FUTURE 17 - REPORT

Team

Tsitsi Mashupeka - MEng Industrial Engineering Stellenbosch University / South Africa

Vittoria Rose Valerio - Political science and international relations LUISS / Italy

Marcelo Ramos Pinto - USP / Brazil

Thiago Menzonatto - USP / Brazil

Mentors

Hoda Mostafa - AUC / Egypt

Carlos Bueno Junior - USP / Brazil

Partner

Cyril Shtabtsovsky - Zimin Institute / Israel

May 2023

Biotech for the Future

Identify at least 20 research areas with

high potential impact on Biotechnology and Healthcare

Introduction

Biotechnology and Artificial intelligence are rapidly growing areas of technology, and their application in healthcare holds vast potential to make a real life impact in improving the quality of life for the people and transforming the healthcare system *(Future Science Group, 2023)* . This potential can be spotted from the emerging and growing research trends over the past few years to include dedicated journals in Future healthcare. A review of these Journals shows how Biotechnology and Artificial Intelligence provide the research body with unrivalled opportunities for learning and progressing the healthcare field. This report details the methodology for selection of 20 research areas with high potential and real life impact. The aim was to provide The Zimin Institutes with recommendations on the research areas whose main objectives are to ensure good health and well-being for all and increase equity in healthcare access and outcome.

Research background

In the face of unprecedented disruptions caused by the COVID-19 pandemic, the world went off track on health related Sustainable Development Goals. Compounding this are social, economic, geopolitical and environmental challenges, placing complex and interconnected threats on population health, especially impacting vulnerable populations, and increased strains on healthcare systems and all its stakeholders. It is with this background that the Zimin institute seeks to ensure stakeholders, industries, countries, and sectors strive to achieve Good health and well being and reduce Inequality by funding researches that implement innovation in science and medicine.

Project Goals

To achieve the aforementioned goals, the Future 17 team was tasked to identify at least 20 healthcare and biotech research topics with high potential and real life impact in the Pharmaceuticals and Healthcare industries.

Research Questions

The project aim raised the following research questions to guide the research and streamline the process:

1. At what stage is the patient/potential patient?
2. What are the healthcare needs of the patient, healthcare provider and partners/vendors or suppliers ?
3. What technologies are available to meet those needs?
4. How are they applied?
5. How does the identified technologies impact other stakeholders in the healthcare system?

To answer the research questions and achieve project aim, the following objectives were carried out:

1. To identify the key stages a patient or potential patient go through
2. To identify their healthcare needs in each of the identified stages
3. To provide a list of research areas with high potential and real life impact in those stages
4. To select criteria for prioritising the research areas
5. To rank the identified technologies based on the identified criteria
6. To propose at least 20 research areas with highest overall potential and real life impact in relation to healthcare.
7. To identify the inevident adjacent areas
8. To develop a funding strategy for the identified 20 research areas

Research Design and Methodology

Given that the project seeks to develop solutions which have a positive impact on the future, it seems important to use a Design thinking/user centred solution focused approach. Design thinking is explained as a method that revolves around a deep interest to understand the people for whom we design products and services (Interaction design Foundation, 2022) . In this case it enabled the team to understand all the key stakeholders in the healthcare system and their needs.

Empathy and Problem definition

The WHO Mortality Database categories causes of deaths into 4 main categories

1. Communicable diseases e.g perinatal deaths-22 completed weeks of gestation and ends 7 completed days after birth, some deaths that are caused by perinatal conditions occur later in life.
2. Intentional and Unintentional Injuries-Leading unintentional injury causes of death include road traffic collisions, falls and drownings. Deaths from natural disasters are also included in this category
3. Non communicable diseases-Among the NCDs, cardiovascular diseases and cancers are the most common causes of death
4. Ill-defined deaths-Ill-defined diseases include symptoms, signs, abnormal results of clinical or other investigative procedures, and ill-defined conditions regarding which no diagnosis classifiable elsewhere is recorded-Mainly affects old age

To understand the healthcare and healthcare system needs of the stakeholders in healthcare, the research team focused on these 4 main categories to identify needs at each stage.

Stage	Stakeholder Needs		
Pre exposure	**Patient**	**Healthcare providers**	**Partners (vendors and suppliers)**
	Predict risk of exposure & take preventive measures	Promote lifestyle changes through patient education to prevent diseases	
Diagnosis stage	Early diagnosis to minimise the impact.	Understand potential patient's health and family health history for early intervention	

Stage	Stakeholder Needs		
Pre exposure	**Patient**	**Healthcare providers**	**Partners (vendors and suppliers)**
	Predict risk of exposure & take preventive measures	Promote lifestyle changes through patient education to prevent diseases	
Diagnosis stage	Early diagnosis to minimise the impact.	Understand potential patient's health and family health history for early intervention	
Treatment stage	Precise treatment, no adverse side effects of drugs	Provide the best care, better working environment through workflow optimization	
	Timely treatment	streamline clinical workflows, reducing bottlenecks and wait times	

	No care variability	optimise of resource allocation, such as staff and equipment ensures standardised processes and procedures are implemented	
	Accurate treatment	Accurate treatment to eliminate readmissions	
Post treatment stage	Patient recovery management	virtual assistants to monitor patient recovery and provide accurate advice about their symptoms to help reduce the number of unnecessary visits	

Ideation

After understanding the needs of the stakeholders in the healthcare system, the team had a brainstorming session to understand how each of the stakeholders would be impacted if the needs are not met. It was established that if these needs are not addressed they have:

1. Life changing impact- A serious health problem that develops during a lifetime can disrupt all aspects of your life, whether it's a chronic or life-threatening illness. e.g Glaucoma.
2. Life limiting impact-A health problem that limits your physical access and accessibility to services. Usually one inherits these or develops during early years or because of Unintended impact for children born with the disease, prenatal conditions or conditions developed at birth.
3. Life shortening impact-A health problem or event that reduces one's life expectancy e.g Unintended injuries.

To promote lifestyle changes, prevent and interfere in disease control, and provide high-quality care under both expected and unexpected circumstances, healthcare providers need a resilient health care system that fosters a conducive working environment. This includes ensuring health data is representative of the population and that people with equal needs receive equal access and health outcomes. This can be easily achieved through technological innovation. This aligns well with (Shyam Bishen, Pierre Jacquet, 2023)'s observations that Innovation has the potential to improve efficiency and outcomes.

The brain storming session guided the identification of the research areas that addresses the above concerns. These are given in Table 2 below:

Stage	Stakeholder Needs			Technologies available
Pre exposure	**Patient**	**Healthcare providers**	**Partners** (vendors and suppliers)	
	Predict risk of exposure & take preventive measures	Promote lifestyle changes through patient education to prevent diseases	Health Insurers need to understand their client's medical history to forecaste claims	Wearable technology, AI based prevention, Healthcare analytics, Paediatric health, Predictive modelling, Ageing Health, Genome editing
Diagnosis stage	Early diagnosis to minimise the impact.	Understand potential patient's health and family health history for early intervention	Early diagnosis and intervention reduces cost on claims on the insurer	Medical diagnosis, AI based diagnostics, Medical imaging, Medical device interoperability, Future Cardiology, Future Neurology
Treatment stage	Precise treatment, no adverse side effects of drugs	Provide the best care, better working environment through workflow optimization	Pharmaceuticals need to understand genetic configuration and how the individual immune system responds to medicine. Engineer drugs to attract only diseased cells and avoid damage to healthy cells.	Precision medicine, Medical robotics, 3D printing, Bioprinting, Regenerative medicine, AI based therapeutic discovery, Nanomedicine, Genome editing
	Timely treatment	streamline clinical workflows, reducing bottlenecks and wait times	Precise treatment reduces cost of claims on the insurer	Mobile health, Biomedical sensors, AI based therapeutic discovery, Future cardiology

	No care variability	optimise of resource allocation, such as staff and equipment ensures standardised processes and procedures are implemented		Medical cybersecurity, Medical device interoperability, Neurodegenerative disease management, Medical robots
	Accurate treatment	Accurate treatment to eliminate readmissions		Personalised medicine, virtual reality,Nanotechnology, AI based treatment, Bioelectronics, Immunotherapy, Health Informatics
Post treatment stage	Patient recovery management	virtual assistants to monitor patient recovery and provide accurate advice about their symptoms to help reduce the number of unnecessary visits		Mobile health, telemedicine, AI based patient management, Medical device interoperability, Aging Health, Virtual Reality, Biomedical sensors

