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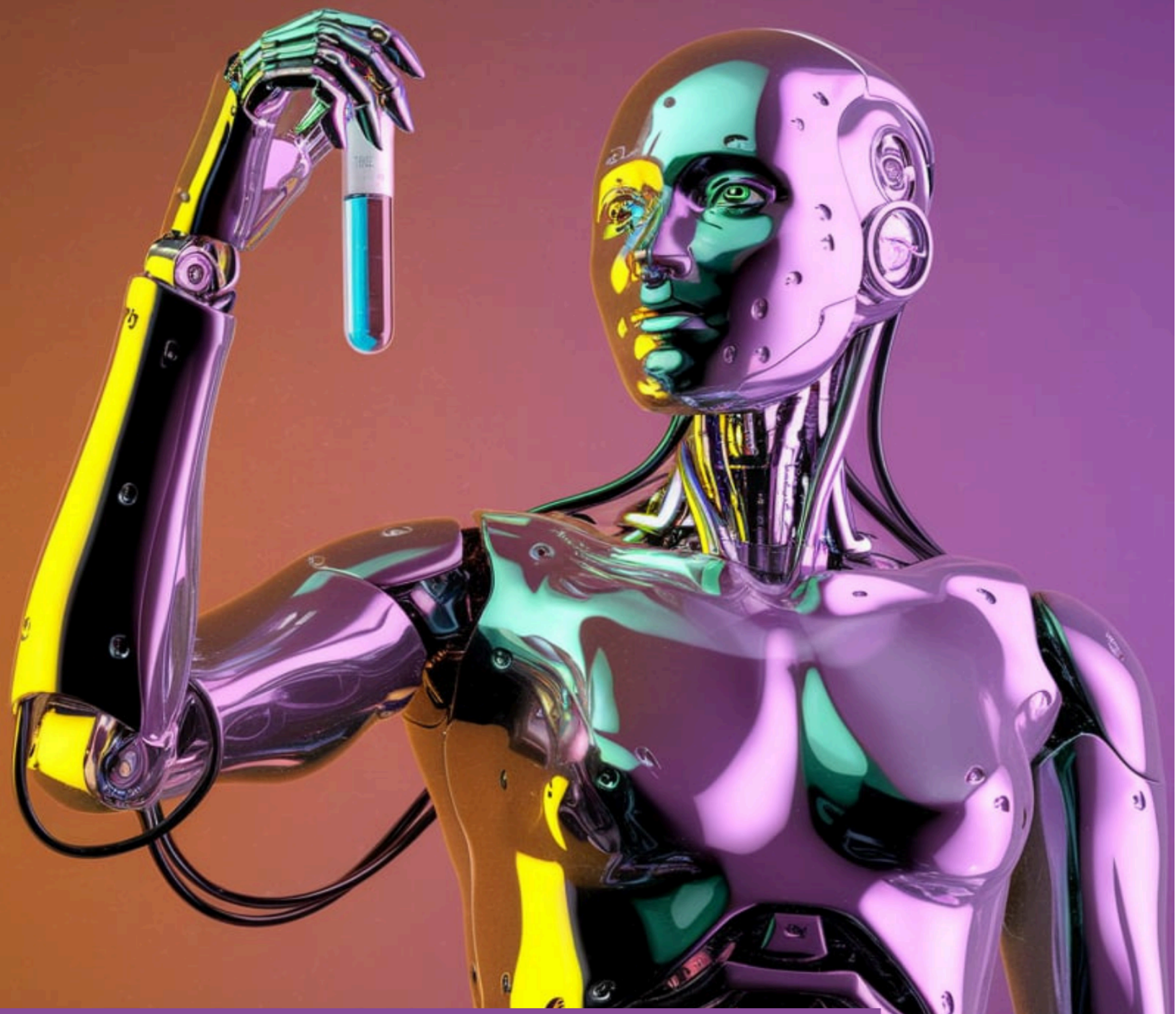

AI READINESS IN THE PHARMACEUTICAL INDUSTRY

Final report - October 2024

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Introduction

1. Context – Artificial intelligence and the pharmaceutical industry

In early 2024, one of the emerging topics in the 42nd annual J.P. Morgan Healthcare Conference was the use of artificial intelligence in the healthcare and pharmaceutical industry.[1] It is revelatory of the new importance that this technology has taken in the field of medicine, although it has been in use for over a decade already.

Broadly speaking, artificial intelligence (AI) refers to a technology – in other words, a machine, such as a computer – capable of reasoning, learning, or acting in ways that would normally require human intelligence. In practice, AI can take many forms, the most common of which are machine learning, deep learning, large language models, and generative AI.

