Unleashing the Power of the Cloud in Healthcare

The cloud emerges as a platform for innovation

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The cloud: Driving healthcare organizations forward on their digital journeys

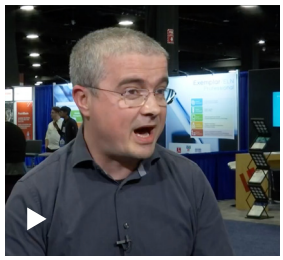
The healthcare industry is increasingly turning to the cloud to advance transformational digital initiatives. Consider the following: According to research conducted by HIMSS Media, the number of healthcare organizations deploying workloads and applications in the cloud was expected to reach 50% by the end of 2019, compared to 39% in 2018 and just 21% in 2017.[1]

The fact that the healthcare industry is gravitating toward the cloud is not that surprising when considering the storage, scalability, and collaboration benefits that the technology can bring to computing initiatives. Provider organizations, for example, can harmonize data from EHRs and other sources in the cloud to make better clinical decisions at the point of care. Health plans and providers can share data and collaborate under value-based care models. Finally, life science companies can tap into cloud-based data to bring drugs and other products to market more efficiently.

This e-book provides insight into how healthcare organizations can use the cloud to provide better patient experiences; tap into the potential associated with artificial intelligence and machine learning; meet the challenges that come with the move toward precision medicine — and move forward with confidence when it comes to compliance, patient care, and data security.

1. HIMSS Media: "Cloud Usage in Healthcare: Preparing for the Next Wave, 2019."

A talk with Joe Corkery: How cloud makes data more secure, agile



BlueBee providing secure, compliant data solutions for bioinformatics

Security in the cloud

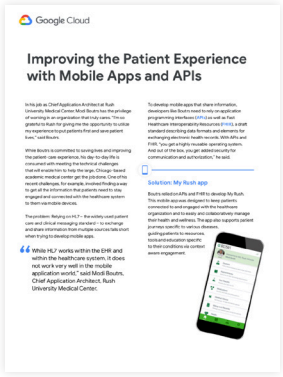
According to the 2019 HIMSS Cybersecurity Survey, 82% of hospitals experienced a breach within the last year.[2] Not surprisingly, with such widespread security risk, the first impulse for some healthcare organizations is to hold their data close to the vest — and avoid placing sensitive information in the cloud.

Such thinking, however, is being challenged as the cloud is emerging as a more secure option than on-premise data storage. "A couple of years ago, nobody wanted to go to the cloud because they were afraid of security, and that has really flipped on its head where security is now a key differentiator in why people are looking at the cloud as an option," said Joe Corkery, Director of Product Management at Google.

In fact, cloud companies can keep data more secure than healthcare organizations because they can more easily keep up with compliance requirements, access the talent necessary to keep data secure, and invest the dollars required to keep security practices and technologies current.

To ensure that data is safe, healthcare organizations need to acknowledge that security is a shared responsibility, and they should work alongside cloud vendors to protect data. In addition, healthcare organizations should work with cloud providers that offer a defense-in-depth approach, which addresses security at every layer of interaction, not just at the perimeter. With security issues addressed, healthcare organizations can keenly focus on the all-important task at hand: improving care for patients.

2. HIMSS. "2019 HIMSS Cybersecurity Survey." https://www.himss.org/sites/hde/files/d7/u132196/2019_HIMSS_Cybersecurity_Survey_Final_Report.pdf.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Improving the Patient Experience with Mobile Apps and APIs

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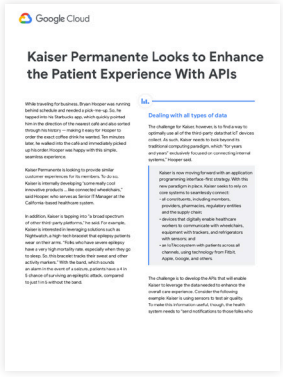
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Kaiser Permanente Looks to Enhance the Patient Experience With APIs

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Driving better patient experiences

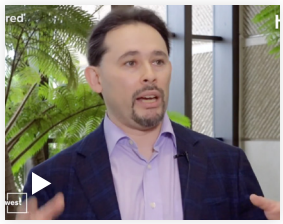
The number of patients enrolled in high-deductible health plans (HDHPs) is growing. Among persons with private health insurance, enrollment in HDHPs has increased 18.4 percentage points, from 25.3% in 2010 to 43.7% in 2017, according to National Center for Health Statistics.[3] Consumers are paying for a greater share of their healthcare bills — in turn demanding more flexible, personalized, and cost-effective care.

To create more personalized experiences, providers must do more than simply digitize health records and create online portals. They need to make it possible for patients to track and share real-time data in an effort to improve overall health. The challenge is to integrate data from multiple sources to give patients the contextual information that can truly enhance the overall patient care experience. By applying this knowledge, healthcare organizations can turn patients into partners who actively participate in managing their health.

A cloud platform offers the infrastructure to securely host customer data and support new personalized experiences from the insights derived. For example, Rush University Medical Center created My Rush, which relies on APIs to access information from a variety of systems and uses a centralized management platform that allows hundreds of separate systems, devices, mobile apps, and third-party apps to communicate and connect via one layer. The app relies on 250 analytics variables to track patient clicks, understand patient priorities and predict their upcoming needs. With this solution, patients can schedule an appointment, get directions, exchange secure messages, access their own electronic health records, estimate wait times, and receive test results. During the first eight months of its implementation, the app received about 20,000 API calls per month. By providing access to all this relevant information, the health system is creating more meaningful experiences for patients.

3. National Center for Health Statistics. "NCHS Health Insurance Data." https://www.cdc.gov/nchs/data/factsheets/factsheet_NCHS_health_insurance_data.htm.

How cloud, AI and ML are transforming radiology



AI helps physicians with their workload and increase efficiency

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Priming your organization for AI and ML

With the proliferation of electronic medical records and the increased use of IoT devices and digital health apps, healthcare organizations are collecting more data than ever before. With this rich set of data, these organizations have what is needed to start using advanced technologies such as artificial intelligence (AI) and machine learning (ML). "This actually was not a feasible task before because we didn't have the data. But now the data's there. It's waiting for us to make use of it," said Alvin Rajkomar, MD, a Senior Research Scientist at Google.

But there's a catch. The challenge for healthcare organizations is to find a way to manage data in a manner that makes it easy to leverage in AI and ML solutions. Data management is a precursor to AI and ML success, as analytics solutions such as these need robust and reliable data to produce relevant insights. After all, decisions made by these advanced analytics tools are only as good as the information they are based on.

The cloud can help empower healthcare organizations to support large-scale data storage and computing capacity. More specifically, cloud technology provides an elastic-computing resource, making it possible to cost-effectively work with various amounts of data as needs continually change. When cloud platforms include managed data services and healthcare-specific application programming interfaces (APIs), healthcare organizations can keenly focus on the innovations that they are developing, instead of spending inordinate amounts of time managing data.

