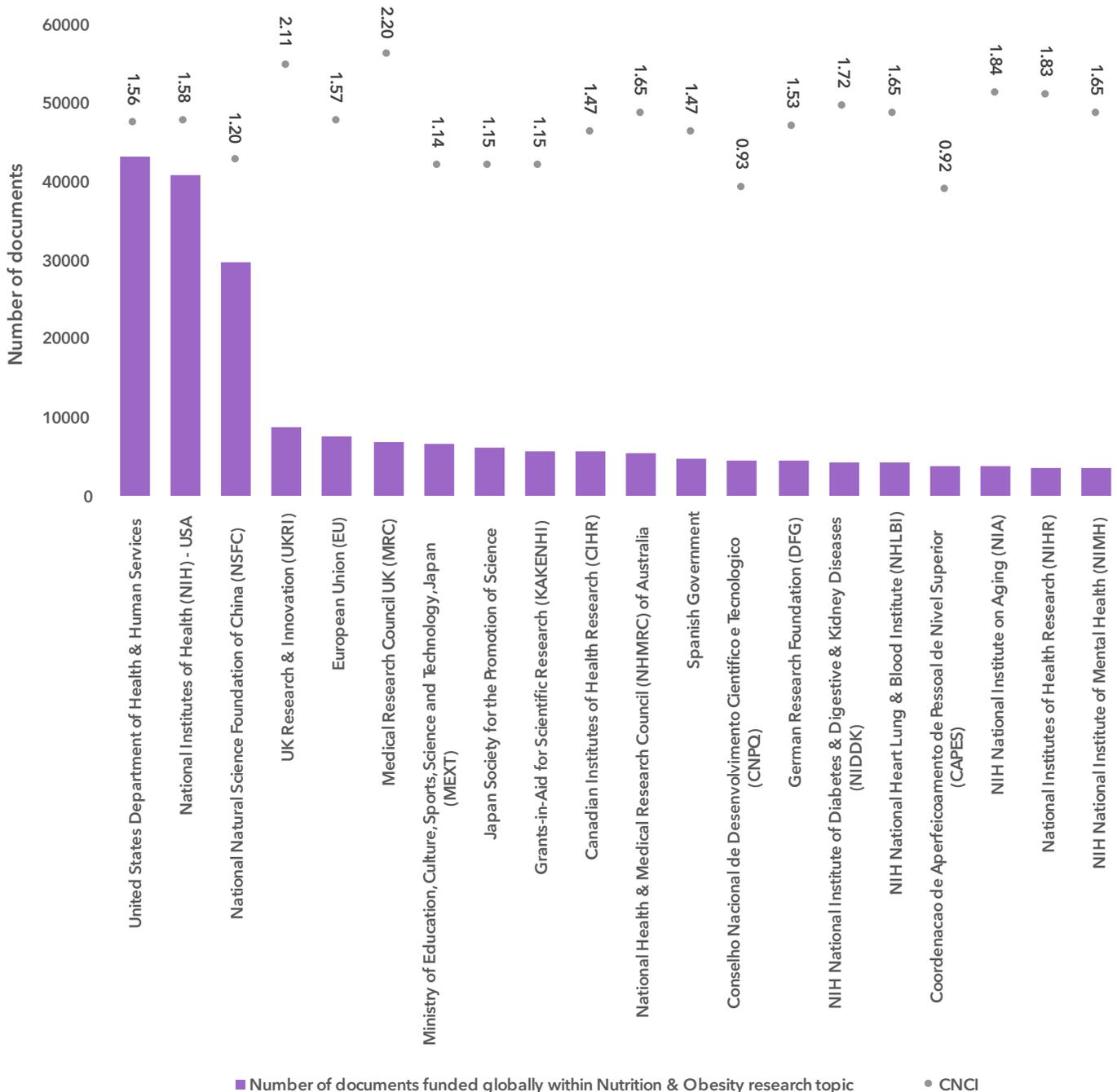
Figure 52: Top 20 funding organizations globally publications in the research topic Nutrition & Obesity in terms of number of publications in the period 2014-2023

4.1.3.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Nutrition & Obesity. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Virology - General: Coronavirus followed by Organic Semiconductors: Stretchable Electronics and Immunology: Neutrophil Extracellular Traps as shown in Figure 53. In Figure 54 The top 20 Saudi Arabia emerging micro-topics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Healthcare Policy: Maternal Mortality followed by Diabetes: GLP-1 and Nutrition & Dietetics: Obesity.

Among Saudi Arabia's top 20 emerging micro-topics, there is one micro-topic that is also an emerging trend globally, which is Virology - General: Coronavirus. It is worth mentioning that the micro-topics Micro & Long Noncoding RNA: MicroRNAs, Nursing: Shared Decision Making and Virology - General: Coronavirus citation share in Saudi Arabia decreased within the total citations of Saudi Arabia publications in the research topic Nutrition & Obesity. Accordingly, one should monitor and assess the relevance of those topics locally and globally.

Figure 53: Top 20 emerging micro-topics globally in the research topic Nutrition & Obesity in the period 2014-2023
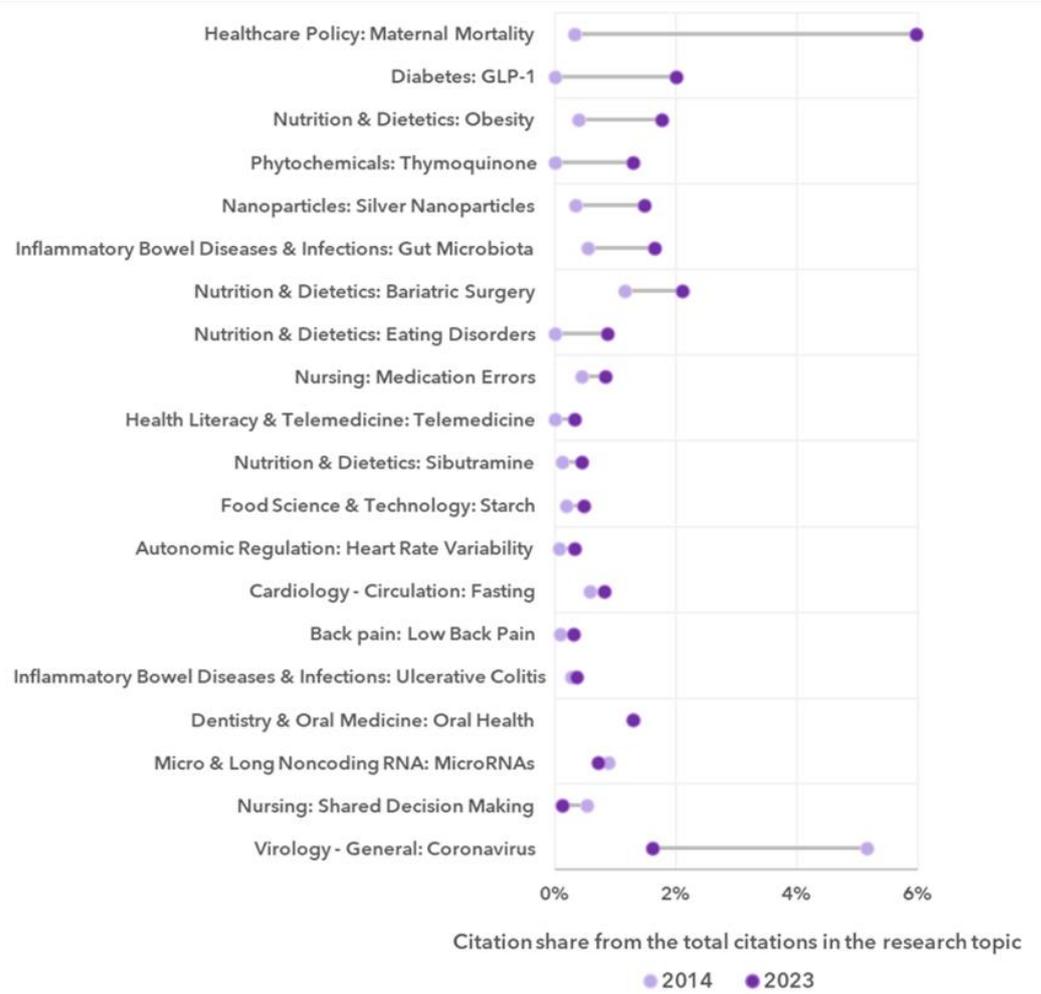
Figure 54: Top 20 emerging micro-topics in Saudi Arabia in the research topic Nutrition & Obesity in the period 2014-2023

4.1.4 Diabetes

4.1.4.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 55. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic are growing. The CNCI of Saudi Arabia publications in this research topic were in several years higher than 1, indicating a citation impact performance higher than the global average.

The CNCI increased from 1.09 in 2014 to 2.07 in 2016 and then decreased to 0.88 in 2019 to then recover to 1.17 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a recovery in 2023.
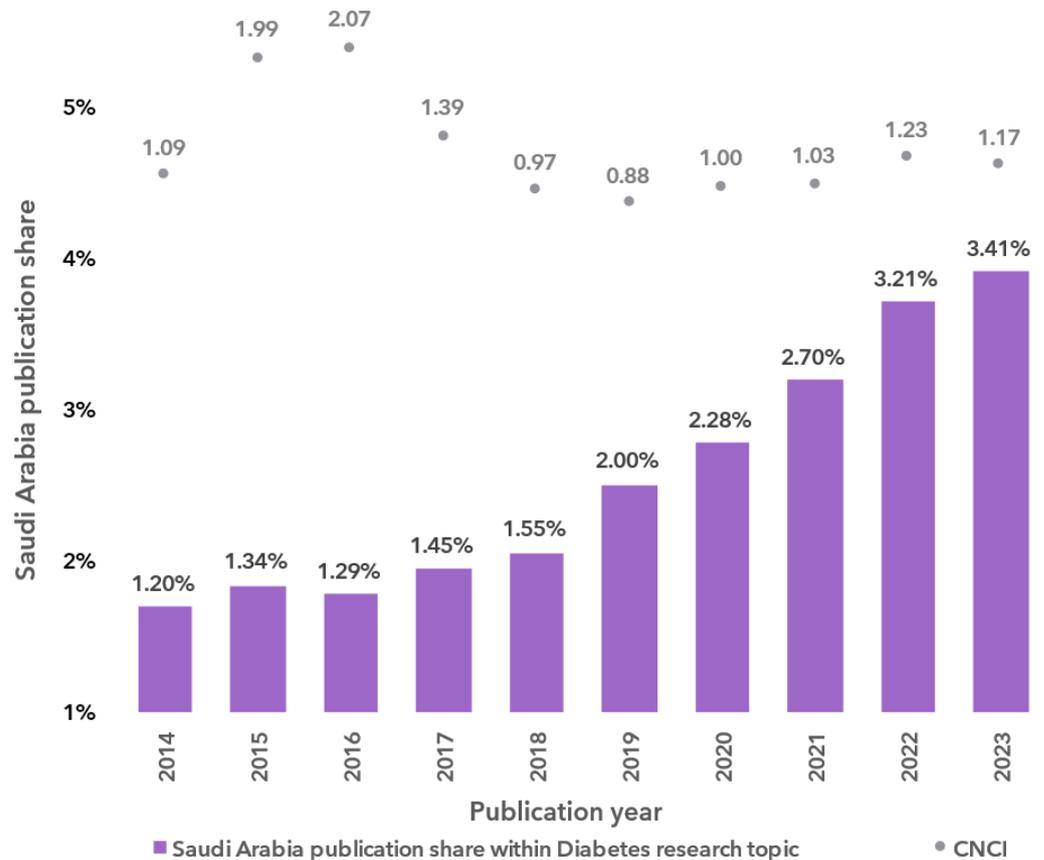
Figure 55: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.4.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is Egypt, followed by India and the United States with 1744, 1096 and 976 publications, respectively, as shown in Figure 56.

In terms of citation impact measured by the CNCI publications published in collaboration with Mainland China, Canada and Australia had the highest CNCI with

7.66, 7.30 and 6.57, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
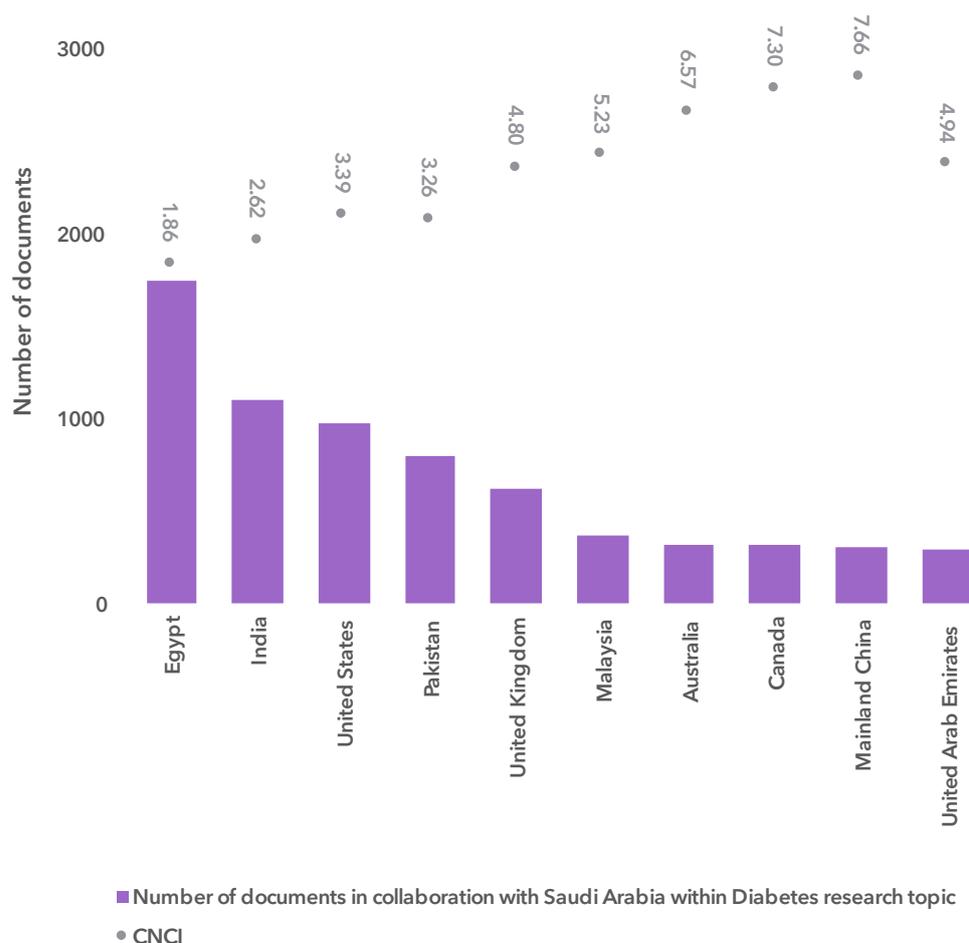

Figure 56: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications on the research topic Diabetes in the period 2014-2023

4.1.4.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by Princess Nourah bint Abdulrahman University and United States Department of Health & Human Services with 714, 213 and 180 publications respectively as shown in Figure 57.

Publications funded by the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT), followed by Medical Research Council UK (MRC) and UK Research & Innovation (UKRI), had the highest citation impact measured by the CNCI with 23.52, 17.48 and 15.09, respectively.
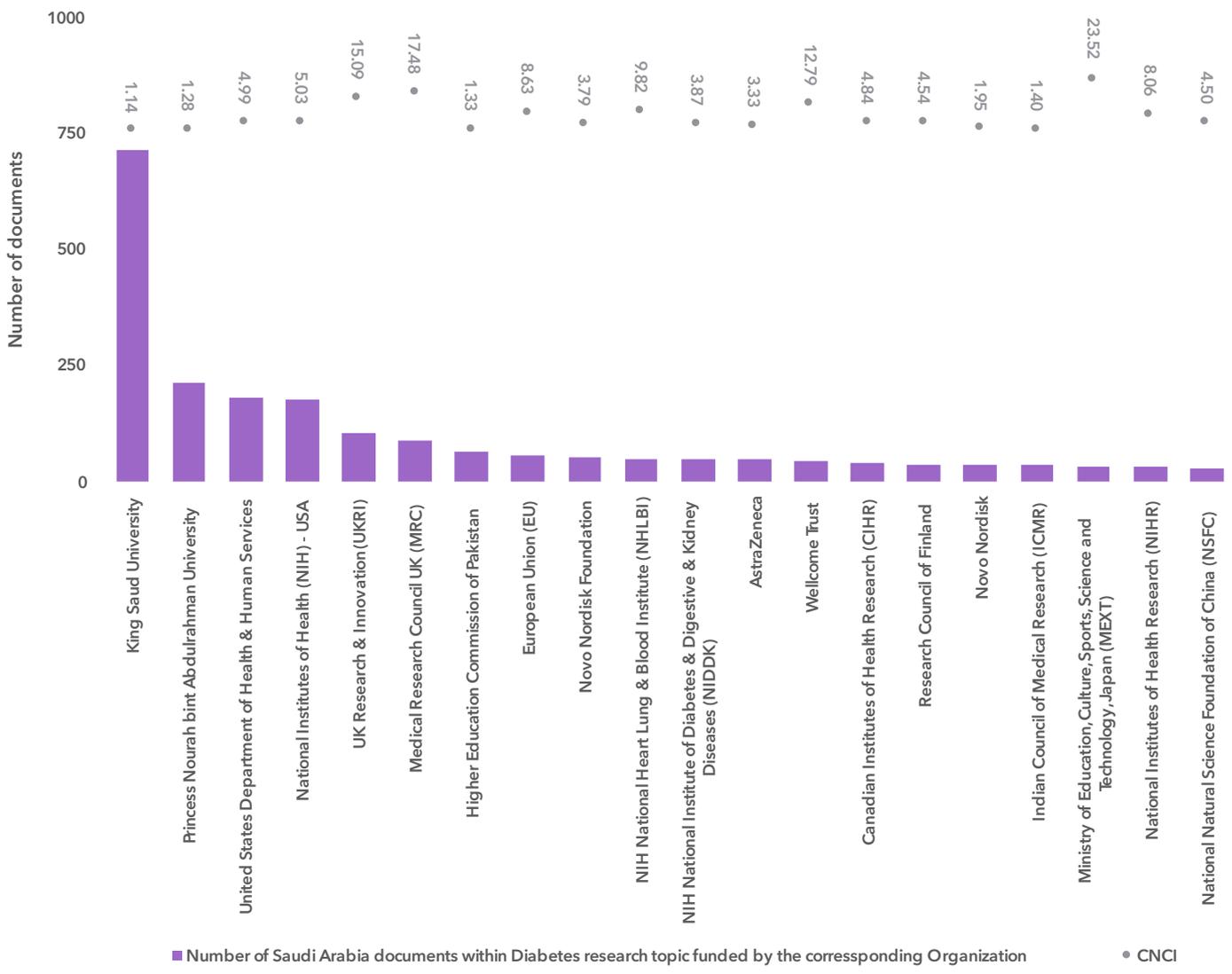
Figure 57: Top 20 funding organizations of Saudi Arabia publications in the research topic Diabetes in terms of number of publications in the period 2014-2023

4.1.4.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University, followed by King Abdulaziz University and King Saud Bin Abdulaziz University for Health Sciences, with 2060, 1416 and 689 publications, respectively, as shown in Figure 58.

In terms of citation impact as measured by the CNCI, University of Ha'il, followed by the Ministry of Health - Saudi Arabia and Jazan University, had the highest CNCI with 5.62, 3.85 and 2.42, respectively. Nevertheless, 14 of the top 20 organizations had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
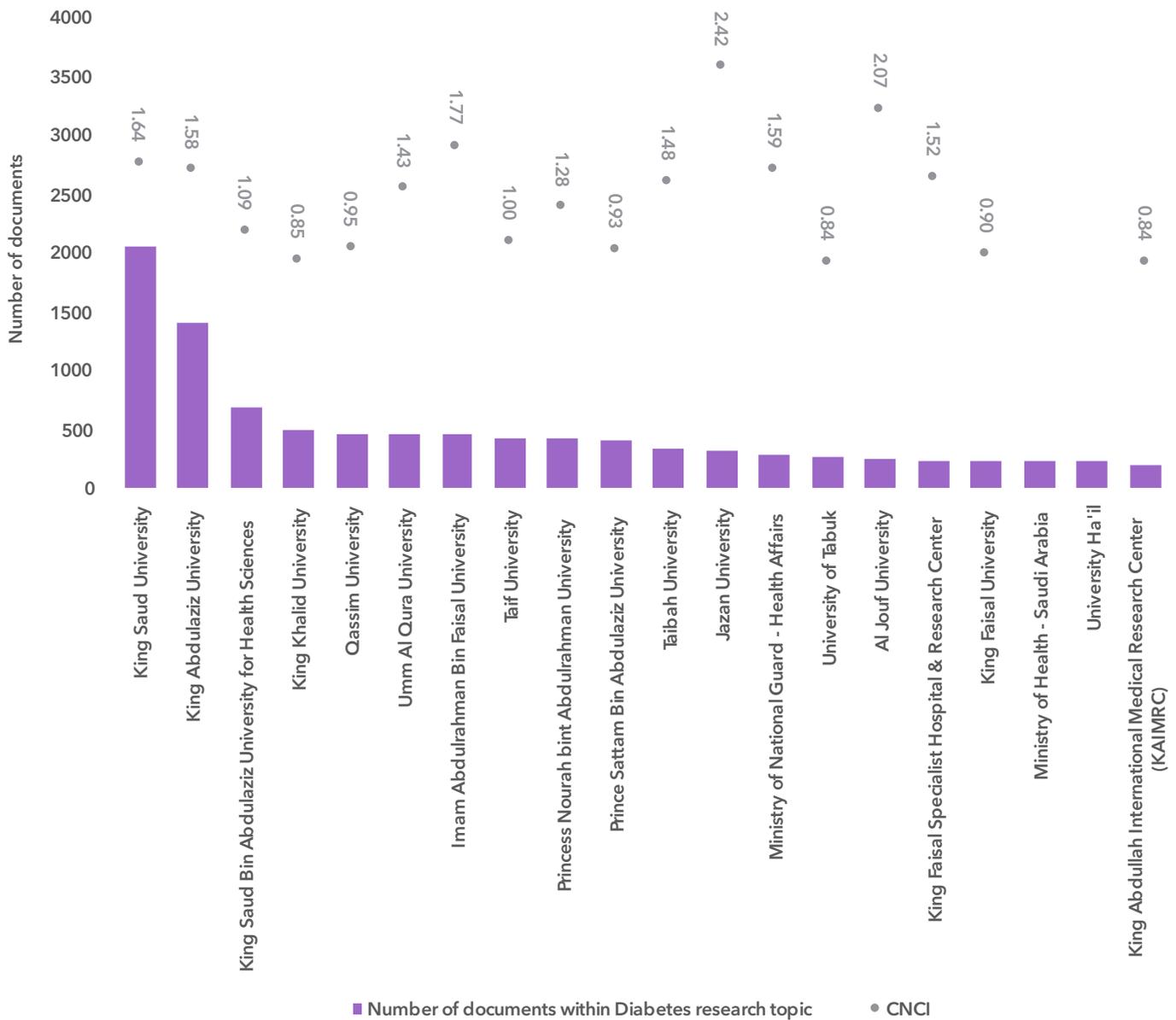
Figure 58: Top 20 Saudi organizations in terms of publications published in the research topic Diabetes in the period 2014-2023 and their corresponding CNCI

4.1.4.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Jaakko Tuomilehto, affiliated to King Abdulaziz University, followed by Nasser M. Al-Daghri, affiliated to King Saud University, and Muhammad Taha, affiliated to Imam Abdulrahman Bin Faisal University, with 130, 70 and 53 publications, respectively as shown in Table 13.

The highest CNCI, number of Top 1% publications and number of Top 10% publications are achieved by Jaakko Tuomilehto with a CNCI of 3.68, 16 and 46 publications in Top 1% and Top 10% respectively.

Table 13: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Diabetes in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Tuomilehto, Jaakko	King Abdulaziz University	130	3.68	16	46
Al-Daghri, Nasser M.	King Saud University	70	1.25	0	14
Taha, Muhammad	Imam Abdulrahman Bin Faisal University	53	1.55	1	17
Sabico, Shaun	King Saud University	41	1.46	0	9
Alokail, Majed S.	King Saud University	39	1.09	0	5
Kamal, Mohammad A.	King Abdulaziz University	39	0.87	1	1
Chigurupati, Sridevi	Qassim University	35	1.33	1	9
Siddiqui, Khalid	King Saud University	35	0.76	0	4
Vohra, Fahim	King Saud University	32	1.46	0	7
Abu El-Asrar, Ahmed M.	King Saud University	30	1.36	0	4
Alshammari, Ghedeir M.	King Saud University	29	1.16	1	3
Tabrez, Shams	King Abdulaziz University	23	0.71	0	1
Al-Attas, Omar S.	King Saud University	22	0.87	0	0
Kamal, Mohammad Amjad	King Abdulaziz University	18	1.06	0	2
Robert, Asirvatham A.	Prince Sultan Military Medical City	18	1.05	0	2
Alenazi, Aqeel M.	Prince Sattam Bin Abdulaziz University	18	0.68	0	0
Batais, Mohammed A.	King Saud University	18	0.48	0	0
Adnan, Mohd	University Ha'il	17	2.03	0	6
Alnaami, Abdullah M.	King Saud University	17	1.36	0	3
Al Darwish, Mohamed Abdulaziz	Prince Sultan Military Medical City	16	1.08	0	3

4.1.4.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (95,404 publications), followed by Mainland China (67,460 publications) and the United Kingdom (28,333 publications), as shown in Figure 59.

The highest citation impact measured by the CNCI is achieved by publications published by United Kingdom, Canada and Germany achieving the same CNCI and Australia with a CNCI of 2.07, 1.96 and 1.92, respectively.

Six of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Canada, Australia, and India.
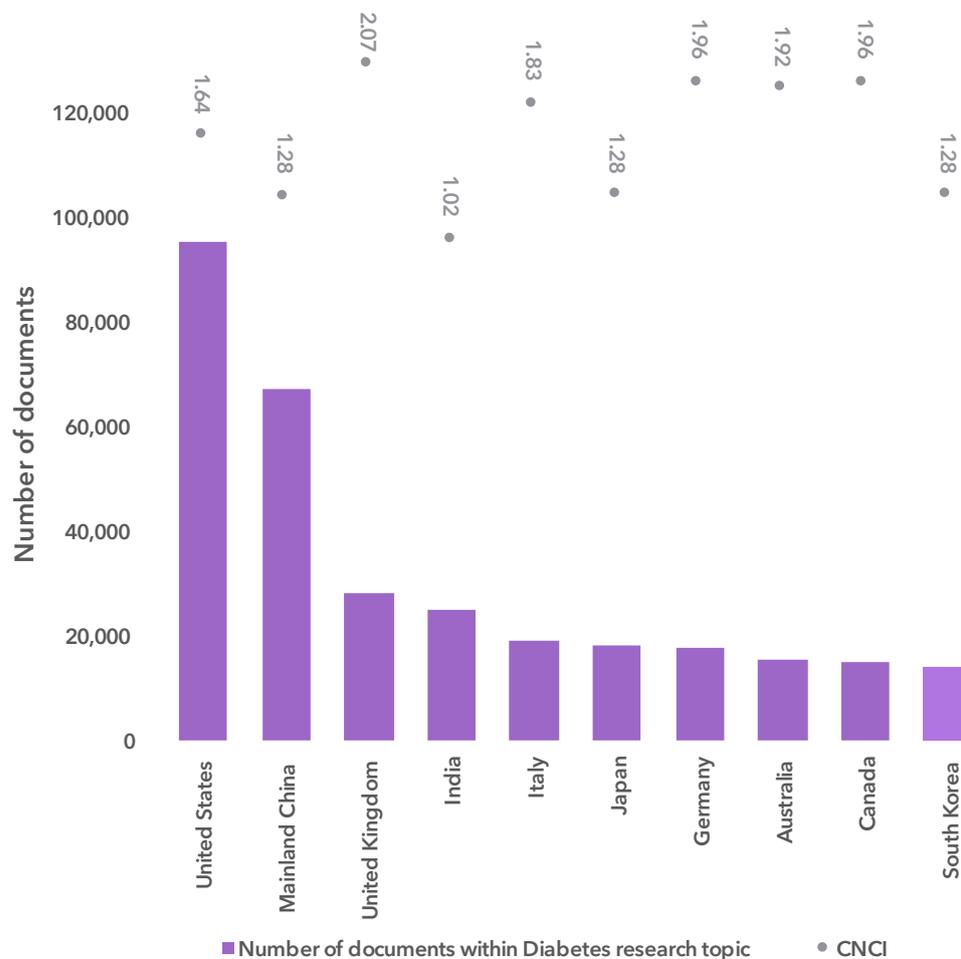
Figure 59: Top 10 countries in terms of number of publications in the research topic Diabetes in the period 2014-2023 and their corresponding CNCI

4.1.4.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are Harvard University (10,391 publications) followed by Harvard Medical School (7,383 publications) and University of London (6,674 publications) as shown in Figure 60.

In terms of citation impact measured by the CNCI, Imperial College London, followed by the University of Oxford and Stanford University, had the highest CNCI with 3.69, 3.60 and 3.46, respectively.

Figure 60: Top 20 organizations globally in terms of number of publications published in the research topic Diabetes in the period 2014-2023 and their corresponding CNCI

4.1.4.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Kamlesh Khunti, affiliated with the University of Leicester, with 365 publications, followed by Peter. Rossing is affiliated with Steno Diabetes Center with 305 publications, and Linong Ji is affiliated with Peking University with 298 publications, as shown in Table 14.

The highest CNCI is achieved by Naveed Sattar affiliated to University of Glasgow. The latter has also the highest number of Top 1% publications with 54 publications and the highest number of Top 10% publications with 138 publications.

Table 14: Top 20 researchers globally in terms of the number of publications published on the research topic Diabetes in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Khunti, Kamlesh	University of Leicester	365	2.45	22	82	England
Rossing, Peter	Steno Diabetes Center	305	5.49	38	93	Denmark
Ji, Linong	Peking University	298	1.17	6	37	Mainland China
Sattar, Naveed	University of Glasgow	293	6.79	54	138	Scotland
Sahebkar, Amirhossein	Mashhad University Medical Science	267	2.79	10	44	Iran
Mohan, Viswanathan	Madras Diabetes Research Foundation	257	2.84	16	49	India
Jia, Weiping	Shanghai Jiao Tong University	253	2.41	15	50	Mainland China
Hu, Frank B.	Harvard University	249	3.59	30	117	United States
Azizi, Fereidoun	Shahid Beheshti University Medical Sciences	242	1.26	2	18	Iran
Roden, Michael	Heinrich Heine University Dusseldorf	240	2.42	14	64	Germany
Larijani, Bagher	Tehran University of Medical Sciences	239	1.87	2	34	Iran
Zhou, Zhiguang	Central South University	233	1.04	2	31	Mainland China
Bhatt, Deepak L.	Harvard University	228	6.09	25	100	United States
Holl, Reinhard W.	Ulm University	225	1.45	3	43	Germany
Heerspink, Hiddo J. L.	University of Groningen	214	5.45	38	98	Netherlands
Ning, Guang	Shanghai Jiao Tong University	197	2.37	9	45	Mainland China
Davies, Melanie J.	University of Leicester	192	2.93	12	37	England
Shimomura, Iichiro	Osaka University	192	1.20	2	22	Japan
Zinman, Bernard	University of Toronto	191	4.53	27	80	Canada
Buse, John B.	University of North Carolina Chapel Hill	190	5.23	28	88	United States

4.1.4.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 34,884 publications, followed by the National Institutes of Health (NIH) - USA with 34,050 publications, and National Natural Science Foundation of China (NSFC) with 30,008 publications as shown in Figure 61.

The highest citation impact measured by the CNCI is observed in publications funded by Medical Research Council UK (MRC), UK Research & Innovation (UKRI) and AstraZeneca with 2.82, 2.67 and 2.31, respectively.

Among the top 20 global funding organizations, 13 are also among the top 20 funding organizations of Saudi publications in this research topic.
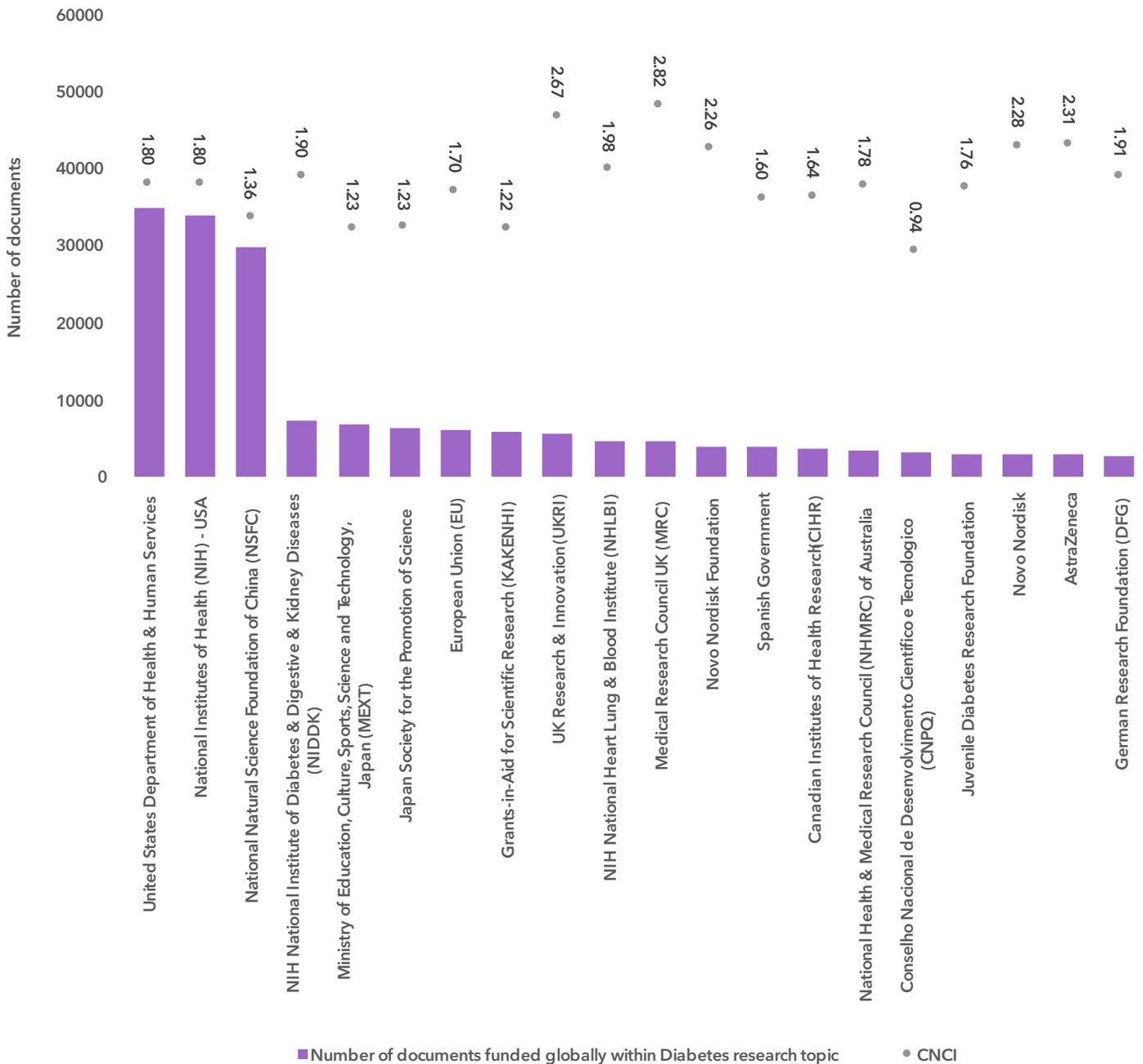
Figure 61: Top 20 funding organizations globally publications in the research topic Diabetes in terms of number of publications in the period 2014-2023

4.1.4.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Diabetes. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Virology - General: Coronavirus followed by Immunology: Neutrophil Extracellular Traps and Protein Structure, Folding & Modelling: Carbonic Anhydrase as shown in Figure 62. In Figure 63 the top 20 Saudi Arabia emerging micro-topics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Computer Vision & Graphics: Retinal Images followed by Protein Structure, Folding & Modelling: Carbonic Anhydrase and Nanoparticles: Silver Nanoparticles.

Among Saudi Arabia top 20 emerging micro-topics there are two micro-topics that are also an emerging trend globally, which are Virology - General: Coronavirus and Protein Structure, Folding & Modelling: Carbonic Anhydrase.

It is worth mentioning that the micro-topics Inflammatory Bowel Diseases & Infections: Gut Microbiota, Diabetes: Type 1 Diabetes, Virology - General: Coronavirus and Nursing: Medication Errors citation share in Saudi Arabia decreased within the total citations of Saudi Arabia publications in the research topic. Accordingly, one should monitor and assess the relevance of those topics locally and globally.
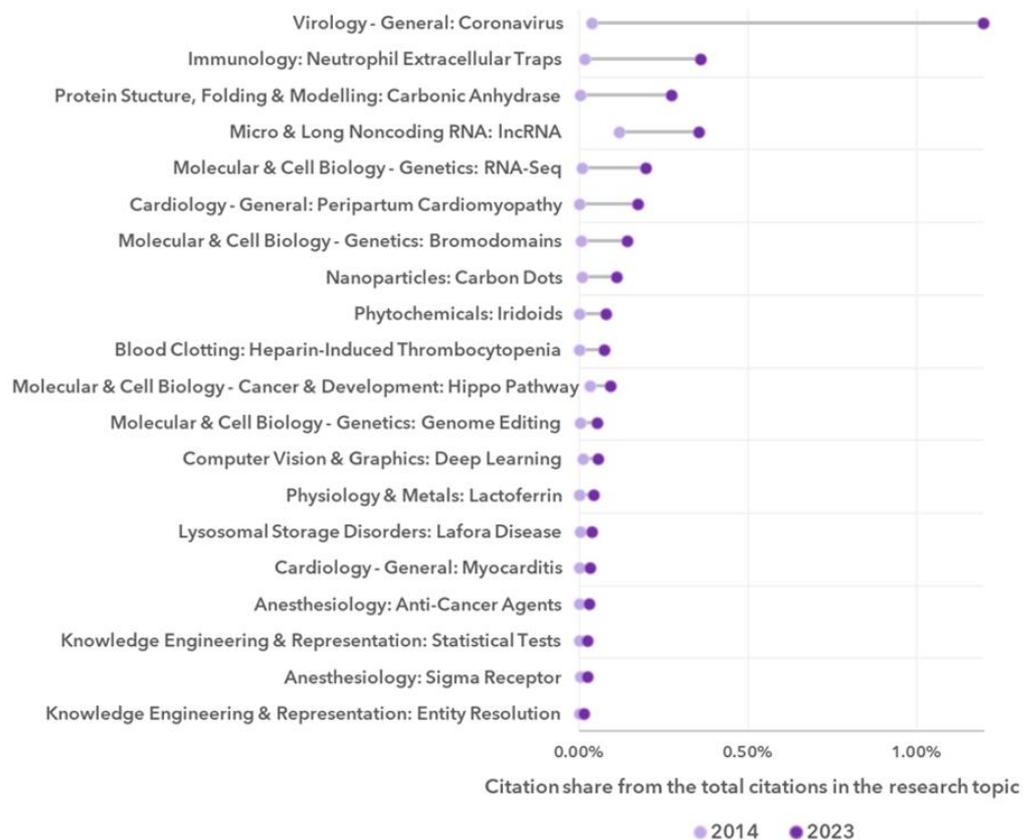
Figure 62: Top 20 emerging micro-topics globally in the research topic Diabetes in the period 2014-2023
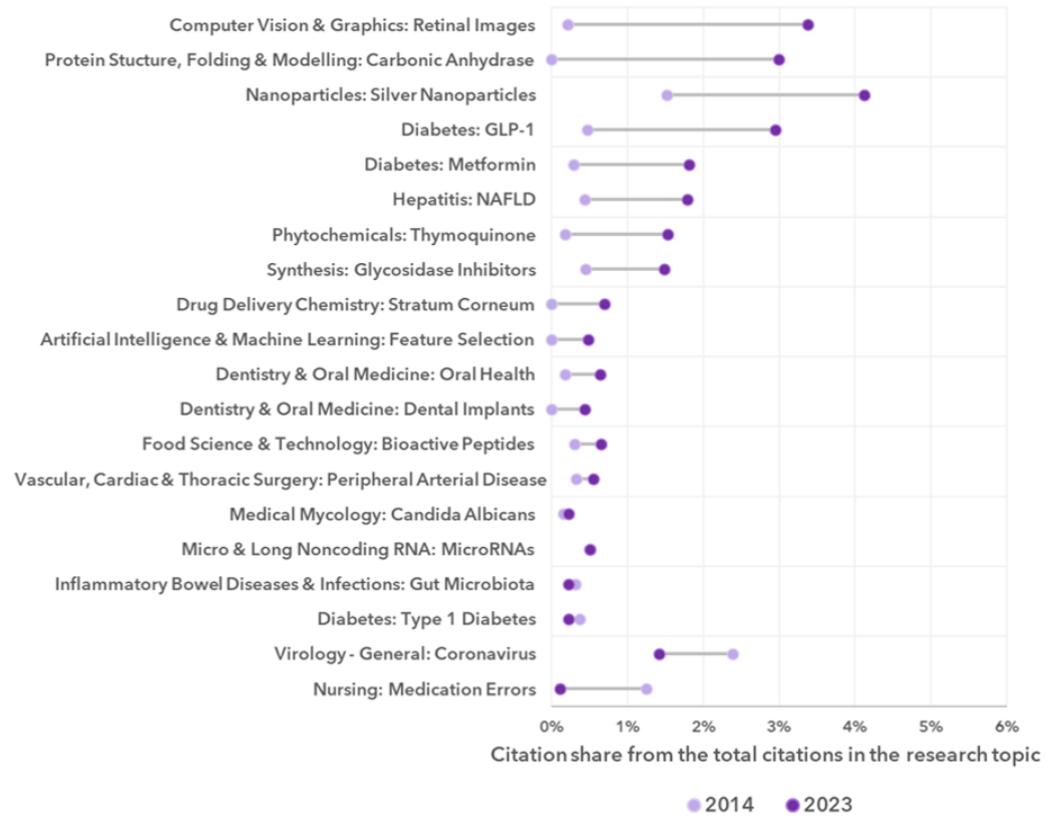
Figure 63: Top 20 emerging micro-topics in Saudi Arabia in the research topic Diabetes in the period 2014-2023

4.1.5 Biopharmaceuticals

4.1.5.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 64. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic were in all years higher than 1, indicating a citation impact performance higher than the global average.

The CNCI increased from 1.00 in 2014 to 1.48 in 2016 and then decreased to 1.00 in 2019 to then recover to 1.23 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a recovery in 2023.
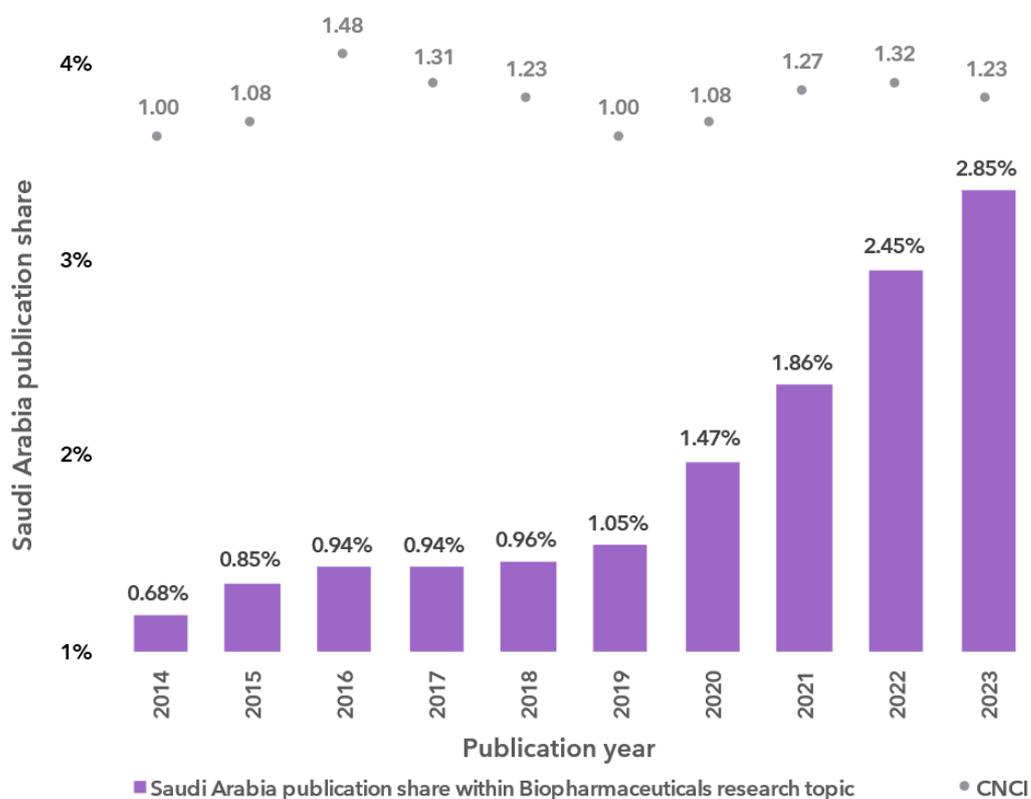
Figure 64: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.5.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is Egypt, followed by India and the United States with 1365, 1277 and 828 publications, respectively, as shown in Figure 65.

In terms of citation impact measured by the CNCI publications published in collaboration with Mainland China, Australia and South Korea had the highest CNCI with 2.07, 1.89 and 1.86, respectively. Nevertheless, all publications with the top 10

collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
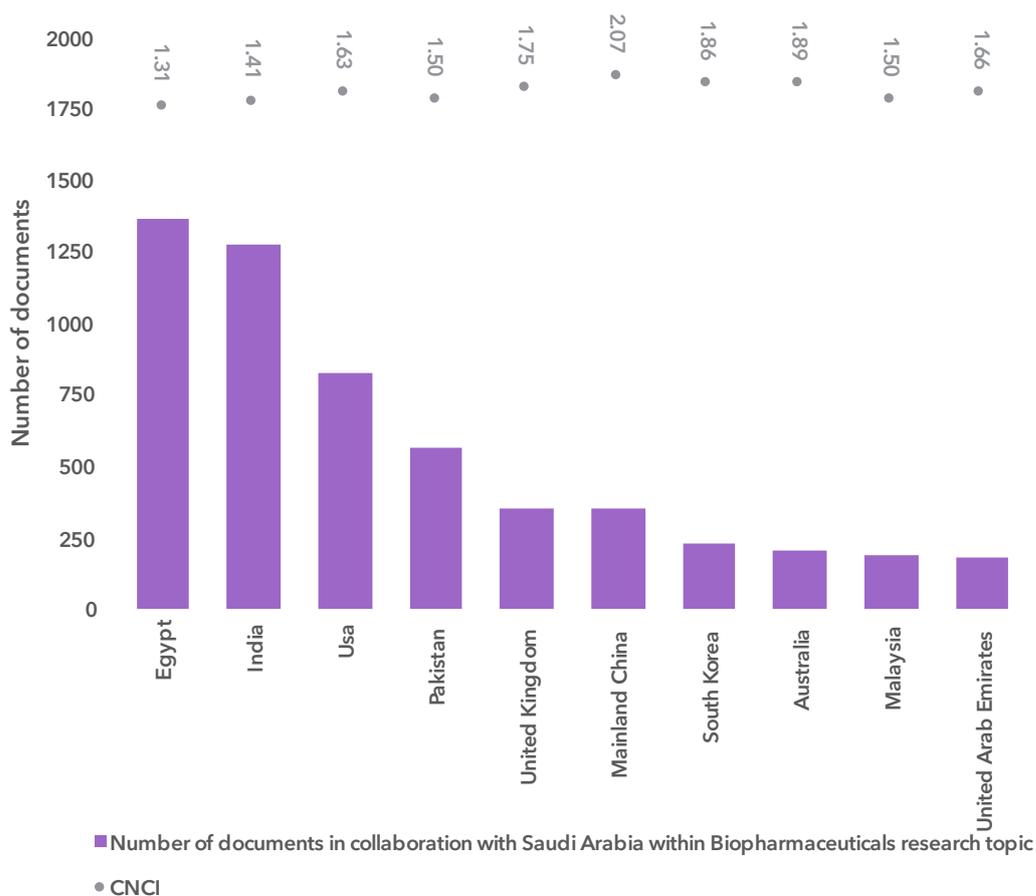

Figure 65: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Biopharmaceuticals in the period 2014-2023

4.1.5.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by Princess Nourah bint Abdulrahman University and United States Department of Health & Human Services with 705, 148 and 144 publications respectively as shown in Figure 66.

Publications funded by Medical Research Council UK (MRC) followed by UK Research & Innovation (UKRI) and National Natural Science Foundation of China (NSFC) had the highest citation impact measured by the CNCI with 3.69, 3.54 and 2.94, respectively.
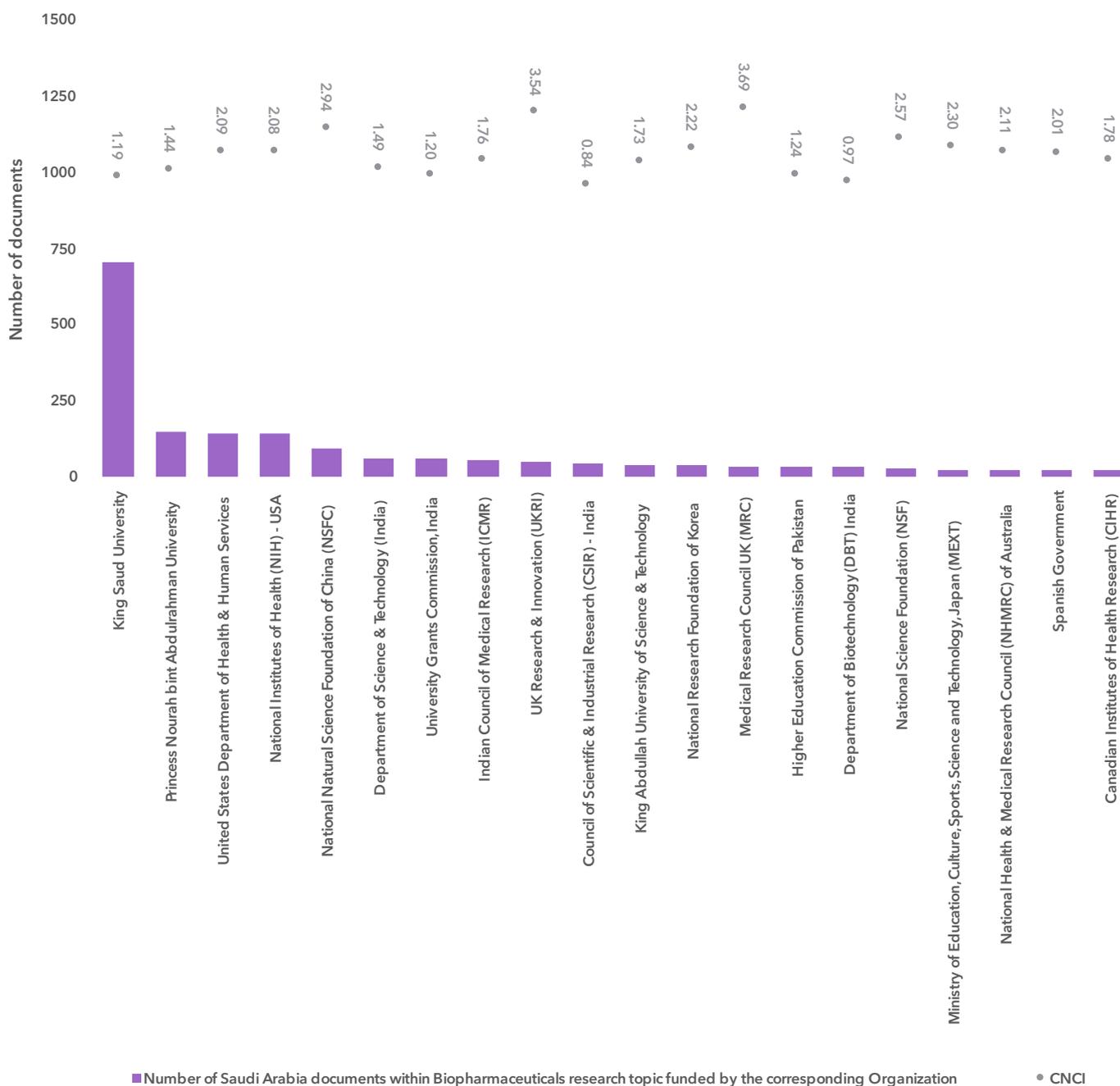
Figure 66: Top 20 funding organizations of Saudi Arabia publications in the research topic Biopharmaceuticals in terms of number of publications in the period 2014-2023

4.1.5.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and King Khalid University with 1495, 975 and 397 publications, respectively, as shown in Figure 67.

In terms of citation impact as measured by the CNCI, King Abdullah University of Science & Technology, followed by King Abdulaziz University, shares the same CNCI with King Faisal University, followed by Princess Nourah bint Abdulrahman University had the highest CNCI with 1.52, 1.47 and 1.35, respectively. Nevertheless, all top 20 organizations, except the University of Jeddah, King Faisal University, King Faisal Specialist Hospital & Research Center, and King Saud Bin Abdulaziz University for

Health Sciences, had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
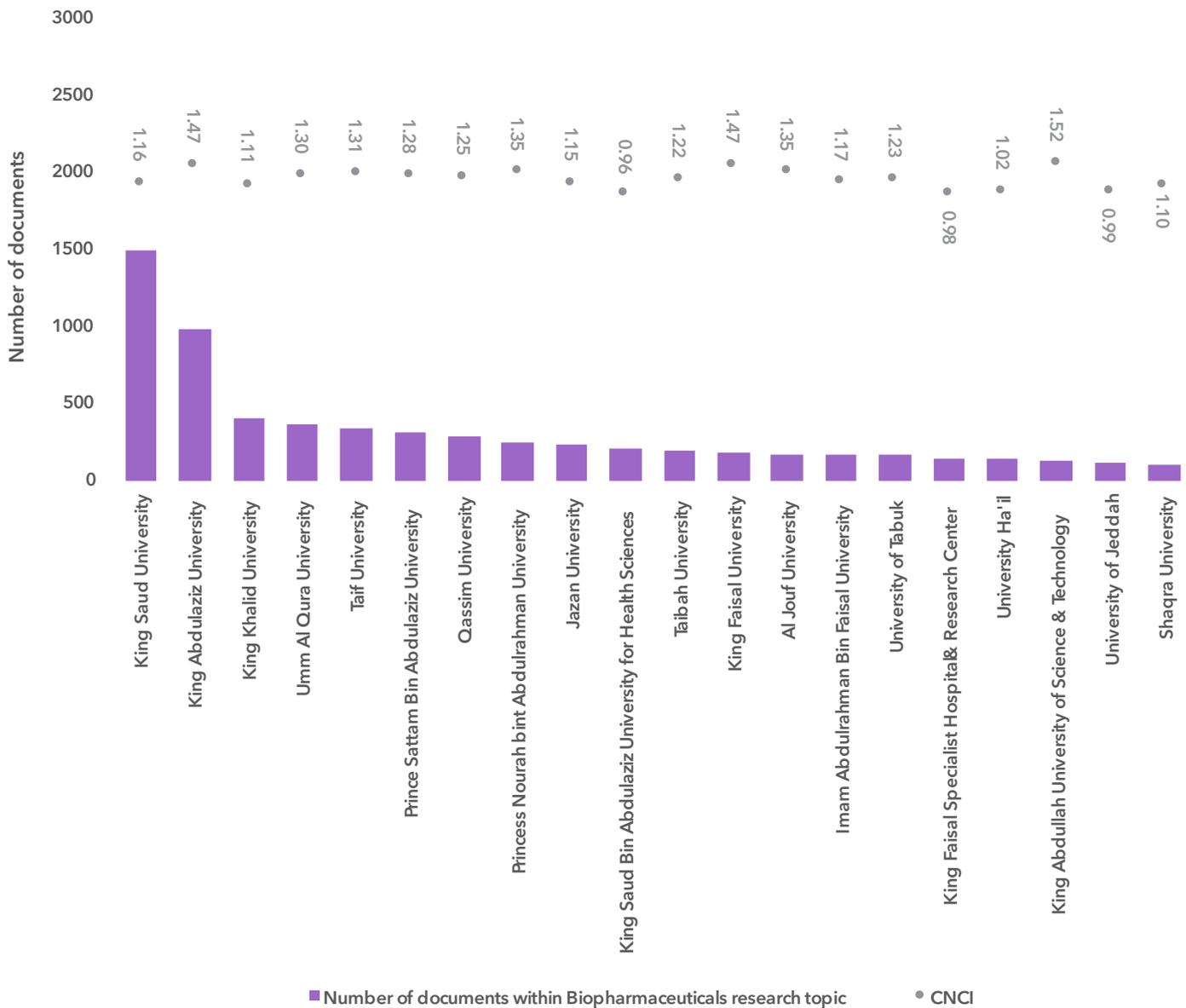
Figure 67: Top 20 Saudi organizations in terms of publications published in the research topic Biopharmaceuticals in the period 2014-2023 and their corresponding CNCI

4.1.5.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Mohammad Amjad Kamal, affiliated with King Abdulaziz University, followed by Sabry M. Attia, affiliated with King Saud University, and Ahmed Nadeem, affiliated with King Saud University, with 45, 34 and 32 publications. Respectively, as shown in Table 15.

The highest CNCI with 2.69 is achieved by Mohammad Azam Ansari. The highest achieved number of Top 1% publications is 1 and this is achieved by several authors. The highest number of Top 10% publications is achieved by Sabry M. Attia affiliated to King Saud University and Mohammad Amjad Kamal affiliated to King Abdulaziz University, both having 10 Top 10% publications.

Table 15: Top 20 researchers affiliated to Saudi organizations in terms of number of publications published in the research topic Biopharmaceuticals in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Kamal, Mohammad Amjad	King Abdulaziz University	45	1.13	1	10
Attia, Sabry M.	King Saud University	34	1.64	0	10
Nadeem, Ahmed	King Saud University	32	1.42	0	7
Bakheet, Saleh A.	King Saud University	31	1.58	0	8
Haque, Shafiul	Jazan University	31	0.85	0	3
Ahmad, Sheikh F.	King Saud University	30	1.33	0	6
Ashraf, Ghulam Md	King Abdulaziz University	28	1.25	0	6
Almatroudi, Ahmad	Qassim University	28	1.12	0	4
Khan, Mohd Shahnawaz	King Saud University	26	1.10	0	4
Alharbi, Metab	King Saud University	25	1.88	1	7
Ansari, Mushtaq A.	King Saud University	25	1.59	0	6
Kazmi, Imran	King Abdulaziz University	24	1.73	1	5
Saeed, Mohd	University Ha'il	23	0.92	0	2
Al-Dhabi, Naif Abdullah	King Saud University	22	1.57	1	5
Arasu, Mariadhas Valan	King Saud University	22	1.20	1	3
Kamal, Mohammad A.	King Abdulaziz University	22	0.59	0	0
Alhumaydhi, Fahad A.	Qassim University	22	1.58	0	8
Alshehri, Sultan	King Saud University	21	1.26	0	3
Allemailem, Khaled S.	Qassim University	21	1.06	0	2
Ansari, Mohammad Azam	Imam Abdulrahman Bin Faisal University	20	2.69	1	5

4.1.5.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (91,448 publications), followed by Mainland China (84,870 publications) and India (20,923 publications), as shown in Figure 68.

