REIMAGINING HEALTH

The Role of Digital Technology in Combating Chronic Disease

Commentary | Posted on: 19th February 2021

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Introduction

Chronic diseases such as diabetes and heart failure are significant burdens on health-care systems around the world and afflict a significant and growing fraction of the global population (potentially [60 per cent of the US adult population](#) and [nearly 40 per cent of the UK adult population](#)). In fact, the cost of managing these chronic diseases already drives a significant majority of health-care expenditure in many countries ([86 per cent in the US](#) and [around 70 per cent in the UK](#)).

The Covid-19 era has shone a spotlight on these conditions with the revelation that over 90 per cent of Covid-19 mortalities are linked to patients with one or more underlying conditions (in [the UK](#) and [the US](#)), many of which are chronic. In mid-2020, the US Centers for Disease Control (CDC) even estimated that [people with underlying health conditions were six times more likely to require hospitalisation and 12 times more likely to die from Covid-19](#).

Lockdown measures, their resulting economic impact, and general unease from the pandemic have compounded the problems of chronic disease management as [many patients have had their routine care disrupted](#). An analysis published in [the Journal of General Internal Medicine](#) suggested that, by April 2020, screening tests for hypercholesterolemia and diabetes fell by 80-90 per cent, and new prescriptions for the first-line medications to treat those conditions fell by 50-60 per cent from the previous month at two major US health-care institutions.

The current crisis underscores the societal urgency to tackle the growing public-health problem represented by chronic diseases. The failure of efforts to contain them has been a result of a complex morass of medical, behavioural, and socioeconomic factors that have proven difficult for traditional health-care delivery models to address. A solution here will require a bold rethinking of traditional models of health-care delivery that should incorporate new digital health-care solutions.

What Are Chronic Diseases?

While definitions and taxonomies vary, most agree that chronic disease centres on the need for long-term, ongoing medical attention to avoid a significant deterioration in quality of life. As a result, many of these conditions are practically incurable and become physically and mentally taxing to patients, caregivers, and health-care providers who must work to manage them over a lifetime. The table below captures some of the most common chronic diseases that afflict populations. It should be noted that while the table provides relatively simple definitions for many diseases, each disease represents a heterogeneous mix of different disorders with different prognoses and different clinical pathways to manage.

Disease	Description	Prevalence	Health System Impact
Coronary Artery Disease	Plaque build-up in arteries that supply blood to the heart	US: 18 million UK: 2.3 million World: 126 million	World's number-one cause of death according to the WHO; leads to higher risk of heart failure and heart attack
Congestive Heart Failure	The heart's inability to sufficiently pump blood to meet the needs of end-organs	US: 6 million UK: ~920,000 World: 26 million	Among leading causes of hospitalisation
Hypertension	Persistent elevated arterial blood pressure	US: 108 million UK: 15 million	Leads to higher risk of stroke, heart attack, heart failure, kidney disease, vision loss, cognitive decline, and other chronic conditions

		World: 1.4 billion	
Atrial Fibrillation	Abnormal electrical rhythm of the upper chambers (atria) of the heart characterised by an irregular, often rapid heartbeat.	US: 5 million UK: 1.6 million World: 37 million	Leads to higher risk of heart failure and stroke (4-5x increase in stroke risk)
Asthma	Long-term inflammatory disease of the airways characterised by hypersensitivity and bronchoconstriction	US: 24 million UK: 5.4 million World: 339 million	Increased risk of respiratory infections (i.e., pneumonia) and can lead to permanent lung damage
Chronic Obstructive Pulmonary Disease (COPD)	Progressive obstructive lung disease usually caused by smoking and air quality issues	US: 16 million UK: 3 million World: 65 million	The third most common cause of death in the world according to the WHO; among leading causes of hospitalisation; increased risk of respiratory infections (i.e., pneumonia), atrial fibrillation, and heart failure
Diabetes	An inability of the body to produce or respond to insulin, which leads to elevated blood sugar levels that can lead to systemic damage	US: 34 million UK: 4.7 million World: 476 million	The ninth leading cause of death in the world, according to the WHO; associated with 2.3x per capita health-care expenditures in the US; leads to higher risk of stroke, cardiovascular disease, kidney disease, neuropathy and other chronic conditions
Chronic Kidney	Persistent kidney damage that results in	US: 37	End-stage patients require lifelong dialysis and/or kidney

