Innovating Innovation in Healthcare - How Covid has torn up the rule book.

Innovation will have an important role to play in recovering from the aftermath of the coronavirus. Indeed, it is through innovation that the world has found its primary defence against the virus; vaccines. The lens of COVID-19 has brought into sharper focus both the complexity and unpredictability of managing innovation, particularly in healthcare. This article considers why today's open, intrinsically unpredictable business environments demand a rethink of established, often binary, theories for managing innovation. The impact of Covid-19 on the healthcare sector has been enormous. It shifted consumer preferences, upset supply chains, prompted a radical rethink of clinical trial protocols, accelerated the adoption of digital tools and catalysed an explosion of investment in home and digital care.

For too long research on innovation has revolved around various dichotomous ideas: Radical versus Incremental (Leiffer et al, 2000): Explore Versus Exploit (March 1991; Lavie & Rosnkopf, 2006): the contrast of openness and control (or differentiation and integration) in managing open innovation (Chesbrough, 2006); the characterisation of either solvers or seekers (Mazzola et al, 2018); the paradox of separation and integration (Todorova and Durisin, 2007); the likelihood of core capabilities turning into core rigidities (Leonard-Barton, 1992; Teece and Leih, 2016); and 'outbound' and 'inbound' flows of innovation (Enkel et al, 2020); outside-in and inside-out (Chesbrough, 2020).

Few could have predicted the Covid outbreak (Cankurturan and Beverland, 2020) with the disruptive and often catastrophic consequences that accompanied it. In dealing with these extraordinary, once-in-a-lifetime events managers are required to break free from their established patterns of thinking. Emancipation from prevailing orthodoxies and ways of thinking is a process well described in *This Idea Must Die*, (Brockman, 2015), which is an anthology of leading scientists and thinkers, each of whom provide a single idea that they think is blocking progress in their particular field. From physics to psychology, computing to mathematics, the book contains thoughts from some of the leading thinkers of our age. Each chapter challenges an idea that embodies established ways of thinking in their field, and which must be destroyed for the community to be free enough to explore afresh.

Similarly, innovation models based on rationality and predictability are much less likely to be successful than had been previously theorised and these might have made a good chapter in Brockman's book. Recently scholars have advanced a new paradigm called *Multidexterity* (Robbins et al, 2021). Multidexterity is the organisational ability to carry out multiple innovation-related search and selection activities based on diverse strategic logics and levels of knowledge with the objective of generating a portfolio of positive innovative outcomes. Multidexterity helps extend the outer parameters of open innovation as well as some of its defining characteristics. It proposes an expanded framework (from Lakhani et al's version in 2013). The new framework accommodates not just citizen crowdsourcing in the quest for novel ideas but also includes a broadly distributed engagement in the selection of the ideas to be resourced too.

The Covid crisis, apart from being an existential threat, does provide a perfect illustration of a wicked problem (Rittel and Weber, 1973) and it also gives real and vivid meaning to the VUCA concept (Miller et al, 2018). As a result, innovation models based on 'rationally' setting and controlling innovation goals and processes are much less likely to be successful than previously theorised (Venkataraman et al, 2012). Equally, theories that imagine innovation as merely dichotomous are now considered outdated (Robbins et al, 2021). Instead, organisations need to pursue strategies that foreground agility, flexibility, dexterity, openness and resilience – all more suited to dynamic, unpredictable operating environments (Schoemaker, et al, 2018). In this paper we contribute to conversations about how theories of innovation must be re-imagined in a way that foregrounds creativity and design led approaches (Brown, 2008), perhaps now more than ever, as we face the greatest global crisis in recent history.

This paper will examine the background to and attempt to explain the underlying mechanisms behind some of the extraordinary innovations and collaborations that have been catalysed by Covid. The scientific community has collaborated in ways hitherto unimagined to develop life-saving medicines and the various actors in the public sector, even including the army, have collaborated to build Covid (Nightingale) hospitals within days rather than years. As McKinsey acknowledge (Cohen et al, 2020), a crisis such as this one can create an unparalleled sense of urgency that rallies people to heroic collaborative effort, breaks right through organisational silos and overcomes institutional inertia. Many commentators wonder, can it last?

Hence, the key question is whether these phenomenally successful partnerships: these spectacular outcomes are, like Covid itself, a Black Swan event; or whether the urgency, the collaboration and the results could possibly be replicated when the dark cloud and ominous threat of Covid has receded? Can the Covid-catalysed pace of innovation become the new normal for innovation projects? In this chapter, we explore the impact of Covid 19 on innovation management and we review the factors that were unique and we discuss the new areas of investigation which have emerged based on this new changed reality.