In recent years, AI has experienced a hype among the general public, with interest in this topic increasing almost tenfold in the past decade.[2] This is mainly due to the appearance of ChatGPT, the most powerful large language model to date. In its wake, other generative AI models appeared focused on image generation (Dall-E, Midjourney, StabilityAI…). Within a couple of years, use of AI has become widespread in the population, both for professional and personal reasons.

Although the attention has mainly been focused on artistic and creative applications of AI, this technology also has a major impact on scientific industries. In fact, the pharmaceutical industry was an early adopter. The recent advances in this technology have made it increasingly valuable, as it can be implemented for various purposes. Examples include greatly reducing time and money needed in research and development, assistance in analysis of data or medical imagery, generating first drafts of reports in clinical trials or drug approval submissions, and

[1] See independent coverage of the event, accessed 7 October 2024: https://www.globalxetfs.com/j-p-morgan-healthcare-conference-2024-renewed-optimism-as-ai-integration-accelerates/

[2] Data according to Google Trends, accessed 7 October 2024: https://trends.google.com/trends/explore?date=all&q=artificial%20intelligence&hl=en

others. Nevertheless, in order to exploit the opportunities presented by AI, actors in the industry must have what it takes to harness it.

2. AI Readiness – Definition and methodology

This report aims to determine the capacity of pharmaceutical companies to adopt and adapt AI technologies to their activities. In sum, AI readiness is just that: what processes and tools have leading industry players implemented to prepare for this technological change? At Pugatch Consilium, we studied a series of factors revelatory of AI readiness, which can be broken down into 3 stages.

1. *Patenting as a proxy for innovation*. The first stage studies patenting trends, mapping patents filed by leading pharma companies related to AI. Through targeted keyword searches, patenting data reveals to what extent different actors see this technology as either a tool or subject-matter of innovation. This analysis was based on data extracted from national and international patent databases, such as USPTO, EPO, WIPO, as well as from the patent analysis platform Patsnap.
2. *Corporate adjustment to AI.* The second stage looks at how companies are adapting on a corporate level. This reveals choices made by companies and their leadership which we believe are crucial to advancing artificial intelligence use and AI readiness. More specifically, factors studied within stage 2 are the following:
    a. AI leadership. General management is the directing force in all pharmaceutical companies. Bearing this in mind, it is possible to track how pharma CEOs have incorporated AI into the strategic vision for their company through public statements in interviews, social media posts, or official documents.
    b. Skilled workforce. To properly incorporate AI into the workflow, pharmaceutical companies need skilled workers in this field. Thus, a company's hiring record – both through internal and external recruitment platforms – is emblematic of its efforts to adapt to AI.

c. Structural divisions. A major concern in AI readiness is the efficiency of allocated resources. This can be done by coordinating AI efforts at a corporate level, through the creation of divisions dedicated to the topic. Both the hierarchical level and scope of divisions are taken into consideration.

3. *External collaborations*. Finally, the third stage maps partnerships between pharmaceutical companies and AI actors. All AI innovation in pharma cannot be achieved in-house; pharma companies must reach out to other actors, outside the pharma industry or more specialized in AI technology. We measure indicators such as the volume, value, nature, and diversity of partnerships to understand how actors are connecting to the broader AI environment.

Transparency is key when it comes to AI. It ensures accountability of pharma companies, better acceptance by the general public, patient safety, and possible regulatory and legal compliance. We tried to incorporate this aspect into our Index, by basing our analysis on public sources of information only. These include patent databases, social media posts, press interviews, official statements, corporate documents and reports, corporate websites, and media articles.

All data that serves as the basis of our analysis was collected until October 2024; this is prone to change, and any posterior evolution of these factors is not reflected in the report.

The 20 companies selected as part of this study are presented in the following table:

AbbVie	Johnson & Johnson
Amgen	Merck & Co
AstraZeneca	Merck KGaA
Bayer	Moderna
BioNTech	Novartis
Boehringer Ingelheim	Novo Nordisk
Bristol Myers Squibb	Pfizer
Eli Lilly	Regeneron
Gilead	Roche
GSK	Sanofi

Key findings

After identifying the main factors for AI readiness, our research was carried out for each of the 20 companies studied. This section presents our findings, as well as the leaders and best practices that we observed in the industry.