Literature Review

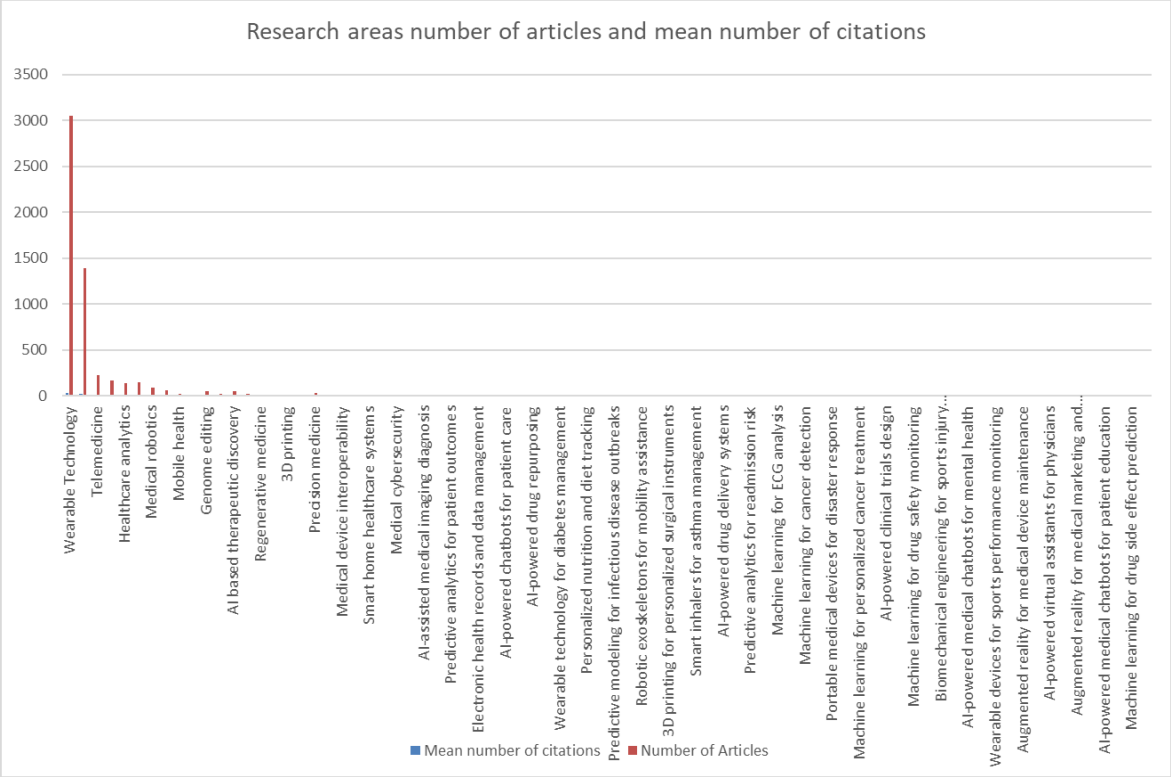
The research team performed a systematic literature review to identify research trends in the academic research body. After identifying the relevant research areas, the added value of 33 selected research areas in real life impact was evaluated. A detailed description of related literature is given in Appendix and a summary of the recent trends from literature review are shown in the following graphs.
The literature database Scopus was searched systematically, and a hand search of different websites (Future Medicine, Future Medicine AI hub, Future Science, RegMedNet and Biotechniques).

The following 33 research areas were identified and selected for further analysis:

Research Trends

In order to identify relevant research areas, a GPT (Generative Pre-trained Transformer) based intelligence model was used to generate a set of 80 research areas. This initial set of possible research areas was then searched on the Scopus platform using the following query: ALL("$RESEARCH_AREA") AND SUBJAREA(MEDI OR NURS OR VETE OR DENT OR HEAL OR MULT) AND PUBYEAR > 2018. In this way, we extracted the number of publications related to each research area, which were within the sub-areas of medicine, nursing, veterinary, and dentistry, and were published after 2018, thus obtaining an overview of these topics in the academic field in the last five years. From the extracted metrics

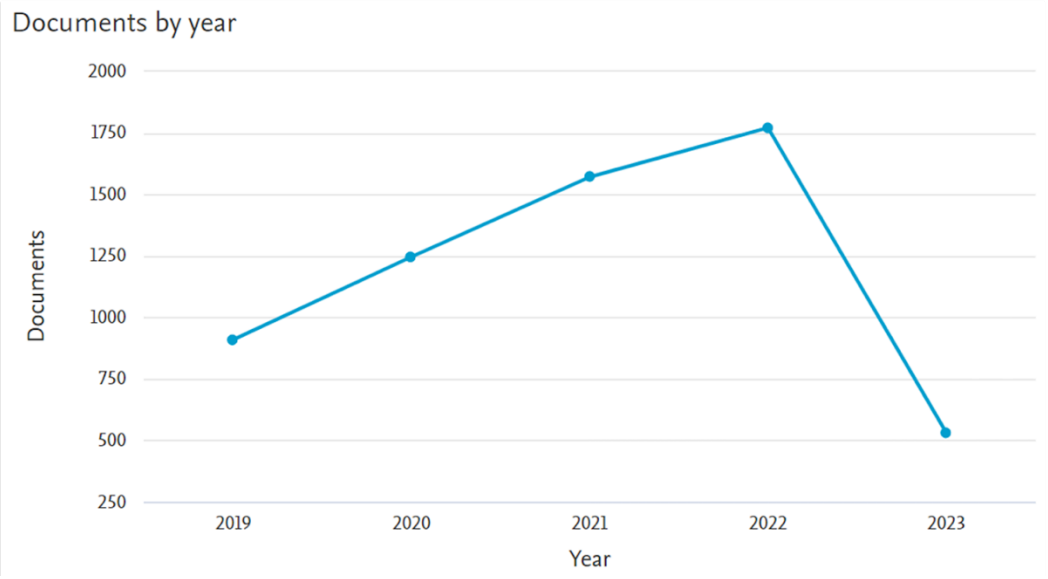
(number of publications and average citations), we defined the top 20 priority research areas for further analysis in the next stages of the report.
The results obtained from this preliminary analysis are presented in the following figure.



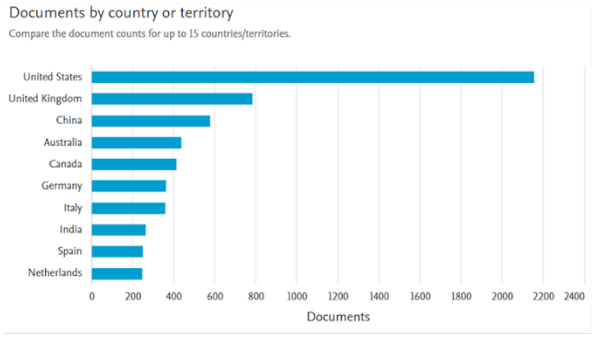
From the initial analysis, we found a direct correlation between the number of publications in a particular research area and the average number of citations. Additionally, we noticed that research areas described by the model in a very specific way showed very small or zero values in terms of publication numbers, precisely due to this specificity. This result guided the decision to opt for 20 research areas with greater generality and without significant overlap of the areas they cover, leading to the selection of areas with a large number of publications and whose descriptions are as general as possible within the biotechnological context.

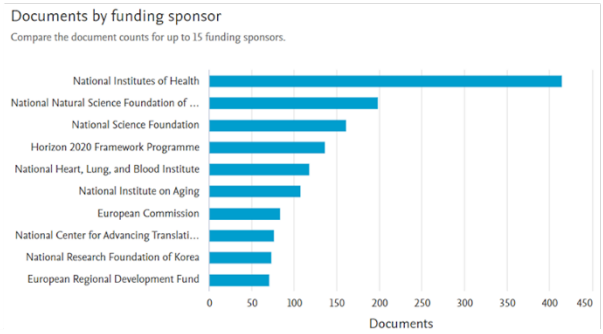
With the 20 selected areas, a more in-depth analysis was performed on the metrics available on the Scopus platform. In order to keep this report concise, we will present the results of this analysis for some of the selected research areas, followed by a general summary of the main trends observed within a global context.

