Transforming Slovenia's eHealth system: **a bold leap into the future**

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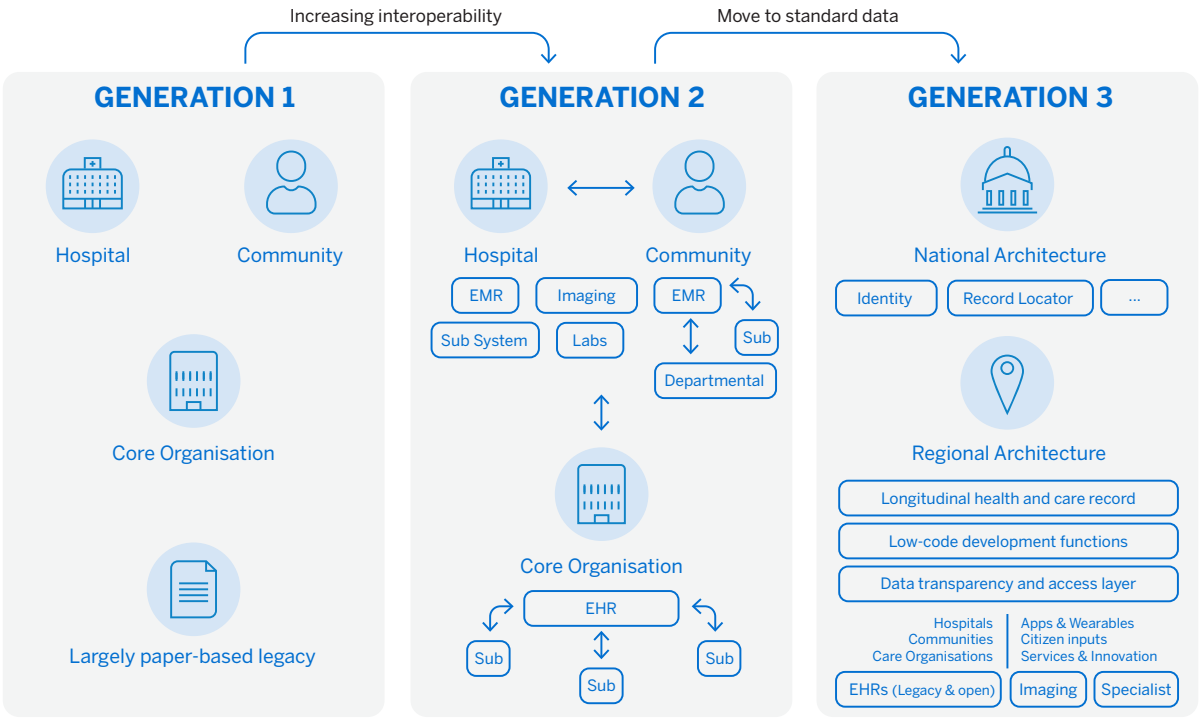
Slovenia's national eHealth system has played a crucial role in modernising healthcare practices and improving patient care. However, as the system evolved over the years, it has become apparent that several limitations hinder its full potential. In response to these challenges, Slovenia is embarking on a comprehensive eHealth system upgrades project that promises to revolutionise the way healthcare information is accessed, managed, and utilised.

SUPPORTING EMERGING MODELS OF CARE

In contemporary healthcare landscapes, the design of most systems revolves around individual organisations or Electronic Health Record (EHR) platforms. Consequently, achieving interoperability often necessitates numerous point-to-point integrations focused on exchanging information between these disparate entities. While this approach may prove effective on a smaller scale, within departments or organisations, its efficacy diminishes when deployed at broader levels, regionally or nationally. Several factors contribute to this challenge, among them legacy systems lacking standardised APIs, the continual evolution of healthcare standards, and an emphasis on technical interoperability over clinical semantics. The amalgamation of these attributes across healthcare systems results in complex, costly, and difficult-to-maintain point-to-point integrations.

Most healthcare systems today are designed around individual organisations or EHR systems, falling into either Generation 1 or Generation 2 architecture. Generation 1 systems are largely paper-based alongside some tactical systems with

siloed non-standardised data, while Generation 2 systems have improved interoperability but are typically organised around individual organisations or EHR deployments. A core component of a Generation 3 architecture is a care record that is centred around the patient — and not an individual organisation or EHR.



Tactical systems with siloed non-standardised data and low organisational reach

EHR-centric landscape with some sharing between organisations & care settings

Open data single unified record for the citizen

Source: prof. Rachel Dunscombe

THE ROLE OF SHARED CARE RECORDS (SCRS)

To address the complexities of traditional interoperability methods, one notable initiative has emerged: shared care records (SCRs). These records, which aggregate data from multiple source systems, aim to mitigate interoperability challenges and enhance collaboration among healthcare teams. Despite their widespread adoption and their benefits, SCR implementations often entail trade-offs.