The highest citation impact measured by the CNCI is achieved by publications published by United Kingdom, Canada, and France with a CNCI of 1.77, 1.70 and 1.64, respectively.

Five of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, South Korea, and India.
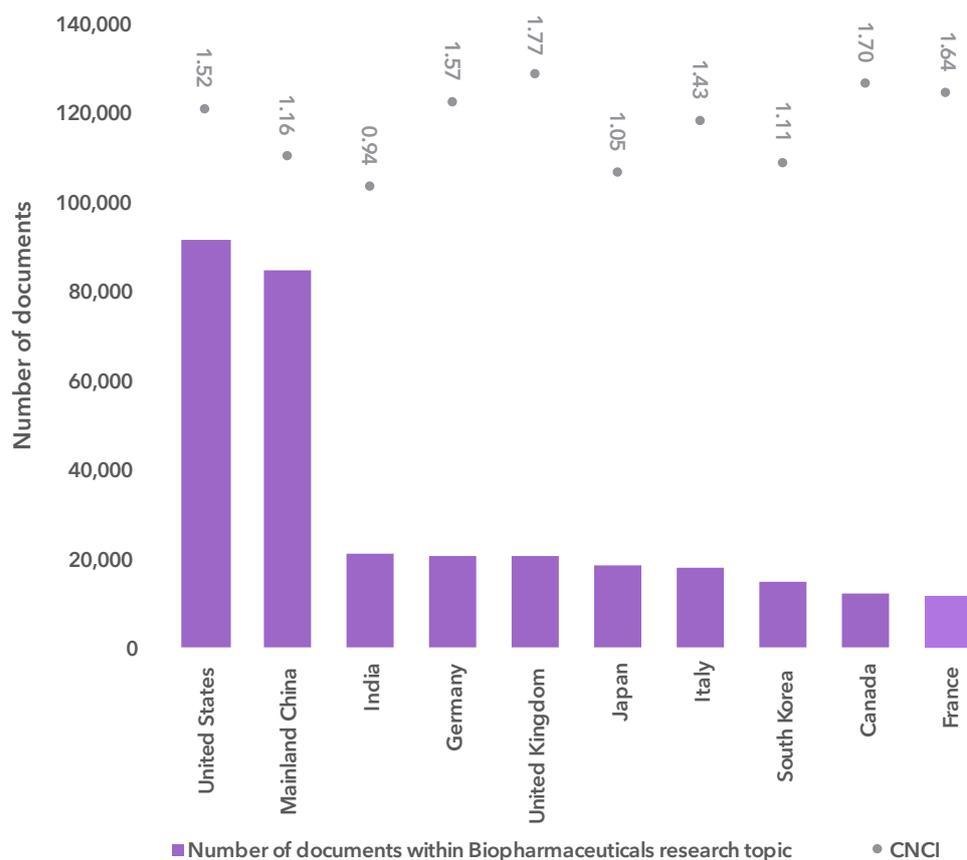
Figure 68: Top 10 countries in terms of number of publications in the research topic Biopharmaceuticals in the period 2014-2023 and their corresponding CNCI

4.1.5.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of the number of publications published on this research topic in the period 2014-2023 are Harvard University (6,928 publications) followed by the Chinese Academy of Sciences (6,185 publications) and Institut National de la Sante et de la Recherche Medicale (Inserm) (5,017 publications) as shown in Figure 69.

In terms of citation impact measured by the CNCI, Harvard University, followed by Harvard Medical School and the University of Pennsylvania, had the highest CNCI with 2.62, 2.57 and 2.45, respectively.
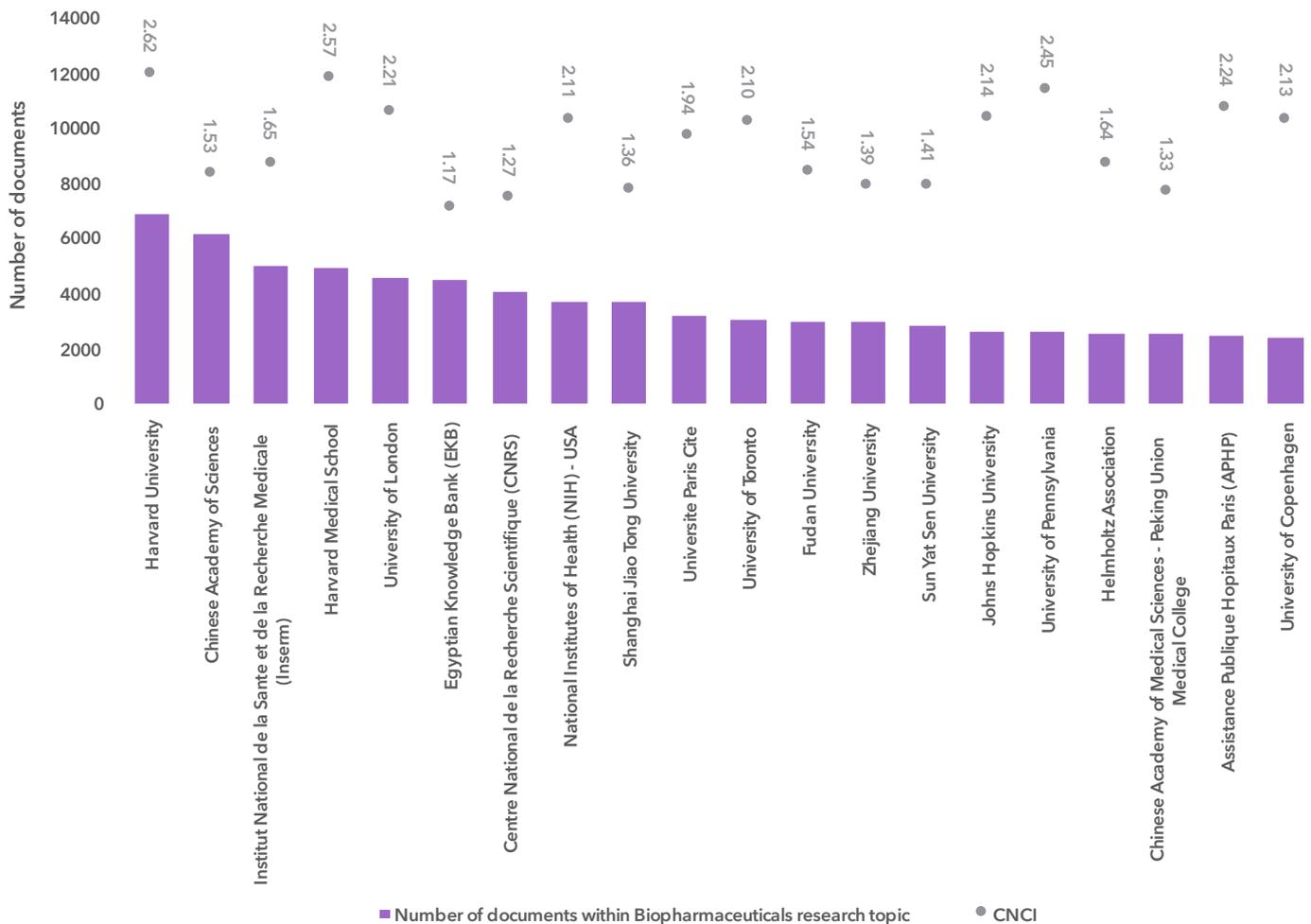
Figure 69: Top 20 organizations globally in terms of number of publications published in the research topic Biopharmaceuticals in the period 2014-2023 and their corresponding CNCI

4.1.5.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Laurent Peyrin-Biroulet, affiliated to CHU de Nancy, with 162 publications, followed by Anurag S. Rathore, affiliated to the Indian Institute of Technology System (IIT System), with 158 publications, and Amirhossein Sahebkar, affiliated to Mashhad University Medical Science with 136 publications as shown in Table 16.

The highest CNCI is achieved by William J. Sandborn, affiliated with the University of California San Diego, with a CNCI of 4.41.

The latter has also the highest number of Top 1% publications with 11 publications and the highest number of Top 10% publications with 41 publications.

Table 16: Top 20 researchers globally in terms of the number of publications published in the research topic Biopharmaceuticals in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Peyrin-Biroulet, Laurent	CHU de Nancy	162	3.08	8	40	France
Rathore, Anurag S.	Indian Institute of Technology System (IIT System)	158	0.72	1	10	India
Sahebkar, Amirhossein	Mashhad University Medical Science	136	1.28	0	22	Iran
Craik, David J.	University of Queensland	131	1.23	1	15	Australia
Curtis, Jeffrey R.	University of Alabama System	130	1.85	4	27	USA
Tanaka, Yoshiya	University of Occupational & Environmental Health - Japan	118	2.08	3	19	Japan
Feldman, Steven R.	Wake Forest University	107	0.99	2	13	United States
Reis, Rui L.	Universidade do Minho	107	1.52	4	24	Portugal
Sandborn, William J.	University of California San Diego	102	4.41	11	41	United States
Zengin, Gokhan	Selcuk University	100	1.31	2	18	Türkiye
Iannone, Florenzo	Universita degli Studi di Bari Aldo Moro	98	1.39	0	23	Italy
Kaplan, David L.	Tufts University	98	1.75	3	27	United States
Watts, Gerald F.	University of Western Australia	89	2.98	9	21	Australia
Villaverde, Antonio	Autonomous University of Barcelona	87	1.10	0	9	Spain
Wang, Hao	Chinese Academy of Sciences	85	1.59	0	21	Mainland China
Cantarini, Luca	University of Siena	85	1.40	0	20	Italy
Mease, Philip J.	University of Washington Seattle	84	3.46	9	35	United States
Zhang, Xian-Zheng	Wuhan University	82	2.68	4	40	Mainland China
Takeuchi, Tsutomu	Keio University	82	2.87	4	15	Japan
Efferth, Thomas	Johannes Gutenberg University of Mainz	81	1.49	1	20	Germany

4.1.5.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the National Natural Science Foundation of China (NSFC) with 46,081 publications, followed by the United States Department of Health & Human Services with 35,787 publications, and the National Institutes of Health (NIH) – USA with 35,387 publications as shown in Figure 70.

The highest citation impact measured by the CNCI is observed in publications funded by Medical Research Council UK (MRC), NIH National Cancer Institute (NCI) and UK Research & Innovation (UKRI) with 2.00, 1.95 and 1.77, respectively. Among the top 20 global funding organizations, 10 are also among the top 20 funding organizations of Saudi publications in this research topic.
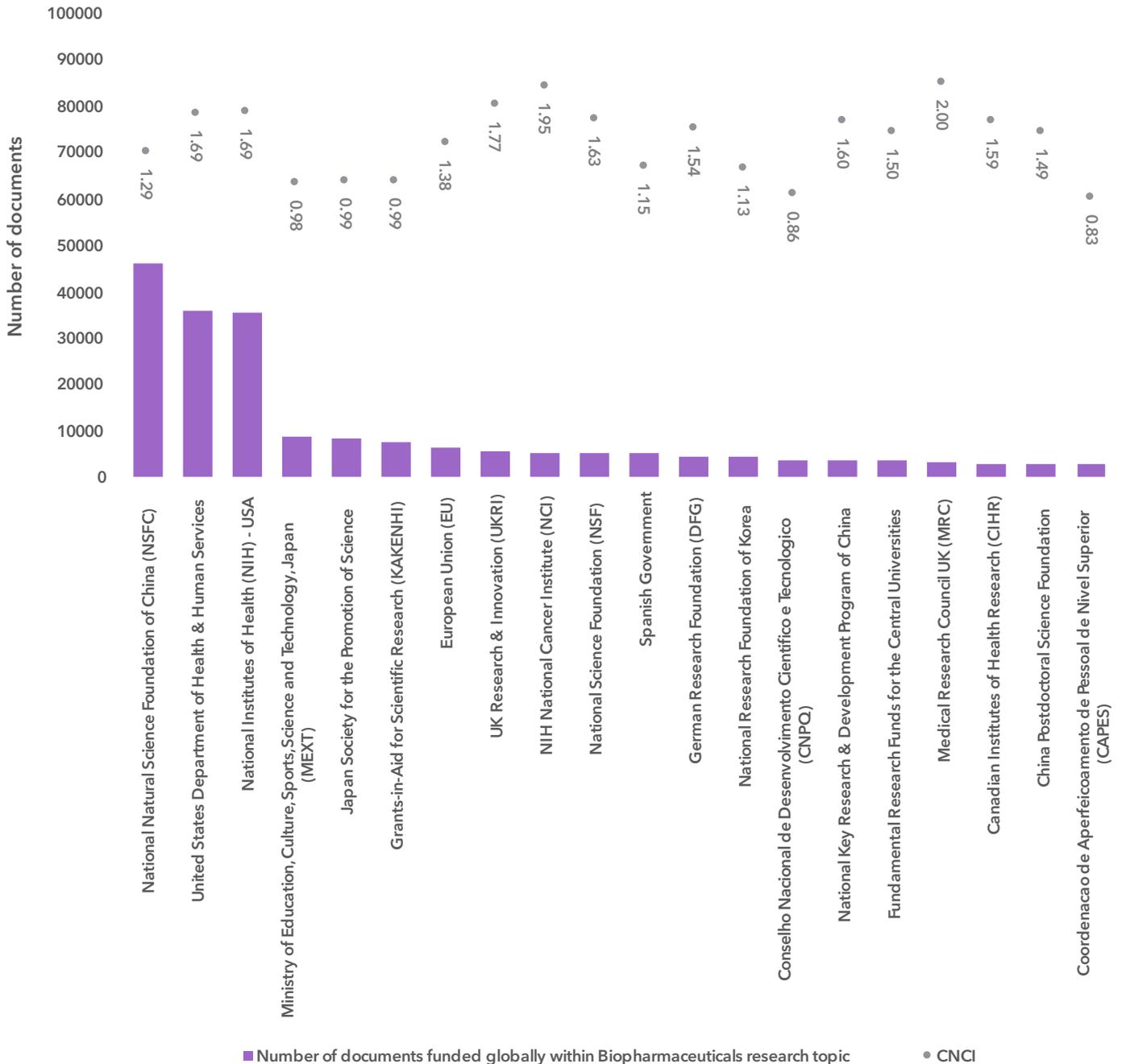
Figure 70: Top 20 funding organizations globally publications in the research topic Biopharmaceuticals in terms of number of publications in the period 2014-2023

4.1.5.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section we investigate the emerging trends globally and in Saudi Arabia in the research topic Biopharmaceuticals. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Virology - General: Coronavirus followed by Micro & Long Noncoding RNA: lncRNA and Cosmetic Surgery: Chronic Rhinosinusitis as shown in Figure 71. In Figure 72 The top 20 Saudi Arabia emerging micro-topics in this research topic are identified.

The top 3 emerging topics in Saudi Arabia are Polymers & Macromolecules: Gene Delivery followed by Nanofibers, Scaffolds & Fabrication: Electrospinning and Virology - Identification & Sequencing: Vaccinia Virus. Among Saudi Arabia top 20 emerging micro-topics there are two micro-topics that are also an emerging trend globally, which are Virology - General: Coronavirus and Statistical Methods: Order Statistics.

It is worth mentioning that the micro-topic Chromatography & Electrophoresis: Human Serum Albumin decreased within the total citations of Saudi Arabia publications on the research topic. Accordingly, one should monitor and assess the relevance of this topic locally and globally.
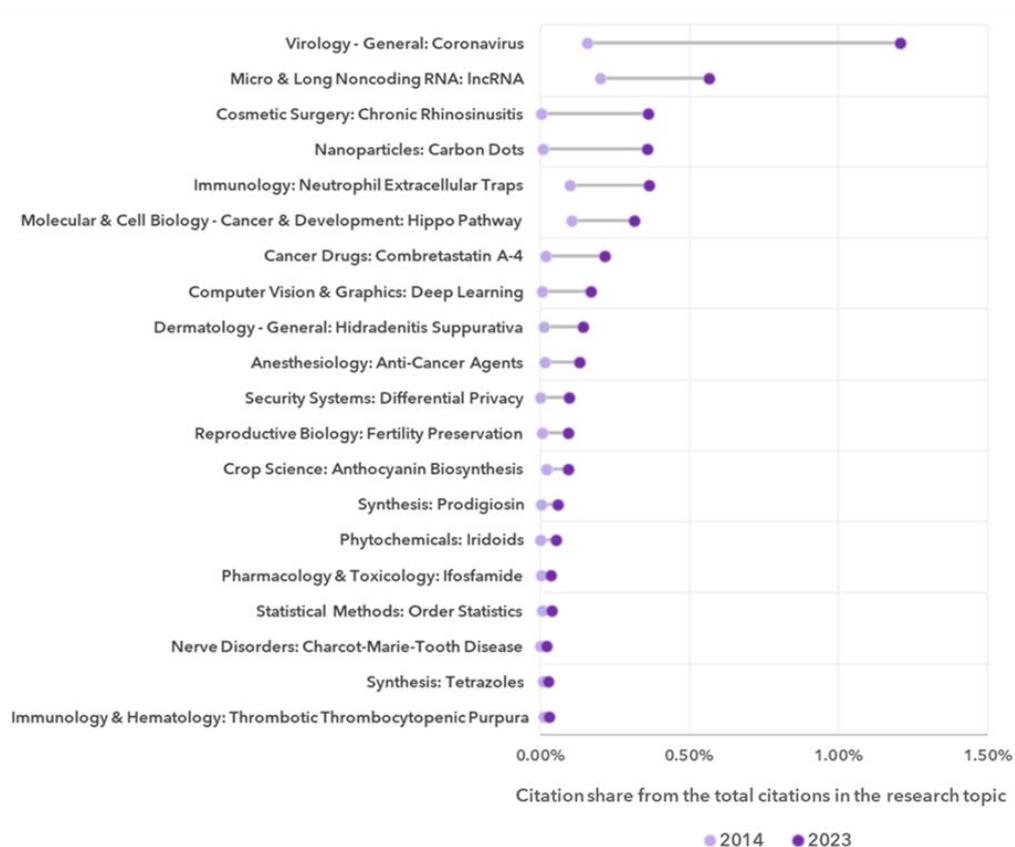
Figure 71: Top 20 emerging micro-topics globally in the research topic Biopharmaceuticals in the period 2014-2023
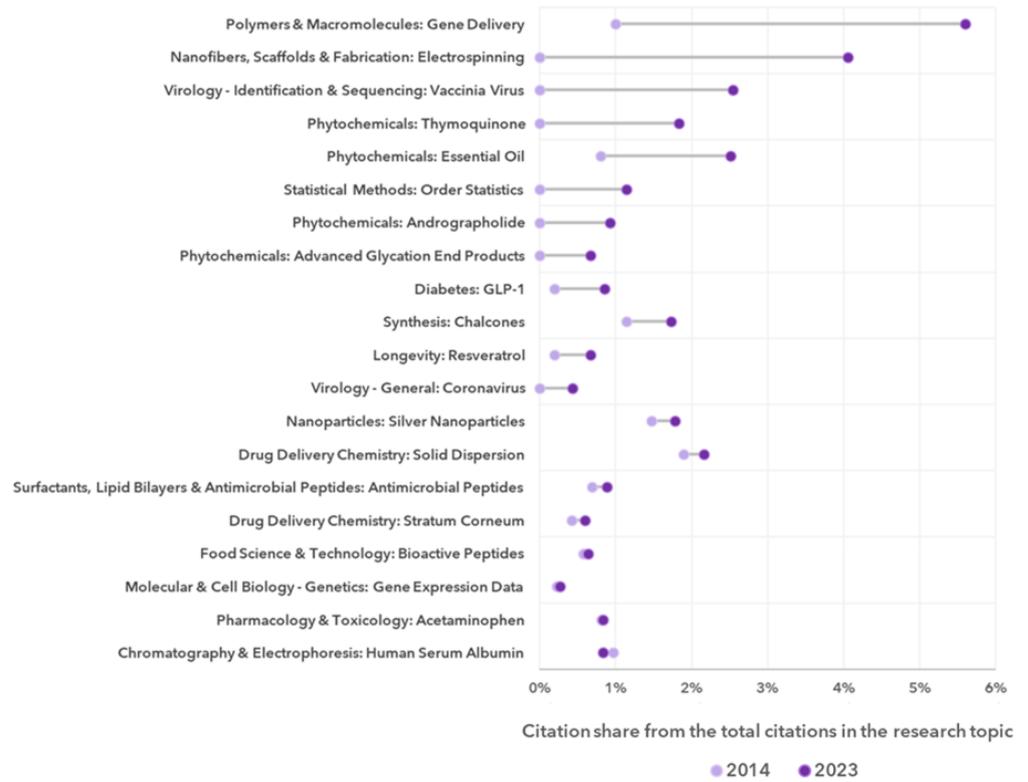
Figure 72: Top 20 emerging micro-topics in Saudi Arabia in the research topic Biopharmaceuticals in the period 2014-2023

4.1.6 Gene / RNA Therapy

4.1.6.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 73. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic was in almost all years higher than 1, indicating a citation impact performance higher than the global average.

The CNCI increased from 1.42 in 2014 to 1.94 in 2017 and then decreased to 0.89 in 2019 to then recover to 1.24 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a recovery in 2023.
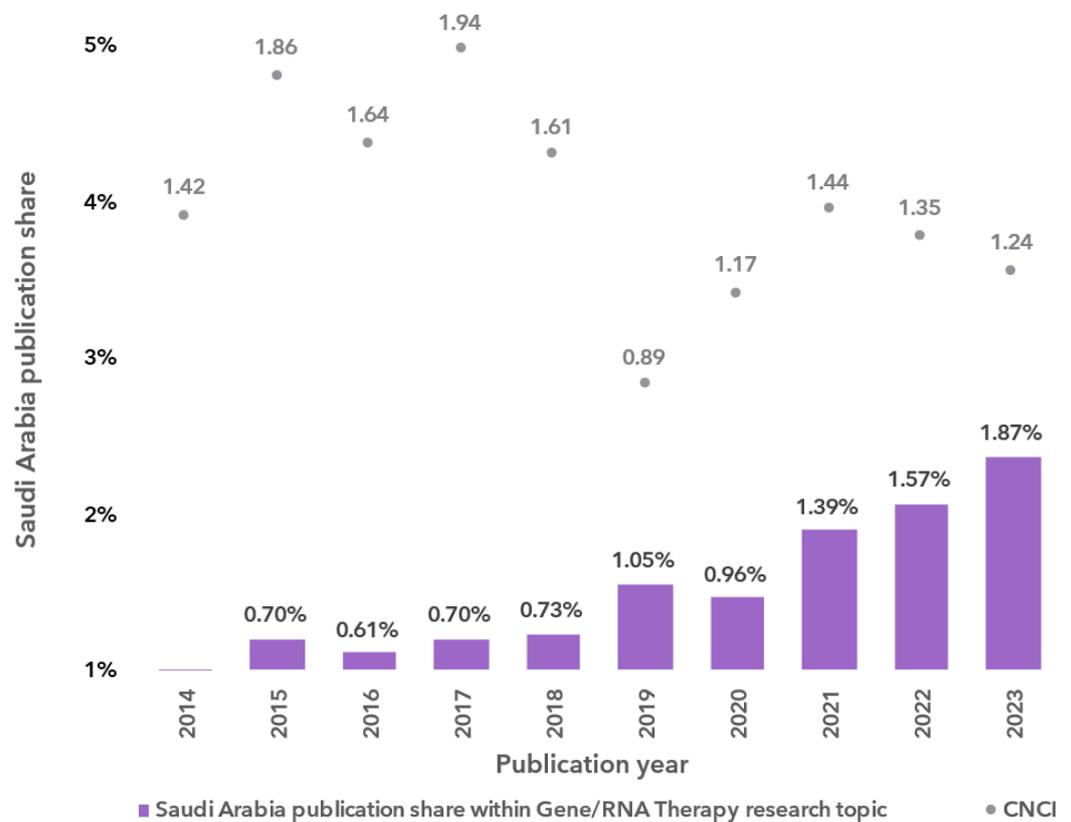

Figure 73: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.6.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is Egypt, followed by India and the United States with 290, 279 and 255 publications, respectively, as shown in Figure 74.

In terms of citation impact measured by the CNCI publications published in collaboration with United States followed by Canada and Australia had the highest CNCI with 2.48, 2.43 and 1.95, respectively. Nevertheless, all publications with the top

10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
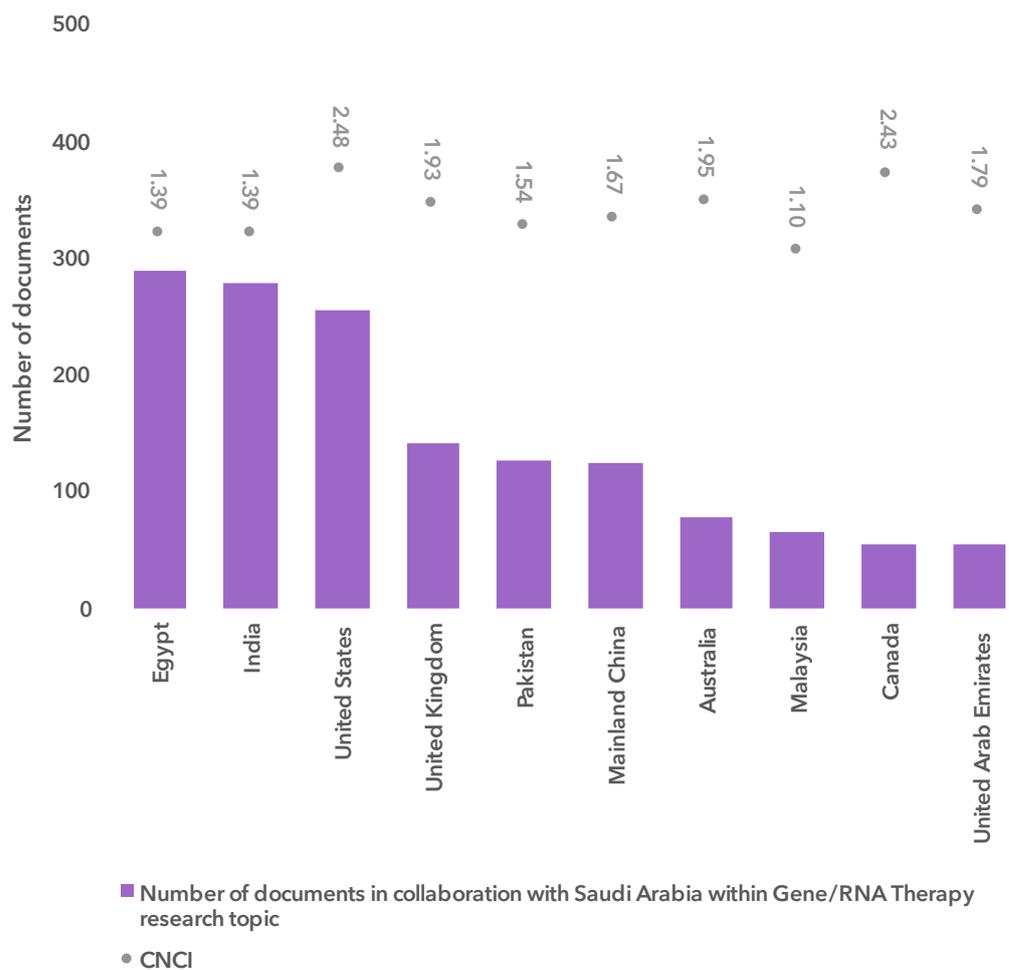

Figure 74: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Gene/ RNA Therapy in the period 2014-2023

4.1.6.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by the United States Department of Health & Human Services and the National Institutes of Health (NIH) – USA with the same number of publications and UK Research & Innovation (UKRI) with 161, 82 and 35 publications respectively as shown in Figure 75.

Publications funded by the United States Department of Defense, followed by the National Research Foundation of Korea and Wellcome Trust, had the highest citation impact measured by the CNCI with 10.46, 9.12 and 5.87, respectively.
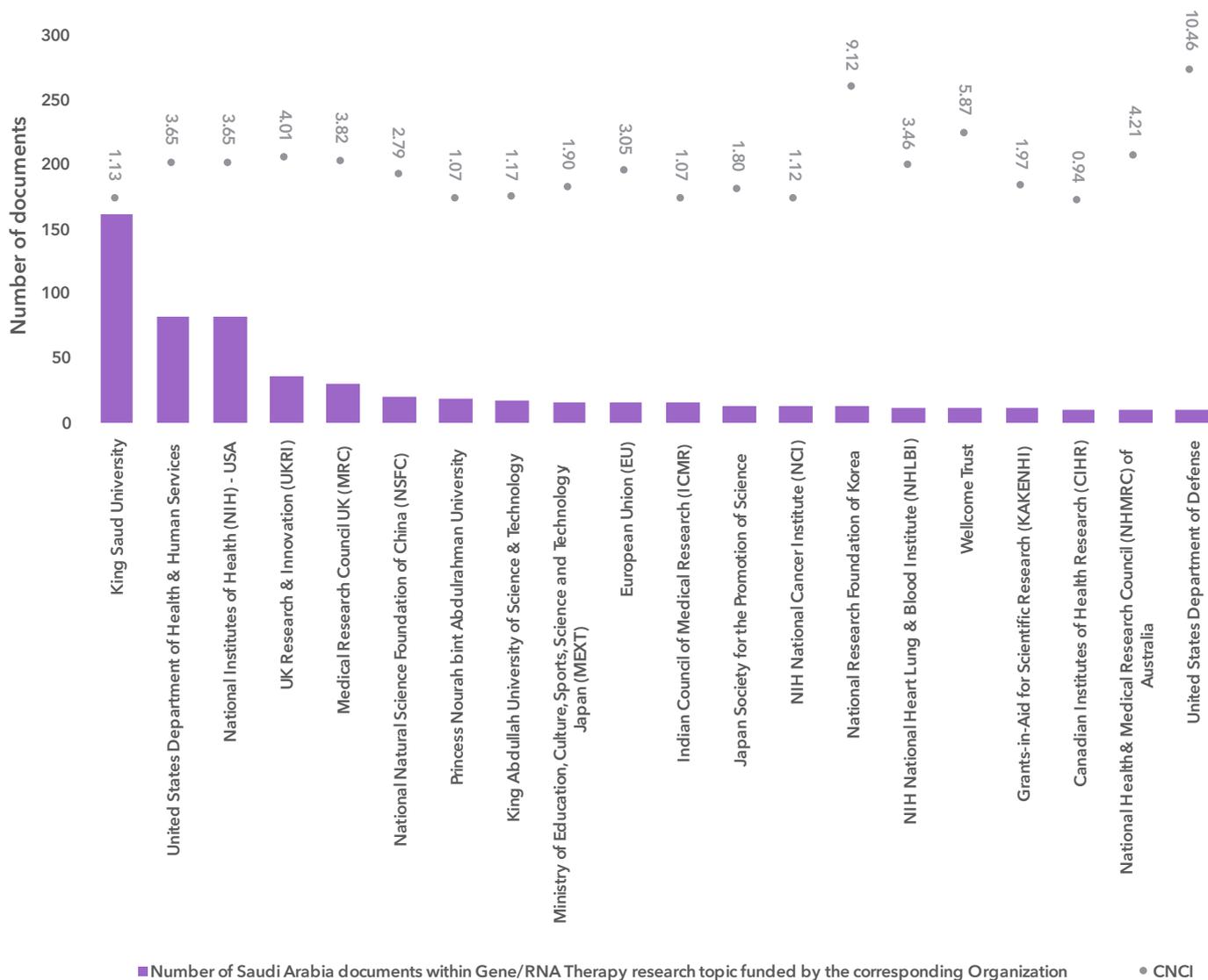
Figure 75: Top 20 funding organizations of Saudi Arabia publications in the research topic Gene/ RNA Therapy in terms of number of publications in the period 2014-2023

4.1.6.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University, followed by King Abdulaziz University and Umm Al Qura University, with 338, 291 and 86 publications, respectively, as shown in Figure 76.

In terms of citation impact as measured by the CNCI, King Abdulaziz University, followed by King Abdullah University of Science & Technology and Prince Sattam Bin Abdulaziz University, had the highest CNCI with 1.93, 1.84 and 1.80, respectively.

Nevertheless, all top 20 organizations, except the Ministry of National Guard - Health Affairs, Taif University, Princess Nourah bint Abdulrahman University and Taibah University, had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
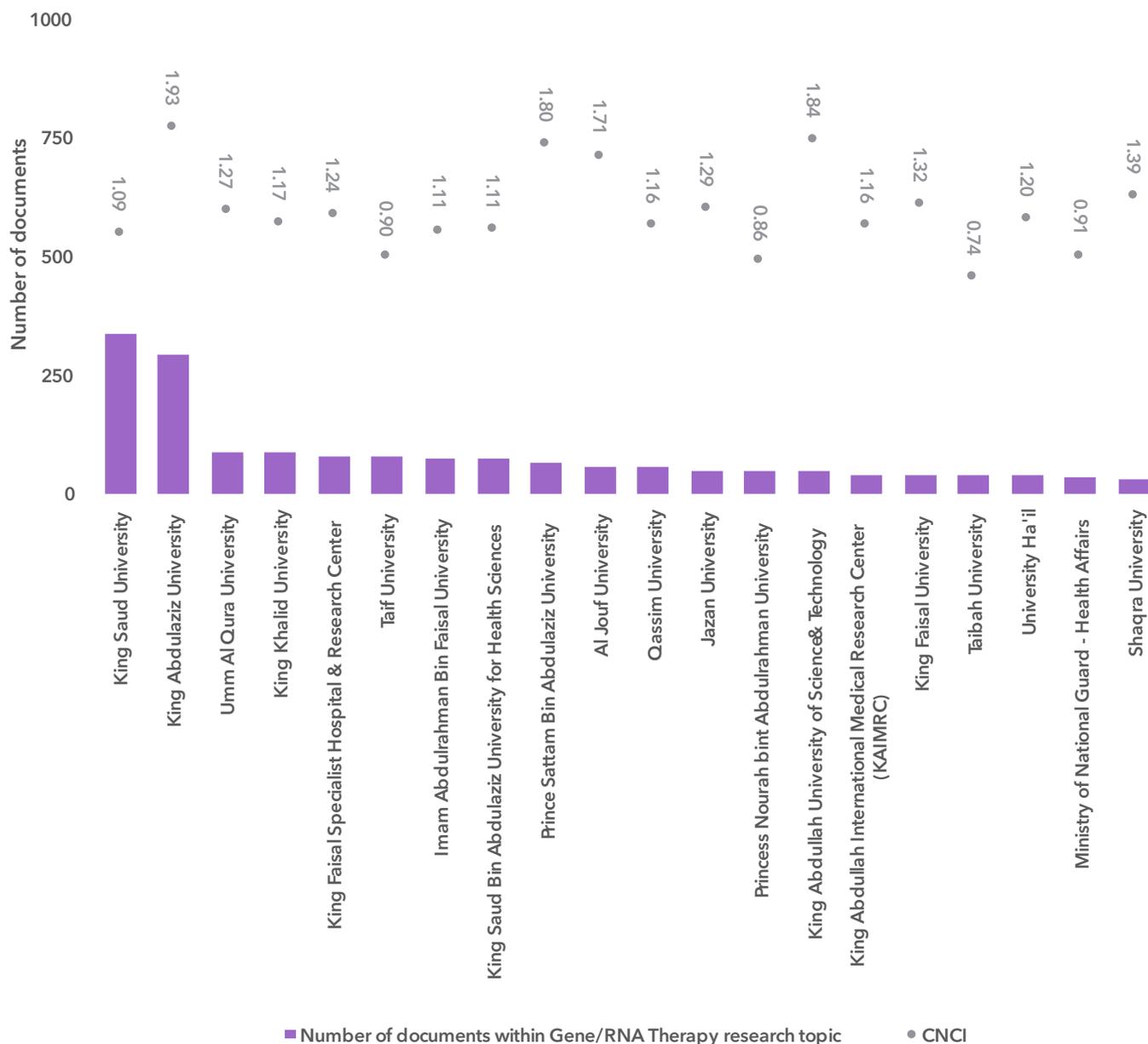
Figure 76: Top 20 Saudi organizations in terms of publications published in the research topic Gene/ RNA Therapy in the period 2014-2023 and their corresponding CNCI

4.1.6.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Mohammad Amjad Kamal, affiliated to King Abdulaziz University, with 19 publications, followed by Loutfy H. Madkour, affiliated to Al Baha University, and Shafiul Haque, affiliated to Jazan University, both with 12 publications, followed by Faheem Hyder Pottoo, affiliated to Imam Abdulrahman Bin Faisal University and Mostafa A. Abdel-Maksoud affiliated to King Saud University both with 11 publications as shown in Table 17.

The highest CNCI is achieved by Arnab Pain affiliated with King Abdullah University of Science & Technology with a CNCI of 2.00. Only two have a Top 1% document and these are Arnab Pain and Shafiul Haque.

Table 17: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Gene/ RNA Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Kamal, Mohammad Amjad	King Abdulaziz University	19	0.60	0	0
Madkour, Loutfy H.	Al Baha University	12	0.02	0	0
Haque, Shafiul	Jazan University	12	1.99	1	2
Pottoo, Faheem Hyder	Imam Abdulrahman Bin Faisal University	11	0.99	0	2
Abdel-Maksoud, Mostafa A.	King Saud University	11	0.51	0	1
Patil, Shankargouda	Jazan University	10	0.68	0	0
Alshatwi, Ali A.	King Saud University	9	0.88	0	1
Alfayez, Musaad	King Saud University	9	1.18	0	1
Aldahmash, Abdullah	King Saud University	7	1.27	0	1
Ahmad, Sheikh F.	King Saud University	7	0.68	0	0
Attia, Sabry M.	King Saud University	7	0.88	0	0
Alhakamy, Nabil A.	King Abdulaziz University	7	0.91	0	0
Soliman, Mohamed Mohamed	Taif University	7	1.12	0	1
Alsaikhan, Fahad	Prince Sattam Bin Abdulaziz University	7	1.67	0	2
Turki, Turki	King Abdulaziz University	7	0.32	0	0
Al-Quraishy, Saleh	King Saud University	7	1.08	0	1
Pain, Arnab	King Abdullah University of Science & Technology	6	2.00	1	1
Shahid, Imran	Umm Al Qura University	6	0.26	0	0
Chinnathambi, Arunachalam	King Saud University	6	1.74	0	2
Alghamdi, Mansour A.	King Khalid University	6	0.77	0	0

4.1.6.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by Mainland China (38,574 publications), followed by the United States (36,047 publications) and the United Kingdom (7,347 publications), as shown in Figure 77.

The highest citation impact measured by the CNCI is achieved by publications published by the United Kingdom, France, and Canada with a CNCI of 1.86, 1.76 and 1.70, respectively.

Five of the top 10 countries, in terms of the number of publications published on the research topic, are also among the top 10 collaborators with Saudi Arabia. These are the United States, Mainland China, the United Kingdom, Canada, and India.
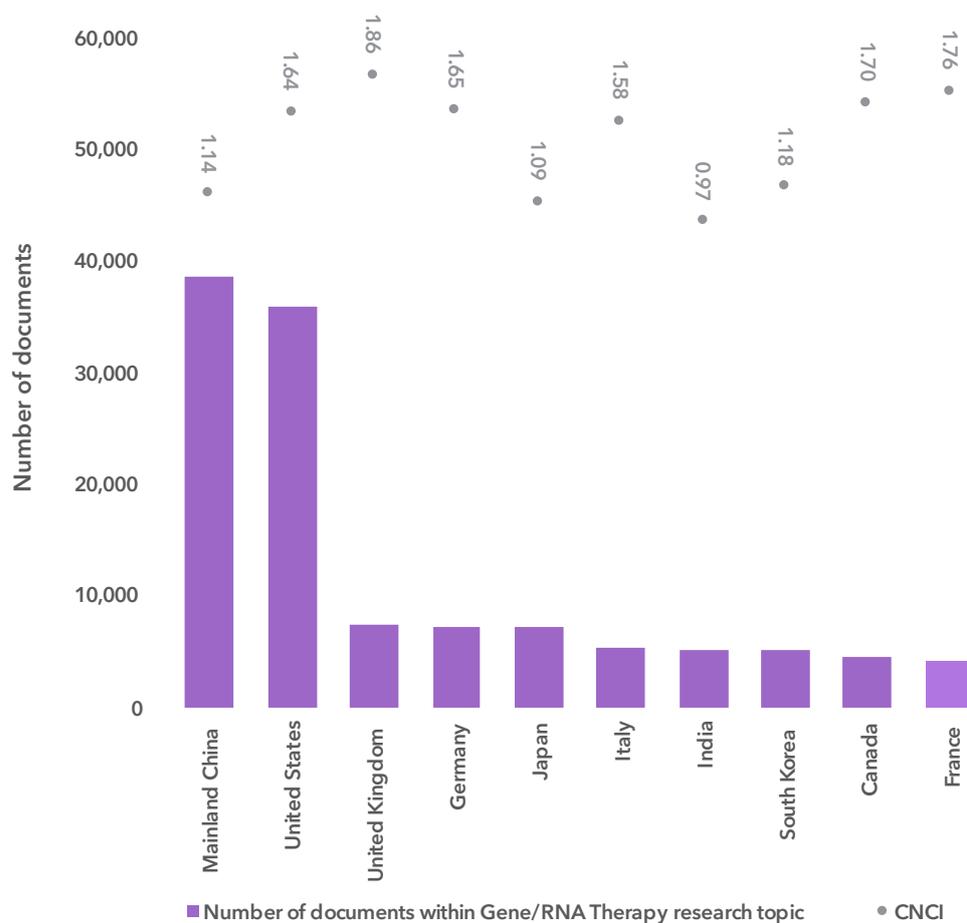
Figure 77: Top 10 countries in terms of the number of publications in the research topic Gene/ RNA Therapy in the period 2014-2023 and their corresponding CNCI

4.1.6.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are Harvard University (3,247 publications) followed by the Chinese Academy of Sciences (2,488 publications) and Harvard Medical School (2,454 publications) as shown in Figure 78.

In terms of citation impact measured by the CNCI, Harvard Medical School followed by Harvard University and University of Pennsylvania had the highest CNCI with 2.97, 2.92 and 2.76, respectively.
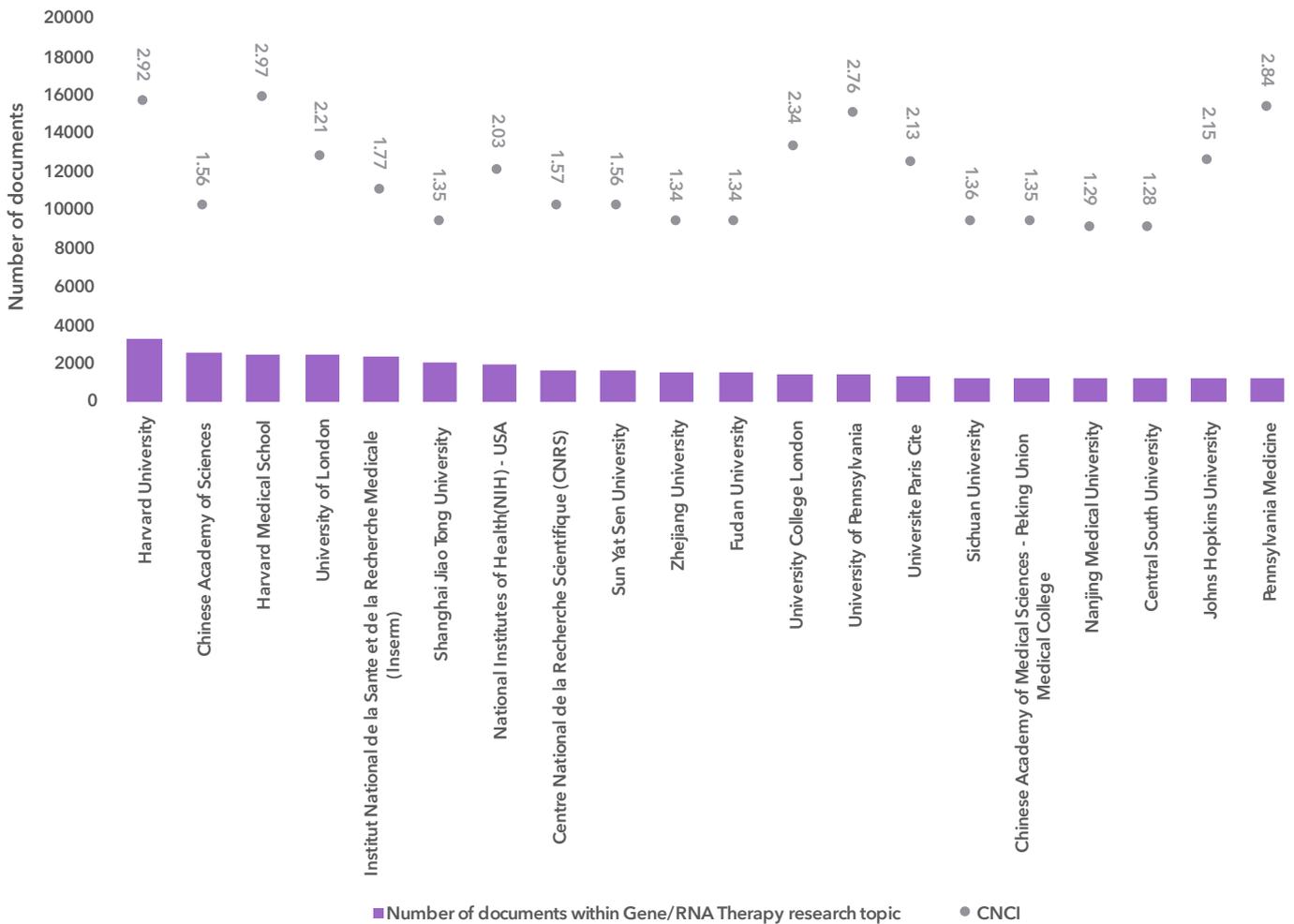
Figure 78: Top 20 organizations globally in terms of the number of publications published in the research topic Gene/ RNA Therapy in the period 2014-2023 and their corresponding CNCI

4.1.6.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications on this research topic are Behzad Baradaran, affiliated to Tabriz University of Medical Science, with 121 publications, followed by Guangping Gao, affiliated to the University of Leicester, with 104 publications, and Robert E. MacLaren, affiliated to the University of Oxford, with 102 publications as shown in Table 18.

The highest CNCI is achieved by Guangping Gao affiliated to University of Massachusetts System with a CNCI of 2.70. The latter has also the highest number of Top 10% publications with 41 publications. James M. Wilson affiliated with University of Pennsylvania has the highest number of Top 1% publications amounting to eight.

Table 18: Top 20 researchers globally in terms of the number of publications published in the research topic Gene/ RNA Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Baradaran, Behzad	Tabriz University of Medical Science	121	1.35	1	21	Iran
Gao, Guangping	University of Massachusetts System	104	2.70	6	41	United States
MacLaren, Robert E.	University of Oxford	102	1.73	4	20	England
Wilson, James M.	University of Pennsylvania	92	2.27	8	32	United States
Schambach, Axel	Hannover Medical School	87	1.34	1	15	Germany
Kohn, Donald B.	University of California Los Angeles	75	2.08	5	19	United States
Kiem, Hans-Peter	Fred Hutchinson Cancer Center	75	1.41	2	11	United States
Harashima, Hideyoshi	Hokkaido University	73	1.57	3	20	Japan
Thrasher, Adrian J.	University College London	72	2.18	4	19	England
Hauswirth, William W.	University of Florida	71	1.84	5	17	United States
Tsang, Stephen H.	Columbia University	70	1.26	0	12	United States
Yla-Herttuala, Seppo	University of Eastern Finland	69	1.05	1	8	Finland
Wagner, Ernst	University of Munich	68	1.00	0	6	Germany
Aiuti, Alessandro	San Raffaele Telethon Institute For Gene Therapy (Sr-Tiget)	67	2.10	3	22	Italy
Obika, Satoshi	Osaka University	64	0.95	1	5	Japan
Xu, Fu-Jian	Beijing University of Chemical Technology	62	1.50	0	16	Mainland China
Yokota, Toshifumi	University of Alberta	61	0.97	1	7	Canada
Sahebkar, Amirhossein	Mashhad University Medical Science	59	1.26	0	12	Iran
Cavazzana, Marina	Universite Paris Cite	59	2.13	3	20	France
Chen, Xuesi	Changchun Institute of Applied Chemistry, CAS	58	1.75	1	18	Mainland China

4.1.6.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the National Natural Science Foundation of China (NSFC) with 20,753 publications, followed by the United States Department of Health & Human Services with 17,126 publications, and National Institutes of Health (NIH) – USA with 16,986 publications as shown in Figure 79.

The highest citation impact measured by the CNCI is observed in publications funded by NIH National Cancer Institute (NCI), Medical Research Council UK (MRC) and UK Research & Innovation (UKRI) with 2.09, 2.05 and 1.91, respectively. Among the top 20 global funding organizations, 13 are also among the top 20 funding organizations of Saudi publications in this research topic.
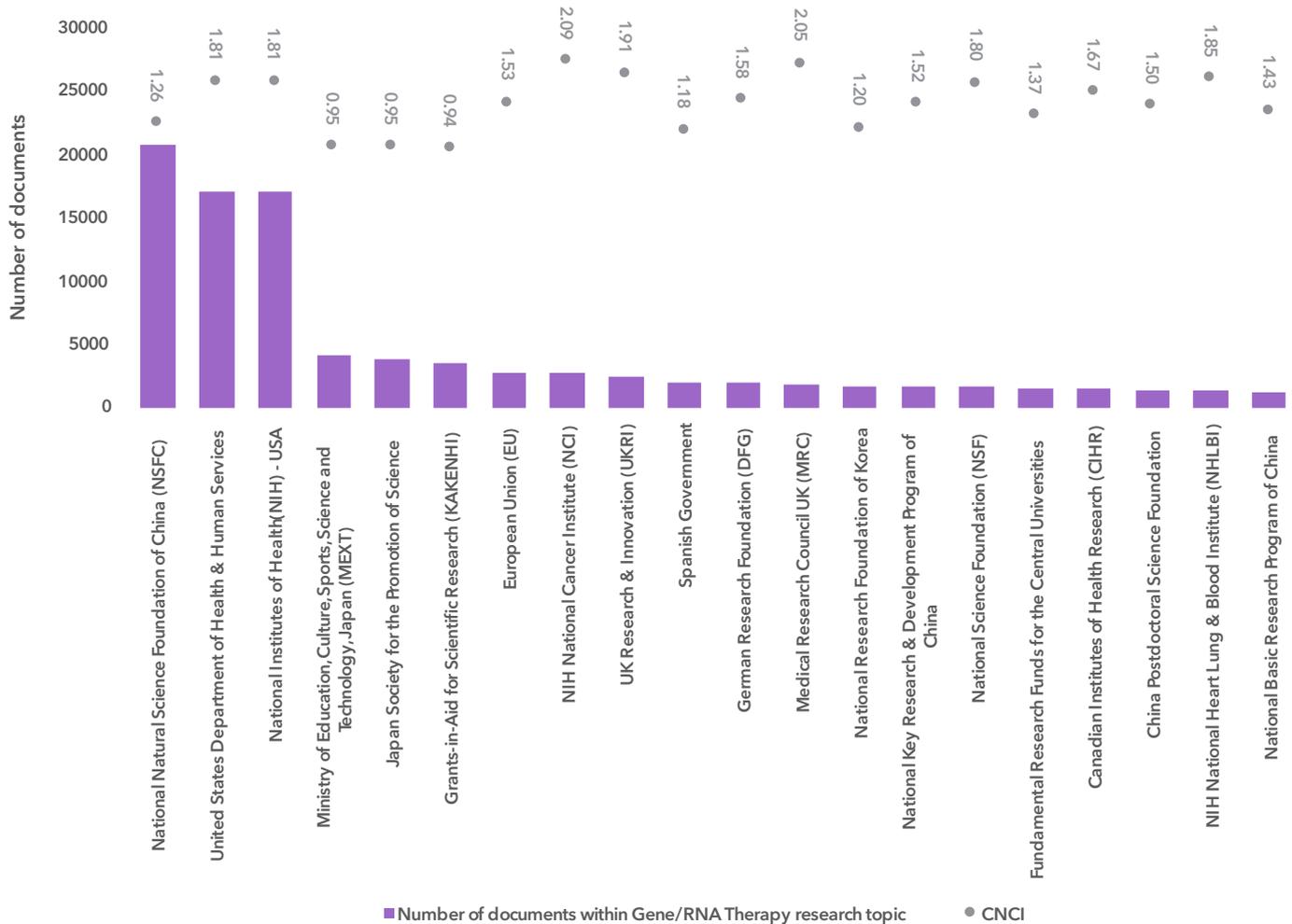
Figure 79: Top 20 funding organizations globally publications in the research topic Gene/ RNA Therapy in terms of number of publications in the period 2014-2023

4.1.6.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Gene/ RNA Therapy. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.
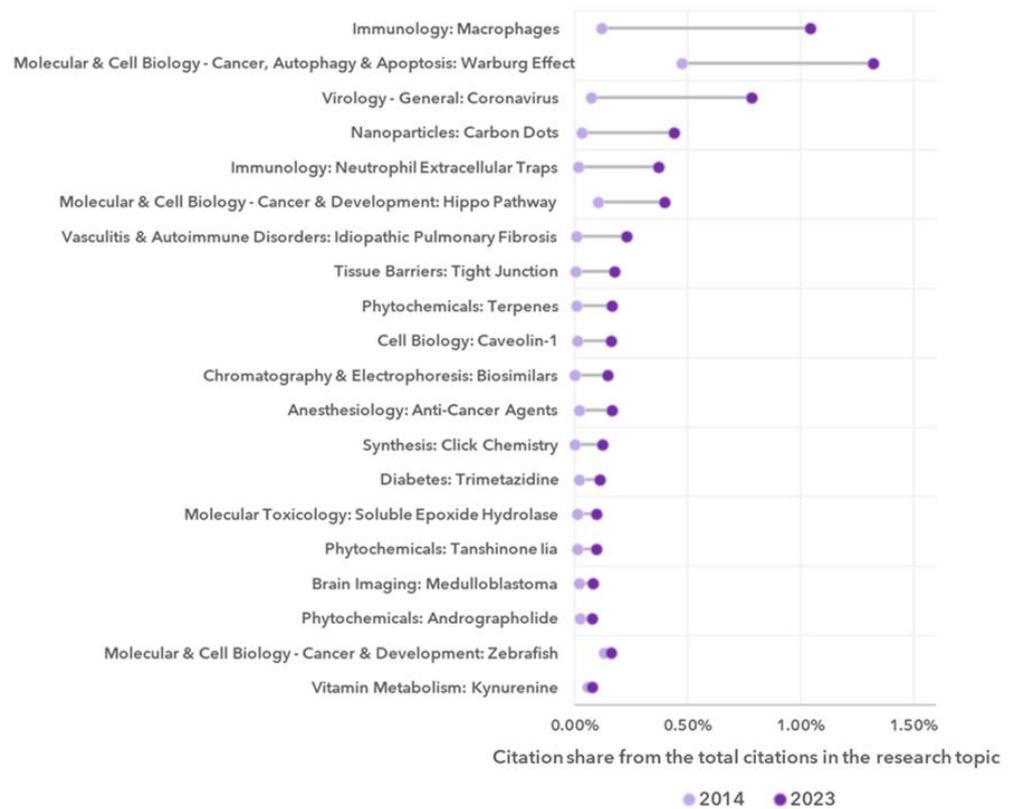
Figure 80: Top 20 emerging micro-topics globally in the research topic Gene/ RNA Therapy in the period 2014-2023

The top 3 emerging micro-topics globally in this research topic are Immunology: Macrophages followed by Molecular & Cell Biology - Cancer, Autophagy & Apoptosis: Warburg Effect and Virology - General: Coronavirus as shown in Figure 80.

In Figure 81 the top 20 Saudi Arabia emerging micro-topics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Micro & Long Noncoding RNA: lncRNA followed by Micro & Long Noncoding: RNA Exosomes and Virology - Identification & Sequencing: Adenovirus.

Among Saudi Arabia's top 20 emerging micro-topics, there is one micro-topic that is also an emerging trend globally: Phytochemicals: Terpenes. It is worth mentioning that the micro-topics Molecular & Cell Biology: Genetics - Gene Expression Data, Blood Disorders: Acute Myeloid Leukemia and Molecular & Cell Biology: DNA Damage - DSBs decreased within the total citations of Saudi Arabia publications in the research topic. Accordingly, one should monitor and assess the relevance of these topics locally and globally.
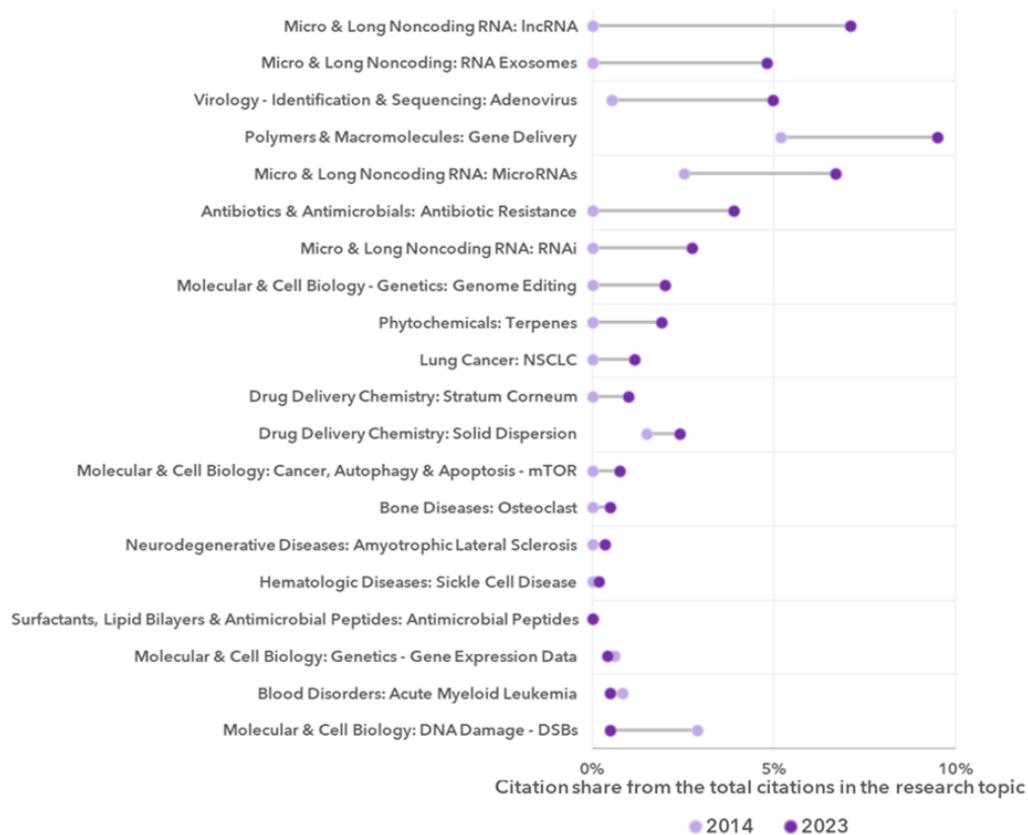
Figure 81: Top 20 emerging micro-topics in Saudi Arabia in the research topic Gene/ RNA Therapy in the period 2014-2023

4.1.7 Genomics

4.1.7.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased continuously from 2014 till 2023, as shown in Figure 82. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabia publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic was in several years lower than 1, indicating a citation impact performance lower than the global average.

The CNCI increased from 1.45 in 2014 to 2.33 in 2015 and then decreased to 0.61 in 2020, then slightly recovered to 0.97 in 2023. In a high publication period, it is usually observed that the citation impact decreases, as also observed in this case.

