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Coronavirus instigated a global pandemic. Unprecedented public health measures mitigated its deadly trajectory, but how did collaboration within the research community lend support?

CRACKING THE COVID-19 CODE: CUTTING-EDGE COLLABORATION

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PREAMBLE

This paper was completed Easter Weekend, 2020 in Lockdown level 4. Looking back at that surreal 'moment in time', lockdown islands, burst bubbles and feelings of isolation have followed. Shifts in mindset are needed, and collaboration has been a means of survival, sustenance, support and sustainability. It is astounding how diverse the Covid-19 response has been in different countries and how the 'facts' have been interpreted. Research, data and facts should be a basis for making informed decisions; a vibrant research community is key. As we open and close our island nation with travel bubbles, it is worth thinking about healthy collaboration, but also reflecting on our well-being and the connectedness that makes us human. The answer is Connection.

> No man is an island entire of itself; every man
> is a piece of the continent, a part of the main.
>
> *MEDITATION XVII, Devotions upon Emergent Occasions.* John Donne

INTRODUCTION

The pandemic created by Coronavirus (SARS-CoV-2) sent shockwaves worldwide, first for humanity and then for the economy. By mid-April, 2020, it was possible to pause and reflect on new realities, and imagine what might lay ahead. Cutting-edge data techniques were employed to identify, track and control COVID-19 and collaborative methods in research helped accelerate positive outcomes in many environments. This paper considers typical contributions from published research collaborations in pandemic problem-solving contexts. It hints at some of the problems of data analysis and the diversity of decisions and perspectives that followed.

The emergence of the COVID-19 pandemic caused by a novel Coronavirus (SARS-CoV-2) created research collaborations that may have gone largely unnoticed, but that are remarkable. The war on this 'invisible enemy' brought out the good, and not so good, in people worldwide. This paper takes a look at some of the many published research collaborations that took place up until mid-April, 2020. Most of these research contributions used real clinical data, of many types, to save lives and to make valuable and material contributions that spanned many fields of endeavour.

A COLLABORATIVE CALL TO ARMS

On December 31, 2019, the Chinese government confirmed dozens of cases of a new virus they were monitoring. By 21 January, confirmed cases were reported in Japan, Thailand, South Korea and the United States (Taylor, 2020). The World Health Organisation declared a global health emergency on 30 January, 2020. By that time, the incidence of the virus was continuing to rise and it soon became evident that a global outbreak was imminent (Sohrabi et al, 2020).

For active researchers, the impetus to explore a global pandemic in greater detail is compelling. It is relatively easy to go beyond headlines to hunt for data and facts. Because of the Sars-CoV outbreak in 2002, some peer reviewed papers were revised and immediately published to update the third Coronavirus outbreak to cross species into the human population within two decades (Daga et al., 2019). Even more research and numerous works-in-progress were published and made freely available, often without peer review, in the first few months of this year. Despite impediments in the accessing of accurate data, a flurry of publication was released to assist researchers world-wide, in a supportive response to the growing COVID-19 pandemic.

TRACKING A KILLER

Data issues immediately manifested. Misdiagnosis, data gaps or sparsity and even infodemics hampered analysis. Downplaying the severity of the virus also helped the virus spread from 1 December, 2019, when the first case was reported in the news. Chinese New Year preparations were curtailed to prevent further spread, as worries about asymptomatic COVID-19 carriers intensified (Guan et al., 2020). Strict regulation on population movements ensued.

The use of big data and digital technologies, began to hasten the fight against the virus (Hua & Shaw, 2020). But machine learning is hindered in both parametric and pattern identification due to mitigating factors found in almost every epidemic, such as super-spreader phenomena and tracking complexities (Ndiaye, et al., 2020). This led to the use of intrusive digital tracking technology to gather data then severely restrict movement in the early weeks of 2020 in an attempt to track and corral those infected. Social media sites could be monitored even more closely than normal. Digital footprints were used to monitor and control individuals. Eventually data from Google granular location data maps, routinely used for ad-targeting and commercial strategies, were released and utilised as the pandemic progressed (Koksal, 2020). These efforts help track the virus with greater accuracy, but also expose the access that technology giants have to our digital data and to further raise ongoing privacy concerns.