For instance, data within SCR systems is often presented in read-only views, limiting the ability of healthcare professionals and patients to contribute to their records actively. Additionally, data aggregated from source systems is often displayed in static views that reflect the original system's structure rather than being organised around the patient, necessitating clinicians to navigate multiple interfaces to access comprehensive patient

information. Moreover, integrating SCR data into existing EHR systems is often complicated, requiring users to access separate applications with distinct login credentials. Furthermore, the tight coupling of external system data with SCR applications without open APIs makes third-party utilisation of integrated data difficult, limiting its potential for diverse applications. Additionally, the unstructured nature of data within SCR systems poses challenges for reusability in clinical decision support and secondary use contexts, such as research and population health. Moreover, SCR implementations typically rely on point-to-point integrations, lacking a common standard to support data exchange, thereby complicating maintenance efforts.

In summary, while SCR systems offer a promising solution to interoperability challenges, addressing the associated trade-offs is essential to fully realise their potential in facilitating seamless data exchange and collaboration across healthcare settings.

EVOLUTION OF EHEALTH IN SLOVENIA: A DECADE OF ADVANCEMENTS IN SHARED CARE RECORDS

The Slovenian Ministry of Health is driving the transformation of Slovenia's healthcare system towards a Generation 3 architecture. The introduction of the Shared Care Record, now deployed and operationalised as the Centralised Registry of Patient Data (CRPD), marks a significant milestone in the evolution of Slovenia's healthcare ecosystem. Designed to serve as a centralised repository of patient information, the CRPD stands as a cornerstone in the country's healthcare infrastructure, facilitating seamless information exchange and collaboration among healthcare providers and stakeholders. Through the CRPD, healthcare professionals gain access to a comprehensive set of patient health documents and records. By consolidating patient data from various sources and enabling interoperability across disparate systems, the CRPD enhances care coordination, promotes efficiency in healthcare delivery, and contributes to improved health outcomes for individuals across Slovenia.

The inception of the Centralised Registry of Patient Data (CRPD) initiative in 2013 marked a significant milestone in Slovenia's eHealth evolution. Initially conceived as an IHE-based

cross-enterprise solution, phase 1 of the CRPD facilitated seamless document exchange among healthcare providers, ensuring continuity of care and enhancing patient outcomes. Standardised patient and provider identification, coupled with robust privacy controls, promoted interoperability while safeguarding data confidentiality. The infrastructure enabled trusted exchange of sensitive information, strengthening governance and harmonising authentication mechanisms across a federated network of healthcare providers. As a result, healthcare providers throughout Slovenia gained access to a comprehensive document-based summary of patient information, regardless of care delivery location.

Following phase 1's success in 2013, the subsequent implementation of phase 2 in 2015 focused on addressing data quality issues. While phase 1 achieved quick wins by ensuring timely access to documents through IHE XDS, limitations arose, such as the inability to search beyond document metadata. Inconsistencies in data capture posed challenges to delivering quality care. To overcome this, the Ministry of Health (MoH) opted for a structured approach using openEHR to enhance data capture and integration. This upgrade bolstered the CRPD's capabilities by establishing a national repository for structured patient records, encompassing vital clinical information for both emergency and non-emergency care. Core clinical data, including problem lists, medication records, and surgical procedures, are

standardised and accessible across all local EHR systems via open APIs. This important step addressed previous challenges of data silos and inconsistencies, thereby promoting data quality and improving clinical decision-making.

The Slovenian Ministry of Health's adoption of an open, ecosystem-based approach to the CRPD has encouraged innovation and collaboration within the healthcare sector. A diverse range of applications, developed by external third parties, are integrated with the CRPD's common data layer. This collaborative ecosystem has facilitated the independent development and implementation of different applications, including the national patient-facing app (zVEM), e-referral services, and e-prescription solutions.

Establishing a national Summary Care Record (SCR) on an open platform offers the advantage of rapid innovation and adaptability to unforeseen circumstances. In December 2020, collaborating with the Slovenian Ministry of Health (MoH) and the Slovenian National Institute of Public Health (NIPH), the consortium swiftly delivered a national COVID-19 screening data management solution within 14 days. This solution seamlessly managed data from screening tests, locations of confirmed cases, test denominators, and evolving case definitions while upholding privacy and reliability for research purposes. It facilitated SMS notifications for citizens and inclusion of COVID-19 test results in patient summary documents. With the availability of COVID-19 vaccines, vaccination data was readily accessible from the national, eliminating the need for additional data solely for certificate purposes. The EU Digital Covid Certificate app, developed by a third-party vendor, utilised care record data, including demographic information, vaccination records, and test results, already present in the CRPD.