Introduction

Innovation and Covid 19

Before Covid, it wasn't uncommon to hear people describe the value of creating a 'Burning Platform' to help drive lasting change. For many businesses, there could be no more powerful such platform than the Coronavirus (Gaskell, 2022). The immediate aftermath of the first lockdowns saw a proliferation of incremental innovation as some 'low hanging fruit' was gathered. Grocery stores installed shields for checkouts, restaurants pivoted to *take-out* services and retail, universally, integrated home delivery into their sales process. In primary care, according to McKinsey (Cohen et al, 2020), GP's adopted tele-medicine in unprecedented numbers (from 11% of customers using it in 2019 to 46% one year later). They also introduced centralised online patient appointment booking especially for vaccinations (Breton et al, 2022).

In other sectors, some more fundamental changes occurred. Education, which had long resisted the pressure for online delivery, suddenly switched to online lectures with some institutions even moving to proctored online examinations. In other sectors, retailers experimented with Amazon's *Just Walk Out* technology which allows customers to shop, collect and pay for their items without the need for a check out service. Hospitality had to refocus its design to focus on 'germ free' environments and some integrated robots into their service teams to boost productivity and efficiency and help reassure customers that the social distancing requirements have not been compromised (Xu et al, 2020).

But, in few industries has the *burning platform* been quite as impactful as in healthcare and the transformation they've witnessed has been similarly seismic. As noted by D'Amico et al (2021), when the World Health Organisation declared COVID-19 a pandemic (WHO, 2020), the global healthcare sector faced the biggest transformational challenges in its history: the precipitous change and inevitable need to swiftly adapt to a new environment where the widespread adoption of digital technologies became an imperative (Nalbandian et al., 2021). Primary care also used AI so that the priority for appointments in busy periods could be modulated according to the reason for the consultation (as reported by the patient). Geolocation was also used to triage patients for vaccination appointments and each patient received automated confirmation by email, phone or text messaging. While observers might think some of these changes were somewhat overdue, according to a Canadian study, they were 'drastically facilitated' by Covid-19 (Breton et al, 2022: p.8).

One outcome which has fascinated academics and managers alike is the way that the Covid pandemic turbo-charged the innovation process and intensified collaboration between new partners, across public, private and third sectors, as well as delivering successful innovation assets in record time. The Covid 19 vaccine was developed in an historically short time, becoming available in 12 months compared to the conventional longer drawn out process for other vaccines which have typically lasted many years (Srinivasan, 2021). Academics have mused as to whether this lightning speed is further evidence of the adage that 'necessity is the mother of invention' or whether these feats could become the norm in R&D-led innovation from here on in. Cooper (2021) has rewritten his seminal stage-gate rule book to accommodate the lessons he believes can be drawn in the area of accelerated product development.

One contributory factor in the startling speed of the vaccine development was, undoubtedly, the significant role played and the equally significant resources provided by the state. There was a massive mobilisation of Government efforts and state funding. Billions of dollars of funding, with few or no preconditions of payback terms or timelines, came from multiple governments and state agencies. Vaccine development projects had almost unlimited funding with minimal costs. Separately, and equally unusually, scientists and researchers in different countries and working for different companies cooperated closely in this grand challenge. Moreover, most other drug development projects were paused to allow space for the vaccine development work. Whether either factor will ever be replicated except in the instance of another existential threat is highly doubtful.

The regulatory agencies, who quite rightly pride themselves on their conservatism and avoidance of risk, also offered an historically benign approval regimen. Their statutory function is to reduce possible downside risks to patient safety, health, wellbeing as well as taking environmental impacts into account before approving any medicine. They must check rigorously for issues that might compromise patient safety; equally they must satisfy themselves about the tolerability of any medicine and, of course, top of the heap - they need to be satisfied with its efficacy i.e. that it offers better clinical outcomes than the medicine currently available.. These regulatory agencies didn't quite relax their rules but they did redraft them to accept remote patient monitoring in Phase II and III and to facilitate speedy processing of dossiers. They also used rolling reviews and emergency authorisations to speed up the approval process for Covid vaccines (Economist Intelligence Unit, 2022). It's not certain that all these regulatory conditions are transferable (although some, certainly are). These three factors: generous, unconditional state funding, expert cross company, international collaboration and a fast tracked approval process suggest to some academics that Covid-19 is an anomaly, a Black Swan which provided an operating context unlikely ever to be repeated (Cooper, 2021).

Finally, a commercial factor has also been cited which made the vaccine development more of a Black Swan event. Academics argue that in bringing the vaccine to the market, they did not have to win market share from any dominant competitor. There was no incumbent to dislodge. In most other instances, there is an incumbent, a brand leader: a dominant technology, active-ingredient or brand which will fight hard to retain its status and salience in the market.

