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Towards an Electronic Health Prevention Record Based on HL7 FHIR and the OMOP Common Data Model

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Abstract. Background: Approximately 40% of all recorded deaths in Austria are due to behavioral risks. These risks could be avoided with appropriate measures. Objectives: Extension of the concept of EHR and EMR to an electronic prevention record, focusing on primary and secondary prevention. Methods: The concept of a structured prevention pathway, based on the principles of P4 Medicine, was developed for a multidisciplinary prevention network. An IT infrastructure based on HL7 FHIR and the OHDSI OMOP common data model was designed. Results: An IT solution supporting a structured and modular prevention pathway was conceptualized. It contained a personalized management of prevention, risk assessment, diagnostic and preventive measures supported by a modular, interoperable IT infrastructure including a health app, prevention record web-service, decision support modules and a smart prevention registry, separating primary and secondary use of data. Conclusion: A concept was created on how an electronic health prevention record based on HL7 FHIR and the OMOP common data model can be implemented.

Keywords. Electronic Health Records, Primary Prevention, Secondary Prevention, HL7 FHIR, OMOP CDM

1. Introduction

The life expectancy of Austria's population shows a rising trend. In 2021 it was at 83.7 years for females and 78.8 years for males, which is slightly above the EU's average (2021, female: 82.9, male: 77.2) [1]. A well established parameter for the quality of the aging society is the so-called "healthy life years" (HLY). The HLY is a measure for the expected number of years that a person – of a defined age group – can live in a healthy condition and without limitations and disabilities. In contrast to the average life

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expectancy of Austria mentioned above, the HLY are – compared to the EU – below average. In 2019, the difference of HLY at birth were 2.9 years for females (AT: 61.3, EU: 64.2) and 2.4 years for males (AT: 61.5, EU: 63.1) [2]. Impacting factors for estimating the HLY are chronic diseases, frailty, disabilities and mortality. According to the Austria Country Health Profile, approximately 40% of the recorded deaths in 2019 were due to behavioural risk factors. These include (tobacco) smoking, low physical activity, dietary risks, and alcohol consumption [3].

Prevention describes the process of avoiding or delaying the onset (primary prevention) and early detection (secondary prevention) of an illness or an adverse medical event. Preventive health interventions offered to Austrian citizens include early detection of common cancers – such as cervical, breast or colon cancer – as well as an annual preventive medical examination. The latter is comprised of early detection of risk factors for cardiovascular diseases and metabolic diseases, prevention of addictive disorders, periodontal diseases and age-related diseases [4].

The use of electronic health records (EHR) and electronic medical records (EMR) with respect to preventive health services has been widely studied in. In the area of primary intervention studies have shown that automatic reminders built on top of EMRs for vaccination and/or antibody screening [5][6][7] can have a positive health outcome. In the area of secondary prevention, predictive models have been built using existing EHR/EMR in areas including dementia [8], early detection of pancreatic cancer or gestational diabetes [9]. Wang et al. [10] investigated the use of deep learning models to detect cognitive decline from clinical notes in EMRs. Jauk et al. [11] showed how delirium in hospitalized patients can be predicted through data stored in EMRs.

Patel et al. [12] address gaps in the accuracy of EMRs regarding smoking history of patients which has an impact on potential lung cancer screenings. This is in line with the observation of Kruse et. al [13] as missing and/or incorrect data in EHR/EMRs being a main barrier in the adoption of the technology.

Our work contributes to the field of primary and secondary prevention by extending the concept of EHRs to incorporate prevention and addressing the gap of missing and/or inaccurate data on disease prevention. The concept of an EHR for prevention includes the usage of Health Level 7 Fast Healthcare Interoperability Resources (HL7 FHIR) to express various elements of the record and the Observational Medical Outcomes Partnership (OMOP) Common Data Models (CDM) to enable secondary use of data for research purposes.

2. Methods

2.1. Identifying a structured prevention pathway

A structured approach to care in a multi-professional and multi-disciplinary prevention network was chosen, based on the principles of P4 medicine [14]:

- Predictive using a risk-stratified approach
- Personalised with the individualisation of measures
- Preventive in the sense of primary and secondary prevention
- Participatory by an active involvement of the user

Following the principles of P4 Medicine, a pathway with a modular structure was designed. Each module, defining an individual action within the pathway, could be operated in person or remote using telemedical solutions. We organized workshops with stakeholders from different medical fields and analysed existing prevention programs, such as the preventive medical examination program of Austria.