Overall, Saudi Arabia publications increased with a higher growth rate than the global average in this research topic but had a relatively low citation impact as measured by the CNCI.

Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a slight recovery in 2023.
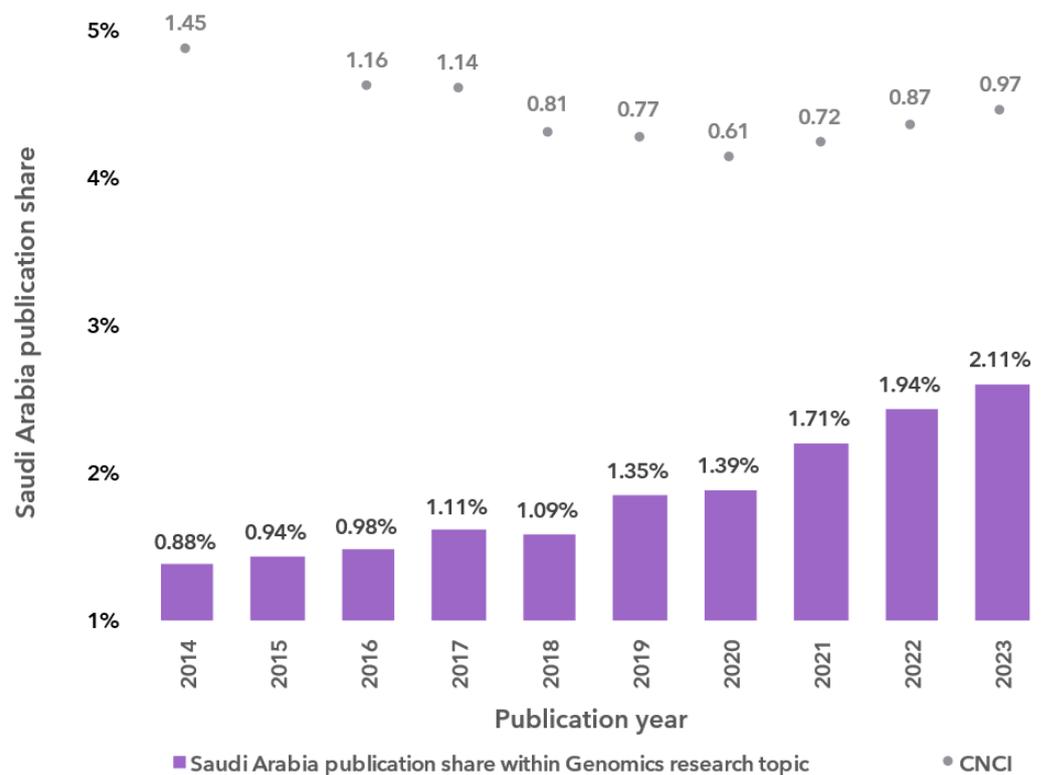

Figure 82: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.7.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating countries with Saudi Arabia in this research topic in the period 2014-2023 are the United States followed by Egypt and India with 647, 491 and 385 publications, respectively as shown in Figure 83.

In terms of citation impact measured by the CNCI publications published in collaboration with France, Mainland China and Australia had the highest CNCI with 4.14, 3.77 and 3.45, respectively. Nevertheless, all publications with the top 10

collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
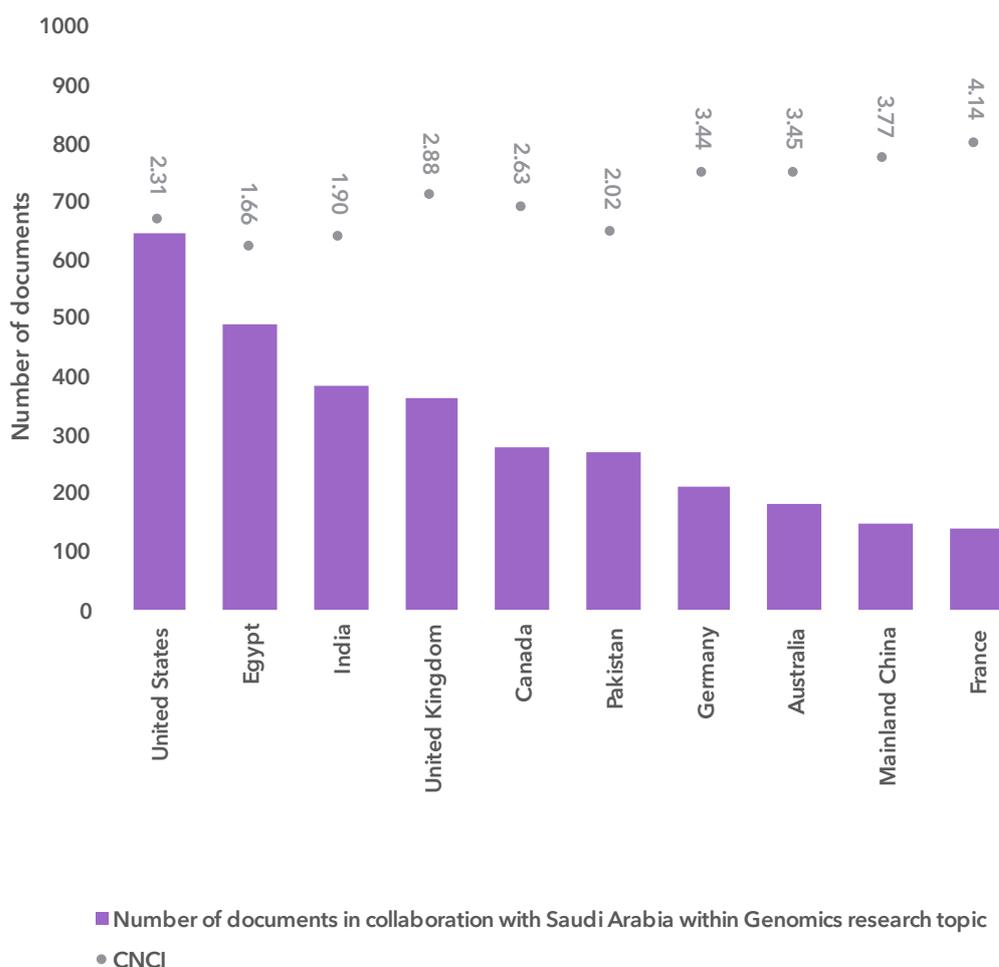

Figure 83: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Genomics in the period 2014-2023

4.1.7.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are the United States Department of Health & Human Services followed by the National Institutes of Health (NIH) – USA and King Saud University with 209, 208 and 171 publications respectively as shown in Figure 84.

Publications funded by Grants-in-Aid for Scientific Research (KAKENHI) followed by Japan Society for the Promotion of Science and Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) had the highest citation impact measured by the CNCI with 10.89, 9.75 and 9.31, respectively.
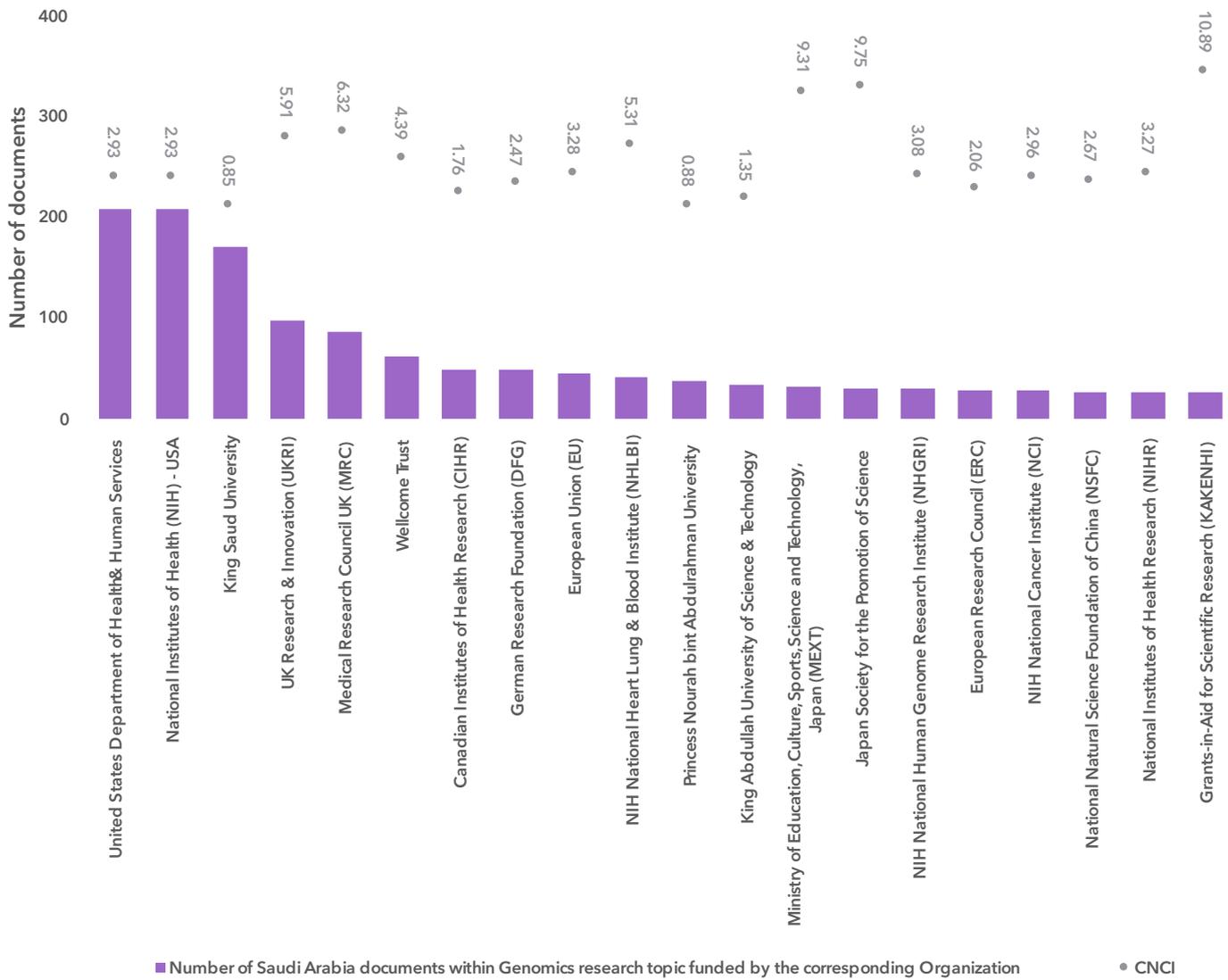
The chart shows CNCI values as points above each bar:
- United States Department of Health & Human Services: 2.93
- National Institutes of Health (NIH) - USA: 2.93
- King Saud University: 0.85
- UK Research & Innovation (UKRI): 5.91
- Medical Research Council UK (MRC): 6.32
- Wellcome Trust: 4.39
- Canadian Institutes of Health Research (CIHR): 1.76
- German Research Foundation (DFG): 2.47
- European Union (EU): 3.28
- NIH National Heart Lung & Blood Institute (NHLBI): 5.31
- Princess Nourah bint Abdulrahman University: 0.88
- King Abdullah University of Science & Technology: 1.35
- Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT): 9.31
- Japan Society for the Promotion of Science: 9.75
- NIH National Human Genome Research Institute (NHGRI): 3.08
- European Research Council (ERC): 2.06
- NIH National Cancer Institute (NCI): 2.96
- National Natural Science Foundation of China (NSFC): 2.67
- National Institutes of Health Research (NIHR): 3.27
- Grants-in-Aid for Scientific Research (KAKENHI): 10.89

■ Number of Saudi Arabia documents within Genomics research topic funded by the corresponding Organization   ● CNCI

Figure 84: Top 20 funding organizations of Saudi Arabia publications in the research topic Genomics in terms of number of publications in the period 2014-2023

4.1.7.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published on this research topic and in the period 2014-2023 are King Saud University, followed by King Abdulaziz University and King Faisal Specialist Hospital & Research Center, with 701, 699 and 564 publications, respectively as shown in Figure 85.

In terms of citation impact as measured by the CNCI, King Abdulaziz Medical City - Riyadh followed by King Fahad Medical City and Ministry of National Guard - Health Affairs had the highest CNCI with 2.91, 2.31 and 1.87, respectively. 11 out of the top 20 organizations had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
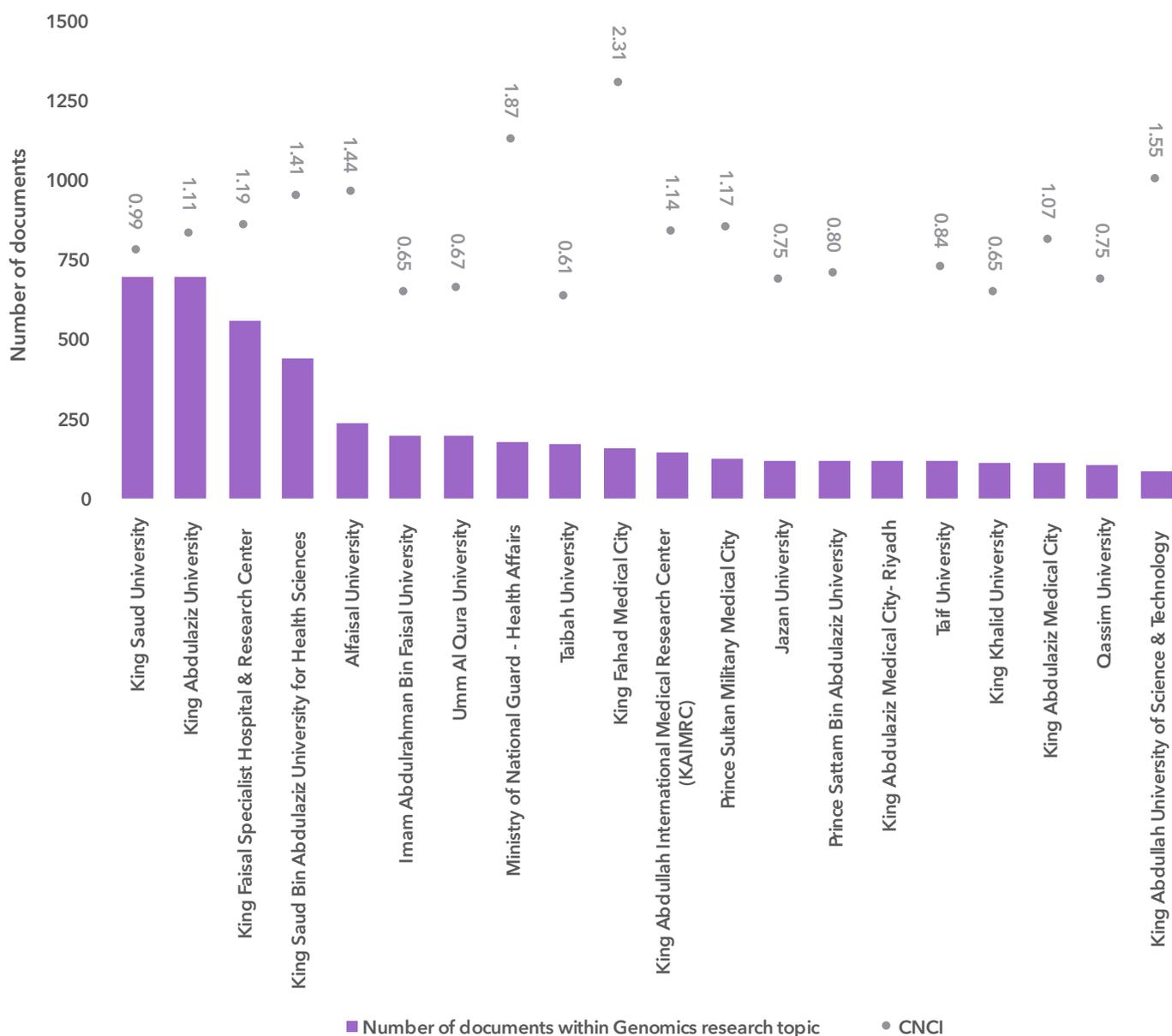
Figure 85: Top 20 Saudi organizations in terms of publications published in the research topic Genomics in the period 2014-2023 and their corresponding CNCI

4.1.7.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Fowzan S. Alkuraya, affiliated to King Faisal Specialist Hospital & Research Center, followed by Majid Alfadhel, affiliated to King Saud Bin Abdulaziz University for Health Sciences, and Sulman Basit, affiliated to Taibah University, with the same number of publications as Muhammad Naseer Imran affiliated to King Abdulaziz University with 102, 66 and 38 publications respectively as shown in Table 19. The highest CNCI is achieved by Mohamed Abouelhoda, affiliated with King Faisal Specialist Hospital & Research Center, with a CNCI of 2.43. The highest number of Top 1% and Top 10% publications is achieved by Fowzan S. Alkuraya, with two Top 1% publications and 40 Top 10% publications.

Table 19: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published in the research topic Genomics in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Alkuraya, Fowzan S.	King Faisal Specialist Hospital & Research Center	102	2.06	2	40
Alfadhel, Majid	King Saud Bin Abdulaziz University for Health Sciences	66	1.35	1	13
Basit, Sulman	Taibah University	38	0.67	0	1
Naseer, Muhammad Imran	King Abdulaziz University	38	0.68	0	2
Ramzan, Khushnooda	King Faisal Specialist Hospital & Research Center	35	0.85	0	3
Umair, Muhammad	King Saud Bin Abdulaziz University for Health Sciences	32	1.90	1	3
Banaganapalli, Babajan	King Abdulaziz University	30	0.70	0	0
Monies, Dorota	King Faisal Specialist Hospital & Research Center	29	2.08	1	12
Shaheen, Ranad	King Faisal Specialist Hospital & Research Center	28	2.26	0	12
Shaik, Noor Ahmad	King Abdulaziz University	27	0.57	0	0
Meyer, Brian F.	King Faisal Specialist Hospital & Research Center	26	1.85	1	7
Salih, Mustafa A.	King Saud University	26	1.68	0	7
Faqeih, Eissa	King Fahad Medical City	25	1.93	0	9
Elango, Ramu	King Abdulaziz University	24	0.71	0	0
Hashem, Mais	King Faisal Specialist Hospital & Research Center	24	2.26	0	12
Rasool, Mahmood	King Abdulaziz University	24	0.71	0	2
Imtiaz, Faiqa	King Faisal Specialist Hospital & Research Center	23	0.78	0	2
Alhashem, Amal	Prince Sultan Military Medical City	22	2.30	1	8
Abouelhoda, Mohamed	King Faisal Specialist Hospital & Research Center	22	2.43	0	11
Al-Owain, Mohammed	King Faisal Specialist Hospital & Research Center	21	2.21	0	10

4.1.7.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (84,469 publications), followed by Mainland China (35,112 publications) and the United Kingdom (23,346 publications), as shown in Figure 86.

The highest citation impact measured by the CNCI is achieved by publications published by Australia, United Kingdom, and Canada with a CNCI of 1.87, 1.84 and 1.78, respectively.

Seven of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Germany, France, Canada, and Australia.
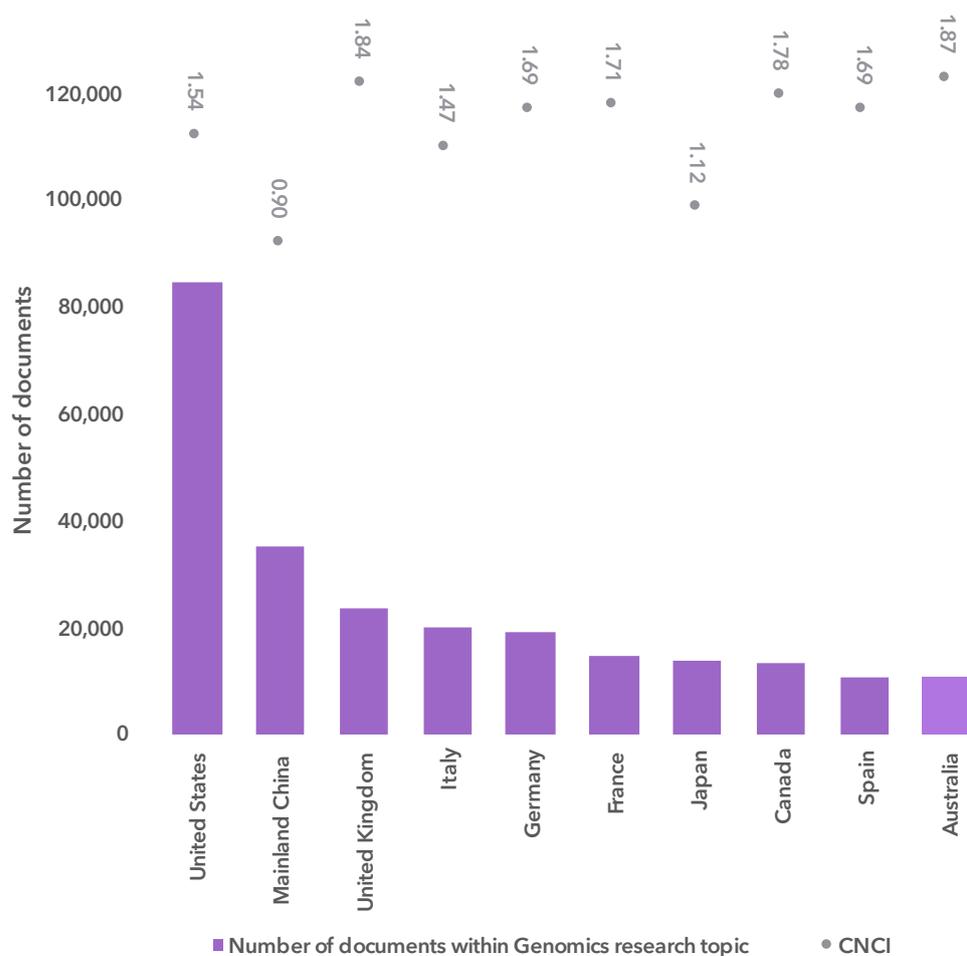
Figure 86: Top 10 countries in terms of number of publications in the research topic Genomics in the period 2014-2023 and their corresponding CNCI

4.1.7.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of the number of publications published in this research topic in the period 2014-2023 are Harvard University (9,294 publications) followed by Institut National de la Sante et de la Recherche Medicale (Inserm) (7,915 publications) and University of London (7,565 publications) as shown in Figure 87.

In terms of citation impact measured by the CNCI, Massachusetts General Hospital, followed by Harvard Medical School and Harvard University, had the highest CNCI with 3.34, 2.93 and 2.88, respectively.
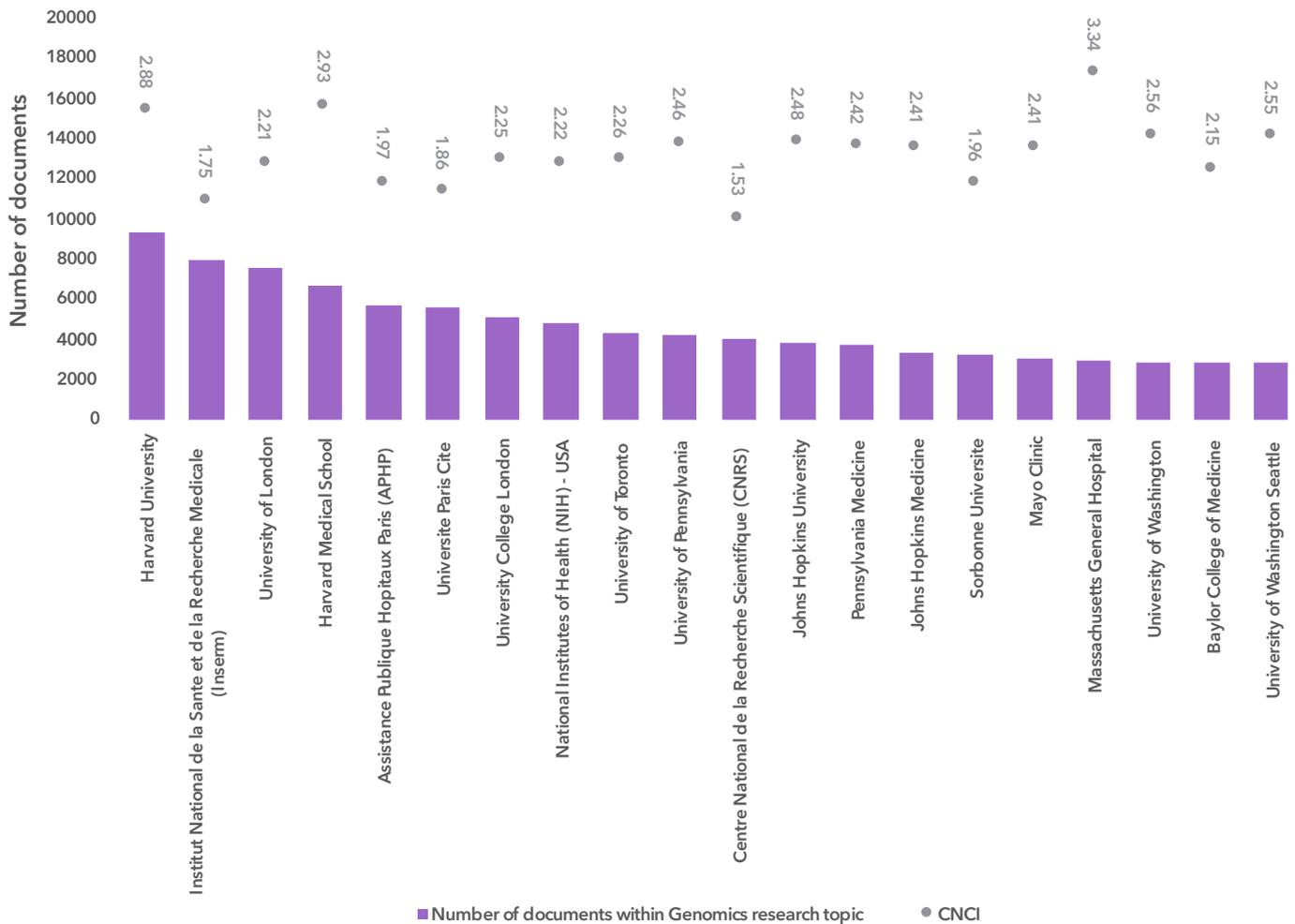
Figure 87: Top 20 organizations globally in terms of number of publications published in the research topic Genomics in the period 2014-2023 and their corresponding CNCI

4.1.7.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Francesco Muntoni, affiliated with University College London, with 201 publications, followed by Eugenio Mercuri, affiliated to Catholic University of the Sacred Heart, with 182 publications, and Jeffrey S. Ross, affiliated to Foundation Medicine with 174 publications as shown in Table 20.

The highest CNCI is achieved by Vincent A. Miller affiliated to Foundation Medicine. Eugenio Mercuri affiliated to Catholic University of the Sacred Heart has the highest number of Top 1% publications with 17 publications and the highest number of Top 10% publications with 82 publications.

Table 20: Top 20 researchers globally in terms of the number of publications published in the research topic Genomics in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Muntoni, Francesco	University College London	201	2.58	15	74	England
Mercuri, Eugenio	Catholic University of the Sacred Heart	182	3.33	17	82	Italy
Ross, Jeffrey S.	Foundation Medicine	174	3.18	13	76	United States
Lupski, James R.	Baylor College of Medicine	151	2.16	3	50	United States
Houlden, Henry	University of London	151	1.87	6	36	England
Boyd, Roslyn N.	University of Queensland	146	1.61	4	23	Australia
Matsumoto, Naomichi	Yokohama City University	143	1.10	0	20	Japan
Chung, Wendy K.	Columbia University	140	2.97	9	59	United States
Tabrizi, Sarah J.	University College London	139	2.59	8	41	England
Ratjen, Felix	University of Toronto	138	2.34	9	41	Canada
Watts, Gerald F.	University of Western Australia	134	3.26	11	37	Australia
Oldenburg, Johannes	University of Bonn	128	1.78	7	21	Germany
Rowe, Steven M.	University of Alabama System	128	3.42	13	49	United States
Bertini, Enrico	IRCCS Bambino Gesu	127	1.76	2	36	Italy
Torres, Vicente E.	Mayo Clinic	126	3.07	11	49	United States
Harris, Peter C.	Mayo Clinic	119	2.96	9	48	United States
Miller, Vincent A.	Foundation Medicine	117	4.12	15	60	United States
Medeiros, L. Jeffrey	UTMD Anderson Cancer Center	115	2.36	4	21	United States
Ogawa, Seishi	Kyoto University	115	2.32	6	37	Japan
Sahin, Mustafa	Harvard University	112	1.93	3	35	United States

4.1.7.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 34,994 publications followed by the National Institutes of Health (NIH) – USA with 34,410 publications, and National Natural Science Foundation of China (NSFC) with 16,386 publications as shown in Figure 88.

The highest citation impact measured by the CNCI is observed in publications funded by the Medical Research Council UK (MRC), UK Research & Innovation (UKRI) and NIH National Cancer Institute (NCI) with 2.52, 2.39 and 2.35, respectively. Among the top 20 global funding organizations, 15 are also among the top 20 funding organizations of Saudi publications in this research topic.
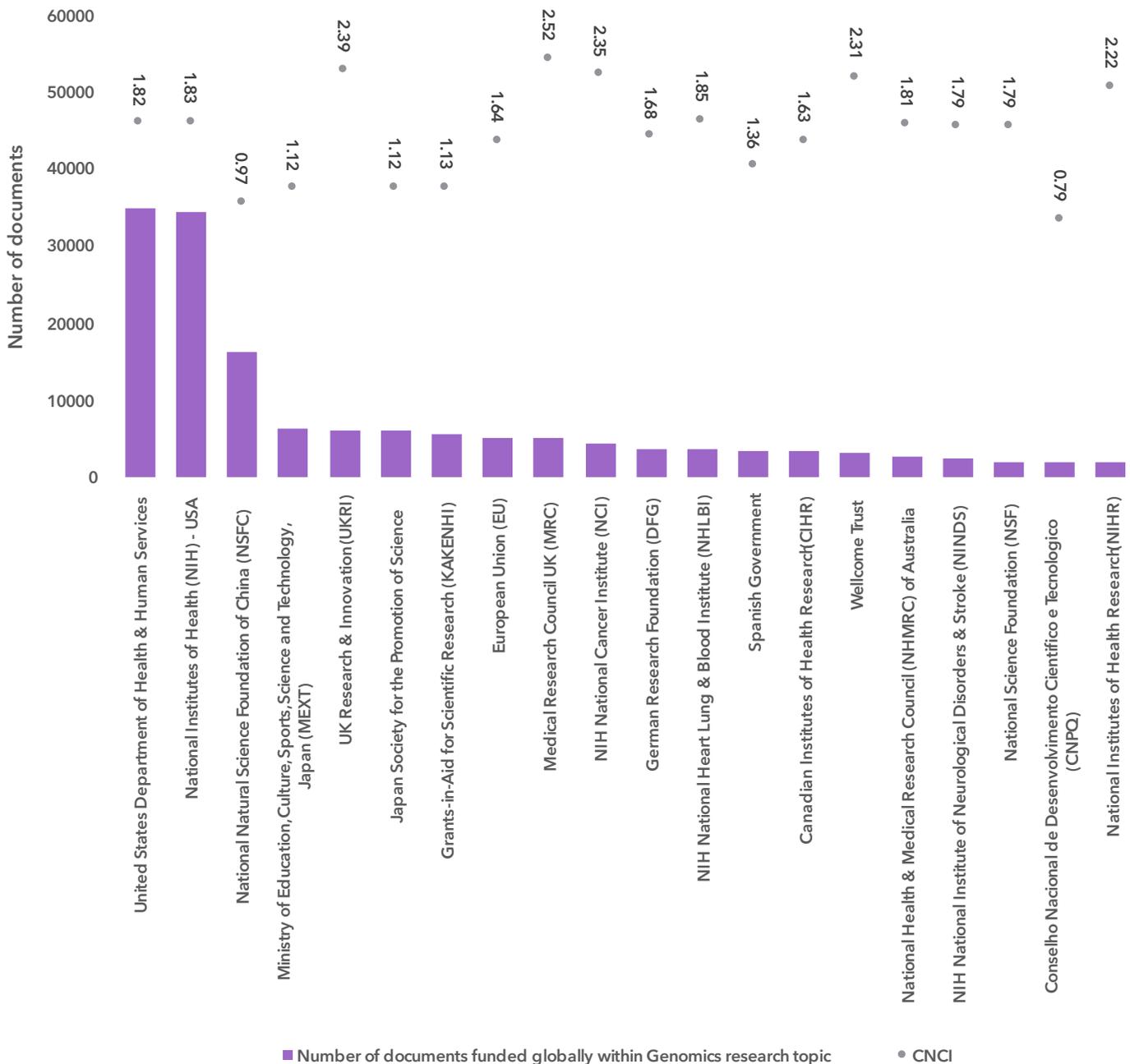
Figure 88: Top 20 funding organizations globally publications in the research topic Genomics in terms of number of publications in the period 2014-2023

4.1.7.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section we investigate the emerging trends globally and in Saudi Arabia in the research topic Genomics. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Molecular & Cell Biology - Genetics: RNA-Seq followed by Molecular & Cell Biology - Cancer, Autophagy & Apoptosis: Warburg Effect and Virology - General: Coronavirus as shown in Figure 89. In Figure 90 The top 20 Saudi Arabia emerging micro-topics in this research topic are identified.

The top 3 emerging topics in Saudi Arabia are Hematologic Diseases, Sickle Cell Disease, followed by Neurodegenerative Diseases, Huntington's Disease, and Genome Studies, BRCA1. Among Saudi Arabia's top 20 emerging micro-topics, there are no micro-topics that are also an emerging trend globally. It is worth mentioning that the micro-topics Lipids: Statins and Thyroid Disorders: Thyroid Cancer decreased within the total citations of Saudi Arabia publications on the research topic. Accordingly, one should monitor and assess the relevance of these topics locally and globally.
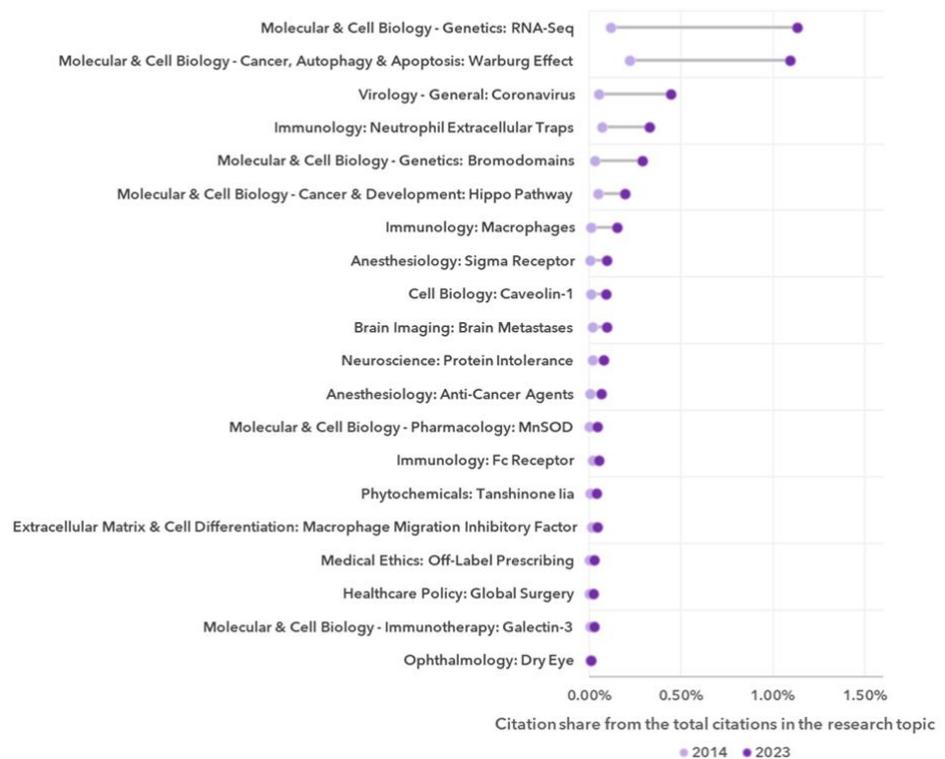
Figure 89: Top 20 emerging micro-topics globally in the research topic Genomics in the period 2014-2023
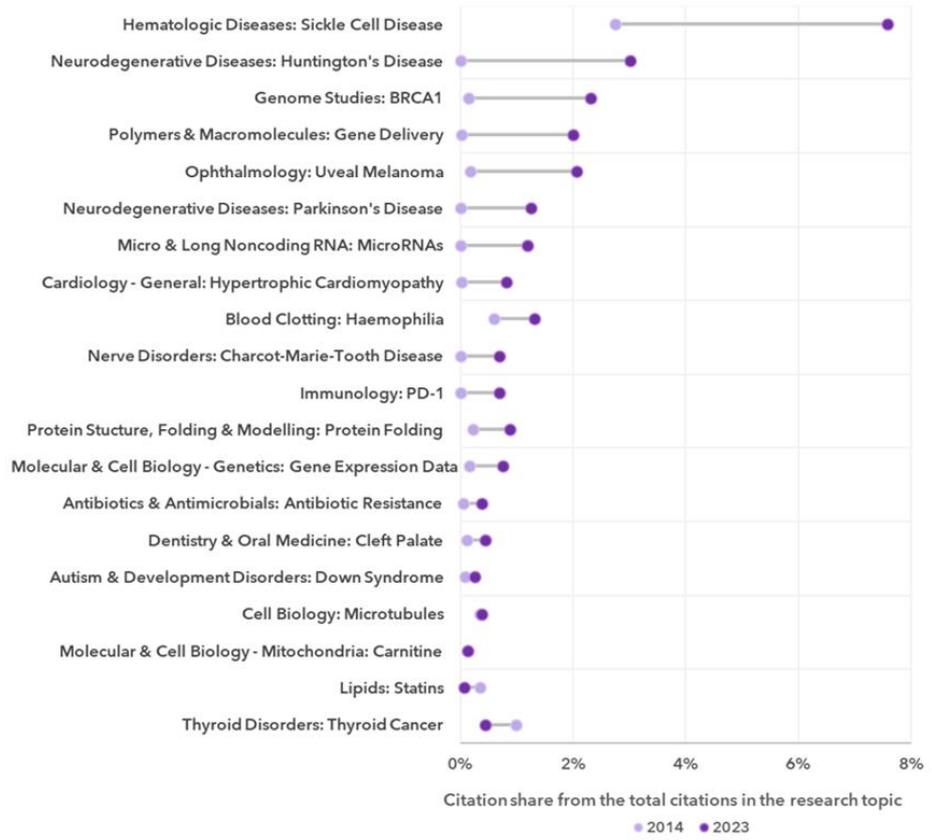
Figure 90: Top 20 emerging micro-topics in Saudi Arabia in the research topic Genomics in the period 2014-2023

4.1.8 CAR-T Cell Therapy

4.1.8.1 Evolution of Saudi publication share of global publications in the research topic

Saudi Arabia did not have any publications on this research topic until 2017. Afterward, the share of Saudi Arabia publications from global publications on the research topic fluctuated between 0.5% in 2014 and 0.91% in 2022 and then dropped to 0.59% in 2023, as shown in Figure 91.

The CNCI of Saudi Arabia publications in this research topic was in several years higher than 1, indicating a citation impact performance higher than the global average. The CNCI increased from 0.26 in 2017 to 2.76 in 2019 and then decreased to 1.18 in 2020 to then recover to 2.35 in 2023.

Overall, as this is a priority research topic, one should increase the output in this category and ensure a good citation impact.
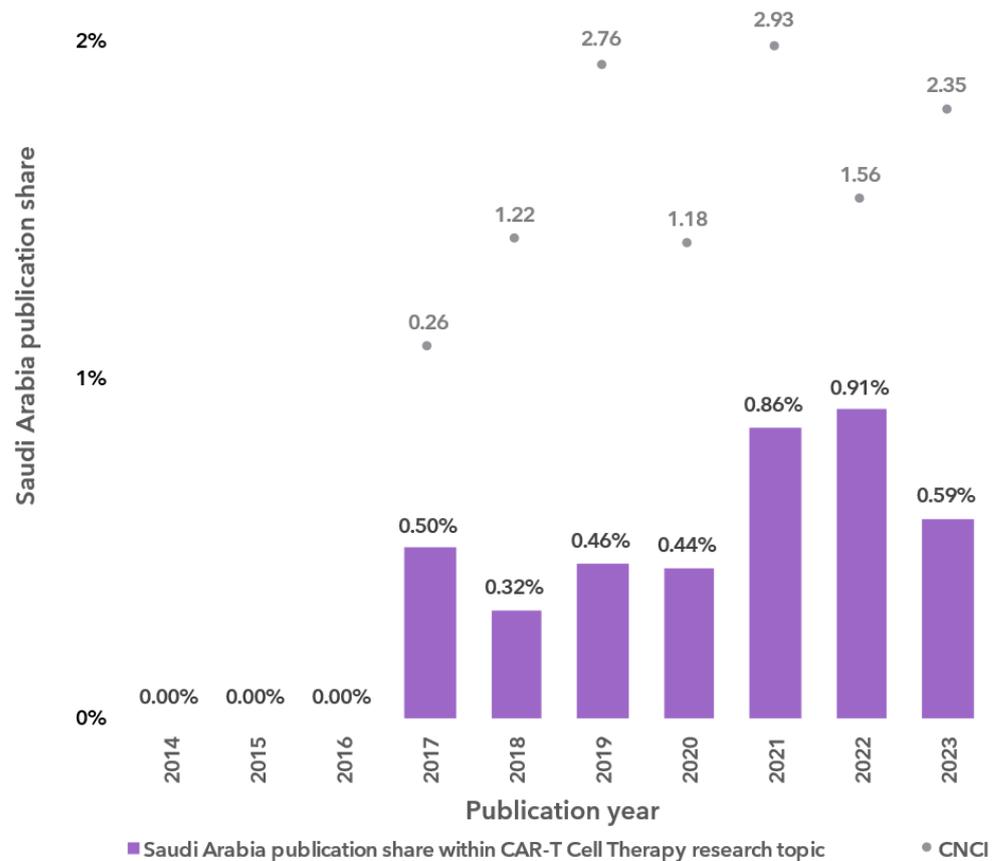
Figure 91: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.8.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating countries with Saudi Arabia in this research topic in the period 2014-2023 are the United States, followed by Germany and Egypt with 23, 14 and 10 publications, respectively, as shown in Figure 92.

In terms of citation impact measured by the CNCI publications published in collaboration with United Kingdom followed by France and Germany had the highest CNCI with 4.77, 4.03 and 3.73, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1 reflecting a performance higher than the global average.
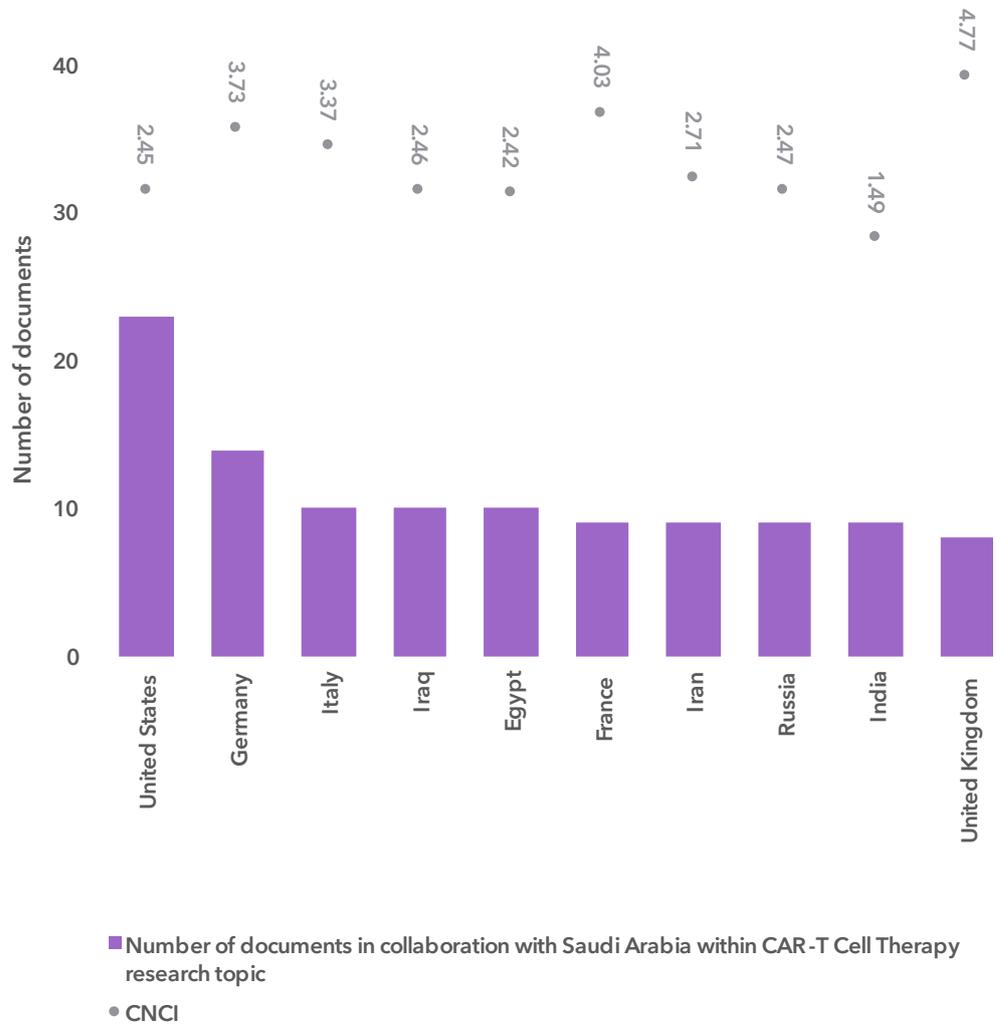
Figure 92: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic CAR-T Cell Therapy in the period 2014-2023

4.1.8.3 Top 20 funders of Saudi publications by number of publications

Three funding organizations were mentioned in the funding acknowledgment of three Saudi Arabia publications on this research topic in the period 2014-2023, and these are NIH National Cancer Institute (NCI), the United States Department of Health & Human Services and the National Institutes of Health (NIH) – USA as shown in Figure 93.

Four organizations were mentioned in the funding acknowledgement of two publications and these are: Medical Research Council UK (MRC), German Research Foundation (DFG), King Saud University and UK Research & Innovation (UKRI). The remaining organization were mentioned in the funding acknowledgement of one document.

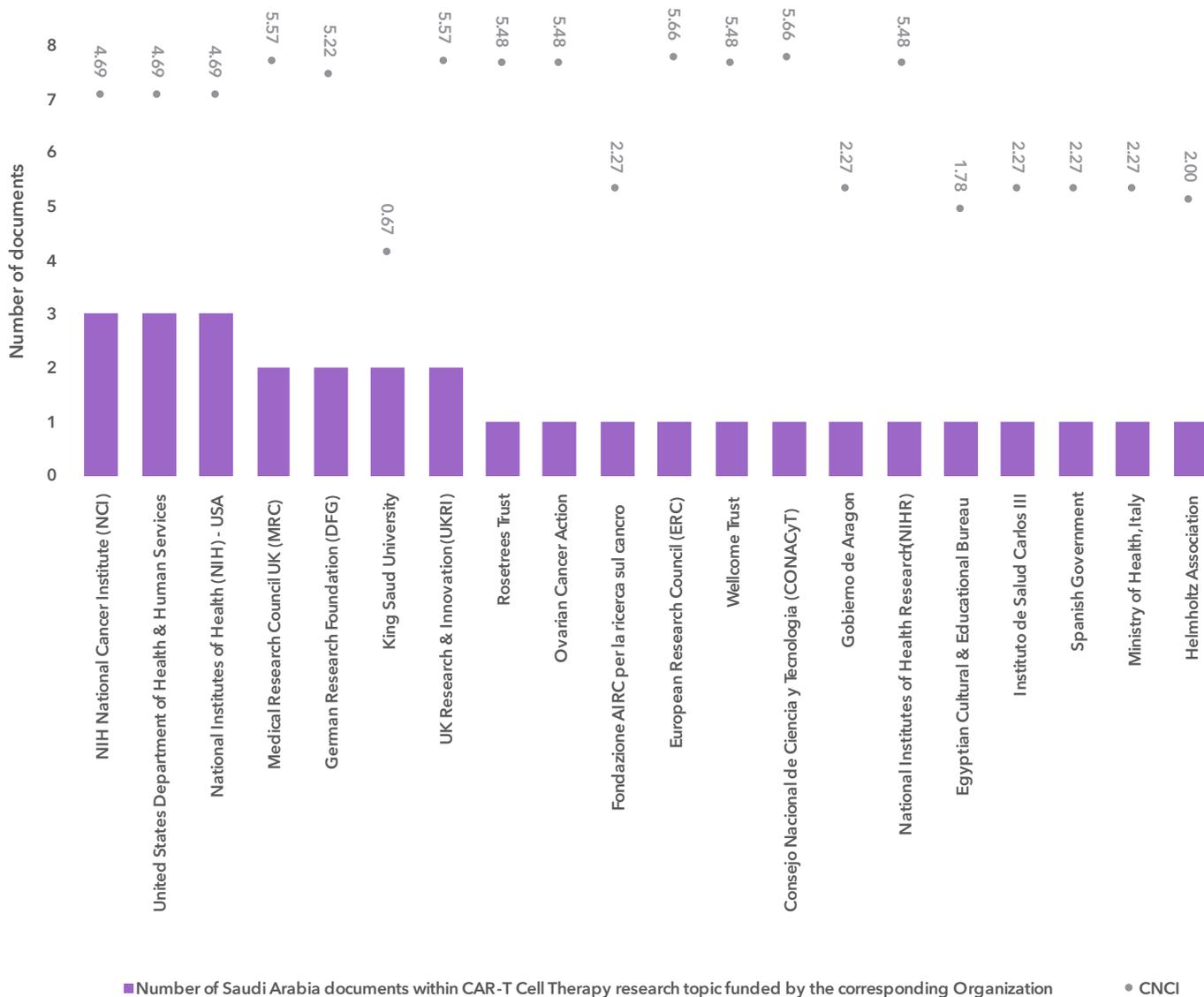All the funded publications have a CNCI higher than 1, except the publications funded by King Saud University.

Figure 93: Top 20 funding organizations of Saudi Arabia publications in the research topic CAR-T Cell Therapy in terms of number of publications in the period 2014-2023

4.1.8.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published on this research topic in the period 2014-2023 are King Faisal Specialist Hospital & Research Center, followed by Prince Sattam Bin Abdulaziz University and King Abdulaziz University, with 14, 9 and 6 publications, respectively as shown in Figure 94.

In terms of citation impact as measured by the CNCI, King Faisal Specialist Hospital & Research Center, followed by Prince Sattam Bin Abdulaziz University and King Khalid University, had the highest CNCI with 3.27, 2.96 and 2.76, respectively.

14 out of the top 20 organizations had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
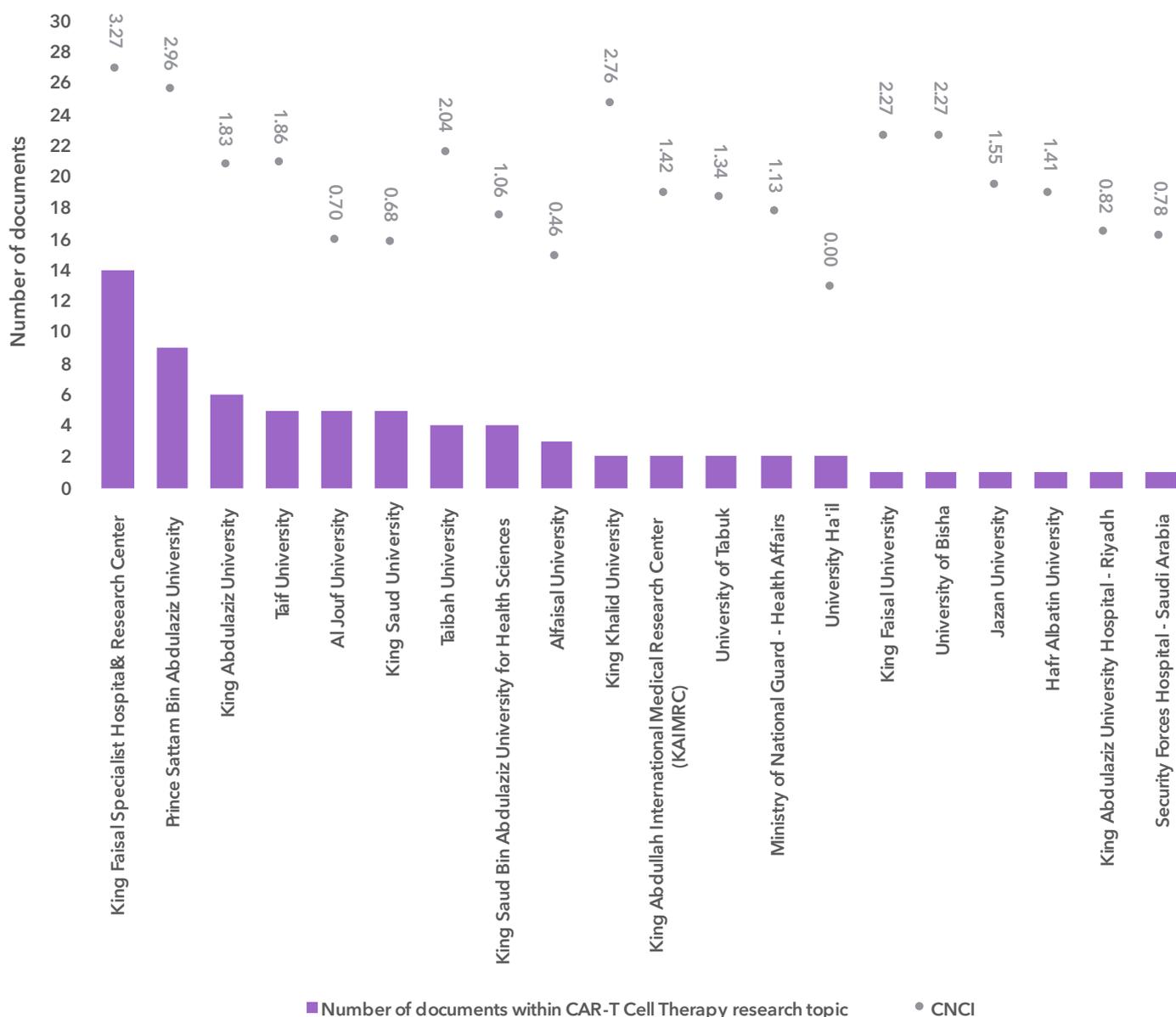
Figure 94: Top 20 Saudi organizations in terms of publications published in the research topic CAR-T Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.8.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Mahmoud Aljurf, affiliated to King Faisal Specialist Hospital & Research Center, followed by Hashem O. Alsaab, affiliated to Taif University, with 7 and 2 publications, respectively as shown in Table 21. All other researchers had only one document on this research topic.

The highest CNCI, the number of Top 1% publications and the number of Top 10% publications are achieved also by Mahmoud Aljurf with a CNCI of 4.01, 1 and 4 publications in Top 1% and Top 10% respectively.

Table 21: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic CAR-T Cell Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Aljurf, Mahmoud	King Faisal Specialist Hospital & Research Center	7	4.01	1	4
Alsaab, Hashem O.	Taif University	2	1.14	0	1
Alsaikhan, Fahad	Prince Sattam Bin Abdulaziz University	1	3.48	0	1
Alotaibi, Saqer S.	Taif University	1	2.64	0	1
Alkayyal, Almohanad A.	University of Tabuk	1	2.19	0	1
Darwish, Manar	Taibah University	1	2.19	0	1
Hashem, Anwar M.	King Abdulaziz University	1	2.19	0	1
Mahmoud, Ahmad Bakur	Taibah University	1	2.19	0	1
Taher, Mustafa	Taibah University	1	2.19	0	1
Alhamhoom, Yahya	King Khalid University	1	1.62	0	0
Hani, Umme	King Khalid University	1	1.62	0	0
Rahamathulla, Mohamed	King Khalid University	1	1.62	0	0
Thajudeen, Kamal Yoonus	King Khalid University	1	1.62	0	0
Albratty, Mohammed	Jazan University	1	1.55	0	0
Meraya, Abdulkarim M.	Jazan University	1	1.55	0	0
Almansour, Nahlah Makki	Hafr Albatin University	1	1.41	0	0
Alwanian, Wanian M.	Qassim University	1	1.41	0	0
Alhabbab, Rowa Y.	King Abdulaziz University	1	0.86	0	0
Abu El-Asrar, Ahmed M.	King Saud University	1	0.82	0	0
Farhana, Aisha	Al Jouf University	1	0.72	0	0

4.1.8.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (4,580 publications), followed by Mainland China (2,132 publications) and Germany (929 publications), as shown in Figure 95.

The highest citation impact measured by the CNCI is achieved by publications published by Canada, France, and Spain with a CNCI of 5.45, 4.20 and 4.01, respectively.

Five of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Germany, United Kingdom, France, and Italy.
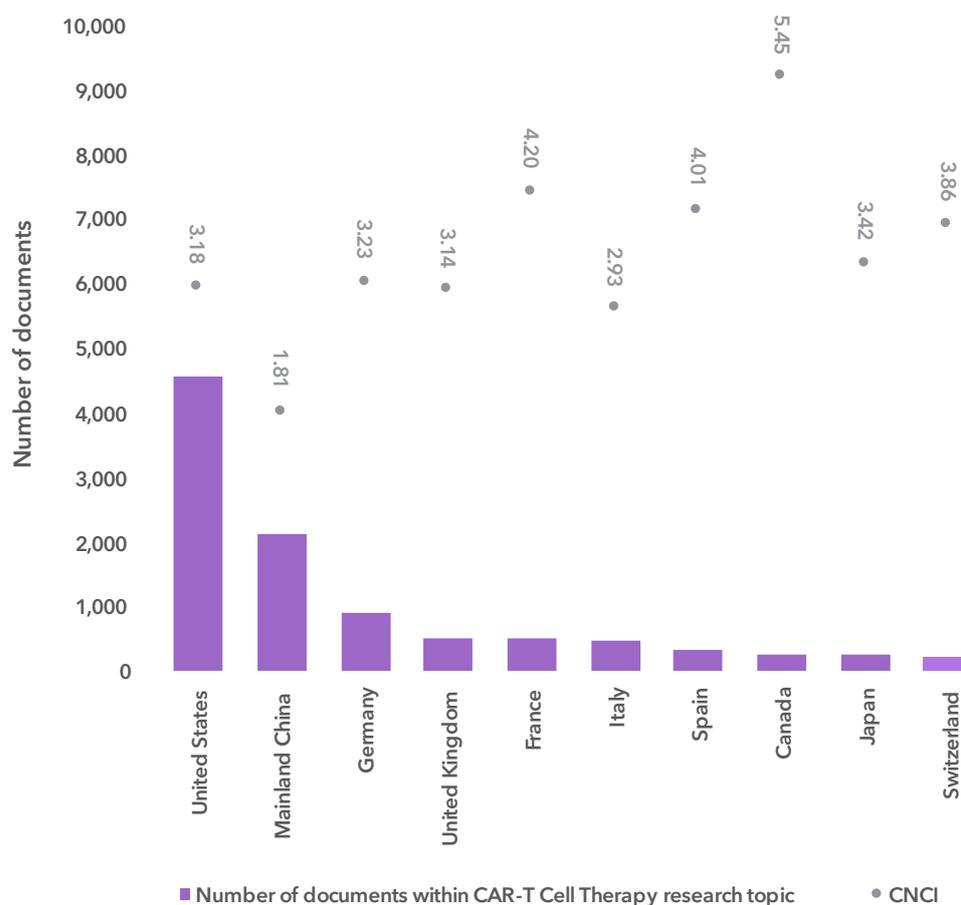
Figure 95: Top 10 countries in terms of the number of publications in the research topic CAR-T Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.8.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are the University of Pennsylvania (568 publications) followed by Harvard University (527 publications) and Pennsylvania Medicine (520 publications), as shown in Figure 96.