Examples of Covid 19 Collaborations

The expertise needed to defeat Covid 19 was as wide-ranging, complex and diverse as the challenges posed by the virus itself. New applications of data-driven health and care solutions, ranging from benchmarking the costs of different treatment paths (Basile et al., 2022) to encouraging more healthcare research (Shaygan and Daim, 2021) to the applications of blockchain technology in areas such as digitalisation of healthcare services (Cerchione et al., 2022; Spano et al, 2021) and, ultimately, the creation of superior value in healthcare . Leveraging know-how such as mobile technology, data analytics, biological engineering, community engagement, med-tech and vaccines, communities came together across disciplinary, firm and geographic boundaries. They were all driven by a desire to use science, engineering and entrepreneurship to solve the biggest existential problem the world has faced for generations. On Jan 11th, Chinese Authorities shared the genetic sequence of the coronavirus. Just two days later, scientists from Moderna finalised the design of a vaccine they hoped would defend against infection. Moderna was founded in 2010 by a team led by MIT. Moderna believed mRNA vaccines could prevent humans, not from being infected by Covid 19, but from the serious consequences of severe infection and hospitalisation.

According to HBR (2021), at the beginning of 2020, hardly anyone had heard of a biotech firm in Cambridge Massachusetts called *Moderna Therapeutics* which was then 10 years old but did not have a single commercial product on the market. By the end of the year, Moderna was selling millions of doses of one of the most effective covid vaccines in the world.

mRNA vaccines have been studied for more than a decade (Maruggi et al., 2019). The vaccines have the capacity to overcome novel vaccine compositions and, just as important, they can be mass manufactured to produce millions of doses (Jackson et al., 2020). Because of the attention to mRNA research in the past number of years, COVID-19 researchers were not starting from scratch. Nevertheless, a six week clinical trial was an indicator of the accelerated progress of this vaccine development.

Clinical Trials: Thanks to Covid, the Future Arrived Early

Clinical trials are an indispensable part of the research and development of new drugs and medical devices. It's essential to evaluate the efficacy, tolerability and safety of potential treatments before they are made available to the general public. But clinical trials come in four successive phases and each phase can take a number of years. From the first pre-clinical tests in a laboratory, to the Phase III trials in humans, it takes an average of 12 years until approval for use in patients, according to the European Federation of Pharmaceutical Industries and Associations. Other estimates assert that from the time an intervention (usually a new drug) is demonstrated to improve clinical outcomes until it is implemented in routine care is typically 17 years (Green et al, 2009). Adding to the complexity, The collection of Phase IV data (after the launch of the product) has also been added to requirements in recent years.

According to ICON Healthcare, a global clinical trial provider, a typical Phase lll clinical trial will include well over 100,000 individual records; it will require roughly

1000 patients over a 3-4 year period and across multiple sites; sometimes as many as 200 locations within multiple countries. It's little wonder that they are increasingly turning to AI and Big Data to manage these enormous projects. Drawing appropriate lessons from the covid vaccine rollout is particularly important: it's a growing challenge, given that there are now more trials than ever. There are more than 400,000 registered clinical trials currently listed by the US National Library of Medicine. The number of results posted from clinical trials per year has increased from just 41 in 2008 to over 52,000 in 2021. This number is expected to go up further as legislation and procedures for clinical trials get streamlined with the help of digital health technologies, making it more important than ever to simplify and update the approval process.

The pandemic required the development of whole new ways of conducting clinical trials which mainly revolved around a far higher reliance on remote and digital monitoring techniques. The covid-19 pandemic and the resulting restrictions on movement forced drug developers to find new ways to set up trials and recruit participants, some of these methods will survive the pandemic. It also spurred drug regulators and pharmaceutical companies to streamline the clinical trial process, with health regulators in several countries now working on new proposals. The results not only enabled covid vaccines to be rolled out within just one year, but are also informing the development of new clinical trial regulations in several markets.

Health regulators are urgently trying to recast how clinical trials might be conducted in order to accelerate the drug approval process, and to exploit the learnings that emerged from the process applied to covid vaccines. In January 2022, for example,

the UK's Medicines and Healthcare products Regulatory Agency (MHRA) published proposals to revamp the existing clinical trial legislation in the country. The aim is partly to support the UK's clinical trial industry following the country's exit from the EU, by reducing unnecessary paperwork while maintaining safety standards.

Meanwhile, the EU's Clinical Trials Regulation, enacted back in 2014, finally came into effect in January 2022, harmonising regulations across all member states. In the same month in the US, the US Food and Drug Administration (FDA) issued new guidance that recommended the use of digital health technologies to acquire data remotely from participants in clinical trials. Other health agencies across the world are expected to follow suit, reviewing regulations in order to attract more clinical trials and to speed up new product development.

