SOFTWARE TRENDS IN LIFE SCIENCES R&D

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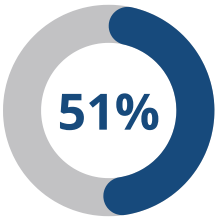
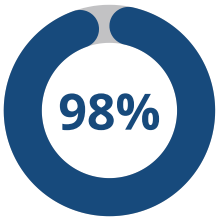
New software tools have been experiencing significant growth across healthcare with over $29 billion raised in just 2021 to finance digital health companies. We have seen the rise of telemedicine, accelerated by COVID-19 limiting patient access to medical professionals, with 5% of doctor visits expected to have been done virtually in 2021.



of respondents in a 2021 Rock Health survey indicated they had adopted live video calls



of respondents in a 2020 McKinsey survey indicated satisfaction with telemedicine appointments they attended.

THERAPEUTIC DEVELOPMENT

With rising development costs and a dependence on outdated tools, therapeutic development and basic life sciences research are ripe for technological innovation. Within the life sciences tools and services market, new software technologies are being developed and implemented from drug discovery through clinical development.

In 2021, over $5 billion was raised to finance life sciences digital research and development companies (Rock Health, 2021).

Applications within discovery:

- New therapeutic candidate evaluation
- Analysis for repurposing of approved therapeutics
- Genetic mapping and analysis
- Automated services to replace existing, slow CROs

Applications within clinical development:

- Real-time analytics
- Clinical trial management
- Identification of clinical trial sites
- Patient identification and engagement

TRENDS WE ARE WATCHING

We characterized each trend by the following attributes:

Potential Industry Impact	***Technology Risk***	***Regulatory Risk***	***Maturity***
Size of possible impact on the industry	Degree of dependence on new technological development	Impact that regulatory decisions can have on the trend	Current stage of development

Trend 1: Leveraging Deep Learning

Advances in artificial intelligence (AI) and machine learning (ML) have as much potential to revolutionize the life sciences as they do in many other industries. 81% of respondents in a 2021 Deloitte survey of 150 biopharma leaders indicated that AI was a current investment priority today and over the next five years. AI is being used across the life sciences workflow from drug discovery through therapeutic manufacturing. Over 200 companies now provide artificial intelligence tools throughout the drug discovery workflow with applications across clinical trial design and recruitment, data aggregation and analysis, and establishment of new biomarkers and therapeutic candidates applications across clinical trial design and recruitment, data aggregation and analysis, and establishment of new biomarkers and therapeutic candidates (Simon Smith, 2021). In September 2021, FDA granted its first clearance to an AI diagnostic when it approved Paige's cancer detection AI for marketing (FDA, 2021). In October 2021, Excientia completed its IPO, raising over $250 million for its AI drug discovery platform. The company was the first to take an AI-designed therapeutic into human testing and has now completed the transition three times (Exscientia SEC, 2021).

Regulatory Risk	Potential Industry Impact	Technology Risk	Maturity
MODERATE	HIGH	HIGH	DEVELOPING

Trend 2: Laboratory Automation

While some level of automation has been occurring within laboratories for several decades, recent advances in software and hardware are making new solutions possible and existing solutions cheaper. The number of PubMed publications with titles that included “robot” or “robotic” has tripled in the past decade (NCBI, 2020). Automation has a wide range of benefits including increased reproducibility and reliability of data, laboratory efficiency, safety, and speed. Automation equipment is now available for most of the laboratory workflow, with physical robotics complemented with software tools that enable greater visibility and control of processes.

The benefits of automation are well known, but over 85% of PubMed papers indicate that researchers use manual methods for processes that have robotic alternatives. This is likely due to the prohibitive up-front costs of automation equipment which can be difficult for many labs to finance. While the ROI of automation can take time to realize, it can be significant. In one well-documented case, total laboratory costs fell over 12% after introduction of automation (Archetti et al., 2017) and another clinical laboratory found that turn-around time fell by 6% as a result of total laboratory automation equipment costs expected to be recouped within five years due to increased revenues from improved efficiency (Kim et al., 2022). We believe it is only a matter of time before labs have automated much of the repetitive, manual processes currently being performed.