In terms of citation impact measured by the CNCI, Stanford University, followed by H Lee Moffitt Cancer Center & Research Institute and Dana-Farber Cancer Institute, had the highest CNCI with 7.90, 6.82 and 6.78, respectively.
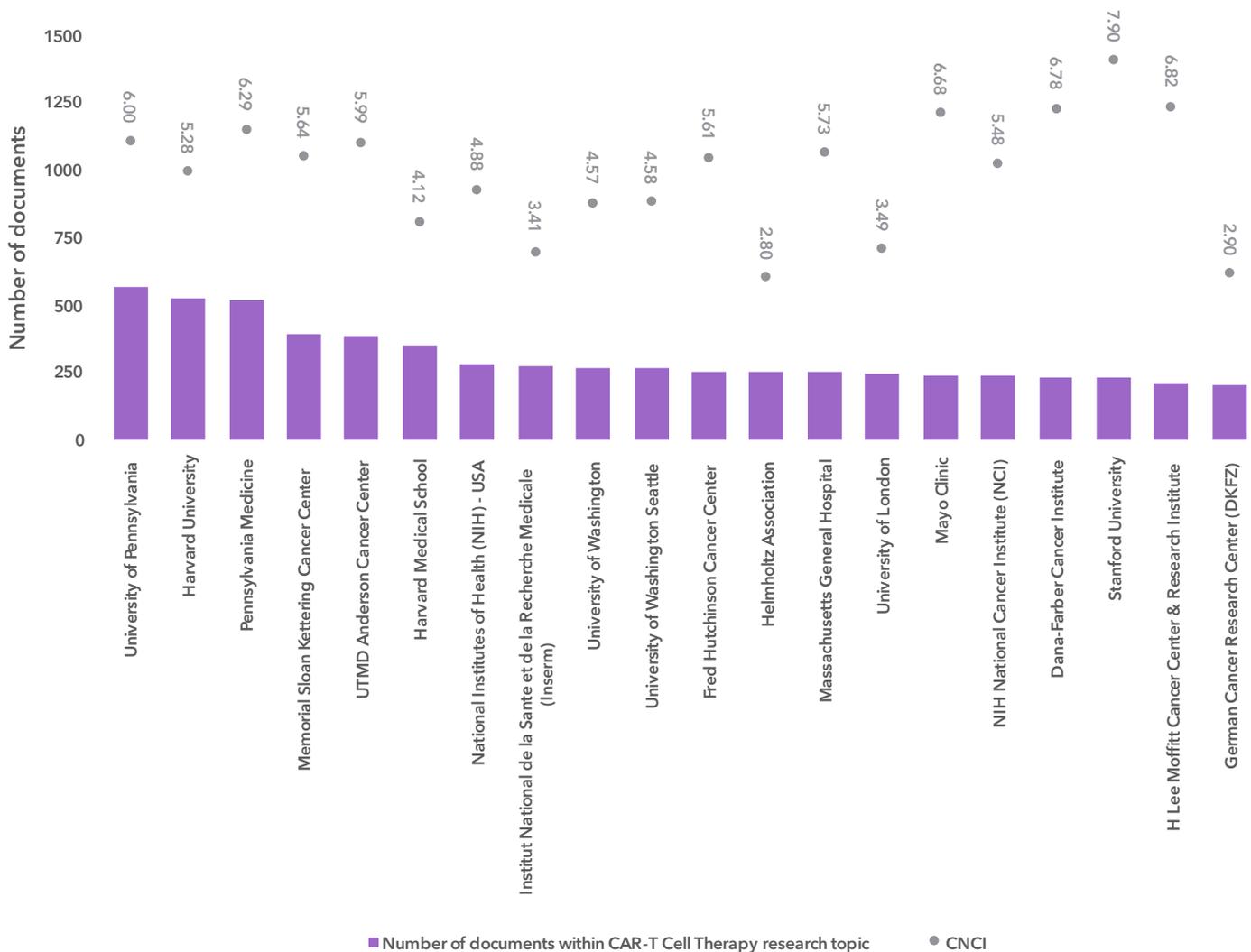
Figure 96: Top 20 organizations globally in terms of the number of publications published in the research topic CAR-T Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.8.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Carl H. June, affiliated to the University of Pennsylvania, with 132 publications, followed by Frederick L. Locke, affiliated to H Lee Moffitt Cancer Center & Research Institute, with 74 publications, and Stephan A. Grupp, affiliated to University of Pennsylvania and He Huang affiliated to Zhejiang University with 71 publications as shown in Table 22.

The highest CNCI is achieved by Simon F. Lacey affiliated to University of Pennsylvania with a CNCI of 13.28. The highest number of Top 1% and Top 10% publications is achieved by Carl H. June with 54 Top 1% publications and 114 Top 10% publications.

Table 22: Top 20 researchers globally in terms of the number of publications published on the research topic CAR-T Cell Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
June, Carl H.	University of Pennsylvania	132	10.74	54	114	United States
Locke, Frederick L.	H Lee Moffitt Cancer Center & Research Institute	74	8.86	19	46	United States
Grupp, Stephan A.	University of Pennsylvania	71	9.06	19	53	United States
Huang, He	Zhejiang University	71	2.03	3	21	Mainland China
Mackall, Crystal L.	Stanford University	61	9.04	26	51	United States
Neelapu, Sattva S.	UTMD Anderson Cancer Center	59	9.47	18	37	United States
Hu, Yongxian	Zhejiang University	59	2.24	3	19	Mainland China
Lacey, Simon F.	University of Pennsylvania	58	13.28	26	49	United States
Dotti, Gianpietro	University of North Carolina Chapel Hill	58	4.36	14	38	United States
Shah, Nirali N.	National Institutes of Health (NIH) - USA	58	6.27	13	30	United States
Brentjens, Renier J.	Memorial Sloan Kettering Cancer Center	56	6.85	14	38	United States
Lin, Yi	Mayo Clinic	55	13.04	19	38	United States
Maus, Marcela V.	Harvard University	55	6.06	12	31	United States
Zhou, Jianfeng	Huazhong University of Science & Technology	53	1.63	1	13	Mainland China
Turtle, Cameron J.	Fred Hutchinson Cancer Center	51	9.84	18	35	United States
Sadelain, Michel	Memorial Sloan Kettering Cancer Center	50	12.49	22	41	United States
Forman, Stephen J.	City of Hope	50	3.08	3	26	United States
Perales, Miguel-Angel	Memorial Sloan Kettering Cancer Center	49	5.37	9	32	United States
Subklewe, Marion	University of Munich	49	5.11	8	28	Germany
Porter, David L.	University of Pennsylvania	48	11.36	17	36	United States

4.1.8.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 1,703 publications, followed by the National Institutes of Health (NIH) – USA with 1,699 publications, and National Natural Science Foundation of China (NSFC) with 1,112 publications as shown in Figure 97.

The highest citation impact measured by the CNCI is observed in publications funded by Novartis, Leukemia and Lymphoma Society and NIH National Heart Lung & Blood Institute (NHLBI) with 7.51, 6.38 and 4.76, respectively.

Among the top 20 global funding organizations, 8 are also among the top 20 funding organizations of Saudi publications in this research topic.
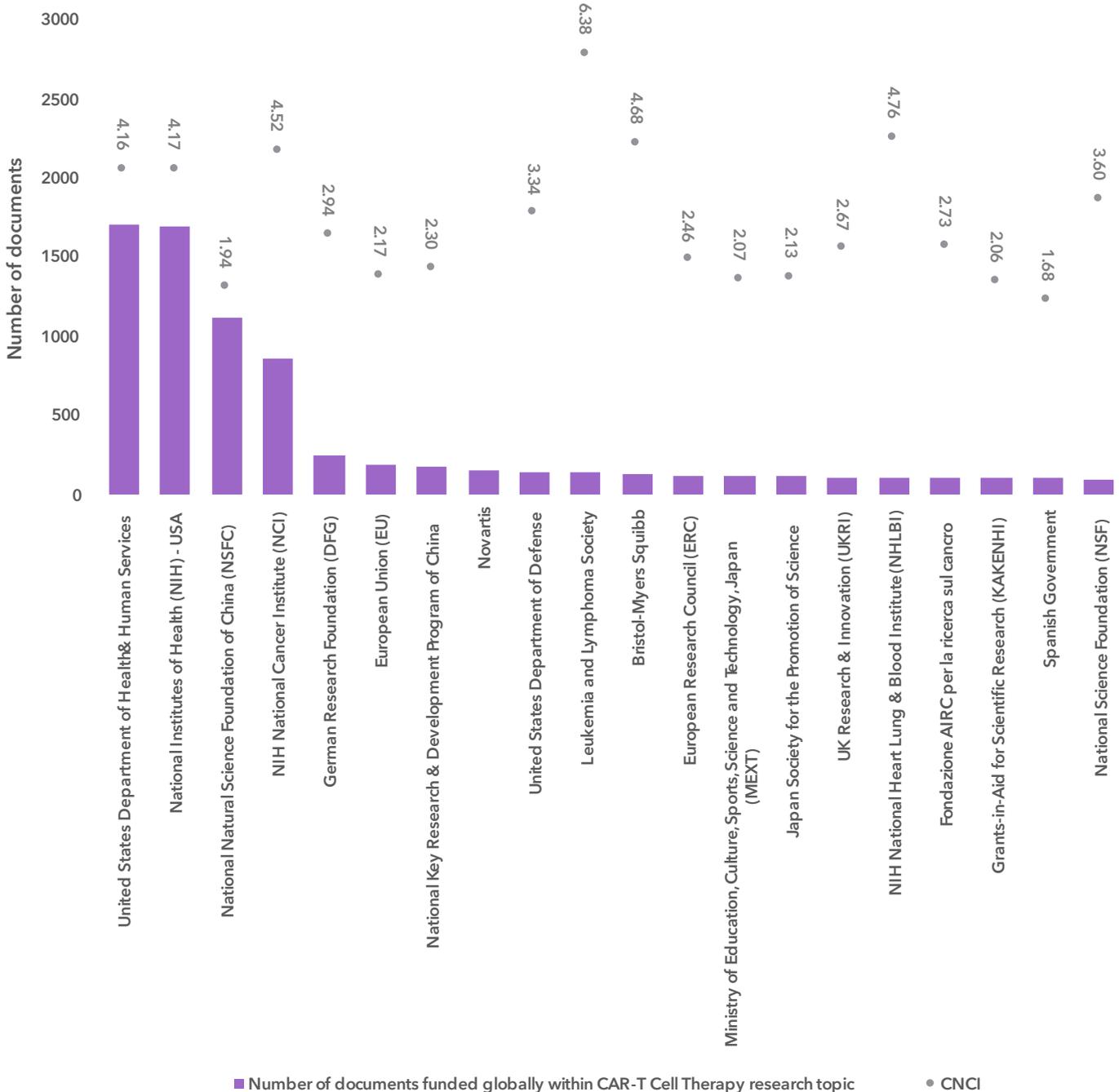
Figure 97: Top 20 funding organizations globally publications in the research topic CAR-T Cell Therapy in terms of number of publications in the period 2014-2023

4.1.8.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of CAR-T Cell Therapy. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Lymphomas: Multiple Myeloma followed by Lymphomas: Lymphoma and Molecular & Cell Biology - Genetics: Genome Editing as shown in Figure 98.

Table 23 shows the identified micro-topics in Saudi Arabia research output in this research topic.

Figure 98: Top 20 emerging micro-topics globally in the research topic CAR-T Cell Therapy in the period 2014-2023

Table 23: Micro-topics identified in Saudi Arabia research output in the research topic CAR-T Cell Therapy in the period 2014-2023

Topic	Number of Saudi Arabia publications in the period 2014-2023
CAR-T Cell Therapy	58
Immunology: PD-1	31
Lymphomas: Lymphoma	5
Molecular & Cell Biology - Genetics: Genome Editing	3
Immunology: Natural Killer Cells	3
Lymphomas: Multiple Myeloma	2
Liver & Colon Cancer: Metastatic Colorectal Cancer	1
Molecular & Cell Biology - Immunotherapy: Phage Display	1
Polymers & Macromolecules: Dendrimers	1
Blood Disorders: Acute Myeloid Leukemia	1
Rheumatology: Psoriasis	1
Photoproductivity: Carotenoids	1
Blood Disorders: GvHD	1
Numerical Methods: Logistic Source	1
Molecular & Cell Biology - Cancer & Development: Cancer Stem Cells	1
Virology - General: Coronavirus	1
Virology - Identification & Sequencing: Adenovirus	1
Molecular & Cell Biology - Pharmacology: Hydrogen Sulfide	1
Lung Cancer: NSCLC	1
Membrane Channels & Receptors: Adenosine	1

4.1.9 Stem Cell Therapy

4.1.9.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications in the research topic increased almost continuously from 2014 till 2023 as shown in Figure 99. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate.

This is evident as the share of Saudi Arabian publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic was in several years lower than 1, indicating a citation impact performance lower than the global average. The CNCI decreased from 1.68 in 2014 to 0.6 in 2018 to then slightly recover to 0.85 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia publications increased with a higher growth rate than the global average in this research topic but had a relatively low citation impact as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact.
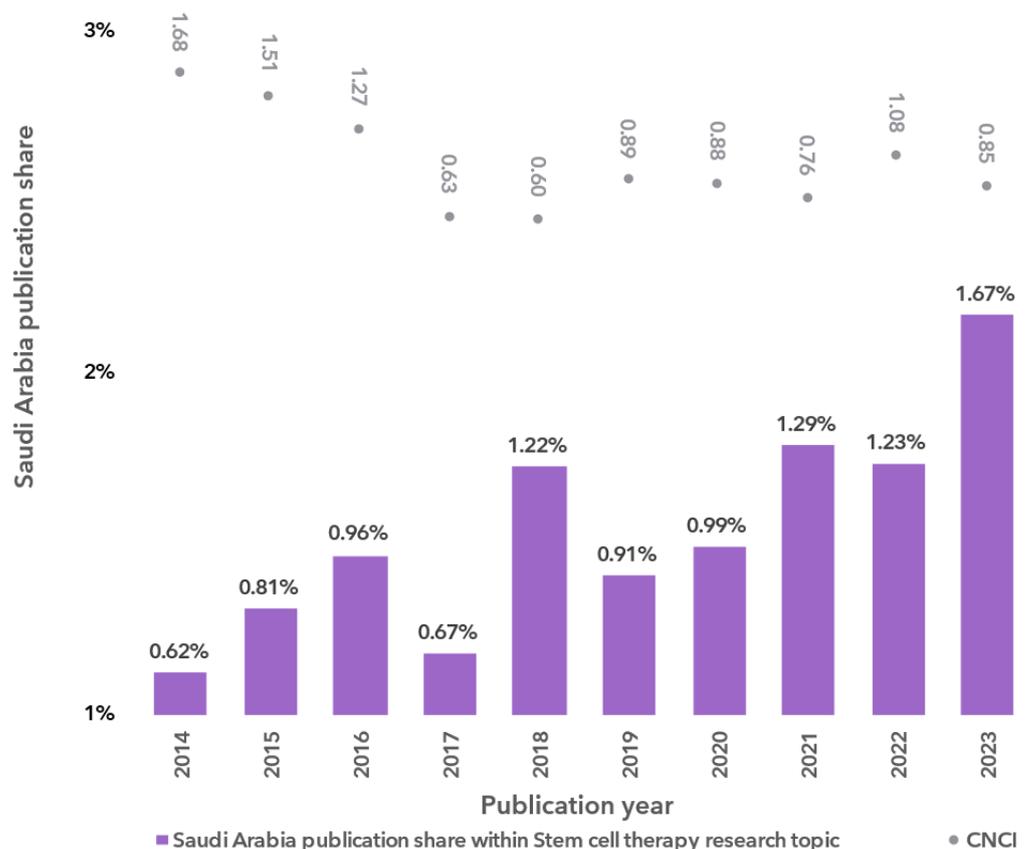
Figure 99: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.9.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating countries with Saudi Arabia in this research topic in the period 2014-2023 are Egypt followed by United States and India with 170, 119 and 93 publications respectively as shown in Figure 100.

In terms of citation impact measured by the CNCI publications published in collaboration with Canada followed by Germany and Italy had the highest CNCI with 2.49, 2.13 and 2.10 respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1 reflecting a performance higher

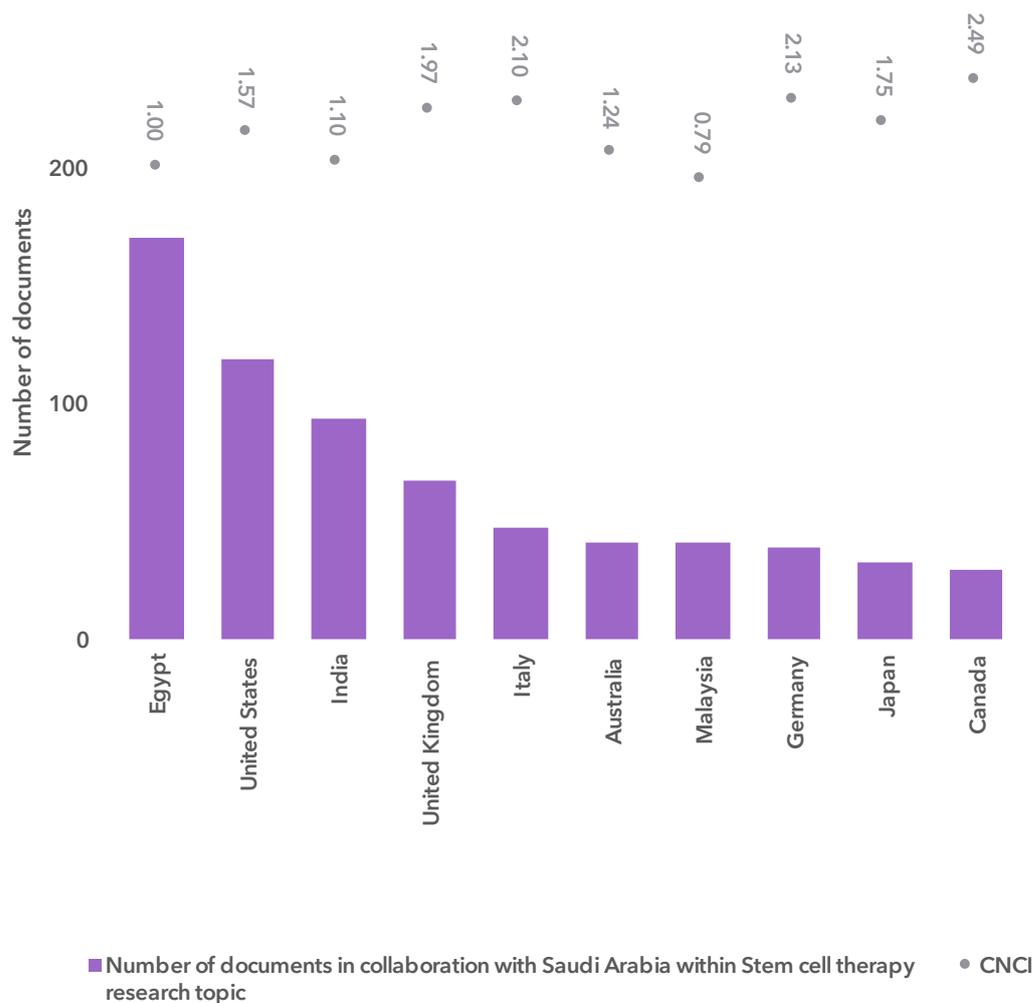than the global average, except publications in collaboration with Malaysia which achieved a CNCI of 0.79.

Figure 100: Top 10 collaborating countries with Saudi Arabia in terms of number of publications in the research topic Stem Cell Therapy in the period 2014-2023

4.1.9.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of number of publications mentioning the organization in the funding text in the period 2014-2023 are United States Department of Health & Human Services and National Institutes of Health (NIH) – USA with the same number of publications followed by King Saud University and UK Research & Innovation (UKRI) with 34, 22 and 17 publications respectively as shown in Figure 101.

Publications funded by Medical Research Council UK (MRC) followed by Grants-in-Aid for Scientific Research (KAKENHI) and United States Department of Defense had the highest citation impact measured by the CNCI with 3.46, 2.75 and 2.72, respectively.
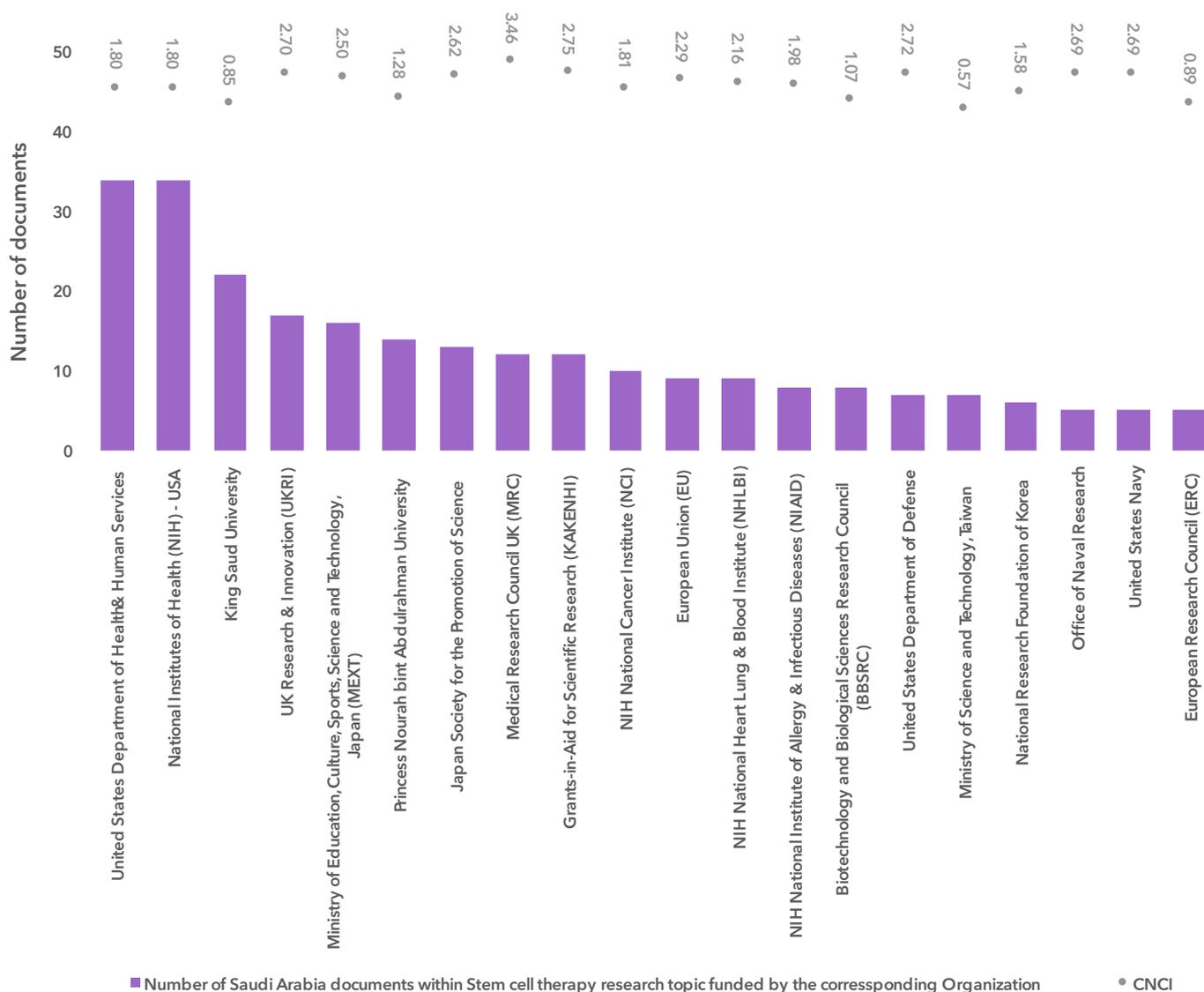
Figure 101: Top 20 funding organizations of Saudi Arabia publications in the research topic Stem Cell Therapy in terms of number of publications in the period 2014-2023

4.1.9.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and King Faisal Specialist Hospital & Research Center, with 121, 119 and 84 publications respectively as shown in Figure 102.

In terms of citation impact as measured by the CNCI, Prince Sattam Bin Abdulaziz University, followed by King Khalid University and King Saud University, had the highest CNCI with 1.33, 1.27 and 1.18, respectively. Only four out of the top 20 organizations had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
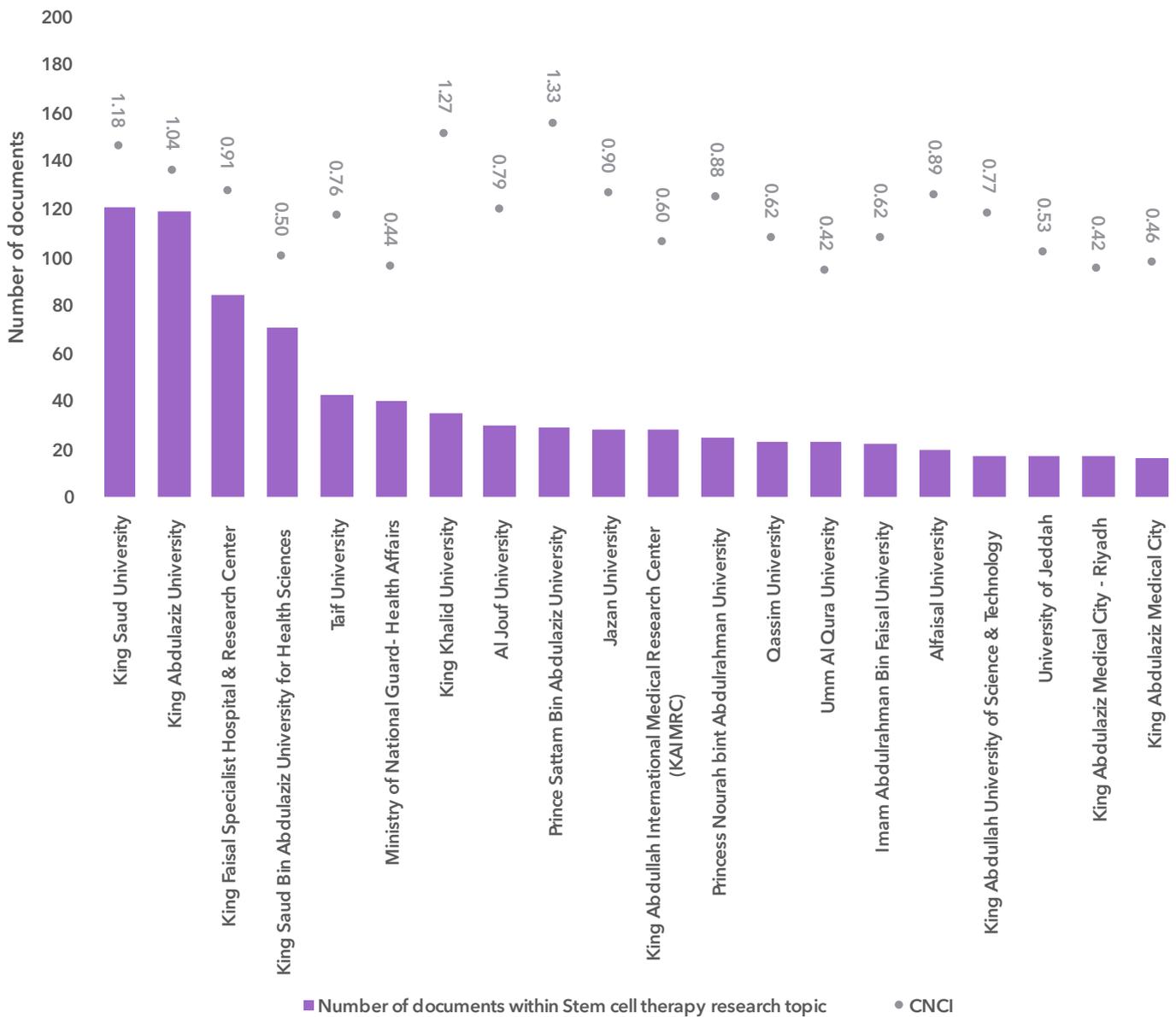
Figure 102: Top 20 Saudi organizations in terms of publications published in the research topic Stem Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.9.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Mahmoud Aljurf, affiliated with King Faisal Specialist Hospital & Research Center, followed by Shankargouda Patil, affiliated with Jazan University, and Abdullah A. Alarfaj, affiliated with King Saud University, with 18, 11 and 10 publications, respectively as shown in Table 24.

Gauthaman Kalamegam affiliated to King Abdulaziz University had the highest CNCI of 3.06 and had the only Top 1% document. Four researchers had two Top 10% publications, and seven researchers had one Top 10% document.

Table 24: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Stem Cell Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Aljurf, Mahmoud	King Faisal Specialist Hospital & Research Center	18	1.05	0	2
Patil, Shankargouda	Jazan University	11	1.43	0	2
Alarfaj, Abdullah A.	King Saud University	10	0.52	0	0
Munusamy, Murugan A.	King Saud University	8	0.57	0	0
El Fakih, Riad	King Faisal Specialist Hospital & Research Center	7	0.42	0	1
Jawdat, Dunia	King Abdullah International Medical Research Center (KAIMRC)	7	0.42	0	0
Rasheed, Walid	King Faisal Specialist Hospital & Research Center	7	0.36	0	0
Al-Mousa, Hamoud	King Faisal Specialist Hospital & Research Center	6	1.44	0	2
Kalamegam, Gauthaman	King Abdulaziz University	6	3.06	1	2
Abumaree, M. H.	King Saud Bin Abdulaziz University for Health Sciences	5	1.27	0	1
Al-Karim, Saleh	King Abdulaziz University	5	0.48	0	0
Alanazi, Asma	King Saud Bin Abdulaziz University for Health Sciences	5	0.91	0	0
Aljahdaly, Noufe H.	King Abdulaziz University	5	1.35	0	1
Almalki, Sami G.	Majmaah University	5	0.92	0	1
Ayas, Mouhab	King Faisal Specialist Hospital & Research Center	5	1.11	0	1
Bhandi, Shilpa	Jazan University	5	1.32	0	1
Elyamany, Ghaleb	Prince Sultan Military Medical City	5	0.13	0	0
Haider, Khawaja Husnain	Sulaiman AlRajhi University	5	1.34	0	1
Hussein, Deema	King Abdulaziz University	5	0.63	0	0
Khatlani, Tanvir	King Saud Bin Abdulaziz University for Health Sciences	5	0.28	0	0

4.1.9.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (17,083 publications), followed by Mainland China (14,591 publications) and Japan (3,856 publications), as shown in Figure 103.

The highest citation impact measured by the CNCI is achieved by publications published by France and the United Kingdom with the same CNCI, followed by the United States and Germany with a CNCI of 1.51, 1.43 and 1.37, respectively.

Six of the top 10 countries, in terms of the number of publications published on the research topic, are also among the top 10 collaborators with Saudi Arabia. These are the United States, Japan, the United Kingdom, Germany, Italy, and India.
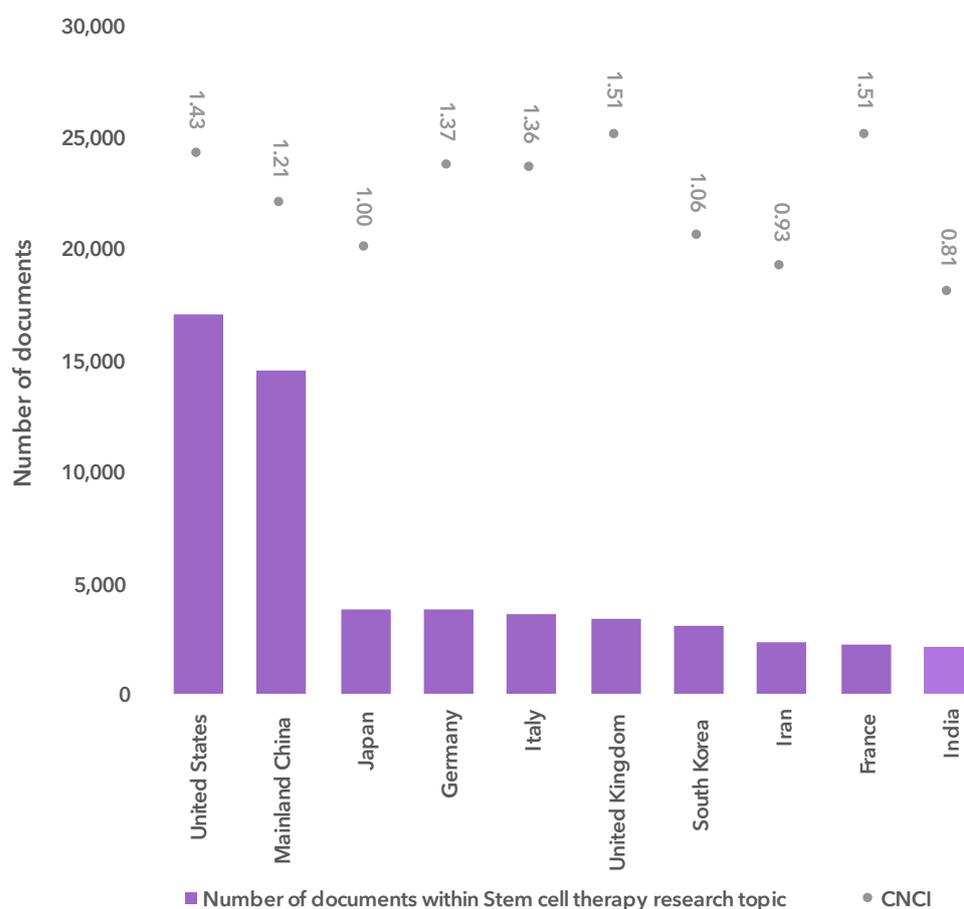
Figure 103: Top 10 countries in terms of the number of publications in the research topic Stem Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.9.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of the number of publications published in this research topic in the period 2014-2023 are Harvard University (1,484 publications) followed by Institut National de la Sante et de la Recherche Medicale (Inserm) (1,204 publications) and Harvard Medical School (1090 publications) as shown in Figure 104.

In terms of citation impact measured by the CNCI, UTMD Anderson Cancer Center, followed by Harvard University and Mayo Clinic, had the highest CNCI with 2.39, 2.21 and 2.13, respectively.
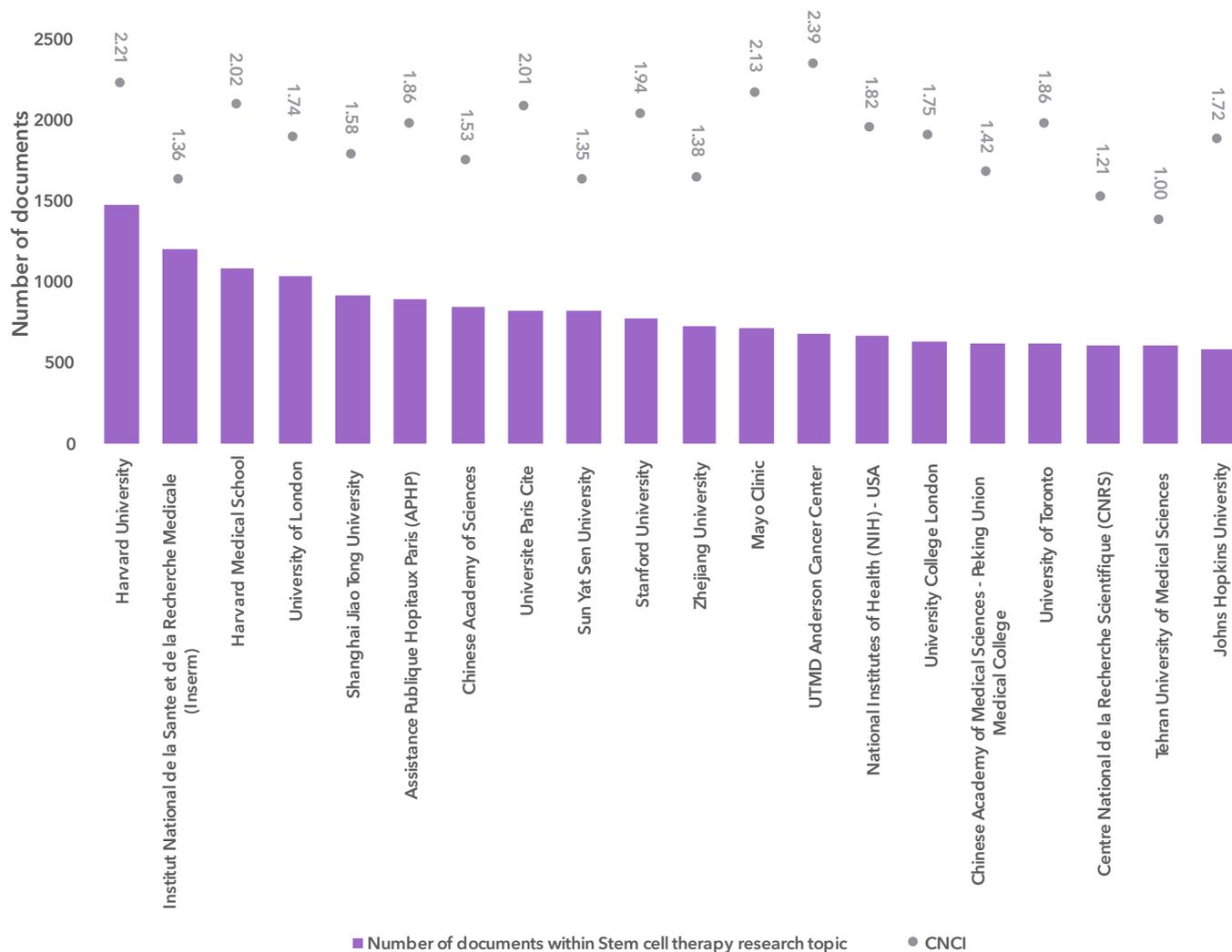
The chart shows bars representing "Number of documents within Stem cell therapy research topic" and dots representing CNCI for each organization:

- Harvard University — ~1480, CNCI 2.21
- Institut National de la Sante et de la Recherche Medicale (Inserm) — ~1200, CNCI 1.36
- Harvard Medical School — ~1080, CNCI 2.02
- University of London — ~1030, CNCI 1.74
- Shanghai Jiao Tong University — ~910, CNCI 1.58
- Assistance Publique Hopitaux Paris (APHP) — ~880, CNCI 1.86
- Chinese Academy of Sciences — ~840, CNCI 1.53
- Universite Paris Cite — ~820, CNCI 2.01
- Sun Yat Sen University — ~810, CNCI 1.35
- Stanford University — ~770, CNCI 1.94
- Zhejiang University — ~720, CNCI 2.13
- Mayo Clinic — ~710, CNCI 2.39
- UTMD Anderson Cancer Center — ~670, CNCI 1.82
- National Institutes of Health (NIH) - USA — ~660, CNCI 1.75
- University College London — ~630, CNCI 1.86
- Chinese Academy of Medical Sciences - Peking Union Medical College — ~620, CNCI 1.42
- University of Toronto — ~615, CNCI 1.21
- Centre National de la Recherche Scientifique (CNRS) — ~610, CNCI 1.00
- Tehran University of Medical Sciences — ~605, CNCI 1.72
- Johns Hopkins University — ~585

■ Number of documents within Stem cell therapy research topic   ● CNCI

Figure 104: Top 20 organizations globally in terms of the number of publications published in the research topic Stem Cell Therapy in the period 2014-2023 and their corresponding CNCI

4.1.9.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications on this research topic are Ibrahim Yakoub-Agha, affiliated to Universite de Lille, with 122 publications, followed by Masoud Soleimani, affiliated to Tarbiat Modares University, with 80 publications, and Mohamad Mohty, affiliated to Sorbonne Universite with 75 publications as shown in Table 25.

The highest CNCI is achieved by Alessandro Aiuti affiliated to Vita-Salute San Raffaele University. The latter has also the highest number of Top 1% publications with 5 publications.

The highest number of Top 10% publications is achieved by Joseph C. Wu affiliated to Stanford University with 25 publications.

Table 25: Top 20 researchers globally in terms of the number of publications published on the research topic Stem Cell Therapy in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Yakoub-Agha, Ibrahim	Universite de Lille	122	0.67	1	9	France
Soleimani, Masoud	Tarbiat Modares University	80	1.09	1	8	Iran
Mohty, Mohamad	Sorbonne Universite	75	1.21	0	13	France
Wu, Joseph C.	Stanford University	71	1.84	0	25	United States
Okano, Hideyuki	Keio University	65	1.56	1	16	Japan
Borlongan, Cesar V.	University of South Florida	60	0.74	0	5	United States
Kroeger, Nicolaus	University of Hamburg	57	1.37	1	12	Germany
Hare, Joshua M.	University of Miami	55	1.99	2	17	United States
Dispenzieri, Angela	Mayo Clinic	54	2.76	3	14	United States
Gertz, Morie A.	Mayo Clinic	54	1.47	0	11	United States
Locatelli, Franco	IRCCS Bambino Gesu	52	1.78	1	16	Italy
Baharvand, Hossein	Academic Center for Education, Culture & Research (ACECR)	47	1.44	2	9	Iran
Ai, Jafar	Tehran University of Medical Sciences	46	0.99	0	8	Iran
Garcia-Manero, Guillermo	UTMD Anderson Cancer Center	46	2.34	3	16	United States
Larijani, Bagher	Tehran University of Medical Sciences	46	0.39	0	0	Iran
Goldschmidt, Hartmut	Ruprecht Karls University Heidelberg	44	1.98	3	11	Germany
Kiem, Hans-Peter	Fred Hutchinson Cancer Center	44	1.47	1	9	United States
Sawa, Yoshiki	Osaka University	44	1.33	0	7	Japan
Aiuti, Alessandro	Vita-Salute San Raffaele University	43	3.28	5	19	Italy

4.1.9.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the National Natural Science Foundation of China (NSFC) with 8,124 publications, followed by the United States Department of Health & Human Services with 6,780 publications, and National Institutes of Health (NIH) - USA with 6,754 publications as shown in Figure 105.
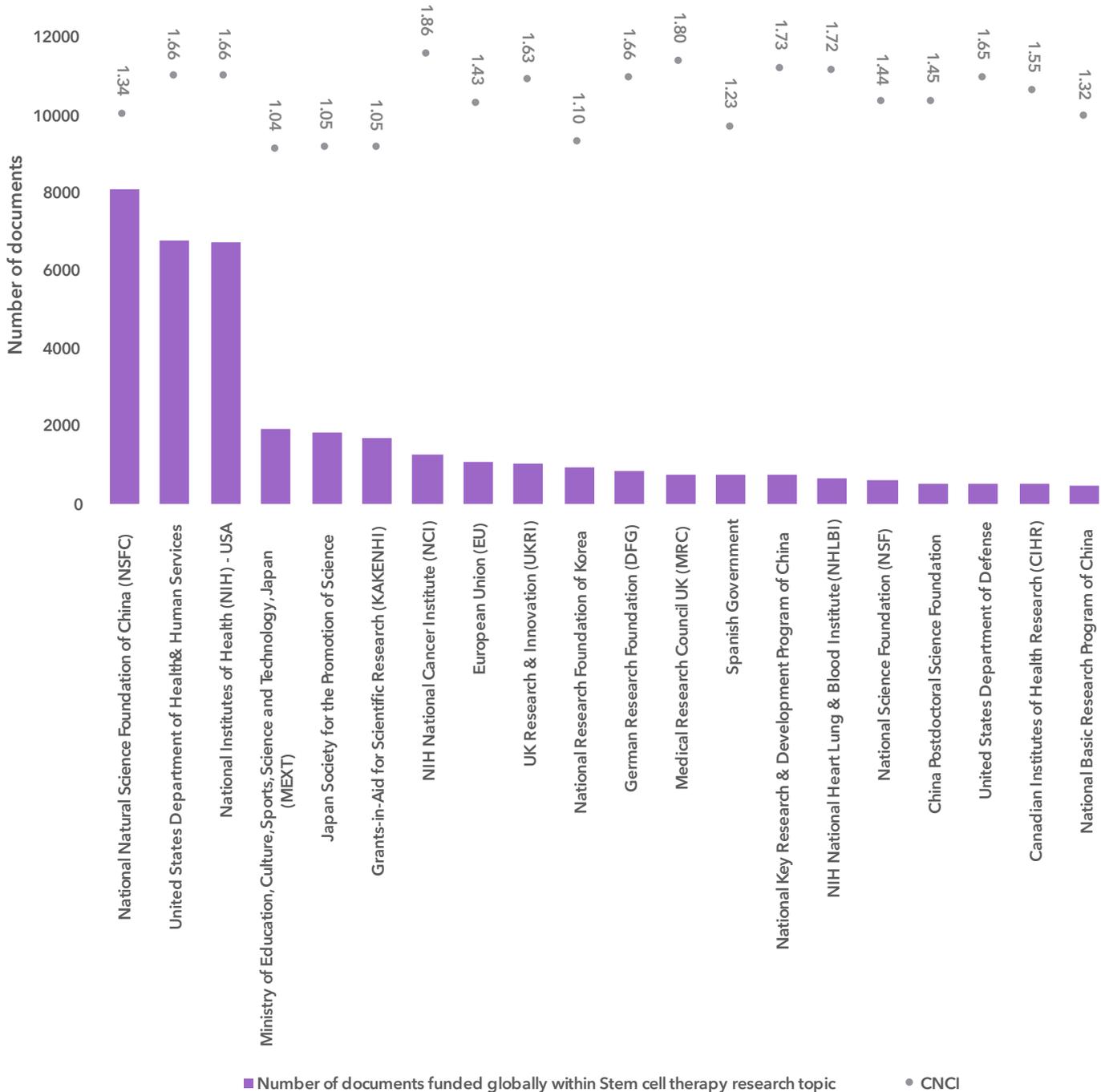
Figure 105: Top 20 funding organizations globally publications in the research topic Stem Cell Therapy in terms of number of publications in the period 2014-2023

The highest citation impact measured by the CNCI is observed in publications funded by NIH National Cancer Institute (NCI), Medical Research Council UK (MRC) and National Key Research & Development Program of China with 1.86, 1.80 and 1.73,

respectively. Among the top 20 global funding organizations, 12 are also among the top 20 funding organizations of Saudi publications in this research topic.

4.1.9.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia on the research topic of Stem Cell Therapy. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Micro & Long Noncoding RNA: Exosomes followed by Immunology: Macrophages and Molecular & Cell Biology - Cancer, Autophagy & Apoptosis: Warburg Effect as shown in Figure 106.

In Figure 107 The top 20 Saudi Arabia emerging micro-topics in this research topic are identified.

The top 3 emerging topics in Saudi Arabia are Molecular & Cell Biology - Cancer & Development: Cancer Stem Cells followed by Micro & Long Noncoding RNA: Exosomes and Polymers & Macromolecules: Gene Delivery.

Among Saudi Arabia's top 20 emerging micro-topics, there are three micro-topics that are also an emerging trend globally.

These are Micro & Long Noncoding RNA: Exosomes, Inorganic & Nuclear Chemistry: Cisplatin and Micro & Long Noncoding RNA: lncRNA. It is worth mentioning that the micro-topics Stem Cell Research: Pluripotency, Stem Cell Research: Mesenchymal Stem Cells, Micro & Long Noncoding RNA: MicroRNAs and Dentistry & Oral Medicine: Dental Trauma decreased within the total citations of Saudi Arabia publications in the research topic. Accordingly, one should monitor and assess the relevance of these topics locally and globally.
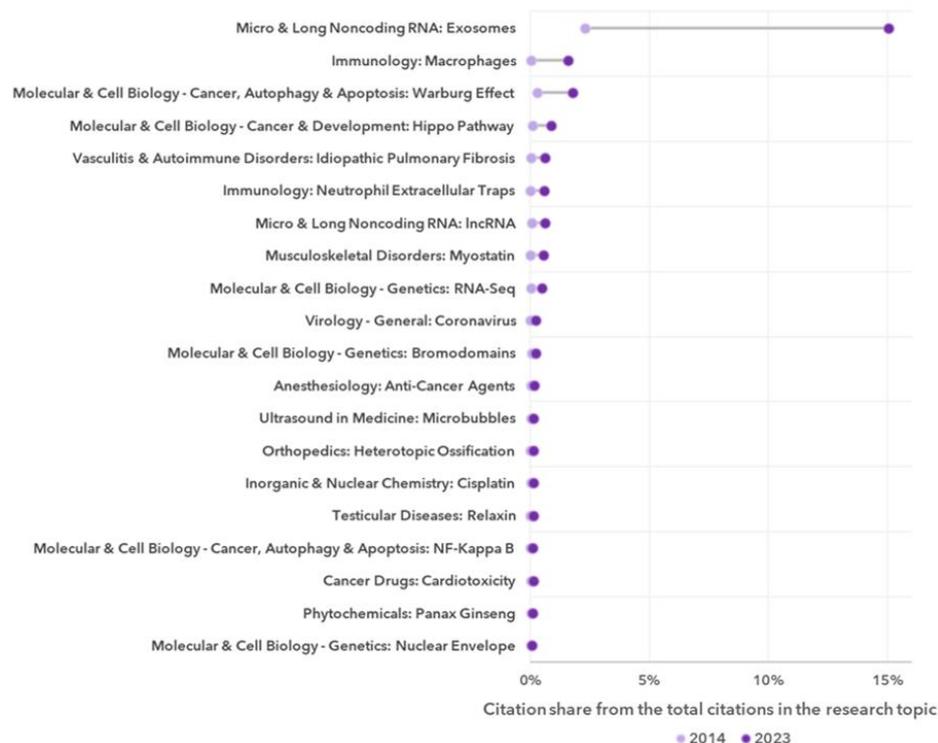
Figure 106: Top 20 emerging micro-topics globally in the research topic Stem Cell Therapy in the period 2014-2023
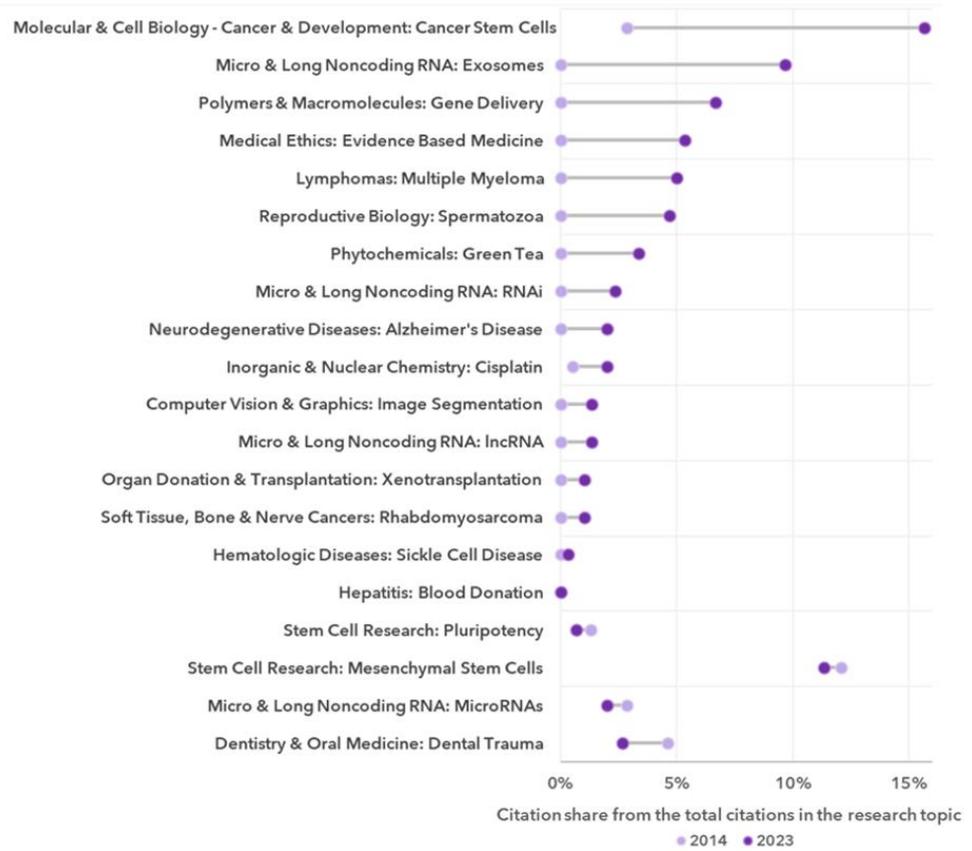
Figure 107: Top 20 emerging micro-topics in Saudi Arabia in the research topic Stem Cell Therapy in the period 2014-2023

4.1.10 Dengue

4.1.10.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications in the research topic increased from 0.61% in 2014 to 2.11% in 2017 and then decreased to 1.50% in 2019 to then increase to 4.25% in 2022 to then decrease to 3.64% in 2023 as shown in Figure 108. This shows that Saudi Arabia was able to increase the number of publications on this research topic with a growth rate higher than the global growth rate in the period 2014-2017 and 2019-2022. This is evident as the share of Saudi Arabian publications in the research topic is growing.

The CNCI of Saudi Arabia publications in this research topic was in several years higher than 1, indicating a citation impact performance higher than the global average. The CNCI increased from 1.07 in 2014 to 6.71 in 2016 to then decrease to 0.67 in 2019.

Afterwards the CNCI recovered from this value reaching 1.83 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia publications increased with a higher growth rate than the global average in this research topic for most years with a relatively good citation impact as measured by the CNCI.
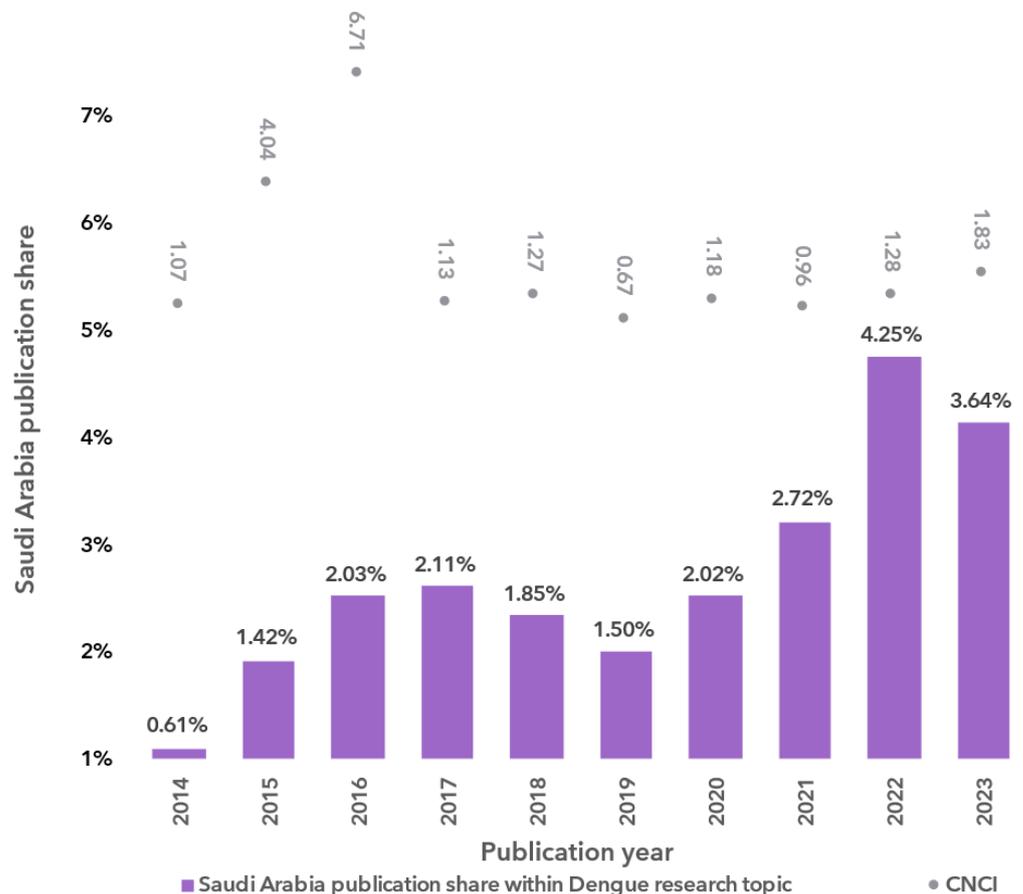
Figure 108: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.10.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating countries with Saudi Arabia in this research topic in the period 2014-2023 are India, followed by Pakistan and Italy, with 167, 77 and 75 publications, respectively, as shown in Figure 109. In terms of citation impact measured by the CNCI publications published in collaboration with the United Kingdom, Taiwan and

Malaysia had the highest CNCI with 11.08, 8.68, and 7.02, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
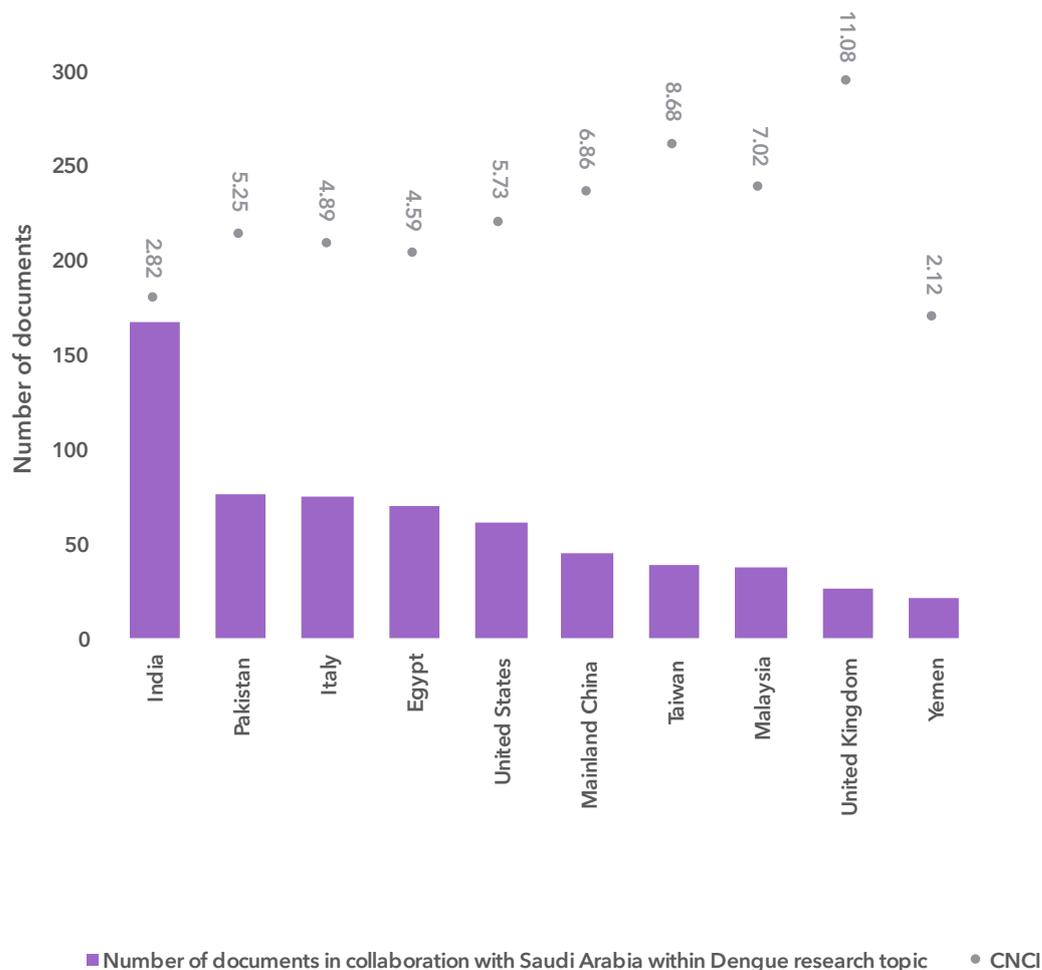

Figure 109: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications on the research topic Dengue in the period 2014-2023

4.1.10.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by NIH National Center for Advancing Translational Sciences (NCATS), Netherlands Organization for Scientific Research (NWO) and NIH Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD) with the same number of publications followed by Ministry of Education, Malaysia and Royal Society also with the same number of publications with 69, 25 and 24 publications respectively as shown in Figure 110.

