# What is Radical Interoperability?

The freedom to explore, create, and innovate with healthcare data

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## Making the most of standards

Achieving broad-based interoperability is an ongoing challenge for the healthcare industry.

For starters, healthcare's highly compartmentalized specialisms promote just the opposite; isolated patient interactions with multiple institutions and departments. On a typical healthcare journey patients encounter many different entities; from hospitals and GPs or primary care physicians to specialist outpatient centers, lab and testing facilities, and both private and public healthcare payers.

Each of these entities (and sometimes different facilities within the same entity) play a unique role in the clinical journey, generating patient data sets managed by specialized, and often highly customized, clinical software.

To break this data out of silos, and move towards a truly interoperable healthcare system, independent non-profit foundations, industry bodies, governments, and the private sector have all either introduced or adopted a number of interoperable data standards.

However, while healthcare data standards such as HL7 FHIR push us closer to an interoperable future, a narrow focus on merely becoming 'compliant' misses the real opportunity.

## Radical Interoperability

To capitalize on the benefits of interoperability a complete picture of the patient's health, clinical or otherwise, is required.

From blood oxygen readings collected in a primary care facility, to anamnesis forms taken by specialists at hospital or gait analysis from a patient's smartwatch, all of this data should ideally feed one centralized or distributed clinical data repository (CDR).

Interoperability is more than a check-box compliance event for a healthcare facility; re-configuring systems to accommodate interoperable data standards marks the beginning of a digital transformation journey.

Imagine extending the advantages of interoperability — the free and secure exchange of data — to the systems in your own organization:

- Serving insights and alerts to patients in real time, triggered by a clinical event or a patient's connected device.
- Deploying analytics and machine learning to assess and provide personalized care pathways for each patient based on their individual health data.

And imagine achieving this without the need to ETL data, negating the need to manage and maintain a sprawling 'spaghetti architecture' of different databases and services.

Interoperability can also facilitate streamlined communication and enhanced care coordination among healthcare providers. For instance, when different providers are able to access and exchange data easily, it can help to reduce redundant tests and procedures, prevent medication errors, and improve overall care quality.

- In part 1 we will explore why MongoDB is the ideal solution to build your interoperable data repository, and why our unique capabilities make us radically different from all others in the interoperability software space.
- In part 2, we will explore how MongoDB's Developer Data Platform empowers you to do more with your data and use your CDR to go beyond interoperability.

 

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# Part 1. An Interoperability Platform

With MongoDB, you own the underlying data store. You're free to work with whatever data standard you want - including building custom schemas of your own - and leverage the data for use cases and applications beyond storage and interoperability.

## The Document Model

MongoDB's document data model is ideal for managing healthcare data.

The document model allows you to save and retrieve data in JSON format directly in the database without needing to flatten or transform it, or record it as a string.

This feature simplifies the implementation of most common interoperability standards that model clinical data (such as HL7 FHIR and openEHR) and terminology standards (like SNOMED and LOINC).

JSON is the de facto standard used in modern application development, supporting the rich data structures and objects prevalent in healthcare, such as patient, encounter, observation, medication and more.

Documents map directly to objects in code, so they are much more natural and efficient to work with, driving higher development velocity. There is no need to decompose data across tables, run expensive JOINs to reassemble objects or integrate a separate ORM layer. Data that is accessed together is stored together, so developers have less code to write and their users get higher performance.

The document model also supports nested and hierarchical data structures, making it easier to represent complex clinical data with varying levels of detail and granularity.

With MongoDB you can store and query data with nested subdocuments and arrays, making it a better fit for clinical data models.

## True Ownership

MongoDB presents information in a human readable format. That makes documents easy for anyone to understand, even when they did not participate in the initial schema design.

As such, documents promote true ownership of the data, allowing healthcare entities to leverage the data beyond the application it was initially created for.