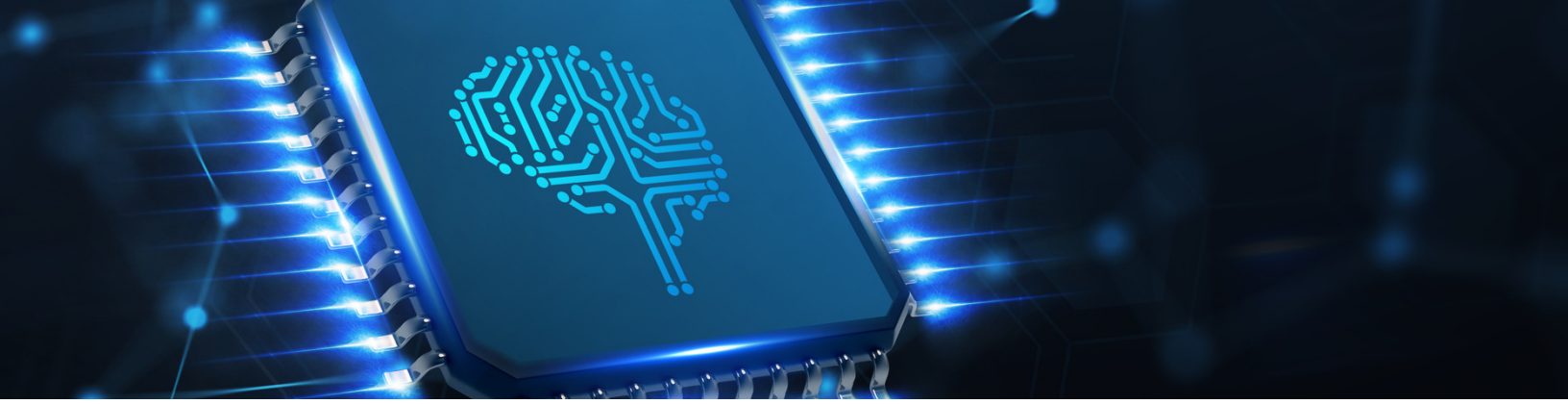
Regulatory Risk	Potential Industry Impact	Technology Risk	Maturity
LOW	MODERATE	LOW	DEVELOPING

Trend 3: Big Data Analysis

On the back of the genomic revolution and the continued digitization of health information, it has become increasingly necessary to develop tools for the management and analysis of large data sets. According to the National Human Genome Research Institute (NHGRI), estimates predict that genomics research alone will generate between two and 40 exabytes of data within the next decade. “Our ability to sequence DNA has far outpaced our ability to decipher the information it contains…” (National Human Genome Research Institute).

The sheer quantity of data will require a new set of skills and tools for researchers. In 2021, the NHGRI set up the Officer of Genomic Data Science to develop and support the genomic data science activities of the NHGRI. Beyond genomics, the life sciences industry will need new data compilation and analysis tools to collect, interpret, and communicate the data provided by the digitization of existing healthcare information as well as the data provided across the multiomic paradigm.

Regulatory Risk	Potential Industry Impact	Technology Risk	Maturity
LOW	MODERATE	MODERATE	DEVELOPING



Trend 4: Real-World Evidence

For a long time, the FDA has used real-world evidence (RWE) for monitoring and evaluating the safety of therapeutics after approval. However, the agency only started using RWE to evaluate the effectiveness of therapeutics in the past decade, including for Defitelio in 2016, Luitathera in 2018, Zostavax in 2017, and Ibrance in 2017. It wasn't until 2018 that the agency released a framework for the use of RWE across the therapeutic development lifecycle, with additional guidance provided in 2019 for the submission of RWE documents. Given this new framework and increased support from FDA, it is likely that we will see a significant uptick in the use of real- world evidence by both biotech and pharmaceutical companies.

Outside of therapeutic development, RWE has a range of uses including patient monitoring, cost and utilization analysis, and public health analysis more broadly. For example, in October 2021, FDA inked an almost $3 mil contract with Aetion to use the company's real-world evidence platform for assessing COVID-19 inpatient medical countermeasures (FDA, 2021).