By expeditiously managing data in the cloud, more organizations will be able to follow in the footsteps of leading institutions that have already leveraged AI and ML to move medicine forward by identifying cancerous tumors on mammograms, detecting skin cancer, and diagnosing diabetic retinopathy in retinal images.

Breaking down the barriers impeding genomic research (DNAstack)

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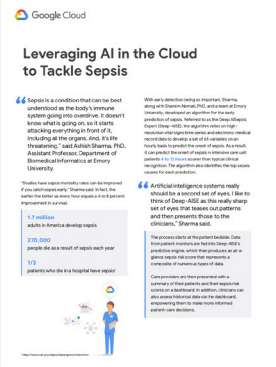
Beyond the precision medicine hype

"The hope of precision medicine is that treatments will one day be tailored to the genetic changes in each person's cancer. Scientists see a future when genetic tests will help decide which treatments a patient's tumor is most likely to respond to, sparing the patient from receiving treatments that are not likely to help … With precision medicine, information about genetic changes in your tumor can help decide which treatment will work best for you."[4]

That's how the National Cancer Institute describes precision medicine's promise. This promise hinges on the ability to optimally manage a large amount of diverse data in a secure environment. Sequencing the full genome of a patient, for example, requires a full terabyte of data. While working with this large amount of data is challenging, doing so can produce specific insights into each individual's health, making it possible to administer highly effective treatments. Healthcare and life sciences organizations need to bring data from multiple sources together to successfully develop such precision medicine treatments. And they need to work quickly, as time is of the essence when individual patients are waiting to receive precise medical treatment to address life-threatening illnesses such as cancer.

Cloud platforms can help with these data challenges. A collaboration among Google, Autism Speaks, and DNAstack, for example, illustrates how a cloud platform can be used to bring together clinical, phenotypic, and genetic information in one environment, making it possible for researchers to better leverage the data for autism research. By relying on a cloud platform, healthcare and life sciences companies can free data buried in silos and apply AI and ML to reveal the most promising molecules, accelerate clinical trial-data analysis, and transform operations along the value chain. Unleashing the potential of data this way will accelerate the pace of discovery and help bring innovative treatments to market more quickly. More specifically, the research will help to identify the many subtypes of autism – a genetically complex disorder — and ultimately help to develop more personalized and effective treatments.

4. National Cancer Institute. "Precision Medicine in Cancer Treatment." https://www.cancer.gov/about-cancer/treatment/types/precision-medicine.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Leveraging AI in the Cloud to Tackle Sepsis

Sepsis is a condition that can be best understood as the body's immune system going into overdrive. It doesn't know what is going on, so it starts attacking everything in front of it, including all the organs. And, it's life threatening," said Ashish Sharma, PhD, Assistant Professor, Department of Biomedical Informatics at Emory University.

"Studies have sepsis mortality rates can be improved if you catch sepsis early," Sharma said. In fact, the earlier the better as every hour equals a 4 to 8 percent improvement in survival.

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With early detection being so important, Sharma, along with Shamim Nemati, PhD, and a team at Emory University, developed an algorithm for the early prediction of sepsis. Referred to as the Deep AISepsis Expert (Deep-AISE), the algorithm relies on high-resolution vital-sign time series and electronic medical record data to develop a set of 65 variables on an hourly basis to predict the onset of sepsis. As a result, it can predict the onset of sepsis in intensive care unit patients 4 to 12 hours sooner than typical clinical recognition. The algorithm also identifies the top sepsis causes for each prediction.

"Artificial intelligence systems really should be a second set of eyes. I like to think of Deep-AISE as this really sharp set of eyes that teases out patterns and then presents those to the clinicians," Sharma said.

The process starts at the patient bedside. Data from patient monitors are fed into Deep-AISE's predictive engine, which then produces an at-a-glance sepsis risk score that represents a composite of numerous types of data.

Care providers are then presented with a summary of their patients and their sepsis risk scores on a dashboard. In addition, clinicians can also access historical data via the dashboard, empowering them to make more informed patient-care decisions.

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A Data-Driven Approach to Solving the Opioid Crisis

The opioid crisis has become a national emergency. The statistics illustrate the weight of the situation:

- 2.4 people million suffer from opioid use disorder
- The economic cost of the opioid crisis exceeded $1 billion from 2001 to 2017
- There were 47,000 opioid-related deaths in 2017
- Total care for patients who experienced an opioid overdose between October 2017 and October 2018 resulted in $1.94 billion in annual hospital costs across 447 healthcare facilities nationwide, according to a Premier Inc. analysis published in 2019[1]

Dealing with the situation places a formidable burden on front-line healthcare workers such as Nilwa Kanhouwa, MD, who spent almost 20 years working as an emergency department physician.

"I have physically laid hands on 80,000 patients. I've seen every aspect of the opiate situation from point of injury to heroin overdoses to death in my emergency department," said Kanhouwa, now Managing Director of Government and Public Services for Deloitte Consulting.

"There's nothing that's more painful than trying to tell somebody at 3 in the morning who's begging and crying for 160 milligrams of Demerol that he or she can't have it because you know they are on the road to addiction. It's a very difficult and complicated situation to deal with from a provider's perspective."

Digging into the data

Making better use of data, however, could help. "In an industry where our data is growing at the rate of petabytes per year, we on the front lines taking care of patients are data poor. Imagine that irony," Kanhouwa said.

Working in cooperation with Google and DataStax, Deloitte created Opioid360, an analytic solution that synthesizes de-identified data from disparate and siloed sources to provide insight into opioid crisis. The solution relies on MissionGraph, an interactive, cloud-based tool to identify connections across large, disparate datasets, which makes it possible to discover real-time, actionable insights.

Three major areas of data are fed into this system:

- Google analytics and ads data, which include targeted ad keyword searches indicating the level of drug use in a community
- Socioeconomic data, which includes personal indicators (i.e., exercise regularly), financial indicators (i.e., owns home), and regional economic-growth indicators
- Public data, which includes medical claims, emergency department visits, and prescription monitoring program information drawn from 30 datasets with up to 5,000 data elements

The solution not only brings together these different types of data but also deploys artificial intelligence and predictive modeling to provide the insight that can empower providers to take tailored interventions matching the medical needs of opioid-addicted patients.