*This code snippet shows how MongoDB displays part of a document for a FHIR observation resource for a laboratory result with a Calcium measurement.*



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Unlike most CDR solutions on the market that act as a monolithic 'black box', CDRs built on top of MongoDB grant healthcare institutions the freedom to evolve their repository according to their future needs, without limitations to existing APIs.

## Document Flexibility

Another key benefit of MongoDB's document model is its flexibility. A document's schema is dynamic and self-describing, so developers don't need to first pre-define it in the database. Fields can vary from document to document. Developers can modify the structure at any time, avoiding disruptive schema migrations.

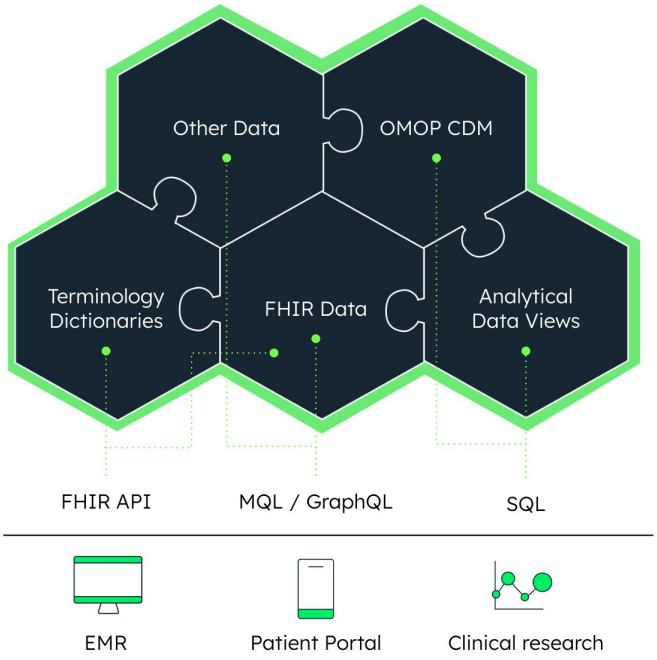
This flexibility makes it easy for healthcare providers to add or update information to clinical documents, for instance when new versions of an interoperability standard are released, or in the case of FHIR, when changes in the profile affect the data model.

With the document model, the same document can store data representing different standards and formats, allowing for a health record that is simultaneously more robust and interoperable than anything that can be stored using a relational database.

The document data model also makes it easy to map clinical data to different models like OMOP, for clinical research, without requiring a different storage and significant schema modifications or complex data transformations, unlike traditional relational databases.

You can even track schema evolution through MongoDB's Schema Versioning pattern, and adapt your applications to newer schema versions without breaking the compatibility of other applications that still use previous versions.

This will ensure that healthcare data is kept accurate and up-to-date, without the need for database reconfiguration or downtime.




In the image above you can see how separate collections or databases can run in the same MongoDB server, implementing different data models to serve the needs of any application.

Each collection can be accessed via standard APIs, like a FHIR API, or through other means, like when an application requires access to data not limited by the bounds of clinical data standards, such as a patient portal.

Developers can also access any data from the database via MongoDB Query Language (MQL), or alternatively through GraphQL.

Finally SQL experts, for instance clinical researchers that use SQL based tools, can also query data using MongoDB Connectors.

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## Scalability and Availability

Managing healthcare data often involves dealing with massive datasets, which can present significant challenges for traditional, relational database systems.

With MongoDB's horizontal scaling, healthcare providers can easily distribute their data across multiple servers, allowing for greater processing power and faster query times. By using horizontal scaling, healthcare providers can easily expand their systems as their data volumes grow, while maintaining performance and reliability, aligning application growth with a predictable cost.

Horizontal scalability also improves reliability by adding more servers or nodes to the system, which reduces the risk of a single point of failure.

## Unrivaled query performance and built-in search

In healthcare, query performance is crucial to efficiently process large volumes of complex data.