Disease	buildup of excess fluid and waste	million UK: 5.6 million World: 700 million	transplantation; leads to higher risk of sudden acute renal failure
Osteoarthritis	Degenerative joint disease which results in persistent joint pain and stiffness	US: 32 million UK: 8.5 million World: 303 million	Among leading causes of hospitalisation due to need for joint surgeries; impact on movement worsens lifestyle factors contributing to other chronic illnesses

The Difficulty of Tackling Chronic Disease

Despite broad recognition of the impact of chronic diseases on health-care spending and outcomes, conventional health-care models have largely been unsuccessful at stemming their rise. A number of factors contribute to the magnitude of the challenge:

- Multimorbidity – how many chronic diseases tend to occur alongside and worsen prognoses for other chronic diseases – increases the complexity of managing chronic-disease patients. Studies suggest that anywhere from 50-70 per cent of chronic-disease patients have more than one chronic condition. This is due both to the underlying disease biology, where the effects of one chronic illness can lead to another (i.e., hypertension and diabetes leading to kidney damage), as well as the fact that shared risk factors underlie many of them (e.g., obesity, genetics, poor diet and exercise, etc.). This results in patients who become more expensive and difficult to manage over time as not only do their

illnesses progress, but they are also likely to develop additional chronic illnesses to manage.

- Behavioural factors have a large impact on the progression and management of many chronic illnesses. [Unhealthy diets, lack of physical activity, substance abuse](#), and [poor medication adherence](#) are all risk factors for many chronic conditions. Sustained change to these factors is needed to halt or reverse the course of a disease, but given their roots in patient psychology and socioeconomic status, these social determinants of health oftentimes prove impervious to best efforts to change them.

- Studies have also shown that [lower socioeconomic status](#), language barriers and [being from a racial or ethnic minority](#) are associated with higher risks of developing chronic disease. Given inequalities in access to and quality of care, it is not surprising that these health gaps translate into worse outcomes on disease progression. This makes the challenge of dealing with chronic disease more than a purely medical question, but also one relating to socioeconomic and racial equity.

These factors challenge traditional models of health care which are [oriented towards acute interventions within relatively siloed specialties](#). Effective chronic-disease management, on the other hand, requires long-term patient management attuned to the challenge of [durable behaviour change](#) and the potential need for [clinical social work](#) to address socioeconomic barriers to care. Given multimorbidity, it also requires thoughtful coordination between multiple specialties on multiple interrelated diseases. Additionally, to successfully stem the tide, health systems will also need to deliver preventative interventions for the broader swathe of the population who are at high risk of developing these illnesses as well.

The socioeconomic and behavioural factors involved also require an expanded set of interventions beyond the confines of traditional health care. Significant public-health efforts need to be made around nutrition, physical activity and drug abuse to curb the key behavioural risk factors that lead to greater chronic disease. Existing education efforts about health risks need to be redoubled and complemented with more aggressive efforts such as "sin taxes" and regulations to encourage healthier behaviours. Policymakers should also address systemic factors related to socioeconomic and racial inequity and their contribution

to unhealthy behaviours such as policies which [reduce food deserts](areas with limited access to affordable and nutritious foods) and [reduce financial barriers to drug adherence](link).

Traditional Chronic-Disease Efforts Are Difficult to Scale

Chronic-disease-management programmes, incentives for preventative care, and long-term patient-centered care models have all emerged as means to tackle the challenges mentioned above. While rigorous studies of these programmes can be difficult to conduct due to widely varying definitions, heterogeneity in providers and patients, and the expense and length of follow up needed, [studies that have been published generally](link) [(but not always)](link) [show significant improvements in health outcomes](link).