AI in the innovation pipeline

We studied patenting trends related to AI over the past 5 years, since 2019. Overall, AI patenting by pharmaceutical companies has increased since 2019. However, the COVID-19 pandemic has had a clear impact on these trends. Both 2020 and 2021 saw a decrease in the number of patent applications relating to AI. Nevertheless, the evolution of the trends is positive in 2022-2023, representing a 300% increase compared to previous years. The year 2024 seems to follow this curve, with strong AI patenting numbers in the first semester.[3]

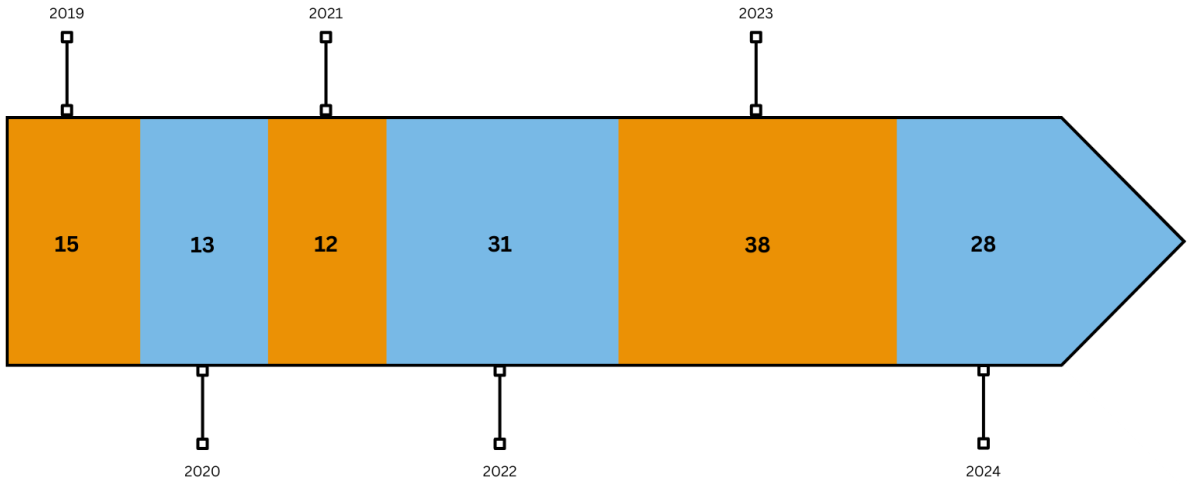


Fig 1.1 – Timeline of AI patents by leading pharma companies, 2019-2024

As mentioned before, this data shows that AI innovation in the pharmaceutical industry predates the boom of generative AI. For the leading 20 pharma companies alone, patenting activity related to AI – primarily as a subject-matter – existed before 2020, in low but non-negligeable numbers. This is reassuring: AI is a bubble, with the current hype around it greatly overplaying its potential and inflating its value; yet, its importance in pharma rests on

[3] Research for stage 1 was carried out in July 2024; patenting data from 2024 is therefore only available for semester 1.

solid foundations. At the same time, while the pharmaceutical industry did not wait for the AI boom to harness this technology, it clearly benefited as well. Major pharma players have shown an increased interest in putting one foot in the AI door by increasing their patenting activities in the field.

To determine real innovation and rank pharma players accordingly, we measure the number of patent families owned: by regrouping patents filed in different countries for the same invention, families reveal how much inventive activity really takes place. According to our research, patenting activity is not homogeneous among the actors studied. Most companies were involved in some patenting in AI in the period covered, with Moderna, Novartis, and Gilead as outliers in this regard. However, among these, almost half owned less than 5 patent families, in other words less than one per year. On the other hand, a handful of companies stand out. Just two companies own roughly 40% of patent families involving AI filed between 2019 and 2024: Roche and Bayer. Other leaders include BMS, Pfizer, AstraZeneca and GSK.

Despite the rise in patenting activity since 2019, there is a clear imbalance between industry players, with the top 3 companies owning almost half of all patent families around AI, while the bottom 10 companies only make up barely 15%.

Rank	Company
1.	Roche
2.	Bayer
3.	Regeneron
4.	Bristol Myers Squibb
5.	Pfizer

Fig 1.2 – Top 5 pharma companies in AI patenting

Corporate AI readiness

A. Strategic vision and leadership

The first aspect of corporate readiness in AI is how general management incorporates this technology in their strategic vision. Prime among them, pharma CEOs have the responsibility of steering the ship when it comes to how this groundbreaking technology will be incorporated into the company's vision.

