The Growing Economic Power of AI in American Healthcare

Vijay Pande, former chemistry, biophysics, and computer science professor at Stanford who now is the founding partner of Andreesen Horowitz's 200-million-dollar Bio Fund, boldly claims that the next industrial revolution will be centered around the Industrial Bio Complex, a name he coined to describe the intersection of bio pharma and healthcare with the ongoing Artificial Intelligence (AI) Boom.[1,2] In his article, "The New Industrial Revolution: Bio x AI," Pande likens the massive innovations in manufacturing and automation post WWII with a forthcoming revolution in our economy as the healthcare industry incorporates revolutionary AI advancements. He predicts that the Industrial Bio Complex will birth new trillion-dollar companies rivaling the tech giants Apple, Alphabet, Amazon, and Meta.[2] Pande's predictions could be deemed extreme, especially when considering the inherent bias– his job is to recruit investors for the growing number of AI-based biotech companies emerging in South San Francisco.[3] Nonetheless, radical economic growth in the healthcare industry, followed by a surge in health-related data support his optimistic projections of global dominance from companies operating within the Industrial Bio Complex.[4-6]

Recent forecasts point to healthcare and genomics industries taking over Big Data in the next decade as the volume of data in all bio-related firms has recently skyrocketed to unprecedented levels with no signs of slowing.[7-9] According to IDC's Data Readiness Condition (DATACON) index, the amount of healthcare data is set to exceed 10 zettabytes in 2025.[10] Stanford University's Human-Centered Artificial Intelligence 2023 Index reported that that the AI focus area with the most investment was medical and healthcare in 2022, surpassing the data management, processing, and cloud division– the highest sector in 2021.[11] Genomics data alone is expected to surpass the data production of YouTube and Twitter by 2025, which is supported by Nucleic Acids Research's most recent report that the Molecular Biology Database Collection increased from 1,645 to 1,764 genomic databases from 2022 to 2023. [12,13]

Why is every tech company and financial institution suddenly increasing AI-healthcare related investments? As notorious bank robber Willie Sutton famously said, "Because that's where the money is." The remarkable rise of economic interest in the pharmaceutical and healthcare industries has resulted in the high monetary value being attributed to this new abundance of health and genomic data. To put it in perspective, the combined amount of U.S. consumer and government spending on healthcare services and goods of $4.4 trillion surpasses the $3.7 trillion combined revenue of Fortune's top ten largest companies by revenue in 2022.[14-16] At the individual level, a single electronic health record can be worth as much as $250,[17] and genome sequences could be worth multiple thousands.[18] Thus, companies able to store and analyze human biological data for innovation or exploitation are contributing to what some have classified as the transformation of health data into a digital currency.[19]

This wealth of investment has been reflected by the growth in AI-health companies and subsidiaries. A recent report released by BiopharmaTrend states that the number of AI-driven drug discovery companies have jumped from 62 to 400 from 2011 to 2022. Tech titans have responded to these young competitors by further developing and investing in health-related services. In 2021 Alphabet launched Isomorphic Labs, a spinoff of DeepMind, focusing on AI for drug discovery.[55] The Google parent company also has influence in the AI-healthcare surge with their life science research organization Verily and their venture capital firm Google Ventures which has increased investment in companies that would fall under the Industrial Bio Complex.[26] Continuing to collect valuable personal health data from millions of consumers who own an Apple watch, reports have speculated that Apple will launch its own health insurance company in 2024.[26] In December of 2020, Amazon launched Amazon HealthLake, its own organization that uses machine learning models for healthcare data, with customers

including a major hospital, an autism research center, and cloud computing organization.[78] It would not be surprising if One Medical, a San Francisco-based chain of primary healthcare clinics, is also using Amazon HealthLake after being acquired by the tech giant for 4 billion last February.[27] This acquisition came shortly after Microsoft released its own 60-million-dollar philanthropic organization, "The Microsoft AI for Health," program that funds AI-health research projects aimed at reducing health inequity and improving research capabilities.[28] This organization is just a drop in the bucket of Microsoft's influence on the AI-healthcare industry as the company dominates in providing cloud services to hospital organizations in addition to collaborating with the biotechnology-AI company Paige.

In addition to changes in the industrial landscape, the surge of financial investment in healthcare —driven by the AI boom—has profoundly impacted the research landscape in recent years. The largest global funding agency of health-related research, the U.S. National Institutes of Health (NIH), has dramatically increased funding for data science and machine learning/artificial intelligence research (ML/AI). Since releasing the "NIH Strategic Plan for Data Science" published in 2018, the institute has continued to pour funds into research coordinated by a new department, The Office of Data Science Strategy (ODSS).[20] Starting with a $585 million yearly budget in 2019, funding for ML/AI research has since more than doubled with an annual budget of $1.486 billion for 2022 and an estimated budget of $1.636 billion in 2023. This is separate from the also newly created Data Science sector, which the NIH granted $1.348 billion in funding in 2022 and an estimated budget of $1.422 billion in 2023 – again more than double its initial 2019 budget of $662 million.[21] (**Figure 1**)