View the full brief >

Real-world applications: Using Cloud-based data to address sepsis and opioid addiction

Leading organizations are relying on the cloud as they develop and implement initiatives to address these long-standing and emerging healthcare challenges. Sepsis, for instance, is a problem that has been plaguing healthcare organizations for many years. It's estimated to affect more than 30 million people worldwide every year, potentially leading to 6 million deaths.[5]

For example, a team at Emory University developed an algorithm for the early prediction of sepsis. Referred to as the Deep AISepsis Expert (Deep-AISE), the algorithm relies on high- resolution vital-signs time series and electronic medical record data to develop a set of 65 variables on an hourly basis to predict the onset of sepsis in intensive care-unit patients four to 12 hours sooner than typical clinical recognition. The cloud is providing Emory with the scalability and flexibility needed to support the Deep-AISE initiative. "We wanted the on-demand nature of the cloud system, and we wanted to be able to rely on elastic computing," said Ashish Sharma, PhD, an Assistant Professor in the Department of Biomedical Informatics at Emory University. In addition, addiction to opioids has turned into a crisis of epic proportions in recent years. Every day, more than 130 people in the United States die after overdosing on opioids, according to the Centers for Disease Control and Prevention.[6]

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Produced by HIMSS

5. Fleischmann C, Scherag A, Adhikari NK, et al. "Assessment of Global Incidence and Mortality of Hospital-treated Sepsis. Current Estimates and Limitations." Am J Respir Crit Care Med. 2016 Feb 1; 193(3): 259-72.
6. CDC/NCHS, National Vital Statistics System, Mortality. CDC WONDER, Atlanta, GA: US Department of Health and Human Services, CDC; 2018. https://wonder.cdc.gov.

Overcoming R&D challenges of handling massive amounts of data (BC Platforms)

How Google Cloud is helping researchers in higher ed

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How to jumpstart your digital transformation

Healthcare is changing at breakneck speed. The use of technologies such as electronic health records, medical imaging, and IoT devices is bringing more data into the healthcare industry than ever before. All this information can potentially help healthcare organizations deliver better care and enhanced experiences to patients.

The challenge for healthcare organizations, however, is to find a way to go beyond simply being mired in data — and to successfully use this information for the greater good. To get started on your healthcare organization's digital transformation, you should focus on:

Organizing and **managing** your data so that it's accessible to people who need it, but secure from everyone else

Integrating data from multiple sources to provide a comprehensive, contextual set of knowledge that can help to improve the overall care experience

Leveraging analytics to gain insights into clinical, financial, and operational workflows, thereby helping to lower costs, reduce staff burnout, and enable better care for more people

Relying on artificial intelligence to aid clinicians making diagnoses and guide patients to better health before, during, and after care

The Google Cloud Platform can provide what's needed to support this digital journey. The Google Cloud team is applying deep industry knowledge to deliver products and solutions built specifically to tackle the toughest healthcare and life sciences problems. We invite you to learn more about how Google Cloud is providing the data storage, interoperability, security, and advanced analytics that healthcare organizations need to improve the overall healthcare experience.

To keep up with the latest uses of Cloud visit Google Cloud for Healthcare & Life Sciences.

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Leveraging AI in the Cloud to Tackle Sepsis

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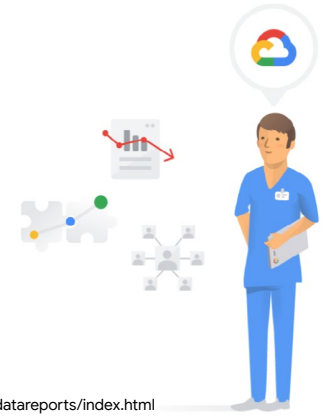

[1] https://www.cdc.gov/sepsis/datareports/index.html

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A comprehensive view of *how, if* and *when* a patient will develop sepsis

Challenges

The challenge, according to Sharma, is to "tease out these clinical wavelengths. As the algorithm predicts and states the incidence of sepsis developing in the next eight hours, it also presents those key clinical indicators that draw the algorithm to that prediction. So, when clinicians log in to the system, they can quickly glean out who are the patients at high risk at this time. They can quickly see the patient name, the base score, and how much has that score changed. So, it's quickly actionable." The predictive engine is ultimately designed to empower clinicians. It doesn't just emit results after analysis, it gives a detailed explanation of how a prediction was realized, ensuring healthcare workers that intervention is warranted.

Solution

Emory chose to deploy Deep-AISE through Google Cloud Platform for scalability and flexibility using the Google Healthcare API, Pub/Sub, Dataflow, ML Engine, TensorFlow, Kubernetes and the Google Container Engine.

> We wanted the on-demand nature of the cloud system, and we wanted to be able to rely on elastic computing," Sharma said

The development team also wanted to leverage the cloud's managed services such as BigQuery, a highly scalable, enterprise data warehouse designed to make analysis more productive by eliminating the need to manage infrastructure. By relying on the cloud's processing power and managed services, Emory will be able to further develop the sepsis program.

> We want to try and validate more algorithms and see how they behave in bigger populations from other institutions. We also want to see how this algorithm will interface and tie into existing IT healthcare systems," Sharma said.

Why Cloud

The sepsis program is just one of many initiatives that are being supported by cloud computing at Emory.

"Our big push for being on the cloud stems from the need to process at scale. We work in precision medicine and precision oncology. So, we need to leverage cloud pipelines to do other IT activities. We are working with real-time data from radiology departments and the fusion of radiology to genomics and pathology to do early outcome predictions. These are very computationally intensive activities. And cloud computing systems give you that added edge that local IT just cannot provide," Sharma concluded.

For more information visit the healthcare website:
https://cloud.google.com/solutions/healthcare/

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ML Powers Clinical & Operational Analytics

Machine learning (ML) has already proved its mettle when working with medical images. For example, when analyzing retinal images, ML can identify diabetic retinopathy better than humans can. Recent research also shows that ML models can look at a retina image and identify a patient's cardiovascular risk – a task that is not humanly possible.

"The retina does have pixels of the patient's blood vessels in the eye. So, there's a hypothesis that it is possible [to assess cardiovascular risk] but humans can't see it. A ML model trained over many examples can easily see that," said Alvin Rajkomar, MD, a Senior Research Scientist at Google.

While these ML use cases are impressive, some clinicians are still waiting for machine learning to have an impact on their daily lives.

> "All of these successes are super cool. But I'm a hospitalist. So, I take care of internal medicine patients, and I don't work with images, for the most part. But there are a lot of tasks that could help doctors like me take care of patients," Rajkomar said.

Indeed, many clinicians would benefit if ML could help them answer questions such as:

- How will my patient progress with a new diagnosis?
- What is my patient's risk of readmission?
- How long will my patient be in the hospital?
- What diagnosis might my patient receive?

Harnessing EHR data

To make such predictions, ML models need to ingest EHR data – something that has only recently become viable. "This actually was not a feasible task before because we didn't have the data. But now the data's there. It's waiting for us to make use of it," Rajkomar said.

