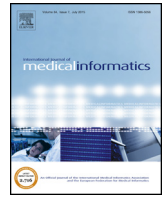




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# Improving the informational continuity of care in diabetes mellitus treatment with a nationwide Shared EHR system: Estimates from Austrian claims data



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## ABSTRACT

**Purpose:** Shared Electronic Health Record (EHR) systems, which provide a health information exchange (HIE) within a community of care, were found to be a key enabler of informational continuity of diabetes mellitus (DM) care. Quantitative analyses of the actual contribution of Shared EHR systems to informational continuity of care are rare. The goal of this study was to quantitatively analyze (i) the degree of fragmentation of DM care in Austria as an indicator for the need for HIE, and (ii) the quantity of information (i.e. number of documents) from Austrian DM patients that would be made available by a nationwide Shared EHR system for HIE.

**Methods:** Our analyses are based on social security claims data of 7.9 million Austrians from 2006 and 2007. DM patients were identified through medication data and inpatient diagnoses. The degree of fragmentation was determined by the number of different healthcare providers per patient. The amount of information that would be made available by a nationwide Shared EHR system was estimated by the number of documents that would have been available to a healthcare provider if he had access to information on the patient's visits to any of the other healthcare providers. As a reference value we determined the number of locally available documents that would have originated from the patient's visits to the healthcare provider himself. We performed our analysis for two types of systems: (i) a "comprehensive" Shared EHR system (SEHRS), where each visit of a patient results in a single document (progress note), and (ii) the Austrian ELGA system, which allows four specific document types to be shared.

**Results:** 391,630 DM patients were identified, corresponding to 4.7% of the Austrian population. More than 90% of the patients received health services from more than one healthcare provider in one year. Both, the SEHRS as well as ELGA would have multiplied the available information during a patient visit in comparison to an isolated local EHR system; the median ratio of external to local medical documents was between 1:1 for a typical visit at a primary care provider (SEHRS as well as ELGA) and 39:1 (SEHRS) respectively 28:1 (ELGA) for a typical visit at a hospital.

**Conclusions:** Due to the high degree of care fragmentation, there is an obvious need for HIE for Austrian DM patients. Both, the SEHRS as well as ELGA could provide a substantial contribution to informational continuity of care in Austrian DM treatment. Hospitals and specialists would have gained the most amount of external information, primary care providers and pharmacies would have at least doubled their available information. Despite being the most important potential feeders of a national Shared EHR system according to our analysis, primary care providers will not tap their full corresponding potential under the current implementation scenario of ELGA.

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## 1. Introduction

Electronic health records (EHRs) provide efficient access to relevant patient data for healthcare providers (HCPs). EHRs were found to be a key enabler of *informational continuity of care* [1]. According

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to Haggerty et al., informational continuity of care represents one of three dimensions of continuity of care and is defined as the use of information on past events and personal circumstances to make current care appropriate for each individual [2].

Continuity of care implies the management of health information in two ways: (a) local information management about the subject of care at the site of care provision, and (b) information interchange between HCPs [3]. In this paper we concentrate on the second, i.e. we will analyze to what extent EHRs may contribute to inter-organizational informational continuity of care. In compliance with ISO TR 20514 we use the term *Shared EHR system* to denote a system for managing information in EHRs, which aims to facilitate integrated shared care within a community of care [4].

According to a recent study [5], HCPs confirm that Shared EHR systems can in fact achieve the goal of supporting inter-organizational patient care. There, seventy percent of the 3700 interviewed physicians say that Shared EHR systems improve coordination of care across care settings and 74% say that Shared EHR systems improve cross-organizational working processes. Similarly, Swedish HCPs report that complete medical records offered by Shared EHR systems allowed them to provide safer and better care [6]. The absence of Shared EHR systems was identified as one of five current organizational barriers to integrated care in the United Kingdom [7]. Reviewing the published outcomes of regional healthcare information systems, Mäenpää et al. found evidence for improved health information exchange (HIE) and communication and coordination between cooperating HCPs [8].

Continuity of care has a positive impact on the care of chronically ill patients [9]. Due to the longitudinal character of chronic disease treatment, which is typically distributed between different HCPs, the sharing of the fragmented information on a common patient becomes particularly significant. The importance of sharing diabetes mellitus (DM) data between different HCPs was identified in earlier work [10,11]. Widespread use of EHR systems among primary care practices was found to be correlated with fewer temporal gaps in the care of DM patients [12]. Similarly, MacPhail et al. reported that Shared EHR systems can provide sufficient informational continuity to prevent gaps and overlaps in DM treatment [1]. Branger et al. showed that DM patients can benefit from an increased communication between their HCPs and a higher availability of data for their HCPs through the application of Shared EHR systems [13]. Further, preliminary findings of a recent study indicate that Shared EHR systems may improve integrated care of patients suffering from chronic kidney failure [14].

Despite the perceived impact of Shared EHR systems in cooperative care settings, quantitative analyses of the actual contribution provided by Shared EHR systems to informational continuity of care are rare. Nationwide Shared EHR systems, which are aspired to by most industrial nations [15], will allow a particularly high contribution due to their broad coverage of patient information. An obvious way of analyzing the contribution of nationwide Shared EHR systems to informational continuity of care would be to measure the information that is actually transferred between the different users

of the system [16]. At the moment, however, most national Shared EHR systems are still in the development phase. In Austria, the development of a national HIE infrastructure has been discussed for more than a decade [17]. This process culminated in the implementation of the Austrian Shared EHR system ELGA [18]. Even though ELGA has become operational in December 2015, the system is still in its early phase and does not provide sufficient data that would allow a meaningful analysis of information transfer.