Publications funded by Instituto de Salud Carlos III followed by Swiss National Science Foundation (SNSF) and NIH National Institute on Aging (NIA) had the highest citation impact measured by the CNCI with 15.12, 14.11 and 12.80, respectively.
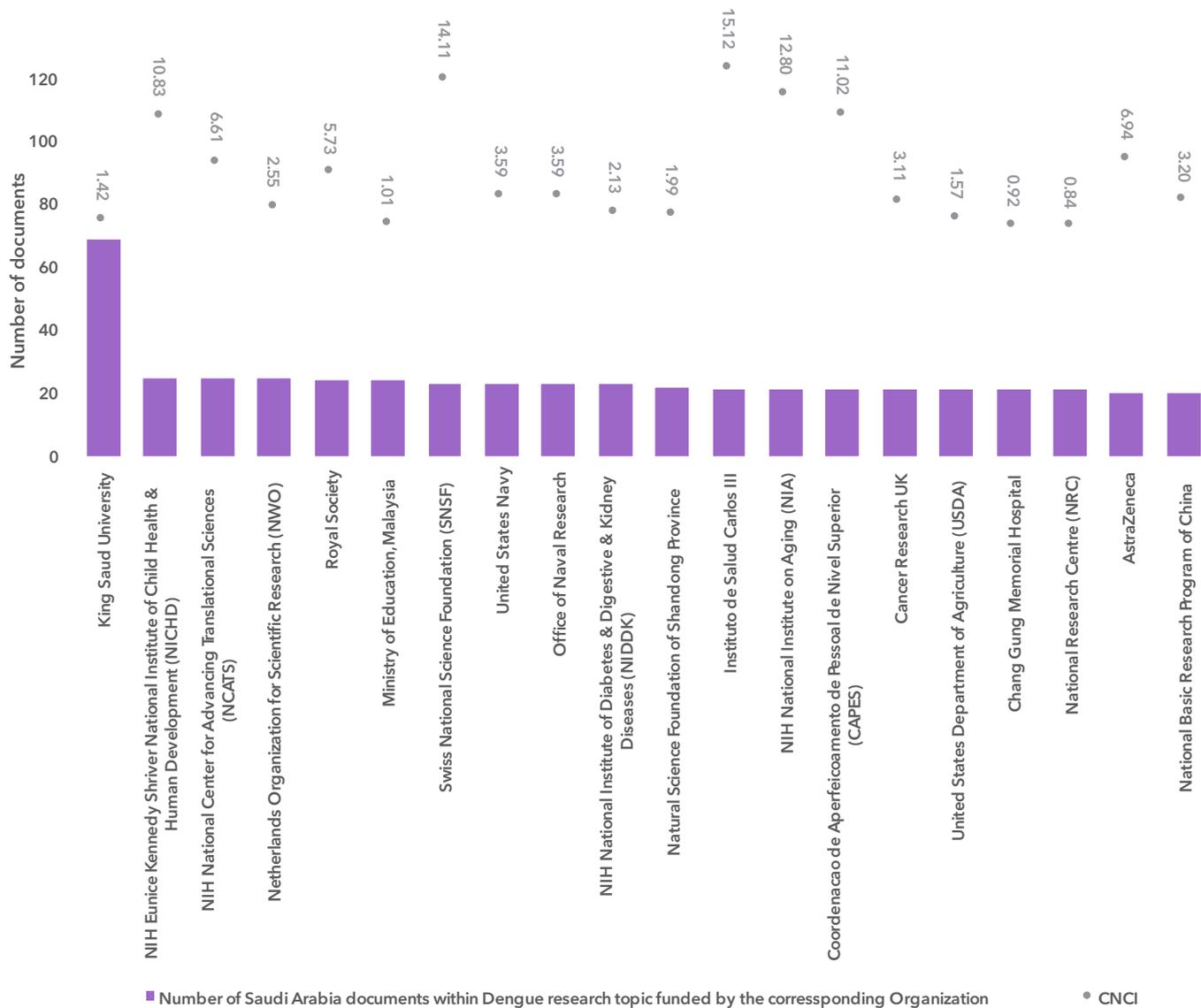
Figure 110: Top 20 funding organizations of Saudi Arabia publications in the research topic Dengue in terms of number of publications in the period 2014-2023

4.1.10.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and University of Tabuk with 132, 109 and 35 publications, respectively, as shown in Figure 111. In terms of citation impact as measured by the CNCI, Alfaisal University followed by Ministry of Health - Saudi Arabia and King Saud University had the highest CNCI with 26.01, 14.91 and 2.66, respectively.

Nevertheless, all top 20 organizations except King Khalid University, Imam Mohammad Ibn Saud Islamic University (IMSIU), Najran University, Umm Al Qura University and King Saud Bin Abdulaziz University for Health Sciences had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
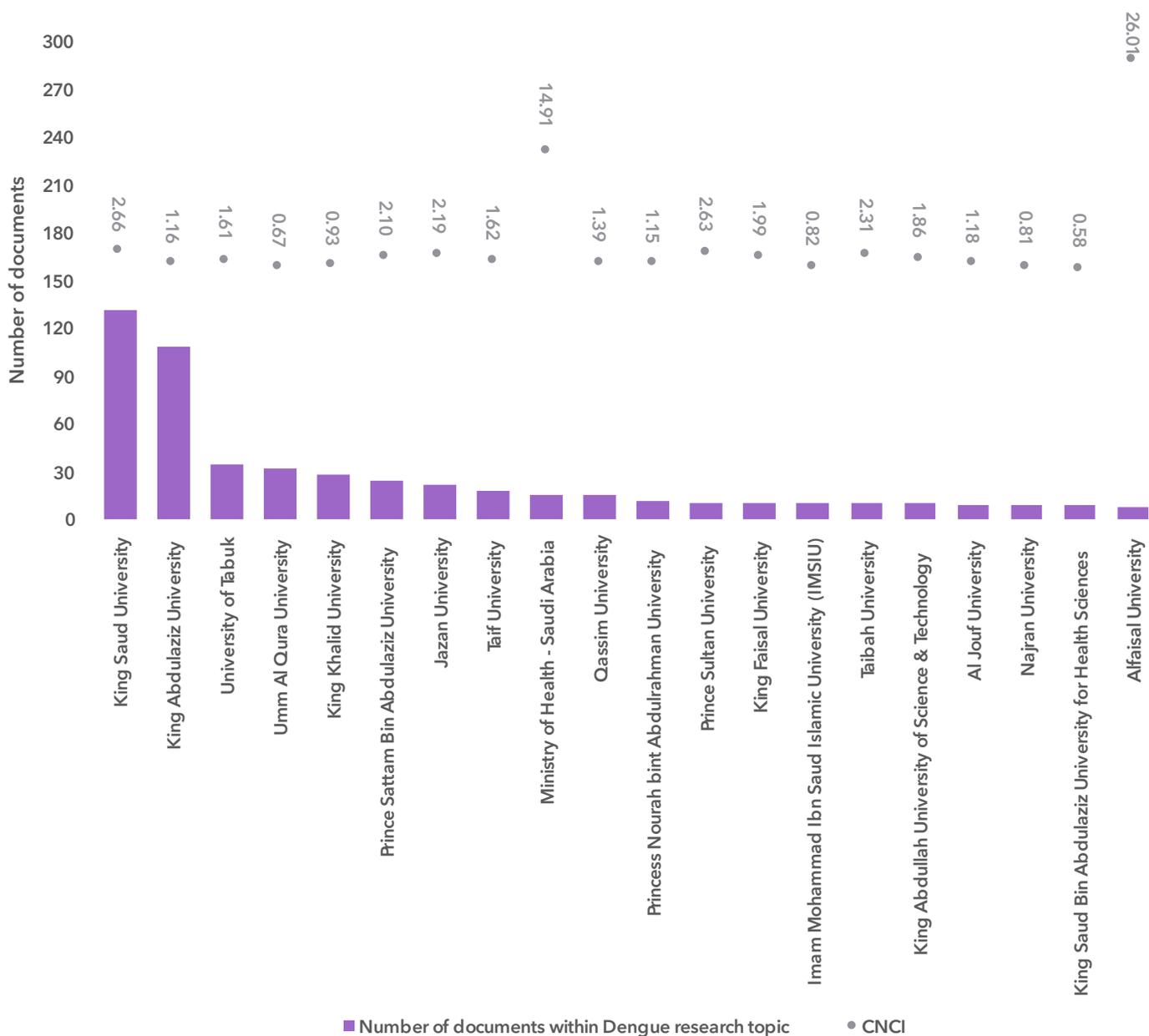
Figure 111: Top 20 Saudi organizations in terms of publications published on the research topic Dengue therapies in the period 2014-2023 and their corresponding CNCI

4.1.10.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Al Thabiani Aziz, affiliated with the University of Tabuk, followed by Naiyf S. Alharbi, affiliated with King Saud University, and Shine Kadaikunnan, affiliated with King Saud University, with 21, 18 and 17 publications, respectively as shown in Table 26.

The highest CNCI, number of Top 1% publications and number of Top 10% publications are achieved by Jamal M. Khaled with a CNCI of 2.28, 1 and 7 publications in Top 1% and Top 10% respectively.
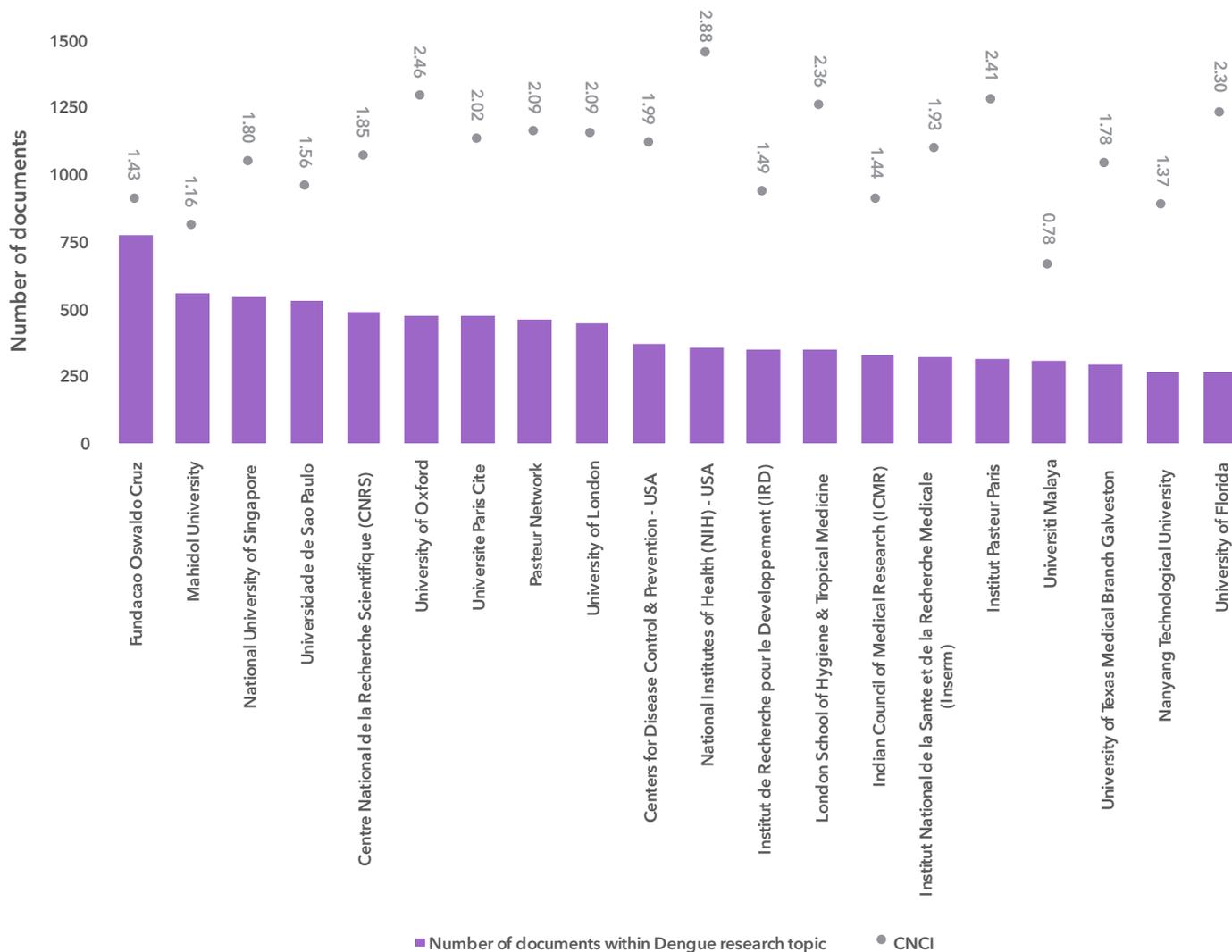
Table 26: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Dengue in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Aziz, Al Thabiani	University of Tabuk	21	1.51	0	5
Alharbi, Naiyf S.	King Saud University	18	1.91	1	6
Kadaikunnan, Shine	King Saud University	17	1.95	1	6
Khaled, Jamal M.	King Saud University	15	2.28	1	7
Mahyoub, Jazem A.	King Abdulaziz University	15	1.50	0	2
Alarfaj, Abdullah A.	King Saud University	14	2.14	0	6
Azhar, Esam I.	King Abdulaziz University	13	1.38	0	2
Alsalhi, Mohamad Saleh	King Saud University	11	1.85	0	4
Devanesan, Sandhanasamy	King Saud University	11	1.85	0	4
Munusamy, Murugan A.	King Saud University	9	2.15	0	4
Ahmed, Anwar	King Saud University	8	0.78	0	0
Al-Dhabi, Naif Abdullah	King Saud University	8	1.39	0	2
Iqbal, Muhammad Shahid	Prince Sattam Bin Abdulaziz University	6	0.03	0	0
Trivedi, Subrata	University of Tabuk	6	2.27	0	2
Alandijany, Thamir A.	King Abdulaziz University	5	1.82	0	2
Alwabli, Afaf S.	King Abdulaziz University	5	0.07	0	0
Bajrai, Leena H.	King Abdulaziz University	5	1.56	0	1
El-Kafrawy, Sherif A.	King Abdulaziz University	5	0.93	0	0
Farraj, Suha A.	King Abdulaziz University	5	0.67	0	0
Hashem, Anwar M.	King Abdulaziz University	5	0.71	0	0

4.1.10.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (5,690 publications), followed by India (2,752 publications) and Brazil (2,504 publications), as shown in Figure 112. The highest citation impact measured by the CNCI is achieved by publications published by United Kingdom followed by France and Singapore with a CNCI of 1.83, 1.79 and 1.72, respectively.

Five of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Malaysia, and India.
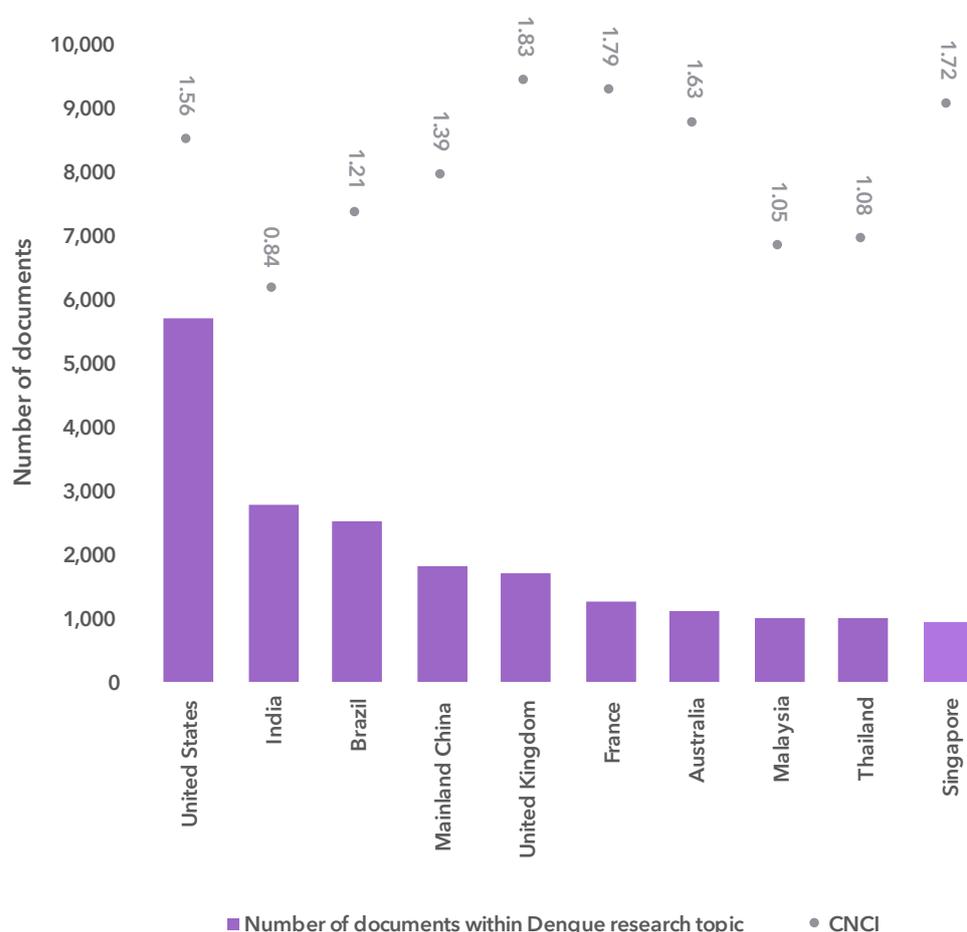
Figure 112: Top 10 countries in terms of the number of publications on the research topic Dengue in the period 2014-2023 and their corresponding CNCI

4.1.10.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are Fundacao Oswaldo Cruz (776 publications) followed by Mahidol University (559 publications) and National University of Singapore (545 publications) as shown in Figure 113.

In terms of citation impact measured by the CNCI, the National Institutes of Health (NIH) - USA, followed by the University of Oxford and Institut Pasteur Paris, had the highest CNCI with 2.88, 2.46 and 2.41, respectively.

Figure 113: Top 20 organizations globally in terms of the number of publications published on the research topic Dengue in the period 2014-2023 and their corresponding CNCI

4.1.10.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Eva Harris, affiliated to the University of California Berkeley, with 143 publications, followed by Giovanni Benelli, affiliated to the University of Pisa, with 117 publications, and Eng Eong Ooi, affiliated to the National University of Singapore, with 83 publications as shown in Table 27.

The highest CNCI is achieved by Thomas W. Scott affiliated to University of California Davis. Eva Harris affiliated to University of California Berkeley has also the highest number of Top 1% publications with 10 publications and the highest number of Top 10% publications with 51 publications.

Table 27: Top 20 researchers globally in terms of the number of publications published on the research topic Dengue in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Harris, Eva	University of California Berkeley	143	2.54	10	51	United States
Benelli, Giovanni	University of Pisa	117	2.48	8	47	Italy
Ooi, Eng Eong	National University of Singapore	83	1.47	1	20	Singapore
de Silva, Aravinda M.	University of North Carolina Chapel Hill	69	1.76	2	17	United States
Jarman, Richard G.	Walter Reed Army Institute of Research (WRAIR)	69	1.41	2	14	United States
Scott, Thomas W.	University of California Davis	65	3.65	7	27	United States
Ritchie, Scott A.	James Cook University	64	1.80	2	15	Australia
Liu, Qiyong	Chinese Center for Disease Control & Prevention	62	2.12	3	20	Mainland China
Morita, Kouichi	Nagasaki University	62	0.72	0	2	Japan
Vasudevan, Subhash G.	National University of Singapore	61	1.59	0	20	Singapore
Diamond, Michael S.	Washington University (WUSTL)	60	3.32	8	29	United States
Shi, Pei-Yong	University of Texas Medical Branch Galveston	60	2.05	3	22	United States
Hoffmann, Ary A.	University of Melbourne	58	2.30	7	23	Australia
Morrison, Amy C.	University of California System	56	1.40	1	12	United States
Govindarajan, Marimuthu	Annamalai University	55	2.14	3	18	India
Weaver, Scott C.	University of Texas Medical Branch Galveston	55	2.14	3	17	United States
Wilder-Smith, Annelies	Nanyang Technological University	55	1.70	1	15	Singapore
Sasmono, R. Tedjo	Eijkman Institute	53	1.14	0	11	Indonesia
Manrique-Saide, Pablo	Universidad Autonoma de Yucatan	51	1.38	1	9	Mexico
Qin, Cheng-Feng	Beijing Institute of Microbiology & Epidemiology	48	1.55	1	10	Mainland China

4.1.10.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 2,305 publications, followed by the National Institutes of Health (NIH) - USA with 2,146 publications, and Consejo Nacional de Desenvolvimento Cientifico e Tecnologico (CNPQ) with 1,067 publications as shown in Figure 114.

The highest citation impact measured by the CNCI is observed in publications funded by the Medical Research Council UK (MRC), Bill & Melinda Gates Foundation and UK Research & Innovation (UKRI) with 2.63, 2.55 and 2.43, respectively. Among the top 20 global funding organizations, one organization is also among the top 20 funding organizations of Saudi publications in this research topic.
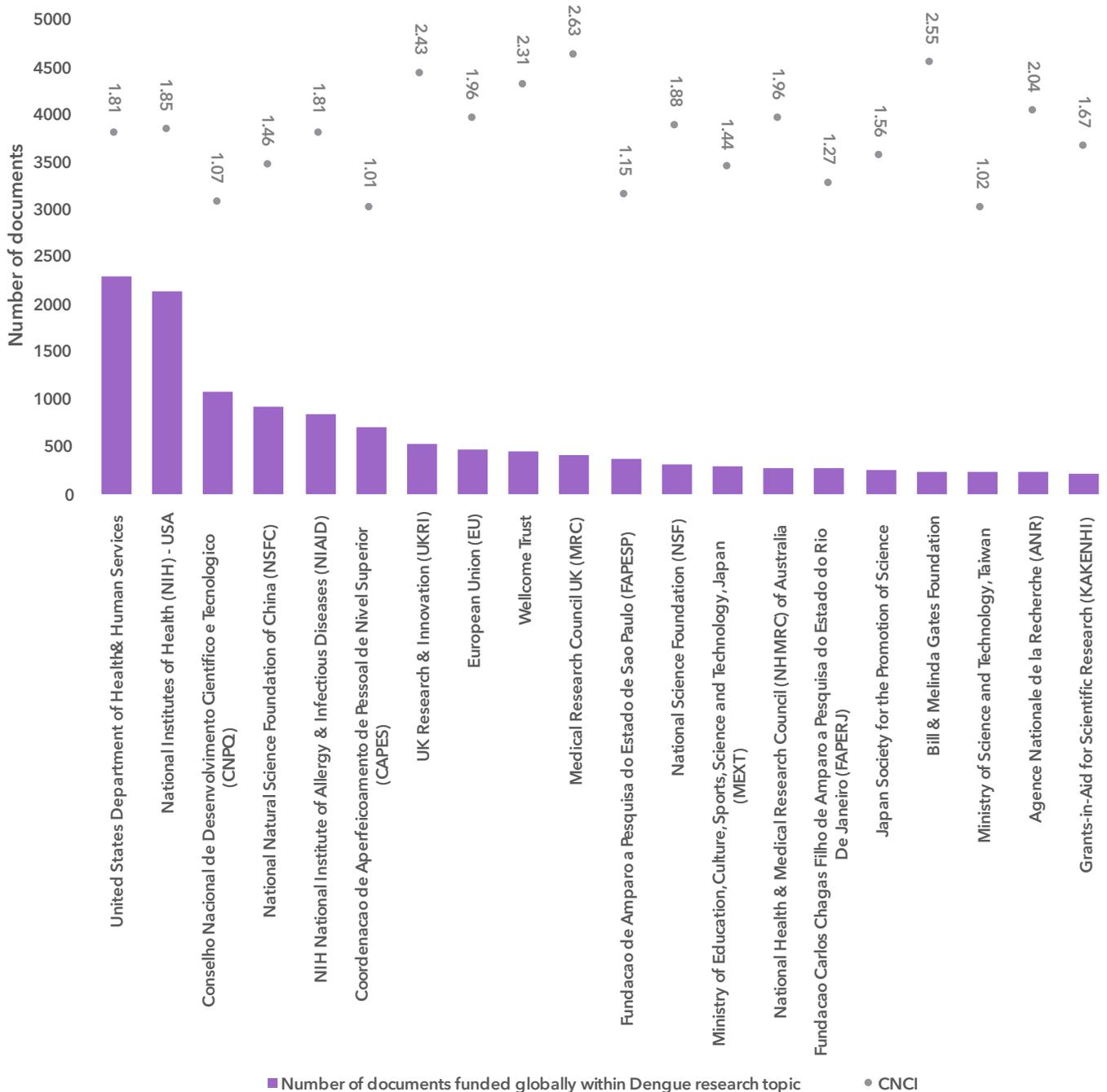
Figure 114: Top 20 funding organizations globally publications in the Dengue research topic in terms of number of publications in the period 2014-2023

4.1.10.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia regarding the research topic of Dengue. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends. The top 3 emerging micro-topics globally in this research topic are Numerical Methods: Fractional Calculus followed by Micro & Long Noncoding RNA: RNAi and Entomology: Wolbachia, as shown in Figure 115.

Table 28 shows the identified top 10 micro-topics in Saudi Arabia research output in this research topic.

Figure 115: Top 20 emerging micro-topics globally in the research topic Dengue in the period 2014-2023

Table 28: Top 10 Micro-topics identified in Saudi Arabia research output in the research topic Dengue in the period 2014-2023

Topics	Number of Saudi Arabia publications in the period 2014-2023
Dengue research topic	476
Virology - Tropical Diseases: Dengue	228
Nanoparticles: Silver Nanoparticles	72
Entomology: Limonoids	49
Numerical Methods: Fractional Calculus	20
Numerical Methods: Global Stability	12
Entomology: Wolbachia	9
Virology - General: Coronavirus	7
Artificial Intelligence & Machine Learning: Rough Sets	6
Parasitology - Malaria, Toxoplasmosis & Coccidiosis: Malaria	5
Health Literacy & Telemedicine: Health Literacy	5
Protein Structure, Folding & Modelling: Protein Folding	5

4.1.11 Vaccines

4.1.11.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased almost continuously from 2014 till 2023, as shown in Figure 116. This shows that Saudi Arabia was not only able to increase the number of publications on this research topic but also had a growth higher than the global growth rate. This is evident as the share of Saudi Arabian publications in the research topic is growing. The CNCI of Saudi Arabia publications in this research topic were in almost all years higher than 1, indicating a citation impact performance higher than the global average. The CNCI increased from 1.34 in 2014 to 3.52 in 2018 and then decreased to 1.21 in 2019, then recovered to 1.54 in 2023. In a high publication period, it is usually observed that the citation impact decreases, as also observed in this case. Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing the citation impact, which shows a recovery in 2022 and 2023.
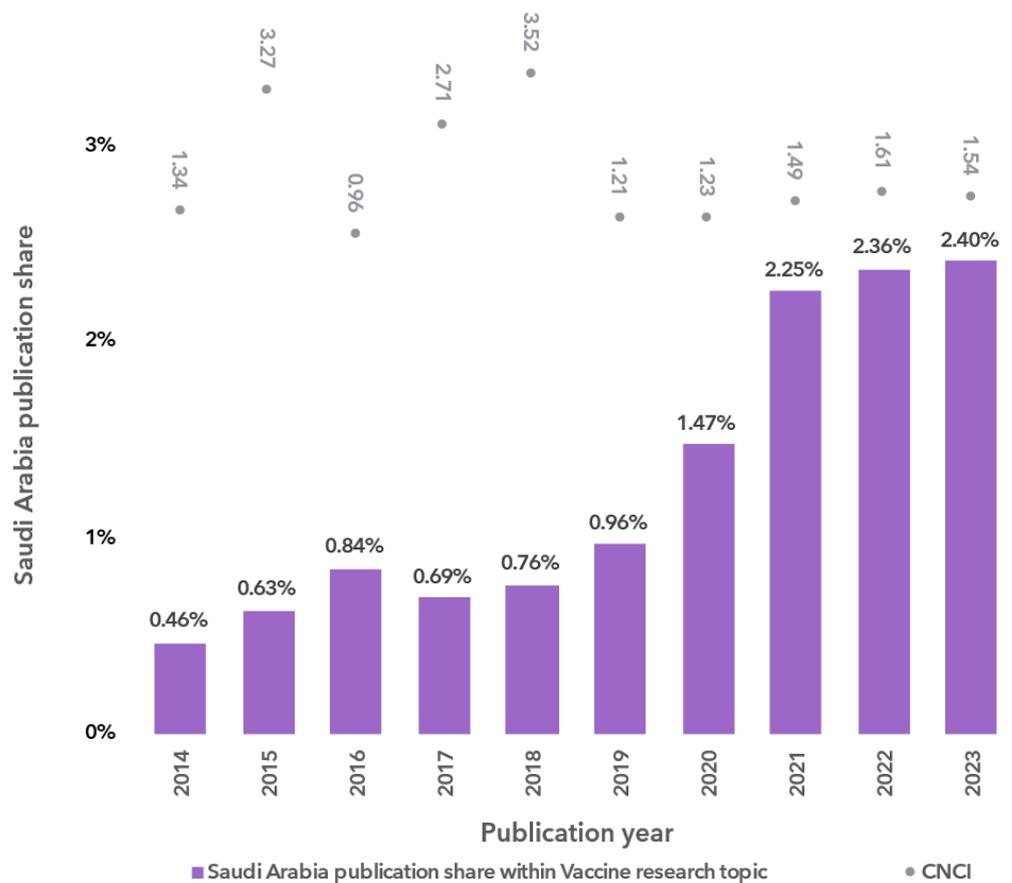
Figure 116: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.11.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating country with Saudi Arabia in this research topic in the period 2014-2023 is Egypt followed by India and Pakistan with 635, 529 and 518 publications, respectively as shown in Figure 117. In terms of citation impact measured by the CNCI publications published in collaboration with Canada followed by Malaysia and United Arab Emirates had the highest CNCI with 8.72, 8.42 and 7.67, respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1 reflecting a performance higher than the global average.
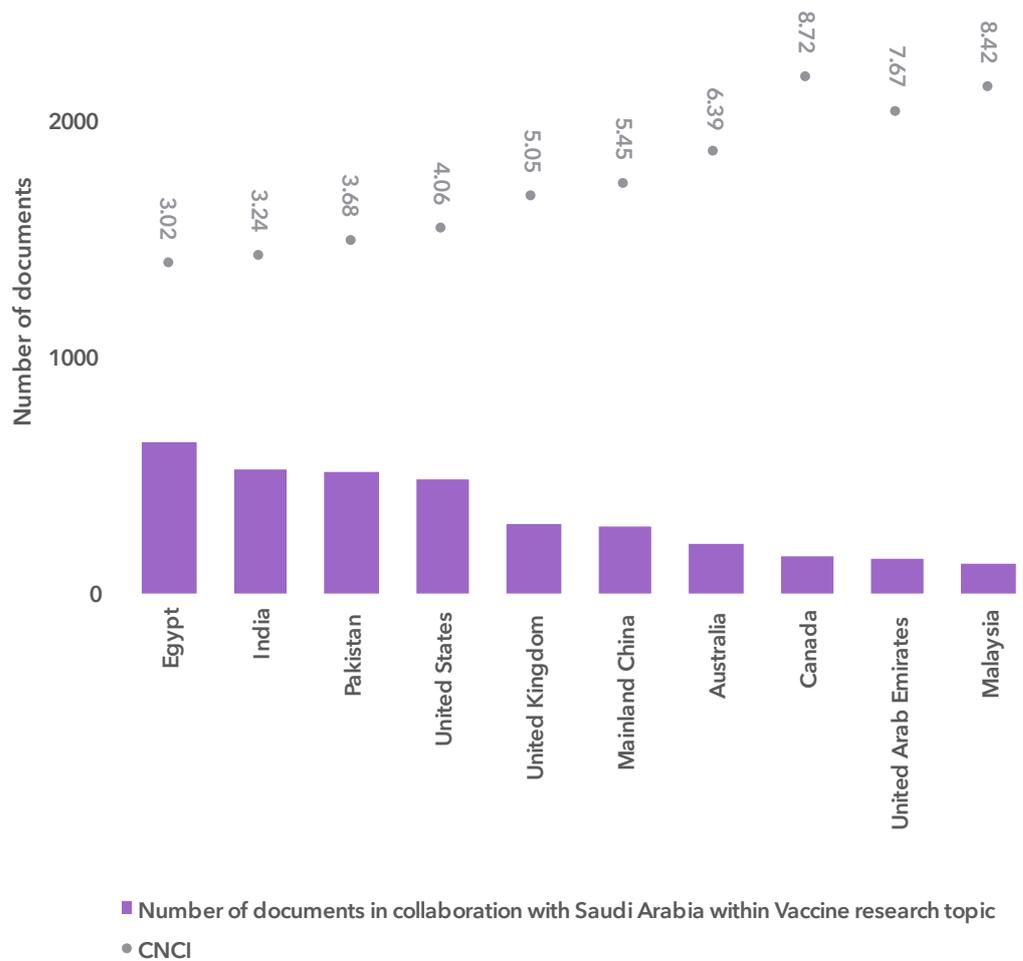
Figure 117: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications on the research topic Vaccines in the period 2014-2023
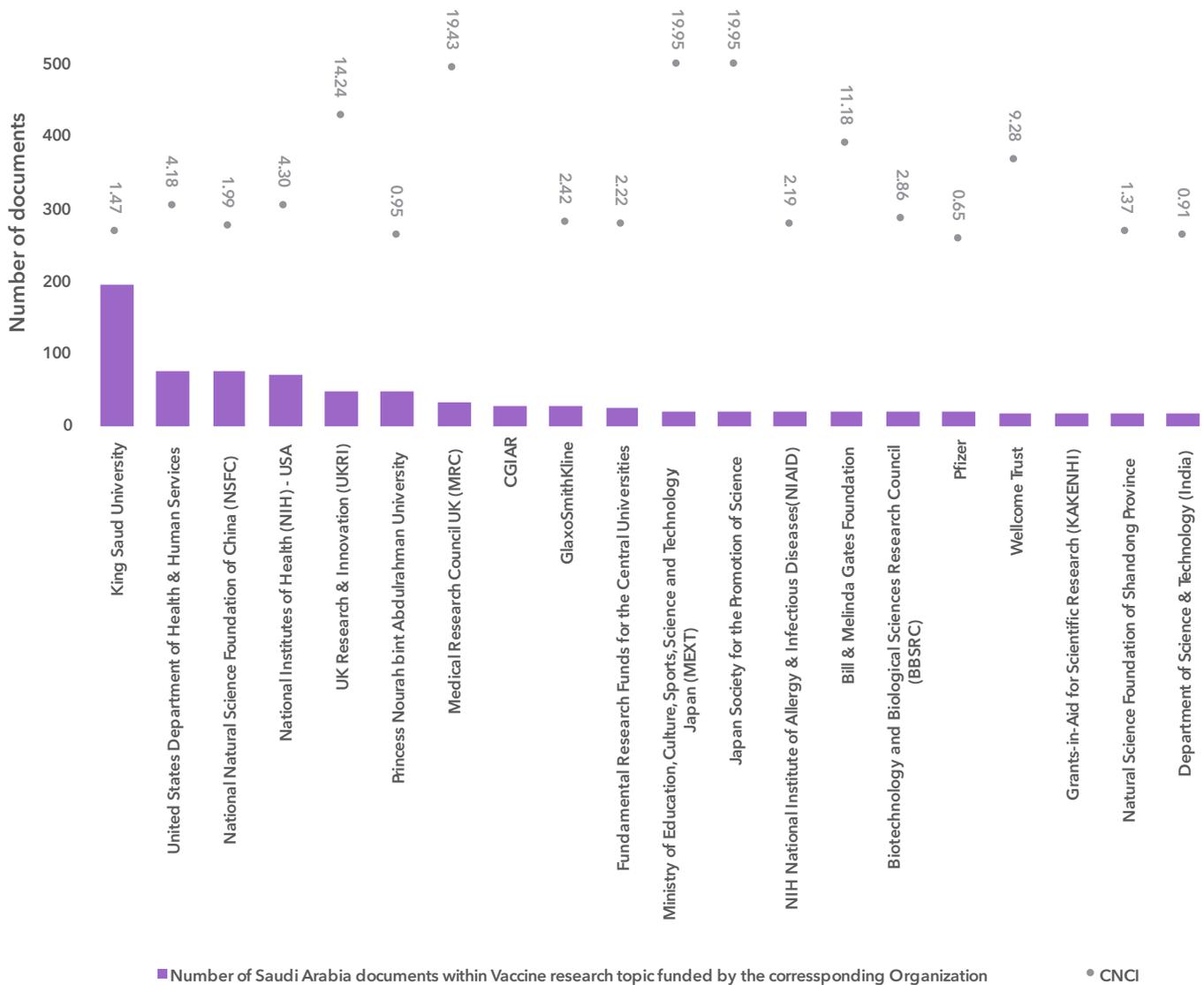
4.1.11.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by the United States Department of Health & Human Services and National Natural Science Foundation of China (NSFC) with 196, 75 and 74 publications respectively as shown in Figure 118.

Publications funded by Grants-in-Aid for Scientific Research (KAKENHI), followed by CGIAR and Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) had the highest citation impact measured by the CNCI with 24.69, 21.68 and 19.95, respectively.

The chart shows "Number of documents" on the vertical axis with values 0, 100, 200, 300, 400, 500.

Bars with CNCI values (from left to right):

- King Saud University — 1.47
- United States Department of Health & Human Services — 4.18
- National Natural Science Foundation of China (NSFC) — 1.99
- National Institutes of Health (NIH) - USA — 4.30
- UK Research & Innovation (UKRI) — 14.24
- Princess Nourah bint Abdulrahman University — 0.95
- Medical Research Council UK (MRC) — 19.43
- CGIAR —
- GlaxoSmithKline — 2.42
- Fundamental Research Funds for the Central Universities — 2.22
- Ministry of Education, Culture, Sports, Science and Technology Japan (MEXT) — 19.95
- Japan Society for the Promotion of Science — 19.95
- NIH National Institute of Allergy & Infectious Diseases(NIAID) — 2.19
- Bill & Melinda Gates Foundation — 11.18
- Biotechnology and Biological Sciences Research Council (BBSRC) — 2.86
- Pfizer — 0.65
- Wellcome Trust — 9.28
- Grants-in-Aid for Scientific Research (KAKENHI) —
- Natural Science Foundation of Shandong Province — 1.37
- Department of Science & Technology (India) — 0.91

■ Number of Saudi Arabia documents within Vaccine research topic funded by the corressponding Organization   ● CNCI

Figure 118: Top 20 funding organizations of Saudi Arabia publications in the research topic Vaccines in terms of number of publications in the period 2014-2023

4.1.11.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and in the period 2014-2023 are King Saud University followed by King Abdulaziz University and King Saud Bin Abdulaziz University for Health Sciences with 601, 504 and 212 publications, respectively, as shown in Figure 119.

In terms of citation impact as measured by the CNCI, Ministry of Health - Saudi Arabia followed by University Ha'il and Alfaisal University had the highest CNCI with 5.82, 5.03 and 4.72, respectively.

Nevertheless, all top 20 organizations except Umm Al Qura University had a CNCI higher than 1, reflecting a citation impact performance higher than the global average.
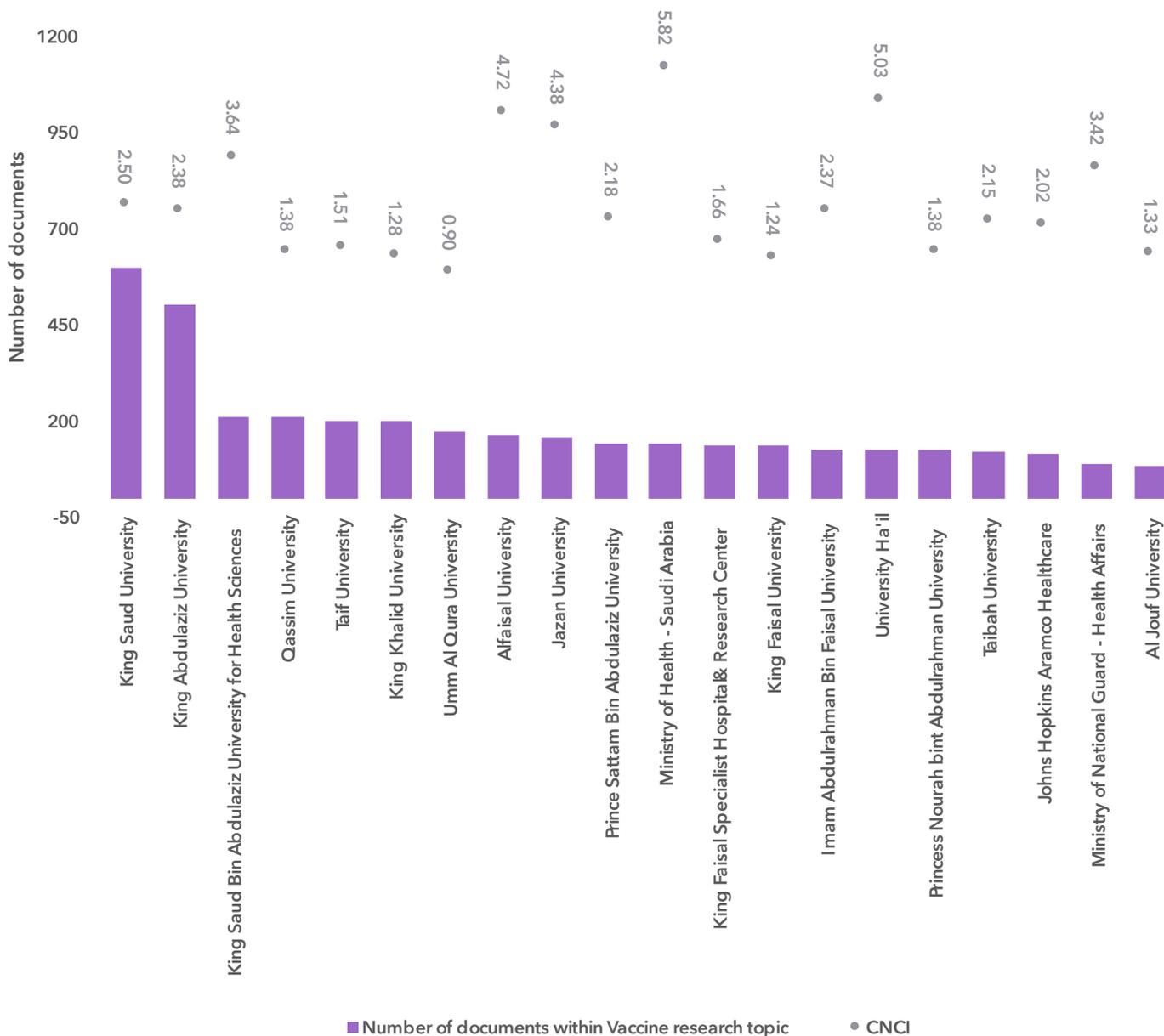
Figure 119: Top 20 Saudi organizations in terms of publications published on the research topic Vaccines in the period 2014-2023 and their corresponding CNCI

4.1.11.5 The top 20 researchers are affiliated with Saudi organizations in terms of the number of publications they publish.

The highest number of publications are published by Ziad A. Memish, affiliated to Alfaisal University, followed by Anwar M. Hashem, affiliated to King Abdulaziz University, and Mohamad-Hani Temsah, affiliated to King Saud University, both with the same number of publications, and Tasawar Hayat, affiliated to King Abdulaziz University with 39, 29 and 28 publications respectively as shown in Table 29.

The highest CNCI and number of Top 10% publications are achieved by Mohamad-Hani Temsah with a CNCI of 16.36 and 18 Top 10% publications. The latter and Ziad A. Memish both had the highest number of Top 1% publications, amounting to eight publications.

Table 29: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Vaccines in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Memish, Ziad A.	Alfaisal University	39	10.42	8	15
Hashem, Anwar M.	King Abdulaziz University	29	1.04	0	7
Temsah, Mohamad-Hani	King Saud University	29	16.36	8	18
Hayat, Tasawar	King Abdulaziz University	28	1.98	2	10
Alshammari, Abdulrahman	King Saud University	22	2.01	0	9
Azhar, Esam I.	King Abdulaziz University	22	0.96	0	4
Alharbi, Metab	King Saud University	21	2.33	0	10
Alharbi, Naif Khalaf	King Saud Bin Abdulaziz University for Health Sciences	20	1.12	0	4
Abdel-Moneim, Ahmed S.	Taif University	19	3.45	2	5
Haque, Shafiul	Jazan University	19	3.36	3	3
Algaissi, Abdullah	Jazan University	17	2.19	2	8
Alzahrani, Khalid J.	Taif University	17	0.89	0	2
Yezli, Saber	Ministry of Health - Saudi Arabia	16	0.86	0	2
Alsaedi, Ahmed	King Abdulaziz University	15	2.43	1	7
Alshukairi, Abeer N.	King Faisal Specialist Hospital & Research Center	14	2.35	1	4
Barry, Mazin	King Saud University	14	2.51	1	6
Nisar, Kottakkaran Sooppy	Prince Sattam Bin Abdulaziz University	14	3.32	0	7
Albutti, Aqel	Qassim University	13	0.98	0	2
Alfelali, Mohammad	King Abdulaziz University	13	0.47	0	0
El-Kafrawy, Sherif A.	King Abdulaziz University	13	0.96	0	1

4.1.11.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (67,165 publications), followed by Mainland China (27,205 publications) and the United Kingdom (18,850 publications), as shown in Figure 120.

The highest citation impact measured by the CNCI is achieved by publications published by United Kingdom, Germany, and Canada with a CNCI of 2.06, 1.83 and 1.81, respectively. Six of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Canada, Australia, and India.
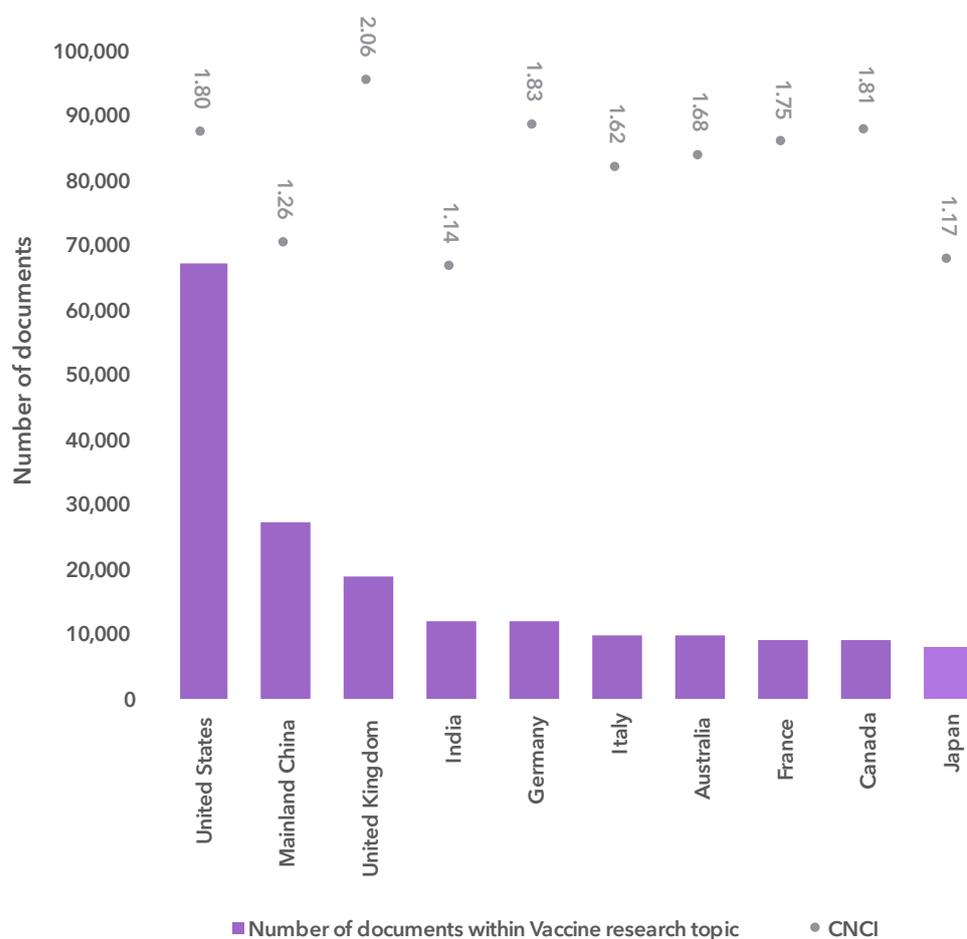
Figure 120: Top 10 countries in terms of number of publications in the research topic Vaccines in the period 2014-2023 and their corresponding CNCI

4.1.11.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of number of publications published in this research topic in the period 2014-2023 are the University of London (5,462 publications) followed by Harvard University (5,328 publications) and Peter Doherty Institute (4,931 publications) as shown in Figure 121.

In terms of citation impact measured by the CNCI, University of Washington Seattle followed by University of Oxford and University of Washington had the highest CNCI with 3.36, 3.35 and 3.34, respectively.
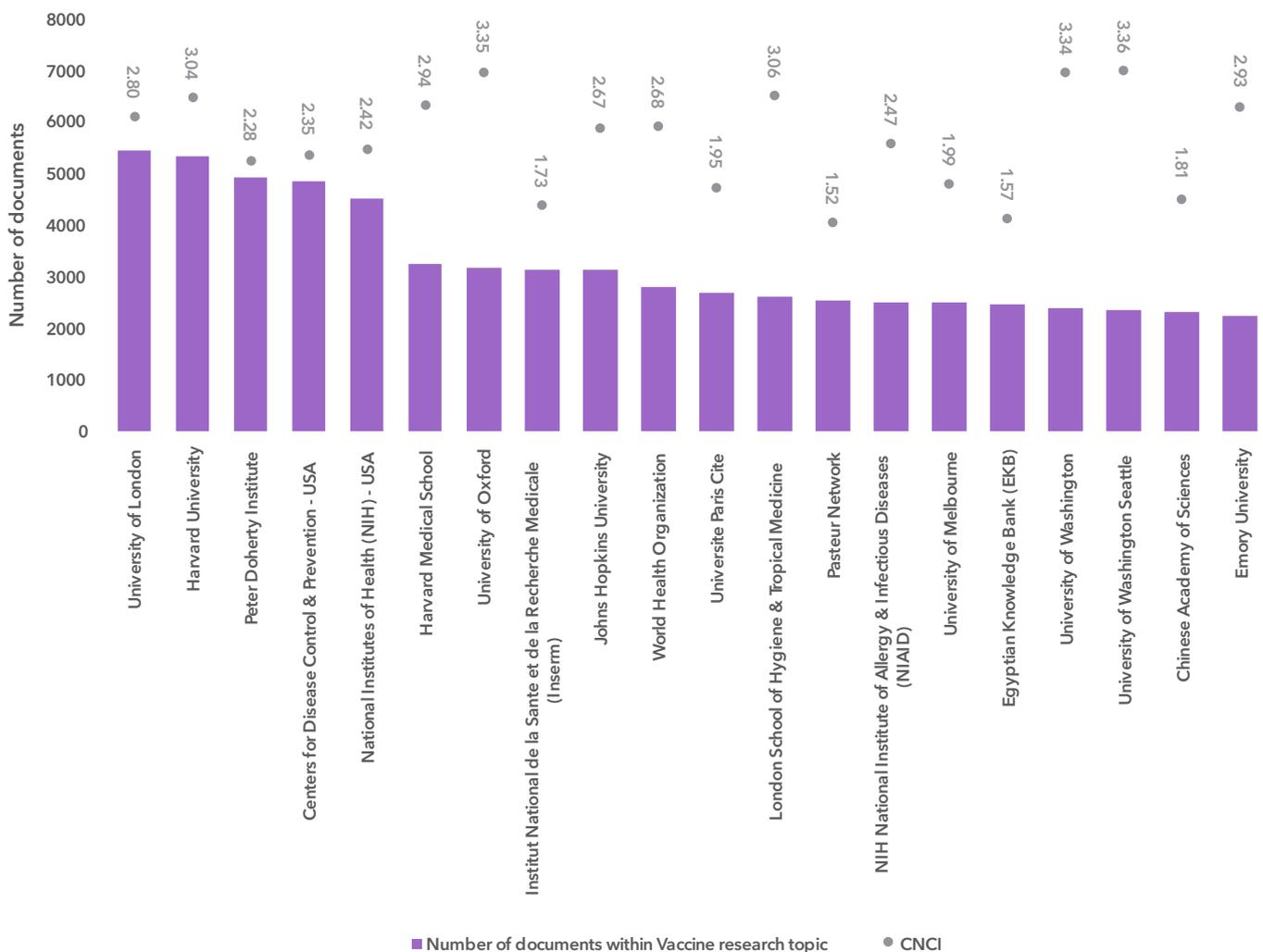
Figure 121: Top 20 organizations globally in terms of number of publications published in the research topic Vaccines in the period 2014-2023 and their corresponding CNCI

4.1.11.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Florian Krammer, affiliated to Icahn School of Medicine at Mount Sinai, with 294 publications, followed by Andrew J. Pollard, affiliated to the University of Oxford, with 263 publications, and David C. Montefiori, affiliated to Duke University with 247 publications as shown in Table 30. The highest CNCI is achieved by Barney S. Graham, affiliated with the National Institutes of Health (NIH) - USA.

The highest number of Top 1% publications is achieved by Galit Alter affiliated to Harvard University. The highest number of Top 10% publications is achieved by Florian Krammer affiliated to Icahn School of Medicine at Mount Sinai.

Table 30: Top 20 researchers globally in terms of the number of publications published on the research topic Vaccines in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Krammer, Florian	Icahn School of Medicine at Mount Sinai	294	4.04	30	128	United States
Pollard, Andrew J.	University of Oxford	263	4.83	26	79	England
Montefiori, David C.	Duke University	247	2.68	16	80	United States
Kent, Stephen J.	Peter Doherty Institute	240	4.66	12	40	Australia
Ward, Andrew B.	Scripps Research Institute	222	3.18	21	122	United States
Mascola, John R.	National Institutes of Health (NIH) - USA	219	4.04	30	117	United States
Alter, Galit	Harvard University	211	4.07	35	102	United States
Sette, Alessandro	La Jolla Institute for Immunology	210	5.48	25	89	United States
Graham, Barney S.	National Institutes of Health (NIH) - USA	209	7.79	30	111	United States
Madhi, Shabir A.	University of Witwatersrand	209	3.66	11	54	South Africa
Parashar, Umesh D.	Centers for Disease Control & Prevention - USA	205	1.70	8	40	United States
Barouch, Dan H.	Harvard University	193	5.14	32	87	United States
Wilson, Ian A.	Scripps Research Institute	192	3.36	19	103	United States
Haynes, Barton F.	Duke University	189	2.56	14	68	United States
Tomaras, Georgia D.	Duke University	185	1.63	6	43	United States
Jit, Mark	London School of Hygiene & Tropical Medicine	178	2.84	8	56	England
Xia, Ningshao	Xiamen University	171	1.01	1	17	Mainland China
Qadri, Firdausi	International Centre for Diarrhoeal Disease Research (ICDDR)	167	1.27	3	26	Bangladesh
Klein, Nicola P.	Kaiser Permanente	164	3.91	19	54	United States
Tate, Jacqueline E.	Centers for Disease Control & Prevention - USA	164	1.41	6	26	United States

4.1.11.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the United States Department of Health & Human Services with 25,295 publications, followed by the National Institutes of Health (NIH) - USA with 23,085 publications, and the National Natural Science Foundation with China (NSFC) with 12,895 publications as shown in Figure 122.

The highest citation impact measured by the CNCI is observed in publications funded by Medical Research Council UK (MRC), UK Research & Innovation (UKRI) and CGIAR, with 3.12, 2.75 and 2.71, respectively. Among the top 20 global funding organizations, 12 are also among the top 20 funding organizations of Saudi publications in this research topic.

■ Number of documents funded globally within Vaccine research topic ● CNCI
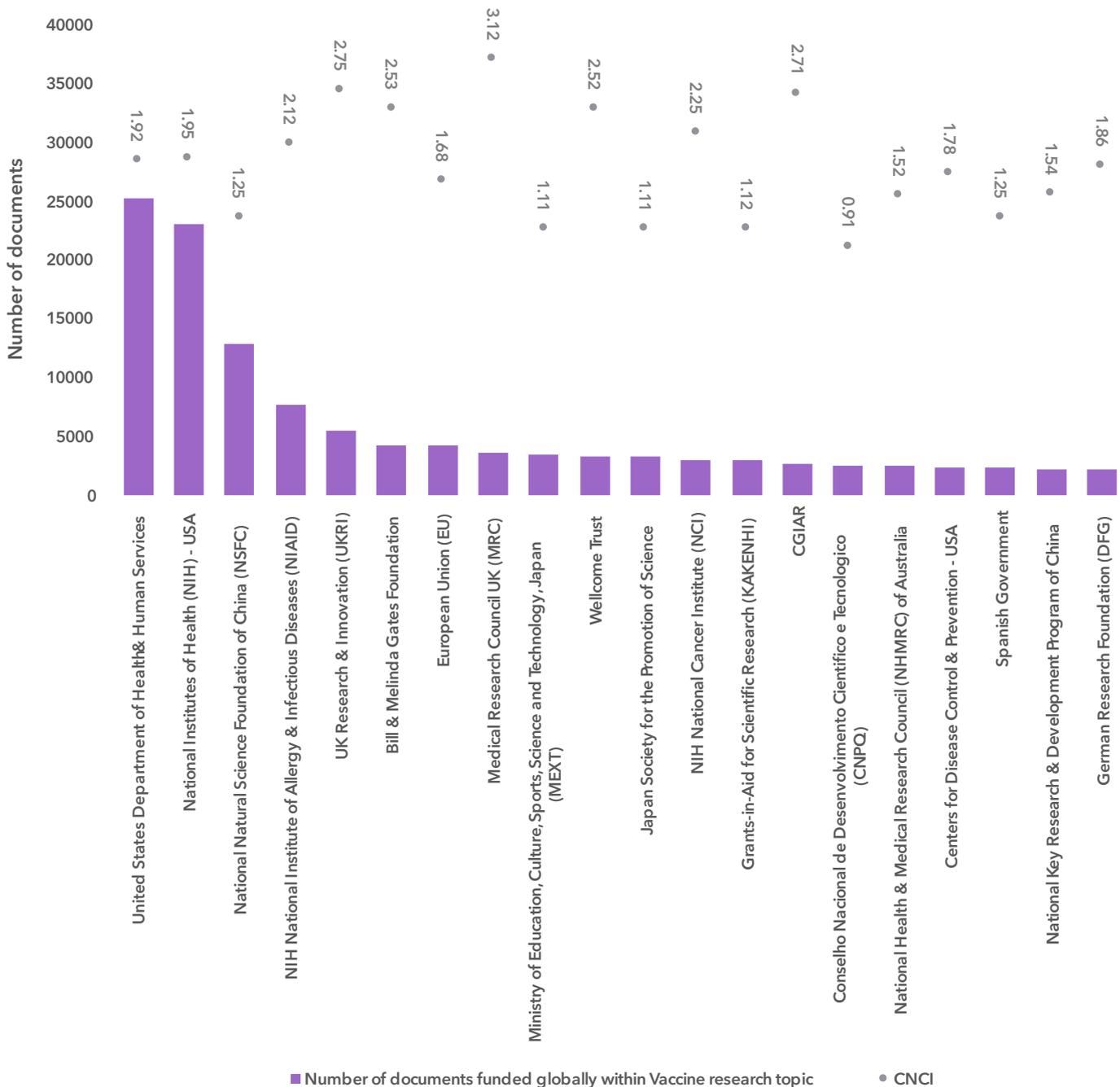
Figure 122: Top 20 funding organizations globally publications in the research topic Vaccines in terms of number of publications in the period 2014-2023

4.1.11.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia in the research topic of Vaccines. For more information on the methodology used to identify emerging trends, please see the section Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Virology - General: Coronavirus followed by Blood Clotting: Heparin-Induced Thrombocytopenia and Cardiology - General: Myocarditis as shown in Figure 123. In Figure 124 the top 20 Saudi Arabia emerging micro-topics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Virology - Identification & Sequencing: Vaccinia Virus followed by Antibiotics & Antimicrobials: Antibiotic Resistance and Numerical Methods: Fractional Calculus.