The pressing and unprecedented need to roll-out large scale, mass vaccinations right across the world prompted drug companies to hold multi-country clinical trials simultaneously. This posed a real challenge in the early days of the pandemic when cases were more random and less predictable and, especially, when lockdowns were imposed which effectively halted most natural transmissions of the disease. Regulatory agencies have two reasons to prefer that clinical trials are conducted locally. First, efficacy and suitability is proven with the local population. A lack of diversity within clinical trial subjects can hamper the collection of valuable insights about the mode or speed of action as well as safety and efficacy of any novel therapy across population sub-groups. Regulators also want to see clinical trials done locally because it gives a fillip to the highly-profitable, local clinical trials industry (Economist, 2022).

There's another lesson to be drawn from the Covid experience on trial data and the need for specificity in the markers chosen and for clarity in the data presented. The confusion over the first sets of AstraZeneca/Oxford vaccine trials show how challenging it is to get this right in multi-country trials. By delivering differing effectiveness rates depending on the trial protocols used, the ChAdOx1 vaccine compared unfavourably with the straightforward 90%-plus efficacy rates reported by Pfizer/BioNtech and Moderna.

Branch-Elliman et al, (2020) acknowledge the benefits that accrued from the greatly compressed time: it allowed for the realisation of goals that had long been pursued by the healthcare community. However, they warn that there is a downside. Low quality evidence with little or no scientific vetting may be too quickly integrated into clinical care and this could have the consequence of squandering opportunities for advancing our scientific understanding about the disease itself and how best to manage patients. It also runs the risk of regulators potentially overlooking some salient piece of data.

Novel Uses of Technology

Another novel use of technology and data came from Bio Bot Analytics, a startup which began requesting sewage samples from districts across the US to test for covid 19 contamination. This was initially done pro-bono by researchers collaborating from MIT, Harvard and other academic institutions. Faeces and urine

are useful barometers of an individual's health simply because what goes into the body inevitably comes out. And thanks to advances in genomic sequencing that allow researchers to decode whatever is present in waste, researchers today can examine sewage to ascertain in real time the presence of drugs like opioids, as well as diseases like salmonella and, increasingly over the past two years, Covid-19. In fact, because Covid-19 has been shown to appear in wastewater in advance of a disease outbreak (a study last year found that Covid-19 was already present in northern Italy in December 2019, before the first recorded cases of Covid-19 in Wuhan, China), wastewater surveillance is now being used as part of a localised early warning system for emerging pathogens of which Covid 19 was the most sinister.

In practice, this meant that city mayors, big employers, university and school administrators who had the grave burden of responsibility in deciding when to call for a lock-down or enforce work from home policies, could use Bio Bot's dynamic map which tracked cases of Covid 19, in real time, as the virus spread geographically across the US. This data was complimentary to insights from local testing but provided an early warning system that aided decision making and undoubtedly saved many lives. When local testing showed evidence of wide scale regional infection, it was often then too late to take the preventative action that might have been indicated by the Bio Bot data.

The omicron variant was first discovered to be spreading inside the United States because it was detected in sewage. With Covid-19 serving as the ultimate test case, wastewater surveillance has transformed from a niche approach to epidemiology to

one widely adopted by scientists, universities, firms, and public health agencies around the United States, including the Centers for Disease Control and Prevention (CDC). It is also being rolled out in at least 63 other countries, according to the COVIDPoops19 dashboard maintained by researchers at the University of California Merced.

The company CEO, a former MIT researcher, Newsha Ghaeli, explains the theory behind this approach:

> *Wastewater epidemiology essentially refers to this field of study where we can understand the health of a large group of people by analysing the sewage that they're all connected to. Some refer to it now as wastewater monitoring or wastewater surveillance, but that's all effectively the same thing as wastewater epidemiology. And it works because almost everything that you eat — the viruses, bacteria, all these things in your body — are excreted in your urine and stool.*

This valuable early warning detection system was the result of rapid collaboration and the use of novel technology combined with big data. This initiative typifies the type of collaboration that was not just made possible, but actually became inevitable because of the pressing needs visited on communities by the pandemic.

The healthcare industry has produced many inspiring examples of creativity and innovation in products, services, in experiences and business models. In one example Sheba Medical Centre in Israel is working with TytoCare. Their objective is to keep Covid patients out of hospital and in their homes to help offset the

overwhelming surge in demand for in-patient facilities in hospitals as more people were getting infected. They supplied patients with special stethoscopes to use in their own homes. These could both listen to the patients' hearts but they could also transmit real-time pictures of their lungs so that the hospital based teams could intervene only when absolutely appropriate and necessary. Tyto Care is an Israeli start-up that allows patients to self-monitor and send data remotely to medics allowing them to monitor patients without exposure to the disease itself Tercatin, 2020) . This radical collaboration hit the headlines in the early months of the pandemic (February, 2020) when passengers from the coronavirus-stricken cruise ship Diamond Princess were being returned to Israel. Tyto's device has been designed as a consumer product and is now available in North America through electronics retailer, Best-Buy for $299. It is intended for parents of babies, those needing to regularly monitor their own health, such as diabetics.