Unfortunately, [the results have been mixed](link) as to whether or not these programmes deliver significant net savings (after accounting for the cost of the programme) to the health-care payer. While findings vary, the mixed results have been primarily attributed to the substantial challenges of delivering [interventions which can arrest or reverse disease progression](link) and the challenges of deploying [preventative measures across a broader, healthier population](link). These mixed results cast doubt on the ability to sustainably apply these programmes over a broader swathe of the population to manage the rising tide of chronic illness. As a result, it is vital to understand the core challenges and how to address them. Among the most important factors contributing to financial sustainability are:

- Limited and costly provider time: Most health systems rely on relatively highly-paid, highly-trained labour in the form of nurses and physicians. While provider involvement is necessary to ensure quality of care, directing their limited bandwidth to additional tasks related to patient monitoring, follow up, and care organisation presents both significant financial costs as well as opportunity costs (in the form of patients not treated or seen) for a health-care system, especially given the growing administrative burdens faced by providers everywhere.

- Lack of visibility into care gaps: Lack of information on which chronic disease patients are most in need of which interventions makes it difficult for health systems to prioritise

interventions. This can result in simultaneously overinvesting in care with marginal benefit while also underinvesting on interventions in patients where they are most needed.

- Complexity of care coordination: Given multimorbidity and the potential need to involve clinical social work as well as regular patient follow up to achieve sustained behaviour change, care coordination is of paramount importance in treating chronic disease patients. However, many clinical workflows and tools were tailored for acute care and not necessarily optimised for long-term multi-team member collaboration and follow-up.

- Insufficient personalisation: Effective management of chronic disease patients over years requires interventions to be tailored to personal context. This should involve granularly tracking key biomarkers, self-reported measures of pain and mood, and patient adherence to medication and lifestyle changes so that care teams can intervene when needs and circumstances change.

- Inconvenient patient experience: The "health-care user experience" for chronic-disease patients extends beyond simple provider "bedside manner" to longer-term interactions with all aspects of health-care and disease management. As a result, patient friction (even minor things like the time to get to and wait in line for a pharmacy, or the need to make a phone call to get something done) has a disproportionate impact on chronic-disease patients.

Leveraging Technology to Scale Effective Chronic-Disease Management and Prevention

New digital technologies present potential solutions to many of these issues. The same technologies that have successfully catalysed transformations in product offerings and operational efficiency in other industries can be applied to managing and preventing chronic illness. While a wide variety of digital innovations are relevant, a few key categories of innovation (summarised in the table below) are critical for scalably tackling chronic illness.

Category	Description	Issues Addressed	Examples

Predicting and identifying patient care gaps	Predictive analytics to identify patients who are at high risk of developing a chronic disease or not being provided with guideline-directed care	• Lack of visibility into care gaps • Limited and costly provider time	HealthPals, Prealize
Care coordination and communication	Tools to coordinate care of complex patients between providers as well as third parties, patients and caregivers	• Complexity of care coordination • Limited and costly provider time	Careteam, Cricket Health, Unite Us
Digital therapeutics	Evidence-based behavioural interventions and protocols delivered mainly through software	• Inconvenient patient experience • Insufficient personalisation	Kaia Health, Omada Health, Pear Therapeutics
Consumer-friendly monitoring	Connected, oftentimes consumer-grade hardware and supporting technology to allow for more frequent and convenient data	• Insufficient personalisation	Carrot, Healthy.io, Propeller Health, smart watch heart-rate monitoring and ECG

	collection on patient vitals and behaviour	• Inconvenient patient experience	
		• Limited and costly provider time	
Telemedicine	Remote patient care delivered over the internet using video, audio and chat-based communication	• Inconvenient patient experience	DoctorOnDemand, Moving Analytics, Teladoc, Zero
		• Limited and costly provider time	

While still in its early stages of adoption, applying digital technology to chronic disease management has a proven track record. Kaiser Permanente, a well-regarded American health system, piloted an initiative it has termed "leveraged primary care" for complex chronic-disease patients. The model pairs traditional health-care providers with a combination of lower cost, non-provider medical assistants who take on more of the day-to-day tasks around patient management; wearable devices for patient monitoring; predictive analytics to prioritise patients for follow up; automated patient reminders for preventive care; pharmacist involvement for medication management; and video telemedicine. Executives at Kaiser saw not only improved outcomes (40 per cent fewer hospitalisations, significantly better control of hypertension than the US national average, and a 40 per cent-plus lower chance of dying from heart disease than the US national average), but also improved financial performance (improved operating profit margins). Similar pilots were run at a number of American primary care organisations that are smaller and less-integrated than Kaiser Permanente which reported similar benefits in outcomes and costs, suggesting intelligent use of new

digital technologies can help successfully and cost-effectively scale chronic-disease management.

