The national e-medication approaches in Germany, Switzerland and Austria: a structured comparison

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Abstract

Background: Recent studies show that many patients are harmed due to missing or erroneous information on prescribed and taken medication. Many countries are thus introducing eHealth solutions to improve the availability of this medication information on a national scale (often called "e-medication"). The objective of this study is to analyse and compare the national e-medication solutions just being introduced in Germany, Switzerland and Austria.

Methods: Information on the situation in the three countries was collected within an expert group and complemented by an analysis of recent literature and legislation in each country.

Results: All three countries formulate comparable goals for the national eHealth solutions, focusing on improving medication safety. All three countries don't have a national e-prescription system. In all three countries, the implementation process was slower than expected and e-medication is not yet fully available. Differences of the three countries exist regarding chosen architectures, used standards, offered functionalities, and degree of voluntariness of participation.

Conclusion: Nationwide e-medication systems and cross-border harmonization are acknowledged as important goals towards medication safety, but they develop slowly mainly due to privacy and security requirements, the need for law amendments and last but not least political interests.

Keywords

Introduction

The medication process is an important sub-process of medical care. It consists of several consecutive activities: diagnostics and treatment planning, prescribing and transcribing, dispensing and distributing, patient information and motivation, taking and administering the drug, and monitoring and assessing the drug effects [1]. Errors in the medication process (e.g. overdosing, allergies, contraindication, drug-drug interactions, and omitted doses) can lead to adverse drug events and patient harm.

In the recent years, the use of information technology has been propagated to reduce the danger of medication errors and associated patient harm [2]. Recommended systems comprise, among others, drug information systems, computerized physician order entry systems (CPOE) with integrated decision-support functionality, automatic dispensing and commissioning systems, barcode systems, electronic medication administration records, smart pumps, mHealth systems for adherence management, and critical incident reporting systems.

Studies indeed showed a significant reduction of medication errors after introduction of computerized physician order entry systems (CPOE) both in inpatient and outpatient areas [3] [4] [5].

However, a challenge in many countries is the distribution of information on prescribed and dispensed medication among several IT systems. For example, a patient may get prescriptions from his general practitioner, by his cardiologist, and by his psychiatrist. When admitted to a hospital, he may get a different medication. In addition, the patient may also buy some drug directly at the pharmacy (so-called over-the-counter drugs) and in some countries even in supermarkets. All these prescriptions and dispensings are typically documented in different health IT systems (e.g. the GP system, the cardiologist system, the hospital CPOE system, the pharmacy system). Due to this fragmentation of medication information, it is extremely difficult to get a medication list for all drugs that have been prescribed for a patient and that this patient is taking at the moment. This increases, for instance, the danger of overlooking potentially dangerous drug-drug interactions.

To address this challenge, health care professionals have been advised to establish a medication history and medication reconciliation processes for their patients [6] [7]. However, this process is time-consuming. In addition, patients are often not able to give adequate information on medication they are taking at the moment [8] [9].

The problem of incomplete medication lists will increase in the next years, as demographic changes will lead to a higher number of elderly patients taking more medication [10] [11] [12]. Elderly patients also suffer more often from clinical consequences of medication errors and especially drug-drug interactions [13] [14].

Many countries are therefore trying to establish national eHealth strategies, aiming at providing an accurate and up-to-date list of all prescribed and dispensed medication of a given patient. The first sources of information for such a national medication list are the prescriptions issued for a given patient. Several countries are on the way of establishing national e-prescription systems [15]. Such a system replaces the paper-based prescription with electronic prescriptions that are sent from the prescribing physician to a pharmacy. This prescribing information is made available through a national e-prescription database and can form the basis of a medication history of a patient.

In fact, e-prescription is a top priority of the European eHealth activities. Guidelines on electronic prescriptions were submitted for approval by the eHealth Network in November 2014 [16]. Some

member states took part in the European Patients Smart Open Services project (epSOS) [17] which ended in June 2014. This voluntary project tested and validated the interoperability of EHR data and electronic prescription data [18]. It reflects Article 11 of the Directive on the rights of patients in cross-border care (2011/24/EU) [19] of the Action Plan for a European eHealth Area that states that interoperability between all member countries systems has to be implemented.