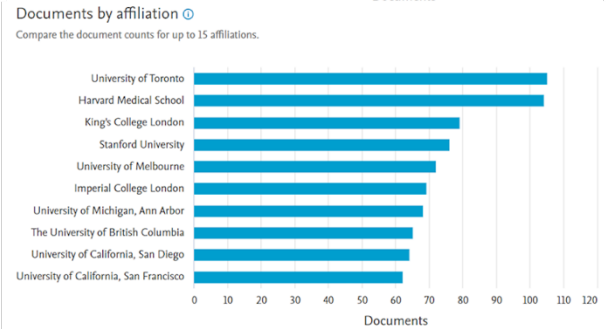
RESEARCH AREA – WEARABLE TECHNOLOGY

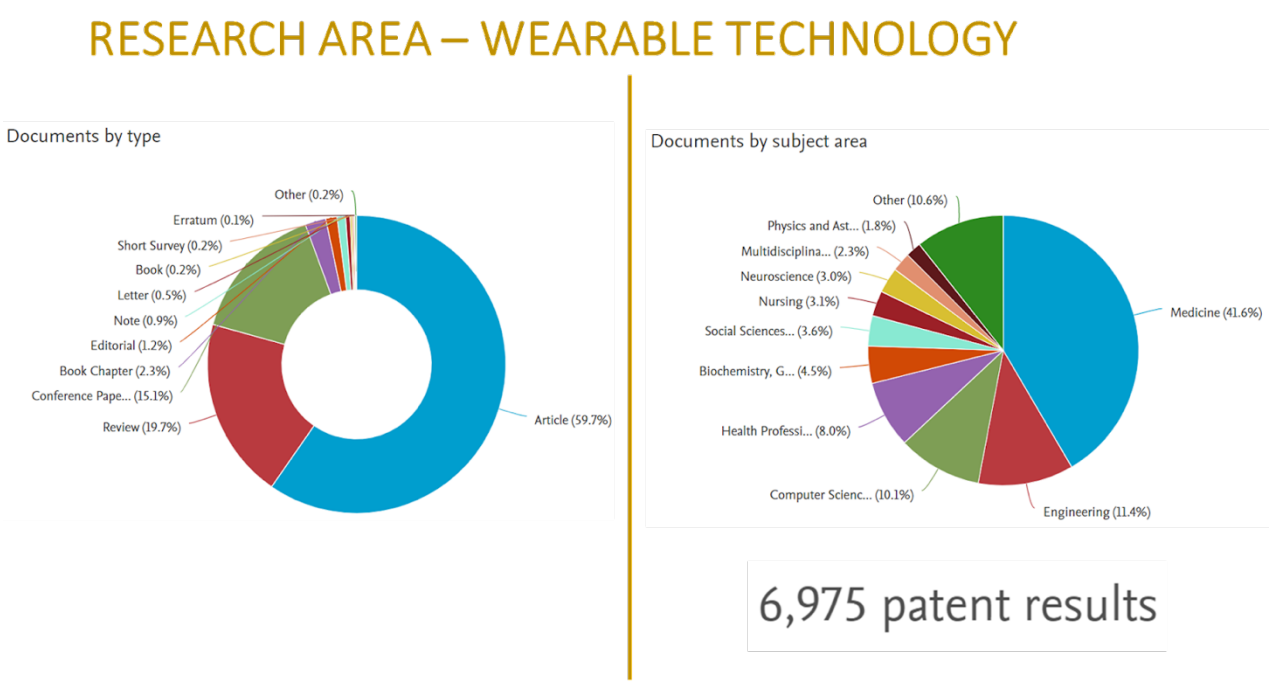


RESEARCH AREA – WEARABLE TECHNOLOGY









From this analysis, information such as the country of origin of the publications, funding sponsor, type of document, subject area, and number of patent documents were extracted. This analysis was performed for all 20 selected areas and its objectives were to have a more in-depth view of each of these areas in terms of political geography and funding, as well as to obtain a framework that would allow weighing each of these areas within the criteria established in the section discussing the Analytical Hierarchical Process (AHP).

In addition to this more quantitative analysis, a qualitative analysis was also performed, where extensive research was conducted in the literature to gather information such as the types of research that had already been conducted in the areas, opportunities, applications, and key stakeholders (e.g., researchers in the field and startup companies). Both files containing the complete analyses of each of the areas will be added as attached documents to the final report.
Some of the local trends observed in relation to the data extracted from the Scopus platform were:

- Most of the research in these areas are based in the United States, European countries and China.
- Wearable technology and mobile health are recent and emergent research fields.
- Most of the funding for this research comes from government sources (National Institute of Health, National Cancer Institute, Horizon 2020, among others).
- North American and European universities are the main affiliations of researchers in these fields.
- The small number of patents indicates that these areas have a large room for research and innovation.

From this analysis, we have gained some initial insights into the global biotechnology research landscape. For instance, most of the research in this field is concentrated in North America and Europe, indicating that exploring investment opportunities in other countries could be a promising option.

Additionally, smaller projects conducted by smaller groups in less-developed countries tend to be more community-driven and can have a significant local impact.

Another interesting finding is that most of the biotechnology projects are publicly funded, while private funding initiatives are still developing in most countries. This suggests that there is significant potential for private investment to grow and provide investors with returns while supporting impactful projects that produce results.

Finally, the relatively small number of patents in most biotechnology research areas indicates that there is still ample room for innovation and commercial product development in these fields, which highlights the potential profitability of investing in biotechnology research.

Prototyping

After identifying the research areas with potential to meet the healthcare system and its stakeholders' needs, the research team went on to evaluate the technologies to identify those technologies with high potential and real life impact. To guide the evaluation process, the team adapted the World Economic Forum's four main strategic pillars for health and healthcare vision 2035 (Shyam Bishen, Pierre Jacquet, 2023). These pillars are (1) Equitable access and outcomes (2) Healthcare system transformation (3) Technology and innovation (4) Environmental sustainability. Other factors considered for selection of priority areas were Financial impact and the potential to eliminate or reduce impact of Life changing conditions, Life limiting conditions as well as life shortening conditions.

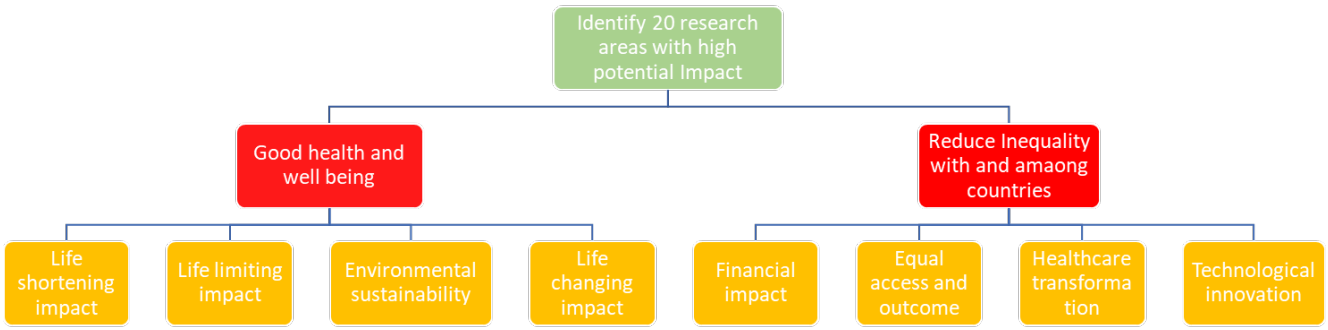
Identifying research areas with high potential impact

Given the multifaceted nature of impact in healthcare, it seemed important to use a multi criteria decision making method (MCDM) to prioritise research areas with high potential and real life impact. Therefore, the Analytical Hierarchy Process (AHP) was used to identify the top 20 research areas.

Analytical Hierarchy Process

The AHP method is described by (Saaty, 1996) as a systematic decision-making method of selecting one alternative from a pool of interrelated alternatives, where multiple selection criteria are involved, and to rank available alternatives based on a rational framework of quantitative comparisons. This approach has been applied in almost every other research field (Yagmur, 2015). It was specifically used in this research area as it is easy to use without any learning curve and the Software's vendor offers a 7 day trial before purchasing the licence.

To carry out the process in this project, "the main goal, criteria, and sub criteria" were broken down as shown in Figure 1 below. The pairwise comparison values are attached in Excel sheet 1 (Main calculations