Predicting and Identifying Patient Care Gaps

Predictive analytics, powered by advances in data infrastructure, machine learning and artificial intelligence, and analytics tooling, have enabled dramatic operational improvements across many industries. [Industrial company Shell](#) utilises predictive analytics to optimise its $1 billion-plus spare-parts inventory to ensure better uptime for its globally distributed operations. [The credit-card industry has been utilising analytics technology since 1992](#) to predict which credit-card transactions are more likely to be fraudulent.

Similar methods can be applied to managing chronic illness. Predictive analytics applied to patient medical records, medical payment information, medical guidelines, and other available data can identify which patients are not being managed well or are most likely to progress to advanced chronic disease, across populations and datasets too large for manual review. This can be sometimes as simple as applying basic demographic and procedure code checks to identify patients overdue for preventative screening, to more complex applications of clinical guidelines and machine-learning algorithms. This allows limited medical resources to be deployed effectively on care which delivers the highest impact, preventing cost-ineffective interventions where they are unnecessary.

Companies like [Prealize Health](#) have developed models which can help providers and health-insurance companies predict which patients are at the greatest risk of requiring high-cost care. This allows its customers to automatically prioritise patient outreach efforts. Similarly, companies like [HealthPals](#) can utilise reimbursement and electronic medical record data to determine which patients are not being managed according to medical guidelines and what changes in care are necessary to alleviate those care gaps. This can provide clear feedback to providers on which actions need to be taken on which patients to bring them back in line with evidence-based medicine.

Care Coordination and Communication

Software systems have transformed how companies share information and coordinate operations to deliver for their customers. [Global hospitality company Marriott](#), for example,

employs customer-service software to provide geographically distributed teams with information on a guest's preferences to make it easier for staff to cater to guests' needs. By providing a history of their interactions with staff, it helps the company follow through 24/7 with commitments across different staff. Digital technologies also allow Marriott to be more responsive by letting staff connect with customers across multiple digital-messenger platforms and to use chatbots to increase efficiency and speed.

Similar approaches can be applied to the challenge of coordinating and communicating care for chronic-disease patients. Software can ensure that care teams, even if they are made up of individuals from different organisations who have never met in person, are aligned on a patient's needs and progress. These plans can be communicated to patients and their caregivers with feedback on a patient's progress relayed to the appropriate members of the care team. Given the long-term and multi-specialty, multi-provider nature of chronic-disease management, even incremental improvements in coordination here can pay dividends over the long term.

Companies like Careteam are bringing collaboration tools that modern enterprises use (task coordination, notifications and reminders, team messaging, etc.) to a health-care setting to improve patient-care coordination. Other companies are focused on facilitating the involvement of non-traditional providers. Unite Us, for example, has developed software to identify patients with socioeconomic issues that can impact their disease management and helps health-care providers work with social services. Still other companies are applying care coordination and communication to specific diseases. Cricket Health, for instance, focuses on chronic kidney disease and works with providers to educate patients about disease management, and involves nurses, dietitians, social workers, mentors and pharmacists to support a comprehensive care plan.

Digital Therapeutics

Leveraging technology to create durable behaviour change is a key priority across many industries. Many consumer technology companies successfully utilise nudges and algorithmic feeds to boost user engagement and monetisation. These methods have also been applied in sectors such as energy. Opower, for instance, works with utilities to help its customers understand how their energy use compares to their neighbours and, by doing so, has

successfully and scalably lowered energy consumption across a utility's residential customer base.

Given the strong role that lifestyle choices such as diet, drug use, physical activity, and medication adherence play in chronic disease progression, applying digitised behaviour change techniques may prove to be as effective as a traditional pharmaceutical product or medical device. This insight has led to the emergence of 'digital therapeutics': software interventions that focus on changing patient attitudes and behaviours to achieve clinical benefits. Because these are less physically invasive than pharmacological or surgical interventions, they can have lower risks and may be better suited for patients who have difficulty making traditional appointments.