These days, the spread of epidemics and infection paths are commonly forecasted using bio-inspired metaheuristic simulations. Such swarm intelligence approaches are self-organising and spontaneous. They can also be modified to include the element of mutation in models. These methods can gauge interactions with specificity using a population-based approach to maximise performance while discarding irrelevant data with iterative updates (Cherrington et al., 2019c). In such a way, it is possible to simulate the spread of Coronavirus from patient zero and also model probability of re-infection. Assumptions are both essential and significant in such analyses, but they can modify quickly to new inputs and conditions. They are most accurate as input parameters, including disease statistics, evolve and resolve; this negates the need for subjective initial inputs. After a few iterations, such Coronavirus models can be used effectively in more complex deep learning models with reasonable accuracy. (Martínez-Álvarez, et al., 2020).

Of course, the pandemic expressed itself differently in numerous countries. Many researchers relied on the initial scholarship and information from China, to improve on Coronavirus intelligence. With Italy and Spain in the midst of unbelievable tragedy, researchers in those countries also scrambled to use swarm intelligence models to fine-tune parameters, given the idiosyncrasies of externalities and demographics in their regions. Fortunately, the language of mathematics is universal and often systems are transferable (Simón, 2020). This is just one of the reasons that in the research community, international collaboration is necessary, encouraged and rewarded.

IDENTIFYING THE CLUES

Other collaborative methods were impactful. Machine learning techniques were integrated into online platforms, freely available to clinical facilities. Supporting research was made directly available in pre-print format. Research portals were deployed and used in over 50 hospitals in Wuhan. As specialist skills were in high-demand, the accuracy of imaging classification techniques using improved visualisation methods became vital tools for COVID-19 screening and evaluation processes (Shi et al., 2020).

The sheer size and speed of the Coronavirus disease overseas prompted the development of deep learning models that were fully automated and that could support beleaguered hospitals. Multi-centred case studies were undertaken using diagnostic tomography and radiography images to automate classification of patient results. Visual scanning techniques have improved vastly in recent years; with high accuracy levels, such techniques are more precise than exhausted healthcare professionals could achieve realistically. It is worth noting too, that when full personal protective equipment is available and utilised, it is restrictive, cumbersome and fatiguing; teams of nurses must work together to ensure critical care patients in ICU receive intensive treatment. When automated techniques are used, they free highly trained medical staff for more specialised care (Xu, et al., 2020). Robotics were used in less intensive settings, for tasks such as disinfecting surfaces and to support medical staff (Peng, J., et al., 2020).

Patient data is especially valuable when assessing behaviour of the virus, treatment efficacy and probable progress of those infected. To support these assessments, patient data was coded and was often made accessible for researchers worldwide. For example, clinical features of patients were analysed and the results were published in the Lancet in January, along with de-identified data, which were made freely available (Huang, et al., 2020).

NEXT MOVE, FAST MOVE

Whether predicting the behaviour of the virus or encouraging informed behaviour in the population, machine learning automation methods are popular. Focusing attention on the vital few features of importance is a selection issue in data analysis that eliminates irrelevant and redundant attributes to simplify learning and improve accuracy (Cherrington et al., 2019f). By the time patients were being screened using electronic records in Tongji Hospital from January 10th to February 18th, 2020, XGBoost machine learning algorithms were forecasting risk of death from only three features using a flowchart of patient enrolment. The accuracy of the model helped hospital doctors with early identification and intervention, to reduce the probability of mortality (Yan et al., 2020). They also helped detect the early progression of symptoms to more ominous warning signs such as pneumonia which required more intensive care and specialised resources (Gong et al., 2020). These methods were able to similarly close the gaps between process times from testing, to confirmation and treatment, which improved recovery prospects.

Classification of the genome sequences can be used to design new primers for detection of the virus using deep learning and viromics. High throughput techniques were used to understand the mechanisms of the virus at a molecular level, and notably, they were soon used to hasten testing regimes and confirmation of those infected with the virus. As the virus took hold, these techniques were quickly deployed to support the fight against the Coronavirus. The collaboration used to ensure automated techniques were trained deftly, is truly inspiring; for example, forty authors contributed to 'Artificial intelligence application in COVID-19 diagnosis and prediction' in the Lancet, to employ AI classification using clinical characteristics and laboratory results to rank attributes for diagnosis and triage so as to reduce clinical workloads (Peng, et al., 2020).