Among Saudi Arabia's top 20 emerging micro-topics, there are four micro-topics that are also emerging trends globally. These are Numerical Methods: Fractional Calculus, Blood Clotting, Heparin-Induced Thrombocytopenia, Cardiology - General, Myocarditis and Virology - General, Coronavirus. It is worth mentioning that the micro-topics Virology - General: Measles, Virology - Identification & Sequencing: HSV-1, Virology - General: Coronavirus and Virology - General: Influenza citation share in Saudi Arabia decreased within the total citations of Saudi Arabia publications in the research topic. Accordingly, one should monitor and assess the relevance of those topics locally and globally.
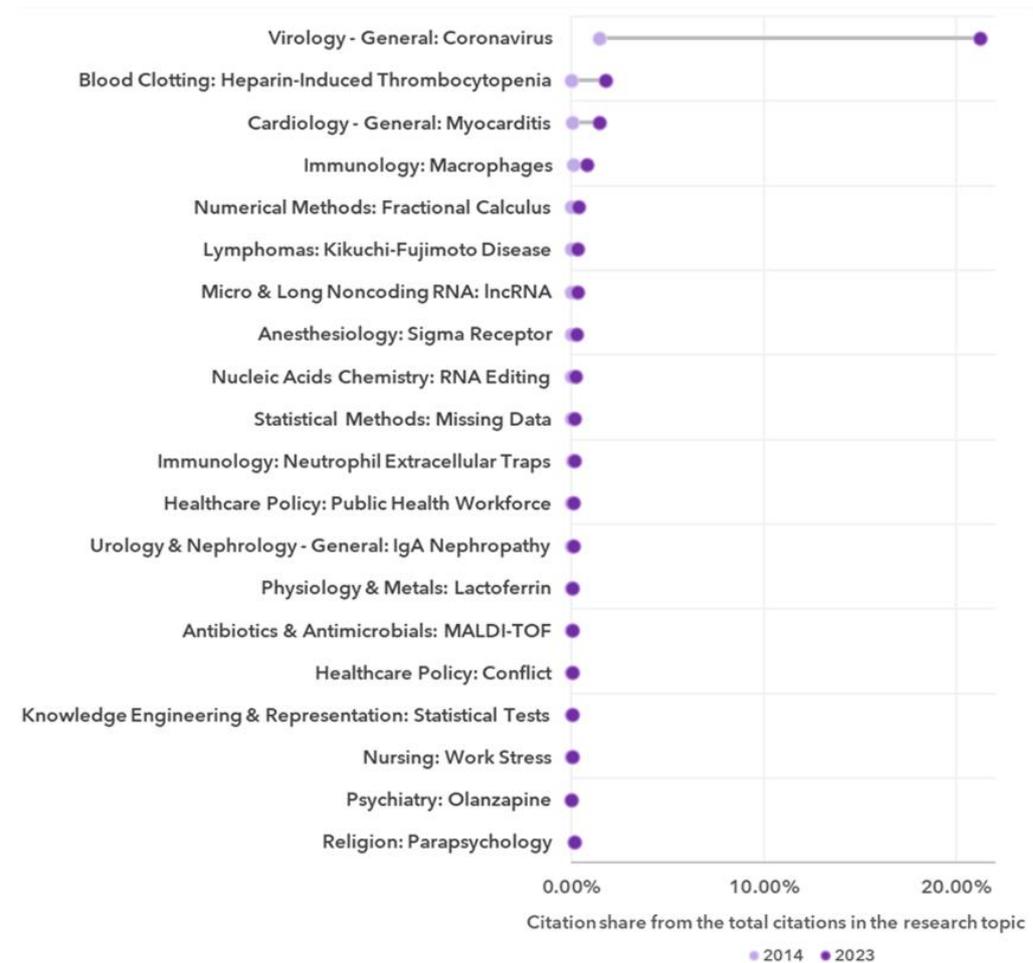
Figure 123: Top 20 emerging micro-topics globally in the research topic Vaccines in the period 2014-2023
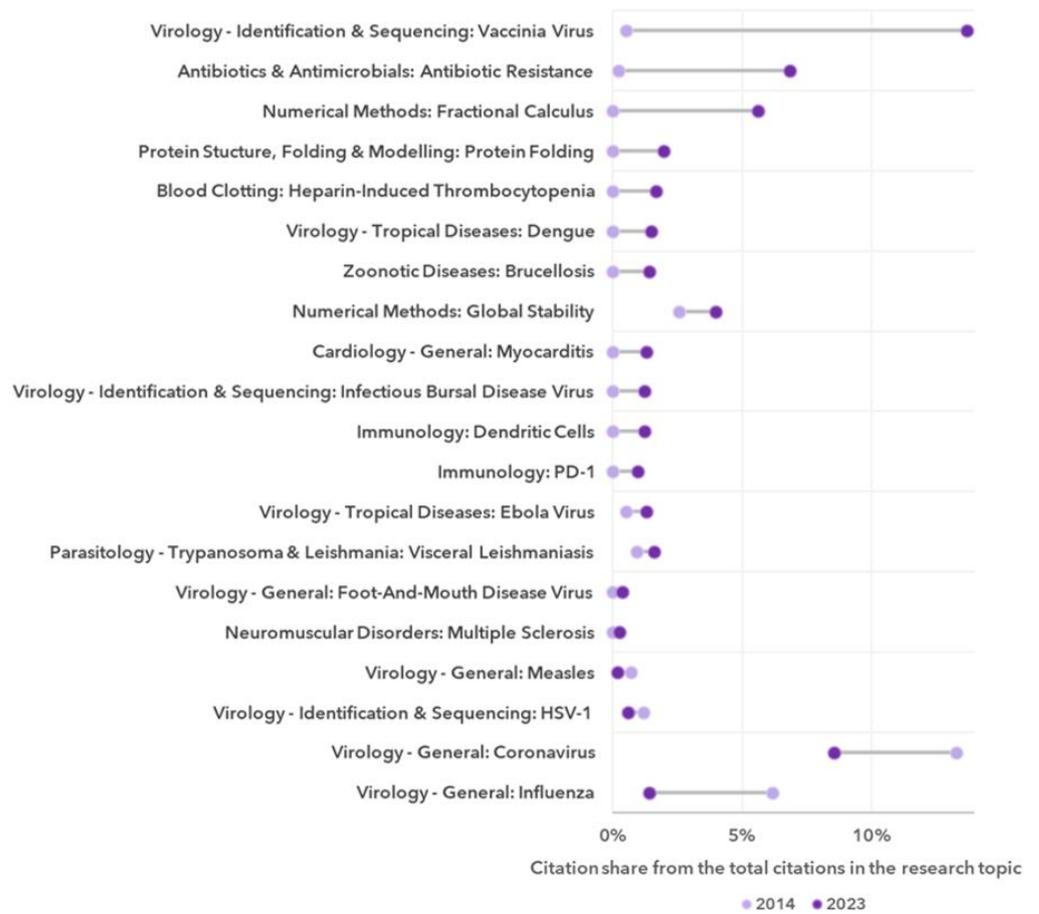
Figure 124: Top 20 emerging micro-topics in Saudi Arabia in the research topic Vaccines in the period 2014-2023

4.1.12 Antimicrobial Resistance

4.1.12.1 Evolution of Saudi publication share of global publications in the research topic

The share of Saudi Arabia publications from global publications on the research topic increased almost continuously from 2014 till 2023 as shown in Figure 125. This shows that Saudi Arabia was not only able to increase the number of publications in this research topic but also having a growth higher than the global growth rate. This is evident as the share of Saudi Arabian publications in the research topic is growing.

The CNCI of Saudi Arabia publications in this research topic were in all years higher than 1, indicating a citation impact performance higher than the global average. The CNCI decreased from 1.44 in 2014 to 1.07 in 2020 to then recover to 1.546 in 2023. In high publication period it is usually observed that the citation impact decreases as also observed in this case.

Overall, Saudi Arabia's publications increased with a higher growth rate than the global average in this research topic and had a relatively good citation impact, as measured by the CNCI. Nevertheless, after this high growth rate in terms of publications, one should focus on increasing/ conserving a high citation impact, which shows a recovery in 2021-2023.
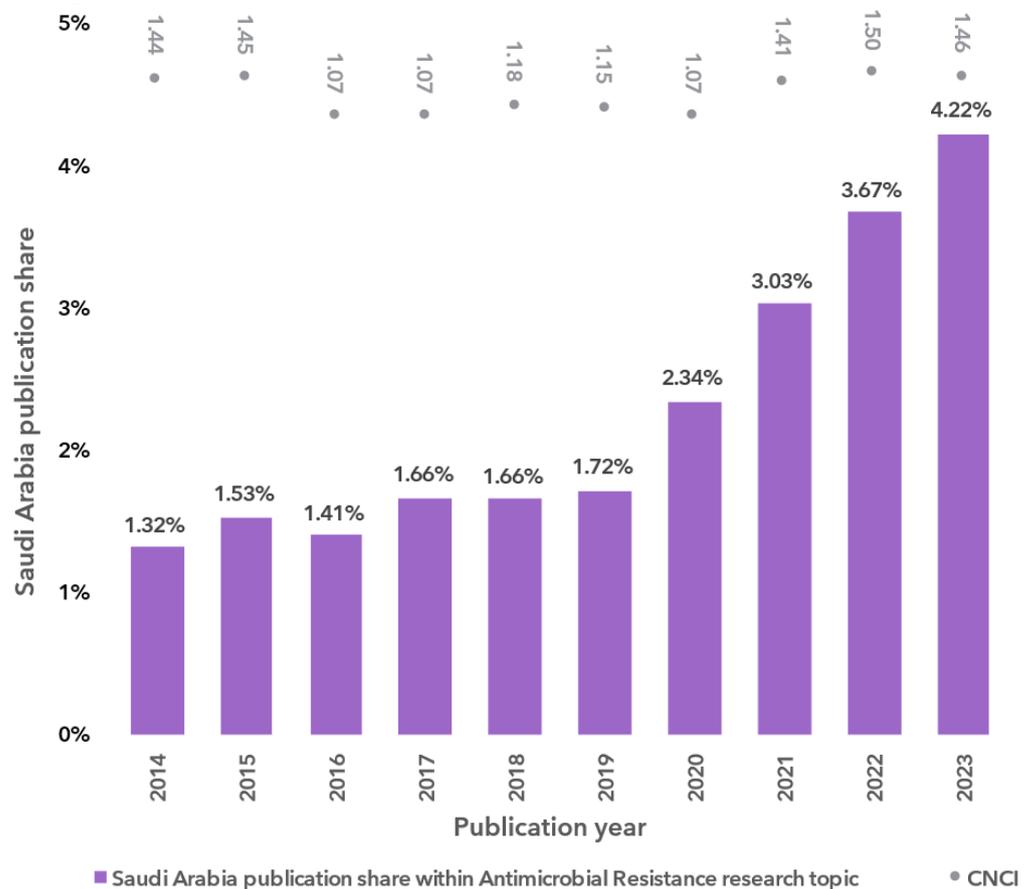
Figure 125: The share of Saudi Arabia from global publications in the research topic and the CNCI of Saudi Arabia publications in the research topic

4.1.12.2 Top 10 countries collaborating with Saudi Arabia

The top collaborating countries with Saudi Arabia in this research topic in the period 2014-2023 are Egypt, followed by India and Pakistan, with 948, 690 and 484 publications, respectively, as shown in Figure 126. Regarding citation impact measured by the CNCI publications published in collaboration with South Africa, Australia and South Korea had the highest CNCI with 4.56, 4.10 and 4.05,

respectively. Nevertheless, all publications with the top 10 collaborating countries had a CNCI higher than 1, reflecting a performance higher than the global average.
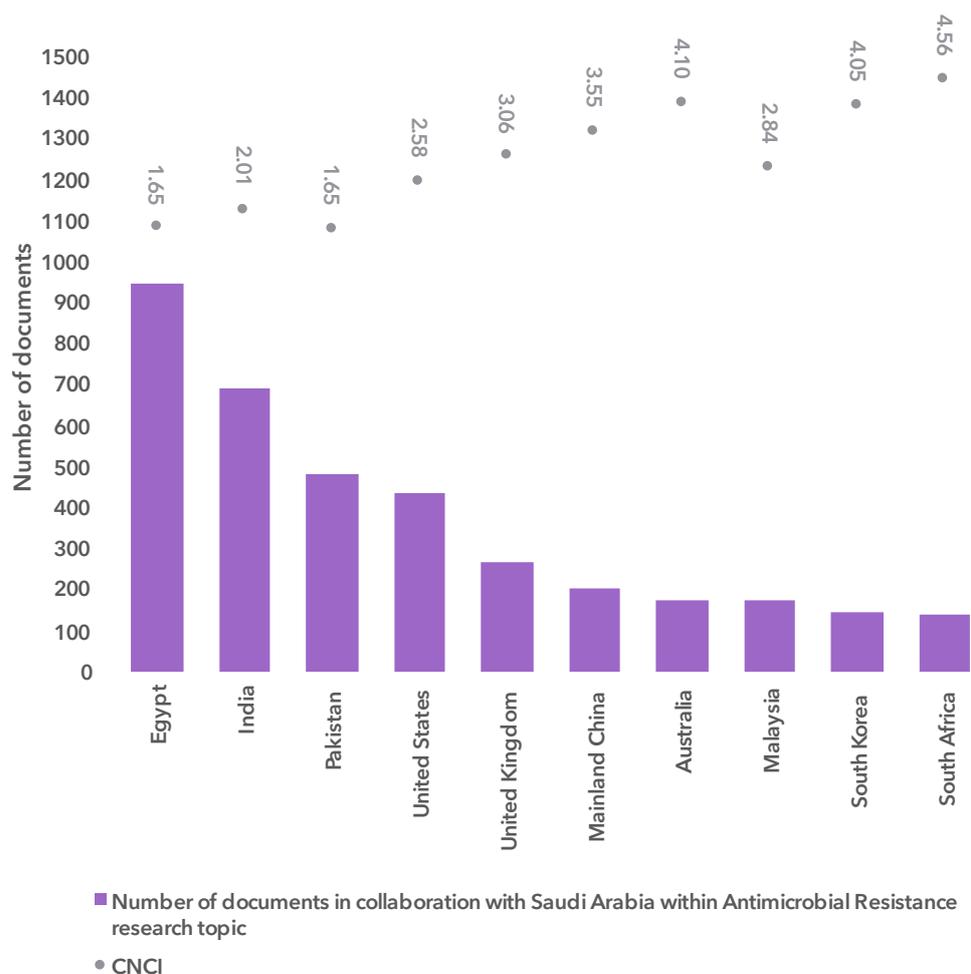
Figure 126: Top 10 collaborating countries with Saudi Arabia in terms of the number of publications in the research topic Antimicrobial Resistance in the period 2014-2023

4.1.12.3 Top 20 funders of Saudi publications by number of publications

The top 3 funding organizations of Saudi Arabia publications in this research topic in terms of the number of publications mentioning the organization in the funding text in the period 2014-2023 are King Saud University followed by Princess Nourah bint Abdulrahman University and UK Research & Innovation (UKRI) with 492, 111 and 55 publications respectively as shown in Figure 127.

Publications funded by Wellcome Trust, followed by National Institutes of Health (NIH) - USA and United States Department of Health & Human Services had the highest citation impact measured by the CNCI with 6.30, 3.77 and 3.69, respectively.
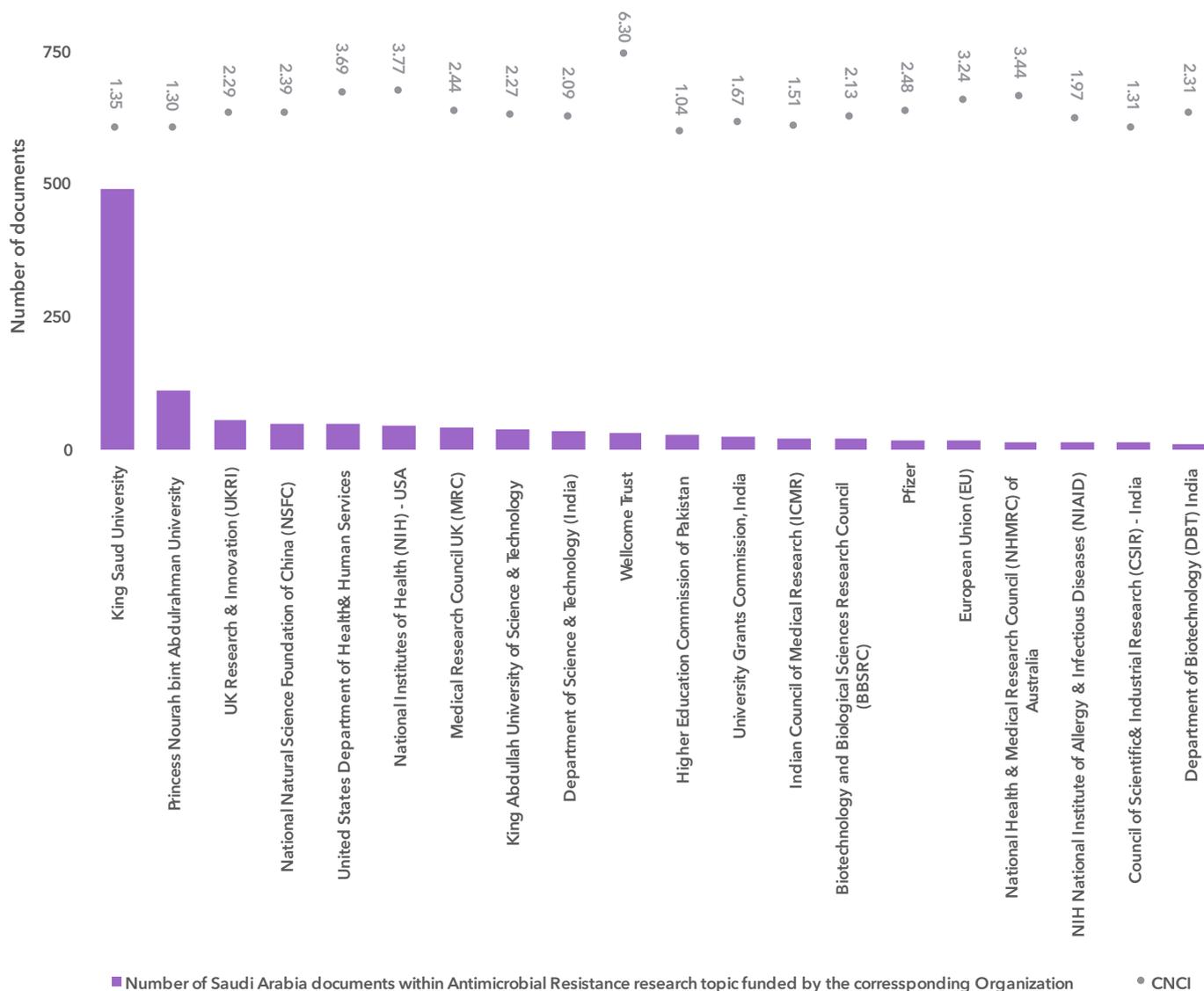
Figure 127: Top 20 funding organizations of Saudi Arabia publications in the research topic Antimicrobial Resistance in terms of number of publications in the period 2014-2023

4.1.12.4 Top 20 Saudi Arabia organizations in terms of number of publications

The top 3 organizations in terms of publications published in this research topic and the period 2014-2023 are King Saud University, followed by King Abdulaziz University and Umm Al Qura University, with 973, 512 and 279 publications, respectively, as shown in Figure 128.

In terms of citation impact as measured by the CNCI, King Abdullah International Medical Research Center (KAIMRC), followed by Alfaisal University and King Saud Bin Abdulaziz University for Health Sciences, had the highest CNCI with 3.30, 2.91 and 2.21, respectively.

Nevertheless, all 20 top organizations had a CNCI higher than 1, reflecting citation impact performance higher than the global average.
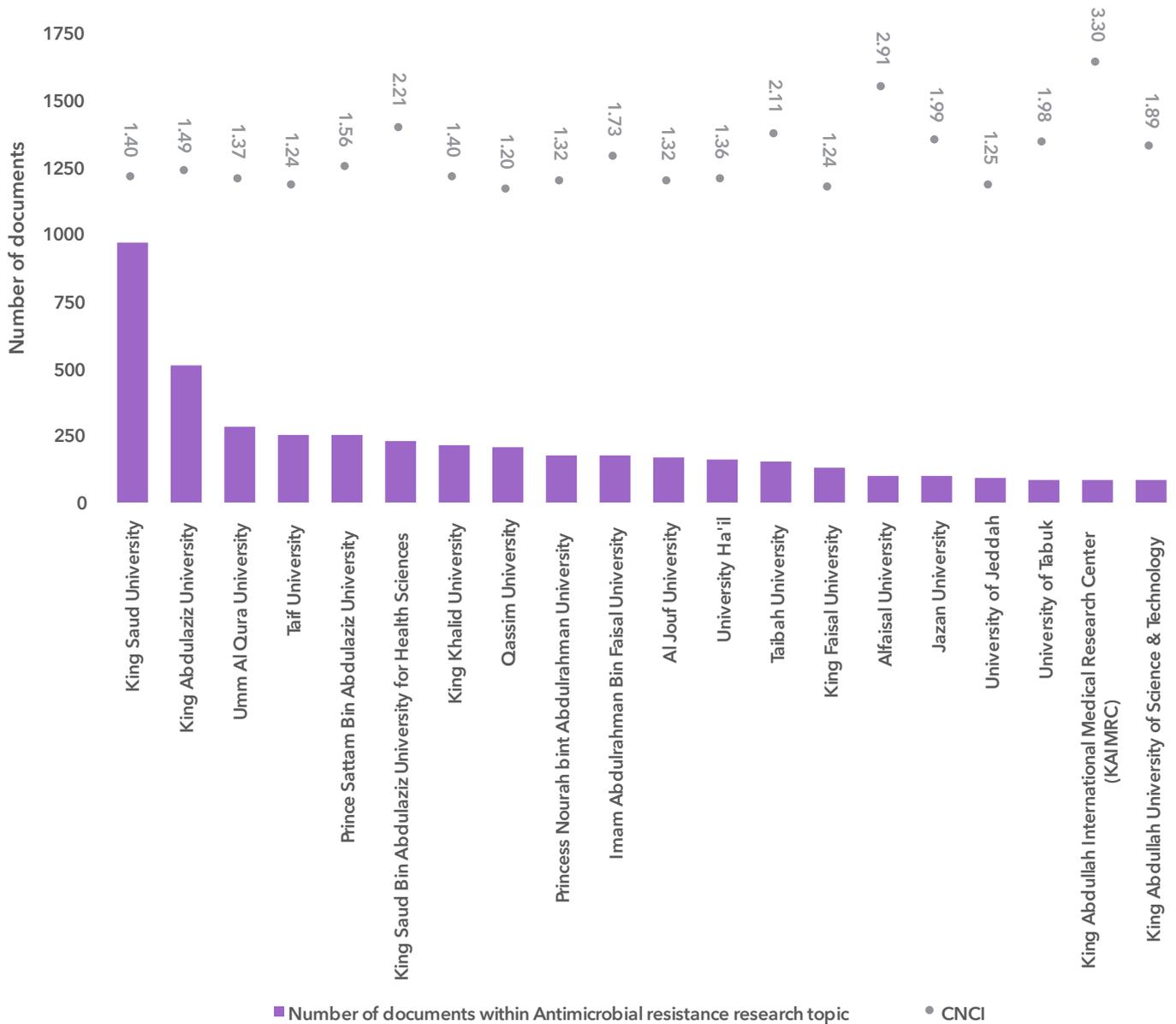
Figure 128: Top 20 Saudi organizations in terms of publications published in the research topic Antimicrobial Resistance in the period 2014-2023 and their corresponding CNCI

4.1.12.5 The top 20 researchers are affiliated with Saudi organizations regarding the number of publications they publish.

The highest number of publications are published by Naiyf S. Alharbi, affiliated with King Saud University, and Abdul Haseeb, affiliated with Umm Al Qura University, with the same number of publications followed by Hasan. Ejaz is affiliated with Al Jouf University, and Fohad Mabood Husain is affiliated with King Saud University with 39, 36 and 35 publications, respectively, as shown in Table 31.

The highest CNCI, number of Top 1% and number of Top 10% publications are achieved by Arnab Pain affiliated to King Abdullah University of Science & Technology with a CNCI of 1.94, 3 Top 1% publications and 7 Top 10% publications.

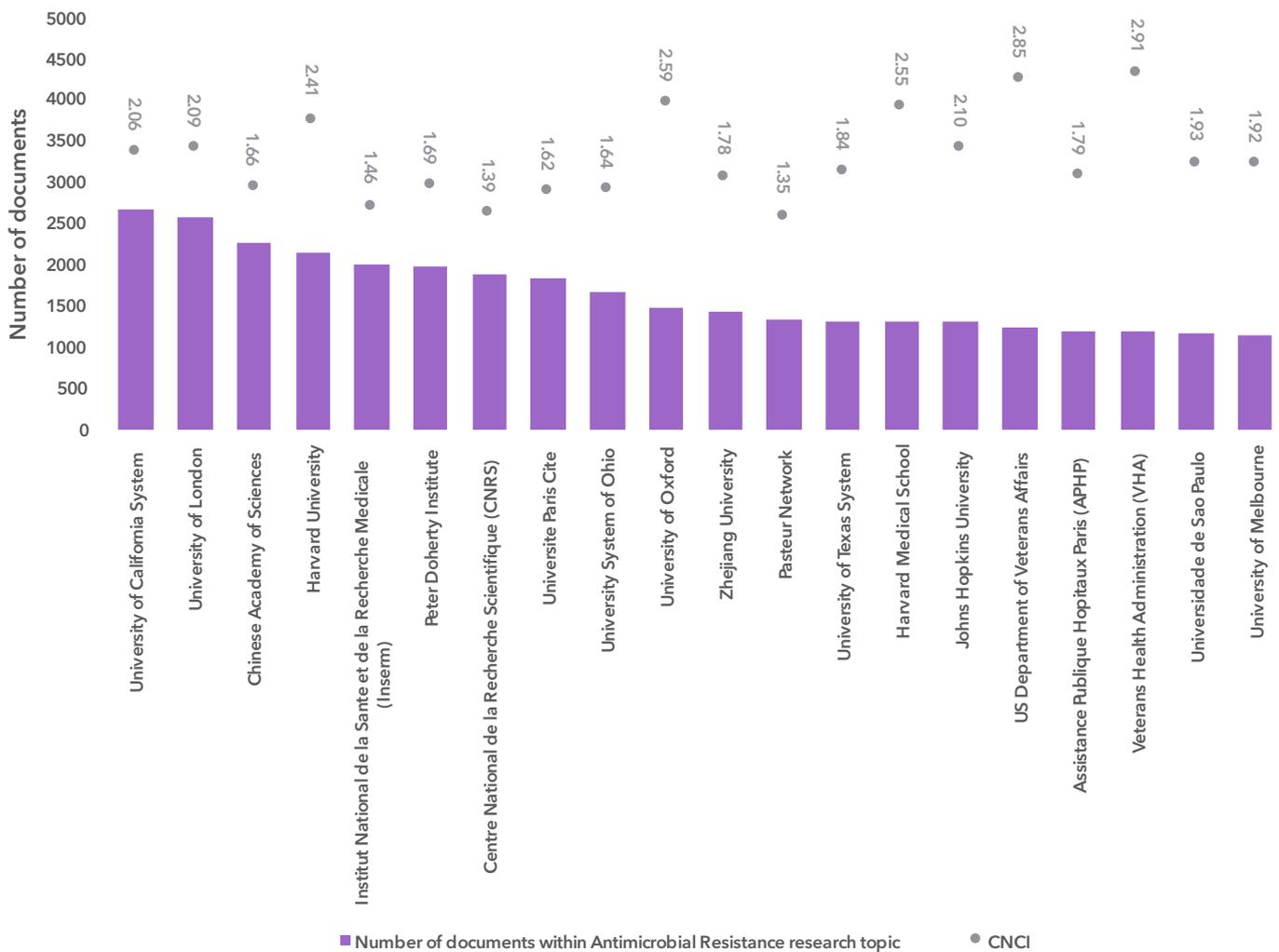Table 31: Top 20 researchers affiliated with Saudi organizations in terms of the number of publications published on the research topic Antimicrobial Resistance in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%
Alharbi, Naiyf S.	King Saud University	39	1.06	0	4
Haseeb, Abdul	Umm Al Qura University	39	1.23	1	5
Ejaz, Hasan	Al Jouf University	36	0.74	0	3
Husain, Fohad Mabood	King Saud University	35	1.39	0	6
Ahmed, Nehad J.	Prince Sattam Bin Abdulaziz University	33	0.31	0	1
Pain, Arnab	King Abdullah University of Science & Technology	32	1.94	3	7
Kadaikunnan, Shine	King Saud University	27	0.99	0	2
Khaled, Jamal M.	King Saud University	25	0.92	0	2
Almatroudi, Ahmad	Qassim University	24	1.18	0	3
Elbehiry, Ayman	Qassim University	24	1.37	0	4
Haque, Shafiul	Jazan University	23	0.88	0	2
Selim, Samy	Al Jouf University	23	1.32	0	3
Al-Dhabi, Naif Abdullah	King Saud University	22	1.11	0	3
Snoussi, Mejdi	University Ha'il	22	1.36	0	3
Venugopala, Katharigatta N.	King Faisal University	21	1.60	0	5
Alharbi, Metab	King Saud University	20	1.60	0	5
Syed, Asad	King Saud University	20	1.37	0	4
Thabit, Abrar K.	King Abdulaziz University	20	1.48	0	5
Yasir, Muhammad	King Abdulaziz University	20	1.11	0	4
Adnan, Mohd	University Ha'il	18	1.82	0	5

4.1.12.6 Top 10 countries in terms of publications

The highest number of publications published on this research topic is published by the United States (32,969 publications), followed by Mainland China (23,711 publications) and India (13,135 publications), as shown in Figure 129.

The highest citation impact measured by the CNCI is achieved by publications published in Australia, the United Kingdom, and Italy with a CNCI of 1.77, 1.72 and 1.167, respectively.

Five of the top 10 countries in terms of number of publications published in the research topic are also among the top 10 collaborators with Saudi Arabia. These are United States, Mainland China, United Kingdom, Australia, and India.

■ Number of documents within Antimicrobial Resistance research topic   ● CNCI
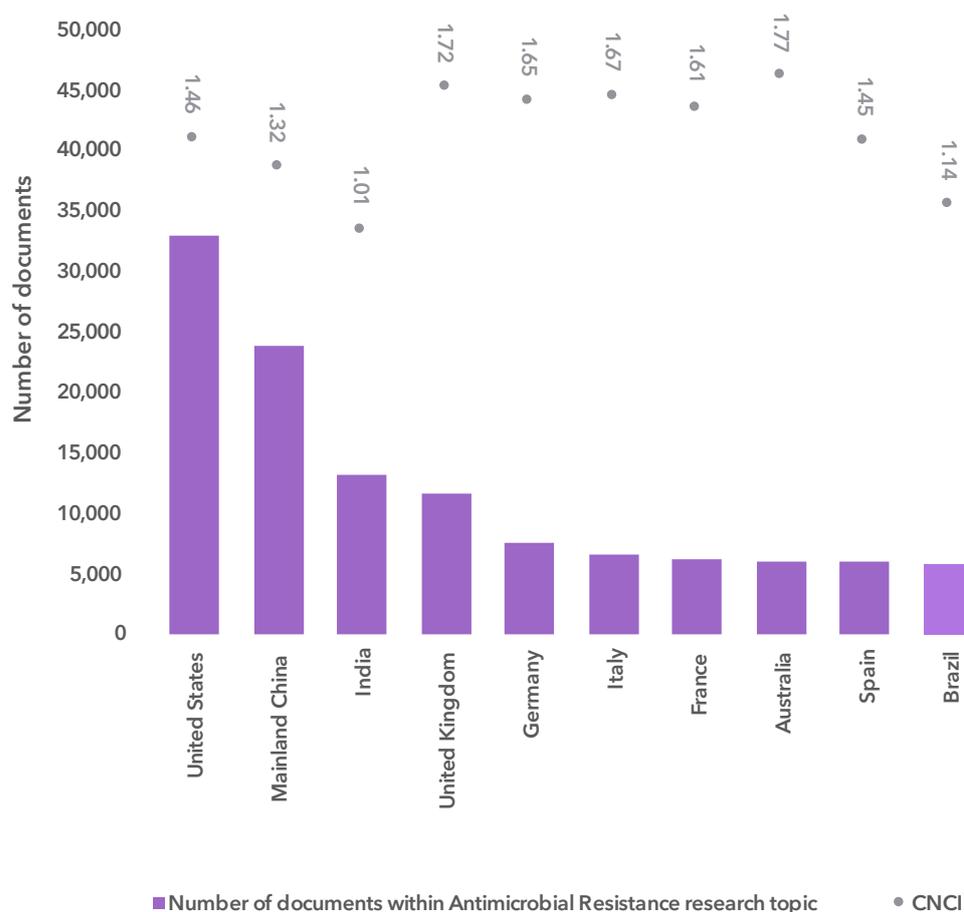
Figure 129: Top 10 countries in terms of the number of publications in the research topic Antimicrobial Resistance in the period 2014-2023 and their corresponding CNCI

4.1.12.7 Top 20 organizations globally in terms of number of publications

The top 3 organizations in terms of the number of publications published on this research topic in the period 2014-2023 are the University of California System (2,667 publications) followed by the University of London (2,593 publications) and the Chinese Academy of Sciences (2,267 publications) as shown in Figure 130.

In terms of citation impact measured by the CNCI, the Veterans Health Administration (VHA), followed by the US Department of Veterans Affairs and the University of Oxford, had the highest CNCI with 2.91, 2.85 and 2.59, respectively.

Figure 130: Top 20 organizations globally in terms of number of publications published in the research topic Antimicrobial Resistance in the period 2014-2023 and their corresponding CNCI

4.1.12.8 Top 20 researchers globally in terms of number of publications

The top 3 researchers globally in terms of the number of publications in this research topic are Robert A. Bonomo, affiliated to Case Western Reserve University, with 235 publications, followed by Benjamin P. Howden, affiliated to Peter Doherty Institute, with 202 publications, and Carmen Torres, affiliated to Universidad de La Rioja with 178 publications as shown in Table 32.

The highest CNCI and number of Top 1% publications is achieved by Yong-Guan Zhu. affiliated to Chinese Academy of Sciences with a CNCI of 3.51 and 18 Top 1% publications.

The highest number of Top 10% publications is achieved by Robert A. Bonomo affiliated to Case Western Reserve University.

Table 32: Top 20 researchers globally in terms of the number of publications published in the research topic Antimicrobial Resistance in the period 2014-2023

Name	Affiliation	Web of Science Publications	CNCI	Publications in top 1%	Publications in the top 10%	Country
Bonomo, Robert A.	Case Western Reserve University	235	2.96	18	82	United States
Howden, Benjamin P.	Peter Doherty Institute	202	2.04	6	30	Australia
Torres, Carmen	Universidad de La Rioja	178	1.28	1	28	Spain
Li, Jian	Monash University	175	1.63	4	32	Australia
Rolain, Jean-Marc	Aix-Marseille Universite	166	1.33	4	18	France
Unemo, Magnus	Orebro University	162	2.19	9	53	Sweden
Yu, Yunsong	Zhejiang University	145	2.31	7	32	Mainland China
Veeraraghavan, Balaji	Christian Medical College & Hospital (CMCH) Vellore	138	1.10	2	18	India
Wang, Yang	China Agricultural University	138	3.43	10	45	Mainland China
Canton, Rafael	Hospital Universitario Ramon y Cajal	129	1.65	2	32	Spain
Nicolau, David P.	Hartford Hospital	129	1.07	1	16	United States
Oliver, Antonio	Hospital Universitari Son Espases	126	1.94	4	39	Spain
Paterson, David L.	University of Queensland	123	2.44	7	37	Australia
Hsueh, Po-Ren	National Taiwan University	121	1.85	5	24	Taiwan
Zhu, Yong-Guan	Chinese Academy of Sciences	120	3.51	15	68	Mainland China
Parkhill, Julian	Wellcome Trust Sanger Institute	119	2.50	6	57	England
Flamm, Robert K.	JMI Laboratories	115	1.45	1	32	United States
Stinear, Timothy P.	Peter Doherty Institute	114	2.12	3	14	Australia
Schwarz, Stefan	Free University of Berlin	113	2.45	5	23	Germany
Poeta, Patricia	University of Tras-os-Montes & Alto Douro	111	1.22	1	18	Portugal

4.1.12.9 Top 20 global funders globally in terms of number of publications

The top 3 organizations in terms of funded publications in this research topic are the National Natural Science Foundation of China (NSFC) with 12,646 publications, followed by the United States Department of Health & Human Services with 11,466 publications, and National Institutes of Health (NIH) - USA with 10,779 publications as shown in Figure 131.

The highest citation impact measured by the CNCI is observed in publications funded by Biotechnology and Biological Sciences Research Council (BBSRC), Medical Research Council UK (MRC) and Wellcome Trust with 2.40, 2.31 and 2.25, respectively. Among the top 20 global funding organizations, 10 are also among the top 20 funding organizations of Saudi publications in this research topic.
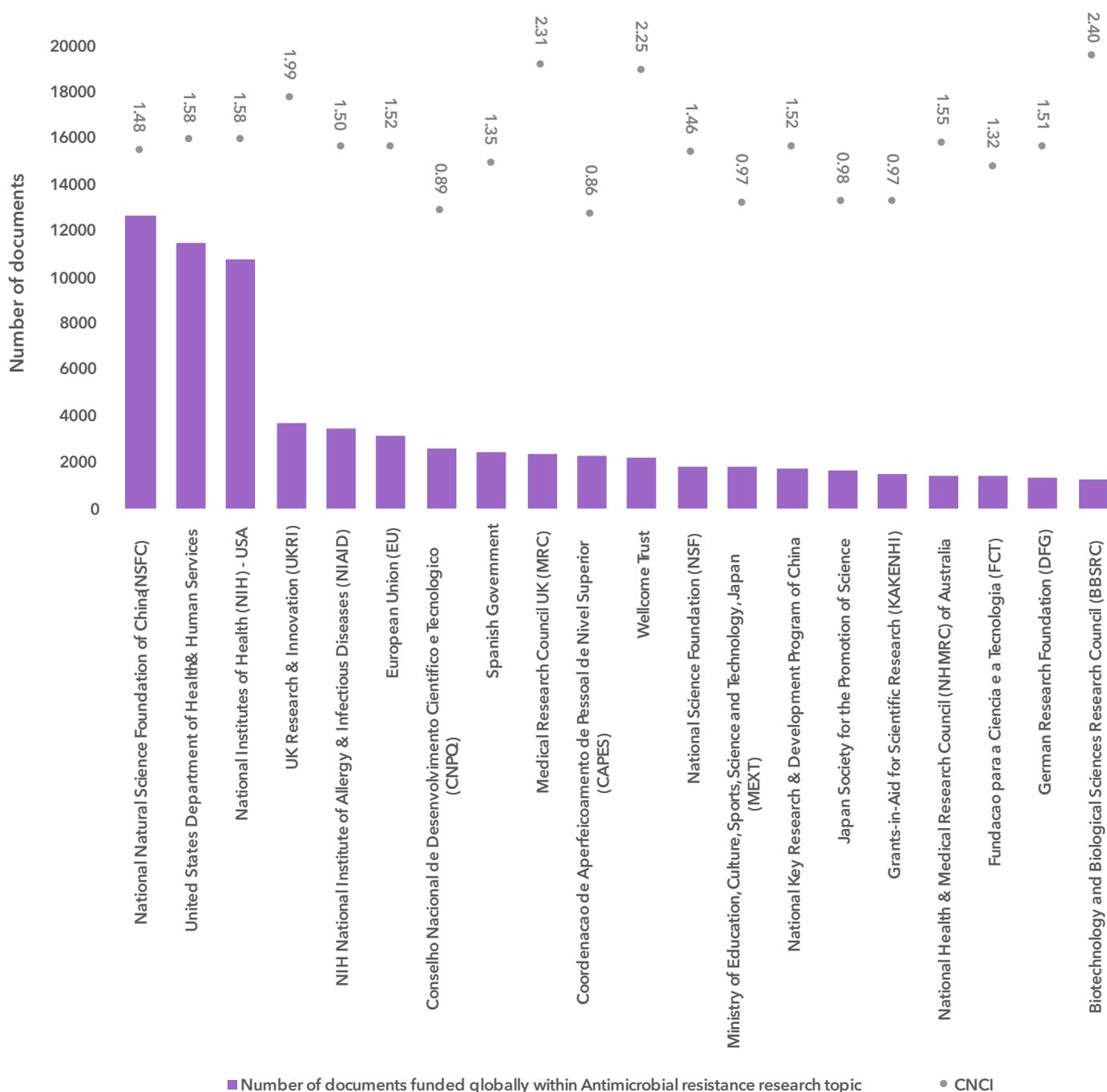
Figure 131: Top 20 funding organizations globally publications in the research topic Antimicrobial Resistance in terms of number of publications in the period 2014-2023

4.1.12.10 Emerging trends in the research topic globally and in Saudi Arabia

In this section, we investigate the emerging trends globally and in Saudi Arabia on the research topic of Antimicrobial Resistance. Please see the section for more information on the methodology used to identify emerging trends Emerging Trends.

The top 3 emerging micro-topics globally in this research topic are Polymers & Macromolecules: Hydrogels followed by Virology - General: Coronavirus and Nanoparticles: Carbon Dots as shown in Figure 132. In Figure 133 The top 20 emerging microtopics in this research topic are identified. The top 3 emerging topics in Saudi Arabia are Bacteriology, Quorum Sensing, followed by Phytochemicals: Essential Oil and Micro & Long Noncoding RNA: MicroRNAs. Among Saudi Arabia's top 20 emerging microtopics, one microtopic is also an emerging trend globally. This is Phytochemicals: Andrographolide.

It is worth mentioning that the micro-topics Mycotoxins: Streptomyces, Gastrointestinal & Esophageal Diseases: Helicobacter Pylori, Medical Mycology: Candida Albicans, Bacteriology: Listeria Monocytogenes, Synthesis: Chalcones and Antibiotics & Antimicrobials: Surgical Site Infection citation share in Saudi Arabia decreased within the total citations of Saudi Arabia publications in the research topic. Accordingly, one should monitor and assess the relevance of those topics locally and globally.
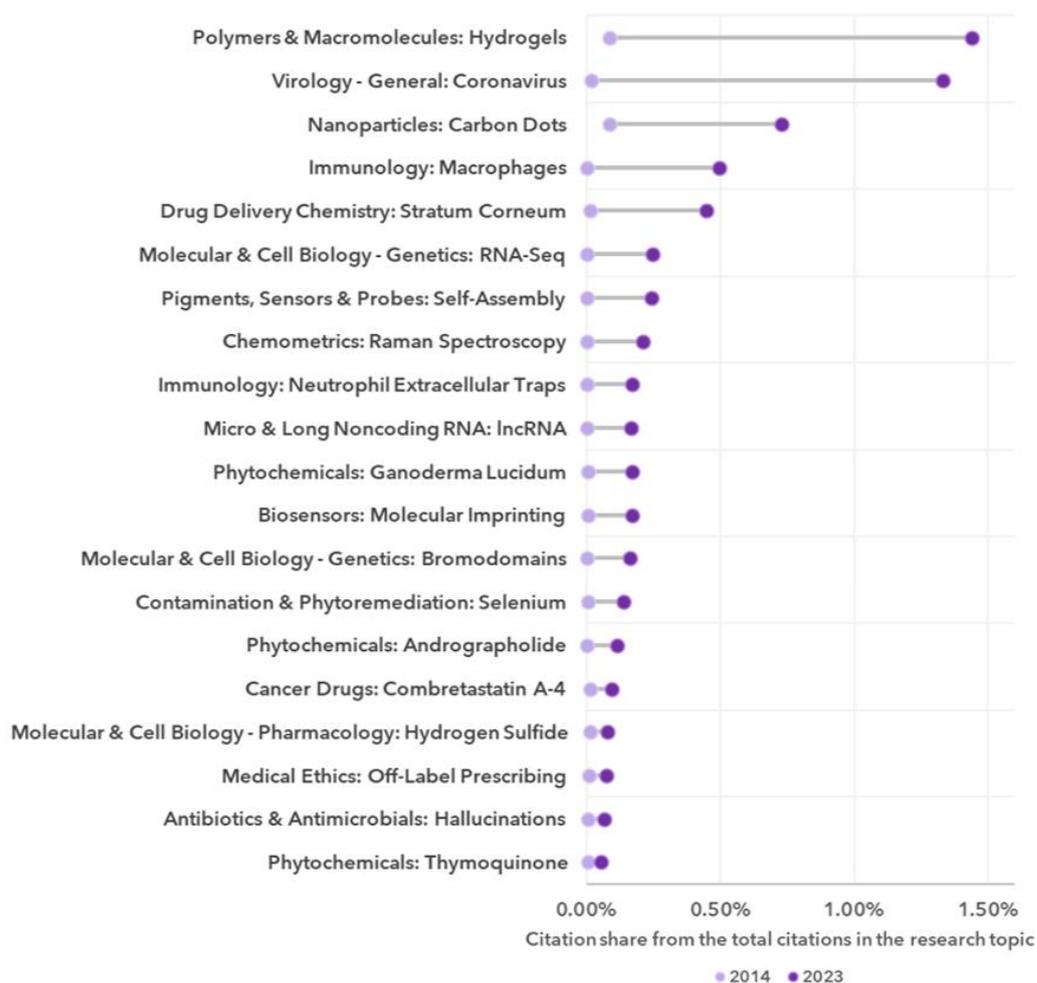
Figure 132: Top 20 emerging micro-topics globally in the research topic Antimicrobial Resistance in the period 2014-2023
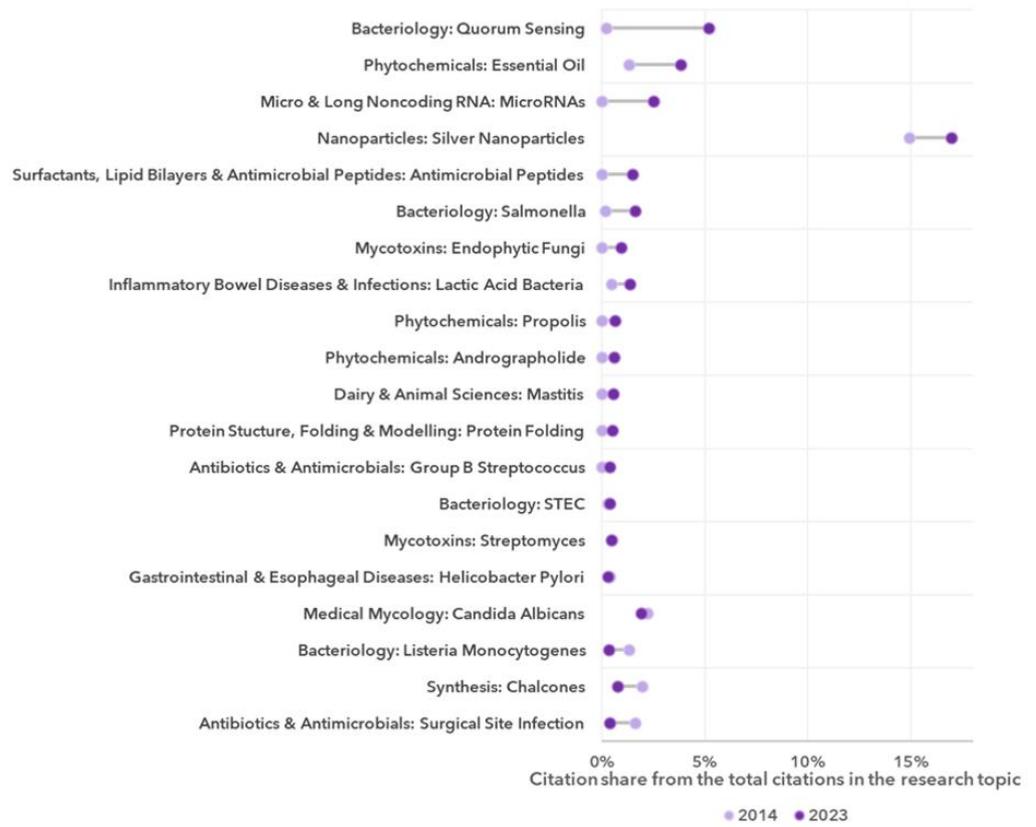
Figure 133: Top 20 emerging micro-topics in Saudi Arabia in the research topic Antimicrobial Resistance in the period 2014-2023

4.2 Invention Performance in the Selected Priority Research Topics

In Figure 134, Saudia Arabia's applied research through inventions has established strength within the Health and Wellness priority area, specifically within the research topic Cancer technology with 368 inventions, followed by Precision Medicine, Telesurgery, and Assistive Biosensors/ MEMS. Recently, there has been high invention strength investment into technologies such as Nanomedicine, Biopharmaceuticlas, Antimicrobial Resistance, and neurological and Chronic respiratory. Telehealth, Implants and Preventative – Mobile Health are lower strength older portfolio for Saudi Arabia, compared to other Health and Wellness technologies. Diabetes, Cardiovacular and Gastrointestinal technologies are newer, higher volume and medium average strength inventions; these are likely newer investments with increasing investment.
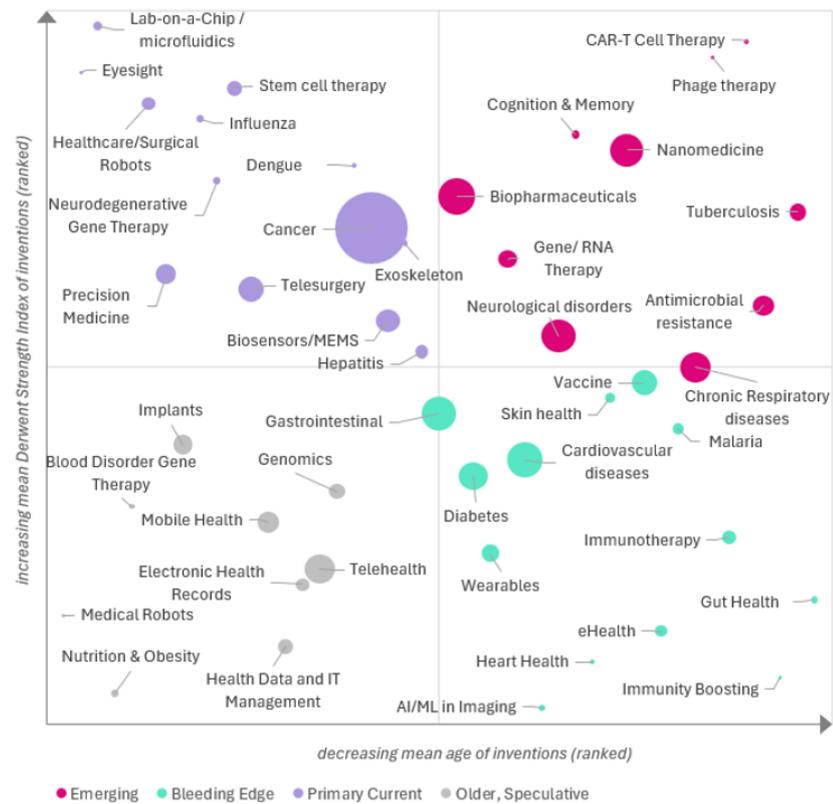
Figure 134: Technical dynamics model for the technologies within the Health and Wellness priority area from Saudi Arabia-based organizations

Comparing Saudi Arabian investment trends to the global applied research dynamics the high volume focus from all innovators on Non-Infecious Cancer is very clear and aligned. This trend is also consistent with gastrointestinal, represented as a mid-strength portfolio on the edge of recent and traditional focus.

In Figure 135, globally Biopharmaceuticals, immunotherapy and Gene, RNA therapies are more recent high-volume focus with high invention strength. Saudi Arabia mirrors this recent investment focus and invention scores in Biopharmaceuticals and Gene, RNA therapies.
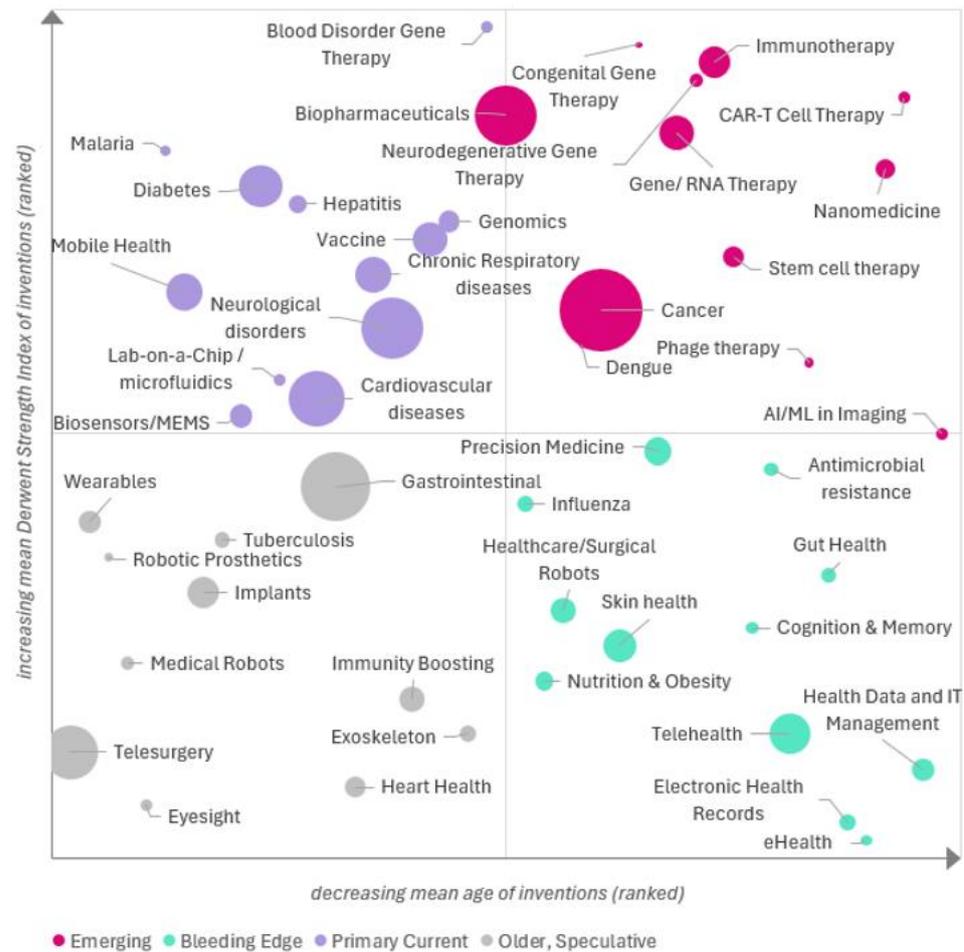
Figure 135: Technical dynamics model for the technologies within the Health and Wellness priority area from global organizations

Compare cardiovascular, neurological and diabetes are traditional high volume and strength investment areas globally. In Saudi Arabia cardiovascular and diabetes are more recent lower strength innovation focuses; however, starting bottom right in bleeding edge and moving up over time and volume into top right primary current is the desired path for sustained innovation. The 78 Saudi Arabian inventions with an invention score of 47.6 are on par with the global average of 47.4, with over 124K inventions globally.

In Figure 136, In the primary top left quadrant, it is apparent that many of the entities are highly commercial organizations, such as the University of California, the University of Pennsylvania and Harvard University; these portfolios are focused on older, broader or high-value technologies such as Cancer, Immunotherapies, Biopharmaceuticals and Cell Therapy, with average DSIs over 84.

The emerging and new entrant technologies in the top right and bottom right are represented far more by corporations such as Samsung, Siemens, Xiaomi, Bristol Myers Squibb, Roche, Qualcomm, Apple, Novartis, and Pfizer. Although there are still Cancer portfolios such as those from Bristol-Myers Squibb, Roche, Pfizer, and Novartis, there is also a significant focus on both the volume of portfolios and size of portfolios in other technologies.