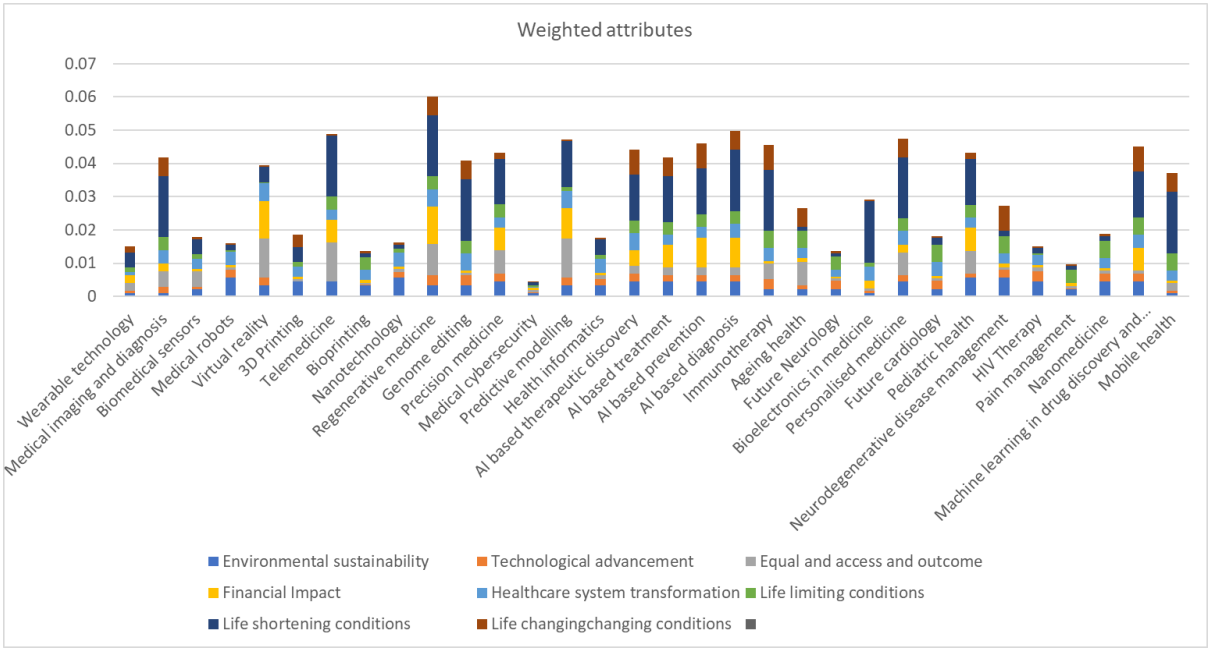


The research areas were evaluated based on their relative importance as suggested by (Saaty, 1998). The calculations were based on the largest eigenvector method, which utilises numerical ranking of the alternatives that indicates the order of preference among them. The added value of the identified research areas was assessed from the following perspectives, this served as the basis for the selection of 20 priority research areas.

1. What are the benefits to stakeholders (patient, healthcare providers, partners, vendors/suppliers)?
2. What is the impact of each technology in the following?
    - Equitable access and outcome,
    - Healthcare system transformation
    - Financial impact
    - Technological innovation
3. To what extent does the technology have potential to eliminate or combat
    - Life shortening conditions
    - Life limiting conditions
    - Life changing conditions

Ranking	Meaning
1	Equal importance
2	Weak importance
3	Moderate importance
4	Moderate + importance
5	Strong Importance

To calculate the final value, the weighted sum method was used. The method combines the attributes of the options to calculate the final value. The results from the AHP evaluation process showing Impact of each technology on the criteria are shown in Fig 2 below. The data table is shown in excel sheet 2 (Technology ranking per criteria).



Based on the assessment results, the following 25 research areas shown in Figure 3 were identified as priority areas with high potential and real life impact. The data table is shown in Excel sheet 3 (Priority by Overall Impact).

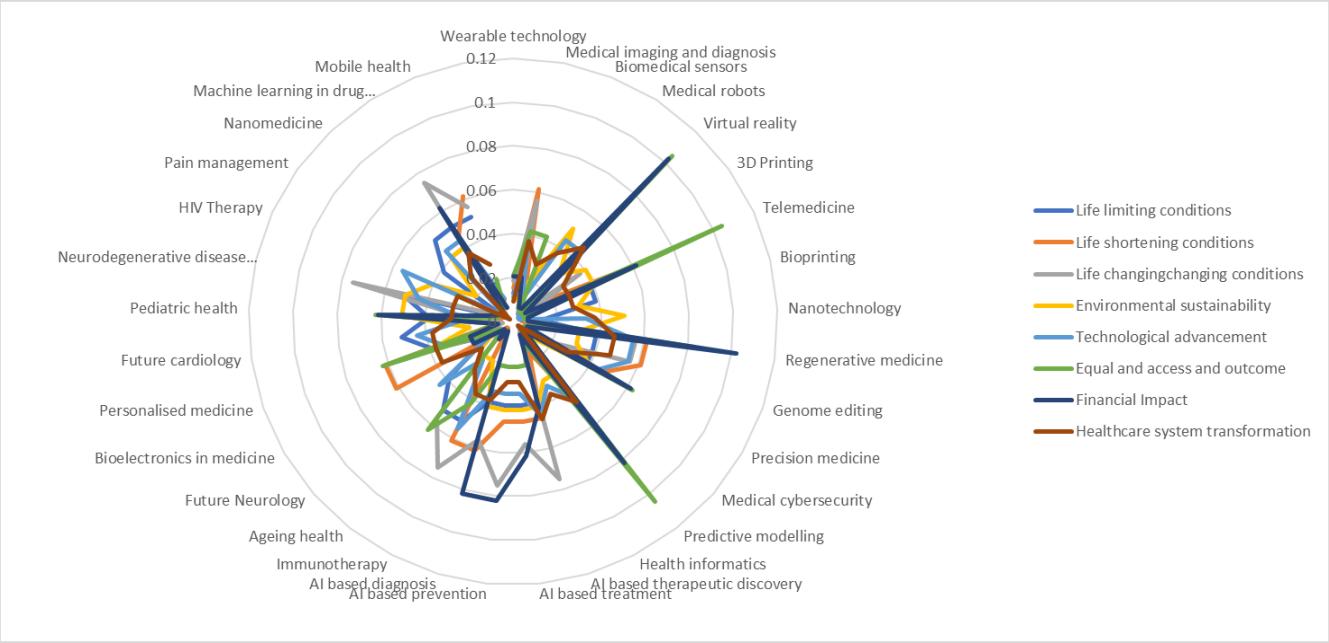


Analysis of Results

Regenerative medicine is noted to have the highest overall potential impact on the selected criteria though it has the same impact with AI based prevention, Immunotherapy, genome editing etc on life shortening conditions criteria. This shows that each technology could be equally important based on the healthcare needs of the stakeholders.

Given the multifaceted nature of the criteria, the organisation may choose specific criteria instead of using all the criteria used in this research. To achieve that, they may choose to eliminate other criteria and focus on only those with interest to them and select research areas with high impact in those criteria.

Figure 4 below shows how technologies can be identified by criteria. The data for this selection process is shown in Excel sheet 4 (Using criteria to select technologies).



Sensitivity analysis

Sensitivity measures how many percentages of value change of the variable alters the final decision, in this case percentage of value change for the given technology based on its impact on the criteria in question. This is used to assess the stability of an optimal solution under changes in the parameters.It can be noted that of the 255 pairwise comparisons in the selection process, only 31 variables are identified as sensitive (Refer to Excel sheet 1; main calculations).

Inevident adjacent Areas

Nanotechnology

Concussions-

Future rare diseases

A rare disease is defined by the Orphan Drug Act as a disease or condition that impacts fewer than 200,000 people in the U.S.The European Union defines a disease as rare when it affects fewer than 1 in 2,000 people (*GARD; 2023).*

Biobanking

Collections of biospecimens linked to relevant personal and health information (health records, family history, lifestyle, genetic information) that are held predominantly for use in health and medical research (*NIH; 2022).*

CAR T-cell therapy

A type of treatment in which a patient's T cells (a type of immune system cell) taken from a patient's blood are changed in the laboratory so they will attack blood cancer cells (RegMedNet, 2023). Currently being studied to treat other cancer cells (RegMedNet; 2023).

Research Contribution

The recommendations aim to benefit primarily The Zimin Institutes in achieving their mission, ''To help tackle the world's most pressing issues by empowering researchers that work on technologies with real-world impact''. The proposed list should be seen as suggestions of research areas with high potential impact in solving real life problems.

The recommendations prioritised technologies with potential to increase disease prevention by identifying risk factors, early and effective intervention, reduced probability of adverse reactions to medicines, reduced medical errors and cross-linkage of all stakeholders in health care.

Thus, the selected research areas have potential to strengthen, improve performance and transform the health systems on a global level, including the marginalised populations.