It soon became clear to the world, that many countries were overwhelmed by Coronavirus. Heuristic modelling methods that worked well in Hangzhou did not work well in Wuhan. A novel solution to schedule drivers for quarantine vehicles was created with sufficient accuracy for Hangzhou, but was developed using the assumption

that such vehicles and their drivers, were freely available. This was not so in areas deluged by the virus. During the peak period of COVID-19, volunteer drivers were sought and worked tirelessly in Wuhan to transport medical staff through road blocks to hospitals, with high-risk individuals. This put efforts to contain the virus in jeopardy, the exact opposite of the purpose behind the development of the vehicle scheduling model (Zhang et al., 2020).

SIGNIFICANT FEATURES

In Wuhan city and Guangzhou, patients were stratified by risk and severity, using demographic, clinical, and laboratory data. Like SARS-CoV, it became apparent that the elderly and those with underlying health conditions were most at risk. This confirmation was beneficial, but could also lead to nonchalance in young, healthy populations. These techniques developed a better understanding of the basis of the novel virus. It highlighted anomalies in the behaviour of the virus, and verified contributing factors such as hypertension, diabetes, coronary heart disease, chronic respiratory disease, tuberculosis disease. The models could predict with high diagnostic accuracy those patients most likely to progress to severe COVID-19, which yielded superior clinical net benefits (Gong et al., 2020).

Understanding aspects of the huge amounts of data that are generated around COVID-19 can be accomplished with neural networks and deep learning models. They provide scalability for high dimensional data, so that good representations of significant features can be drawn out of high dimensional data and raw inputs. These automatic learning techniques are abstractions that can support inquiry by learning complex functions mapping of systems (Cherrington et al, 2019d). Subsequently, black box systems can divulge hidden insights, detecting unusual occurrences or be used for prediction.

TECHNOLOGY TECHNIQUES

With travel restrictions, friends and families depend on mobile apps and zoom, especially in lockdown or quarantine conditions. As schools close, learning continues online. Society relies on technology to enable our connectedness, social cohesion. It also helps authorities focus on how people are linked (Cherrington et al, 2019a). Using high dimensional data, digital trends and challenges are captured and revealed. Valuable and untapped resources can be discovered. Opportunities and collaborations can be leveraged and be used to deliver new evidence-based information that might otherwise go unnoticed or be unseen, to solve unique or complex problems (Cherrington et al, 2019e). Data technologies are invaluable in pandemics; they are more reliable than memory when back solving social contacts of fatigued hospitalised Coronavirus patients.

Mobile phones can be employed as one of the most commonly available, accessible and cheap tools for patient monitoring, health surveying, epidemiological surveillance and public health awareness (Madanian et al. 2019). For countries expecting travellers to self-isolate or quarantine, amplifying the probability of adhering to protocols is crucial. Identifying factors associated with adherence is important and mobile phones can be used as tools to encourage positive behaviours (Webster et al., 2020). Mobile phones can be tools that support whole communities to fight a pandemic and also be employed for emergency response services and alerts. This form of cooperative, collaborative approach is beneficial.

Moving ahead of Coronavirus disease is essential. Using Google search data in the private subscription Google Health Trends API, daily query frequencies were used to monitor the prevalence of the disease with good results. This method was sought, because data accuracy was an issue with the emerging COVID-19 pandemic; training using unsupervised, or semi-supervised machine learning and data smoothing techniques were used and regular updates were made available (Lampos, et al., 2020). Social media and communications applications can classify or cluster information that is rapidly changing, made especially difficult with mixed media content and semantic nuance (Cherrington et al, 2019b). Critical investigation of social media sites such as Weibo were used to disseminate

information using natural language analysis to classify situational information (Li et al., 2020). Tweets were analysed to support the implementation of disease control measures, to gauge attitudes towards preventative measures and guide ongoing public communications (Alhajji, et al., 2020).

COMPETITIVE RIVALRY

Of course, not all COVID-19 related progress will arise out of collaboration. Finding a vaccine will prove a lucrative proposition for those with a first mover advantage. Antiviral treatments are already being used in hospitals, even without rigorous testing regimes. Partnerships with big pharma and tech giants are leveraging quick solutions to market. (Turner, 2020). This is another economic reality of the pandemic; access to treatment is not universal. This has flow on effects: with the Coronavirus re-focus, research and clinical trials for other diseases are on hold.