Unfortunately, among leading pharma companies, some figures have been unwilling to assume this leadership role. This is first seen in public statements regarding AI. In the period since 2020, 35% of CEOs had not shared their views on this technology or how it folds into their plan for the company. Even among those who did speak on AI, 30% kept their statements minimal – less than one statement per year. In total, this represents over half of key leadership figures failing to manifest sufficient interest in the topic. Yet, AI readiness of pharmaceutical companies first and foremost requires a clear understanding of how to harness its power within the company, lack of which may lead to serious misallocation of resources on the ground. On the other hand, the CEOs of Pfizer, Sanofi and Moderna stand out from their clear vision on artificial intelligence. Albert Bourla and Paul Hudson, especially, have been very vocal about their support to the integration of AI into the workflow, speaking on the issue in very public settings – media articles, televised interviews, international summits and conferences.

However, they each focus on different applications of AI. A first possibility, adopted by Moderna and Sanofi, is for AI to be envisioned as a company-wide solution, used by all employees for everyday decision-making. In other cases, CEOs focus on specific uses: protein design (a major focus for Amgen), large-scale data analytics (brought up by Bayer CEO), or R&D acceleration and optimization (as is the case for Pfizer). The only pharma CEO to distance himself from this overall optimism around AI is Novartis's Vas Narasimhan, who has cautioned that AI may not have a big impact in the short-term.

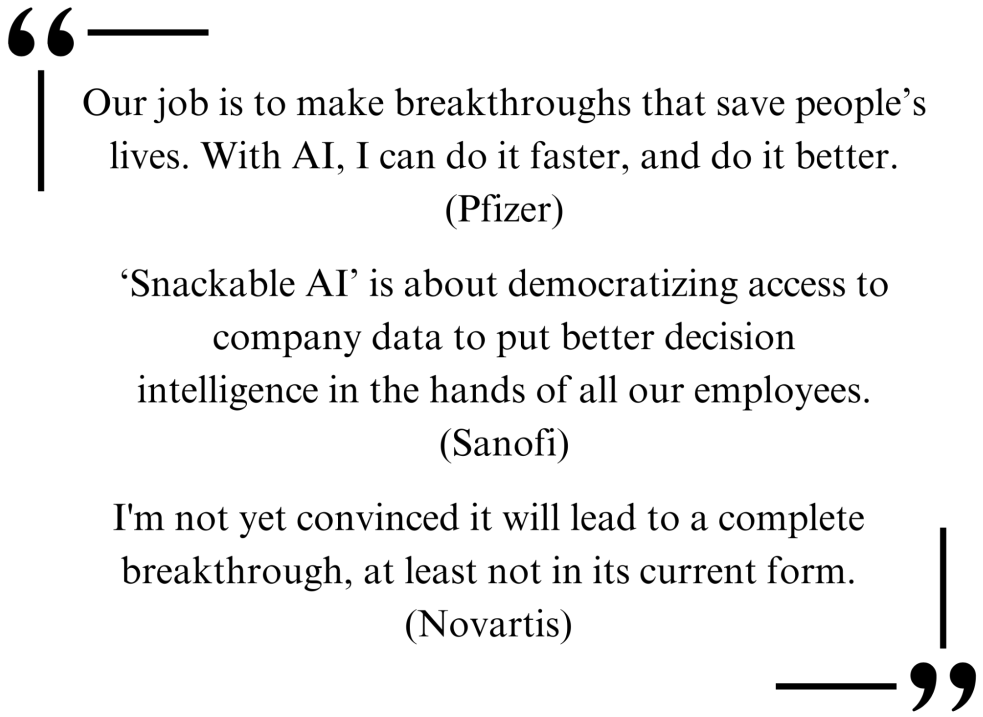


Fig 2.1 – AI vision of leading pharma CEOs

B. Skilled workforce in AI

Human capital is a key feature of AI readiness, conditioning the capability for companies to implement and use AI solutions. This has been well understood by the industry, as all 20 pharma companies we studied had active recruitment processes requiring AI competences or education. With this in mind, some companies nevertheless put more attention on this factor: thus, Eli Lilly, GSK, and Johnson & Johnson had the highest levels of AI hiring. Note that this should be approached with caution, as a snapshot in time providing insight on general trends.

More revealing of AI readiness is the diversification of technical fields concerned by AI recruitment. The three main areas concentrating 75% of all applications mapped are IT, R&D, and Ops. This is not a surprise, as they are the most obvious applications of AI in pharma: IT jobs tend to take care of development and maintenance of AI tools and computing power infrastructure, mapped positions in Ops typically require competences in utilizing AI data analytics tools, whereas R&D has seen the biggest hype around AI in pharma with generative

artificial intelligence allowing breakthroughs in drug discovery. Still, this predominance is unfortunate as it leaves out another 10 categories in which AI can and should be applied as well. As such, hiring skilled workforce in other areas increases AI readiness by allowing greater technological change across the board. Sanofi is a perfect example of this possible diversity, with AI-related jobs that can be tied to 8 different fields. Overall, companies with higher rates of specialized recruitment tend to diversify the categories to which this applies. On the contrary, companies at the bottom of the ladder rarely go beyond the big three of IT, R&D and Ops, with the notable exceptions of Moderna and Merck Group.