In this paper we estimate the contribution to informational continuity of DM care that could be achieved by a nationwide Shared EHR system. We use pseudonymized claims data of the Main Association of Austrian Social Security Institutions. This includes data on outpatient (general practitioners and specialists) and inpatient care. Overall, the database contains medication data of 7.9 million persons from all age groups who received medical care that was paid for by one of the Social Security Institutions in Austria between 2006 and 2007. The mean Austrian population size in these years was 8.28 million [19]. The data covers about 95% of the entire population, the missing five percent are due to insurance carriers not covered by the database (e.g., municipalities and unemployment service), or due to insufficient data quality (e.g., missing age or gender). According to the Austrian data protection law, pseudonymized as well as anonymized health data that do not allow personal identification of the corresponding patient, may be legally used for research without requiring prior patient consent. The present study was approved by the ethics committee of the Medical University of Vienna.

## 2. Objectives

This paper aims to answer two questions:

1. To what extent is information fragmented between HCPs treating Austrian DM patients, and thus to what extent do these HCPs depend on information interchange? The answer to this question helps to clarify to what extent HIE technologies, such as Shared EHR systems, are relevant in the context of DM.
2. What amount of information (in terms of number of documents) from Austrian DM patients would be made available by a nationwide Shared EHR system for HIE? The corresponding analysis will be done for (i) a “comprehensive” Shared EHR system, where we assume data to be recorded for each patient visit to a HCP, and (ii) based on data in a format as will be recorded in the Austrian ELGA system.

## 3. Methods

### 3.1. Identification of diabetes mellitus patients

Pharmaceutically treated DM patients were identified if at least one type of diabetes-specific medication (see Table 1) was dispensed to them between 2006 and 2007. We did not require these patients to have a documented diagnosis of DM, as our database

**Table 1**  
ATC codes of diabetes-specific medication according to Chini et al. [20].

ATC code	Description
A10AB	Insulins and analogues for injection, fast-acting
A10AC	Insulins and analogues for injection, intermediate-acting
A10AD	Insulins and analogues for injection, intermediate- or long-acting combined w. fast-acting
A10AE	Insulins and analogues for injection, long-acting
A10BA	Biguanides
A10BB	Sulfonamides, urea derivatives
A10BD	Combinations of oral blood glucose lowering drugs
A10BG	Thiazolidinediones
A10BX	Other blood glucose lowering drugs, excluding insulins

contains coded diagnoses only from hospital visits; only 25% of our DM patients had a hospital stay between 2006 and 2007.

DM patients not receiving a pharmaceutical treatment (e.g. persons administered with a diet) could only be partially identified. For this purpose we added persons to our population with a primary or secondary diagnosis of DM (all ICD-10 codes of DM “E10” to “E14”) during a hospital stay between 2006 and 2007, who did not receive a diabetes-specific medication during the two years. Non-pharmaceutically treated DM patients without a hospital visit between 2006 and 2007 could not be identified in our data.

Patients with missing age and/or gender records were excluded from our study population.

### 3.2. Validation of identified population of diabetes mellitus patients

We validated our study population by comparing it with two reference data sources. As our first reference we used data from the Austrian Health Survey 2006/07 [21]. Here we compared all of our DM patients aged 15 years and older (only persons of this age group were interviewed in the Austrian Health Survey) in 2006<sup>1</sup> with the number of persons who answered yes to the survey question “Did you suffer from DM in the last 12 months”.

As our second reference data source we used anonymized data from a nationwide register of juvenile DM patients maintained at the Medical University of Vienna with status December 31st, 2006 [22]. In accordance with the age group monitored by the register, we only considered patients from our study population who were aged 14 and younger in 2006 for the comparison.

### 3.3. Analysis of fragmentation of our diabetes mellitus patients’ treatment

According to Reid et al. [16], the number of HCPs with whom the patient had contact during an episode of care intuitively indicates the need for HIE between these HCPs. We calculated the number of different HCPs for each of our study patients by identifying those unique HCPs, who provided at least one healthcare service for the patient during one year.

### 3.4. Identification of visits to healthcare providers

Visits do not exist as separate objects in our database. Therefore we had to use an approximate procedure to derive visits by grouping all individually billed healthcare services provided by a particular HCP to a particular patient during one day [23]. This procedure assumes that the dates of healthcare services are documented at a granularity of days. In our database, this granularity is only provided for all three domains relevant for us (inpatient, outpatient, and pharmacy domains) by one insurance carrier, namely the insurance carrier NOEGKK of the province of Lower Austria. For the identification of visits we therefore had to restrict ourselves to patients insured by the NOEGKK, i.e. to 16% of our total study population.

We considered the following categories of HCPs in our study: (i) “primary care providers (PCPs)”, i.e. general practitioners (GPs), paediatrics, and internal medicine, (ii) “specialists”, i.e. dermatology and sexually transmitted diseases, gynaecology and midwifery, neurology and psychiatry, ophthalmology, orthopaedics, otorhinolaryngology, pathology, pneumology, psychotherapy and clinical psychology, radiology (i.e. general radiology, nuclear medicine,

CT/MRT and radio-oncology), surgery (i.e. general surgery, plastic surgery, neurosurgery, accident surgery), and urology, (iii) “hospitals”, and (iv) “pharmacies”. This categorization of HCPs is based on the grouping used in [23] and was adapted to the Austrian scheme of medical disciplines. We only considered HCPs with an active contract with a public health insurance institution. For hospital visits, transfers to a different department within the same hospital during one visit were not counted as separate visits.