2.2. Architecture of an IT infrastructure

In order to comply with and extend the standard for Austrian EHRs (ELGA), interoperability with them had to be achieved. A concept for further development of ELGA to an eHealth architecture, designates HL7 FHIR for the mapping of medical and administrative information in a finely granular and standardized form using resources, and the OMOP CDM as standardized starting point for a possible persistence scheme with the focus on processing medical data for research purposes [15].

HL7 FHIR standardized data exchange between software systems in healthcare sector using resources. There were a variety of resources, the most relevant for the IT infrastructure were:

- Patient: contains demographic and administrative information about an individual receiving care or other services which are health related.
- PlanDefinition: aims to standardize clinical decision support, guidelines and care plans in healthcare.
- CarePlan: enables a structured planning, documentation and coordination of care of patients and can be designed to be patient-centred by considering the patient's individual needs and preferences. CarePlans can be linked to other FHIR resources. This allows seamless integration with clinical data, which in turn contributes to holistic and coordinated patient care.
- Questionnaire: focuses on the standardized collection of data in the healthcare sector. These questionnaires provide a structured framework for collecting patient information, clinical data and other relevant information.
- Goal: describes intended objectives e.g. weight loss.
- DiagnosticReport: represents the set of information that is typically provided by a diagnostic service when investigations are complete.

Possible different sources, types and formats of data, related to prevention were identified. Suitable OMOP CDMs were determined for harmonisation. A data-transfer-specification was created that defines the process of extracting data from the source system, transforming it into a harmonised form and loading it in a target system (ETL-process).

3. Results

3.1. Modular Prevention Pathway

Management of prevention was identified as the core module of the prevention pathway (**Figure 1**), as it enabled a personalised view on each participant. Information exchanged via computer interfaces, e.g. from preventive medical examinations and the collection of findings from EHR/EMR, determined the further direction along the pathway. This could be enabled by a decision support module or by the assistance from a prevention nurse -

identified as a necessary role - to aid participants with advice regarding prevention e.g. to find the most appropriate intervention considering the personal environment.

Continuing from the prevention management, three branches of the pathway were identified:

- Risk assessment carried out by a physician to determine health potentials and risks.
- Diagnostic measures for early detection of diseases, attributable to secondary prevention, like different screening programs or laboratory.
- Interventions as preventive measures like physical activity, smoking cessation, nutrition, addiction management, resilience strategies, or vaccinations, attributable to primary prevention.

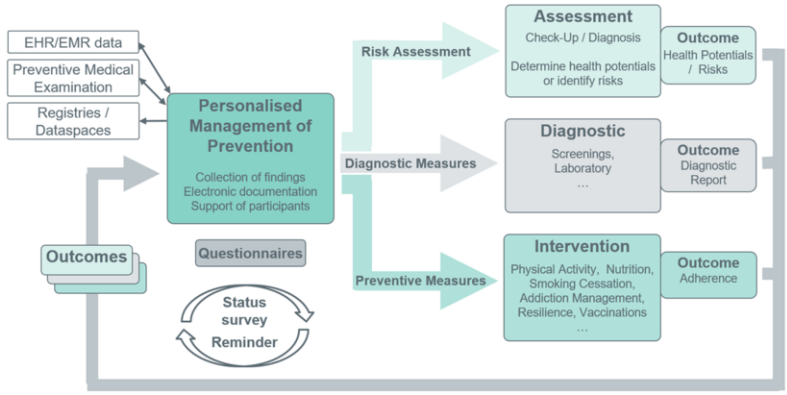

Figure 1. Overview of the prevention pathway. A personalized management of prevention module directs the way to risk assessment, diagnostic measures or preventive measures and enables questionnaires for a status survey and reminders.

For each of these branches, a specific outcome was identified to ensure measurability of the effectiveness of the action. Outcomes of previous routes were used again at the prevention management to allow even more personalised decisions for a further cycle within the prevention pathway. Possible outcomes for the aforementioned branches were a list of health potentials and risks, diagnostic reports or information about a participant's adherence with an agreed intervention (e.g. adhering to a program or vaccinations).