It also is now possible to use EHR data in ML models because "we have modern algorithms and software infrastructure to actually harness all that data. At Google, we commonly use TensorFlow, but that software didn't exist 10 years ago," Rajkomar said. TensorFlow is an open-source framework for high performance numerical computation.

Indeed, there's plenty of potential in EHR data, according to Patrik Sundberg, a Google Software Engineer. "There can be a lot of different data points in the electronic health records, especially with long, complicated hospital stays. There's usually a ton of data.

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The classic logistic model might use an average of something like 27 variables. Machine-learning models can use 150,000 variables or more to create more accurate predictions," Sundberg.

The problem is that EHR data is difficult to work with. For every prediction, "you have to first define which variables you actually want to put into the model," Rajkomar said. "Once you define these concepts, extracting them from medical records is extremely hard. Writing SQL queries to extract the right variables in one health center's data might be fine. But if you take a different health center's data, and try to run the same SQL queries, it won't work. And every time you want to address a new prediction, you're stuck on that same cycle — defining the variables, extracting the variables, cleaning them, building a new model."

Scalable models

The challenge is to build models that are scalable and can accommodate more than a single health center's data. To accomplish this ML models need to:

Accept data in a standard format. When working with EHR data, "having a standard format is really a critical ingredient to making sure that you're not creating custom converters for every single piece of data that goes into your model," Rajkomar said.

Fast Healthcare Interoperability Resources (FHIR) makes it possible to arrive at a common representation of data. With data, "you have things like labs and observations" that are "analogous to the pixels in the imaging world, where you have edges and colors," Sundberg said. When using FHIR, all of the healthcare data is mapped into a single format, similar to how DICOM standardizes imaging information.

Accommodate different data volumes

> It is important to accommodate the fact that some patients actually have decades of data, and some patients only have a few minutes of data when they arrive in an emergency room," Rajkomar said.

Account for time. "If you get Ceftriaxone, Ciprofloxacin, and Flagyl all at one time, it means something very different than if you get those antibiotics spaced out over time," Rajkomar said. The data input representation needs to encode the time element, as it is an important piece of temporal information that leads to accurate predictions.

Include clinical documentation. Critical patient information is often found in the free-form clinical notes. As such, it's important to include these notes, not just structured information in ML.

By taking these steps, healthcare organizations can use EHR data in ML models – making it possible to finally leverage the vast knowledge that exists in these records to improve patient care.

For more information visit the healthcare website:
https://cloud.google.com/solutions/healthcare/

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Improving the Patient Experience with Mobile Apps and APIs

In his job as Chief Application Architect at Rush University Medical Center, Modi Boutrs has the privilege of working in an organization that truly cares. “I’m so grateful to Rush for giving me the opportunity to utilize my experience to put patients first and save patient lives,” said Boutrs.

While Boutrs is committed to saving lives and improving the patient-care experience, his day-to-day life is consumed with meeting the technical challenges that will enable him to help the large, Chicago-based academic medical center get the job done. One of his recent challenges, for example, involved finding a way to get all the information that patients need to stay engaged and connected with the healthcare system to them via mobile devices.

The problem: Relying on HL7 – the widely used patient care and clinical messaging standard – to exchange and share information from multiple sources falls short when trying to develop mobile apps.

> “While HL7 works within the EHR and within the healthcare system, it does not work very well in the mobile application world,” said Modi Boutrs, Chief Application Architect, Rush University Medical Center.

To develop mobile apps that share information, developers like Boutrs need to rely on application programming interfaces (APIs) as well as Fast Healthcare Interoperability Resources (FHIR), a draft standard describing data formats and elements for exchanging electronic health records. With APIs and FHIR, “you get a highly reusable operating system. And out of the box, you get added security for communication and authorization,” he said.

Solution: My Rush app

Boutrs relied on APIs and FHIR to develop My Rush. This mobile app was designed to keep patients connected to and engaged with the healthcare organization and to easily and collaboratively manage their health and wellness. The app also supports patient journeys specific to various diseases, guiding patients to resources, tools and education specific to their conditions via context aware engagement.

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Relying on APIs and FHIR

My Rush relies on APIs to assess information from a variety of systems. This makes it possible for patients to schedule an appointment with a doctor, get directions, exchange secure messages with providers, access their own electronic health records, estimate wait time and receive test results. The app even uses APIs to interact with external systems, making it possible to schedule an Uber ride, monitor wearables such as Apple Watch, and access data from the Centers for Medicare and Medicaid Services.

The My Rush app relies on "literally – and I'm not exaggerating – over 100-plus APIs," Boutrs said. To manage this complexity, Rush is relying on Google Apigee, a centralized management platform that allows hundreds of separate systems, devices, mobile apps and third-party apps to communicate and connect via one layer.

> With the platform, "you are able to control and shape the traffic that's coming to your APIs. You could have granular access to specific services. The management platform also handles your authorization, authentication and access control," he said. What's more, it enables developers to use APIs securely and to measure API performance and usage.

"Apigee basically allows us to have a façade so our internal network does not have to be exposed to the outside world. It also enables you to monitor for malicious intent and, if needed, you can deny service. Basically, you can keep the bad guys out," Boutrs pointed out.

Leveraging analytics

Rush is also using Google Analytics to understand patients' priorities and predict their upcoming needs through intelligent application-usage tracking. "We're able to track the clicks on the screen, and we're able to track which functionality is being used more. It tells us which features the patients like; it detects how often the app is used and how many users are using the app. We're also able to know which devices are being used so we can meet the needs of that specific device as we move forward. So, we're able to cater to patients' needs," Boutrs said.

> Indeed, by using Apigee with the My Rush app, "we have enhanced the patient experience by putting the power in the hands of the patients to become the center of their own care."

Other healthcare organizations are likely to follow Rush's lead, as they acknowledge the need to go beyond simply providing patients with on-the-go-access to data. To create more meaningful digital experiences, these organizations are apt to realize just how important it is to take data out of legacy systems and integrate it in the cloud to provide patients with the contextual information that can truly enhance the overall patient care experience.

For more information visit the healthcare website:
https://cloud.google.com/solutions/healthcare/

Google Cloud

Using Kubernetes, Containers and ClearDATA to Solve the Biggest Challenges in Healthcare IT

One healthcare organization wanted to develop a groundbreaking application in record time. Another wanted to distribute workloads across multiple clouds so that it could take advantage of various services such as the analytics tools in the Google Cloud Platform.

Complex problems, but these healthcare organizations were able to meet these challenges by turning to containerization, according to Matt Ferrari, Chief Technology Officer at ClearDATA.

Container transformation

Containers can transform the way developers deploy and manage applications while maintaining the highest levels of security. Not surprisingly, containers are becoming a popular choice for healthcare organizations looking to quickly move forward with innovative applications. More than 50 percent of global organizations will be running containerized applications in production by 2020, according to Gartner Research.[1]

As such, an increasing number of developers are also leveraging Kubernetes — an open-source container-orchestration system for automating application deployment, scaling and management — to manage all of their containers.