### 3.5. Handling of visits where medications were prescribed or dispensed

Within the database, visits where a medication was dispensed occurred at regular pharmacies (76%) and at GPs with an attached in-house pharmacy (24%). The latter are common in rural areas of Lower Austria. Three of the 257 in-house pharmacies had to be ignored in our analyses, as we could not identify the GP where the in-house pharmacy was located due to incomplete data.

The database is limited by the fact that visits, where a medication was dispensed, refer to the ID of the prescribing HCP but not to the visit where the prescription was issued. We therefore assumed that the prescription took place at the visit of the patient at the prescribing HCP that was temporally closest in a 30 day interval<sup>2</sup> before the visit where the medication was dispensed. Based on this assumption, a visit where the prescription presumably occurred could be identified in 91% of the visits, where the medication was dispensed at a regular pharmacy. To correct for the missing 9%<sup>3</sup> we assumed that the prescription visit at the prescribing HCP occurred four days<sup>4</sup> before the visit where the medication was dispensed.

For 98% of the visits, where the medication was dispensed at an in-house pharmacy, a corresponding prescription visit could be identified on the same day as the dispensing occurred. For an additional 1%, a corresponding prescription visit could be identified within the 30 days interval. To correct for the missing 1%, we assumed that the prescription visit at the prescribing HCP occurred at the same day<sup>4</sup> as the medication was dispensed.

### 3.6. Estimation of the amount of information provided by a national Shared EHR system

For each visit of our study patients in 2007, we calculated the number of medical documents on the respective patient from the year (365 days) before the visit<sup>5</sup> that would have been available to the HCP from earlier visits of the patient (i) to the same HCP (local documents), respectively (ii) to any other HCP (external documents). We then calculated the ratio of external to local documents to determine the proportion of information that could have been provided by a fully connected national Shared EHR system. This is related to the metric “volume” in the scheme proposed by Liang et al. for measuring HIE usage [24]. In contrast we focus on the ratio of documents accessible with/without HIE instead of the ratio of electronically exchanged documents to all exchanged documents.

We assumed two variants of a national Shared EHR system, namely the Austrian ELGA and a fictive “comprehensive” Shared

<sup>2</sup> In Austria prescriptions are valid for a maximum of one month.

<sup>3</sup> As the database exclusively holds data on prescribed medications, there must have been a prescription visit for each dispensed medication. One reason for the missing prescription visits was that the prescription was issued by a provider not contracted by the NOEGKK and thus no corresponding visit data was available to us. This was the case in 44% of the missing 9% of prescription visits.

<sup>4</sup> The mean temporal distance between the prescription and corresponding dispensing visits was four days (regular pharmacies) respectively zero days (in-house pharmacies).

<sup>5</sup> We assumed that any information older than one year is discarded from the system.

<sup>1</sup> For reasons of patient de-identification, we only had access to the year of birth, not to the exact birthday. We used 2006 as reference year, so we included only patients who were born in 1991 or earlier in this comparison.

EHR system (SEHRS). Both allow each participating HCP a HIE “breadth” of 100% [24], i.e. they enable exchange of information with any other PCP, specialist, hospital, and pharmacy in the country. So ELGA as well as the SEHRS cover information from the inpatient and from the outpatient sectors. The two systems mainly differ in the HIE dimension “diversity” according to Liang et al., i.e. the range of exchanged document types:

- 1) For the SEHRS we assume that each patient visit to a HCP results in a single progress note within the system. Visits to in-house pharmacies are attributed to the PCP, where the in-house pharmacy is located. All kinds of healthcare services provided by one HCP to a patient on the same day (e.g. an examination and a prescription of a medication by a GP and the dispensing of the medication in the attached in-house pharmacy) are assumed to be compiled into one common document.
- 2) ELGA allows four specific document types<sup>6</sup> to be shared: hospital discharge letters, radiology reports, medication reports (prescribed as well as dispensed) [25], and laboratory reports.

- We assumed that a hospital discharge letter would result from each hospital visit of our study patients.
- A radiology report was assumed to result from each visit of our study patients at a radiologist.
- Medication reports were assumed to result from (i) each visit of our study patients, where a medication was dispensed (at a regular or in-house pharmacy), and (ii) from the corresponding visit at the PCP or specialist, where the same medication was prescribed. Dispensing reports created by in-house pharmacies were attributed to the PCP, where the in-house pharmacy was located. If more than one medication was prescribed/dispensed by a HCP for a patient on the same visit, we counted this as one single medication report. However, according to the ELGA procedure, the prescription and dispensing of a medication were always counted as two separate medication reports, even when performed on the same day by a GP with attached in-house pharmacy.
- We could not consider laboratory reports in our analysis as data quality was insufficient.