MongoDB holds data in a format that is optimized for storage and retrieval, allowing it to quickly and efficiently read and write data. MongoDB's advanced querying capabilities, backed by compound and wildcard indexes, make it a standout solution for healthcare applications.

Furthermore, the MongoDB Atlas' Lucene indexing enables efficient querying across vast data sets, handling complex queries with multiple fields. This is especially useful for Clinical Data Repositories (CDRs), which permit almost unlimited querying flexibility.

Lucene indexing also allows for advanced search features, like full text search, autocomplete, and fuzzy searching, enabling medical professionals to quickly and accurately access the information they need from any device.

## Secure by default

The security of sensitive clinical data is paramount in the healthcare industry. That's why MongoDB provides an array of robust security features, including fine-grained access control and auditing.

With Client-Side Field-Level Encryption (CS-FLE) and Queryable Encryption, MongoDB is the only data platform that allows the processing of queries on randomly encrypted patient data, providing the highest level of data security, with no impact on performance.

Additionally, MongoDB Atlas supports VPC Peering and private links that permit secure connections to healthcare applications, wherever they are hosted.

By implementing strong security measures from the start, organizations can ensure privacy by design.


*MongoDB Atlas has been independently audited and confirmed to meet compliance standards for data security.*

 

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## Large partner ecosystem

While it is possible to build a CDR from scratch, most healthcare organizations leverage existing solutions.

MongoDB is the only non-relational database and modern data platform working directly with CDR vendors like Exafluence, Smile, Firely, Better, Dedalus, Kodjin, and Conduent.

While some CDR vendors offer MongoDB as an alternative to a relational database, others like Exafluence FHIR server, Dedalus platform DC4H, and Kodjin FHIR server underpin their solution exclusively on MongoDB.

SmileCDR and Firely CDR offer MongoDB as an option, especially where scalability is a priority.

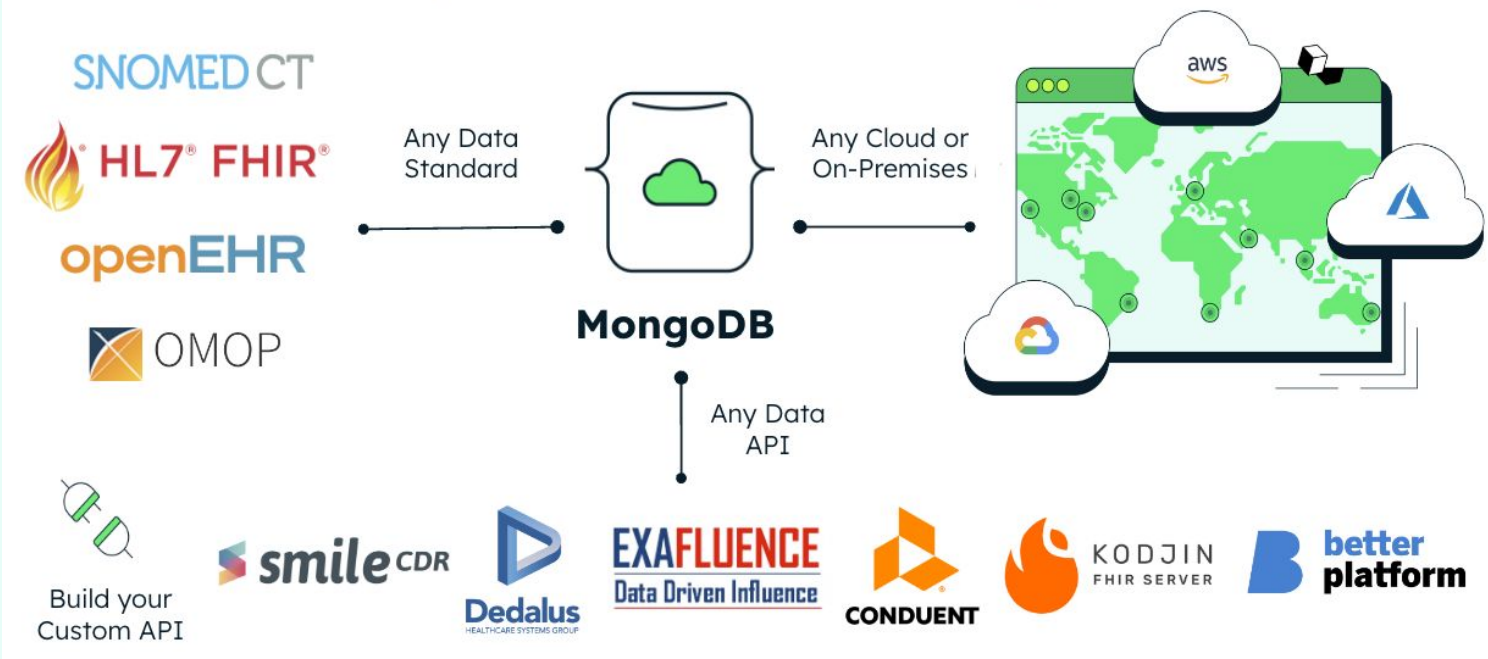
Better Platform, the premier openEHR CDR, implemented MongoDB as a fast layer database to enhance the performance of queries and accelerate the development of new applications.