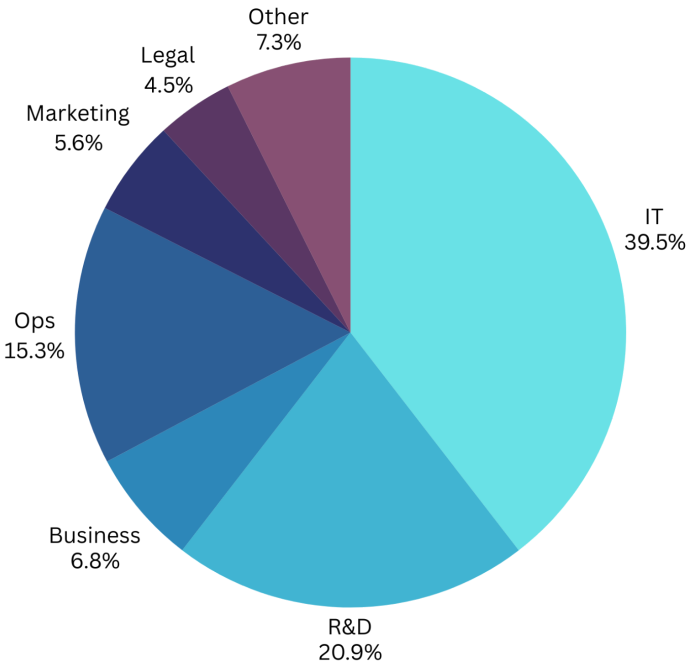


Fig 2.2 – Categorical distribution of skilled workforce recruitment processes

C. Structural AI divisions

The final component of corporate AI readiness has to do with the organization of pharma companies, and how AI is incorporated into this structure. Although more political in nature, this category reveals the choices made by companies regarding implementation and coordination of AI tools and efforts. Readiness in this field requires solid structural AI divisions, capable of overseeing the development and application of tools across the corporate board. This is lacking among Amgen and Boehringer Ingelheim, the only two studied companies for which no AI divisions could be found publicly. This can denote a lack of transparency or organizational attention, both of which are detrimental to their overall AI readiness. Among the remaining companies, all mapped divisions are not considered on the same level.

The first element to take note of is the scope of such divisions. They can be divided into categories: those with broad competences, and those with limited domains. In the latter, divisions are typically constrained to a specific application of AI. One such characteristic example is AbbVie, who has a division dedicated to AI in R&D Research. Another example is Moderna's division on AI Products & Platforms, this time limited in terms of technological medium. On the other hand, some companies have opted for general-purpose divisions, as is the case for Bayer (division of Data Science & AI), Regeneron (Data Analytics & AI), or Sanofi (Data & AI Strategy). Broad divisions are more prone to efficiently coordinating company-wide efforts, and are more likely to prevent misallocation or waste of resources.

The second element relates to the hierarchical level of AI divisions. Tying back to the previous element, structures with broad scopes are generally higher placed on the hierarchical ladder of the company, further consolidating their coordinating potential. As such, pharma companies should strive to appoint figures responsible for AI divisions at high levels of management. This is the case of a number of leading companies – Bayer, GSK, Pfizer, Roche – where AI leaders are among Senior Vice Presidents. Merck Group stands out as the only company with AI represented within the C-suite, with their Chief Data & AI Officer. This should serve as a model, ensuring that decisions around AI are centralized to minimize inefficiency and promote coherence in the AI strategy.

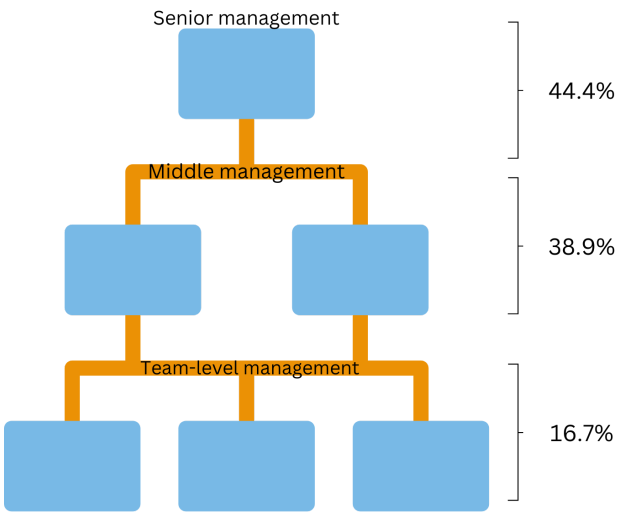


Fig 2.3 – Hierarchical distribution of AI divisions

External collaborations in AI

We tracked external collaborations by pharma companies through public information available through public statements, media articles and corporate documents. These can reveal information about the nature and financial aspects of these agreements, and compiling them provides an overview of the volume and diversity of partnerships that exist.