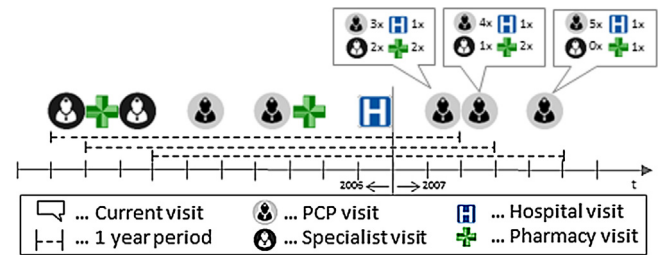
We calculated the number of documents that would have been available to the HCP at a particular visit as follows:

- For the local EHR system we counted the number of earlier visits of the same patient to the same HCP in the year before the current visit.
- For the national Shared EHR system we counted the number of earlier visits of the same patient to any other HCP in the year before the current visit. For the SEHRS any earlier visit in this period was counted. For ELGA only earlier visits were counted, where one of the ELGA document types mentioned above was created. HCPs were grouped into PCPs, specialists, hospitals and pharmacies. We adhered to the defined ELGA access rights, i.e. in ELGA pharmacies only have access to medication reports, whereas the three other HCP types may access any document of their patients.<sup>7</sup>

We then calculated the median and 90th percentile of available documents at a visit and grouped the results in available documents

<sup>6</sup> This is the initial set of available document types at the start of ELGA. Further document types, such as patients’ provisions, health care proxies, and records of epidemiologic registries, are planned to follow.

<sup>7</sup> ELGA further allows patients to optionally overrule these standard access rights, e.g. by restricting or extending the access rights of particular providers. This option was not considered in our study.



**Fig. 1.** Calculation of the number of documents available to PCPs from earlier visits in the year before the current visit. The example shows the process for the first three visits of one particular patient in 2007. For reasons of simplicity we assume here that the same PCP was contacted in all PCP visits, i.e. these visits all resulted in local documents; visits to a different PCP than contacted in the current visit would actually be counted in a separate category of external PCP documents. For the first visit in 2007, the number of local(PCP), external(specialist), external(hospital), external(pharmacy) documents would be (3, 2, 1, 2) and the ratio of external to local documents would be 5/3. For the second visit the number of documents would be (4, 1, 1, 2) and the ratio 4/4. For the third visit the number of documents would be (5, 0, 1, 1) and the ratio 2/5. The number of documents available to specialists, hospitals, and pharmacies were calculated analogously.

from PCPs, specialists, hospitals and pharmacies. We chose the 90th percentile in addition to the median to gain an impression of those 10% of the visits where HCPs could gain most from information from earlier visits (i.e. “heavy users”) and from having access to external documents.

Fig. 1 provides an overview of our procedure for calculating the number of available documents for the local EHR system and the SEHRS. Starting with the first visit of a given patient in 2007, all visits of the patient in the last year were examined. Visits to the same HCP were interpreted as local documents; visits to other HCPs were interpreted as external documents and grouped by HCP type. Further the ratio of the numbers of externally to locally available documents was calculated for the current visit. The one year time window was then moved to the patient’s second visit in 2007 and the procedure was repeated until the patient’s last visit in 2007 was reached. The same steps were repeated with all other patients’ visits. Finally, the median and 90th percentile of externally and locally available documents, and of their ratio were calculated for all visits in 2007. For ELGA the procedure was identical, except that we only counted those visits that would have resulted in an ELGA document (see above).

We further determined the fraction of visits in 2007, where external information from earlier visits was available. This information would have been missed without a mechanism for HIE such as provided by a Shared EHR system.

The numbers of documents provide a quantitative measure of what could have been gained from a national Shared EHR system for informational continuity of care in comparison to a completely isolated local EHR system, where no HIE occurs with other HCPs.

## 4. Results

### 4.1. Identified diabetes mellitus patients

We identified 391,630 DM patients (4.7% of the mean Austrian population between 2006 and 2007), who satisfied our inclusion and exclusion criteria and form our study population. Within the study population, 352,698 (90%) patients were identified via a diabetes-specific medication. The remaining 38,932 (10%) patients did not receive a diabetes-specific medication; they were identified via a primary or secondary diagnosis of DM during a hospital stay. The comparison of the study population with the Austrian Health Survey (patients  $\geq 15$  years) and the juvenile DM register (patients 0–14 years) is shown in Table 2.

**Table 2**  
Comparison of our study population with reference data sources. The reference population corresponds to the data from the Austrian Health Survey 2006/07, exceptions are indicated. The numbers of the Austrian Health Survey 2006/07 represent an extrapolation from a sample of about 25,000 persons. For each number in the reference population that originates from the survey, the 95% confidence interval and the corresponding range for the difference between study and reference populations are therefore shown in brackets.

	Study population	Reference population	Percentage of difference of data sources
Total	391,630	390,982 (363,117 to 418,847)	+0.17% (–6% to +8%)
0 to 14 years	<b>1811</b>	<b>1316*</b>	<b>+38%</b>
Female	868	644*	+35%
Male	943	672*	+40%
≥ 15 years	<b>389,819</b>	<b>389,666 (361,801 to 417,531)</b>	<b>+0.04% (–7% to +8%)</b>
15 to 29	6107	6328 (2699 to 9957)	–3% (–39% to +126%)
30 to 44	21,743	23,773 (16,746 to 30,800)	–9% (–29% to +30%)
45 to 59	87,600	82,210 (69,185 to 95,235)	+7% (–8% to +27%)
60 to 74 years	155,761	141,278 (124,260 to 158,296)	+10% (–2% to +25%)
≥75 years	118,608	136,078 (119,372 to 152,784)	–13% (–22% to –1%)
Female	196,928	215,359 (194,436 to 236,282)	–9% (–17% to +1%)
Male	192,891	174,307 (155,440 to 193,174)	+11% (0% to +24%)

\* Numbers originate from the juvenile DM register.