> In fact, 83 percent of the 2,400 developers and IT professionals who participated in a survey conducted by the Cloud Native Computing Foundation cited using Kubernetes as a container management tool.
>
> The survey also found that 58 percent of respondents are using Kubernetes in production, while 42 percent are evaluating it for future use.[2]

Because Kubernetes automates application testing and deployment, healthcare organizations can reduce time to market and offer more transparency into production pipelines.

> Kubernetes solves one of the biggest challenges in healthcare IT: the time it takes to deploy a new application or expand an existing one. With Kubernetes, users can dynamically deploy new containers on demand with a simple API call," wrote Ferrari in a blog titled *Kubernetes Compliant Solutions Enable Healthcare Innovation*.

"These deployments incorporate an organization's existing security and compliance rules around the implementation, removing the need to individually configure security and compliance post-deployment. Healthcare organizations simply spin up new container clusters and deploy their code, leveraging the platform to launch new applications in a fraction of the time."[3]

Scalability and efficiency

ClearDATA's Kubernetes solution enables healthcare and life sciences organizations to use cutting-edge container technology across multiple cloud platforms, including Amazon Web Services and Google Cloud Platform (GCP) while viewing the state of compliance against HIPAA, GxP, General Data Protection Regulation (GDPR) and other common standards and regulations. In addition to improving scalability and efficiency, ClearDATA's Kubernetes provides healthcare developers with a secure way to develop, deploy and scale applications while minimizing risk.

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> While containers are not new, having a fully managed way of deploying compliant containers in the cloud using Kubernetes is groundbreaking, and we are excited for healthcare organizations to take advantage of this game-changing technology," Ferrari said.

The ClearDATA solution makes it possible to take advantage of Kubernetes without having to worry about the security risks associated with open source, public hosted environments.

More specifically, by using ClearDATA's Automated Safeguards for Kubernetes, healthcare organizations have access to the container orchestration to dynamically deploy new containers on demand; monitor the health of each container for threats and seamlessly roll back faulty application updates to a previous version; and avoid systemwide downtime, ensuring secure continuous access to patient data.

Security

Automated Safeguards protect personally identifiable information (PII) and protected health information (PHI) throughout an application's entire lifecycle by detecting and remediating non-compliant activities. A compliance dashboard works alongside the automated safeguards so that developers can map a specific regulation back to an asset inside of the cloud.

As such, a public-facing cloud-storage bucket that contains PHI will not only be detected and remediated, but the incident will also be noted in the dashboard, which can be used as a record of compliance evidence, according to ClearDATA.

> Kubernetes makes it much easier for healthcare organizations to containerize applications, run various tests on them in an automated fashion and launch them into production. This enables organizations to move forward with innovative solutions.

[1] Petty, C., *6 Practices for Creating a Container Platform Strategy*, Gartner, October 31, 2017, https://www.gartner.com/smarterwithgartner/6-best-practices-for-creating-a-container-platform-strategy/.
[2] Kaitlyn Barnard, *CNCF Survey: Use of Cloud Native Technologies in Production Has Grown Over 200%*, Cloud Native Computing Foundation, August 29, 2018, https://www.cncf.io/blog/2018/08/29/cncf-survey-use-of-cloud-native-technologies-in-production-has-grown-over-200-percent/.
[3] Ferrari, M, *Kubernetes Compliant Solutions Enable Healthcare Innovation*, ClearDATA, https://www.cleardata.com/blog/kubernetes-compliant-solutions-enable-healthcare-innovation/.

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Saving Lives by Bringing Precision Medicine to Patients

Precision medicine appears to be exactly what cancer patients need. The results of the NCI (National Cancer Institute) – MATCH (molecular analysis for therapy choice) precision medicine trial, which were presented at the 2019 American Society of Clinical Oncology Annual Meeting, showed that a drug combination designed to target cancers with certain BRAF gene mutations was effective in in 35 patients with 17 distinct tumor types.[1]

Therefore, it would stand to reason that patients would opt for the precision medicine route. However, here's the problem: Because the gene sequencing required to implement precision medicine treatments is such a complicated endeavor, patients typically need to wait up to six weeks to get such treatments started – and this delay brings tremendous risk.

> So, if you or a family member is diagnosed with cancer, do you choose immediate conventional therapy, or wait three to six weeks to receive precision medicine?" asked Takayuki Yoshino, Director for the Department of Gastroenterology and Gastrointestinal Oncology and Head of the Clinical Research Coordinating Division at National Cancer Hospital East in Japan.

That's a difficult question to answer "as waiting three to six weeks is a very long time if you have cancer." The decision, however, needs to be balanced with the fact that survival rates are significantly better with precision medicine, and "some patients might even be cured, even those diagnosed with advanced stage cancer," Yoshino said.

The current routine

Currently, in order to initiate precision medicine cancer treatments, healthcare providers must conduct a patient visit, obtain tissue through a biopsy, and then render a pathological diagnosis, all of which takes one to two weeks. However, the creation of additional tissue slides and next generation sequencing (NGS) — a non-Sanger-based, high-throughput DNA sequencing method used to determine a portion of nucleotide sequence of an individual's genome — does add another two to four weeks into the process. While NGS is much faster than the previously used Sanger method, which required more than a decade to sequence a single gene, it still "takes too much time," Yoshino said. "It takes two to four weeks to simultaneously manage the more than 100 genes needed for each patient."

The SCRUM-Japan GENESIS Virtual Sequencing Project is addressing this challenge. Through this nationwide cancer screening initiative, more than 270 hospitals, 17 pharma companies, and 50 clinical trials are joining together to create a large-scale database composed of patient history — including clinical, medication, chemotherapy, and treatment history — as well as specimen history, adverse-event details, inspection results, medical images, and genetic information.

[1] Salama AKS, Li S, Macrae ER, et al. Dabrafenib and trametinib in patients with tumors with BRAF V600E/K mutations: results from the molecular analysis for therapy choice (MATCH) Arm H. Presented at: 2019 American Society of Clinical Oncology Annual Meeting; May 31-June 4, 2019; Chicago, IL. Abstract 3002

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Developing a virtual sequencing method

The project's researchers are relying upon artificial intelligence algorithms to support a virtual sequencing method identifying and categorizing cancer genome alterations based on pathology images. To create these algorithms, FFPE (Formalin-Fixed, Paraffin-Embedded) section-image and genome-analysis results are collected. Data is then used to train and verify the accuracy of the algorithm. With these virtual sequencing algorithms, it is possible to sequence genes in a matter of minutes or seconds. As a result, two to four weeks is shaved off from the current precision medicine clinical course by eliminating NGS sequencing. In addition, virtual sequencing cuts the thousands of dollars associated with NGS for each patient out of the equation.