Conduent iOX, another healthcare solutions provider, offers a FHIR server on top of MongoDB as part of a broader interoperability suite specifically designed for health insurance.

Recently, Exafluence has extended AWS FHIR Works, enabling payers and healthcare providers to conveniently deploy a FHIR server with MongoDB Atlas through the AWS Marketplace.

Overall, MongoDB's ability to work directly with CDR vendors and its unique approach to data storage and retrieval, already deployed and helping millions of patients worldwide.

In addition, customers can be sure that if they use a solution built with MongoDB, they always have fundamental access to, and ownership of their data, without vendor lock in.




*Storage of your data remains independent of the clinical data model you use, the APIs and vendor solutions for your CDR, and whether you decide to run on premises or on any cloud provider.*

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# Part 2. Beyond Interoperability

While MongoDB is ideal for building an interoperable clinical data repository, the platform offers so much more.

Our clients use MongoDB's inherent flexibility and built-in tools to create new products, mobile apps, and digitally transform the healthcare experience.

## Application-Driven Analytics

In a world where data is at the center of every innovative business, and real-time analytics is top-of-mind for executives, product owners, and architects alike, most data lakes and other traditional analytics processes don't deliver.

Transforming your organization into a data-driven enterprise requires a more agile approach to managing and working with ever-growing sums of data.

Copying data out of operational healthcare applications into centralized analytical data warehouses and data lakes takes time and creates a separation between analyzing healthcare events and taking actions.

Instead, analytics needs to become an integral part of the healthcare application. This integration is what we define as application-driven analytics.

With MongoDB Atlas, healthcare developers have powerful analytics capabilities that fit their workflows.

They can manage data of any structure, index, query, and analyze it in any way they want, and then archive it. All of this can be done while working with a unified API and without the need to build their own data pipelines or duplicate data.

At the same time, healthcare analytics teams get access to live application data using their preferred tools or using Atlas Charts, the native data visualization tool built for MongoDB Atlas.

They can work with this live data without interrupting the application, and have the ability to share insights with the business teams that need it.

