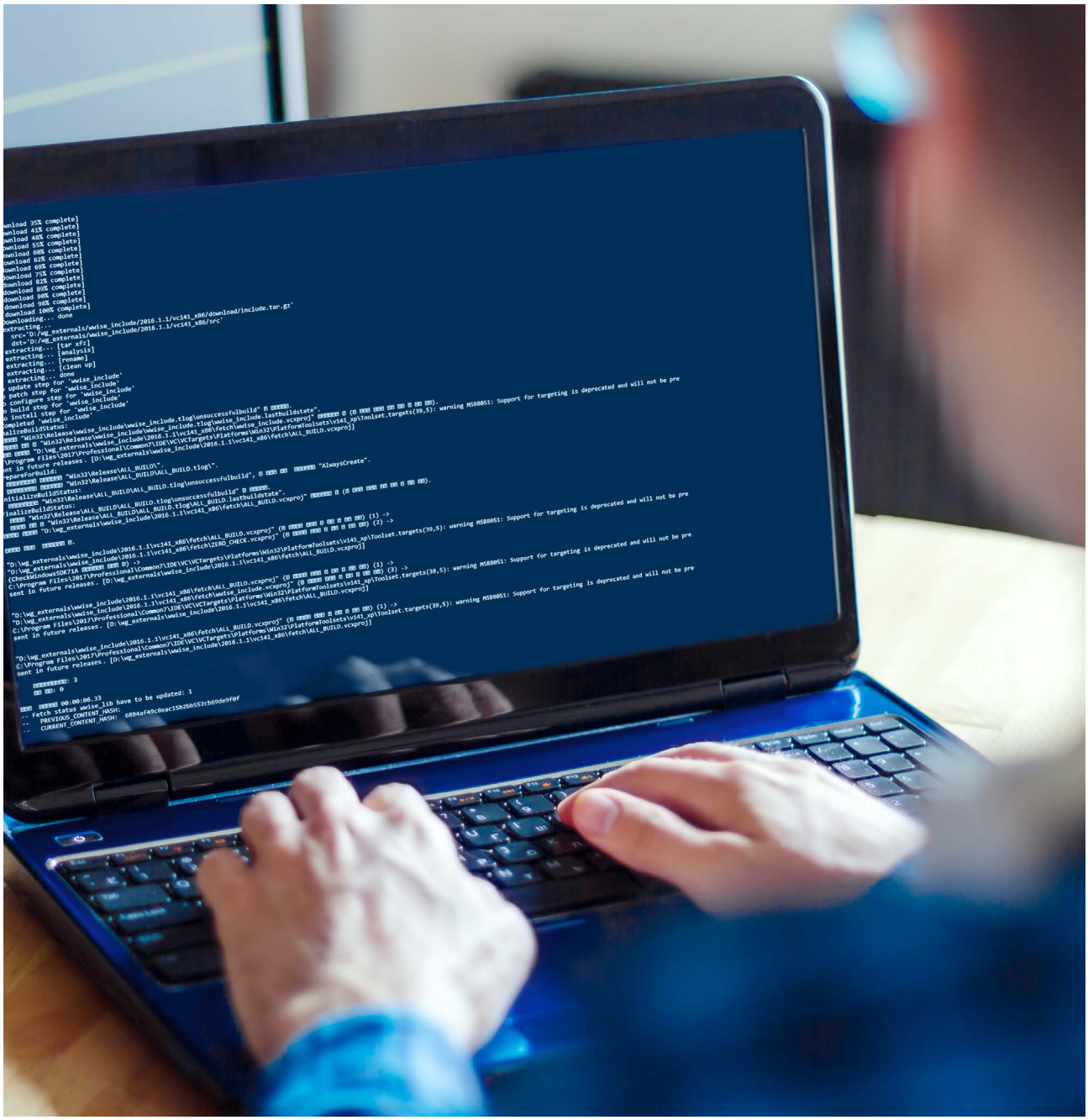
The next-generation HIE powered by machine learning



Orion Health White Paper
102021

Imagine a world where we can identify the right patient, create a custom healthcare plan for them and deliver care in a location that best suits the patient's needs at the time they need it the most.