**Table 3**  
Fragmentation of our DM patients' treatment (study population n = 391,630) in 2006 and 2007.

	Number of patients	Portion of study population
At least one HCP visited (2006)	386,605	99%*
Exactly 1HCP (2006)	15,721	4%
Exactly 2HCPs (2006)	36,873	9%
Exactly 3HCPs (2006)	50,314	13%
Exactly 4HCPs (2006)	54,884	14%
Five or more HCPs (2006)	228,813	58%
At least one HCP visited (2007)	374,044	96%†
Exactly 1HCP (2007)	14,344	4%
Exactly 2HCPs (2007)	34,126	9%
Exactly 3HCPs (2007)	47,786	12%
Exactly 4HCPs (2007)	52,307	13%
Five or more HCPs (2007)	225,481	58%

\* The remaining 1% or 4% (2007) of our patients did not receive health care services in the respective year.

For the identification of visits and thus for the estimated amount of information provided by a national Shared EHR system we had to focus on data of the insurance carrier of Lower Austria (NOEGKK). From our study population we identified a subset of 61,300 DM patients, who were insured by the NOEGKK. This corresponds to 16% of the study population's DM patients (portions within the age and gender categories of Table 2 were between 14% and 18%). In the following, the subset of patients insured by the NOEGKK within our study population will be called the NOEGKK population.

#### 4.2. Identified fragmentation of our diabetes mellitus patients' treatment

Table 3 shows that 95% (92%) of our study patients received health services from more than one HCP in 2006 (2007). As HCPs we considered PCPs, specialists, hospitals, and regular pharmacies. In-house pharmacies were considered as being part of the GP where they are located, i.e. they were not considered as extra HCPs.

#### 4.3. Estimated information provided by a national Shared EHR system

Fig. 2 depicts the number of documents that a HCP could have accessed at a NOEGKK patient visit in 2007 locally from earlier visits of the patient to himself/herself (leftmost column), and from earlier visits of the patient to any other HCP (other columns). Document quantities are represented as bars for the SEHRS as well as for ELGA.

The ratios of the total number of externally available documents to the locally available documents are shown in Table 4 for both systems. By means of the SEHRS (numbers for ELGA are almost

identical), external information from earlier visits to other HCPs would have been available in

- 97.4% of the visits to a PCP; in 2% of the visits this external information would have been the only existing documentation on the patient as the latter was new to the PCP.
- 99.8% of the visits to a specialist; in 28% of the visits this external information would have been the only existing documentation on the patient as the latter was new to the specialist.
- 98.8% of the visits to a hospital; in 46% of the visits this external information would have been the only existing documentation on the patient as the latter was new to the hospital.
- 99.9% of the visits to a pharmacy; in 4% of the visits this external information would have been the only existing documentation on the patient as the latter was new to the pharmacy.

## 5. Discussion

### 5.1. Plausibility of study population

The validation of our study population yielded a good overall agreement with the Austrian Health Survey 2006/07 for DM patients aged 15 years and above. Only the age group “≥ 75 years” showed a small significant deviation from the reference population.

For patients younger than 15 years our study population contains 38% more patients than the nationwide register of juvenile DM patients. The low agreement is mainly caused by the fact that the numbers from the register represent the state as of December 31st, 2006, i.e. it does not contain patients who were diagnosed for DM in 2007 for the first time. If we remove all patients from our study population, who showed the first indication (dispensing of a

diabetes-specific medication or diagnosis of DM in a hospital) for DM after December 31st, 2006, we receive a cohort of 1321 patients. This would correspond to a 0.4% overreporting of the age group “0 to 14 years” in our study population in comparison to the register, i.e. a good agreement.

Using the same set of ATC codes as we did, Chini et al. found a prevalence of 4.4% for DM in the Italian region of Lazio in 2006 based on claims data of drug prescriptions [20], which is comparable to our 4.7% between 2006 and 2007. They also compared their result with the Italian National Health Survey of 2005 and estimate over-reporting at 9% for their DM cohort.

5.2. Fragmentation of information

Considering that more than 90% of our study population received health care services from two or more different HCPs in one year and more than half of our patients even from five or more HCPs, fragmentation of information seems to be high among Austrian DM patients.

Similar findings were made for the fragmentation of care of Medicare beneficiaries in 2003 [26]. According to this report, 92%

Table 4

Median (90th percentile) of all visit-specific ratios “total external to local documents”. For the calculation of visit-specific ratios, we added 0.5 to each numerator as well as each denominator to avoid undefined ratios that would have been caused by zero local documents.

Visited HCP	Ratio for SEHRS	Ratio for ELGA
PCP	1 (3)	1 (2)
Specialist	19 (107)	14 (79)
Hospital	39 (143)	28 (107)
Pharmacy	2 (10)	1 (7)

of patients suffering from coronary artery disease, congestive heart failure, or DM visited two or more HCPs, and 45% visited six or more HCPs in one year.

In an earlier stage of our project, where we only focused on pharmaceutically treated DM patients and did not consider pharmacies within the spectrum of HCPs, we reported a portion of 73.5% of Austrian DM patients, who received diabetes-specific health services by two or more different HCPs between 2006 and 2007 [27].