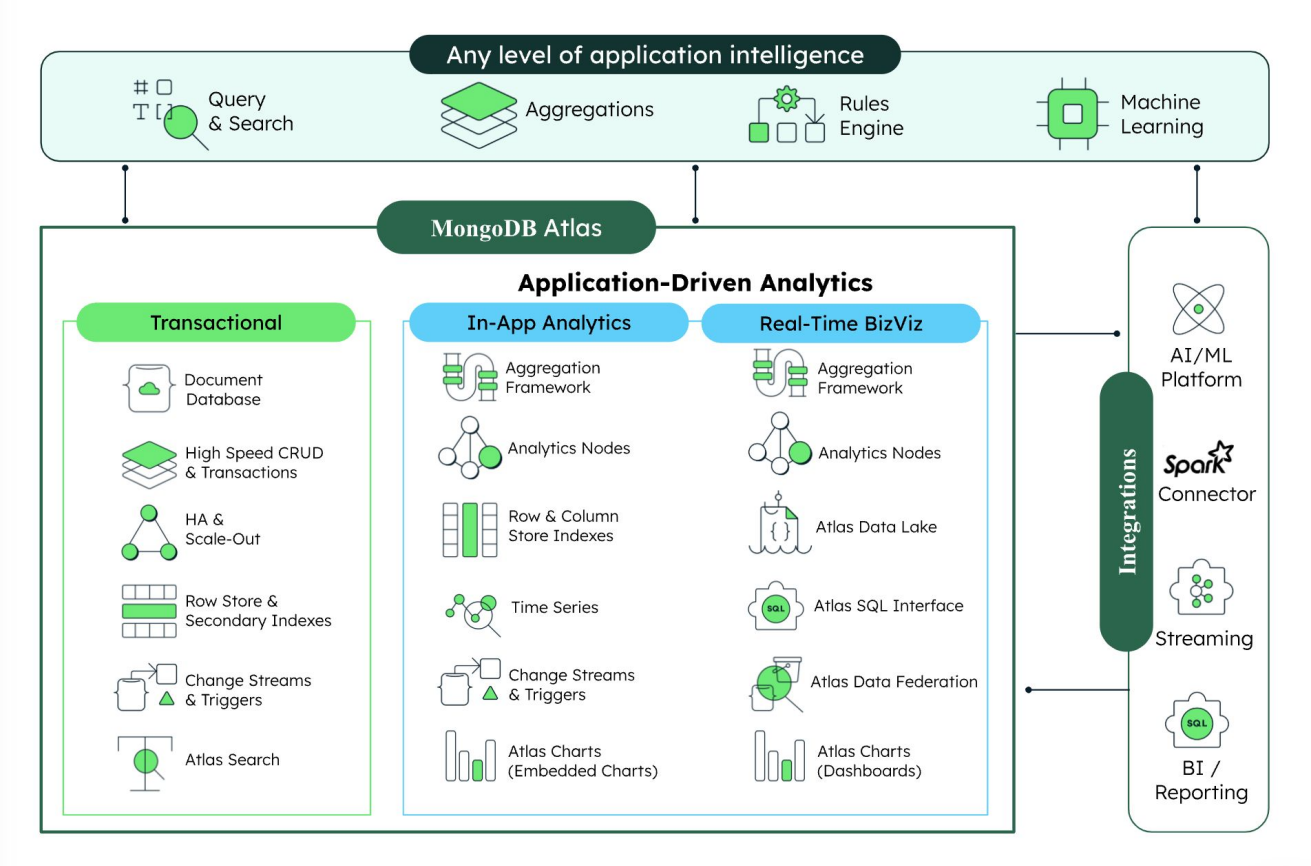
This helps healthcare organizations make more informed decisions, ultimately improving patient outcomes and reducing costs.

As shown in the figure on the next page, MongoDB Atlas unifies the core transactional and analytical data services needed to deliver application-driven analytics.

It supports any level of healthcare application intelligence, from querying and searching records to aggregating and transforming data through to feeding rules-based engines and machine learning models.

## Application-Driven Analytics Explained

Atlas automatically optimizes how data is stored, maximizing the efficiency of the application's operational and analytical workloads. These capabilities are packaged in an elegant and integrated multi-cloud data architecture.




### IoT and Time-Series Data

The Internet of Medical Things (IoMT) allows healthcare providers to remotely monitor patients using wearables and connected devices.