Moderna pioneers the movement of external collaborations in AI, cooperating with Amazon Web Services for their cloud technology since Moderna's inception in 2010. More targeted partnerships started in 2015, with BioNTech, Merck & Co, and Novo Nordisk leading the field. But overall, the number of partnerships started picking up in 2018, climbing from 8 to 21 in a year, and especially in the last 3 years, with a 250% increase between 2021 and 2024. Today, Johnson & Johnson, Sanofi and Pfizer count the highest number of external partnerships in AI, totaling almost 25% of all collaborations mapped. In addition, we looked at the nature of external AI collaborations. The vast majority (98%) take the form of simple partnerships – contractual agreements – or funding. Other interesting forms include joint initiatives set up by the pharma company and their partner; finally, Bayer and BioNTech stand out as the only companies having carried out acquisitions as part of their AI strategy, clearly diving into the deep end of the pool.

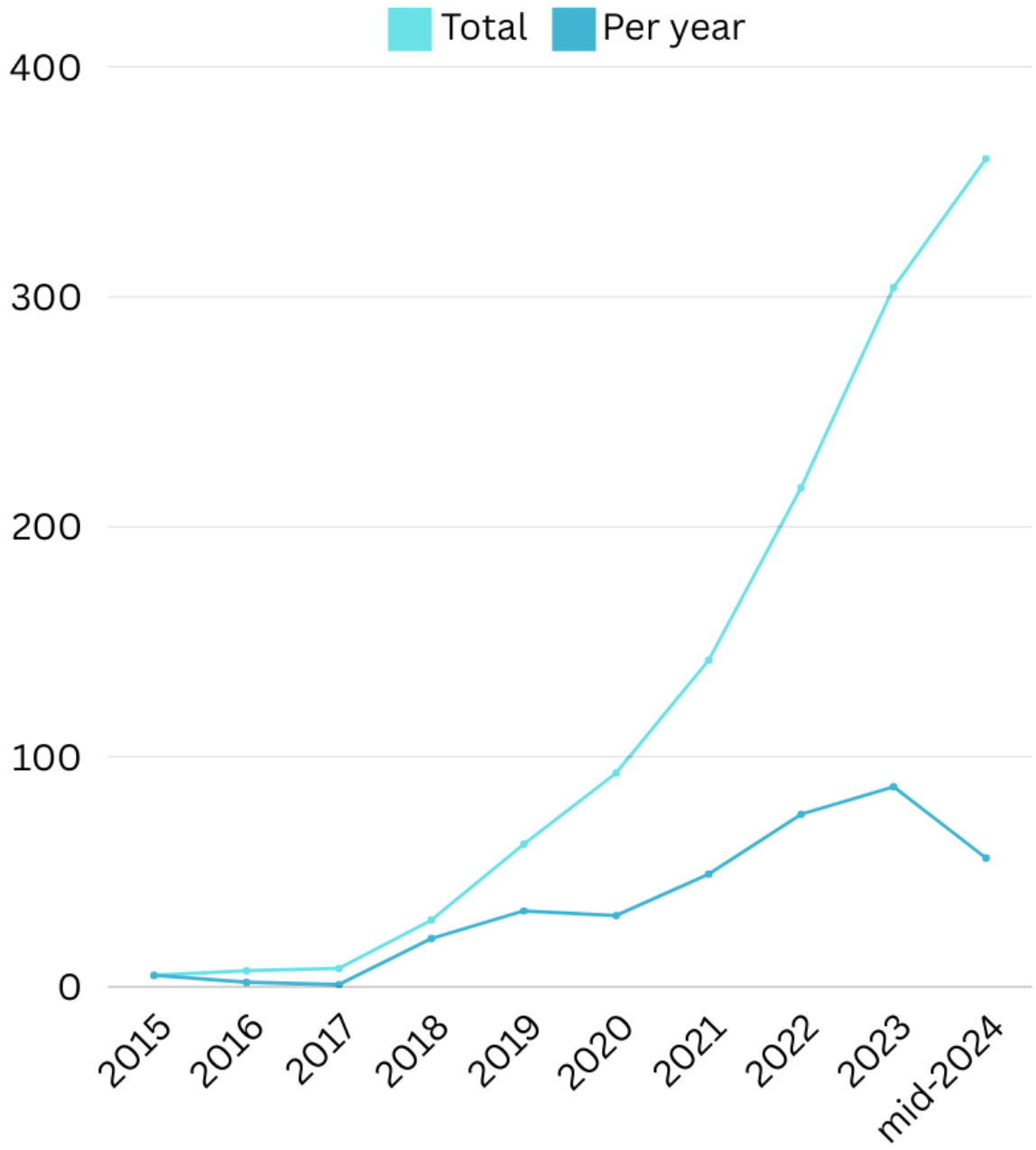


Fig 3.1 – External collaborations in AI by leading pharma companies

In total, leading pharma companies collaborated with 220+ partners, of which 55 are recurring. Top partners are split between IT companies with a focus on increasing computing power, with Microsoft in the lead, and AI startups specializing in biopharma and drug discovery,

such as Exscientia and Insilico. By far the largest area of collaboration was therapy advancement: partnerships aiming at drug development/design/discovery, target identification, or biomarker development represented roughly 51% of all collaborations mapped. However, with IT partners, pharma companies mainly focused on infrastructure development, especially increased computing power.

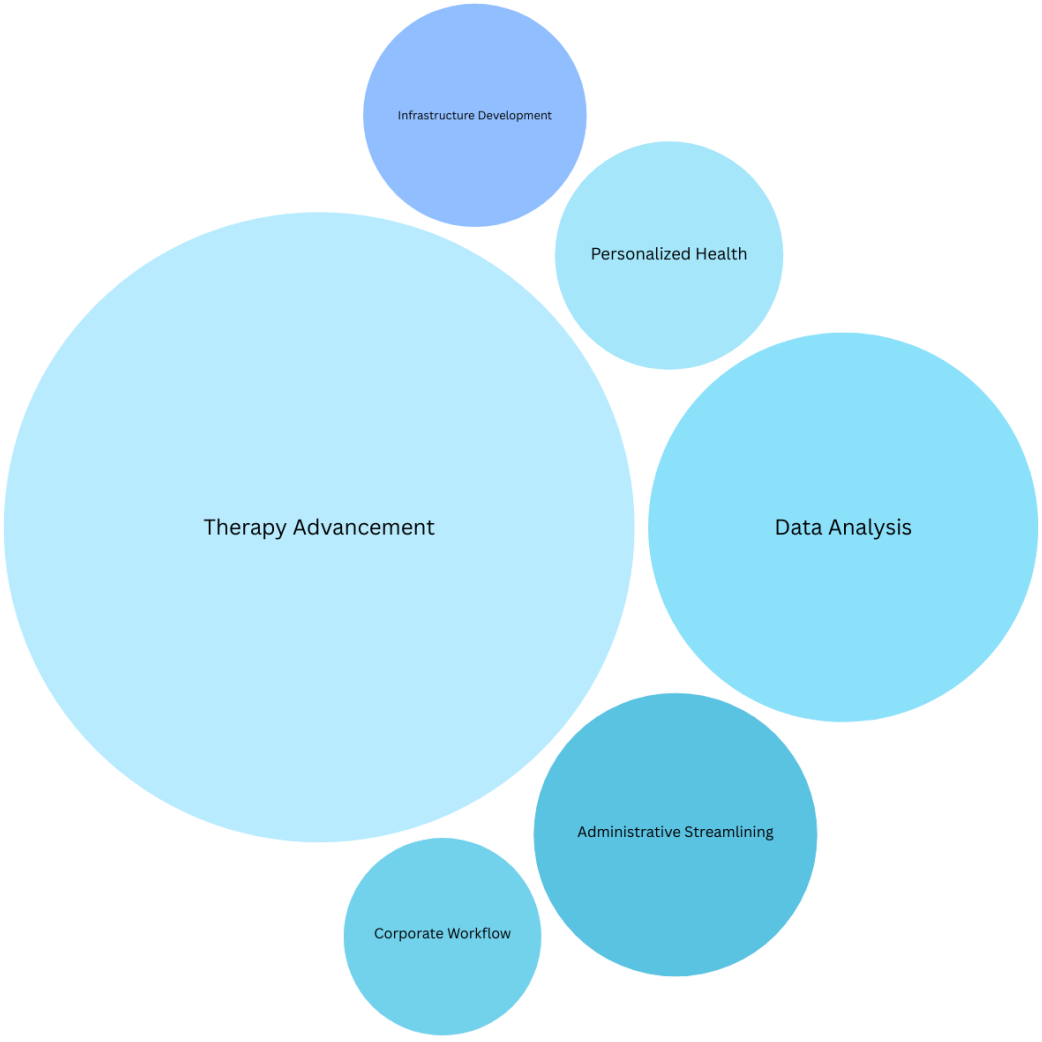


Fig 3.2 – Largest areas of external collaboration

Value-wise, external collaborations represent a huge budget. Including milestone payments, investments by pharma companies in AI through external partnerships could