A world where the integrating of care across traditional primary, secondary and community care providers will reduce duplication and gaps in care. This collaborative effort will enable healthcare providers to maximise resources by targeting specific cohorts of the population, reduce unnecessary healthcare costs and sustainably utilise resources.

Although the vision is sound, the real question is can we address the current challenges health systems face today, and can this be done sustainably?

The reality is that globally, healthcare entities are working within constrained budgets and resources. In recent years, the explosion in the volume and variety of data has proven difficult for health providers to manage. Today's Health Information Exchange (HIEs) need to address these challenges and present data as information that is relevant, intelligent and timely.

To deliver on this vision and address these practical realities, we need to target care more effectively within existing constraints. This calls for a next-generation HIE.

The next-generation HIE will enable the strategic management of data as a core asset and derive maximum value from the data collected. While a clinician may review each patient's record in isolation, deriving certain insights from the information available, no single person has the capacity to do this across the millions of records housed in today's HIEs.

Leveraging the collective experience that this data represents requires enhanced capabilities such as risk prediction, natural language processing, pathway and resource optimisation along with modern technology and standards.

This white paper will discuss the need for a 'next-generation' HIE, delivering the right care to the right patient in the right care setting.

The importance of HIEs

The concept of HIEs in healthcare is simple: to improve the quality, coordination and cost-effectiveness of healthcare in respective communities. HIEs help disparate healthcare systems such as hospitals, clinicians, labs and community-based healthcare organisations to share patient-level health information to provide better care, better outcomes and ultimately lower costs.

Making siloed or previously unobtainable information available to healthcare professionals has already proven invaluable in enabling a broader understanding of community needs that can help to improve care coordination in the delivery of both day to day and emergency care.[1]

The potential for today's HIEs

Most HIEs in today's medical arena are focused on basic functions such as the sharing of laboratory results from one organisation to another and require extensive clinician effort in order to fully utilise the capability of the HIE.

HIEs have helped boost Electronic Health Record (EHR) adoption significantly among clinicians yet have added to their clerical burden and increased the risk of professional burnout.

One study found that clinicians spend approximately 33% of their work hours performing direct clinical work and 49% completing clerical tasks and interfacing with the EHR. For every hour of clinical work, clinicians spent two hours on clerical or EHR-related tasks. [2]

A next-generation HIE must aim to reduce or ease the burden of clerical tasks for clinicians.

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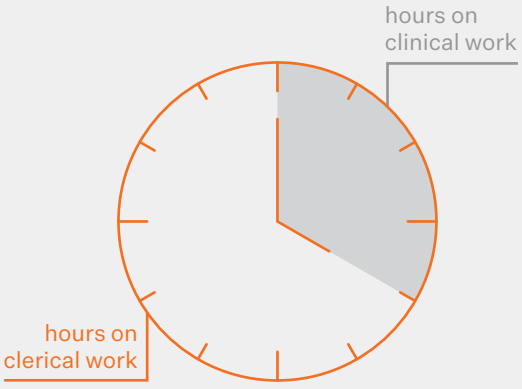


[1] Forum on Medical and Public Health Preparedness for Catastrophic Events; Board on Health Sciences Policy; Board on Health Care Services; Institute of Medicine. The Impacts of the Affordable Care Act on Preparedness Resources and Programs: Workshop Summary. Washington (DC): National Academies Press (US); 2014 Aug 27. 5, Needs and Logistics of Data Sharing and Health Information Technology. Available from: https://www.ncbi.nlm.nih.gov/books/NBK241386/

[2] Murphy, D. R., Meyer, A. N., Russo, E., Sittig, D. F., Wei, L., & Singh, H. (2016). The Burden of Inbox Notifications in Commercial Electronic Health Records. JAMA internal medicine, 176(4), 559–560. https://doi.org/10.1001/jamainternmed.2016.0209

Volumes of data and not enough time

With recent outbreaks, a constant influx of the latest medical information, new treatments, vaccine development and the need for increasing levels of patient tracking and documentation, healthcare providers can quickly find themselves overwhelmed with information.