This empowers providers to deliver better quality care to a larger population of patients, while reducing the need for frequent in-person visits.

For example, a patient at home can report blood pressure or oxygen saturation levels. Medical staff can track, in real time, a patient undergoing hemodialysis in a hospital or home setting.

In both examples, the information can be streamed to an electronic healthcare record for aggregation and analysis, enabling physicians to make timely and impactful healthcare recommendations and treatments. MongoDB's data platform supports time series collections, optimizing storage and performance when collecting data from IoT devices.

As a result, MongoDB Atlas has become a popular choice for many healthcare providers who are building IoMT and medical device solutions, and leading companies globally who use MongoDB as the database underpinning their IoMT device platforms.



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## Build Offline-First Mobile Apps

The healthcare industry increasingly relies on mobile applications for patient interaction and care. The problem that most mobile developers face is building apps that continue to work, and later synchronize data, when the connection is dropped. For instance, when a homecare nurse is working at a patient's home and their device constantly moves in and out of network signal.

With MongoDB Realm and Atlas Device Sync, healthcare organizations eliminate the need to develop thousands of lines of code, gaining out-of-the-box conflict resolution and networking capabilities that solve these problems, providing a seamless, offline-first experience for patients and staff alike.

## Run. Anywhere.

MongoDB enables the seamless transition from on-premises, to cloud, and multi-cloud environments.

For instance, a hospital system that has patient data stored on-premises, but also uses various cloud providers for other services, can use MongoDB's multi-cloud managed platform, MongoDB Atlas, to leverage the strengths of different cloud providers. Imagine simultaneously taking advantage of AWS S3 buckets for storage, Google Cloud Platform for machine learning, and Microsoft Azure security features.

- Portability. MongoDB runs the same everywhere. From your device, to on-premises or in the cloud.
- Cloud Agnostic. Leverage the benefits of a multi-cloud strategy with no lock-in.
- Global coverage. MongoDB Atlas is available in 100+ regions across AWS, Azure, and Google Cloud.
- MongoDB Atlas for Government. With FedRAMP® Moderate Authorization, government customers can deploy MongoDB on Amazon Web Services (AWS) to use the full functionality of MongoDB

Also, with MongoDB's data federation and cluster-to-cluster synchronization, a hospital can create a flexible and cost-effective data architecture that allows for easy and secure access to patient data across all their cloud services.

MongoDB's portability ensures that the database operates consistently regardless of the environment it runs on, providing a unified experience that gives you the freedom to run anywhere - allowing you to future-proof your work and eliminate vendor lock-in.

 

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# Our Clients

MongoDB is trusted by 6 of the top 10 largest healthcare organizations in the world, and several regional and national governments, many of which have their FHIR and openEHR clinical data repositories underpinned by MongoDB.

## Humana took FHIR to the cloud and drove better patient experiences

With interoperability comes the promise of personalized patient experiences and better patient outcomes, driven by the seamless and secure exchange of healthcare data.

But large enterprise organizations, particularly those with decades' worth of legacy systems or multiple acquisitions, have a steep hill to climb. How can healthcare IT organizations effectively modernize data interoperability to enhance patient experience without compromising data integrity and security?

Leveraging the cloud-first approach with MongoDB Atlas to Fast Healthcare Interoperability Resources (FHIR) implementation, leading health insurance provider Humana avoided a rip-and-replace approach for modernizing legacy systems.

"When we attacked this problem, we recognized that it was not possible to modernize at the core platform level or within core systems to handle interoperability in a very short amount of time," Levi Bailey, Humana AVP of Cloud Architecture Healthcare Interoperability Services.

Humana tackled this problem by building a core data fabric that had the ability to both provide data from their systems of record and make them available to support additional requirements.

"It had to be something that could serve data very fast… that's where we leverage technologies like MongoDB to model out the data we're pulling from those core platforms, with this ODL layer, to store a more standardized format that is ready for consumption for interoperable APIs." Levi Bailey, Humana AVP of Cloud Architecture Healthcare Interoperability Services.