potentially reach up to 60 billion USD. For example, in 2023 alone, pharma companies committed roughly 14 billion USD, representing the equivalent of 10% of R&D spending of top 20 pharma companies.[4] In this regard, companies should be cautious about the efficiency of allocation of these resources. Although the future of AI in pharma lies in successful partnerships, these investments have not necessarily yielded the intended returns to date, and the industry should keep in mind that more investments do not systematically warrant better quality.

Conclusions and recommendations

The degree of AI readiness of leading pharma companies has been steadily increasing over the last years. However, there is a clear gap within the industry. Overall, the same companies often lead in all criteria of AI readiness, while AI-lagging companies show weaknesses in all categories. Artificial intelligence has the potential to greatly improve patient outcomes by increasing efficiency while reducing time and cost at all levels of the pharmaceutical development process, but leading players must make tough decisions. The choices made for the implementation of AI must send a clear message that the industry is ready to take on this challenge in an efficient and responsible manner.

The following measures are what we consider to be the best practices currently observed in the industry, and should be looked up to as models for other companies to follow in their steps. This report provides pharma with a guide to AI readiness, but leaders should keep in mind to implement these measures with efficiency. The results that we have observed, although they reveal a very positive trend, are not entirely satisfactory in terms of return on investment. One reason for this may be the disconnect between leadership's vision for AI and operational teams' inability or unwillingness to implement it. Although improving the categories contained in this report should naturally tend towards higher efficiency, this should also be done with enough flexibility so as to empower leaders at all corporate levels.

That said, here are our recommendations based on best practices:

[4] Deloitte, "Global pharma companies' return on R&D investment increases after record low", 29 April 2024 https://www.deloitte.com/uk/en/about/press-room/global-pharma-companies-return-on-rd-investment-increases-after-record-low.html

- AI technology should be included in corporate strategy by general management. Leaders should be clear on how they envision AI taking the company forward, while establishing how operational teams can take effective steps to that effect.
- Human capital is essential in AI readiness. Pharmaceutical companies should push the process forward, by multiplying recruitment of skilled AI workers while diversifying the departments that hirees are affected to. Overall, all departments implementing AI solutions should have the skills necessary to do so.
- In parallel, companies should ensure that AI integration can be coordinated by internal structural divisions. However, to do so efficiently, such divisions should have the necessary scope and hierarchy to oversee the application of the company's AI strategy across the board. This should be done with caution, however, leaving enough flexibility for team leaders to adapt these solutions to their operational needs.
- Finally, strength lies in unity: external collaborations will be key in harnessing the power and advances of AI technology. While approaching these partnerships strategically, companies should diversify the areas of collaboration with all types of actors, and make sure that the investments thus made yield effective results.

Company	Stage 1	Stage 2A	Stage 2B	Stage 2C	Stage 3
AbbVie					
Amgen					
AstraZeneca					
Bayer					
BI					
BioNTech					
BMS					
Eli Lilly					
Gilead					
GSK					
J&J					
Merck & Co					
Merck Group					
Moderna					
Novartis					
Novo Nordisk					
Pfizer					
Regeneron					
Roche					
Sanofi					

Fig 4.1 – Heat map of pharma companies based on AI readiness factors

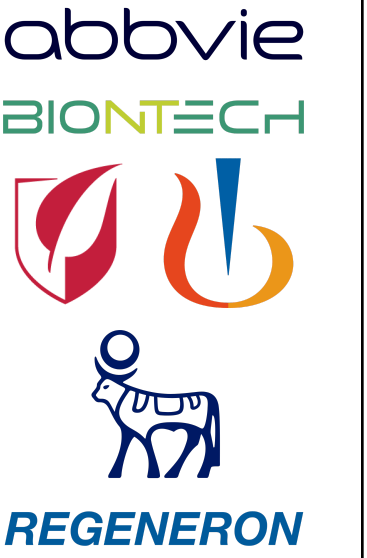
Group 1	Group 2	Group 3
		

Fig 4.2 – Chart of pharma companies' AI Readiness