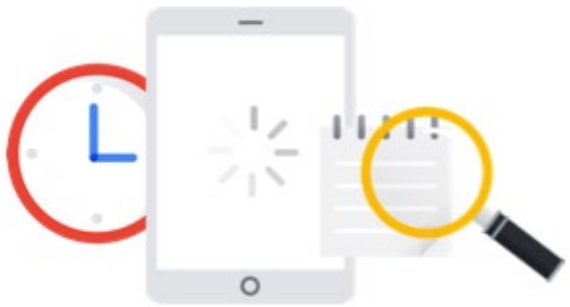
Confidence in the accuracy of the virtual sequencing is high. "Preliminary results show AUC .94, which means near perfect concordance between the NGS sequencing and the virtual sequencing," Yoshino said.

Turning to the cloud

Because of the significant volume of medical images and genome information, the project requires large storage capacity as well as "GPU intensive calculation." According to Ayatoshi Yoshizumi, Cloud Ace Chairman, the Google Cloud Platform makes this "mission-impossible" project possible by offering:

- ready-to-use servers, available at any time;
- a large number of graphics processing unit (GPU) nodes worldwide;
- a high level of security, capable of protecting medical information; and
- an excellent cost-performance balance compared to other cloud services.

In essence, the core infrastructure of the Google Cloud Platform makes it possible to securely access data, while the cloud services and application layers enable "providers and researchers to ask and answer new questions using the information they have," said Arie Meir, Google Cloud Product Manager. As such, the Japan SCRUM team is able to "essentially use data from the medical and pathology images that is equivalent to genetic information," which in turn is helping to "save time and help reduce anxiety for cancer patients" as they seek to undergo personalized medicine treatments. In the final analysis, the clinical value of virtual sequencing will be experienced by patients as the path to precision medicine treatments becomes much easier to traverse.



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Tackle Precision Medicine's Big Data Challenges

In the 18th Century, if a patient had what is now known as leukemia, it would be diagnosed as a "dysregulation of the second humors." Such a diagnosis was correct but not very precise. As a result, the treatment would be "completely wrong" and "would not help the patient," said Paul Avillach, MD, an Assistant Professor at Harvard Medical School.

The good news is that the industry has moved towards more precise diagnoses and, therefore, more effective treatments over the past few hundred years. Consider the progress that has been made with leukemia: "Fifty years ago, there were four main diagnosis of leukemia — acute, chronic, myeloid, and lymphoblastic leukemia. Today there are more than 400 diagnoses," Avillach said. These more precise diagnoses, in turn, make it possible for providers to administer more effective treatments.

Plenty of potential

The potential associated with precision medicine is clearly illustrated in the widely publicized case of actor Angelina Jolie. With a family history of breast cancer and genetic testing revealing that she had a mutation in her BRCA1 gene, the mother of six discovered that she had an estimated 87 percent risk of breast cancer. As a result, she decided to undergo a double mastectomy. "That's a perfect example of precision medicine" making it possible to "decide what to do and to actually receive treatment before getting the disease," Avillach said.

Jolie's experience is not the norm, though, as the healthcare industry is still only scratching at the surface of precision medicine's potential. For example, a more precise diagnosis has prompted healthcare providers to identify more cases of autism than ever before.

> "One boy out of 54 has autism. Is there more autism today than there was before? No, it's just that we have a more precise diagnosis," Avillach said.

These diagnoses, however, are not precise enough. "We still don't have any treatment, because we can't find the subgroups. So that's what we're working on," Avillach said. Similarly, precision medicine could have a significant impact on chronic obstructive pulmonary disease, the third-leading cause of death in America, if researchers could "find the subtypes that enable the treatment that would work for each patient."

Significant data demands

Identifying more precise diagnoses and creating more effective treatments requires working with vast amounts of data. "For example, sequencing the full genome of a patient [requires] one terabyte of data," Avillach said.

Developing precise treatments for patients is also a time-consuming endeavor, according to Aarno Palotie, MD, Research Director of the Human Genomics Program at the Institute for Molecular Medicine in Finland. "It's hard to find the right treatment for the

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right patient. It's also hard and too slow to develop any treatment. From discovery to clinical practice takes too much time," he said.

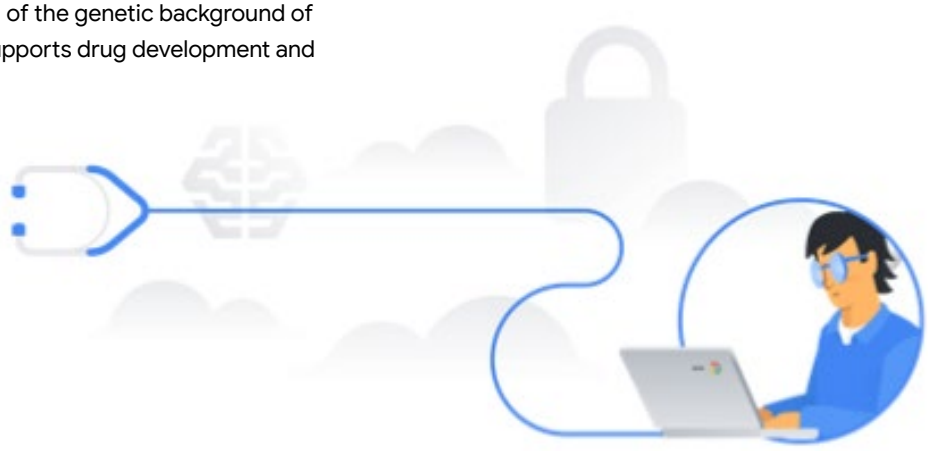
The country of Finland is in a unique position to help move precision medicine efforts forward. The Nordic country was founded by a small number of settlers thousands of years ago — and it has almost quadrupled in population in the last 200 years without significant immigration. This has created a "genetic bubble," where there is little genetic variation and a population that shares disease-free genes. Considered a "homogenous isolate," the population "is of special interest when thinking of how to develop new drug targets so that we can have a better understanding of potential side effects," Palotie said.

The country also has collected extensive patient data. Every time a citizen purchases a prescription, sees a provider, or is admitted to the hospital, "the information goes into a central location. This was originally built for administrative purposes, but it has become a rich source for research," he said.

The FinnGen research project is taking advantage of Finland's unique characteristics and is integrating genomic information with existing health outcome data to create a data repository designed to improve the understanding of the genetic background of diseases. It also supports drug development and the implementation of precision medicine in clinical practice. The project is seeking to analyze up to 500,000 unique blood samples, collected by a nationwide network of Finnish blood banks.