In the European Union, countries such as Denmark [20], Estonia [21], Iceland and Sweden [22] first started to implement national e-prescription systems. Besides these pioneers, some countries have reached a high percentage of e-prescriptions recently, e.g. Croatia [23]. Similar approaches can be found outside Europe too. In Turkey, for example, in 2013 80% of prescriptions were transferred electronically [24]. In the United States, the Medicare Improvements for Patients and Providers Act and the Medicare and Medicaid Electronic Health Record Incentive Programs lead to an increase in the number of physicians e-prescribing via EHR from 7% in 2008 to 70% in 2014. All states were using e-prescription at this time [25].

When comparing the different national approaches towards e-prescription, significant differences can be observed:

- Some countries establish regional e-prescription systems, e.g. in Italy [16], Poland [26] and Portugal [27], while others establish nationwide e-prescription systems, e.g. Sweden [22].
- Some countries only focus on the primary care systems, others only on secondary and tertiary care, and others on both, e.g. Great Britain [28].
- Some countries make participation in e-prescription mandatory, e.g. France, Finland [29], Greece [30]; in other countries, participation is voluntary, e.g. in Czech Republic [16].
- Some countries chose centralized architectures, e.g. Finland [29], Northern Ireland [31]; other countries establish decentralized e-prescription architectures (e.g. in Spain different models are used in the regions [15]).
- Some countries use international standards (e.g. HL7 and SNOMED CT), e.g. in Latvia [32], Estonia [21].
- Some countries offer incentives for participation, e.g. planned in Belgium [33].
- In some countries, the acceptance of e-prescription is quite high, e.g. the feedback from physicians, pharmacists and patients is very good in Croatia [23]; in others, the acceptance is quite low, e.g. the acceptance by physicians and pharmacists of the first e-prescription pilot in Belgium [33].

Besides these differences in the approaches, most are operated by public institutions or state-owned companies to guarantee reliable systems [29].

Although many countries are on the way towards national e-prescription systems, this is not sufficient to build up a national medication history. In order to achieve this, information on *dispensing* in pharmacies (and physicians' offices) is needed also. First, not all prescriptions are dispensed and given to the patient. Dispensing information shows which drugs are really taken home by the patient. Second, patients may buy over-the-counter drugs in pharmacies. Therefore, dispensing information also has to be gathered on a national scale to contribute to a national medication list.

Although a national e-prescription system is a good basis for a comprehensive medication history, not all countries take this path. Germany, Switzerland and Austria are all countries that do not yet have a national e-prescription system. Still, all three countries have a national eHealth strategy, and all three countries plan to establish a national system for the availability of the medication history in

the near future. In this paper, we will describe the individual path that each country is planning to take.

The authors of this paper are part of a group of experts from Austria, Germany and Switzerland which has met several times in the last years to discuss opportunities and challenges of using information technology to improve medication safety. The group has already launched several publications (e.g. [1], [34]). In two recent workshops (May 2015 in Vienna/AT, June 2014 in Biel/CH), the group discussed and compared national approaches of e-medication, to allow learning from each other. The discussions in these workshops motivated this paper.

Objective

To analyse and compare the approaches chosen by Germany, Switzerland and Austria to establish a national medication list without having a national e-prescription system.

Methods

Information from public sources (official project web sites, scientific papers) as well as personal knowledge of the authors who are all involved in the eHealth project in their respective country were used to collect information. Information was collected between December 2014 and July 2015. Each author was responsible to collect information from one specific country. All authors have been involved in the eHealth and e-medication projects in their countries and were thus able to access and collect most recent information and reports. To validate the collected information, each author contacted up to three other national domain experts. The information from each country was then compared with the information from the other two countries to identify gaps and open questions. Open questions were resolved by the authors by discussion. The categories to describe the information were developed inductively, based on the collected information, and were agreed on among all authors.

The following categories were used to structure the information.

a) The national health care system
b) Background and motivation for the national e-medication project
c) Objective of the national e-medication project
d) Organizational and legal framework
e) Structure, stakeholders and processes
f) Current status and prospects

Results

All three countries share a common language, a comparable quality of life, a comparable quality of the health care system, and all have national eHealth initiatives. We will now present the situation in each country in more detail, structuring the information as described before. We will then, in a table, summarize the most important similarities and differences.