Pham et al. examined the fragmentation of care of 1.79 million Medicare patients between different HCPs [28]. According to their

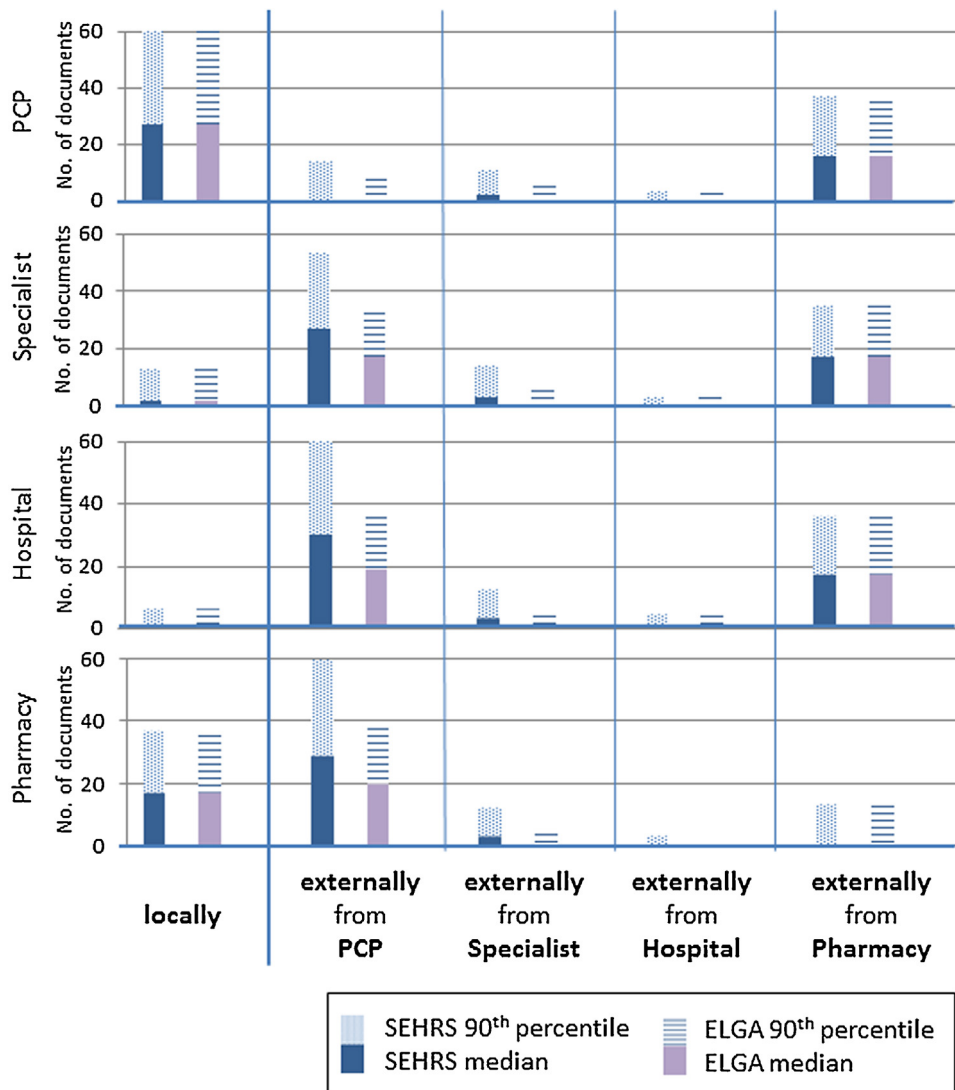


Fig. 2. Median and 90th percentile of the number of documents that a HCP could have accessed at a NOEGKK patient visit in 2007. The leftmost column shows the number of documents that would have been available in a local EHR system, whereas the other columns show the number of external documents that would have been available via the SEHRS and ELGA. Documents created at GPs with attached in-house pharmacies were assigned to HCP type “PCP”. HCP type “pharmacy” only covers documents created in regular pharmacies.

findings the typical DM patient saw a median of three GPs and six specialists in a single year. Their study population was restricted to patients with 65 years of age or older. In comparison, our NOEGKK patients aged 65 years or older saw a median of one GP and two specialists per year.<sup>8</sup> This seems to indicate that the contribution potential of a nationwide Shared EHR system might even be higher for Medicare patients suffering from DM than shown in our study.

### 5.3. Estimated information provided by a national Shared EHR system

For both scenarios, namely the SEHRS as well as ELGA, at practically all visits of our NOEGKK patients in 2007, information would have been available from earlier visits of the same patient at external HCPs. This supports the insight that fragmentation of DM care is high in Austria (compare Section 5.2).

Providing the highest portions of external documents in median, PCPs and pharmacies would have been fruitful sources of external information. Concerning the planned coverage of these two HCP types in ELGA, pharmacies who will feed all dispensing information into the system seem to be well-covered in ELGA. However, PCPs seem to be rather underrepresented as information sources in ELGA. As the two bars for the available external documents from PCPs in Fig. 2 show, ELGA's strategy of restricting PCPs to feeding only medication prescriptions into the system leads to a substantial reduction of externally available PCP documents in comparison to the SEHRS. The fact that a PCP could have accessed only little external information from other PCPs (the same holds between a pharmacy and other pharmacies) seems to indicate a certain degree of patient loyalty.

Specialists and hospitals would have played a rather negligible role as sources of external documents. Though the specialists' contribution of external documents would have already been low in the SEHRS, it would have been further reduced in ELGA by restricting their inputs to certain document types. However, the actual number of external documents from specialists in ELGA would be higher as we could not consider laboratory reports in our study since data quality was insufficient. Hospitals appear to be particularly dependent on external information, as at almost every second hospital visit, the patient was new to the hospital.

Concerning the ratios of external to local documents, at least as many external documents could have been accessed as were available locally during a typical visit of our NOEGKK patients at all four HCP types in 2007—this minimum ratio of “1:1” was found for PCP visits (SEHRS as well as ELGA) and pharmacy visits (ELGA). Ratios of specialist visits were already substantially higher with 19 (SEHRS), or 14 (ELGA) times more external than local documents. The highest due of external documents was identified for hospital visits, 39 (SEHRS), and 28 (ELGA) times more external than local documents could have been accessed. The top 10% of visits with the highest due of external information was identified for PCPs (ELGA) with at least twice up to at least 143 times more (SEHRS) external than local documents for hospital visits.