With Google Cloud, it is possible to manage this large volume of data; perform analysis that can lead to better decisions; leverage artificial intelligence and machine learning capabilities; and support collaboration. One of the specific challenges associated with this project is to find a way not only to combine data from multiple sources but also to provide access to this data in a secure manner. Because the project is working with the data of an entire nation, it became "obvious that it can't be stored in a nonsecure environment," Palotie said. "The data has to be in a safe environment where you cannot download it, but you can access it and analyze it within that environment. That's clearly where Google Cloud is providing the most secure option and the most opportunities to build this system."

As precision medicine moves toward becoming the norm rather than the exception, an increasing number of organizations will find themselves working with large volumes of data. And, In the final analysis, the success of precision medicine initiatives will hinge on a healthcare organization's ability to optimally manage a large amount of data in a secure environment.



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Kaiser Permanente Looks to Enhance the Patient Experience With APIs

While traveling for business, Bryan Hooper was running behind schedule and needed a pick-me-up. So, he tapped into his Starbucks app, which quickly pointed him in the direction of the nearest café and also sorted through his history — making it easy for Hooper to order the exact coffee drink he wanted. Ten minutes later, he walked into the café and immediately picked up his order. Hooper was happy with this simple, seamless experience.

Kaiser Permanente is looking to provide similar customer experiences for its members. To do so, Kaiser is internally developing "some really cool innovative products ... like connected wheelchairs," said Hooper, who serves as Senior IT Manager at the California-based healthcare system.

In addition, Kaiser is tapping into "a broad spectrum of other third-party platforms," he said. For example, Kaiser is interested in leveraging solutions such as Nightwatch, a high-tech bracelet that epilepsy patients wear on their arms. "Folks who have severe epilepsy have a very high mortality rate, especially when they go to sleep. So, this bracelet tracks their sweat and other activity markers." With the band, which sounds an alarm in the event of a seizure, patients have a 4 in 5 chance of surviving an epileptic attack, compared to just 1 in 5 without the band.

Dealing with all types of data

The challenge for Kaiser, however, is to find a way to optimally use all of the third-party data that IoT devices collect. As such, Kaiser needs to look beyond its traditional computing paradigm, which "for years and years" exclusively focused on connecting internal systems," Hooper said.

> Kaiser is now moving forward with an application programming interface-first strategy. With this new paradigm in place, Kaiser seeks to rely on core systems to seamlessly connect:
> - all constituents, including members, providers, pharmacies, regulatory entities and the supply chain;
> - devices that digitally enable healthcare workers to communicate with wheelchairs, equipment with trackers, and refrigerators with sensors; and
> - an IoT/ecosystem with patients across all channels, using technology from Fitbit, Apple, Google, and others.

The challenge is to develop the APIs that will enable Kaiser to leverage the data needed to enhance the overall care experience. Consider the following example: Kaiser is using sensors to test air quality. To make this information useful, though, the health system needs to "send notifications to those folks who

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have respiratory issues," Hooper said. As such, Kaiser needs to tie the air-quality testing devices "back to our core systems in an easy and seamless manner."

Data considerations

While APIs make such connectivity possible, Kaiser is finding that it's important to take the following into account:

Data security. "We have to be very sensitive as to how the data is being used when exposed," Hooper said. Exposing data can result in a "huge negative impact. So, while we want to deliver better experiences, we need to make sure we are doing so with caution."

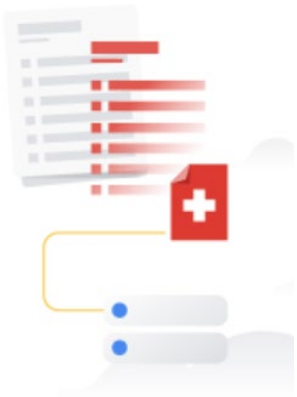
Speed and scale. Kaiser already has more than 1,000 APIs in place, and "85% to 90% of those are all internal," Hooper said. As the health system works with additional third-party IoT devices, the number of APIs could grow to more than 3,000. "The challenge is to manage not only the scale associated with that growth but also the speed at which all of these new services and new platforms are being delivered."

Member experience. Kaiser is developing APIs as a means to provide better overall patient care experiences to its members. "This is a challenge and this is an opportunity...to help drive our growth and our membership," Hooper said.

To support API development, Kaiser is using Google Cloud Apigee, a platform used to design, scale, and secure APIs. Google Cloud Apigee is enabling Kaiser to unlock the power of data by providing API management services such as a developer portal, an API gateway, and API lifecycle management and analytics capabilities. The platform is permitting Kaiser to experience the following benefits:

- Freedom from back-end policy creation development
- Self-service access
- Increased operational efficiency
- Acceleration of digital transformation
- Kaiser positioned as a player in the device ecosystem
- Ability to scale cloud-native applications

As such, Kaiser is now capable of developing secure APIs in hours, instead of months, as 80% of use cases are addressed by prebuilt patterns in Apigee. This efficiency is expected to produce 75% cost savings. Most importantly, with an API first strategy in place, Kaiser is able to optimally tap into data emanating from both internal and external devices and systems to create satisfying customer experiences.



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A Data-Driven Approach to Solving the Opioid Crisis

The opioid crisis has become a national emergency. The statistics illustrate the weight of the situation:

- 2.4 people million suffer from opioid use disorder.[1]
- The economic cost of the opioid crisis exceeded $1 trillion from 2001 to 2017.[1]
- There were 47,000 opioid related deaths in 2017.[2]
- Total care for patients who experienced an opioid overdose between October 2017 and October 2018 resulted in $1.94 billion in annual hospital costs across 647 healthcare facilities nationwide, according to a Premier Inc. analysis published in 2019.[3]

Dealing with the situation places a formidable burden on front-line healthcare workers such as Meera Kanhouwa, MD, who spent almost 20 years working as an emergency department physician.

"I have physically laid hands on 80,000 patients. I've seen every aspect of the opiate situation from point of injury to heroin overdoses to death in my emergency department," said Kanhouwa, now Managing Director of Government and Public Services for Deloitte Consulting.

> "There's nothing that's more painful than trying to tell somebody at 3 in the morning who's begging and crying for 350 milligrams of Demerol that he or she can't have it because you know they are on the road to addiction. It's a very difficult and complicated situation to deal with from a provider's perspective."

Digging into the data

Making better use of data, however, could help. "In an industry where our data is growing at the rate of petabytes per year, we on the front lines taking care of patients are data poor. Imagine that irony," Kanhouwa said.

Working in cooperation with Google and DataStax, Deloitte created Opioid360, an analytic solution that synthesizes de-identified data from disparate and siloed sources to provide insight into opioid crisis. The solution relies on MissionGraph, an interactive, cloud-based tool to identify connections across large, disparate datasets, which makes it possible to discover real-time, actionable insights.