The influx of information comes with an unspoken expectation that clinicians will review each item of data, decipher and respond to this data in addition to coping with their existing responsibilities.

On average primary care physicians spend over an hour or 66.8 minutes each day processing notifications. And because a single notification often has multiple data points, such as metabolic panels containing multiple laboratory values, the actual cognitive effort placed on the clinician is even greater. This burden is continuing to increase as HIEs grow to store more and more data than ever before.

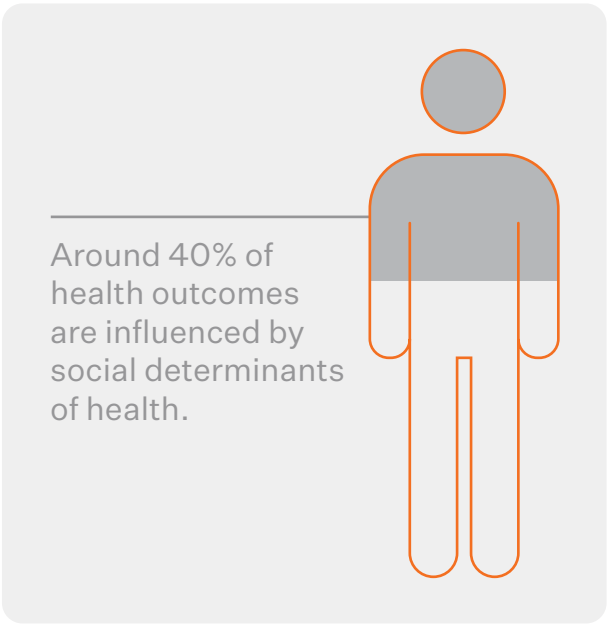
With the explosion of new types of data, we now have tools to process such information and find contextual insights that apply to a patient's situation. Current HIEs can do better at identifying what data is useful and the right treatment and prevention plan for each patient.

The need to support emerging data types

HIEs today can be better at supporting emerging and non-traditional data types such as social determinants of health, environmental, genomics, patient device data and patient generated data.

Experts now agree that the environment people live in, their socio-economic status, lifestyle and cultural background affect the health status of an individual far more than previously understood. Across many studies, authors agree that social determinants of health contribute to approximately 40% of an individual's health outcomes, morbidity and mortality.[3]

For instance, the World Health Organization recently stated that 3.8 million deaths were linked to the environment in 2018. Every year 4.2 million deaths result from exposure to ambient (outdoor) air pollution and 12.6 million deaths each year are linked to the environment. A deeper level of understanding of social factors can provide invaluable insight into improving a patient's health status for predicting outcomes.



[3] Conference Paper: Hyojun Park, A., Roubal A., Roubal, B., Rudolph R., Booske C November 2013 Relative contributions of health determinants on health outcomes at the county level Conference: 141st APHA Annual Meeting and Exposition 2013.

Another example, such as the recent COVID –19 outbreak highlighted the importance of HIEs, as disease spread modelling became a high priority for the prediction of services demand, ICU admissions and expected deaths. To do this effectively, various information such as confirmed daily cases, the effectiveness of control measures in place, ICU capacity and travel patterns of citizens became essential information to have at hand – data that traditional HIEs could not readily store. [4]

Imagine the further effectiveness of such disease modelling if it were combined with diagnoses to predict those most at risk within a specific area and those most in need of a vaccine when one becomes available. The New Zealand Algorithm Hub, which is a national, central repository for validated algorithms and models to support New Zealand's health system, can illustrate this capability.

The hub works with local and international health, research and data science communities to identify, prioritise and deploy algorithms for New Zealand and to open access to these algorithms and models to a wider New Zealand audience, including the Ministry of Health, District Health Boards and other healthcare organisations and government departments.

First generation HIEs were not built to address emerging and non-traditional data types and therefore are not as efficient in providing a holistic view of population health. Having this capability holds great potential for improved risk prediction, early interventions and preventative care, particularly when combined with traditional health data.