One of the design principles behind the core data fabric is that it's cloud-native. With this principle in mind, Bailey's team looked at what delivery mechanisms would be used to consume healthcare data for interoperability.

This led the team to an API-first methodology for integration. The APIs within the FHIR standard are based on RESTful protocols, which fit perfectly into MongoDB's application data platform.

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# GE HealthCare Uses MongoDB to Manage IoT Device Lifecycle

GE HealthCare, a global leader in medical technology, has turned to MongoDB to manage the lifecycle of its IoT devices, from deployment (Beginning of Life or BoL) to retirement (End of Life or EoL).

The MongoDB document model easily combines data from diverse source systems while preserving its full fidelity. This flexibility allows seamless onboarding of new customers and related data sources without requiring time consuming schema modifications.

According to Emir Biser, Senior Data Architect at GE HealthCare, MongoDB Atlas is very appealing to the team because of its effective management, built-in monitoring and backup, global vertical and horizontal scalability, built-in security, and multi-cloud support.

## Recent tests resulted in an 83% decrease in retrieval time for critical data elements.

When all these features are put together, the tech stack is designed to help healthcare providers enhance productivity by reducing the complexity and time required to manage databases, enabling faster deployment of IoT devices.

## “MongoDB Atlas is a gamechanger. This technology stack is helping us streamline commercialization and bring market-ready solutions to deliver advanced healthcare.”

Emir Biser, Senior data Architect, GE Healthcare

The team at GE HealthCare uses MongoDB Atlas to help ensure clear separation between clinical and non-clinical as permissions, sensitivity, and access differs.

MongoDB’s real-time analytics capabilities help track key device performance metrics, such as battery life and identify trends and patterns in device usage.

According to Emir, the teams using MongoDB Atlas are excited about the benefits it brings, and they are looking forward to exciting new developments in Atlas platform.

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## Italy's official vaccination passport app developed in less than 45 days

The EU Digital COVID Certificate (DCC) was introduced by the European Commission in May 2021 to help citizens move freely and safely within the EU during the COVID-19 pandemic.

Italy was one of the first countries to take part, building the platform and the app that are known today as the "Green Pass".

Green Pass is a digital or paper certificate showing that the holder has been vaccinated, tested negative or recovered from COVID-19 and is required by all workers as well as for cultural and sporting events, long-distance travel, nightlife and indoor dining in restaurants in Italy.

Sogei, an in-house company of the Italian Ministry of Economy and Finances, played a key part in this strategic project.

"When we started looking at the requirements for the Green Pass project, we knew we had only a few days to create a solution that would have to manage enormous amounts of data and equally enormous numbers of users…the scale was one more aspect that led us towards MongoDB, since the technology had already proven its flexibility and scalability." Marco Oppedisano, Head of business line Education, Interior, Health & Environment at Sogei

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## Driving Healthcare Innovation for Thailand's Leading Hospital Group

Due to the rapid growth of Bangkok Dusit Medical Services' (BDMS) network, the need for interoperability was already paramount and proved even more so several years later when COVID-19 hit.

But to achieve digital transformation they needed to start with the integration of fragmented data and siloed systems to become interoperable on a standardized platform.

Using MongoDB, BDMS were able to build the prototype software platform in just a few months.

But this was only the first step. The hospital system was looking towards a cloud-based strategy to support its data needs as well as requirements for ongoing scalability, innovation, and enhanced security.

So, when the application was ready to go into production, BDMS made the simple move from MongoDB running on-premises to MongoDB Atlas, the cloud database service, which was deployed on AWS.

"MongoDB's document model helped us quickly figure out that there was no way a relational database was going to work for us…we had so many different types of data and documents spread across the hospital network." Tinnarat Aromsuk, Director of Enterprise Data Architecture GLS

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