The German medication list

a) The health care system in Germany

Germany is a federal republic with about 81 million inhabitants in 16 federal states. Nearly 90% of the population is covered by the statutory health insurance scheme. Contributions of insured individuals are based primarily on their income, up to a certain limit (contribution assessment threshold). Above this contribution threshold it is possible to take out private health insurance. Family members are usually covered by the statutory health insurance but are not required to contribute. Benefit entitlements in the statutory health insurance scheme are independent of the level of contributions paid in.

Germany spends about 10.6% of its GDP on health care. The facilities of the health care system include 2,087 hospitals with approximately 136,000 medical staff, about 21,400 pharmacies and 138,000 general practitioners and specialists [35]. From 2015 onwards, evidence of statutory health insurance for insured individuals and thus access to its benefits is only possible via the electronic health card. Only the core data of the insured person (name, address, date of birth, gender, insurance number, insurance status, and validity of the card) are stored on the electronic health card at this stage. Medical data will only be stored on the card in the coming years via the planned applications "Emergency data" and "Medication documentation".

b)   Background and motivation: The electronic health card and the Action Plan for Drug Safety

The Lipobay scandal in 2001 showed the urgent need of an overview of medications in current use. Cerivastatin (Lipobay®) had to be taken off the market in August 2001, since it caused deaths due to rhabdomyolysis with subsequent kidney failure. The risk of this adverse effect was significantly greater in patients who received concomitant treatment with gemfibrozil and cerivastatin than in patients treated with cerivastatin alone.

These events were one of the factors that initiated the legislation on the electronic health card in Germany [36]. It was planned to introduce the electronic health card in Germany in 2006. According to § 291 a, para. 3, sentence 3, SGB-V [Social Security Code, Book 5] it was planned to include documentation of medicinal products in the electronic health card. Access to the medicinal product documentation would be via a secure telematics infrastructure.

The development of a telematics infrastructure was found very demanding, particularly because the requirements for data protection are very strict in Germany. For example, the plan for the electronic health card envisioned that the patient could only inspect his medication data together with a doctor or pharmacist, or in an "environment that ensures that the patient's rights can be safely executed".

Documentation of patient medication was still not available via the electronic health card in 2010, and so options were sought in the "Action Plan of the Federal Ministry of Health for Improvement of Drug Safety (AMTS) in Germany", initiated by the Federal Ministry of Health, for provisional means of documenting patient medication without the use of the electronic health card.

The Federal Ministry of Health had already published the outline of an initial action plan for improvement of drug safety in Germany in late 2007, with the aim of optimising the safety of medicinal treatment [37]. The publication of an action plan in which all relevant and feasible means of improving drug safety were mentioned was an important step towards better drug safety in Germany. This action plan involves all groups concerned with the medication process in the analysis of problems associated with this process and the development of strategies and measures for risk minimisation.

A leaflet for patients on the safety of medicinal treatments was quickly developed in the Drug Safety Action Plan. Again, this leaflet recommended to maintain a list of currently administered medications. In the discussion of how settings for the safe execution of patients' rights can be arranged, it soon became clear that most patients will need a medication list on paper to organise their own treatment, regardless of the availability of an electronic health card.

c)   Objectives of the uniform federal medication list

The Coordination Group for the Drug Safety Action Plan formulated the essential requirements for a uniform patient-focused medication list in 2010 [38]:

1.   It is designed to provide an orientation and reminder tool for patients based on their medicinal treatment, and to support them in taking their medications as prescribed.
2.   It should increase the adherence of patients to their medication list.
3.   It should also facilitate updating of the medication and its coordination between physicians, pharmacists and nursing staff.

To ensure that the degree of complexity remains reasonable, the scope of the medication list should be limited. The medication list is a (paper-based) snapshot of the patient's current medicinal treatment, and not a substitute for an (electronic) medical record. It cannot be used for permanent documentation, it is not a substitute for a prescription and it should not be confused with one.