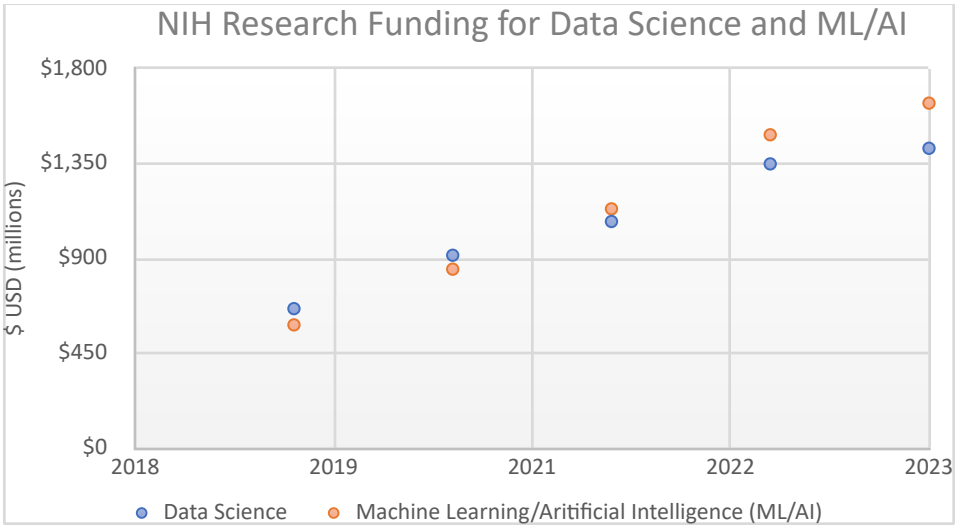

Figure 1: NIH funding for Data Science and Machine Learning/Artificial Intelligence research since development of program in 2019.

Consequently, there has been a startling increase in AI publications and patents coming from the healthcare and pharmaceutical research sectors. Typing the keyword "artificial intelligence" into PubMed's search engine shows that AI publications increased 38% from 2020 to 2021 and 23% from 2021 to 2022.[22] (**Figure 2**) While patent applications have steadily increased the past two years as well, policy disagreements have developed causing the rate of patent acceptances to remain stagnant.[23]

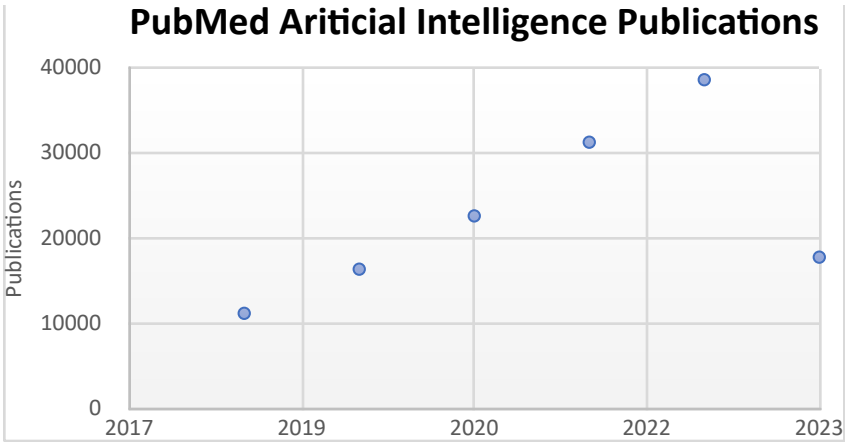

Figure 2: NIH funding for Data Science and Machine Learning/Artificial Intelligence research since development of program in 2019.

Beyond the rapid advances in machine learning and artificial intelligence in healthcare over the past two years, these technologies are also driving promising breakthroughs in basic science, particularly in the field of drug discovery. Computer-aided drug design (CADD) has been a vital component in drug discovery processes since the early 1980s.[24] Programs embedded with a classical and/or quantum mechanical mathematical framework to describe the positions and interactions of subatomic particles have been developed and used by computational chemists to predict potential disease-inhibiting molecules based on their affinity and selectivity to biological targets. While using computational chemistry programs to analyze drug-target interactions is much more cost-efficient than the old-school experimental trial and error method, the process of choosing the potential candidates for virtual screening has been the greatest challenge considering the nearly infinite sample space of small organic molecules. This is where the major breakthroughs in deep learning applications have transformed the field in the past few years. Using the advancements in computational power and data storage, AI has been able to provide a rational approach to drug discovery by identifying the structures of biological molecules involved in disease pathways, predicting drug properties, and designing drugs from scratch.[25]

Arguably the most well-known innovation in the AI-bio field was the announcement by Google's DeepMind of the of the neural network-based model AlphaFold for protein structure prediction in 2021.[26] AlphaFold architecture uses supervised learning on the genome sequences provided in the Protein Data Bank (PDB) to accurately predict their structures. Using AlphaFold, pharmaceutical companies such as Insilico Medicine have shortened the time from target discovery to hit molecule down to 30 days.[27] Insilico just announced it is entering Phase 1 clinical trials– the first AI-discovered drug developed from an AI-discovered target to reach this milestone. [28] Now thousands of researchers are using AlphaFold to further understand human biology and develop novel disease treatments. Some outlined in a recent article by Drug Discovery and Development include discovery of neglected diseases, combating antibiotic resistance, studying the nuclear pore complex, developing a malaria vaccine, and understanding genetic predisposition to diseases.[29] There is a reason why AlphaFold's original *Nature* publication in 2021 has been cited more than 12,000 times, with a Forbes contributor calling it the most important achievement ever in the entire AI field.[30] While AlphaFold on its own may not revolutionize drug discovery,[31] it clearly has contributed to the beginning of an AI/Pharma revolution when combined with other AI tools, such as Insilico's end-to-end AI platform Pharma.AI.[28]

The funding and infrastructure devoted to AI in healthcare are driven by the still-unrealized expectation that data scientists will harness large-scale data to develop innovations that lead to cures for

human diseases. In this context, it's fitting that educational institutions and private companies have expanded open-source educational resources focused on AI in healthcare and drug discovery. While it's uncertain whether the *Industrial Bio Complex* will dominate the economy as Pande predicts, a failure to deliver on these anticipated innovations could carry significant economic consequences.

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