The Tyto device, connected with an app which can be downloaded on both Android and IOS operating smartphones, allows people without any medical background or experience to carry out examinations of heart, lungs, throat, ears, skin, abdomen, heart rate, and body temperature. The tests can be conducted also by the patients on themselves. As for the lungs, one of the most sensitive areas to detect possible symptoms of the coronavirus, the tool offers a digital stethoscope that can auscultate the respiration and detect possible signs of infection.

The Impact of Work From Home on Creativity and Science

As Acosta (2020) puts it in just a few short weeks, the world as we knew it changed. It changed to a scale not witnessed since the Great Depression. Covid 19 has had dramatic consequences for the world economy, for society and for business. But digitisation has helped offset some of this damage (Almeida et al, 2020). The forced move to 'working from home' (WFH) made necessary by the pandemic is described by scholars as 'the most significant organisational shock of our lifetimes.' (George et al, 2020 p.1744). Remote working was not a new phenomenon in certain communities like multinational firms and open source communities but the pandemic emphatically accelerated it to 'all remote all the time' and this resulted in a frantic race to adapt to remote collaboration and to acquire the right technological infrastructure and to develop the appropriate team culture and protocols to transition seamlessly into this new way of working. At the same time, it has become necessary to redesign management and collaboration models to help ensure that no staff are left behind and feel excluded from the direction the organisation is moving through its digitisation process. A new research agenda is emerging to look into the particular and optimal combinations of people, tasks and infrastructure that enable organisations to thrive in distributed forms and this new stream is quickly gathering momentum. One question on this research agenda is whether remote collaboration requires modularisation of work? This is a central question because collaboration and communication are known to contribute to creative behaviour and outcomes. So, there is a strong probability that organisational creativity will suffer because of WFH. Few would dispute that face-to-face interaction plays a positive role in group-level creativity but what is not known is the degree to which this can be replicated (or even improved upon) in online contexts.

Process innovation within organisations has been boosted by the pandemic. Adoption of digital technologies, cloud-based applications in terms of routine ways of working in private, public and third sector organisations has become the norm. This required firms and teams to become rapidly digitally enabled. In corporate life the pace of change has been unprecedented but this has been echoed in people's private lives too as contactless technologies, digital money and cashless payment systems have become all pervasive.

Scientific R&D is widely considered not just to play a central role but is actually the engine room of innovation (Shao et al., 2021; Zhang and Wang, 2020; Fischer and Newell 2008). But even before Covid, the R&D innovation engine was showing unmistakable signs of slowing down. Scholars agree that there is little prospect of that great era of innovation between 1870 and 1970 where important and transformational innovations such as the internal combustion engine and electrification will be repeated (Gordon, 2016). Part of this debate is the *publish or perish* culture that has permeated the scientific community and gives rise to concerns that it is citations and publications which are now the aim of much research rather than genuine scientific advances. It has been argued that further investment in R&D is likely only to support additional research papers without the filling the gap between the published research and societal needs (Sarpong et al, 2022).

But the digitisation of everything poses some key questions for innovation management, especially in healthcare. There appears to be a decline in interest in the large physical infrastructure needed to deliver scientific breakthroughs as researchers and scientists are constrained in terms of coming to work, in large

in-person groups or teams, in these facilities. This reluctance towards co-location, could have the effect of atomising some blue-sky, scientific breakthrough projects into discrete elements or virtualising the design of large, integrated labs needed to make them happen. This might mean that some overarching themes or critical insights are overlooked as each partner focuses exclusively on their link in the chain. Could 'Big Science' end up taking a back seat? Already, drug development and clinical trials of non-Covid related therapies have been postponed, some indefinitely. The pandemic has raised questions about the conduct of science and drug discovery and the role of the traditional, R&D, innovation architecture such as labs, buildings, centres of excellence and people - and how they might now need to be reimagined.

Conclusion

Medicine is a branch of science which is distinguished by its investment in and dependence on the continual process of discovery. In recent years, we've seen AI getting better at reading chest X-Rays than Radiologists (Cohen et al, 2022). Inexpensive genomic sequencing has allowed for the personalisation of cancer treatments and big data has facilitated huge advances in population health management. The response to the COVID-19 crisis has required continuous, real-time innovation that has affected the way care gets delivered on the front lines, across geographies, and across the healthcare value chain. It required a reboot of the techniques through which we get the best evidence to clinicians, guide them through decision-making, build new treatment algorithms, and retain and retrain scores of redeployed health workers — while connecting the dots between what they were seeing and what the emerging clinical evidence of the moment was presaging.