Unrealised value from data

Machine learning has significant potential to deliver value within healthcare. For instance, incorporating machine learning into clinical and operational workflows can help predict outcomes, demand for services, support improved prioritisation and triage, and search and summarise medical information. [5]

While some simpler, well-established models and algorithms such as the Framingham Coronary Heart Disease Prediction Scores, have been adopted widely, many gaps still exist between creating a new machine learning model and implementing it to be used operationally and safely.

This is because efforts often end once a model is developed and published. In order to operationalise machine learning, healthcare organisations need a specific set of tooling, skills and processes to deliver what is often called 'the last mile' – safe and effective integration with workflows that drive action and deliver value through APIs that can insert machine learning insights within a process at the exact moment they are required.

An ideal (next-generation) HIE needs to provide an innovative ecosystem that is compatible with event-driven machine learning.

[4] Lenert, L. and McSwain, B., 2020. Balancing health privacy, health information exchange, and research in the context of the COVID-19 pandemic. Journal of the American Medical Informatics Association, 27(6), pp.963–966.

[5] Alvin Rajkomar, M.D., Jeffrey Dean, Ph.D., and Isaac Kohane, M.D., Ph.D. Machine Learning in Medicine , The New England Journal of Medicine 2019

Introducing the next-generation Health Information Exchange

The next-generation HIE presents relevant information in an intelligent and timely manner, has flexibility for emerging and non-traditional data types, organises data so that it is easy to access and use, and provides an innovative ecosystem for future developments.

Let's discuss how each of these capabilities will revolutionise how HIEs can deliver healthcare more efficiently in the future.

Personalised care

Every individual is unique, and their healthcare should be too. Unfortunately, the current health practices are, by necessity, largely based on a "one size fits all" healthcare approach.

More recently, healthcare providers are looking at a more holistic patient approach. Access to a comprehensive patient record will mean clinicians can identify and address the right factors that will have the most impact on a patient's well-being. For instance, addressing poor housing might be the root cause of sickness, rather than recommending a disease-specific management pathway.

Technologies deriving insights from genetic profiling, targeted biomarkers, biometric analysis and clinical evaluations are used to create highly personalised unique care plans to optimise and maintain each individual patient's health and longevity.

This approach allows any health system to focus on appropriate and timely care enabled by early detections of health risk factors, prevention and management of illness and optimal use of health resources.

The recent outbreak of COVID-19 highlighted the dangers of not matching resources to demand. It is largely agreed, in the healthcare space, that there is a need to adopt and use machine learning in these workflows.

HIEs that aggregate that data are the right place to adopt machine learning, so they can enable the clinician to do more and better.

Today most HIEs do not operationalise machine learning. With isolated machine learning, there is a considerable lag between data stored and the machine learning insight. The next-generation HIE will have machine learning-driven insights accessible in real-time.

With the next-generation HIE, known risk factors such as patient living situation, comorbidities, recent hospital admissions and test results can be captured and with the help of machine learning, we can predict whether a patient will be readmitted to hospital within 30 days of discharge.

Innovative ecosystem encouraging future improvements

Interoperability – or rather a lack of interoperability – remains a dilemma for many healthcare organisations. Globally, health systems had growing concerns about interoperability; data silos had to be broken down, and access to information needed to be enabled in real-time, especially with the uptake of mobile apps. This gave rise to Fast Healthcare Interoperability Resources (FHIR).

FHIR revolutionises healthcare information sharing by providing a comprehensive view of each patient, pulled from both traditional and non-traditional sources. With FHIR, healthcare providers can make better assessments of their patients and innovate to provide better care.

FHIR covers the format of information and how data is exchanged, so it is both a model and an API. It promises to make health information easily and securely accessible from any device, anywhere.

The next-generation HIE will be fully interoperable with improved access to a complete patient record by breaking down data silos, removing participation barriers and encouraging clinician-led technology innovations.

Powered by Machine Learning

The real benefit of the next-generation HIE can be attributed to its capability of bringing enhanced value to interoperability through machine learning.

An HIE augmented by machine learning can help with extracting value from raw data sets to solve predictive tasks, including decision support, forecasting, ranking, classifying (e.g. cancer diagnoses) and detecting anomalies.