At the core of the CRPD's success lies its platform-based architecture, which transcends traditional health information exchange models. By decoupling data management from individual applications and implementing integration at the data layer, Slovenia has cultivated a multi-vendor ecosystem characterised by interoperability and flexibility. This approach has enabled rapid implementation and widespread adoption of the CRPD, transforming healthcare delivery across the nation over the past decade. Moreover, it has facilitated the introduction of new use cases without the traditional hurdles of interoperability, ensuring the continuous modernisation of healthcare infrastructure while maximising return on investment. As Slovenia's

eHealth journey continues, the CRPD remains the pillar of innovation, driving sustainable advancements and empowering stakeholders at every level of care.

Since CRPD's initial launch in 2013, Better has collaborated closely with the Ministry of Health to support an iterative rollout that now encompasses all citizens and healthcare providers across Slovenia. A key driver of the successful delivery has been the focus on understanding the user needs and delivering solutions that address clinicians' barriers. Additionally, a national consortium of IT vendors has been established, laying the groundwork for a collaborative and integrated approach to eHealth solutions from project inception.

Current situation

600+ million clinical records

85% documents structured

98% of the shared national health data stored on a platform

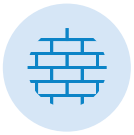
1500 health providers included

8 clinical documents per person

101 document types exchanged

26 openEHR templates used

20 M read
8 M create
transactions on average per month



WHAT WERE THE LIMITATIONS AND CHALLENGES

The existing eHealth system in Slovenia encounters several challenges due to outdated technology and architectural limitations. The demographic data infrastructure, crucial for healthcare operations, is hampered by reliance on proprietary technology and models that have not been updated for over 15 years. This lack of progress not only limits scalability but also hinders interoperability with modern healthcare frameworks and emerging standards. Additionally, the system's fragmented architectural approach adds to these issues, with disparate components using their own set of APIs, resulting in a lack of standardisation across the ecosystem. This lack of cohesion makes it difficult to integrate critical healthcare data, impeding collaborative efforts and the system's ability to adapt to evolving healthcare needs.

In the realm of integration, despite efforts to leverage the CRPD's APIs, inconsistencies persisted across various healthcare providers' systems. While each electronic health record (EHR) system successfully integrates CRPD data, the absence of standardised integration methodologies results in varied presentations of crucial healthcare information. This disparity in data representation poses significant challenges for clinicians navigating the care settings, as they encounter different renditions of CRPD data based on each system's integration approach. Moreover, the reliance on individual EMR vendors for system modifications further highlights the lack of uniformity across the ecosystem, hindering efforts towards standardisation and interoperability. As a result, healthcare practitioners are confronted with fragmented data landscapes that obstruct their ability to deliver optimal patient care.

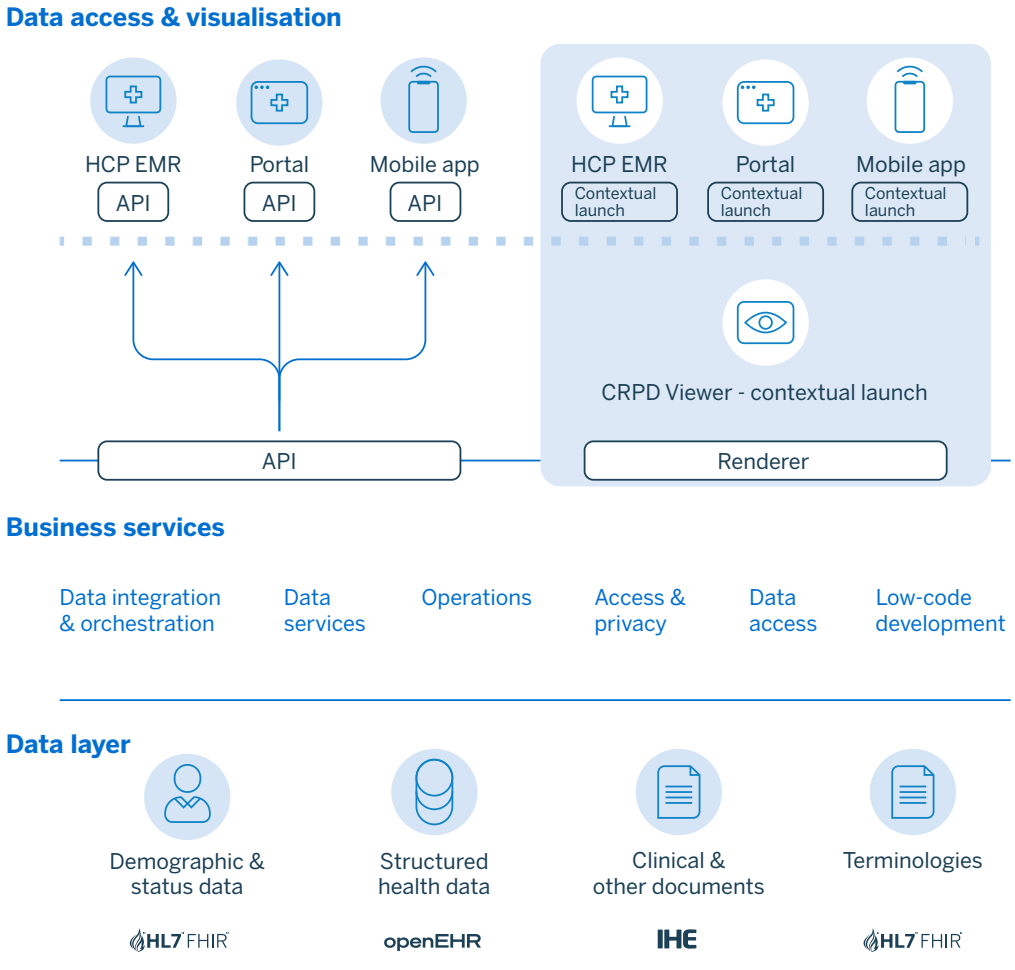
Authentication and authorisation within the eHealth system present additional hurdles, as security measures primarily hinge on user roles. This reliance on role-based access control (RBAC) introduces inefficiencies, as accessing critical data often requires traversing through multiple layers of authorisation, contributing to workflow bottlenecks and operational inefficiencies. Moreover, the system's authentication mechanisms lack granularity, failing to consider contextual factors such as the purpose of access, time, and location. This simplistic approach to authentication and authorisation not only compromises data security but also undermines user experience, as clinicians grapple with access