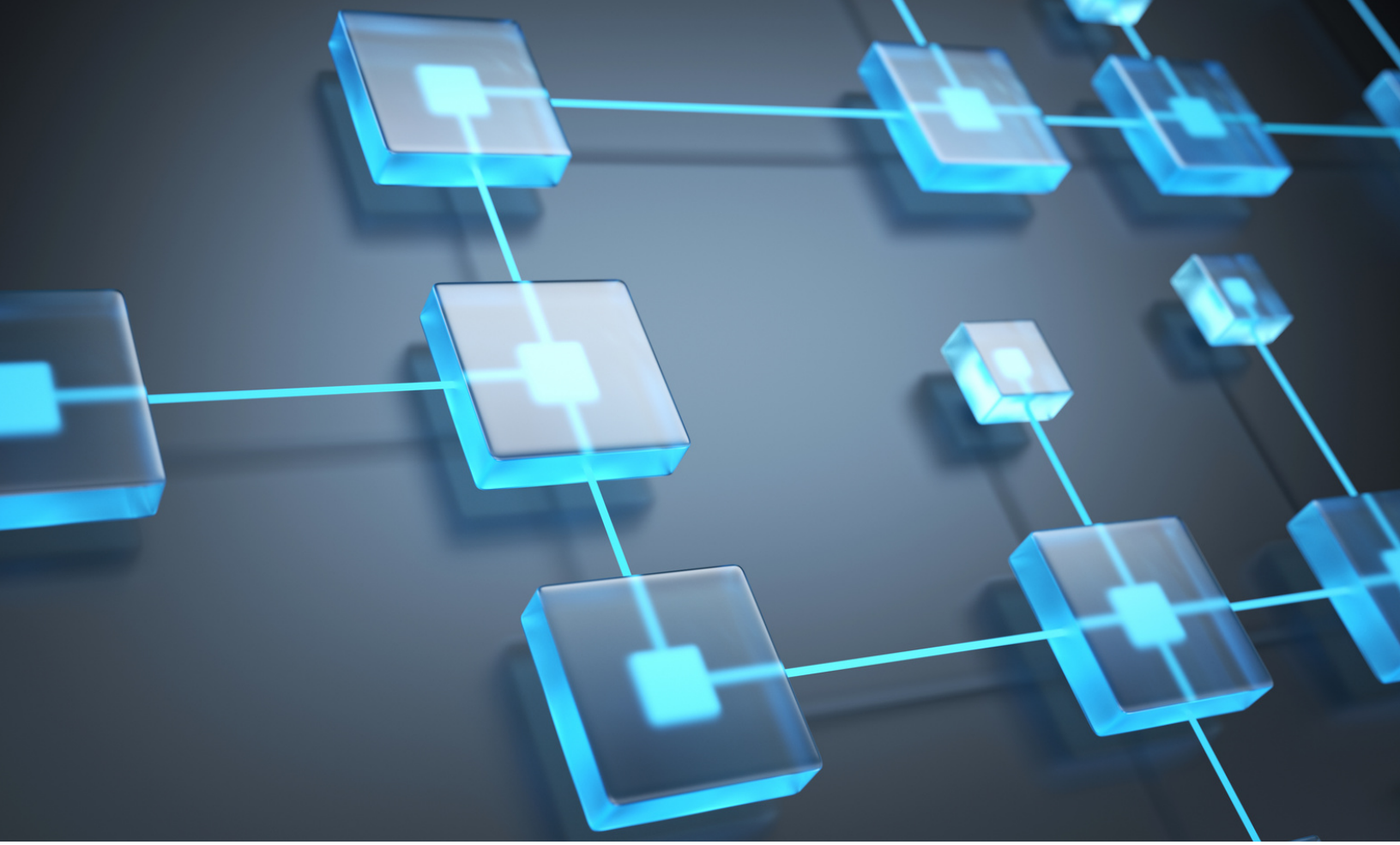
Broadly, McKinsey estimates that an average top-20 pharma company could unlock more than $300 million a year across its value chain through adoption of advanced RWE analytics alone (McKinsey, 2020).

Regulatory Risk	Potential Industry Impact	Technology Risk	Maturity
MODERATE	**MODERATE**	**MODERATE**	**DEVELOPING**

Trend 5: Decentralized Trials

With 70% of patients living more than two hours from clinical sites, it is no surprise that 80% of clinical trials are delayed due to lack of enrollment (Sanofi, 2017). Decentralized trials that utilize advances in mobile technology and telemedicine have the opportunity to significantly accelerate clinical trial completion. According to a 2021 Science 37 survey, 80% of biopharmaceutical executives had planned to execute a clinical trial with decentralized elements in the next year, but 60% lacked in-house decentralized trial capabilities. Furthermore, respondents to another 2021 Science 37 survey indicated that 40% expect to run a fully decentralized trial in the next 12 months (Science 37, 2021). The benefits of decentralized trials include better patient experience and retention, as well as faster recruitment and lower costs.

Regulatory Risk	Potential Industry Impact	Technology Risk	Maturity
MODERATE	MODERATE	LOW	DEVELOPING



OTHER TECHNOLOGIES TO TRACK

Internet of Technology (IoT)
supply chain tracking and tracing

Wearables
remote monitoring

Virtual and Augmented Reality
remote equipment configuration and troubleshooting

Quantum Computing
faster data processing; especially useful for understanding complex biological interactions

Digital Twins
digital modeling of physical processes

Blockchain
secure data sharing and auditability

BROADOAK PORTFOLIO

BroadOak has made several investments within life sciences IT and is actively looking for more.

Genomenon

Genomic health IT company providing software and curated datasets used in the interpretation and downstream analysis of genetic variants

antibodies-online

Leading e-commerce platform for the distribution of antibody, ELISA, and protein products for the life sciences

**acquired by Rockland Immunochemicals in 2022*

Rarelife

Provider of a digital platform for connecting stakeholders within the rare disease industry

Cardea

Provider of the only commercially available biosignal processing unit (BPU), a chip that converts near real-time streams of multiomics signals into digital information

PubGrade

Digital advertising and business intelligence platform for life sciences businesses

BioNex

Provider of advanced technology systems for laboratory automation and liquid handling