Companies like Omada Health and Kaia Health are commercialising protocols using digitised cognitive-behavioural therapy, community support and habit tracking to help patients manage diabetes/pre-diabetes, hypertension, musculoskeletal pain and COPD. Companies like Pear Therapeutics are even seeking regulatory approval for their digital therapeutics to be prescribed alongside or instead of traditional pharmacological interventions for a variety of conditions such as pain, insomnia and certain gastrointestinal conditions.

Consumer-Friendly Monitoring

The boom in smartphone adoption has led to dramatic improvements in cost and quality for internet-connectivity and sensor technology. This has resulted in a remarkable explosion of wearable and internet-connected devices. The resulting data has been a catalyst for operational improvements and new business models. Shipping giant UPS's ORION system utilises data from drivers' Delivery Information Acquisition Devices (DIAD) and vehicle telematics hardware to optimise delivery routes (including favouring right turns over left turns due to time and fuel savings on American roads), identify areas for efficiency, and provide updates to consumers on delivery timing. Similarly, insurance companies like Allstate have begun to leverage connected telematics devices to offer usage-based automotive insurance products, promising lower rates for drivers based on their actual driving behaviour.

These technologies can also be applied to the challenge of monitoring and personalising care for chronic-disease patients. By leveraging simple-to-use smartphone apps and internet-

connected devices, providers can gain insight into a patient's vitals and disease progression between clinical encounters. This data enables providers to prioritise follow ups or intervene earlier, if a patient's disease is taking a turn for the worse, and to make that determination without requiring an in-person visit. The data can also improve chronic-disease prevention by letting a care team encourage healthy habits and provide personalised advice on changing behaviour.

Innovative companies are beginning to leverage connected consumer devices to improve disease monitoring. Healthy.io, for example, has developed in-home diagnostics for chronic kidney disease and other conditions which can be read using a smartphone camera and app. Companies have also developed connected devices like Propeller Health's connected inhaler and Carrot's connected carbon-monoxide monitor to help track asthma/COPD and progress towards smoking cessation. The medical field has also begun to appreciate the use of wearable devices with multiple studies showing that photoplethysmographs (optical pulse detection) and ECGs (electrocardiograms) on popular smartwatch platforms can be used as clinical-grade population-scale cardiovascular-health monitors.

Telemedicine

Social-distancing measures in response to the Covid-19 pandemic have dramatically increased the public's acceptance of the internet for conducting many types of business. This has accelerated a trend which in recent years has seen previously completely in-person activities convert to online-only modalities (for example, the ability to now receive an accredited academic degree through an online course platform like Coursera).

Telemedicine, the provision of medical services remotely, holds the promise to dramatically expand access to quality medical care for patients with chronic illness. By making it possible to consult with providers, obtain prescriptions and carry out medical protocols remotely, chronic disease patients can get more responsive care. This can reduce patient friction, something which has a disproportionate effect on chronic disease patients who must manage their diseases over their lifetime. Telemedicine may also alleviate health-system staffing constraints by allowing part-time or geographically distributed providers to participate in disease management.

There has been an explosion of innovation in the telemedicine arena in recent years. This ranges from offering general remote physician consultations like what Teladoc and DoctorOnDemand do. It also includes efforts tailored towards specific chronic diseases and treatment protocols. For example, consumer telemedicine company Ro offers Zero, a smoking-cessation programme that combines remote physician consultations with prescriptions for pharmacological agents proven to help with helping patients quit smoking. Still other companies like Moving Analytics are focused on supporting in-home versions of protocols like cardiac rehabilitation, which have proven to have dramatic impacts on patient outcomes.

The Role of Policy in Supporting Digital Innovation for Chronic-Disease Care

Policy has a central role to play in supporting the digital-health innovations that are needed to help health-care systems manage chronic disease. There are three key pillars for supportive policy for digital health care.

First, policymakers must help regulators and public health-care payers play a more supportive role in adopting new digital innovations. Even in countries where private-health insurance is widely used, public payers play an outsized role in determining which innovations are adopted. As a result, policymakers need to push public payers and regulatory agencies to modernise their frameworks to account for interventions and innovations which do not fit elegantly in traditional buckets of medical capital equipment, pharmaceuticals, diagnostics, medical devices, and procedures. To be clear, this is not a call for lowering of standards of quality and safety, but for recognising how blind adherence to traditional categorisations and rules can create roadblocks for new care modalities and technologies as they have for the US's largest public payer, the Centers for Medicare and Medicaid Services (CMS) when it comes to new digital health technologies.