The fact that hospitals were most strongly affected must be taken with care, as the amount of information collected during a typical hospital visit usually is much larger than at a typical outpatient visit. In this sense hospitals were penalized in our analysis, as we treated a hospital discharge letter as one document in the same way as we did with a pharmacy's medication report for example.

<sup>8</sup> The degree of fragmentation of our patients' treatment shown in Table 3 seems to suggest a higher number of providers per patient. However, in Table 3 also pharmacies and hospitals were considered, whereas here we only considered GPs and specialists.

In this work we exclusively focused on the amount of external information that would be available to a HCP by means of a national Shared EHR system. Clearly also patients would benefit by receiving access to their EHRs, provided that the national Shared EHR system includes a patient interface. Traditional local EHR systems operated by HCPs rarely allowed patients to access their data and were mostly limited to the data created by a single HCP.

The estimated information that could have been provided by the ELGA system is similarly distributed between the different HCP types as with the SEHRS. The lower absolute numbers of ELGA documents from PCPs and specialists is a consequence of the fact that only four document types are currently fed into ELGA. Pharmacies' access to external ELGA documents is further reduced by the fact that they may only see their patients' medication reports according to the ELGA access policies.

Several earlier studies focused on the availability of information from earlier visits at external HCPs [29–31]. Even though they did not compare the fractions of local versus external information or examine the number of available documents from earlier visits, they all identified missing information from earlier visits and thus indicated a need for a more extensive HIE.

Naturally, different factors will influence information fragmentation and the need for HIE. As an example, the frequency of care transitions, i.e. changes of HCP between two subsequent visits, may be seen as an indicator for the need for HIE [23]. Rudin et al. reported lower rates of care transitions for patients visiting group practices, where more transitions occur between HCPs of the same group. These HCPs are assumed to use the same EHR system and thus no HIE is required for intra-group transitions. Further, HIE may be more relevant in health care systems that provide a free choice of HCPs for their patients as opposed to health care systems that restrict patients' access to HCPs in some way. In systems with free choice of HCPs the average number of HCP visits is significantly higher than for example in the United States and Canada, where referral arrangements are part of the system [32]. The increased number of visits in combination with a free choice of HCPs may increase the likelihood for information fragmentation and may thus also increase the need for HIE.

This leads us to the point that it is not sufficient to identify settings in which HIE is needed, we also need to discover which external information will actually be of value. Typically only a subset of information from earlier visits will be relevant at the current patient visit. One approach to identify relevant information is to analyze how often different types of information are actually accessed [33,34]. Hereby unavailable but needed information may be overlooked. Other work aimed to identify information needs by means of interviews [35] or observations [36]. Hübner-Bloder et al. analyzed information needs in the context of DM by means of a triangulation study [37]. They identified a set of 449 information items that are relevant in 10 typical DM treatment situations. Based on their results a Shared EHR system architecture was developed that allows HCPs to filter only information that is relevant in a particular treatment situation from all existing EHR documents of a patient [38]. As this solution is built on the same technical basis as ELGA, it could be easily integrated in the latter.

### 5.4. Limitations

Due to different kinds of error sources in the process of coding diagnoses, ICD-10 codes may not be accurate [39], and deriving patient cohorts on the basis of their documented ICD-10 codes may lead to errors. We address this problem by the fact that we identified 90% of our patients by their medication. The remaining 10%, however, may include patients who were wrongly selected based on erroneous diagnoses.

As our database neither contains data from private HCPs nor from ambulant hospital visits, the calculated fragmentation of our DM patients' treatment represents a lower bound to the actual value.

The forced restriction on the patients insured by the NOEGKK (insurance carrier of Lower Austria) for visit-based analyses reduced our patient cohort to 16% of our study population for the estimation of information provided by a national Shared EHR system. To coarsely assess the corresponding representativeness of the NOEGKK collective for Austrian DM patients in general, we compared the fragmentation of DM treatment in all nine Austrian provinces. As in six other Austrian provinces, NOEGKK patients visited five different HCPs (median) per year. Patients insured by Vienna's and Vorarlberg's carriers had a median of six and two HCPs per year, respectively. Concerning the mean number of different visited HCPs per year, NOEGKK patients ranked third lowest with a value of 5.4 (values ranged from 2.8 to 6.4 in the nine provinces). If we assume that the degree of fragmentation is directly proportional to the amount of information on a patient that is stored by external HCPs, the NOEGKK population seems to represent the Austrian DM patients in the country's other provinces rather well, maybe slightly underestimating the overall values.

An effect of the restriction to the NOEGKK population was that we could not consider those visits of the NOEGKK DM patients, which occurred at HCPs who did not have a contract with the NOEGKK.<sup>9</sup> Three percent of the average NOEGKK DM patient's HCPs did not have a contract with the NOEGKK. The missing visits at these HCPs and the fact that our database neither contains visit data from private HCPs nor from ambulant hospital visits entails that our estimations of the information provided by a national Shared EHR system will likely underestimate the actual values.

Due to missing documentation we could not consider prescription reports if the concerned medication was not reimbursed. Further, we did not have data on medications that were dispensed in hospitals. Consequently we may have underestimated the actual number of medication reports. Our calculations of the available ELGA documents further underestimate the actual values due to the fact that (i) our database only covers prescribed medications, whereas ELGA will also include medication reports on over the counter drugs, and (ii) we could not consider ELGA laboratory reports due to missing data.