protocols. As a result, the system falls short of ensuring timely access to vital patient information, which affects clinical decision-making and patient care outcomes.

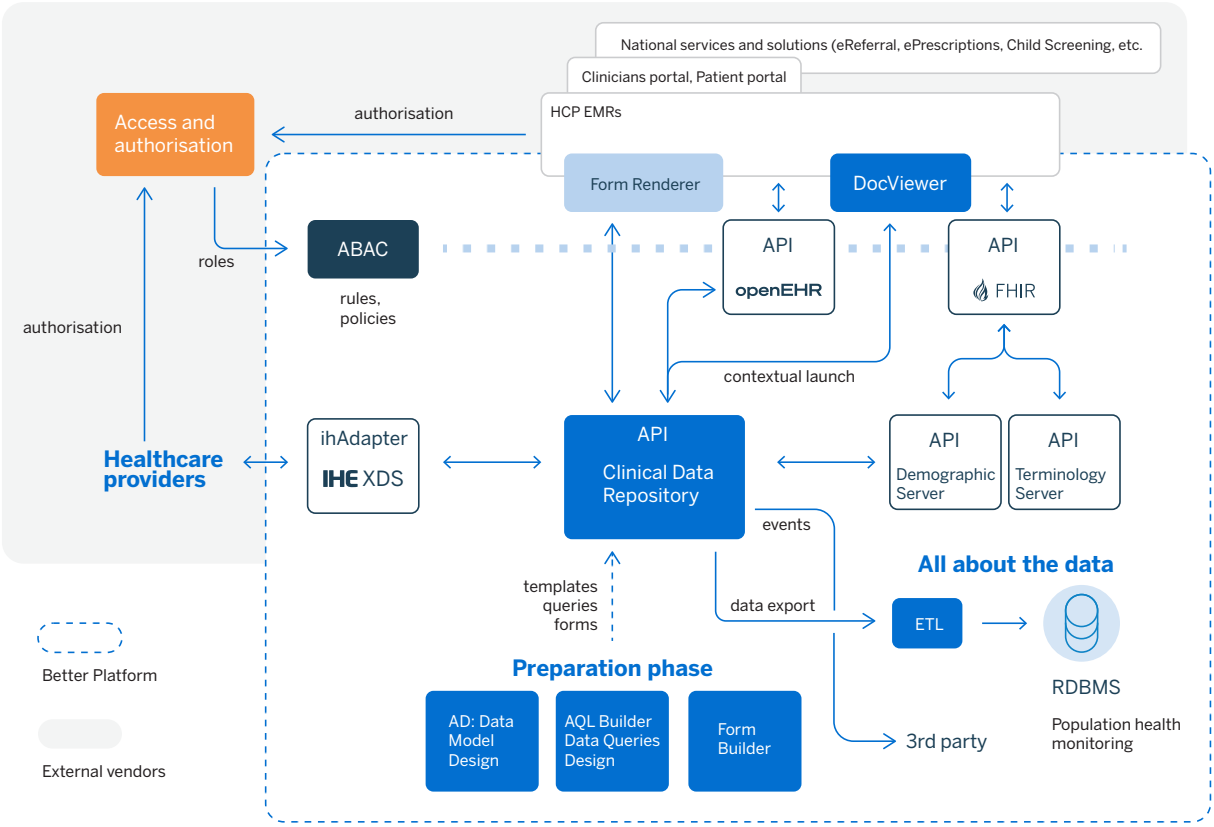
The storage of vast amounts of unstructured healthcare data within the system, comprising free-text clinical notes, narrative reports, and other unstandardised information, creates hurdles in quickly accessing, comprehending, and extracting actionable insights from this wealth of data, and clinicians often grapple with the time-consuming task of sifting through these unstructured documents.