Babina et al, 2020 provide a degree of optimism that the Covid experience can produce some enduring benefits for society. They note that great, global crises are not exclusively destructive events but they can also be a source of sustained and lasting innovation. The study focused specifically on the impact the Great Depression had on innovation in the United States, both in the short and long-term. The analysis found that in the short-term, the quantity of innovation decreased, especially among independent innovators and single entrepreneurs taking out patents, but that the quality increased and that large organisations really thrived and their innovation prospered. Our research shows similar trends arising from the pandemic. Other commentators (Cain, 2022) liken the pace of innovation in healthcare, over the last two years, to what happened during the Great War or even the NASA 1960's space race where there was a proliferation of technology developed in record time in response to an external stimulus of considerable magnitude.

Aside from the overhang of the pandemic, Pharma is also witnessing a democratisation of its drug discovery processes. No longer does the image of the clandestine, high-security, well-guarded, remote-location testing lab apply. Instead, according to Sarpong et al, (2022), 15 of the top 21 pharma companies are actively scouting campus companies and canvassing inventors and research clusters looking to collaborate. They routinely operate corporate venture capital funds. One element which is certain to characterise the industry in the future is the widespread, if not universal, adoption of Open Innovation - it holds the possibility of diversifying, accelerating and adding novelty to pharma R&D.

Evidence of this new, more transparent operating model in pharma comes in the form of new, and previously unlikely, partnerships and collaborations. McKinsey (Cohen et al, 2020) say that the lines are blurring between competitors and colleagues or allies with new partnerships forming such as that between Pfizer and BioNTech in developing treatments and then GSK in manufacturing them. These new partnerships augur well for the continued development of creative alliances and new business models as well as for the future of R&D more generally.

But, aside from the potential positive legacy of covid, commentators are also alert to some of the downsides of the Covid experience in healthcare. First, they say, there is burn out throughout the value chain within the patient care system. They also acknowledge the very heavy toll that has been taken on mental health for patients and healthcare workers alike (Cain, 2022). It is hoped that these are transient. For many patients, Covid-19 forced a cessation or suspension of preventative and elective procedures. It disrupted supply chains for critical equipment and medicines for non covid-related therapy areas.

Bain & Company (2021) have attempted to predict who will be the winners and losers in terms of healthcare companies. They ask will Covid-19 help or hinder healthcare companies? Readers shouldn't be surprised to read their conclusion: 'it depends!.' They are forecasting a high level of growth in digital, home or pharmacy based testing and diagnostics as people will be reluctant to attend hospital unless there is no alternative. This reflects a substantial shift to outpatient settings while the demand for hospital based elective procedures is likely to decrease.

Nevertheless, if we look at the likely future for patients, for public health and for investment opportunities, the reasons to be cheerful are clear. The system now has the IT infrastructure to allow for the widespread consumer adoption of digital approaches and this wasn't always the case. Telemedicine, virtual care and home-based diagnostics will improve patient care. Both consumers and healthcare providers have embraced models that are not restricted to a particular in-patient facility. In doing so, healthcare leaders and patient groups have recognised virtual care's positive impact on the management of chronic conditions and in the provision of broader access to care.

Big data and AI can make possible advances in public health and epidemiology as well in specific individual medical practices like radiology. Clinicians need to make decisions on treatment that are evidence based but sometimes, such as in the pandemic, that evidence does not yet exist in the reassuring form of peer-reviewed literature. Covid-19 has reinvented processes to speed information to clinicians and help guide them through care decisions and has helped close the, sometimes wide, gap between what's happening in care settings and what's published in high-ranking, academic journals. AI's potential in healthcare is immense. It is already proven in hospital settings to be accurate in predicting hospital acquired infections such as sepsis but by powering clinical surveillance with AI, healthcare professionals can proactively identify a growing range of medical conditions, both chronic and acute, with greater precision than ever before.

Overall, while a terrible crisis led us to this point, it seems that the pandemic does present the healthcare sector with a powerful and historic opportunity to develop and embrace innovation at a quicker pace than ever before. It offers us the chance to transform elements of the system that were broken and not working for enough people and to embrace these forces for change and harness them for public good.

Ends

Bibliography

Almeida, F; Duarte Santos, J; and Augusto Monteiro, J. *"The Challenges and Opportunities in the Digitalization of Companies in a Post-COVID-19 World,"* in *IEEE Engineering Management Review*, vol. 48, no. 3, pp. 97-103, 1 thirdquarter,Sept. 2020, doi: 10.1109/EMR.2020.3013206.

Babina, T., Bernstein, A. and Mezzanotti, F., 2020. Crisis innovation (No. w27851). National Bureau of Economic Research.

Bain and Company, 2021. Will Covid-19 Hurt or Help Healthcare Companies? It depends. Healthcare Insights. [online] Bain & Co. Available at: <https://www.bain.com/insights/will-covid-19-help-or-hurt-healthcare-companies-snap-chart/> [Accessed 20 June 2022].