The Samsung Mobile Health portfolio outweighs all other portfolios in Health and Wellness by ownership of the strongest inventions 182 high-strength inventions. Notably Universities dominate the top forty high-strength DSI portfolios, all stale portfolios with the lowest DSI score amongst the strongest inventions and the lowest time remaining of their 20-year timeline.
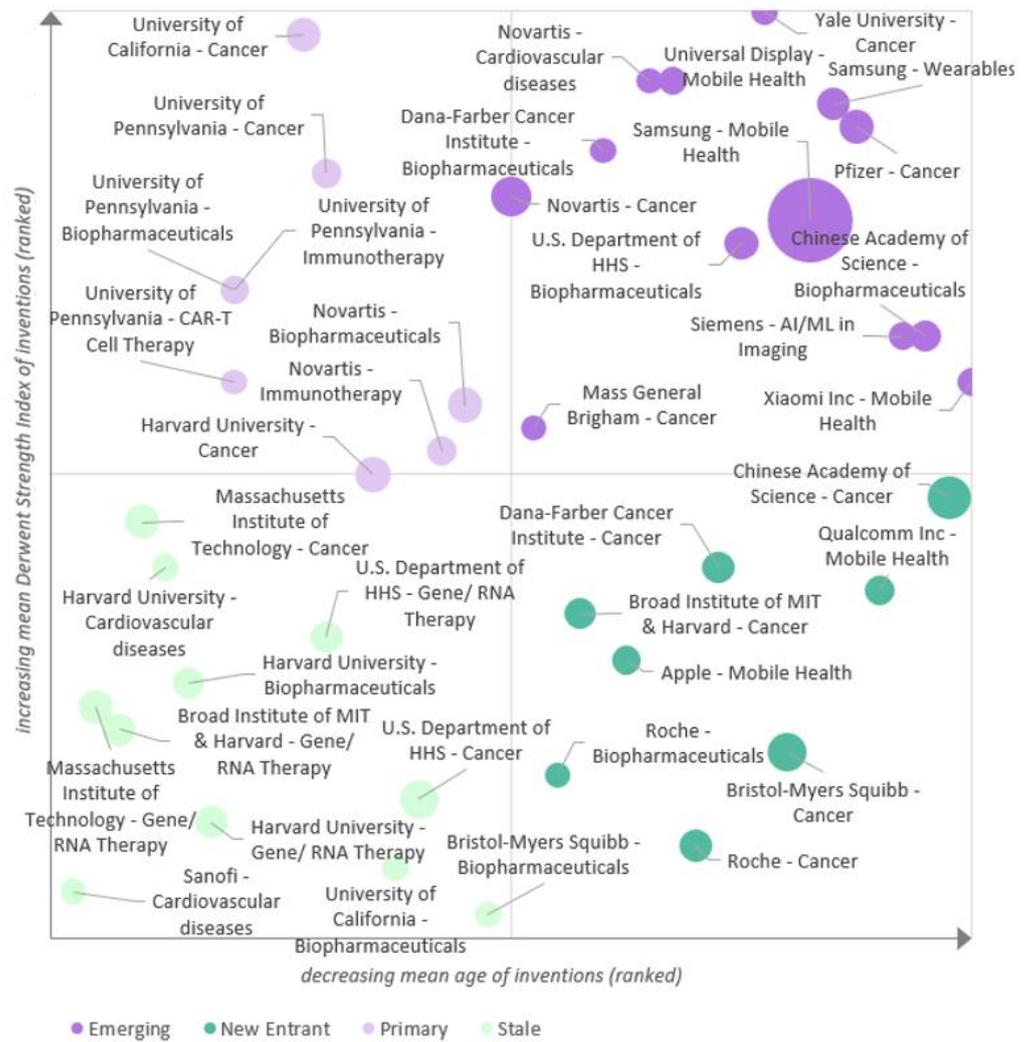
Figure 136: A view of the top forty global organizations with the strongest inventions awarded a score of 80+/100 on the Derwent Strength Index within the priority area of Health and Wellness
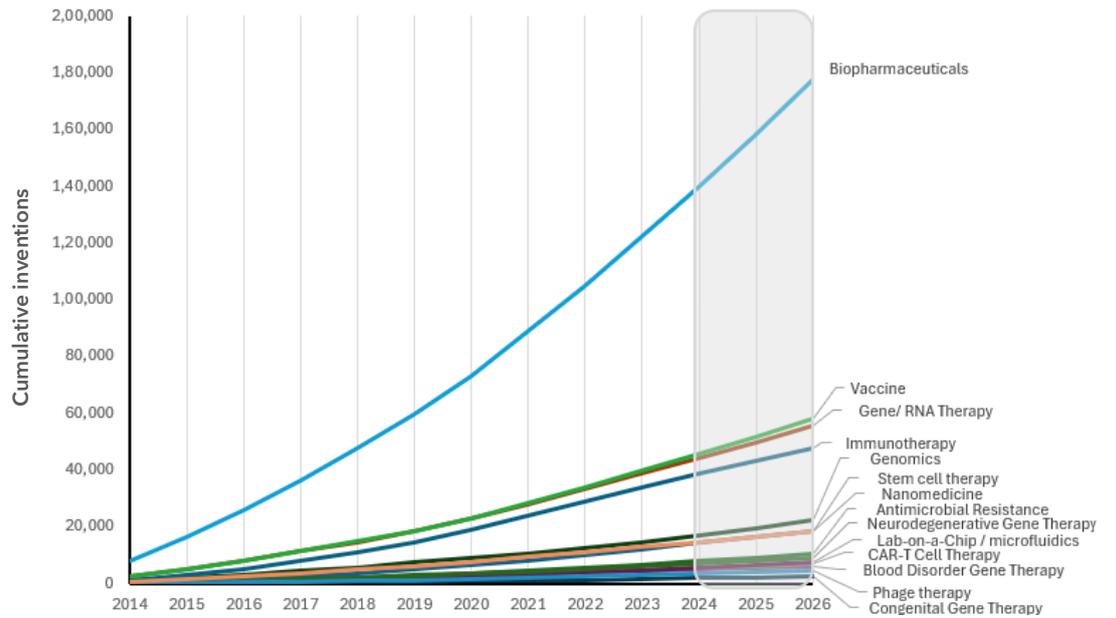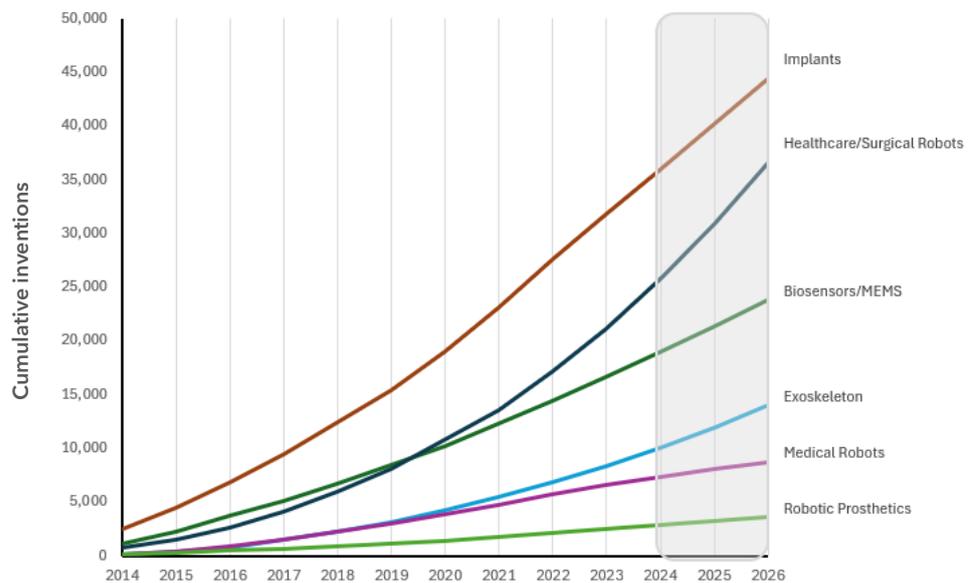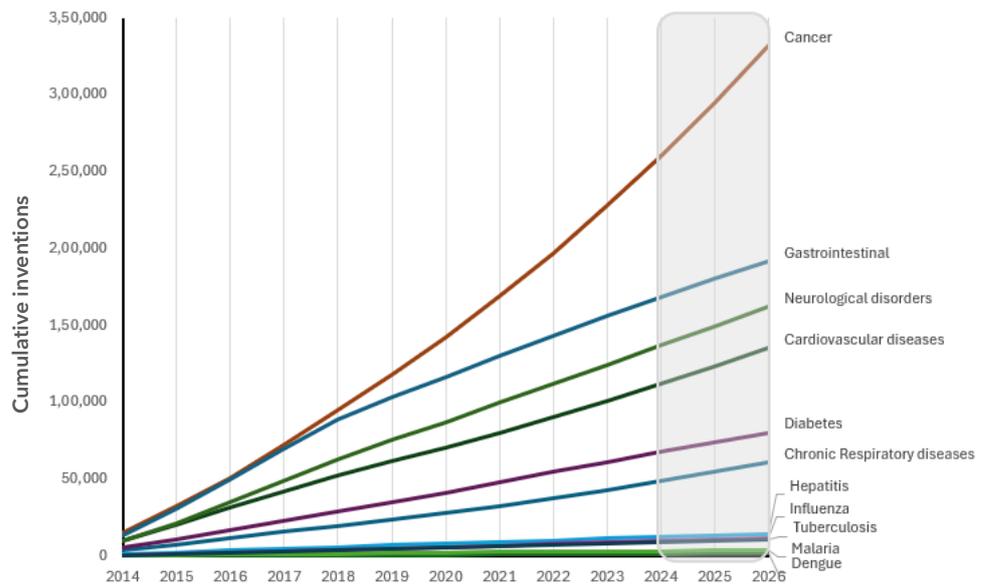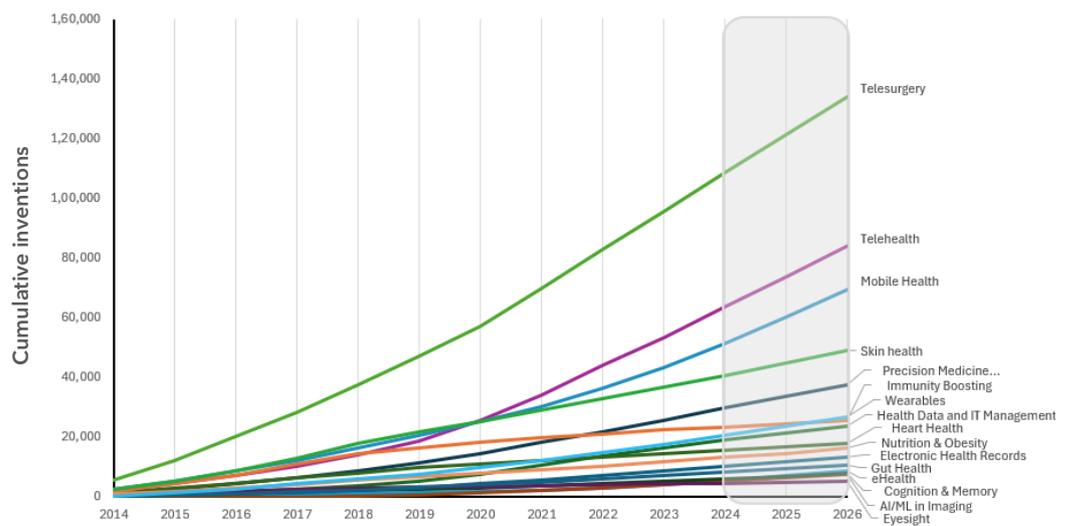
Figure 137: Cumulative inventions globally between 2014-2023 across research topics within the Health and Wellness priority area

Figure 137 shows the accelerating growth of Biopharmaceutical technologies and further extrapolation expected through to 2026 in comparison to other Med-Tech technologies. Vaccine, Gene Therapy, Immunotherapy technologies are also accelerating at a faster rate than the remainder of Medtech technologies.

Figure 138: Cumulative inventions globally between 2014-2023 across Assistive, Surgical and Implant research topics within the Health and Wellness priority area

Implant technologies are at the highest volume of inventions within Figure 138. However, Surgical Robots have the highest rate of growth, expected to nearly double the volume of inventions between 2023 and 2026; this is in contrast to Medical Robotics and Robotic Prosthetics, which are predicted to have relatively flat growth over the next couple of years.

Figure 139: Cumulative inventions globally between 2014-2023 across and disease research topics within the Health and Wellness priority area

Cancer technologies are expected to have increased the number of inventions by 50% from 2022 – 2026 in Figure 139. Other technologies for Gastrointestinal, Neurological, Cardiovascular, Diabetes and Chronic Respiratory conditions are tracking similar growth trajectories globally.

Figure 140: Cumulative inventions globally between 2014-2023 across Digital Health and Preventative research topics within the Health and Wellness priority area

In Figure 140 Telesurgery has the highest volume of inventions globally within Digital and Preventative Health and Wellness technologies and set to continue growing. Telehealth and Mobile health technologies are tracking similar acceleration to telesurgery, these increases may be driven by breakthroughs in related technologies such as 6G enabling risk reduction and greater level of communication.

4.2.1 Cancer

Mainland China is the leading source of Cancer technology inventions between 2014 – 2024, producing 123,990 inventions seen in Figure 141 . Followed by the US with 56,042 inventions, South Korea with 14,309 inventions, Japan with 11,280 inventions and India with 7,359 inventions.

Figure 141: Global distribution of inventions related to Cancer. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.
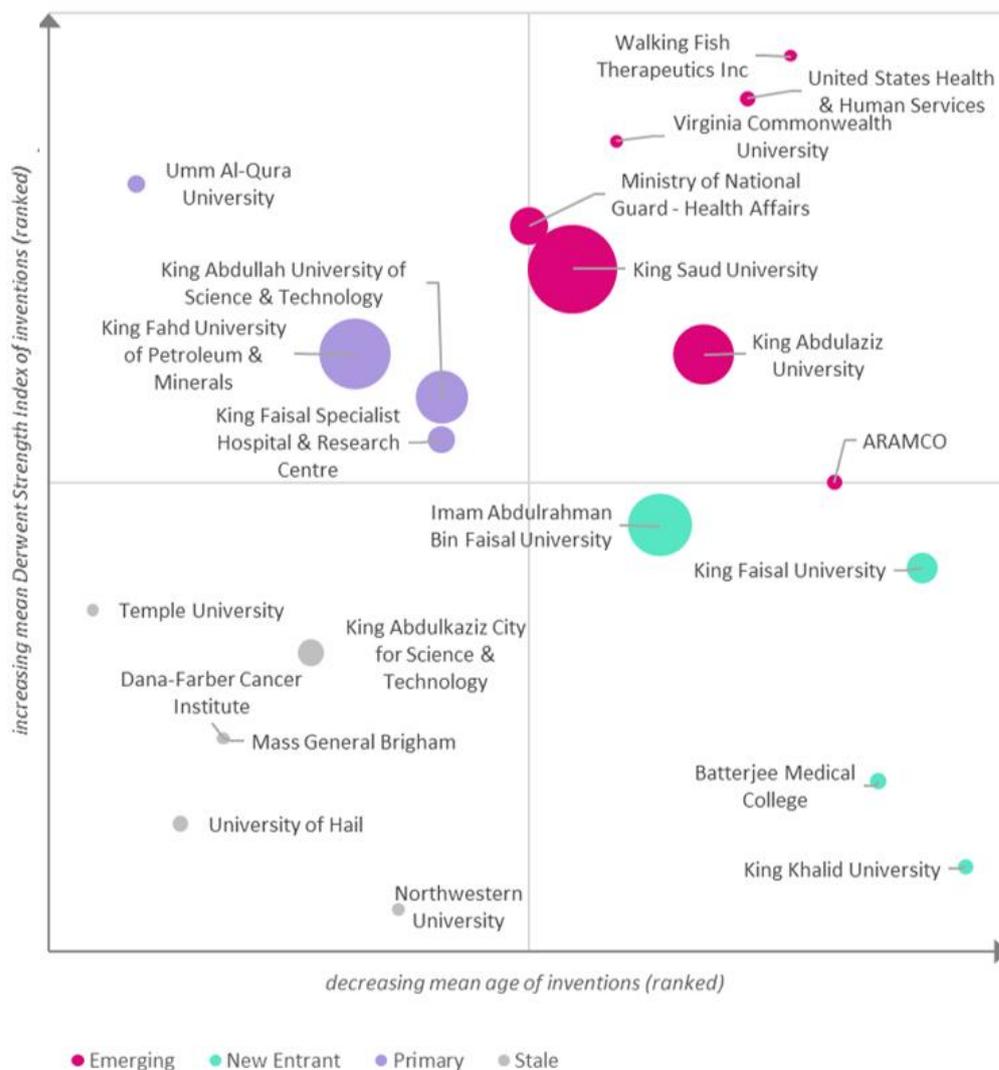

Figure 142: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Cancer

King Saud University holds the most recent high-strength invention portfolio from Saudi Arabia in the field of Cancer technologies with 96 inventions, as shown in Figure 142. This was followed by King Abdulaziz University with 46 inventions and, notably, Saudi Aramco with three inventions.

The more established high-strength portfolios are held by King Fahd University of Petroleum & Minerals, with 62 inventions and a mean strength score of 53.5; KAUST, with 34 inventions; and King Faisal Specialist Hospital & Research Centre, with nine inventions.

Three Academic institutions are found within the top right quadrant of Figure 143 Denoting recent high-strength invention portfolios relating to Cancer from any geographical source. The University of Texas has 987 inventions with a mean invention score of 52.3, Jiangsu Hengrui Medicine has 637 inventions with a score of 52.8, and Stanford University has 620 inventions scoring 50.4.

Located within the top left quadrant are numerous international corporations with the largest high-strength established invention portfolios; United States Health & Human Services has 1,810 inventions scoring 54.1, followed by Roche with 1,802 inventions scoring 59.2, Bristol-Myers Squibb with 1,487 inventions scoring 60.3, University of California with 1,380 inventions scoring 50.3 and INSERM with 1,160 inventions scoring 49. Sanofi has the highest invention score of 61 across 663 inventions.
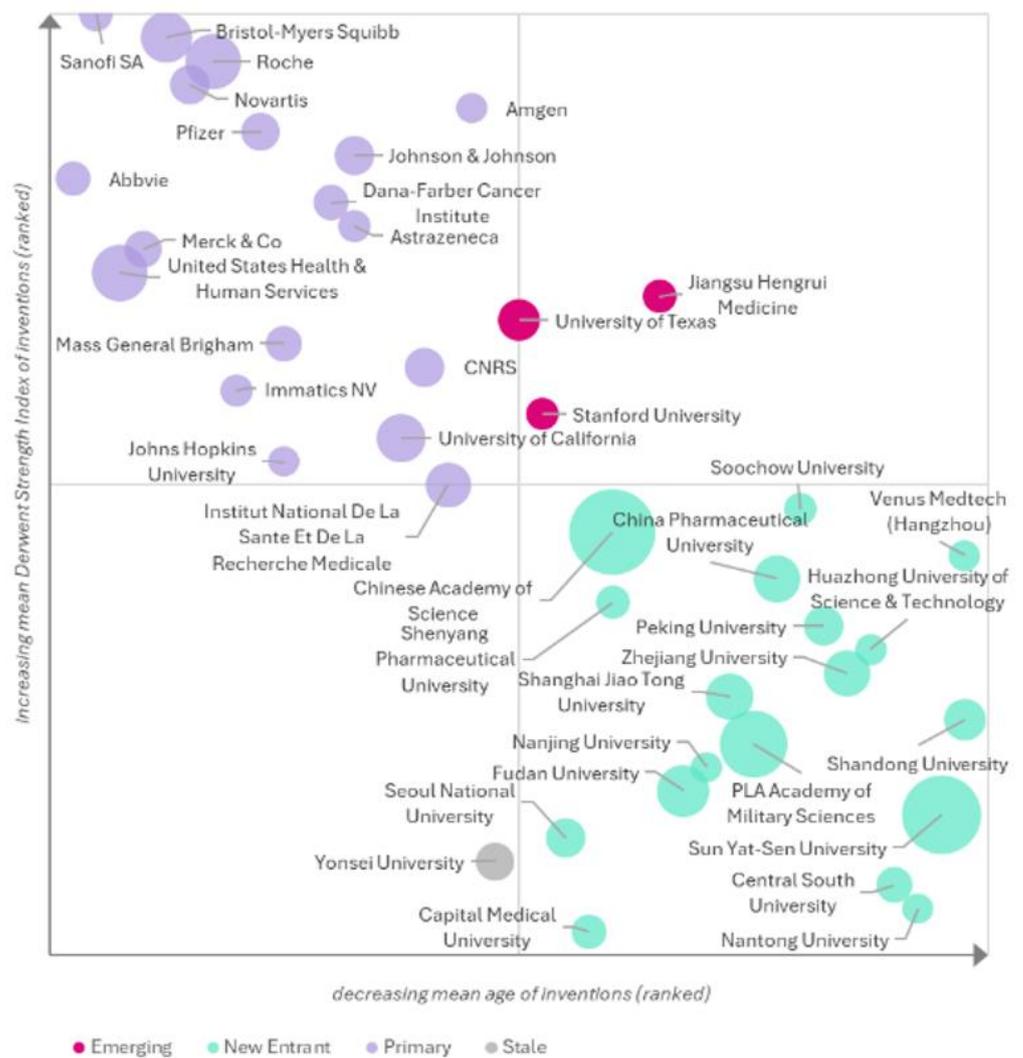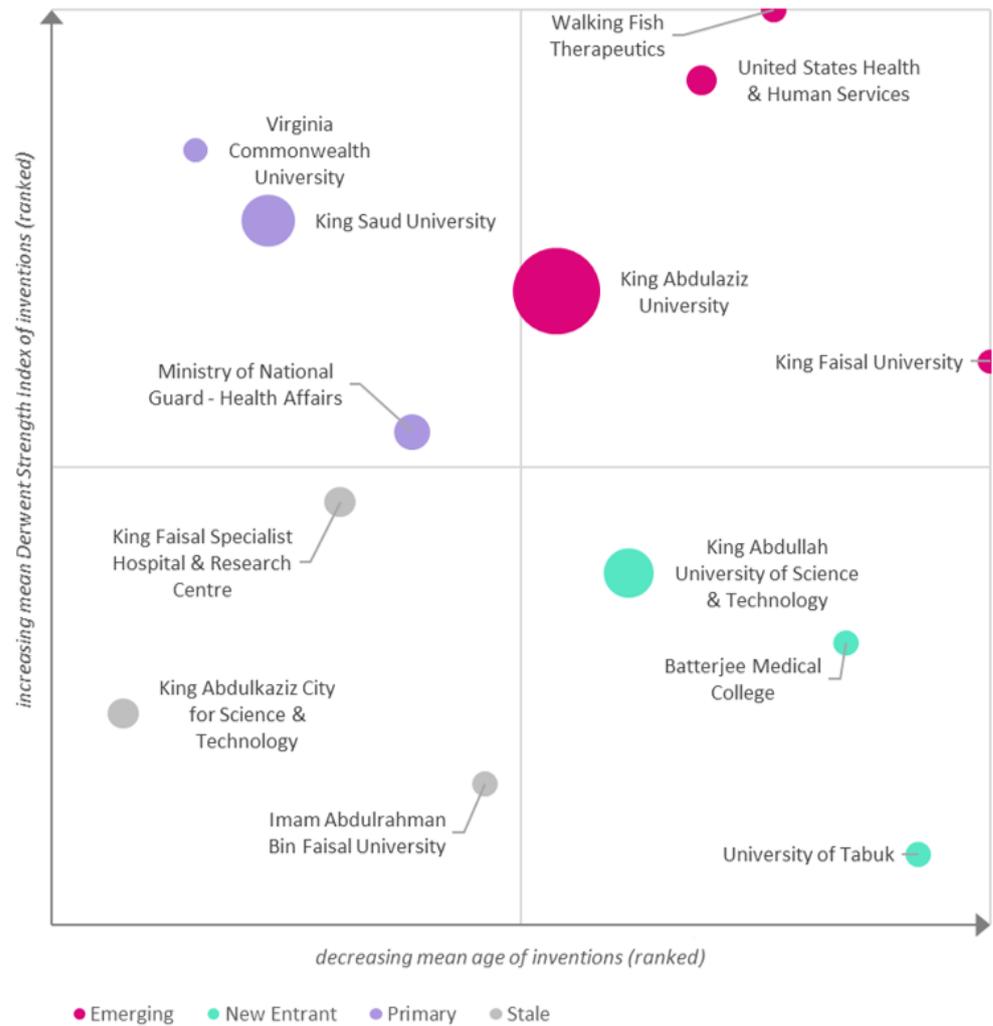

Figure 143: Commercial dynamics model for the top global patent assignees in the research topic Cancer

4.2.2 Cardiovascular Diseases

Figure 144: Global distribution of inventions related to Cardiovascular Diseases. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 144 Mainland China is the leading source of Cardiovascular Diseases technology inventions between 2014 – 2024 producing 59,796 inventions. Followed by the US with 21,820 inventions, Japan with 5,695 inventions, South Korea with 5,188 inventions and Germany with 3,173 inventions.

Figure 145: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic of Cardiovascular Diseases

King Abdulaziz University holds the largest recent high-strength invention portfolio from Saudi Arabia in Cardiovascular Diseases technology with 24 inventions with a mean invention strength score of 54.6 seen in Figure 145 Followed by King Faisal University, which has two inventions. King Saud University, with nine inventions, holds a more established, high-strength portfolio.

Cardiovascular Diseases technologies have two academic institutions holding high-strength recent portfolios from CNRS and Paris Cité University with 272 and 188 inventions, respectively, found within Figure 146.

In the top left quadrant for the largest high-strength established inventions, Roche holds 620 inventions, Johnson & Johnson 590 inventions, and United States Health & Human Services with 503 inventions. Sanofi holds the highest mean strength large portfolio with 459 inventions, scoring 65.4.
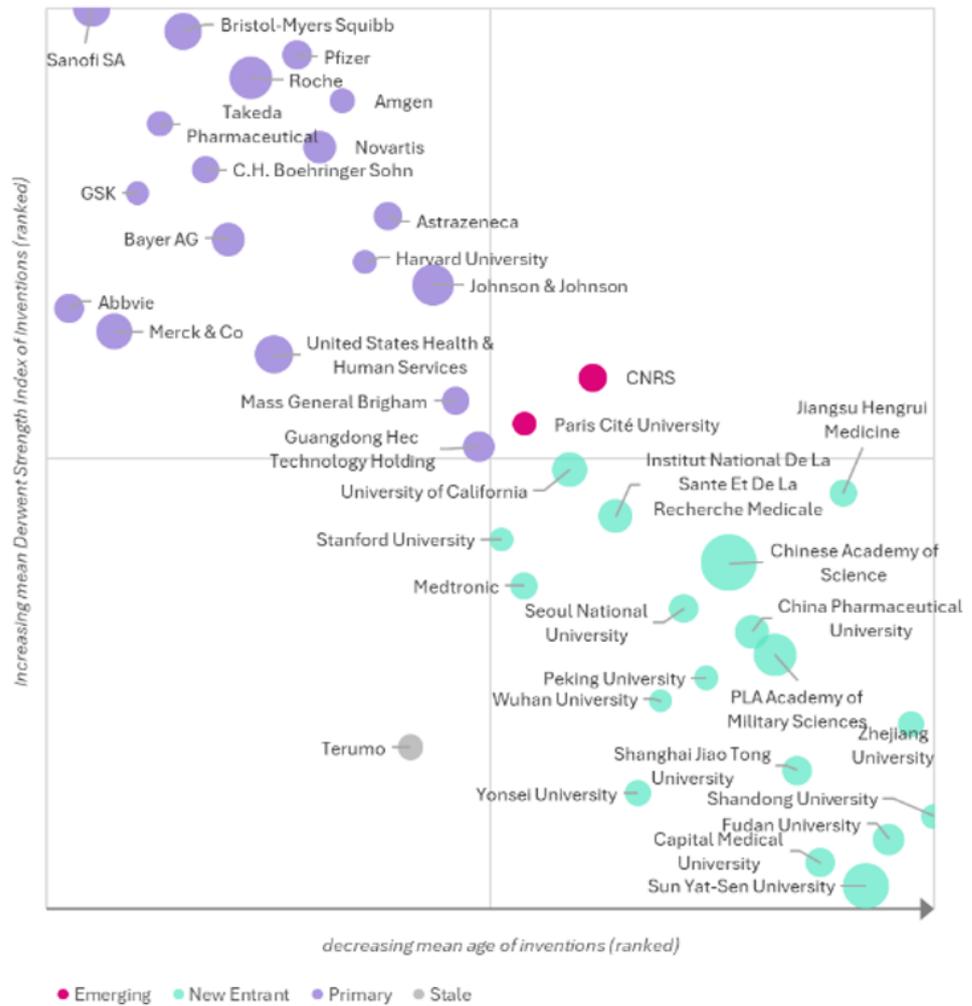
Figure 146: Commercial dynamics model for the top global patent assignees in the research topic of Cardiovascular Diseases

4.2.3 Nutrition & Obesity

Figure 147: Global distribution of inventions related to Nutrition & Obesity. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 147, Mainland China is the leading source of Nutrition & Obesity inventions between 2014-2023 with 8,318 inventions. Followed by the United States with 1,155

inventions, South Korea with 928 inventions, Japan with 410 inventions and India with 301 inventions.
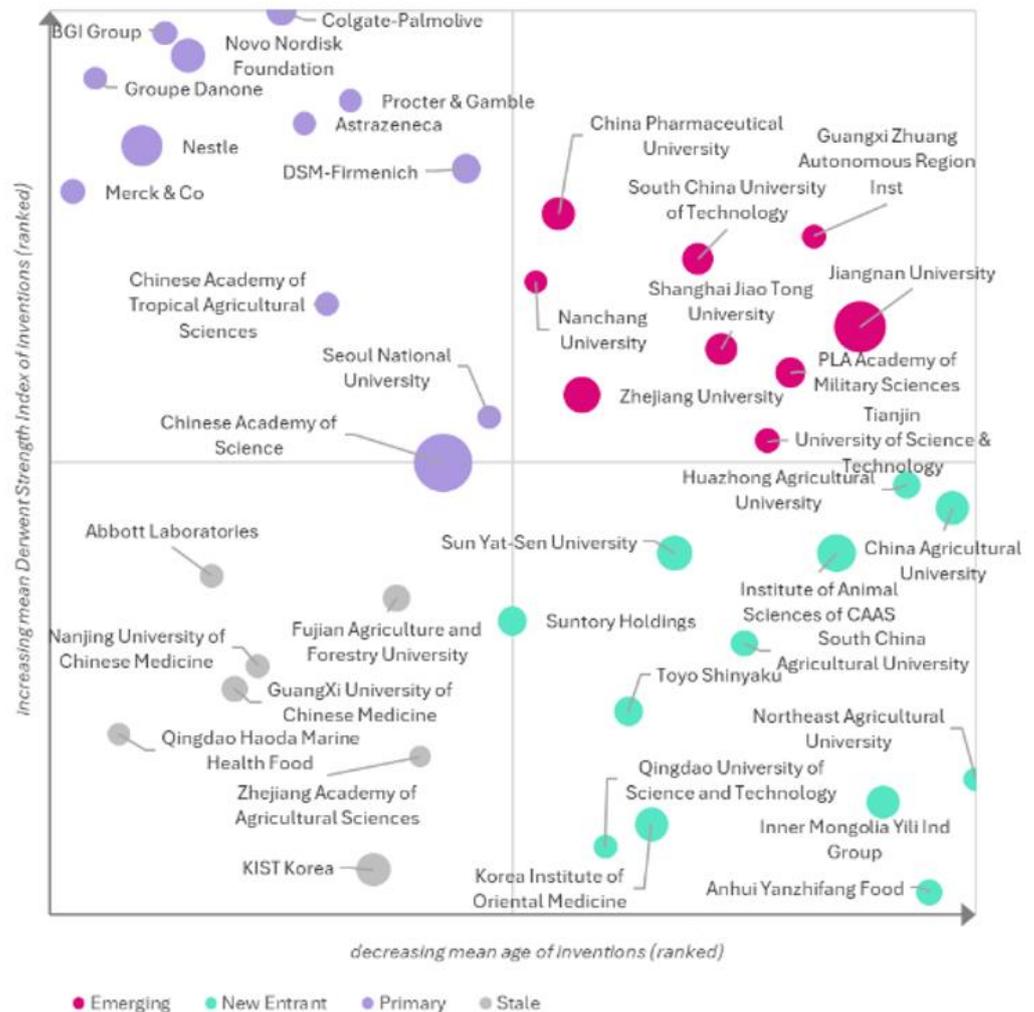
Figure 148: Commercial dynamics model for the top global patent assignees in the research topic Nutrition & Obesity

Jiangnan University has produced the largest portfolio of inventions globally in the field of Nutrition & Obesity technologies, holding 85 inventions with a mean invention strength score of 46 found in Figure 148, followed by Zhejiang University with 41 inventions and China Pharmaceutical University with 35 inventions.

In the top left quadrant for organizations with more established high-strength portfolio contains numerous corporations such as Nestle with 54 inventions, Novo Nordisk Foundation with 38 inventions, Colgate-Palmolive with 28 inventions, DSM-Firmenich with 27 inventions, Merck & Co with 20 inventions, and Chinese Academy of Science with 109 inventions.

4.2.4 Diabetes

In Figure 149, Mainland China is the leading source of Diabetes technology inventions between 2014 – 2024 producing 31,935 inventions. Followed by the US with 14,764 inventions, South Korea with 4,441 inventions, Japan with 3,663 inventions and India with 3,006 inventions.

Figure 149: Global distribution of inventions related to Diabetes. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

decreasing mean age of inventions (ranked)

● Emerging   ● New Entrant   ● Primary   ● Stale

Figure 150: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Diabetes

King Abdulaziz University holds the largest high-strength recent invention portfolio from Saudi Arabia in Diabetes research with eight inventions with a mean invention

strength score of 56.5, seen in Figure 150, notably followed by Saudi Aramco with two inventions, Imam Abdulrahman Bin Faisal University with two inventions, and King Faisal University with two inventions. King Saud University holds a more established high-strength invention portfolio of ten inventions with a mean invention strength score of 50.8.
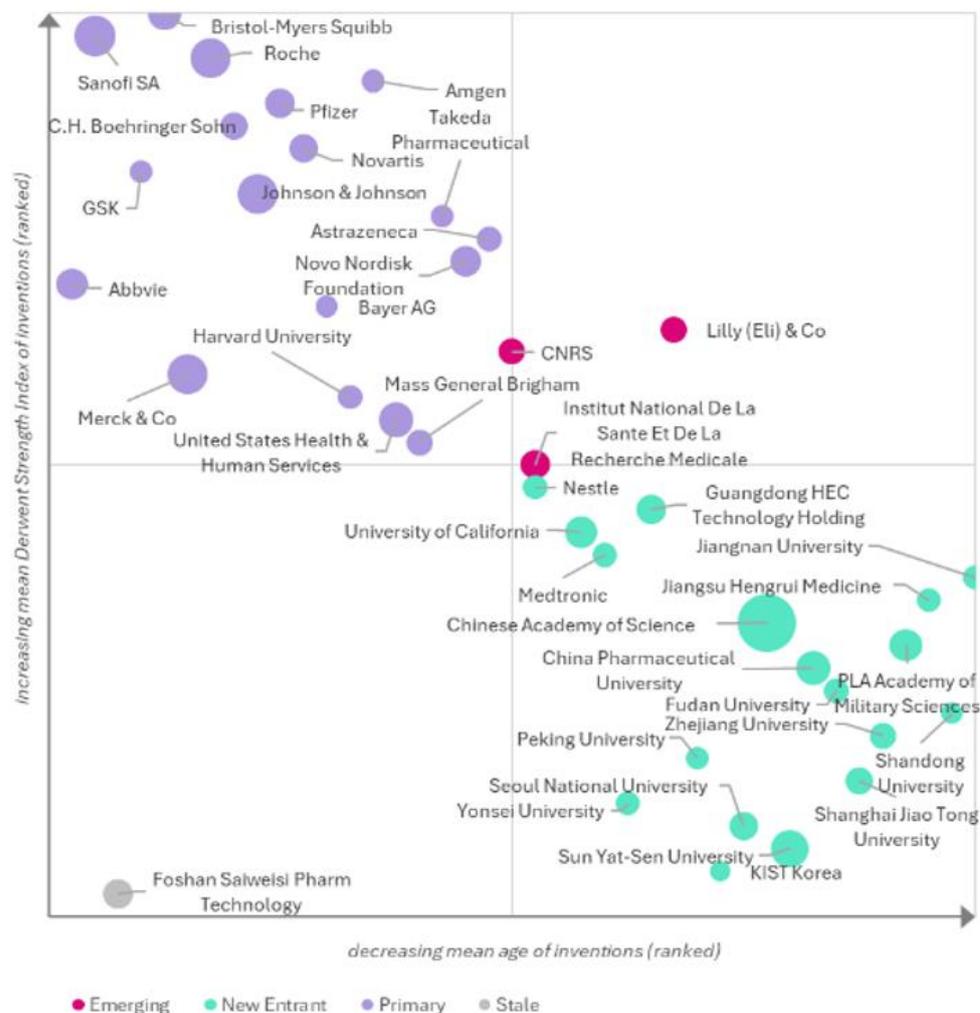

Figure 151: Commercial dynamics model for the top global patent assignees in the research topic Diabetes

INSERM, Eli Lilly, and CNRS are located within the largest high-strength recent portfolios globally for Diabetes technologies, holding 229, 191 and 191 inventions, respectively, in Figure 151. In the top left quadrant for the largest established high-strength inventions, Bristol-Myers Squibb scores the highest average invention strength of 65 across 305 inventions. Followed by Sanofi with 452 inventions with a score of 64.7, Roche with 431 inventions scoring 64.3, and Johnson & Johnson with 438 inventions scoring 60.4.

4.2.5 Biopharmaceuticals

In Figure 152, Mainland China is the leading source of – Biopharmaceuticals technology inventions between 2014 – 2024 producing 51,466 inventions. This is followed by the US with 43,316 inventions, South Korea with 6,996 inventions, Japan with 6,710 inventions and Germany with 5,699 inventions.

Figure 152: Global distribution of inventions related to Biopharmaceuticals. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.
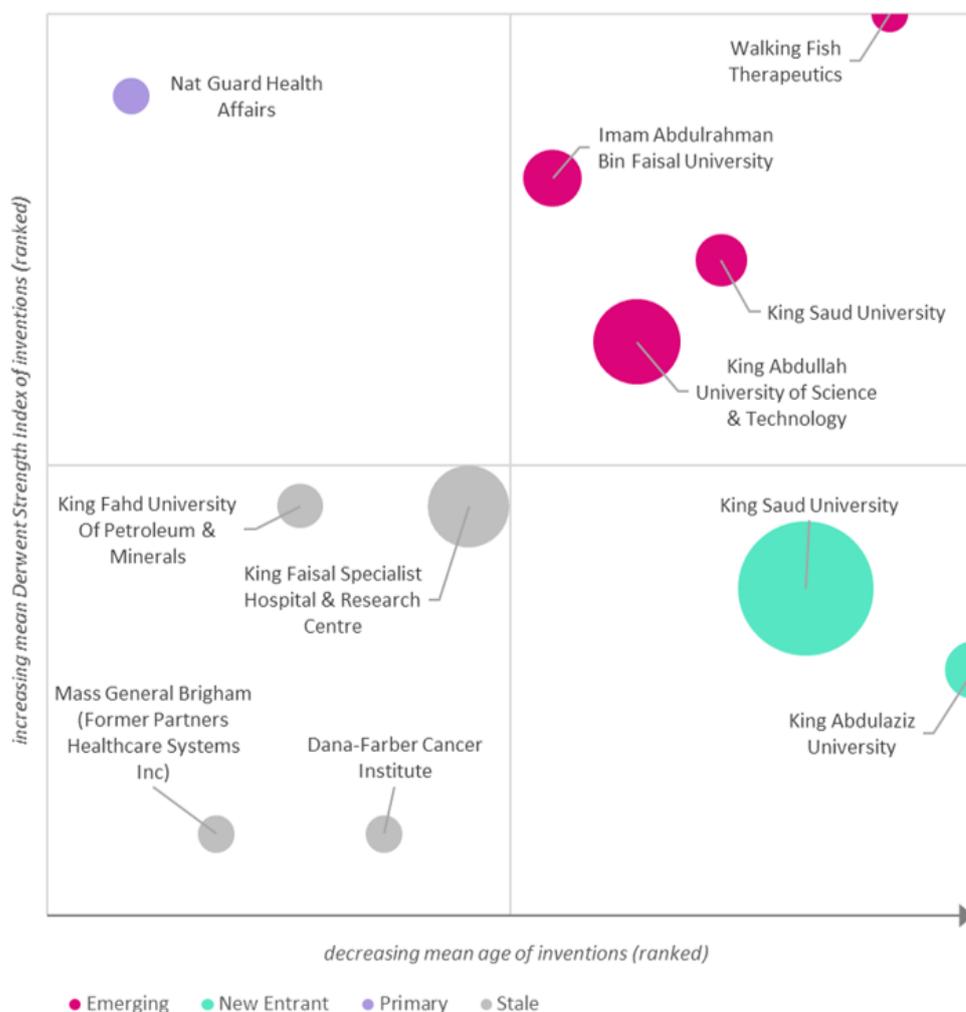

Figure 153: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Biopharmaceuticals

KAUST holds the largest high-strength invention portfolio from Saudi Arabia in Biopharmaceuticals, with 11 inventions scoring 50.8, as seen above in Figure 153,

followed by Imam Abdulrahman Bin Faisal University with five inventions and King Saud University with four inventions.

King Faisal Specialist Hospital & Research Centre holds ten inventions with slightly lower remaining years and a mean invention score of 50.4; KFUPM holds three inventions with the same strength.
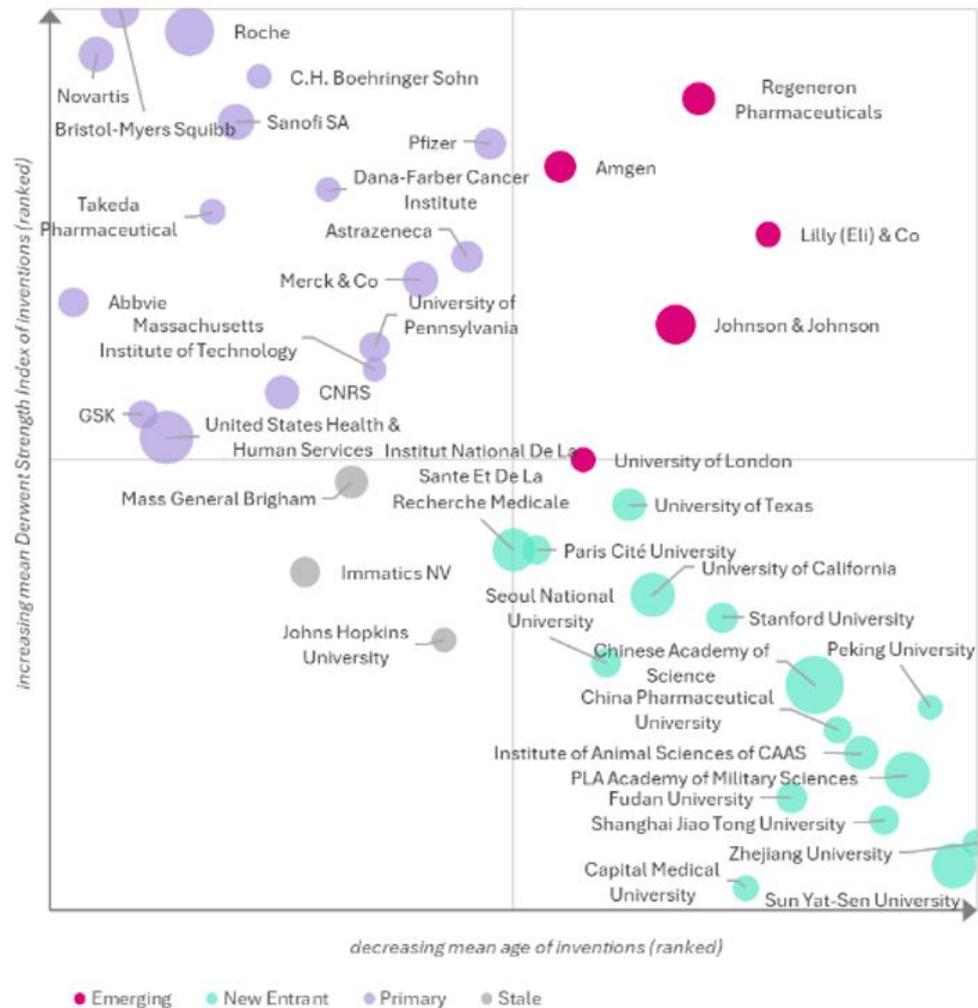

Figure 154: Commercial dynamics model for the top global patent assignees in the research topic Biopharmaceuticals

The largest recent high-strength inventions globally within Biopharmaceuticals technology have been produced by Johnson & Johnson, Regeneron Pharmaceuticals, Amgen, and Eli Lilly, with 833, 631, 562 and 375 inventions, respectively, in Figure 154.

Located within the top left quadrant of the largest high-strength established inventions portfolios are United States Health & Human Services, Roche, Bristol-Myers Squibb, Sanofi, Merck & Co, and Novartis with 1,638, 1,383, 837, 759, 725 and 695 inventions, respectively.

4.2.6 Gene/ RNA Therapy

Figure 155: Global distribution of inventions related to Gene/ RNA General Therapy. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 155, the United States is the leading source of – Gene/ RNA Therapy technology inventions between 2014 – 2024 producing 16,255 inventions. Followed by Mainland China by 13,945 inventions, South Korea 2,565 inventions, Japan with 2,469 inventions and Germany with 1,890 inventions.
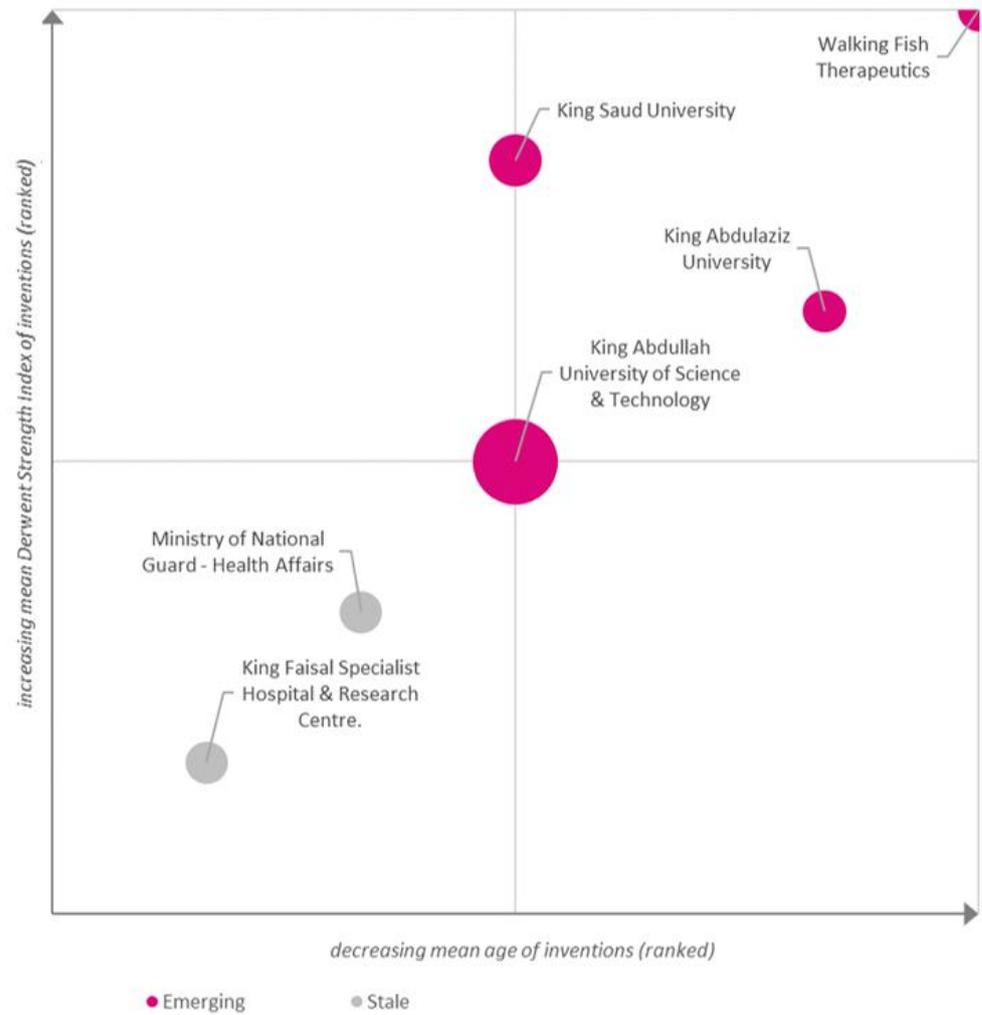
Figure 156: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Gene/ RNA General Therapy

KAUST has the largest number of high-strength inventions from Saudi Arabia for Gene/ RNA Therapy, with eight inventions and a mean strength score of 48.9 in Figure 156 . It is followed by King Saud University, with 54.2 inventions, and King Abdulaziz University, with two inventions.
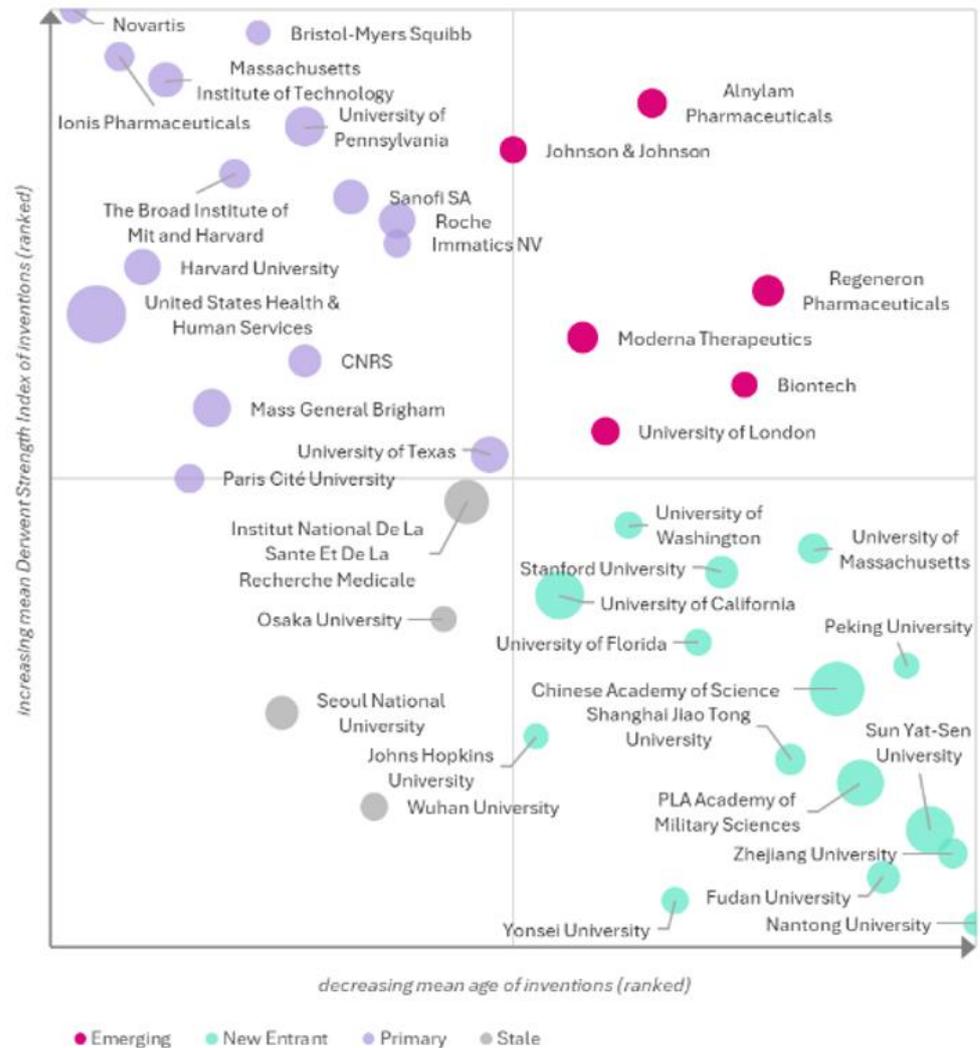
Figure 157: Commercial dynamics model for the top global patent assignees in the research topic Gene/ RNA General Therapy

The largest high-strength recent invention portfolios globally within Med-Tech – Gene/RNA General Therapy are Regeneron Pharmaceuticals, Moderna Therapeutics, Alnylam Pharmaceuticals, University of London, Johnson & Johnson and Biontech, with 235, 226, 200, 180, 173 and 163 inventions, respectively seen in Figure 157.

Notably, only UK, France, and US public research/ Academica are found within the two high-strength quadrants of this technology. Located within the top left quadrant for the largest high-strength established inventions portfolios are United Stated Health & Human Services, University of Pennsylvania, Mass General Brigham University of Teas, and Roche with 786, 364, 333, 316, 305 inventions, respectively.

Notably, amongst other organizations, Novartis and Bristol-Myers Squibb have the highest mean invention scores of 64.5 and 60.1.

4.2.7 Genomics

Figure 158: Global distribution of inventions related to Genomics. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 158, Mainland China is the leading source of Genomics technology inventions between 2014 – 2024 producing 5,829 inventions. Followed by the US with 5,595, South Korea with 988 inventions, Japan with 781 inventions, and the UK with 727 inventions.
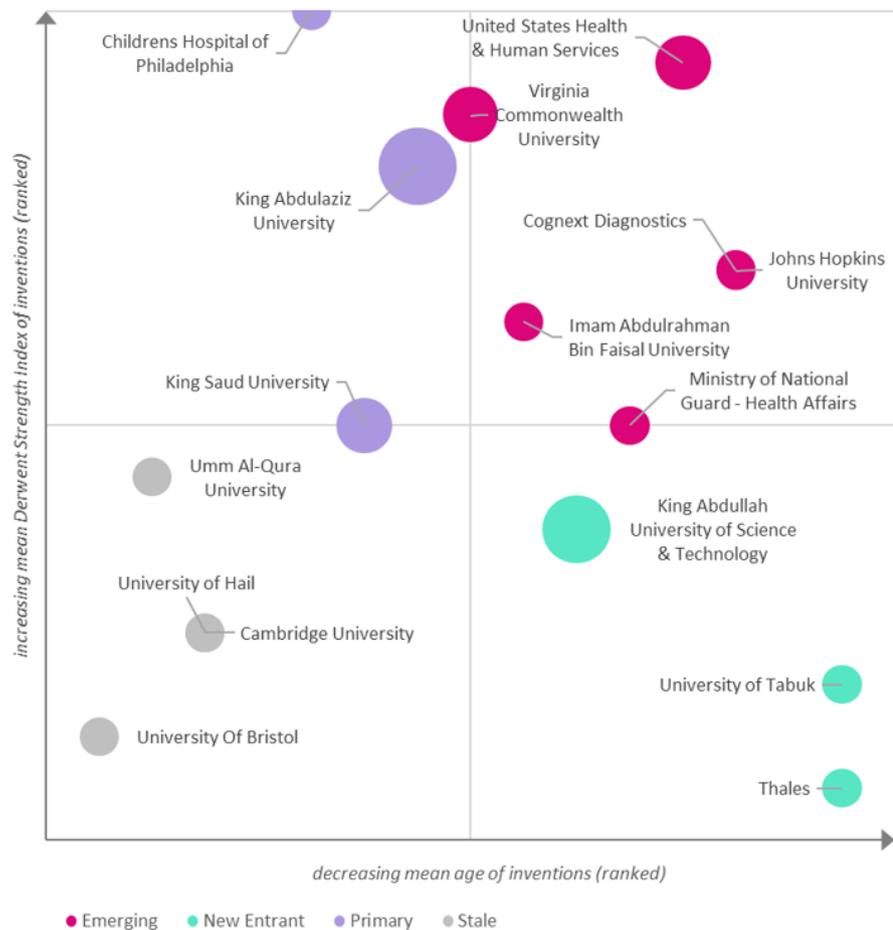

Figure 159: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Genomics

In Figure 159, King Abdulaziz University holds the largest high-strength invention established portfolio from Saudi Arabia in the field of Genomics with four inventions with a mean score of 48.7, followed by King Saud University with two inventions and Imam Abdulrahman Bin Faisal University with one invention.
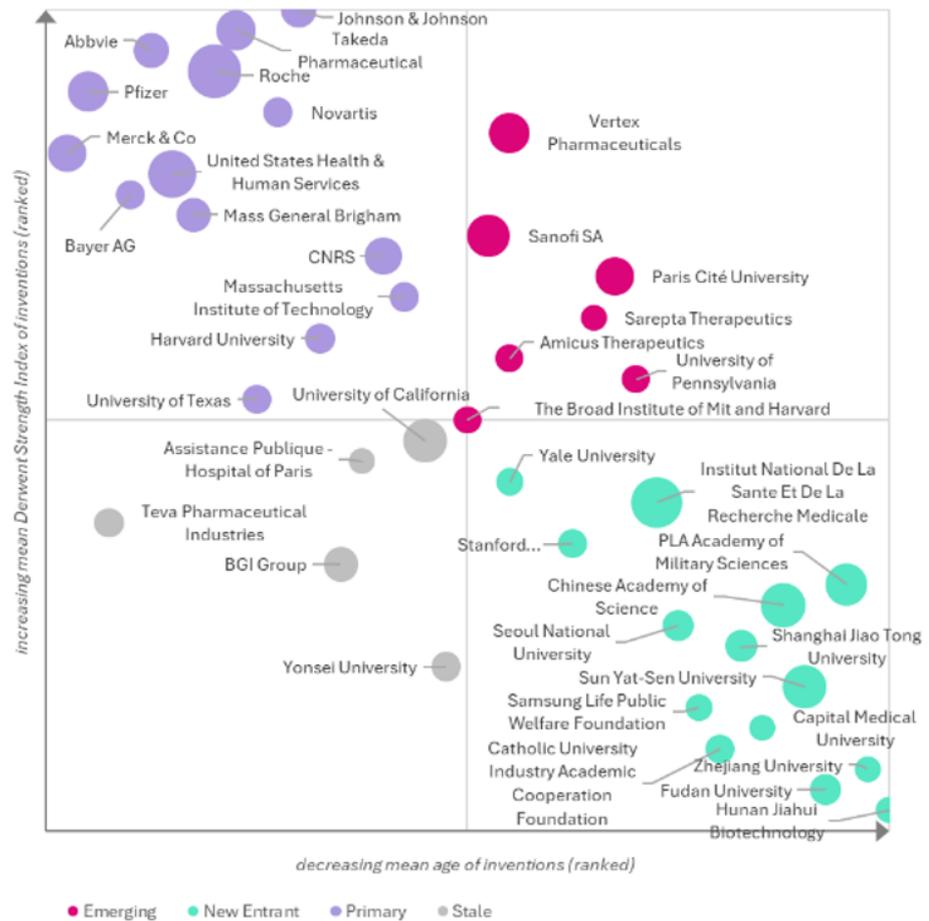

Figure 160: Commercial dynamics model for the top global patent assignees in the research topic Genomics

Sanofi has the largest high-strength recent invention portfolio globally within – Genomics, with 126 inventions scoring 54.5, shown in Figure 160. Followed by Vertex Pharmaceuticals with 117 inventions, Paris Cité University with 102 inventions, the University of Pennsylvania with 57 inventions, Amicus Therapeutics with 55 inventions, The Broad Institute of MIT and Harvard with 52 inventions and Sarepta Therapeutics with 47 inventions.

Located within the top left quadrant are leading organizations with the largest high-strength established inventions portfolios; Roche has 198 inventions, scoring 58.5. Followed by United States Health & Human Services with 156 inventions, Pfizer with 116 inventions, Takeda Pharmaceutical with 111 inventions, Merck & Co with 101 inventions, CNRS with 99 inventions and Johnson & Johnson with a very high mean score of 59.5 across 87 inventions.