WHAT DO RECENT UPGRADES BRING?

The deployment of a platform-based architecture has streamlined integrations across applications and vendors, with all integrations now completed at the data layer. The addition of FHIR, alongside openEHR and IHE, has significantly enhanced interoperability within the CRPD platform, fostering the development of a robust multi-vendor ecosystem. This transformation of our



national eHealth system into a digital health platform, integrating IHE, openEHR, and FHIR R4 standards, marks a significant advancement toward a future-ready healthcare infrastructure. The platform's improved interoperability and standardised data exchange capabilities are instrumental in promoting enhanced patient care, streamlined workflows, and collaborative healthcare practices.

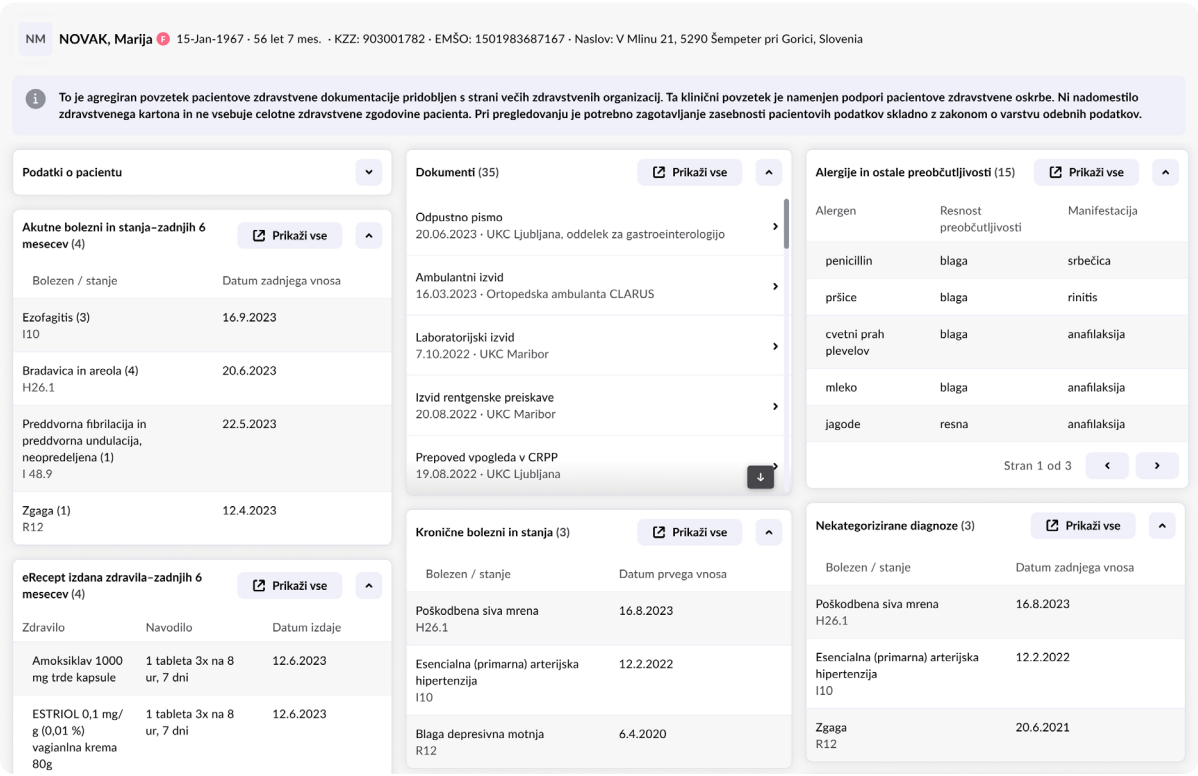


Using FHIR for demographic data

In tems of demographics data, the transition from a proprietary data repository to a FHIR R4-based approach not only modernises the system but also ensures its adaptability to future healthcare innovations. The FHIR R4 repository facilitated efficient management of patient records, practitioner details, organisational structures, care teams, and group entities, streamlining information exchange and collaboration. This repository encompasses a robust resource model implementation, leveraging core FHIR profiled resources such as Patient, RelatedPerson, Organisation, Location, Practitioner, PractitionerRole, CareTeam, and Group. It manages comprehensive data attributes and their relationships, aligning with the standardised structure defined by FHIR standards. This approach ensures the structured representation and management of critical healthcare information.