Basile, L.J; Carbonara, N, Pellegrino, R and Panniello, U - Business intelligence in the healthcare industry: the utilization of a data-driven approach to support clinical decision making Technovation (2022), Article 102482, 10.1016/j.technovation.2022.102482

Branch-Elliman, Westyn; A Rani Elwy, Paul Monach, Bringing New Meaning to the Term “Adaptive Trial”: Challenges of Conducting Clinical Research During the Coronavirus Disease 2019 Pandemic and Implications for Implementation Science, Open Forum Infectious Diseases, Volume 7, Issue 11, November 2020, ofaa490, https://doi.org/10.1093/ofid/ofaa490

Breton, M. et al. (2022) ‘COVID-19 - an opportunity to improve access to primary care through organizational innovations? A qualitative multiple case study in Quebec and Nova Scotia (Canada)’, BMC Health Services Research, 22(1), pp. 1–18. doi: 10.1186/s12913-022-08140-w.

Brockman, J., 2015. This Idea Must Die: Scientific Theories That Are Blocking Progress (Edge Question Series).

Brown, T. 2008, "Design Thinking", *Harvard business review,* vol. 86, no. 6, pp. 84-92.

Cain Brothers, 2022. *Looking back, a golden age of healthcare innovation*. House Calls Podcast: March 8th, 2022 (https://podcasts.apple.com/us/podcast/house-calls/id1483699530)

Cankurtaran, P. & Beverland, M.B. 2020, "Using design thinking to respond to crises: B2B lessons from the 2020 COVID-19 pandemic", *Industrial Marketing Management,* vol. 88, pp. 255-260.

Cerchione, R., Centobelli, P., Riccio, E., Abbate, S. and Oropallo, E., 2022. Blockchain's coming to hospital to digitalize healthcare services: Designing a distributed electronic health record ecosystem. *Technovation*, p.102480.

Chesbrough, H., 2006. *Open business models: How to thrive in the new innovation landscape*. Harvard Business Press.

Chesbrough, H. 2020, "To recover faster from Covid-19, open up: Managerial implications from an open innovation perspective", *Industrial Marketing Management*, vol. 88, pp. 410-413

Cohen, D., Furstenthal, L. and Jansen, L., 2020. Healthcare innovation: Building on gains made through the crisis. *McKinsey & Company. URL: https://tinyurl. com/2p8d3scv [accessed 2021-07-08]*.

Cooper, R.G., 2021. Accelerating innovation: Some lessons from the pandemic. *Journal of Product Innovation Management*, *38*(2), pp.221-232.

D'Amico, F., Peyrin-Biroulet, L. and Danese, S., 2020. *Inflammatory bowel diseases and COVID-19: the invisible enemy. Gastroenterology*, *158*(8), pp.2302-2304.

Economist Intelligence Unit (2021) Future of Healthcare Delivery and Demand *EU Economist Intelligence Viewpoint*

Enkel, E., Bogers, M. & Chesbrough, H. 2020, "Exploring open innovation in the digital age: A maturity model and future research directions", *R&D Management,* vol. 50, no. 1, pp. 161-168.

Fischer, C. and Newell, R.G., 2008. Environmental and technology policies for climate mitigation. *Journal of environmental economics and management*, *55*(2), pp.142-162.

Gaskell, A., 2022. *How The Coronavirus Is Transforming Innovation.* Forbes, [online] (Online Edition). Available at:

<https://www.forbes.com/sites/adigaskell/2020/06/04/how-the-coronavirus-is-transforming-innovation/?sh=380ab48bc73e> [Accessed 15 June 2022].

George, Gerard, Karim R. Lakhani, and Phanish Puranam. "*What Has Changed? The Impact of COVID Pandemic on the Technology and Innovation Management Research Agenda.*" Journal of Management Studies 57, no. 8 (December 2020).

Gordon, R.J., 2016. The rise and fall of American growth. In *The Rise and Fall of American Growth*. Princeton University Press.

Green LW, Ottoson JM, García C, Hiatt RA. Diffusion theory and knowledge dissemination, utilization, and integration in public health. *Annu Rev Public Health* 2009; 30:151–74.

Harvard Business Review. 2022. *The Innovation System Behind Moderna's Covid-19 Vaccine*. [online] Available at: <https://hbr.org/podcast/2021/09/the-innovation-system-behind-modernas-covid-19-vaccine> [Accessed 15 June 2022].

Jackson, L.A., Anderson, E.J., Rouphael, N.G., Roberts, P.C., Makhene, M., Coler, R.N., McCullough, M.P., Chappell, J.D., Denison, M.R., Stevens, L.J. and Pruijssers, A.J., 2020. An mRNA vaccine against SARS-CoV-2—preliminary report. *New England journal of medicine*.