Three major areas of data are fed into this system:

- Google analytics and ads data, which include targeted ad keyword searches indicating the level of interest in opioids
- Lifestyle data, which includes personal indicators (i.e., exercises regularly); financial indicators (i.e., owns home); and regional economic-growth indicators
- Public data, which includes medical claims, emergency department visits, and prescription monitoring program information drawn from 30 datasets with up to 5,000 data elements

The solution not only brings together these different types of data but also deploys artificial intelligence and predictive modeling to provide the insight that can empower providers to take tailored interventions matching the medical needs of opioid addicted patients.

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More specifically, the tool makes it possible to identify who is at risk for opioid addiction. "Imagine you're in an emergency department, and you get two people who both come in with back pain. Both of them have been prescribed Percocet, Ativan, Flexeril — whatever the cocktail du jour is. It's impossible to know who's going to be at higher risk of addiction [at the point of care], but that's also the best time for a provider to intervene," Kanhouwa said.

Comprehensive data informs treatment

The problem is that medical data alone is not enough to determine the level of risk. Consider the following example: When working with just medical data, analysis shows that "Persona A" has a 15 percent risk of addiction, while "Persona B" has a 13 percent risk. Adding lifestyle and financial data into the equation, however, changes the analysis considerably. When it is discovered that Persona A patients tend to be married, have children, own their own homes, eat healthily, exercise, and live in economically growing areas, the risk for addiction is reduced to just 3 percent. And, when considering that Persona B patients tend to have a high rate of divorce, don't eat healthily or exercise, and have a high level of financial stress, their addiction risk increases to 45 percent.

Opioid360 also makes it possible to understand specific barriers to care, leading to timely and effective interventions. One of the main problems with opioid addiction is that only two of 10 people receive the treatment they need. "Social determinants of health are 80 percent of the equation," Kanhouwa said. And, by providing insights into where patients live, where they work as well as their sleep, diet and exercise habits, Opioid360 enables providers to implement more effective treatments.

> The country is spending a fortune on treatment but people are not getting it. So, we need to know the barriers. Unpacking that and understanding the barriers to care is an important issue for the nation. said Sean Conlin, Principal for Analytics & Cognitive Government and Public Services at Deloitte Consulting.

For example, something as simple as lack of access to transportation could be preventing a patient from receiving needed care. Opioid360 makes it possible to understand who is at "risk and what's worked, what interventions have been successful for people who fit into personas, and which ones have not been. So, you can more intelligently make decisions around resource allocation."

By capturing data from a variety of sources, healthcare organizations can better understand the full picture of that patient's lifestyle and help with the opioid crisis. And, perhaps most importantly, healthcare organizations can gain the insights that will make it possible to more effectively address, and ultimately eradicate the crisis.

[1] Altarum. Economic Toll of Opioid Crisis in U.S. Exceeded $1 Trillion Since 2001. https://altarum.org/news/economic-toll-opioid-crisis-us-exceeded-1-trillion-2001
[2] Centers for Disease Control and Preventions. *Drug and Opioid-Involved Overdose Deaths – United States*, 2013-2017. https://www.cdc.gov/mmwr/volumes/67/wr/mm675152e1.html
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Tapping into the Value of Unstructured Clinical Notes

Healthcare organizations work with a variety of data streams, including medical imaging, pathology, claims, and genomics information — plus a complex mix of data types as well. Bringing all of this data together, and deriving value from it, is challenging but doable, thanks to an array of standards that make the data recognizable. In fact, healthcare organizations can access this data, place it into files, and start making sense of it by running it through analytics engines.

Data that resides in electronic health records is one of the most valuable, albeit difficult data types to work with.

> The clinical note is supposed to be the repository of the physician's decision-making process. The evidence that they found, how they did the differential diagnosis, and what the treatment plan is for the patient isn't really captured anywhere else," said Marianne Slight, Product Manager for Cloud Healthcare at Google. "In terms of messiness, I think EHR data, and particularly clinical notes data, is some of the messiest and hardest to extract real value from when you are trying to integrate multiple sources of data together," she said.

Dealing with difficult EHR data

Clinical notes are difficult to work with because of a variety of challenges, such as:

A lack of uniformity. "The notes physicians write as they document progress for an acute stay, or discharge, come through in lots of different formats. These notes can be structured or unstructured," Slight said.

Difficult-to-decipher abbreviations. "There are many abbreviations in the notes. Often some of the abbreviations are in Latin as well. So, it's not really obvious as to how you go about extracting the clinical meaning," she noted.

Too much information. In many cases, clinical notes run long. "So, there's a lot of information to plow through," Slight said. Clinical documentation often contains many different notes as well. "The most common example of this is within the ICU, where patients typically stay for a longer period of time."

Tricky formats. Tabular data, for example, can be difficult to understand. What's more, different headers might offer different information about a note, "but that needs its own special parsing," Slight said.

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Copied notes. Instead of entering new notes, physicians often cut and paste notes into the EMR. In fact, research conducted at the University of California San Francisco Medical Center analyzed 23,630 notes written by about 500 clinicians and found that in a typical note, almost 50 percent was copied and another 36 percent was imported, while just 18 percent of the note was manually entered. According to the researchers, "copying or importing text increases the risk of including outdated, inaccurate, or unnecessary information, which can undermine the utility of notes and lead to a clinical error."[1]

Grooming data for analytics

The challenge for healthcare organizations is to "get this messy data into shape so that it can be used for artificial intelligence and machine learning applications," Slight said. Tools such as Google's BigQuery, an enterprise data warehouse that supports fast SQL queries using the processing power of Google's infrastructure, can help organizations meet this challenge.

To ensure that data can be leveraged for data analytics, healthcare organizations need to harmonize and align fields, terminologies and units so that data can be mapped from one system to another. Doing so can help to ensure that data is used in a standard manner. For example, "when you're in a NICU and you're measuring the weight of a neonate, typically that's done in grams," Slight said. "But when you're measuring the weight of an adult, that's typically done in pounds or kilos. And so, making sure that unit-mapping alignment happens is really critical to being able to use the data for analytics and machine learning."

Today's providers can rely on clinical entity extraction and natural language processing (NLP) to produce usable information. This extraction makes it possible to unstructured notes into "structured data or at least have them added into the clinical warehouse for analytics," said Slight. What physicians need extracted differs from what medical coders or payers or clinical documentation-improvement specialists need. As such, "one-size-fits-all" clinical extraction and NLP APIs will not work.

To address this challenge, Google provides healthcare organizations with clinical entity extraction and natural language processing APIs that can be used independently or in conjunction with other APIs — making it easier for organizations to meet various data extraction needs. Healthcare organizations can then start deriving value from all data, including the difficult-to-wrangle information found in clinical notes.

[1] Wang, M. et. al. *Characterizing the Source of Text in Electronic Health Record Progress Notes*. JAMA Internal Medicine. Aug. 2017. https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2629493

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