Unified view of patient records with CRPD viewer

One of the standout enhancements in this upgrade is the shift from API-based integration to a context launch model, which streamlines user interface integration by embedding the CRPD's interface directly within local EHR systems. This innovative approach eliminates the need for users to navigate through additional layers, enhancing the user experience and reducing operational complexities. With the implemented full-text search API, users can efficiently search for content within individual documents. This model offers an application canvas managed centrally and embedded within each local EHR, requiring users to sign in only once to their EHR system without the need for additional credentials. Delivered through low code tooling, organisations can take ownership of the front-end user experience and control the pace of delivery. Integrating applications with Single Sign-On (SSO) and leveraging contextual launches further enhances user experiences by enabling access to multiple applications, strengthening security through centralised authentication and access control, reducing IT overhead, and ensuring compliance with comprehensive audit trails. This integration minimises password fatigue, enhances security practices, and ensures efficient access management, fostering a more convenient, secure, and compliant digital environment.



OpenAPI and advanced access control

The adoption of OpenAPI REST interface simplifies API development, enables collaboration, and ensures comprehensive documentation and validation, enhancing the overall efficiency and interoperability of the CRPD ecosystem.

Additionally, the CRPD's commitment to data security and access control is highlighted through the adoption of Attribute-Based Access Control (ABAC). ABAC allows for fine-grained access control, taking into account various attributes, such as user identity, purpose of access, time, and location, when determining access permissions. This approach provides stricter control over data access, enhancing security and privacy. Together, these initiatives aim to foster innovation, flexibility, and security, ensuring that the Slovenian CRPD remains adaptable and responsive to the evolving needs of healthcare, ultimately benefiting both healthcare providers and patients.

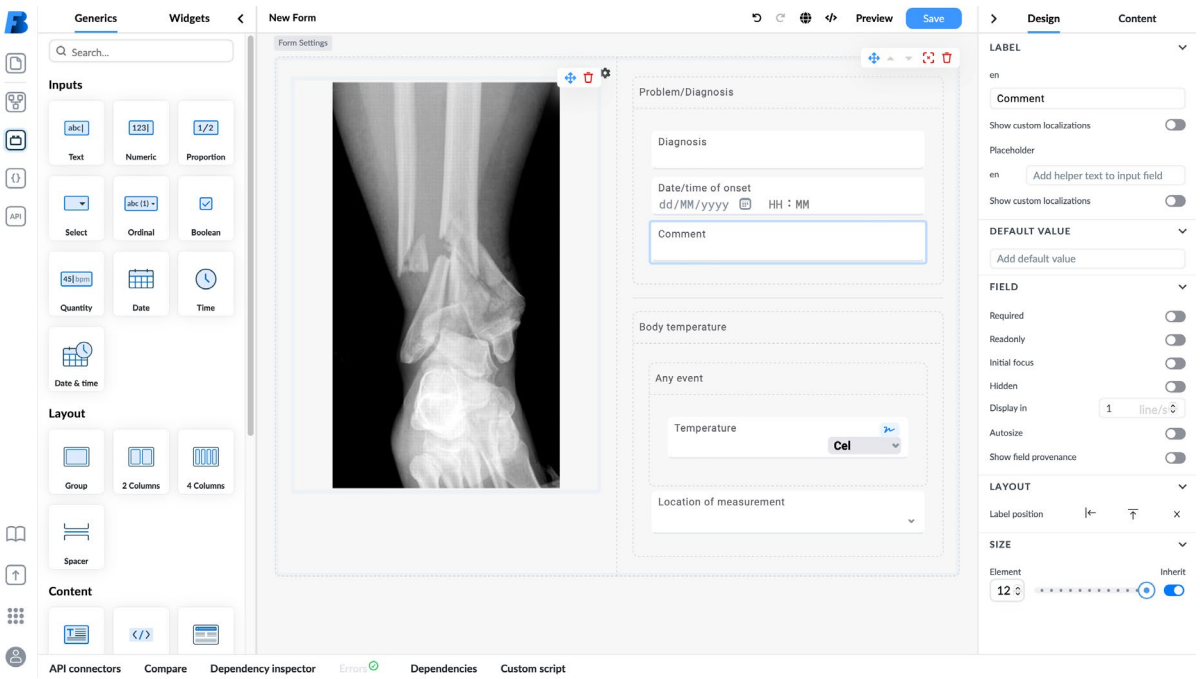
Terminology services

A national terminology server is a central repository that manages standardised healthcare terminologies, codes, and related resources within a country's eHealth system. By leveraging HL7 FHIR's robust resources and CodeSystem ValueSets, this server ensures a unified and standardised approach to terminologies, enhancing interoperability and data consistency across the healthcare ecosystem. It facilitates the precise definition and exchange of clinical concepts and information, fostering a shared understanding of healthcare terminologies among diverse healthcare entities.