A modern framework for approaching digital health should also be coupled with a focus on transparency in communicating the rules for how regulators and payers will evaluate new technologies and set coverage rates. Public payers and regulatory agencies need to learn to shift their role from being primarily a gatekeeper to a more active participant on the design

and monitoring of studies conducted by innovators. This helps innovators manage costs and timelines, but also ensures that studies are designed and carried out to collect data that helps advance care. Initiatives like the UK's National Institute for Health and Care Excellence (NICE), in conjunction with the National Health Services (NHS), on [communicating evidence standards for digital-health technologies](#) and efforts to [conduct studies on digital therapeutics](#) are examples of how transparency and active involvement from government agencies can foster digital innovation.

Second, governments need to modernise their health-technology infrastructure. While success with health-care digitisation varies widely by country, adoption and roll-out of even basic elements of health technology infrastructure such as electronic medical records continues to be a significant challenge for countries like the UK and Germany. Even when basic infrastructure is adopted, it too often [blindly mirrors legacy, offline bureaucracy](#) or [suffers from poor interoperability](#). This reduces the utility of digital-health innovation as, without access to patient data, even the most advanced predictive algorithms, health-care apps and care coordination software are little more than fancy ones and zeros.

To support digital innovation, policymakers need to close remaining adoption gaps for basic digital medical infrastructure like electronic medical records and patient portals. These pushes need to be paired with clear guidelines on interoperability and meaningful use to make sure that the technology can have a meaningful impact on care. Rules that protect patient privacy need to be codified, but they should also be complemented with guidelines for how patients can easily authorise use of their data by third parties [for research purposes](#) or [to provide valuable medical services or applications](#). Governments should also work with patient advocates, digital innovators, and providers to [help define open standards on patient data de-identification](#) and standard tiers of data sharing to give patients better options that can balance access and privacy while providing innovators with clear standards to follow and innovate around.

Third, policymakers need to support providers in embracing digital innovation in health care. This requires addressing provider discomfort around potential operational and legal issues that may arise. Providers need certainty and assurances around how new technologies may impact their legal liabilities (i.e., lawsuits or complaints about providers missing evidence of an

adverse event from increase in remote monitoring, liability uncertainties around use of diagnostic algorithms, etc.). Licensing and registration should also be modernised to recognise how digital innovations enable medical care to go beyond in-person visits to encompass care delivered by algorithms or remote providers. Rules that prevent providers from working with remote patients should be updated to account for the growing importance of telemedicine. Policymakers should also make it clear to providers which new technologies and care modalities are properly registered and approved for use.

Policy support must also extend to providing financial support to help smooth the path to piloting and embracing new innovations. This is especially true due to the fact health-care organisations already struggle with an understandable cultural aversion to taking chances. Grants for participating in pilots that get published or subsidies for medical scribes and training programmes to help patients, in particular those with less familiarity with technology due to age or socioeconomic status, are two examples where financial support can have a tremendous impact on adoption. Policymakers should also explore providing subsidised or outcome-linked financing to health-care organisations to encourage investment in long-term cost reducing technologies.

Conclusion

Without innovation, improved infrastructure, and better forms of intervention, the burden of chronic disease will continue to grow. The human cost of having prolonged periods of life diminished by disease will be profound, not just for the individual but also for all those impacted by it. The consequences for health systems will also be severe. Today, an estimated 86 per cent of US and 70 per cent of UK health expenditures are directed at the treatment of such conditions, and without reform, it will be a struggle to sustain quality care.

However, as we open up new possibilities in biology and software, we are opening up exciting avenues to improve the quality and quantity of life and alleviate some of the blight that sickness plays on people and families the world over. For governments, Covid-19 has shown the primacy that health should play in policy, while also highlighting the need for individuals to not solely rely on the state to care for them. More broadly, it has revealed the weakness of elements of our health systems and where we need to accelerate action. Those with chronic

disease have been some of those most severely impacted by the pandemic and we desperately need to see progress to mitigate against the impact of their dangerous increase on public health. Technology and innovation will be key to breaking some of these vicious cycles in health outcomes and governments around the world need to go harder at accelerating their adoption.

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