Within our database visit dates were provided only on the granularity of days. Therefore, if a patient visited different HCPs on the same day, the actual sequence of these visits was unknown to us. Hence, when we calculated for a particular visit *V* at date *D*, the number of available documents from all visits of the patient in the year before *D*, we ignored potential other visits of the patient on *D* as we did not know whether they occurred before or after visit *V*. If we assume that a new document is made available to the other users of the national Shared EHR system immediately after a patient visit (this may not always be achievable due to technical limitations), the before-mentioned limitation lead to a minor underestimation of the available documents.

As mentioned in Section 3.5 we had to use a heuristic to identify the date when a dispensed medication was prescribed. This may have led to some imprecision concerning the actual timing of prescription visits.

Considering the fact that patients may freely choose HCPs in Austria, our findings are not directly transferable to countries with a more regulated access to HCPs.

Reid et al. stated that besides information transfer between HCPs, also the uptake and use of this information is essential for informational continuity of care [16]. Our study only analyses the need for information transfer and the amount of information on a patient that could be shared with other HCPs via a national Shared EHR system. As the actual exchange of this information is only hypothetical, our study cannot consider the uptake and use of this information at the fictive recipients.

## 6. Conclusion

Our analyses showed a high fragmentation of information about the status of care of Austrian DM patients among HCPs. We conclude that there is a need for HIE between our study patients' HCPs to achieve a higher degree of informational continuity of care. A national Shared EHR system such as the SEHRS assumed in our study, or the Austrian ELGA system, could have provided the required HIE in an efficient way.

We pointed out that if a SEHRS- or ELGA-type system had been operational during a typical patient visit at any HCP, these systems could have multiplied the available information on the patient in comparison to an isolated local EHR system. Hospitals and specialists would have gained the most amount of external information, PCPs and pharmacies would still have at least doubled their information. Consequently, the analyzed types of national Shared EHR systems seem to have a substantial potential to informational continuity of care in Austrian DM treatment.

Clearly, the informational gain would have typically been less than the step from an isolated local EHR system to a national Shared EHR system. Even though national Shared EHR systems are currently still rare [15], most HCPs already have been employing some kind of HIE mechanisms in the last decade. According to a recent report of the European Commission, 32% of the GPs in the EU send and receive discharge letters routinely, 23% routinely share laboratory reports, 20% routinely share medical patient data, 17% routinely share medication lists, and 16% routinely share radiology reports [40]. On the other hand, these numbers show that the majority of GPs in the EU does not yet have access to the HIE functionality that a national Shared EHR system will provide. Secondary care also seems to be insufficiently equipped with HIE technologies; only 3% of secondary care DM centres used EHR systems with the ability to interface with hospital and PCP EHR systems according to a recent UK study [41].

Concerning ELGA it must be stated that information from PCPs seems to be insufficiently covered in the context of DM treatment. Our analysis shows that PCPs represent the most important source of external information. However, according to the current plan, PCPs will only feed medication prescriptions into ELGA. Consequently, an extension of PCPs' information input into ELGA seems to be advisable.

Besides improving informational continuity of care, EHRs can reduce healthcare delivery costs [42] and improve numerous facets of care coordination if equipped correctly [43]. However, the mere existence of national Shared EHR systems will not automatically lead to coordinated care. Further organizational and technical measures will be required to achieve this goal; amongst others, the fee-for-service reimbursement common in many countries rather promotes the documentation of billable services in EHRs than of data that are relevant for care coordination [44]. Further, suboptimal handling has been identified in the coordination of PCPs and specialists when jointly treating DM patients, indicating a need for quality- and performance based educational interventions [45]. Finally, the high absolute number of external documents that can be expected within a national Shared EHR system for a DM patient according to our analysis indicates the need for efficient

<sup>9</sup> Amongst others this occurred, if an NOEGKK DM patient visited a provider in a province other than Lower Austria. This is for example frequently the case for those residents of Lower Austria, who live close to Vienna and prefer to utilize the broad supply of providers there.



### Summary points

What was already known on the topic:

- Continuity of care has a positive impact on the care of chronically ill patients.
- HIE is a prerequisite for achieving informational continuity of care.
- Shared EHR systems support HIE on common patients between the healthcare providers of a community of care.

What this study added to our knowledge:

- More than 90% of Austrian DM patients visited two or more different healthcare providers in one year, i.e. there was a need for HIE between these healthcare providers.
- A national Shared EHR system could have multiplied the available information during a typical visit of an Austrian DM patient in comparison to an isolated local EHR system, indicating a substantial contribution potential to informational continuity of care in Austrian DM treatment.
- Primary care providers only feed a fraction of the data they produce into the Austrian national Shared EHR system ELGA.

search strategies and engines to retrieve the relevant information in acceptable time [38].

### Author contributions

All authors of this paper meet the requirements for authorship and have approved the final version of the paper to be published. Conception and design of the study: Christoph Rinner, Georg Heinze, Simone Katja Sauter, Georg Duftschmid; Acquisition of data: Simone Katja Sauter; Analysis and interpretation of data: Christoph Rinner, Georg Duftschmid, Simone Katja Sauter, Georg Heinze, Peter Klimek, Stefan Thurner, Gottfried Endel; Drafting the article: Christoph Rinner, Simone Katja Sauter, Georg Duftschmid; Revising the article: Christoph Rinner, Simone Katja Sauter, Georg Duftschmid, Georg Heinze, Peter Klimek, Stefan Thurner, Gottfried Endel.

### Conflict of interest

None declared.

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