Foster innovation with low-code tools

Given that the CRPD is built using a platform-based approach, the Ministry of Health (MoH) has the advantage of using the broader array of services offered by the underlying platform. Among these services is a low-code development studio, empowering non-developers to swiftly create applications based on an openEHR data model. This fosters the creation of applications and services that harmonise with the eHealth system, facilitated by a low-code development environment. By providing access to low-code tools and leveraging openEHR, diverse stakeholders can concentrate on constructing applications in

a more adaptable and scalable manner. Through the utilisation of openEHR and established design principles, the result brings new digital services that are fully interoperable and will further enrich national patient records.



Population health monitoring data service

Collaboration with the National Public Health Institute further emphasises the commitment to proactive healthcare interventions and advanced analytics. Secondary use API services facilitate the derivation of insights from extensive data repositories, enabling informed decision-making and fostering population health management initiatives. By leveraging technological advancements and nurturing a culture of innovation, the CRPD ecosystem remains agile and responsive to the dynamic healthcare landscape.

Use of AI to enhance the use of unstructured documents

In addition to the above-mentioned, recent efforts have been directed towards unlocking the value embedded within unstructured healthcare data managed by the platform. The development of a proprietary NLP engine represents a significant breakthrough, enabling the extraction of SNOMED-coded clinical codes from unstructured documents. This transformative tool empowers clinicians with actionable insights, streamlines healthcare analytics, and facilitates evidence-based decision-making.

KEY ADVANTAGES OF THE UPGRADED SYSTEM

Transitioning from health information exchange to a digital health platform brought several advantages, enhancing efficiency, patient-centric care, safety, and collaboration within the healthcare ecosystem. This transformation has significantly improved the resilience of healthcare data, fostering better patient outcomes.

- **Continuity of care**: the standardised format and patient-centric nature of openEHR ensure continuity of care across multiple settings, reducing the need for patients to repeat their medical history. The CRPD provides a comprehensive view of health information, promoting coordinated and patient-centered care.

- **Improved patient safety**: comprehensive auditing tools and data access controls facilitate real-time audits across care settings, increasing patient safety and ensuring the confidentiality of sensitive health information.

- **Streamlined data sharing**: relevant medical records are seamlessly shared among stakeholders involved in patient care, ensuring specialists have a comprehensive understanding of the patient's condition.

- **Improved data resilience**: standalone repositories ensure data availability even when local systems are offline, ensuring critical health information's continuous accessibility.

- **Improved collaboration**: the platform's modular and standard-based architecture ensures vendor neutrality, reducing dependency on any single vendor within the digital health ecosystem.

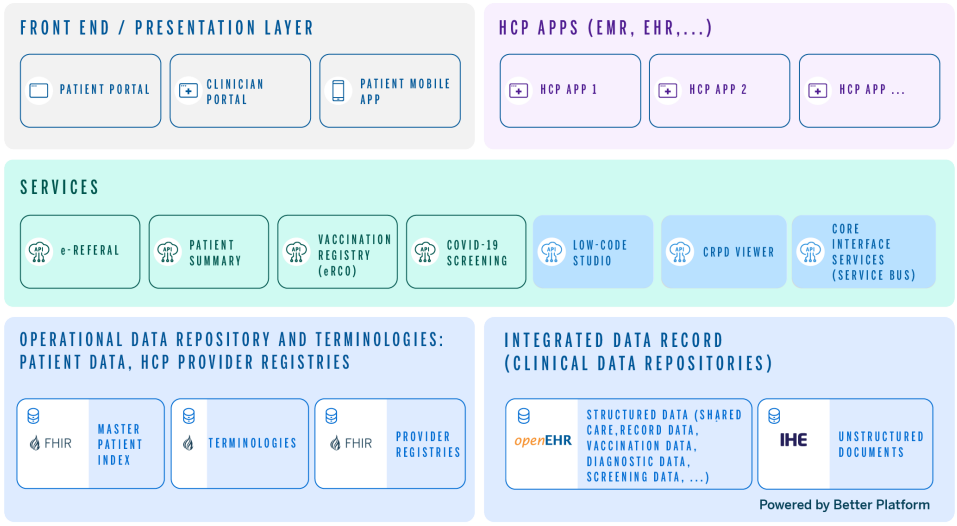
- **Patient-centred care**: integration with the national Patient Portal empowers patients with quick access and control over their shared care records.

- **Improved efficiency**: real-time collaboration among medical teams has been revolutionised through systematic and seamless data collection and management across various sites, reducing patient transfer times and minimising the need for follow-up appointments. Structured data entry supports extensive analysis, benefiting clinical practices and research activities.

ENVISIONING THE FUTURE OF SLOVENIA'S EHEALTH SYSTEM

The adoption of the CRPD represents a transformative shift in Slovenia's healthcare system. With the CRPD, Slovenia got an efficient system, centred on the patient, with the highest safety measures in place. All of this is also fostering a culture of collaboration and innovation within the healthcare landscape.