Competition can be just as productive as collaboration; they are both necessary to drive innovation forward.

FUTURE IMPLICATIONS – HE WAKA EKE NOA

'He waka eke noa' is a whakataukī (Māori proverb) that reminds us we are all in this together, that we rise or fall as one. Decisions made in the effort to save lives, are now tipping in favour of decisions concerning economic recovery. Economic decisions based on data and facts will always be better than mere guesses, especially in times of unparalleled turbulence and upheaval. The techniques used to crack the COVID-19 code can be used to navigate shifts in economic data as well. Data sharing, privacy and ethical concerns are issues that we will continue to grapple with as machine learning and AI become more pervasive.

There has been an outpouring of collaborative research to improve our understanding of the structure and expression of this novel Coronavirus. Data analysis and machine learning have been used to find the features most likely to predict diagnosis and prognosis as well as to underpin artificial intelligence and deep learning models that automate and hasten decisions and delivery of countless needed supplies and resources. Novel methods of tracking COVID-19 supported tough life-and-death decisions. From patient data to mining social media, quantitative and qualitative research in many fields is a basis for turning data into information and into knowledge for better decision-making (Cherrington et al, 2020). The sharing of information and collaboration through networks of individuals, agencies, organisations and leaders proved critical to outcomes in this pandemic and will continue to be critical in our recovery phase.

A collaborative research community will continue to play a vital role in providing data that is informative, predictive and that can be used to leverage and improve outcomes. But there is still a huge amount of private wealth and talent that lies waiting to be tapped into, to improve economic and social realities, post-COVID-19. (O'Sullivan, 2020, p. 2.). The tourism industry is currently decimated as well as those small businesses that depend on it; there is no timeframe for when the lucrative international tourism markets will reopen. Some service businesses will never reopen their doors. There will be new challenges and opportunities that result in new ways of working.

New Zealand, as an example, managed the 'human cost' of the pandemic well, but cannot go to level one lockdown status by the end of April in order to ramp up the economy; unlike other countries, New Zealanders have virtually zero immunity to COVID-19. Former Prime Minister, Bill English said "New Zealand now has zero net migration, zero tourists, zero foreign students and zero inflow of temporary workers. These flows, which have been drivers of the labour market and the housing market, won't just turn on again" (Rutherford, 2020, p. C1). Tourism, and the myriad of small businesses which depend on tourists, will be difficult to resurrect immediately. But the lucrative international student market could be attracted to New Zealand as a safe haven from the virus, even if quarantine restrictions are not immediately lifted, with the longer-term goal of attaining residency. With the newly instigated New Zealand Institute of Skills and Technology, the government has a vested interest in the polytechnic sector. Fast-tracking international student applications is easy to action.

Everyone is speculating about the likely environment as restrictions lift and the true extent of the economic fallout is evaluated. With an election looming in New Zealand, people will forget about ICU wards and need jobs to pay their mortgage and put food on the table. Voters will "not care about financial markets – it is the real economy that matters" (Rutherford, 2020, p. C1).

Businesses will have to act more sustainably and deliver greater value to be financially self-sustaining in the future. We have been reminded that all resources are precious; they must be employed wisely. What we do at a local and national level truly does have global consequences. Life will inexorably alter. We have seen the magnitude of human inter-connectedness in all its glory and in all of its frailty.

CONCLUSIONS

There is still so much to be done collectively; it is the perfect time to reflect on our values, beliefs and actions. There is still room to leverage outcomes through collaboration in our communities, our nations and worldwide, using our networks and our abilities to grow our spheres of influence. Thankfully, work in the research community is based on sharing, collaboration and contribution; the way forward must continue to be based on wise, informed decisions. Pragmatic decisions should always be based on improving outcomes for society, including economic recovery.

Today is Easter 2020, as apt a day as any to reflect on a pandemic, as well as our lives and contributions on this planet. Collaboration is the act of working together to produce; research is wasted without the intention of improving the health and wellbeing of our world in some way. Research is not just meant for publication; research is meant to build knowledge, to foster understanding and to make a tangible difference in the lives of others. We need more pragmatic, collaborative research. COVID-19 has been a clarion call.

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