4.2.8 CAR-T Cell Therapy

Figure 161: Global distribution of inventions related to CAR-T Cell Therapy. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 161, the United States is the leading source of CAR-T Cell Therapy technology inventions between 2014 – 2024 producing 2,845 inventions. Followed by Mainland China with 1,442 inventions, UK with 263 inventions, Germany with 250 inventions, Switzerland with 232 inventions.
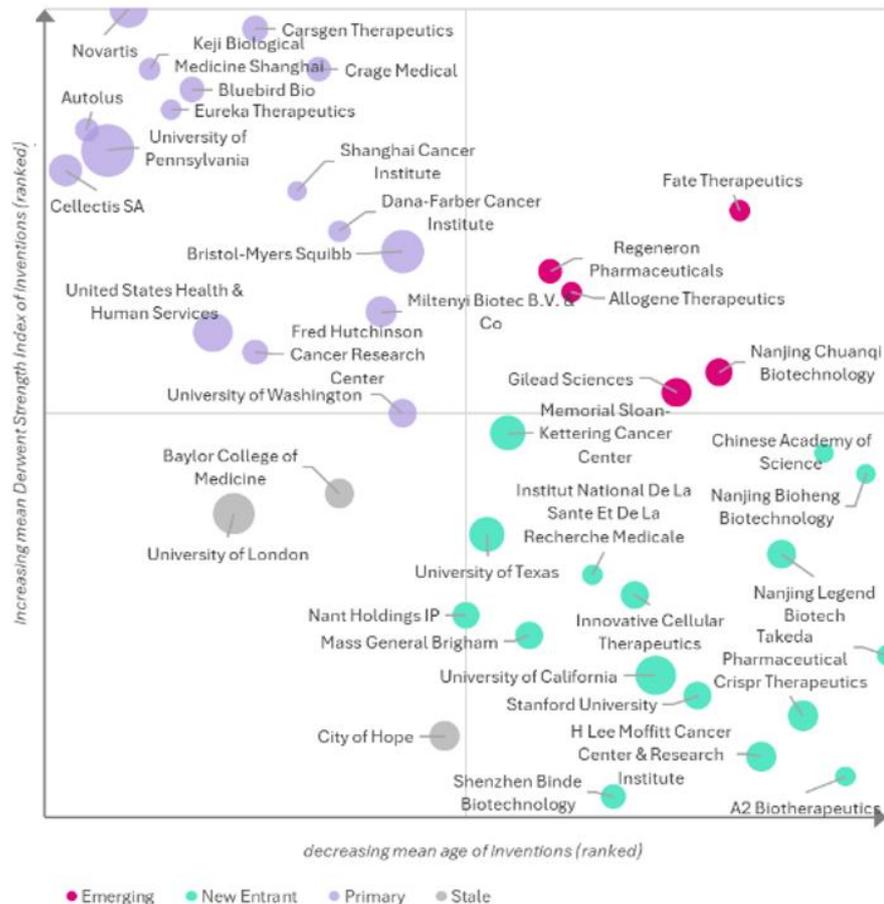

Figure 162: Commercial dynamics model for the top global patent assignees in the research topic CAR-T Cell Therapy

In Figure 162, Gilead holds the largest high-strength recent invention portfolios globally, producing 58 inventions with a mean invention strength score of 53.6, followed by Nanjing Chuanqi Biotechnology with 50 inventions scoring 54.1, Regeneron Pharmaceuticals with 40 inventions scoring 55.5, Fate Therapeutics with 30 inventions and Allogene Therapeutics with 29 inventions.

Located within the top left quadrant for the largest high-strength established inventions is the University of Pennsylvania, with 188 inventions. Followed by Bristol-Myers Squibb with 126 inventions, Unted States Health & Human Services with 103 inventions, Novartis with 94 inventions and Cellectis with 71 inventions.

4.2.9 Stem Cell Therapy

Figure 163: Global distribution of inventions related to Stem Cell Therapy. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 163, Mainland China is the leading source of Stem cell therapies technology inventions between 2014 – 2024 producing 5,736 inventions. Followed by the US with 3,621 inventions, South Korea with 1,573 inventions, Japan with 1,014 inventions and Germany with 236 inventions.

KAUST holds the largest high-strength recent inventions from Saudi Arabia for Stem cell therapies, with five inventions scoring 58.9 shown in Figure 164, King Abdulaziz University has two inventions with a mean invention score of 68.1. King Saud University holds five inventions with a mean invention score of 54, King Faisal Specialist Hospital & Research Centre with five inventions with a mean invention score of 56.

Zhejiang University holds the largest high-strength recent invention portfolio globally within – Stem Cell Therapy, producing 84 inventions with a mean strength score of 48.4, shown in Figure 165. Followed by Stanford University with 79 inventions, INSERM with 66 inventions, Osaka University with 57 inventions, Fujifilm with 50 inventions Crispr therapeutics with 38 inventions and Magneta Therapeutics with 37 inventions.

The left quadrant contains the largest high-strength established portfolios which contains University of California with 146 inventions, United States Department of Health & Human Services with 112 inventions, Mass General Brigham with 79 inventions and the University of Texas with 76 inventions.

Figure 164: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Stem Cell Therapy
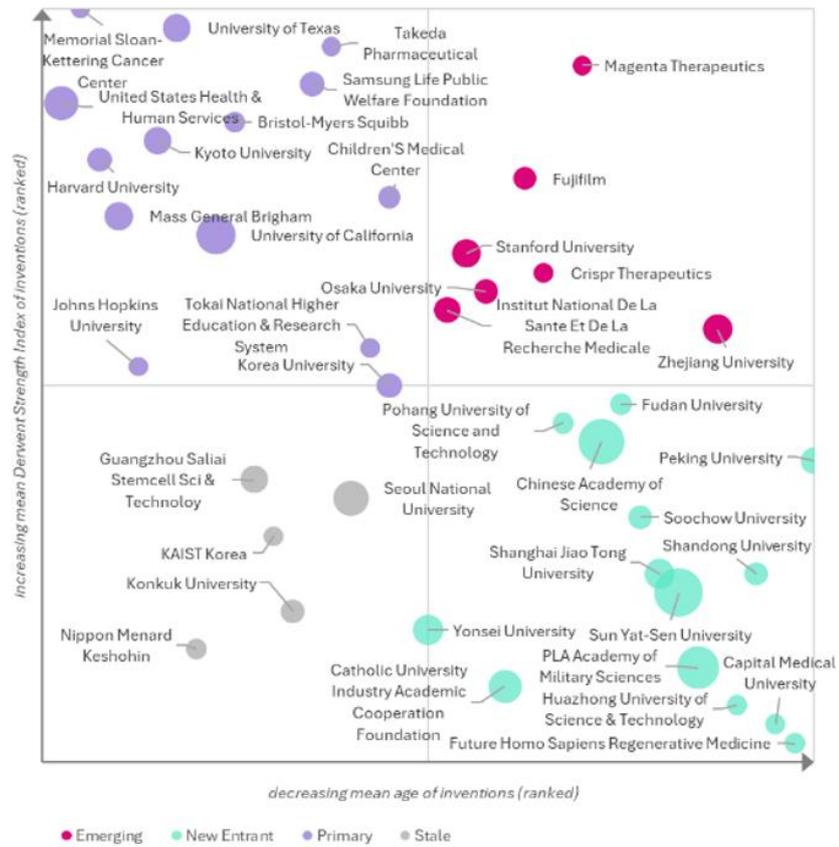

Figure 165: Commercial dynamics model for the top global patent assignees in the research topic Stem Cell Therapy

4.2.10 Dengue

Figure 166: Global distribution of inventions related to Dengue. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 166, the United States is the leading source of – Dengue technology inventions between 2014 – 2024 producing 521 inventions. Followed by Mainland China with 502 inventions, India with 130 inventions, South Korea with 97 inventions and France with 62 inventions.
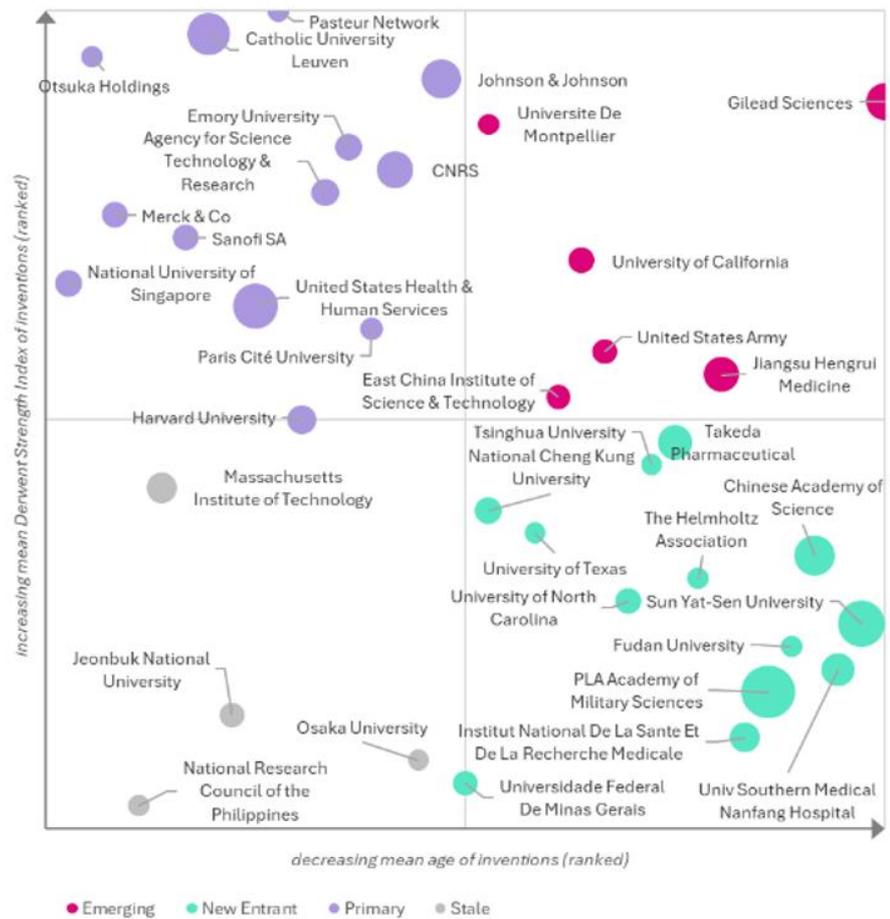

Figure 167: Commercial dynamics model for the top global patent assignees in the research topic Dengue

Gilead has the largest recent invention portfolio with high strength globally, with Dengue Technologies holding 21 inventions with a score of 61.6, as shown in Figure 167. Followed by Jiangsu Hengrui Medicine with 18 inventions, East China Institute of Science & Technology with nine inventions, United States Army with nine inventions and Universite De Montpellier with seven inventions.

Located within the top left quadrant for the largest high-strength established inventions is United States health & Human Services with 30 inventions, Catholic University Leuven with 27 inventions, Johnson & Johnson with 23 inventions, CNRS with 20 inventions and Havard University with 12 inventions.

4.2.11 Vaccine

Figure 168: Global distribution of inventions related to Vaccines. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 168, Mainland China is the leading source of – Vaccine technology inventions between 2014 – 2024 producing 22,386 inventions. Followed by the US with 9,157 inventions, South Korea with 1,847 inventions, Germany with 1,603 inventions, and Japan with 1,389 inventions.

Imam Abdulrahman Bin Faisal University has the largest number of high-strength inventions from Saudi Arabia for Vaccines, with four inventions with a mean invention strength score of 55.3, shown in Figure 169 , and King Faisal University with four inventions with a score of 49.8. Notably, King Abdulaziz University has 17 recent inventions with a mean score of 48.4.

Zhejiang University holds the largest recent high-strength invention portfolio globally for Vaccine technologies, producing 144 inventions of 49.6 strength seen in Figure 170. Followed by the University of Texas with 132 inventions, Biontech with 118 inventions, Roche with 103 inventions and The Helmholtz Association with 101 inventions.

Located within the top left quadrant are the holders of the largest high-strength established portfolios, such as United States Health & Human Services with 514 inventions, Inmmatics NV with 354 inventions, GSK with 304 inventions, Johnson & Johnson with 275 inventions and Merck & Co with 258 Inventions. Sanofi, C.H. Boehringer Sohn and Novartis have the highest strength portfolios above 100 inventions within this quadrant, producing 190, 176 and 141 inventions, respectively.
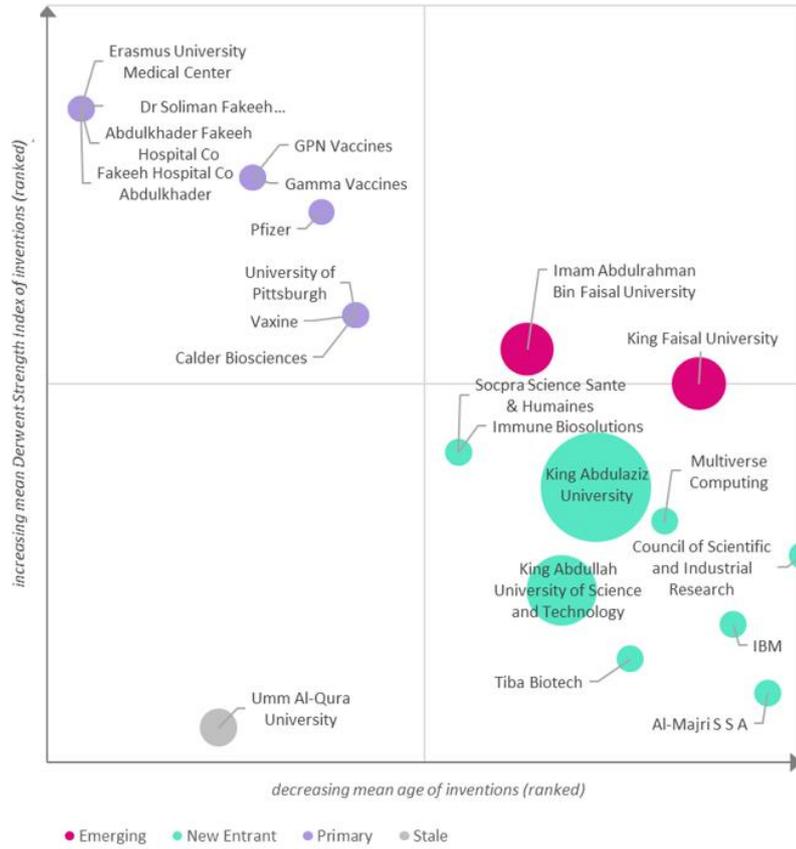
Figure 169: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic of Vaccine
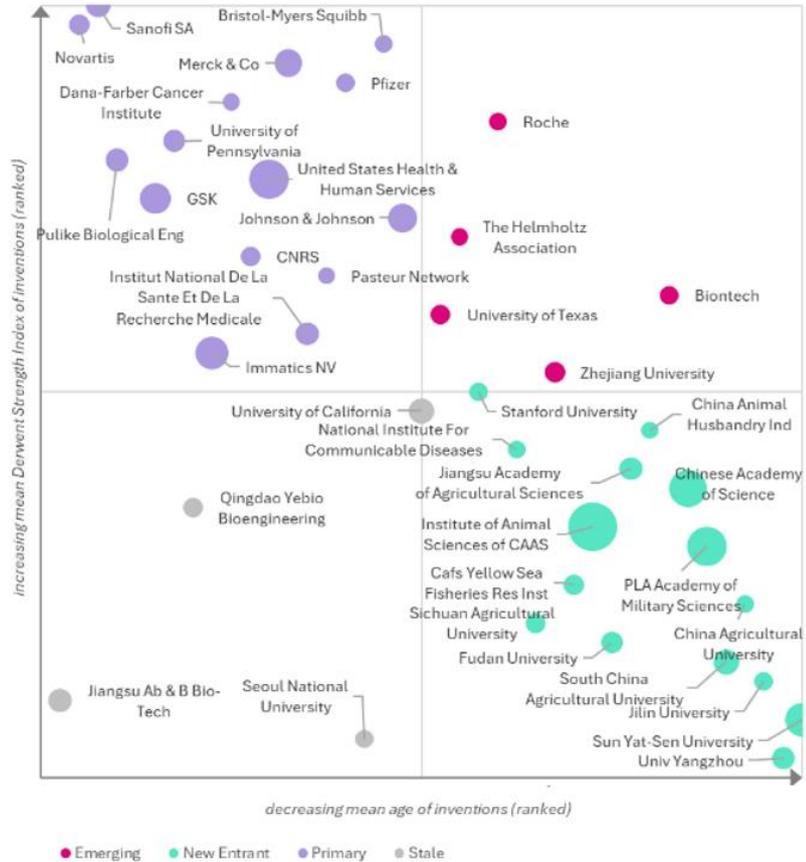
Figure 170: Commercial dynamics model for the top global patent assignees in the research topic Vaccine

4.2.12 Antimicrobial resistance

Figure 171: Global distribution of inventions related to Antimicrobial resistance. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.

In Figure 171, Mainland China is the leading source of – Antimicrobial resistance technology inventions between 2014 – 2024 producing 3,578 inventions. Followed by the US with 1,285 inventions, South Korea with 508 inventions, India with 344 inventions and Japan with 180 inventions.

Figure 172: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Antimicrobial resistance
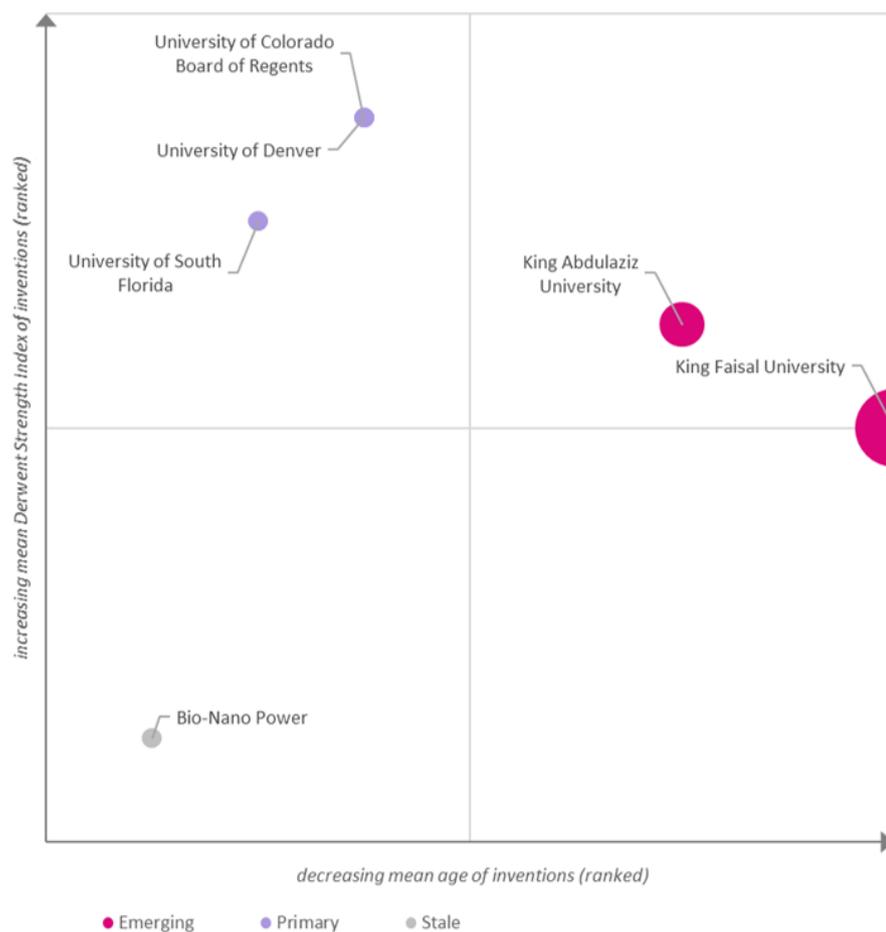
King Faisal University has the largest number of high-strength inventions from Saudi Arabia in Antimicrobial resistance, with 15 inventions scoring 53.1 in Figure 172, followed by King Abdulaziz University, holding five inventions with a score of 56.8, King Saud University with three inventions with a score of 36.7 and Imam Abdulrahman Bin Faisal University with one invention scoring 37.8.
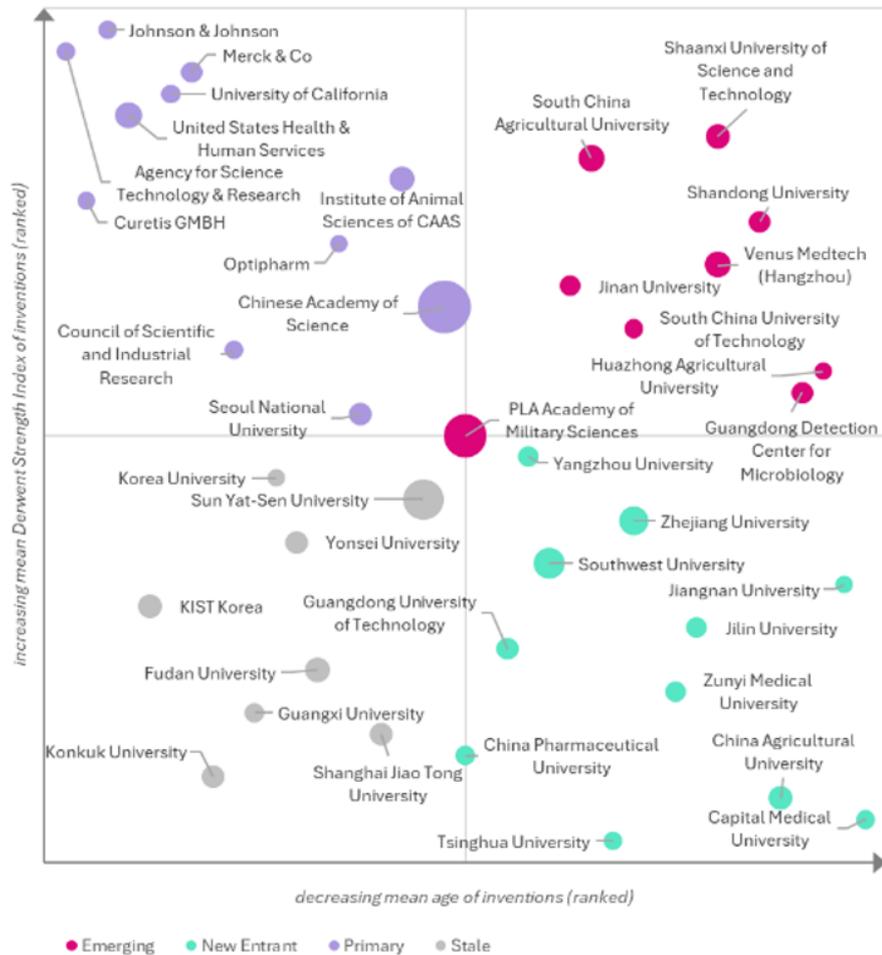
Figure 173: Commercial dynamics model for the top global patent assignees in the research topic Antimicrobial resistance

PLA Academy of Military Sciences holds the largest recent high-strength invention portfolio globally for Med-Tech – Antimicrobial resistance technologies shown in Figure 173, producing 108 inventions, with a mean invention score of 44.7. Followed by South China Agricultural University with 41 inventions and Venus Medtech (Hangzhou) with 238 inventions.

Located within the top left quadrant for the largest high-strength established inventions, Chinese Academy of Science lead with 161 inventions, scoring 46, United States Health & Human Services with 41 inventions, Institute of Animal Sciences of CAAS with 34 inventions, Seoul National University with 30 inventions and Merck & Co with 25 inventions.

5 Key findings within Health and Wellness
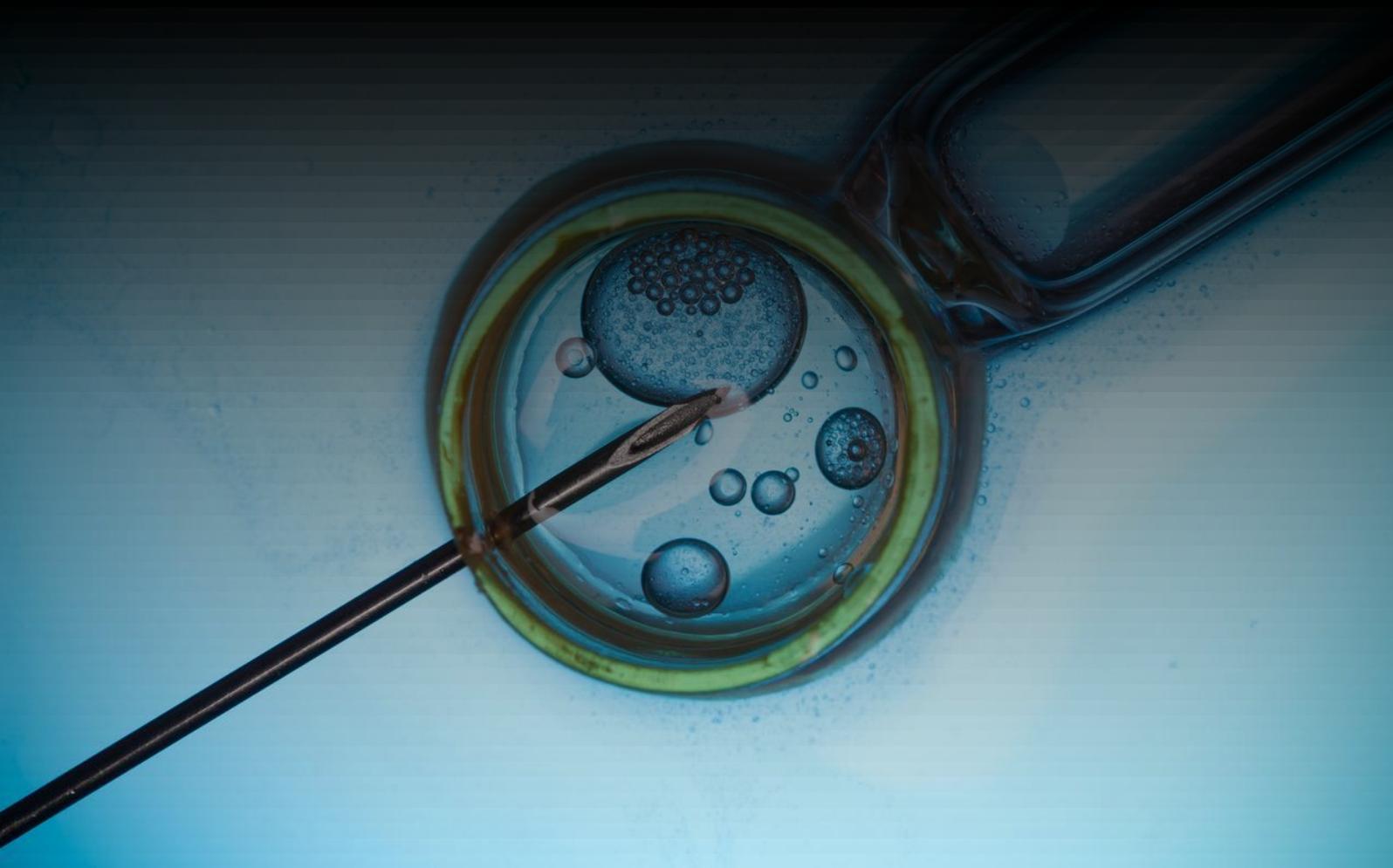
Drawing upon the insights from research and invention performance, Academic-Corporate Partnerships, and Technology Maturity evaluation for Saudi Arabian and global organizations, this section provides key findings tailored to the relative position of Saudi Arabia for each technology by using industry-leading metrics to provide the next steps. These findings will outline the potential of the technologies specifically for Saudi Arabia, where to invest, and ultimately whether more academic funding is required, further Academic-Corporate Partnerships, transfer of technology from academic to private entities, and potentially to continue the existing strategies.

Table 33: Health and Wellness research topic scorecard

				High	Medium	Low

	Saudi Arabia's Research Strength	Saudi Arabia's Invention Strength	Saudi Arabia's Partnership Strength	Saudi Arabia's research productivity	Technology maturity	Future Predicted Growth
Dengue	871	64	1.0%	1.9	5	6.8%
Antimicrobial Resistance	4972	2349	1.9%	2.1	5	8.5%
Biopharmaceuticals	6392	3470	2.2%	1.3	8	7.6%
CAR-T Cell Therapy	120	99	1.7%	0.5	5	8.1%
Gene/ RNA Therapy	1864	908	1.9%	0.9	7	7.6%
Genomics	3489	715	2.4%	1.2	8	7.9%
Stem Cell Therapy	610	655	1.8%	0.9	7	7.5%
Vaccines	5012	1649	2.5%	1.3	7	7.8%
Cancer	26943	19594	1.6%	1	8	7.5%
Cardiovascular Diseases	9396	3246	2.2%	0.8	9	6.3%
Diabetes	9931	3247	2.0%	1.8	8	6.3%
Nutrition & Obesity	8196	77	1.3%	1.1	7	6.7%

The scorecard above contains factors analyzing Saudi Arabia's position per research topic. They are defined as:

- **Research Strength: Total number of Saudi Arabian research papers multiplied by CNCI.** The Category Normalized Citation Impact (CNCI) of a publication is calculated by dividing the actual count of citing items by the expected citation rate for publications with the same publication type, year of publication and subject area.

- **Invention Strength: Total number of Saudi Arabian inventions multiplied by DSI.** A Clarivate metric of the strength and quality of a patented idea. Based on the impact of the invention on others (based on the frequency of downstream citation by the patent applications of third parties), the global footprint of patents granted (based on the % of world GDP covered by the patent asset), the investment level in the invention by the applicant (based on the number of patent jurisdictions in which the applicant sought protection)

and the inventions rarity (based on the number of inventions in the global database that share the same technology mix).

- **Partnership Strength:** The mean partnership % for research papers and inventions in Saudi Arabia

- **Research Productivity:** The productivity relative to the global productivity is measured by the number of Saudi Arabia papers in specific research topic divided by the number of global publications in the same research topic and period.

- **Technology Maturity:** Each of the research topics within the National Priority Areas has been mapped to individual Technology Maturity Index from 1 – least mature through 9 – most mature.

- **Future Predicted Growth:** CAGR predicted growth extrapolated from historic inventions level.

Vaccines and **Diabetes** score highly on research and invention volume and average strength by CNCI and DSI relative metrics. Similarly, both technologies have an average of 2.5% and 2.0% ACPs across research papers and inventions. The technology maturity is high in both technologies at 7 for Med-Tech Vaccine and Diabetes 8, denoting high commercialization readiness; international examples could include COVID-19 Vaccines and Ozempic from Novo Nordisk. Future predicted growth levels of 7.8% and 6.3% show a steady growth rate, and research paper-to-invention ratios of 3,054: 48 and 8,333: 87 display a legacy focus on research papers.

To boost Vaccine invention levels by focusing on King Abdulaziz University's invention portfolio by collaborating with large international filers such as Sanofi, Novartis, Pfizer, Merck & Co, Bristol-Myers Squibb, GSK, Roche, Johnson & Johnson, Biontech and Inmatics NV all with 100s of inventions in this field. Novartis and the University of Pennsylvania have previously collaborated to produce 14 inventions in vaccine technologies. The above pharmaceutical corporations could also boost inventions from other vaccine research academic institutions in Saudi Arabia, such as King Saud University and King Abdulaziz University, with over 450 research papers each.

To further enhance Diabetes technology, leverage expertise from Saudi Arabian university inventions from organizations such as King Abdulaziz University, King Saud University, KAUST, Imam Abdulrahman Bin Faisal University and King Faisal University. International ACP with organizations such as Sanofi SA, Johnson & Johnson, Roche, Merck & Co, Bristol-Myers Squibb, Abbvie, Novo Nordisk Foundation, Pfizer, Novartis, C.H. Boehringer Sohn, AstraZeneca, Amgen, Bayer AG, Takeda Pharmaceutical, Eli Lilly, or GSK. It is predicted that Diabetes could add $0.65 billion to Saudi Arabia's economy; if 1,667 inventions are protected in this field, the likely yield would be around 15 very strong inventions.

Gene Therapy and **Nutrition & Obesity** research topics both have high research volume and quality in Saudi Arabia, however lower invention volumes and strength. These technologies have medium average ACP levels across research and invention data at 1.9% and 1.3%, and 7.6% and 6.7 predicted invention growth respectively, accompanied by high technology maturity at 7 and 8, respectively. These technologies have a high research paper-to-invention ratio of 1,361:26 and 6,581:4 inventions, respectively.

Focusing on academic invention yield and conversion from papers to inventions may boost overall volumes and conversion to Saudi Arabian corporations. – Gene therapy innovators such as KAUST, King Saud University, and King Abdulaziz University have the highest volume and strength of inventions. These innovators would benefit from ACPs with international innovators such as Novartis, Bristol-Myers Squibb, Sanofi, Roche, Inmatics NV, Johnson & Johnson, Moderna Therapeutics, Biontech, Regeneron and Alnylam Pharmaceuticals, with invention portfolios of 150 – 305 inventions specialized in Gene therapy. Academic research partnerships may also

boost invention output from Saudi Academic institutions with international Academic institutions such as the University of London, University of Pennsylvania, Mass General Brigham, University of Texas, MIT, Broad Institute, Paris Cite University and Harvard University – all with over 180 inventions. Notable collaborative invention production includes Biontech with Univ Mainz Tron Translationale Onkologie with 56 inventions and Novartis with the University of Pennsylvania with 40 inventions. In the field of Diabetes, expanding and increasing invention production from Saudi Arabia's academia, such as King Abdulaziz, King Saud University and King Faisal, would build upon existing high-strength invention portfolios. International collaboration with leading established innovators such as Sanofi, Bristol-Myers Squibb, Roche, Pfizer, Amgen, GSK, Eli Lilly, Novartis, Johnson & Johnson, AstraZeneca, Takeda, Amgen, Abbvie, Novo Nordisk, Bayer, Merck & Co – would leverage proven global pharmaceutical companies. Academic Collaboration with Harvard University, Mass General Brigham, CNRS, and INSERM may also boost earlier-stage academic research.

The Nutrition & Obesity field in Saudi Arabia could benefit from focusing on producing greater levels of inventions from existing research organizations such as King Saud University, King Abdulaziz University, University of Tabuk and King Saud University and others seen in Table 10. Given the high maturity of the technology, it could be beneficial to enhance APC levels via international organizations such as Novo Nordisk, Danone, P&G, AstraZeneca, DSM-Firmenich, Merck & CO, BGI Group and Colgate-Palmolive.

CAR-T Cell Therapy and **Stem Cell therapies** have lower volume and strength in research and inventions in Saudi Arabia compared to other Health and Wellness technologies. They have medium levels of research and invention ACPs, with 1.7% and 1.8%, respectively, and medium levels of research productivity, with 0.5% and 0.9%, respectively. The maturity level of cell therapy is medium at 5, whereas Stem Cell therapies are at seven and have 8.1% and 7.5% predicted invention growth. From a research paper: invention ratio, these technologies score 29 and 36, respectively; typically, there is an expected lower research paper-to-invention ratio in more mature technologies.

CAR-T Cell Therapy may benefit from both international academic partnerships to boost invention levels and established global pharmaceutical companies to strengthen commercially applied research. University of Pennsylvania, Shanghai Cancer Institute, Dana-Farber Cancer Institute, Fred Hutchinson Cancer Research Center, Keji Biological Medicine Shanghai, and University of Washington all appear as established high-strength innovators. Potential Corporate collaborators include Novartis, Autolus, Cellectis, Carsgen Therapeutics, Bluebird Bio, Eureka Therapeutics, Bristol-Myers Squibb, Regeneron, Fate Therapeutics, Allogene, Gilead Sciences and Crage Medical. Notably, the University of Pennsylvania scores in the top 40 technology portfolios for CAR-T Cell therapy by high-strength inventions, with 18 averaging a DSI score of 83.8. Novartis and the University of Pennsylvania have 69 ACP-generated inventions. Similarly, the University of London and Autolus have created 38 inventions together in this field; Autolus was spun out of the University of London.

To leverage existing academic research from institutions in the field of Stem Cell therapies, such as King Abdulaziz University and King Saud University, with high CNCI and the highest Saudi invention scores, to develop further academic inventions. However, due to the technology maturity and low levels of research and invention strength across Saudi Arabia, prioritizing areas of greater strength and lower maturity may yield higher economic returns.

Genomics is a field of high research strength consisting of volume and CNCI, low research productivity, and low invention strength; this is despite being an area of high ACP levels, high technology maturity and high future predicted invention levels. There have been 3,597 research papers published in the last 10 years compared to only 22 inventions; this ratio would be expected in a lower-maturity technology.

Considering the historic low innovation in this field, it would be advised to focus on higher-strength technologies within Health and Wellness, for example, Cancer therapies. For this field to advance its production of inventions, ACPs with large-experienced corporations such as Abbvie, Pfizer, Johnson & Johnson, Takeda, Roche, Novartis, Bayer, Sanofi, and Vertex Pharmaceuticals would focus research efforts into more commercial applications. Suitable Saudi Arabia Academic Institutions would be King Saud University, King Abdulaziz University and King Saud Bin Abdulaziz University for Health Sciences.

Dengue therapies have relatively lower research volume and CNCI alongside lower invention volumes and strength compared to other Health and Wellness technologies. There have historically been low ACP levels, high research productivity and medium technology maturity. As there are low predicted levels of invention growth combined with this technology performing as strongly as other Health and Wellness technologies, ad hoc academic funding would be suitable. KAUST has previously filed an invention in Dengue. International corporations with strength in this technology include Merck & Co, Sanofi, Johnson & Johnson, and Gilead Sciences – notably, their portfolios in this area are relatively small, holding between 8-21 inventions each.

Antimicrobial Resistance and **Biopharmaceuticals** in Saudi Arabia perform as areas of medium research volume combined with CNCI, as well as invention volume and strength. Antimicrobial Resistance has experienced medium ACP levels, High research productivity and is considered a medium mature technology with predicted high levels of invention growth. Biopharmaceuticals are highly collaborative technologies in Saudi Arabia, with medium research productivity, high technology maturity and only medium prediction invention level growth. Antimicrobial Resistance would benefit from ad hoc academic funding into King Faisal University and King Abdulaziz University to develop further inventions as the technology matures. The 100 Biopharmaceutical inventions in Saudi Arabia could be transferred into commercial applications, the strongest portfolios are held by King Abdulaziz University, KAUST. However, it may be more efficient to establish further ACPs with large international Pharmaceutical companies such as Novartis, Bristol-Myers Squibb, Roche, Sanofi, Boehringer Ingersoll, GSK, Pfizer, Takeda, Abbvie, Merck & Co and AstraZeneca with significant portfolios and experience taking therapies to global markets. It is predicted that Biopharmaceuticals could add $0.75 billion to Saudi Arabia's economy if 1,667 inventions are protected in this field; the likely yield would be around 17 very strong inventions.

Cardiovascular Diseases research topic are an area of high research volume by CNCI and high invention strength for Saudi Arabia. This field has medium levels of ACPs, low research productivity, high technology maturity and low predicted levels of invention growth. There are 6,608 published research papers compared to 94 inventions; however, inventions in Health and Wellness are often protected in many countries globally. Considering the high maturity level and good levels of inventions in Saudi Arabia, applying these inventions in products in the market will provide a return on investment for research funding. If further inventions are needed, ACPs with international organizations may provide further innovation to be commercialized by Saudi Arabian organizations such as King Abdulaziz University with 24 inventions or King Saud University with nine inventions. International innovators such as Sanofi, Bristol-Myers Squibb, Pfizer, Roche, Takeda, Amgen, GSK, Boehringer Ingersoll, AstraZeneca, Bayer Merck & Co, Abbvie and Johnson & Johnson. It is predicted that Cardiovascular Diseases technologies could add $0.54 billion to Saudi Arabia's economy if 1,667 inventions are protected in this field; the likely yield would be around seven very strong inventions.

Cancer is the technology with the highest research volume, CNCI, and invention strength. This is despite relatively low levels of ACPs, low research productivity, and only medium-predicted invention-level growth. This technology area has high technology maturity and the highest number of research papers across all RDIA-prioritized technologies, with 22,527 and 513 inventions. There has been 9% ACP across inventions; however, only 1.43% within research paper partnerships. The

academic institutions with strongly established portfolios with more than five inventions are KFUPM, KAUST, King Faisal Specialist Hospital & Research Centre; more recently, King Saud University, King Abdulaziz University, and Ministry of the National Guard – Health Affairs have obtained over ten inventions each. King Saud University leads with 96 inventions from Saudi Arabia; notably, Saudi Aramco also holds three inventions. Considering the maturity of the technology and the depth of both research and inventions in the Saudi Arabian health ecosystem, it would be suitable to take this technology to market. However, there is a notable absence of private organizations with products on the market. Routes to creating private organizations could include spin-offs from the above academic institutions and/or joint ventures with large, experienced international pharmaceutical organizations. Potential joint ventures or further ACP partners include Sanofi, Bristol-Myers Squibb, Roche Novartis, Pfizer, Abbvie, Merck & Co, Johnson & Johnson, Amgen, AstraZeneca and Immatics – who all appear in the established high-strength established portfolio quadrant. Examples of those with over 40 inventions in collaboration with Academia include Novartis, Biontech, Autolus and Bayer. It is predicted that Cancer technologies could add $0.62 billion to Saudi Arabia's economy; if 1,667 inventions are protected in this field, the likely yield would be around 14 very strong inventions.

In conclusion the Health and Wellness priority area for Saudi Arabia has significant potential accumulated within the Academic Institutions, built upon a base of research projects yielding research papers. To successfully take the research to market, further investment and focus are required to spin out specialist start-ups to prioritize specific therapies and therapeutic targets. Considering the long research and development cycles within large international pharmaceutical companies, laying the groundwork for Academic-Corporate Partnerships with experienced organizations will fast-track taking Saudi research into international healthcare markets. Joint ventures, strategic R&D centers, incubators, and merger & acquisition activity may also be suitable options to further enhance Saudi Arabia's commercially focused research in the field of Health and Wellness.

6 Definitions, metrics and data sources
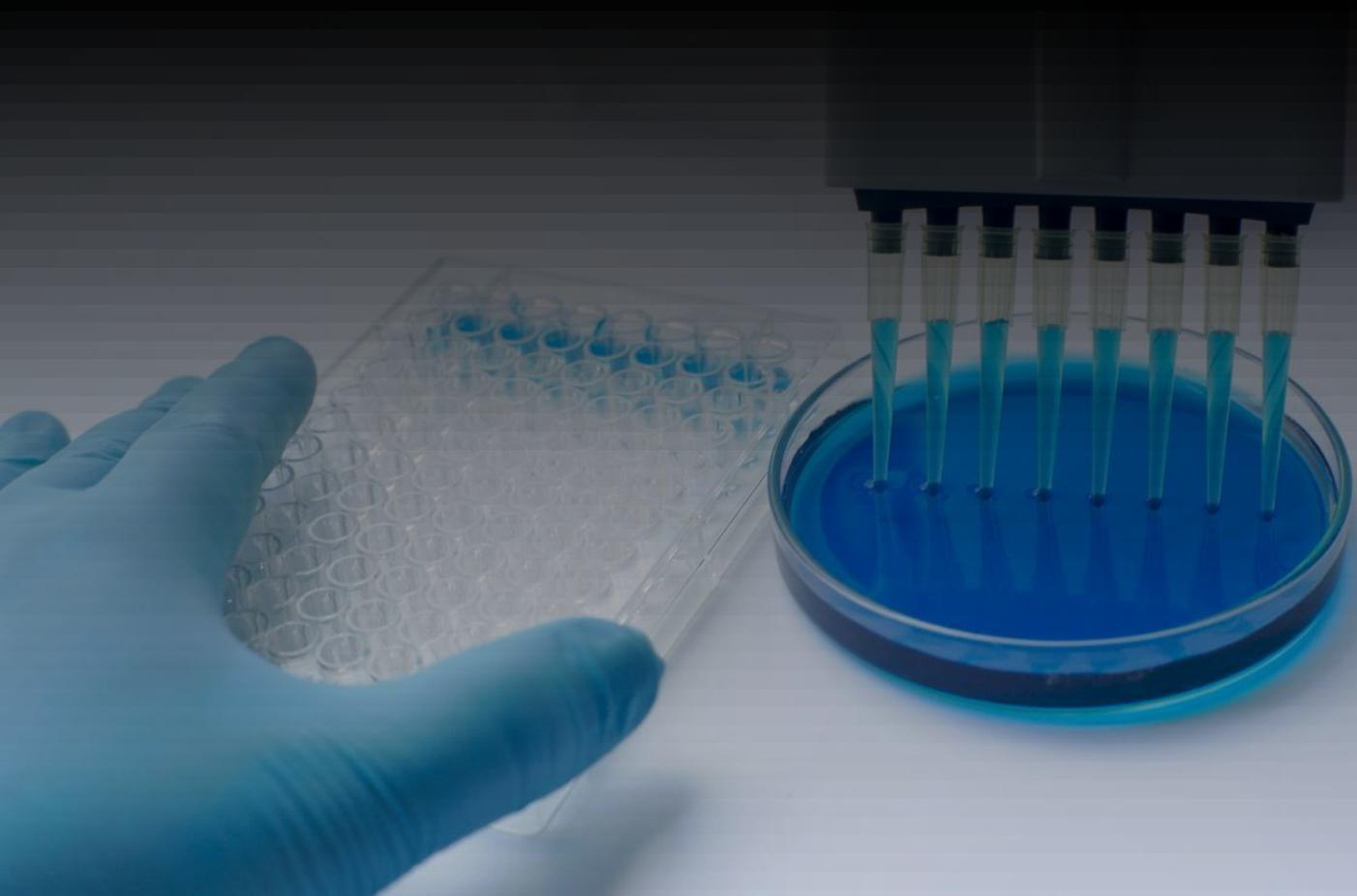
6.1 General definitions

Academic institution

An establishment dedicated to education and research, generally conferring academic degrees across various levels of learning. While academia can more widely be used as a term for primary education through tertiary education, we limit and define the tertiary sector only for the purposes of this study. However, note that we further expand the definition of academia in this study to government research institutions more generally.

Academic-Corporate Partnership

Refers to a collaborative arrangement between educational institutions and business entities, aiming to leverage their respective strengths for mutual benefit, often in the realms of research, technology development, and knowledge exchange. The relationship typically involves shared resources, strategic alignment, and a commitment to achieving common objectives that advance both academic and corporate interests. Defined and identified in this study as a scientific publication or a patent family that contains bibliographic information as authors or inventors from organizations that are both an academic institution and a corporate entity.

Applied Research

Refers to the process of systematic investigation that aims to solve practical problems by applying scientific knowledge. It typically involves collaboration with industry to develop tangible solutions, such as new products, technologies, or processes, that directly address specific challenges in various fields.

Basic Research

Often also called pure or fundamental research, this refers to the process of systematic investigation aimed at gaining a deeper understanding and knowledge of the underlying principles of phenomena and observable facts without immediate practical application in mind.

Commercialization

Commercialization refers to the process of managing, typically via a business or corporate entity, activities in return for economic or monetary gain. It involves introducing a new product or service to the market and is often associated with the production, distribution, marketing, and sales necessary to achieve commercial success. Frequently used in the context of scaling up business operations to reach a broader market. This study is specific to understanding the level of commercialization activity and the directionality of research areas.

Corporation

A corporate entity is a legally recognized organization designed to conduct business. Typically, a corporation is a body formed and authorized by law to act as a legal person, distinct from the natural persons owning or operating within the entity. Corporate entities can enter contracts, own assets, and are subject to taxation while providing limited liability protection to their owners.

Innovation

Refers to the process of progressing new ideas or inventions into products, services or other economic activity that is valued and in demand by businesses or consumers. As a general principle, innovation can encompass the direction of creativity, technical knowledge, and information and can target the conversion of new and useful products and services. In this study, we focus on the definition of technical innovation and the process of developing and applying new technologies or improving existing ones to create advancements in various fields. It involves the use of technical knowledge and expertise to address challenges, enhance efficiency, and create value through novel solutions.

Invention

A novel or unique method, device, or process developed from research and experimentation, typically patented and designed to solve a specific problem or improve existing solutions. Within this study, due to the database structure of the Derwent World Patents Index, we use "invention" as synonymous with "patent family" (see definition) - an individual idea meeting the criteria of an invention, as patented at various patent offices around the world. This definition includes patent applications that have not yet been granted. This definition removes the need to deduplicate multiple patent publications surrounding the single invention/idea and, in turn, transforms the collection of multiple patent publications into metadata of invention strength.

Nominal Gross Domestic Product (GDP)

Nominal Gross Domestic Product (GDP) is a macroeconomic metric that measures the total market value of all finished goods and services produced within a country's borders at a specific time, using current prices without adjusting for inflation. Presented here in US dollars.

6.2 Patent related definitions

Patent

A patent is a legal instrument that grants an inventor exclusive rights to use, sell, or manufacture their invention for a limited period, typically 20 years, in exchange for public disclosure of the invention.

Patent Assignee

A patent assignee is the individual or entity that holds the ownership rights to a patent. This transfer of rights is typically formalized through a written contract or assignment agreement, which grants the assignee the exclusive rights to the patented invention, including the right to make,

use, sell, or license the invention. The assignee assumes all associated rights and responsibilities from the original patent holder, known as the assignor. Typically, the assignment takes place because of employment contracts that require employees to assign intellectual property rights to their employer for creating an invention during their employment.

Patent Family

A patent family refers to a collection of patent applications or granted patents that are related to each other and cover the same or similar technical content. These related publications are typically filed in different countries, originating from a single priority application or a set of priority applications. The concept of a patent family is instrumental in tracking the legal protection status of inventions globally and is recognized by various patent offices and databases. The family definition used in this study is specific to the Derwent World Patents Index™, which provides for a synonymous relationship between each family and an individual invention – e.g., one specific set of claims language (the section of a patent document detailing what is protected) in each legal jurisdiction in which protection has been sought.

Patent Jurisdiction, Patent-Issuing Authority

Refers to the legal authority granted to a country or region over the creation, use, and enforcement of patents within its territory. This includes the power to grant patents, determine their validity, and adjudicate disputes related to patent infringement. The jurisdiction is defined by the territorial scope within which the patent rights are applicable and enforceable, and it is typically the responsibility of national or regional patent offices to oversee these legal rights. Notably, patents are local rights that are only valid and have exclusivity

within the jurisdiction of the patent office. There are multiple "regional" patent jurisdictions, such as the European Patent Convention or the Gulf Cooperation Council Patent Office.

Patentability

In order to be valid, a patent application needs to fully disclose an invention so that it can be understood by the average person with training in the technical field, and it must be novel (never seen in the public domain before), useful (typically, it must have a real world use, and must actually work) and not be an obvious extension of previous technology (typically, simply combining multiple previous ideas together).

Technical maturity index (TMI)

A mathematical model that aggregates global scientific, engineering and technological structured disclosures (i.e. peer-reviewed scientific papers and patented inventions), alongside assertion of technology, to empirically measure the maturity of a technology field, approach or use case. It can be used to assess differing fields and sectors alongside each other, due to the normalization of measures incorporated into the model.

Technical readiness level (TRL)

A scale is used to estimate the maturity of a technology during the acquisition phase of a program. It provides a consistent and uniform discussion of technical maturity across different types of technologies. The scale ranges from 1 to 9, with 9 being the most mature technology. TRL assessments are critical in managing the progression of technology from conception to deployment. Originally created in the 1970s by NASA as a way of managing technical development

readiness and safety for human spaceflight, the TRL system has been widely adopted by the International Standards Organization in 2013 as a qualitative measure of basic, through applied and then commercialized technology progression. In this study, TRL and TMI become synonymous - as the advanced measurement of global public science, research and technology assertion is captured and mathematically modeled so that it maps empirical measures of maturity onto (in relative terms) the structure of a TRL.

6.3 Research related definitions

Citation

An academic citation is a formal reference to a published or unpublished source that is used to support the author's arguments or findings in a scholarly work. It acknowledges the original creator of an idea or piece of information and provides readers with the details necessary to locate the source material themselves. Citations are essential in academic writing to avoid plagiarism, uphold intellectual honesty, and facilitate the verification of facts or ideas presented.

Patent citation is a similar process and refers to any significant document or research paper that a patent applicant, examiner, or third party cites as relevant to the content of a patent application. It serves as a formal acknowledgment of prior art and related work in the field, providing a trail of the intellectual property landscape pertinent to the invention.

In both cases, citation is a significant source of impact metadata, as the aggregation and analysis of papers, patents, topics, organizations and economies via citation measures provides a method of assessing the preponderance of downstream

reference research and innovation the work has on others, thereby reflecting the importance and impact of the cited work itself.

Citation Topics

Citation Topics are named document clusters based on cited and citing relationships between publications. They are algorithmically derived citation clusters (using an algorithm developed by CWTS, Leiden). This is a three-level hierarchical document-level classification system. The three levels of the hierarchy and their content according to the 2024 clustering are:

- Macro-topics (10)

- Meso-topics (326)

- Micro-topics (2449)

Macro- and meso-topics are manually labeled based on their contents. Micro-topics are algorithmically labeled with their most significant keyword. As Citation Topics are based on citation relationships and not the content or subject matter of their constituent publications, topics are labeled by inference, and any name may not be descriptive for every document in the topic. More information and a description of the 2024 schema can be found on the Clarivate website.

Papers/publications/publications

A written document that presents the results of original research or an innovative study in a systematic and standardized format. A core activity of the scientific method, the publication of research via a formal paper is intended to communicate new research and knowledge discovery to the scientific community and to contribute to global and collective knowledge. Such papers are peer-reviewed and published in academic journals, ensuring the integrity and validity of the research presented. Clarivate abstracts publications,

including research journal articles, editorials, meeting abstracts and book reviews. The terms "paper," "document," "Web of Science Document," and "publication" are often used interchangeably to refer to printed and electronic outputs of many types. In the analyses presented here, the terms used exclusively refer to substantive journal articles, reviews and proceedings papers.

Researcher Affiliation

Researchers affiliated organization. A single researcher could provide several affiliations in one publication. The publication is then associated with all organizations and, correspondingly, all geographical locations in which these organizations are located.

6.4 Saudi Arabia-Specific Definitions

Research, development and innovation (RDI)

The Research, Development and Innovation (RDI) sector in Saudi Arabia refers to the collective activities and initiatives aimed at fostering scientific research, technological development, and innovation across various fields. This sector is pivotal to the Kingdom's Vision 2030, driving economic diversification and sustainable development. The RDI sector encompasses a network of institutions, policies, and programs that support and finance scientific research, coordinate activities of research centers, and propose legislation to nurture an environment conducive to innovation and technological advancement.

National Priority Areas

Refers to the strategic objectives set by the Kingdom to guide its development and innovation efforts. These priorities include Health and Wellness, Sustainability and Essential Needs, Energy and Industrials, and Economies

of the Future. They are designed to enhance the nation's global competitiveness and align with the goals of Saudi Vision 2030.

Vision 2030

Saudi Vision 2030 is a strategic framework aimed at diversifying Saudi Arabia's economy and transforming the nation into a global investment powerhouse. Launched in 2016, Vision 2030 seeks to foster economic, social, and cultural development by capitalizing on the country's strategic location and enhancing the quality of life for its citizens. It emphasizes three core pillars: a vibrant society, a thriving economy, and an ambitious nation, with a focus on public sector efficiency, private sector growth, research and innovation, and international collaboration.

6.5 Description of Data Sources

Web of Science™

The data used in this study came from the Clarivate Web of Science databases, which give access not only to journals but also to conference proceedings, books, patents, websites, and chemical structures, compounds and reactions.

Web of Science has a unified structure that integrates all data and search terms together and, therefore, provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The Web of Science Core Collection is the premier resource on that platform and includes over 22k peer-reviewed, high-quality scholarly journals published worldwide (including Open Access journals), over 308k conferences, over 151k editorially selected books and 92M records going back to 1900.

Coverage is both current and retrospective in the sciences, social sciences, arts and humanities. Clarivate has extensive experience with databases on research inputs, activity and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

InCites™

Additionally, InCites Benchmarking & Analytics was used in this project to generate relevant metrics and indicators.

InCites is a customized, citation-based research evaluation tool enabling analysis of productivity and benchmarking of output against peers worldwide, with underlying data drawn from the Web of Science Core Collection™.

InCites provides disambiguated data for all publications in the Web of Science Core Collection.

Darts-ip™

Darts-ip is a comprehensive database and analytics platform that provides detailed information and insights on intellectual property (IP) litigation cases globally.

Derwent World Patents Index™

The Derwent World Patents Index (DWPI) is a comprehensive database that compiles patent applications and grants from 59 patent-issuing authorities worldwide. It provides abstracts in English, detailing the nature and use of inventions, and indexes them into technology categories for easy retrieval. DWPI also defines patent families, linking related patents globally around a Basic Patent (the first disclosure of the invention appearing in the database), facilitating the tracking of an invention's protection status internationally as further applications or granted patents

published in multiple patent jurisdictions.

6.6 Metrics

Web of Science Documents

This is an indicator to refer to substantive journal articles, reviews and proceedings papers and excludes editorials, meeting abstracts or other types of publication. It is based on the Web of Science Core Collection™ dating till Sunday, December 31, 2023.

Category Normalized Citation Impact

The Category Normalized Citation Impact (CNCI) of a document is calculated by dividing the actual count of citing items by the expected citation rate for publications with the same document type, year of publication and subject area. When a document is assigned to more than one subject area, an average of the ratios of the actual to expected citations is used. The CNCI of a set of publications, for example, the collected works of an individual, institution or country/region, is the average of the CNCI values for all the publications in the set. CNCI is a valuable and unbiased indicator of impact irrespective of age, subject focus, or document type. Therefore, it allows comparisons between entities of different sizes and different subject mixes.

- A CNCI value of 1 represents performance at par with the global average.
- Values above 1 are considered above average.
- Values below 1 are considered below average.
- A CNCI value of 2 is considered twice the global average.

CNCI is an ideal indicator for benchmarking at all organizational levels (institution, region etc). When dealing with small sets of publications though, for example, the publications of one individual, the CNCI values may be inflated by a single highly cited paper. More information can be found on InCites website.

Growth and Average Growth

In this study, we visualize the evolution of the number of Web of Science publications for a certain entity and period. In order to quantify the change in the number of publications from one year to another, we use the growth. The growth is then the number of publications in the most recent year (Ny2) subtracted from the number of publications in an earlier year (Ny1) and divided by it and represented as a percentage:

G= (Ny2- Ny1)/ Ny1

The average growth over a certain period is the arithmetic average of the growth from one year to another in that period. Sometimes, a considered entity does not have publications in a certain year, causing division problems for the considered year. In such cases, the growth for that year is excluded from the arithmetic average.

Funding Acknowledgment

The Funding Agencies Explorer in InCites, which includes more than 1000 unified funding organizations found in and curated from Web of Science funding acknowledgments, was utilized to identify publications with funding acknowledgment and the corresponding funding agencies.

Industry Collaboration

Papers that contain two or more Organizations with at least one Organization listing its organization type as corporate or global corporate. An industry collaborative publication is one that lists its organization type as "corporate" or "global corporate" for one or more of the co-author's affiliations. It's not possible to unify

data for every affiliation of all publications in InCites; therefore, only unified entities have an organization type. There will be corporate affiliations that are not yet unified and without an organization type. As such, these affiliations will not identify as an industrial collaboration. Clarivate Analytics has made considerable efforts to identify the largest corporations and unify them; however, these efforts tend to focus on large multinational corporations and may lead to regional bias.

International Collaboration

Papers that contain one or more international co-authors.

Number of active researchers

The number of active researchers is calculated by considering the number of unique researchers appearing on papers with an affiliation to an organization in a certain location within a certain period. To calculate the number of unique researchers we utilize the researcher ID on Web of Science platform. The ID to each research name is assigned through an algorithm or manually by the researcher. Errors in the assignment could emerge, especially in situations in which different researchers use same names or the same person is not using their name on publications consistently. To approximate the error in the dataset used for Saudi Arabia, a sample set was reviewed and compared with the number of IDs. From this an approximate error of around ±15% in the number of researchers was derived. It is important also to note that researchers could be affiliated to several organizations in different countries and could use different affiliations on different publications and could change affiliations in time.

Invention Strength

A Clarivate metric of the strength and quality of a patented idea. Based on the impact of the invention on others

(based on the frequency of downstream citation by the patent applications of third parties), the global footprint of patents granted (based on the % of world GDP covered by the patent asset), the investment level in the invention by the applicant (based on the number of patent jurisdictions in which the applicant sought protection) and the inventions rarity (based on the number of inventions in the global database that share the same technology mix).

Emerging Trend

To investigate emerging trends globally and in Saudi Arabia in a research topic, we use the micro-topics as defined in the Citation Topics schema that is explained in the section.

Citation Topics

To identify the emerging trends, we identify the top 20 micro-topics in the research topic in terms of the growth of the number of publications in the micro-topic from 2014 to 2023. We then rank the top 20 micro-topics in terms of difference in the share of citations from total citations in the research topic between 2014 and 2023. The growth in terms of publications identifies micro-topics within the research topic that have grown fastest within the considered period. The difference in citation share from the total citations in the research topic identifies micro-topics that have also grown their relative number of citations in the research topic, which reflects that these topics are also trending among the researchers active in the research topic.

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