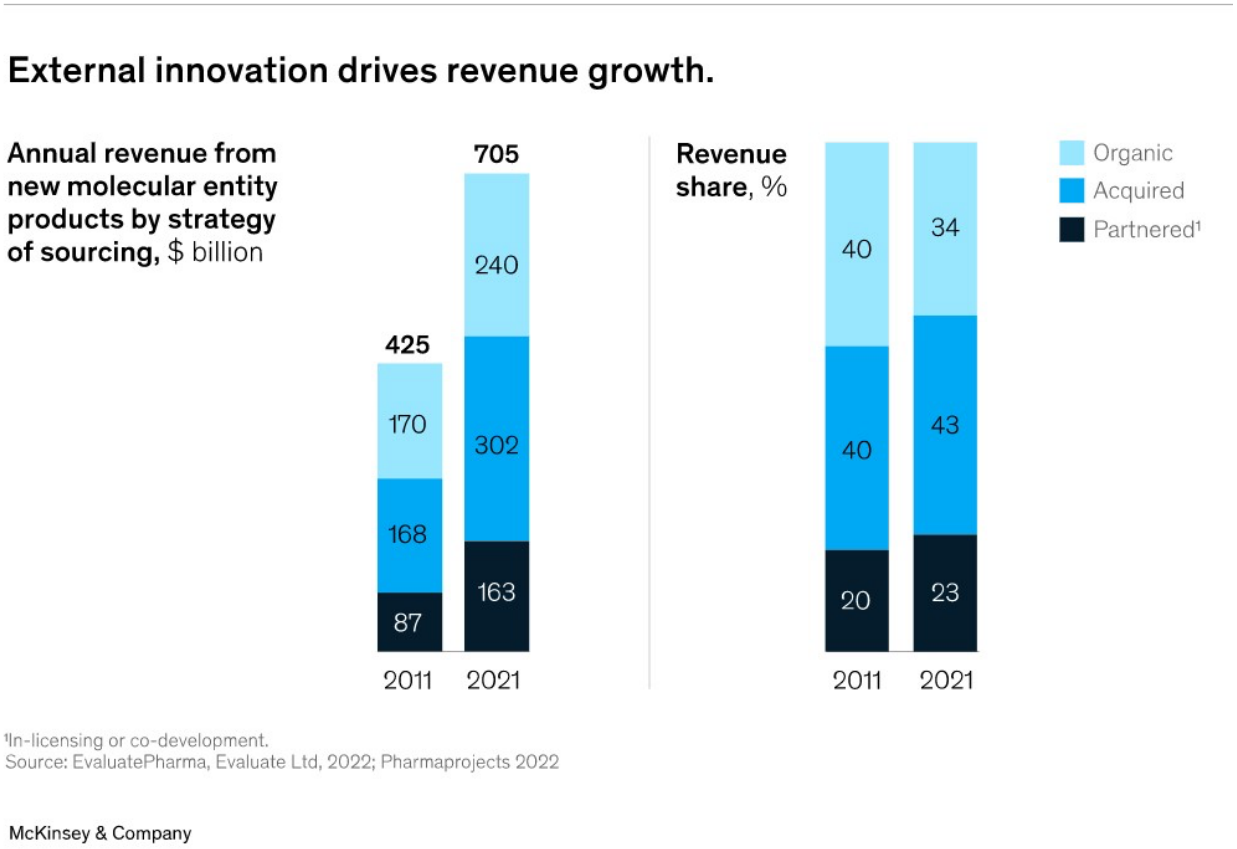
On an individual level, patient safety would be improved through healthcare's ability to make more informed medical decisions based, clinical workflow optimization through improved efficiency and prediction.

Funding Strategy

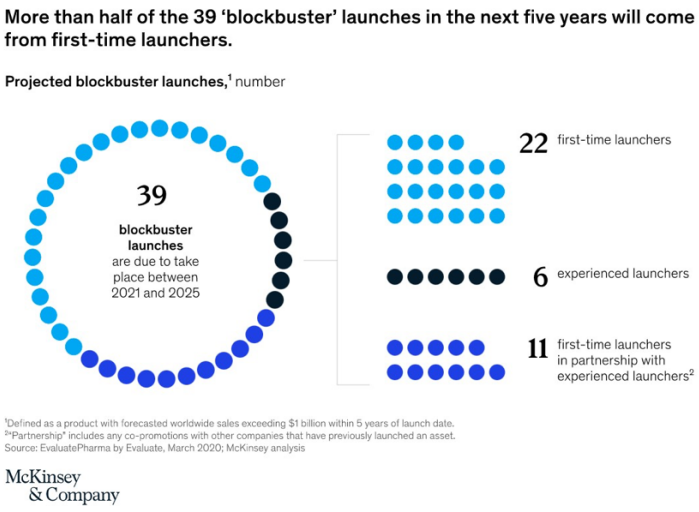
The team's approach in this subject was bringing ideas, concepts and perspectives from agents directly involved in the market in order to sustain the arguments. This way, the scenario presented can be more truthful and realistic.

Situation and Trends

According to *McKinsey & Co.*, ***"Bio Revolution"*** is under way. Biotechnology funding, deals, and IPOs reached the highest levels worldwide in 2020, with venture-capitalist (VC) funding for biotech companies up more than 80 percent year-over-year, and IPO values increasing by more than 180 percent.



The potential for new projects and startups is there. However, value creation is not guaranteed. Increasing complexity—scientific, supply chain, access, etc.—raises the bar for high-quality talent and successful execution. For example, less than 50 percent of biotech launches meet expected forecasts.



Regarding regions

Europe is performing well on patents and incremental innovation overall. According to McKinsey's analysis based on the World Intellectual Property Organization's (WIPO) patent data, over the past five

years, more than 40,000 health-biotech patents were granted in Europe, compared with about 50,000 in the United States and 39,000 in China.
Where there is more incremental innovation, Europe outperforms the United States on Bio Revolution–related technologies, with 20,000 in food-related technology, 30,000 for macromolecular chemistry and 25,000 for environmental technology. Furthermore, the growth of patent approval in these areas is faster in Europe than in the United States, and China is making significant progress.
For cross-functional clusters, specifically bioinformatics, biomaterials, cell-based clusters, gene-based clusters, genomic analysis, molecular diagnostics and synthetic biology, investment volume was more than four times higher in the United States ($52 million) than in Europe ($14 million) from 2018 to 2020. This is despite the fact that the volume of such investment doubled in Europe from 2015 to 2017.

In the case of emerging smaller clusters such as plant-based meat and microbiomes, the difference in investment volume between the United States and Europe is even larger (more than five times investment volume versus more than ten times, respectively). The only cluster in which funding was comparable from 2018 to 2020 was microalgae.

The European market is fragmented because it comprises many smaller national markets with different languages and regulations as well as barriers and this aspect hinders the ability of Europe's Bio Revolution players to scale up. In healthcare, notably, differences in reimbursement and regulation lead to fragmentation and a smaller home market value.

Public and private capital is rising for biological innovation, but the fact remains that Europe's investor base is still dispersed. Another hurdle to the progress of the Bio Revolution in Europe is the absence of a risk-taking, entrepreneurial culture.

China leads on environmental technology with 45,000 patents over the past five years and a 5 percent compound annual growth rate, compared with 3 percent in Europe. If we look deeper, however, at critical Bio Revolution technologies such as cell printing or engineered bacteria, analysis using Spark Beyond data finds that US-based players hold nine out of the ten top spots for patent holders.

About UN SDGs

Sustainability and climate risk

These are becoming core priorities for not only policy makers but also many investors and CEOs. Researchers found that the Bio Revolution could reduce annual average man originated greenhouse-gas emissions from 7 to 9 percent of emissions levels, even while raising prosperity. But biological innovation has many other applications that can help create a collectively more sustainable economy:

- Reality: Reaching net-zero emissions.
- Reality: Sustainable manufacturing and materials.
- Tendency: Bioremediation, that involves removing toxins from the environment—soil, water, and the atmosphere—by using biological organisms, including plants, algae, fungi, and microorganisms, such as through wastewater clearance and recycling textiles or plastics.

Social impacts

As well as sustainability, the real impact on communities and individuals, impacting positively their health and sanitary conditions is crucial to all market stakeholders. Specific stock market segments and compliance based investments are strong tendencies, mainly focusing:

- Curing or slowing down progression of diseases.
- Investing in prevention.
- Enabling people to live longer in better health.
- Making healthcare accessible and affordable.
- Improving quality of life.

The Healthcare segment

Considering US data, from *CME - Centers for Medicare & Medicaid Services, specifically National Health Expenditure Data (NHE)*, projecting, 2021-2030:

- On average over 2021-30, National Health Expenditures (NHE) and Gross Domestic Product (GDP) are both projected to grow 5.1 percent per year; as a result, the projected NHE share of GDP in 2030 (19.6 percent) is similar to 2020 (19.7 percent).

- Near-term NHE patterns are significantly influenced by the COVID-19 pandemic. NHE growth in 2021 is projected to have slowed to 4.2 percent (down from 9.7 percent growth in 2020) as federal COVID-19 supplemental funding declined substantially.

- Following the declines observed in 2020, health care utilisation is expected to rebound starting in 2021 and normalise through 2024. By 2024, the government (federal and state & local) share of health spending is expected to fall to 46 percent as COVID-19 supplemental funding is expected to wane, down from an all-time high of 51 percent in 2020.
- The percentage of the population with health insurance is expected to peak in 2022 at 91.1% (mainly due to Medicaid enrollment) before falling back towards pre-pandemic levels as the public health emergency is assumed to end. The 2030 rate is projected to be 90.5%.