3.2. Architecture of IT infrastructure

The IT infrastructure for an electronic health prevention record (EHPR) has been designed as a web-based IT service that could basically be divided into the areas of primary and secondary use of data (Figure 2). The technological foundation of these services was the HL7 FHIR standard to ensure interoperability with other systems (e.g. ELGA 2.0). An HL7 FHIR server was used to store the data and offers REST interfaces to process and exchange data.

In the primary use, a web service was provided for the record itself, in which healthcare professionals could manage prevention and the associated measures for participants. This web service allowed the definition of configurable FHIR Questionnaires that could be used e.g. for anamnesis. A web-based health app was conceptualised to stay in contact with participants. Thus, the progress and results of the

prevention measures could be monitored. The IT service allowed personalized suggestions with recommendations for action to be stored for every participant. A decision support module could be utilized for automatically generated suggestions based on available data. Architecturally, these modules were separated by clear FHIR interfaces, as they are potential medical products relevant to undergo a certification process.

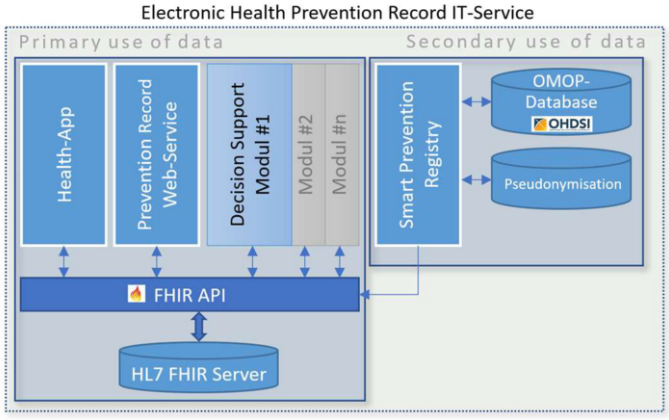

Figure 2. Architecture of the EHPR IT-Service. The primary use of data shows a HL7 FHIR server which can exchange data with e.g health-apps or prevention record web services via a dedicated API. The secondary use of data depicts a smart prevention registry, which uses a OMOP database that contains pseudonymized data, and also connects to the FHIR server via the API.

The core element of the EHPR were personalised FHIR CarePlans that were transformed from generic FHIR PlanDefinitions, containing all relevant information to support the participant in terms of prevention referencing other FHIR Resources like Questionnaires, ServiceRequests, DiagnosticReports, Tasks or Goals.

Besides the primary use, the data collected as part of prevention programs was also relevant for research questions, e.g. in the field of population health. For this purpose, the architecture provided a separate area for secondary use in the form of a Smart Prevention Registry (SPR) or dataspaces. The SPR was automatically filled with data from the record, whereby the person's identification data was pseudonymized. In the registry itself the data was mapped to according OMOP CDMs. The data of the prevention record was transformed in a relational, analysis-friendly format. Furthermore, this harmonized format allows for linkage with other OMOP-compatible databases to provide even more insight in the participants medical histories.

4. Discussion

In this work the concept of a modular prevention pathway based on the principles of P4 medicine was created and used to design the architecture for an electronic health prevention record based on HL7 FHIR enabling interoperability and the OMOP CDM harmonising data and providing a structure to analyse data in an efficient way. To the best of our knowledge, this is a novel approach in the field of electronic health prevention. The architecture of an IT infrastructure provided a separation into primary and secondary use of data, where the primary data structured in FHIR could be transformed to the secondary data in the OMOP CDM.

Furthermore, to enable a personalised approach supported by software, it was considered to separate the decision support modules, because they needed to be considered as software as medical device, covered by the medical device regulation (MDR - (EU) 2017/745). This aspect has not been addressed in this publication. The intended purpose of such a module - with application to humans for the diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease - could be considered a Class IIa or higher medical device according to "Annex VIII: Classification rules" Rule 11. To implement such a device, clear guidelines for prevention following rules would be needed, which could also be used for a software.

The presented results provide a concept how a prevention pathway based on P4 medicine can be implemented with digital support. The next step could be an implementation in a pilot study in a real-world setting. Such a study would help with the validation of the concept, as well as with identifying possible obstacles within the pathways (e.g. prevention of multiple identical records).

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