HIEs augmented with machine learning can help clinicians make better patient predictions. Equipped with capabilities like population-level insights, smart segmentation and non-traditional data information, clinicians can identify intelligent ways to treat different groups of people individually based on their needs.

Let's look at three examples of how the next-generation HIE can leverage machine learning to produce valuable insights from data.

Predicting surgical mortality risk

Take, for instance, predicting surgical mortality risk in New Zealand. The nzRISK calculator is a preoperative risk prediction tool developed specifically for the New Zealand population, using New Zealand data.

The data used comes from New Zealand's Ministry of Health and captures 99% of hospital admissions in New Zealand between 2011 – 2016. The risk calculator can directly impact the efficiency of the health system by avoiding unnecessary appointments for low-risk individuals and initiating better informed conversations with high-risk individuals, thereby improving the quality of clinical decision-making resulting in better clinical value.

Patients and clinicians can input various pieces of information, such as age, gender, ethnicity, type of procedure, and pre-existing conditions, and the nzRISK calculator, powered by machine learning, will produce a mortality risk score for that patient at one month, one year and two years after surgery.

Applying Natural Language Processing in the clinical domain

The large amount of free text documentation now available in EHRs has led to an increase in research to advance Natural Language Processing (NLP) methods and applications for the clinical domain. Enhanced by machine learning, NLP tools have shown potential in advancing the care continuum.

One example demonstrates how NLP tools enhanced by machine learning have shown potential for detecting complex patients who may benefit from enhanced care coordination.

By extracting meaningful information from large datasets, these tools can provide clinicians with the information they need to detect complex patients. For instance, researchers at Massachusetts General Hospital applied NLP techniques to the EHR to help providers identify key terms associated with the social determinants of health.

The team found that 22 terms provided enough specificity to reliably identify patients at higher-than-average risk of psychological, social, and behavioural impacts on their health.[6]

Predicting complications during pregnancy or birth

A large US insurer wanted to predict complications during pregnancy or birth sooner and more accurately than the standard rules-based antenatal risk assessment, which is typically done at 12 weeks.

Equipped with 17,000 different data inputs (combining claims and clinical data with free-text clinical notes) for predicting pregnancy complications, they utilised the power of machine learning models to identify significant risk factors. By using a wide range of data inputs and applying machine learning techniques, they were able to lift precision to 77% and AUC to 82% (see diagram).

This example highlights how HIEs, augmented with machine learning, enables less medically trained individuals to predict high risk of complications, leaving the clinician or surgeon to only need to assess the high-risk cases, saving clinician time and reducing clinician cognitive overload.

[6] Oreskovic NM, Maniates J, Weilburg J, Choy G. Optimizing the Use of Electronic Health Records to identify High-Risk Psychosocial Determinants of Health. JMIR Med Inform 2017; 5(3): e 25

Conclusion: What's in the future

This white paper highlights how machine learning really is the key in the next generation HIE. While there is still a long road ahead in achieving full digital transformation in healthcare systems, there is a lot to look forward to. However, healthcare providers need to consider what the opportunity cost is of doing nothing.

The next-generation HIE is here and ready for adoption. It's built through research collaboration with end users and focuses on the importance of health systems to deliver on the promise of better use of data. From predicting patients' risk profiles with machine learning, to removing data silos to ensure full tech enablement, we are starting to join up the dots in order to fully realise the value of a next-generation HIE.

The technology for the next-generation HIE exists, but it is up to the healthcare providers to reach out and integrate these into their organisations to save more lives and do that cost-effectively.

Interoperability – or rather a lack of interoperability – remains a dilemma for many healthcare organisations. Globally, there are growing concerns and challenges in this area; data silos need to be broken down, and access to information must be enabled.

References

1. Forum on Medical and Public Health Preparedness for Catastrophic Events; Board on Health Sciences Policy; Board on Health Care Services; Institute of Medicine. The Impacts of the Affordable Care Act on Preparedness Resources and Programs: Workshop Summary. Washington (DC): National Academies Press (US); 2014 Aug 27. 5, Needs and Logistics of Data Sharing and Health Information Technology. Available from: https://www.ncbi.nlm.nih.gov/books/NBK241386/

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