- For 2025-2030, factors that typically drive changes in health spending and enrollment, such as economic, demographic, and health-specific factors, are again expected to primarily influence trends in the health sector.

And these are additional data from *US American Medical Association (AMA)*:

Health spending in the U.S. increased by 2.7% in 2021 to $4.3 trillion or $12,914 per capita. This growth rate is substantially lower than 2020 (10.3% percent). This substantial deceleration in spending can be attributed to the decline in pandemic-related government expenditures offsetting increased utilisation of medical goods and services that rebounded due to delayed care and pent-up demand from 2020.

Overall, health spending was 18.3% of GDP in 2021 compared with 19.7% of GDP in 2020.

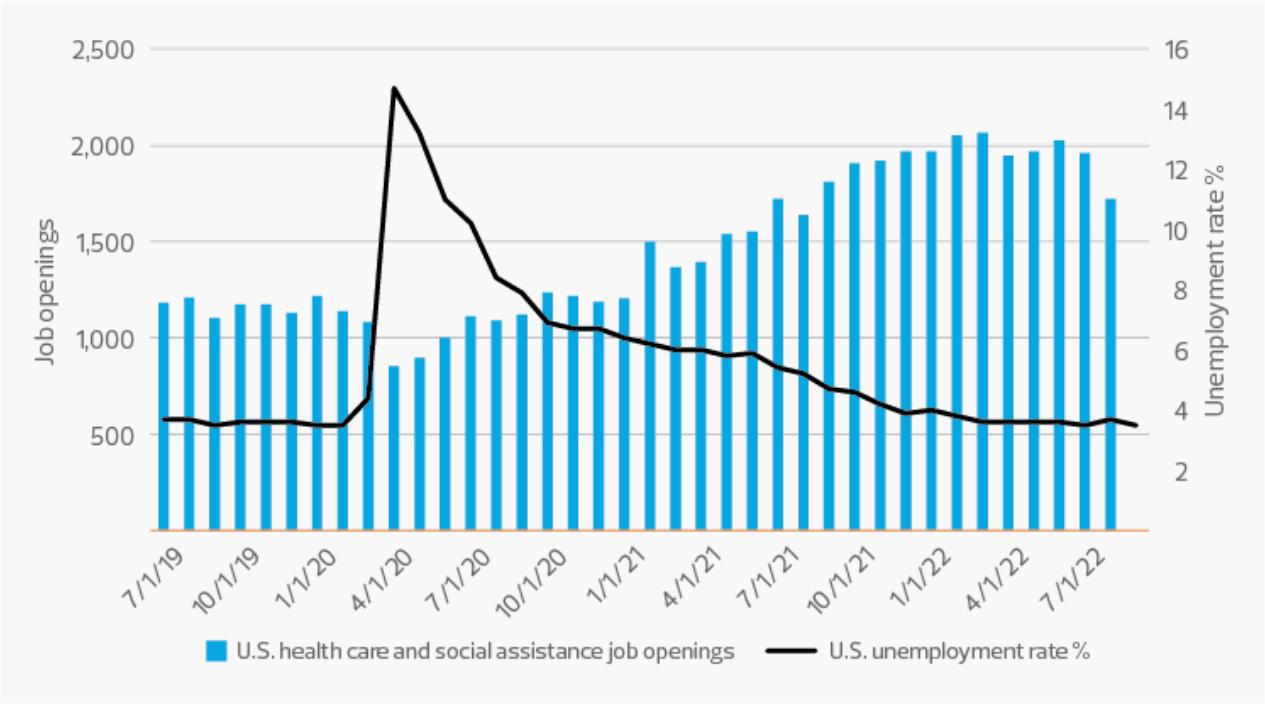
This spending can be broken down into the following categories:

- Hospital care
- Physician services
- Clinical services
- Prescription drugs
- Nursing care facilities
- Home health care
- Other personal health care costs
- Government administration
- Net cost of health insurance
- Government public health activities
- Investment spending

The* RSM Consulting *company, also stated:

From staffing shortages to supply chain disruptions and technology strategy challenges, health care providers have much to address now and in the coming months. Likewise, overall economic uncertainty remains top of mind for many senior leaders, along with the following financial and operational issues:

- Clinical staff departures continue to burden the healthcare industry, and the projected shortage of registered nurses is drawing concern, given that an ageing U.S. population in need of increased care will continue to stress health care systems.
- The total number of new health care jobs of 52,600 is slightly below the three-month moving average. However, hospital hiring fell to 10,800, which is less than half of September's 25,100 added jobs, while senior/nursing care hiring increased 50%, to 11,100 from 7,400.
- Robust senior care hiring is a good thing, given that the sector remains 9.7% below pre-pandemic employment levels. Senior care employed 3,048,500 as of October, compared to 3,377,200 as of February 2020.
- Strong hiring in healthcare is a positive indicator of the sector's overall health. But there is still work to be done. As the following chart demonstrates, hiring demand in this sector is consistently outpacing the unemployment rate.



Source: U.S. Bureau of Labor Statistics, Job Openings and Labor Turnover Survey (JOLTS); RSM US LLP

- To address rising costs and seek higher reimbursements, providers will work to renegotiate contracts with insurers. As a result of these negotiations, however, the cost of employer health care coverage for families will likely increase, something providers must be mindful of in the coming months.
- Digital transformation will continue to be a priority for health care organisations, given the need for enhanced telehealth solutions and improved data management. Likewise, cybersecurity will be paramount. According to Healthcare IT News, a HIMSS Media publication, more than 40 million patient records were compromised in 2021 by incidents reported to the federal government. Cyberthreats will continue to be a major concern for providers in 2023.

A path forward

While challenges persist, providers can address some of the financial and operational concerns in the coming months by considering the following measures:

Explore financial transformation

Now is the time for providers to explore centralised operating models to address supply chain and labour management inefficiencies.

- Review cost structures to identify additional cost savings and efficiencies.
- Conduct an evaluation at the service line level and make decisions about the lines that require continued attention and investment, as well as those that require an exit strategy.

Address patient satisfaction with reduced readmission rates
Providers can look to increase satisfaction by keeping the rate of patient readmission down. Decreased readmissions means lower costs to patients.

- Evaluate the quantity, quality and effectiveness of follow-up care.
- Consider using a cost-effective telehealth solution to implement a follow-up care strategy as an alternative to readmission.

Fortify cybersecurity
Cybersecurity in health care continues to be critically important. Ignoring security needs or failing to appropriately analyse and invest in protective measures will lead to heightened exposure, increased costs and disruption of patient care:

- Conduct a general risk analysis that covers data storage measurement, access controls, security policies, governance, antivirus protection, incident response planning, liability insurance and more.
- Perform a remote workforce assessment by evaluating employee tools, solutions, controls, shared data processes, virtual private networks and regulatory requirements.
- Implement a framework certification that fits organisational needs and can help control risks.

As the likelihood of a recession increases, 2023 will be a year of challenge but also of great opportunity. Health care leaders will need to maintain agility and focus in order to capitalise on the positive and mitigate the impact of the negative financial and operational challenges ahead.

The information above (CME, AMA, RSM) are more focused on the United States of America, but can be useful as a parameter to other countries. And it's clear the role of biotechnology and healthcare innovation (regardless region) in optimising services and offering simpler and faster solutions to the communities. This way the whole supply chain will have real benefits, especially customers/patients.

Investing Possibilities

According to *Deloitte*, "What is required to scale?"

As biotech companies attract fresh investment, they need to consider how they can scale up and what is required, in order to deliver on their promise of providing innovative medicines to patients. Early in the life cycle, a biotech company's management team typically grows the business through a few core assets and limited programmes, focusing its resources where the most value can be gained such as differentiation in manufacturing, understanding of disease and biology, or drug chemistry.

Five key dimensions to succeed in the scaling journey

- the core goals and
- the prioritisation of markets
- the extent of use of partnerships or collaborations

- the balancing of scientific considerations with market access
- the timeline to pursue

Qualio informed, in the biotech industry, that costs for research and development alone are sky-high, and these are the possibilities to deal with this reality:

- Apply for Government or Corporate Grants
- Partner with a Research University
- Reach Out to Biotech Experts
- Pitch to Venture Capitalists
- Look for Angel Investors

Forvis, on the other hand, considers:

Funding for Early-Stage Life Sciences Companies

Many life sciences companies that raised capital during 2021 will require additional investment during the coming year. Innovative and novel discoveries hold the promise of long-term profits and much-needed remedies, but there can be significant challenges along the way.
When evaluating funding source options, medical technology and biotechnology startups will often consider government grants, early seed funding, and venture capital (VC) funding:

- *Government grants* **–** Government grants are an attractive funding source for startup life science companies because they are often non-repayable.
- *Early seed funding* **–** Startup life sciences companies often seek other sources of early seed funding such as an angel investor.
- *VC funding* **–** Life sciences startups that require more significant investments often seek VC funding. VCs have specific strategies and are often highly specialised. Partnerships with medtech or biotech-oriented VCs should be well vetted and based on suitable connections, not just available funding.