Lakhani, K., Lifshitz-Assaf, H. & Tushman, M. 2013, " Open innovation and organizational boundaries: Task decomposition, knowledge distribution and the locus of innovation" in *Handbook of Economic Organization: Integrating Economic and Organization Theory* Edward Elgar Publishing, , pp. 355-382.

Lavie, D. & Rosenkopf, L. 2006, "Balancing Exploration and Exploitation in Alliance Formation", Academy of Management Journal, vol. 49, no. 4, pp. 797-818.

Leifer, R., C. M. McDermott, G. O'Connor, L. Peters, M. P. Rice, and R. Veryzer. 2000. *Radical innovation: how mature companies can outsmart upstarts.* 1st ed. Boston, MA: Harvard Business School Press.

Leonard-Barton, D. 1992, "Core Capabilities and Core Rigidities: a Paradox in Managing New Product Development", *Strategic Management Journal* (John Wiley & Sons, Inc.), vol. 13, pp. 111-125.

Madhavan, N., White, G.R. and Jones, P., 2021. *Identifying the value of a clinical information system during the COVID-19 pandemic. Technovation*, p.102446.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science* 2(1): 71-87.

Maruggi, G., Zhang, C., Li, J., Ulmer, J.B. and Yu, D., 2019. mRNA as a transformative technology for vaccine development to control infectious diseases. *Molecular Therapy*, *27*(4), pp.757-772.

Mazzola, E., Acur, N., Piazza, M. & Perrone, G. 2018, ""To Own or Not to Own?" A Study on the Determinants and Consequences of Alternative Intellectual Property Rights Arrangements in Crowdsourcing for Innovation Contests", *Journal of Product Innovation Management*, vol. 35, no. 6, pp. 908-929.

Miller, C., Groth, O. & Mahon, J.F. 2018, "Management innovation in a VUCA world: Challenges and recommendations", *California Management Review,* vol. 6, no. 1, pp. 5-14.

Nalbandian, A., Sehgal, K., Gupta, A., Madhavan, M.V., McGroder, C., Stevens, J.S., Cook, J.R., Nordvig, A.S., Shalev, D., Sehrawat, T.S. and Ahluwalia, N., 2021. Post-acute COVID-19 syndrome. *Nature medicine*, *27*(4), pp.601-615.

Rittel, H.W.J., & Webber, M. (1973). Dilemmas in a general theory of planning Rittel. *Policy Sciences* 4(2), 155–169.

Robbins, P., O'Gorman, C., Huff, A. and Moeslein, K., 2021. Multidexterity—A New Metaphor for Open Innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(1), p.99.

Schoemaker, P.J.H., Heaton, S. & Teece, D. 2018, "Innovation, Dynamic Capabilities, and Leadership", *California Management Review,* vol. 61, no. 1, pp. 15-42.

Shao, W., Yang, K. and Bai, X., 2021. Impact of financial subsidies on the R&D intensity of new energy vehicles: A case study of 88 listed enterprises in China. *Energy Strategy Reviews*, *33*, p.100580.

Spanò, R., Massaro, M. and Iacuzzi, S., 2021. Blockchain for value creation in the healthcare sector. *Technovation*, p.102440.

Srinivasan R. *Will haste make waste: A counter-point to the benefits of accelerating innovations*. *J Prod Innov Manag*. 2021;38:242–244

Teece, D. & Leih, S. 2016, "Uncertainty, Innovation, and Dynamic Capabilities: An Introduction", *California Management Review,* vol. 58, no. 4, pp. 5-12.

Tercatin, R., 2020. Israel's Tyto Care to prevent coronavirus exposure from patients at Sheba. *Jerusalem Post*, [online] p.10. Available at: <http://jb.post.com> [Accessed 20 June 2022].

Todorova, G. and B. Durisin, Absorptive Capacity : Valuing a Reconceptualization. Academy of Management. The Academy of Management Review, 2007. 32(3): p. 774

Venkataraman, S., Sarasvathy, S.D., Dew, N. & Forster, W.R. 2012, "Reflections on the 2010 Amr Decade Award: Whither the Promise? Moving Forward with Entrepreneurship as a Science of the Artificial", *Academy of Management Review,* vol. 37, no. 1, pp. 21-33.

Xu, S., Stienmetz, J. and Ashton, M. (2020), "How will service robots redefine leadership in hotel management? A Delphi approach", International Journal of Contemporary Hospitality Management, Vol. 32 No. 6, pp. 2217-2237. https://doi.org/10.1108/IJCHM-05-2019-0505

Zhang, X., Wang, L. and Chen, F., 2021. R&D subsidies, executive background and innovation of Chinese listed companies. *Economic research-Ekonomska istraživanja*, *34*(1), pp.484-497.