As we conclude our journey through the transformation of Slovenia's national eHealth system, it is evident that the recent upgrades have set the stage for a future defined by innovation, efficiency, and patient-centred care. It is clear that the advancements achieved through the adoption of the Centralised Repository of Patient Data (CRPD) represent a promising future for healthcare in Slovenia. As we look ahead, there are many possibilities for leveraging the technical capabilities of this digital health platform.



Here are some key areas where we envision significant advancements and opportunities in the future:

1 **Curated shared care record**: the CRPD's curated shared care record serves as the cornerstone of future healthcare delivery in Slovenia. It offers clinicians a comprehensive view of each patient's medical history, diagnoses, treatment plans, and care preferences, enabling more informed decision-making and personalised care delivery. By centralising patient data and ensuring its accessibility across care settings, healthcare providers can collaborate more effectively, leading to improved care coordination, reduced medical errors, and enhanced patient safety.

2 **Dynamic care planning options**: building upon the foundation of the CRPD, future iterations of Slovenia's eHealth system will feature dynamic care planning options tailored to individual patient needs. Clinicians can create personalised care plans that take into account each patient's unique medical history, clinical conditions, and treatment goals. These dynamic care plans evolve over time, adapting to changes in patients' health status and preferences, thereby promoting continuity of care and optimising treatment outcomes.

3 **Timeline view for holistic patient management**: the introduction of a timeline view within the CRPD offers clinicians a holistic perspective on each patient's healthcare journey. This visual representation allows healthcare providers to track key milestones, interventions, and outcomes over time, facilitating retrospective analysis, trend identification, and proactive intervention planning. The timeline view serves as a valuable tool for care coordination, patient education, and shared decision-making.

4 **Ecosystem development using the low-code environment**: with the CRPD's low-code development environment, Slovenia's Ministry of Health and national speciality groups can collaboratively build a vibrant ecosystem of digital health applications and services. The low-code platform empowers stakeholders with varying technical expertise to design, develop, and deploy healthcare solutions rapidly, without extensive coding knowledge. This democratisation of app development fosters innovation, accelerates time-to-market, and promotes interoperability within the eHealth ecosystem.

5 **Empowering clinicians with informed decision-making**: by including the possibilities of AI and machine learning to Slovenia's eHealth system, clinicians now have the tools they need to make informed decisions, improve diagnostic accuracy, and enhance patient outcomes. AI-powered monographs provide disease and problem-specific views on patient data, offering clinicians actionable insights and evidence-based recommendations tailored to each patient's unique clinical profile.

6 **Using AI and machine learning for advanced clinical insights**: the integration of AI and machine learning technologies into Slovenia's eHealth system represents a shift in healthcare delivery, particularly in the realm of natural language processing (NLP) and clinical document understanding. The advanced NLP tools, powered by machine learning algorithms, enable the CRPD to parse and analyse unstructured clinical documents with unprecedented accuracy and efficiency. These NLP tools, enhanced with SNOMED linking capabilities, enable clinicians to interact with unstructured text in a more intuitive and clinician-friendly manner, facilitating the extraction of relevant clinical information at the point of care. Moreover, AI-driven algorithms can automatically structure unstructured text, transforming it into structured data elements that can be then integrated into the patient's electronic health record.

7 **Interoperability and integration with emerging technologies**: as Slovenia's eHealth system continues to evolve, interoperability remains a core focus area. The CRPD's adherence to international standards such as IHE, openEHR, and FHIR ensures integration with emerging healthcare technologies and innovations. This interoperable framework enables the integration of advanced analytics, artificial intelligence, telehealth solutions, and remote monitoring tools, enhancing the system's capabilities and future-proofing it against technological advancements.

8 **Advanced analytics and insights**: the wealth of data now available within the CRPD presents many opportunities for advanced analytics and insights generation. With the help of artificial intelligence and machine learning algorithms, healthcare providers can derive actionable insights from vast datasets.

9 **Population health management**: with comprehensive data aggregation and analytics capabilities, the CRPD enables robust population health management initiatives. By identifying trends, patterns, and risk factors within populations, healthcare authorities can implement targeted interventions, preventive measures, and public health campaigns to improve overall population health and reduce healthcare disparities.

As Slovenia continues to embrace technological advancements, the future holds promise for further innovation, data sharing, and improved patient care within its national EHR ecosystem. Slovenia can address emerging healthcare challenges and deliver more efficient, accessible, and patient-centred care for all.

In summary, the future of Slovenia's eHealth system is characterised by a convergence of technical capabilities, patient-centricity, and collaborative innovation. The CRPD and emerging technologies it uses, Slovenia can redefine healthcare delivery, making quality care more accessible, personalised, and efficient for all its citizens. As we embark on this journey towards a digital future, we remain committed to benefiting from all the aspects of technology to make sure that every patient receives the care they deserve, whenever and wherever they need it.

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