Accelerate the Path to Regulatory Approval for Medical Device Startups
As investors evaluate opportunities, they often choose partners that are later stage, more established companies. For younger companies it's important to create a faster pathway for breakthrough medtech products to reach markets and alleviate patient suffering, it also has the potential to create a more vibrant and sustainable medtech ecosystem.

And *Fundera* suggested five options for Biotech Startup's financing:

- Public / Government Grants
- Corporate and Research Organizations

- University Funds
- Venture Capital
- Startup Loans

Fundera also quotes the aspects below as crucial for a real funding possibility:

- Determine pre money valuation
- Offer organised and reliable data
- Be diligent and focus on results, not processes
- Built a strong network

Investment Discussion

Below follow highlights of an interview about funding in Healthcare and Biotechnology by *Sage*, offering a broad outlook, from the market's perspective.

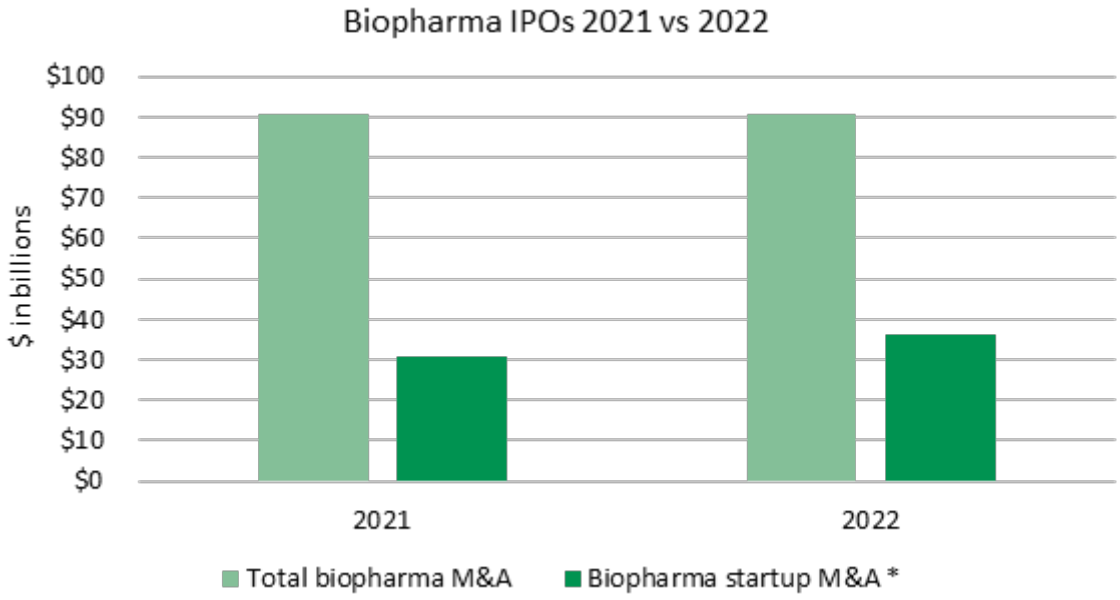
- Theme: "Biotech financing outlook 2023"
- Personality: Richard Murphey, from *Bay Bridge Bio*

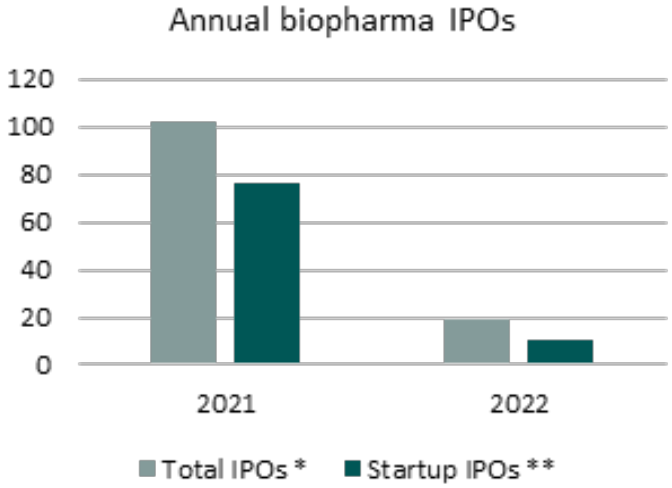
Context

After a brutal 18 months, biotech stocks finally seemed to recover in February 2021, only to be dragged down again by the overall market developments of still-rising inflation, and a Federal Reserve determined to continue raising interest rates.
The biotech market has seen an unprecedented influx of funding since Covid-19, and 2022 was still one of the strongest years on record in terms of Biotech funding.

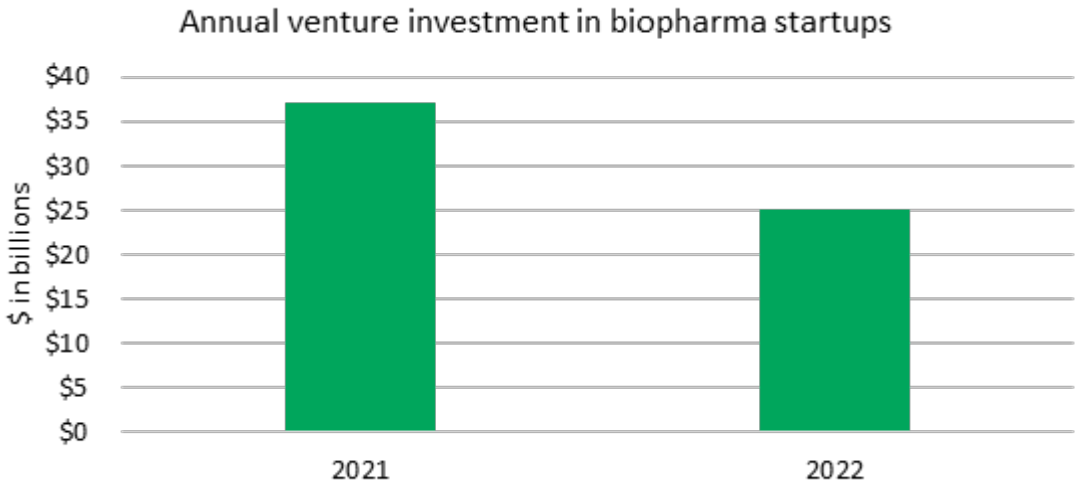
Interview and Data

Q.: Can you give us a recap of the biotech market for 2022, with a roundup of the year?
A.: 2022 was a bit of a rough year for biotech, but the good news is that in terms of the overall funding, it was still one of the strongest years on record.





2022 in contrast, had just 19 IPOs total, and only 10 of those were startup IPOs that raised over $50 million. The overall tally of money raised by startups and IPOs went from $13.6 billion in 2021 to $1.4 billion in 2022. The IPO market is taking a step back with its worst year since 2012. The loss of $12 billion in IPO proceeds for biopharma startups was the biggest on record in the history of the industry. That drop in IPO activity has filtered through to the private markets. We saw $25 billion in VC investment in biopharma startups in 2022, which is down about 33% from 2021. A drop, but not quite as dramatic as in the IPO market.



Q.: What does that mean for this year? Where do you see things going?

A.: The outlook for biopharma startups in funding in 2023 will depend a lot on the broader economy. But if things continue as people expect them to with maybe a mild recession and potentially a Fed pivot in the back half of this year, it seems like 2023 will be the year when the public market issues start to trickle into the earlier-stage venture markets.

Over the last decade, the IPO market has been the major source of liquidity and returns for venture investors. These investors were able to flip a lot of companies that were private onto the public market through IPOs at attractive valuations.

That was a great business for those venture investors. But as the IPO market has disappeared, that poses a challenge for that model. There's also a little bit of a lag between when the public market gets hit and when private markets hit. The IPO markets started to slow down in Q3 of 2021, and it came to a halt essentially by the second quarter of 2022.

Q.: Will that make it harder to start a new biotech company?

A.: We think so. But the good news is that there is still a lot of money available. Early-stage venture funds have raised massive capital in 2020 and 2021, and they still have a lot of that left. The big question though is how they will deploy it.

Will they hold that money and use it to support their existing portfolio, or will they continue to invest in new companies? It helps to take a step back and think through things like where these venture investors are, and how their business has been affected by the crash in the IPO market.

The mid- to late-stage venture market was the most immediately impacted by the IPO slowdown. These funds would invest in the last private round of a company, help them go public, and then they would make a profit in doing so.

What's going to happen to a lot of these companies is that it will be harder to raise venture funding in the later stages because the crossover investors have stepped back. The IPO market has shut down. So that's not an option for many of these companies.

Many funds may look at these facts and say, "Hey, we're going to hold our capital a little bit, reserve it to protect our existing portfolio companies, and maybe not do as many deals." On the other hand, some funds may decide to build companies because others are stepping back. This is a great opportunity.

Some pharma companies in particular will view this as a compelling time to do more partnerships with early-stage companies with interesting science and platforms. And that could lead to some very fruitful relationships this year.

Q.: What do investors care about? Is it all in the research or are there also considerations like does this company have a good handle on their costs? How much do they spend with their vendors? To what degree do business fundamentals play a role in the evaluation of a company?

A.: When investors have to circle the wagon and discuss which companies they're going to be able to commit further capital to, a lot of that does come down to who's going to make the best use of funding.

When you have to make tough decisions about prioritisation of programs and devoting value to your company, it's hard to do that if you don't know where your money's going today. Especially if you don't know how much you're spending on assets or programs versus how much you're spending on the platform.

If a company is going to make a strategic change, or a financial change, or double-down on something that they really believe in, it helps. It's essential to know how much you're already investing in different lines of your business before you can make a reasonable change to that, that funding strategy, or capital-allocation strategy.

And if you're on the board of a company and you're trying to think about how you want to deploy your next amount of capital, you need to know how much it's going to cost to fund 1 program versus another.

Having really good data on that is essential to making these kinds of strategic financing decisions.

Justification of criteria

1. Environmental sustainability

Reducing the healthcare industry's environmental impact, preparing for, and addressing climate change for better health and wellness. A report by (Shyam Bishen, Pierre Jacquet, 2023) reviewed that the healthcare sector contributes to 4% of GHG Emissions, with supply chain 50%, emissions from patient care contribute 1 gigatons of emissions globally.

The healthcare industry has a large climate footprint, accounting for an estimated 4.4% of global net carbon dioxide emissions. In England, the NHS accounts for around 4% of greenhouse gas emissions. Of this, 62% of emissions are from medicines, equipment and other supply chain sources (e.g. freight).

Pharmaceuticals contribute around 20% of the emissions, compounded by over £300 million in medicines going unused each year in England resulting in sub-optimal usage of therapeutics and over-prescribing and waste, causing soil and water contamination.Increasing focus on how prevention and better management of chronic conditions can improve carbon emissions (Fordham, 2020)

Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress.

Reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health, particularly through reduced air pollution.

2. People's access and outcomes

Equilibrating access to determinants of health, ensuring health data is representative of the population and people with equal needs achieve equal health outcomes.

3. Healthcare transformation

Structuring resilient healthcare systems to provide high-quality care under both expected and unexpected circumstances.

A. *Patient engagement:* AI-powered chatbots and virtual assistants can help patients get quick and accurate advice about their symptoms and direct them to the appropriate care setting. This can help reduce the number of unnecessary visits to emergency departments and primary care providers, freeing up resources for those who need them most.
B. *Predictive analytics:* AI can predict patient demand for specific services and allocate resources accordingly. For example, AI-powered models can forecast the number of patients needing a particular type of surgery or test and thus schedule appointments to reduce wait times.
C. *Resource allocation:* AI can optimise resource allocation, such as staff and equipment, to minimise wait times. For example, AI-powered scheduling tools can help match patient demand with available resources, ensuring patients receive care as quickly as possible.
D. *Workflow optimisation & triage:* AI can help streamline clinical workflows, reducing bottlenecks and wait times. For example, AI-powered tools can help healthcare providers prioritise patients based on urgency and ensure that tests and procedures are completed promptly.
E. *Patient flow management:* AI can track patient flow through hospitals and clinics, identifying bottlenecks and allowing healthcare providers to intervene before they become problematic. For example, AI-powered tools can monitor patient wait times in emergency departments and alert staff when wait times exceed a certain threshold.

(L.E.K Consulting, 2023)

4. Technology and innovation

Innovation has the potential to reduce overall healthcare spending by improving efficiency and outcomes. For example, National Health Service (NHS) England says one in four general practitioner appointments are potentially avoidable, and telemedicine is important for relieving the burden on the health system.

A study in Houston showed that 5,570 patients treated with telehealth-enabled care over 12 months showed a 6.7% absolute reduction in potentially medically unnecessary emergency department visits, $928,000 annual cost savings ($2,468 saved per visit averted).39 In the US, chronic diseases affect 50% of the population and contribute to more than 85% of healthcare costs.

5. Financial Impact

Over the last two years, an extra £36bn was added to NHS budgets specifically to fund temporary impacts of Covid on the NHS, such as PPE, testing and infection control measures, Guardian October 2022. The NHS resource budget in England is currently at £152bn and will increase to over £162bn in 2024-25 – the highest spend on health and care in any government's history.

"The NHS is concentrating on new ways of working to increase efficiency, save staff time, and ensure value for money. Our plan for patients sets out the next steps, including removing unnecessary bureaucracy to help improve access for patients and speeding up hospital discharge."

6. Asia-Pacific Region

Healthcare systems across the region are rapidly evolving, with overall healthcare spending projected to surge to US$2.3 trillion by 2026. Ageing populations and the rapidly growing burden from noncommunicable diseases.

7. Non-Communicable diseases

1. Noncommunicable diseases (NCDs) kill 41 million people each year, equivalent to 74% of all deaths globally.
2. Each year, 17 million people die from NCD before age 70; 86% of these premature deaths occur in low- and middle-income countries.
3. Of all NCD deaths, 77% are in low- and middle-income countries.
4. Cardiovascular diseases account for most NCD deaths, or 17.9 million people annually, followed by cancers (9.3 million), chronic respiratory diseases (4.1 million), and diabetes (2.0 million including kidney disease deaths caused by diabetes).
5. These four groups of diseases account for over 80% of all premature NCD deaths.

Detection, screening, and treatment of NCDs

Poverty is closely linked with NCDs. The rapid rise in NCDs is predicted to impede poverty reduction initiatives in low-income countries, particularly by increasing household costs associated with health care. Vulnerable and socially disadvantaged people get sicker and die sooner than people of higher social positions, especially because they are at greater risk of being exposed to harmful products, such as tobacco, or unhealthy dietary practices, and have limited access to health services.

Low-cost solutions exist for governments and other stakeholders to reduce the common modifiable risk factors. Monitoring progress and trends of NCDs and their risk is important for guiding policy and priorities.

Investing in better management of NCDs is critical. Management of NCDs includes detecting, screening and treating these diseases, and providing access to palliative care for people in need. High impact essential NCD interventions can be delivered through a primary health care approach to strengthen early detection and timely treatment.

References

https://www.advanceduninstaller.com/Analytic-Hierarchy-Process-b076d659f9b80ee5eac868fcf08085db-application.htm

https://www.cell.com/matter/fulltext/S2590-2385(22)00415-5?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2590238522004155%3Fshowall%3Dtrue

https://www.fmai-hub.com/ask-the-experts-the-medical-potential-of-chatgpt/#question1

https://www.cell.com/matter/fulltext/S2590-2385(22)00415-5?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2590238522004155%3Fshowall%3Dtrue

https://www.fmai-hub.com/beyond-radiology-the-role-of-ai-in-healthcare/

Noncommunicable diseases (who.int)

https://rarediseases.info.nih.gov/about

https://www.cancer.gov/publications/dictionaries/cancer-terms/def/car-t-cell-therapy

https://www.mckinsey.com/industries/healthcare/our-insights/prioritizing-health-a-prescription-for-prosperity

https://www.mckinsey.com/industries/life-sciences/our-insights/first-time-launchers-in-the-pharmaceutical-industry

https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nhe-fact-sheet

https://www.ama-assn.org/about/research/trends-health-care-spending

https://rsmus.com/insights/industries/health-care/financial-health-care-trends.html

https://www2.deloitte.com/us/en/insights/industry/life-sciences/scale-up-strategy-for-early-stage-biotech-companies.html

https://www.qualio.com/blog/biotech-funding

https://www.forvis.com/article/2023/04/funding-strategies-trends-medtech-biotech-startups

https://www.fundera.com/business-loans/guides/how-to-finance-a-biotech-startup

https://www.science.org/content/page/where-search-funding

https://www.evaluate.com/vantage/articles/insights/ma/biopharmas-bolt-bonanza-set-continue

https://www.sage.com/en-us/blog/biotech-financing-outlook-2023-qa-funding-highs-and-lows/ - *Video of full interview*

https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

https://www.theguardian.com/society/2022/oct/06/nhs-england-health-budget-shortfall-extra-costs