As long as the electronic health card does not allow access to medication data, some thought must also be given to a method of updating the information, since transcribing medication lists is time-consuming – which often means that they are not updated at all. In addition, handwritten alterations of a medication list are an important cause of errors, because the legibility of the list is impaired and different interpretations of the document are possible.

d)   Organisational and legal framework

The basis for the introduction of the medication list is the German eHealth legislation [39] that was passed end of 2015. It states that a patient with more than three prescribed medications has the right to obtain a medication list from his healthcare provider.

The driving force behind the Action Plan (and therefore the medication list) is the "Coordination Group for Implementation and Adaptation of the Action Plan". It meets 3 to 4 times a year and is responsible for monitoring the individual measures mentioned in the Action Plan as well as its further development.

The scientific secretariat of the coordination group has been based at the Drug Commission of the German Medical Association (DCGMA) since October 2008. It is responsible for communication between the participating institutions and coordinates implementation of the measures of the Action Plan and therefore the medication list.

e)   Structure, stakeholders and processes

An important point in the design of a uniform paper-based so-called medication list ("Medikationsplan" in German) for patients was to keep it as simple as possible. This should make it clear and quick to complete. The medication list contains all medications that are currently taken

regularly as well as those taken as required. Figure 1 shows how the German medication list looks like as printout.

Medikationsplan

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AKTIONSPLAN ZUR VERBESSERUNG DER
**ARZNEIMITTEL
THERAPIESICHERHEIT**
IN DEUTSCHLAND

für: Armin Müller

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Wirkstoff	Handelsname	Stärke	Form	Mo	Mi	Ab	zN	Einheit	Hinweise	Grund
Metoprololsuccinat	Metoprololsuccinat 1A Pharma® 95 mg retard	95 mg	TAB	1	0	0	0	Stck	Mit 1 Glas Wasser	Herz/Blutdruck
Ramipril	Ramipril-ratiopharm®	5 mg	TAB	1	0	0	0	Stck	Mit ausreichend Flüssigkeit	Blutdruck
Clopidogrel	Clopidogrel Zentiva®	75 mg	FTA	0	0	1	0	Stck		Herz
Pantoprazol	Pantoprazol dura®	20 mg	TMR	1	0	0	0	Stck	1 Stunde vor der Mahlzeit	Magen
Insulin aspart	NovoRapid® Penfill®	100 E/ml	PAT	20	0	20	0	I.E.	Wechseln der Injektionsstellen, unmittelbar vor einer Mahlzeit spritzen	Diabetes
Simvastatin	Simva-Aristo®	40 mg	FTA	0	0	1	0	Stck	Mit ausreichend Flüssigkeit	Blutfette
Torasemid	Torsamid Hexal®	5 mg	TAB	1	0	0	0	Stck	Mit etwas Flüssigkeit	Blutdruck

Zeitlich befristete Medikation

Clarithromycin	Clarithromycin-TEVA®	250 mg	FTA	alle 12 Std. 1				Stck	von 1.4. bis 6.4.	Bronchitis

Selbstmedikation

Myrtol	GeloMyrtol®	120 mg	KPS	2	2	2	0	Stck	Mind. Halbe Stunde vor dem Essen mit einem großen Glas kaltem Wasser	Bronchitis
Johanniskraut	Laif® Balance	900 mg	FTA	1	0	0	0	Stck	Nach dem Frühstück	Stimmung

Selbstmedikation bei Bedarf

Magnesium	Magnesium® Verla	121,5 mg	BTA	bei Bedarf 1-2				Stck		Wadenkrämpfe
Diphenhydramin-HCl	Vivinox® Sleep Schlaftabletten stark	50 mg	TAB	0	0	0	1	Stck	b. Bed. 30 min vor dem Schlafengehen mit ausreichend Flüssigkeit	Schlafstörungen

DE-DE-Version 2.0 vom 10.10.2013

ARM!N Modellprojekt Sachsen/Thüringen

Figure 1: The German medication list ("Medikationsplan" in German), indicating ingredients, drug name, strength, form, intake recommendations and reason for prescription (fictional names used).

For straightforward transfer of information between healthcare facilities a 2D barcode was used (Datamatrix according to ISO / IEC 16022). Two-dimensional barcodes are now used with great success in many areas - transmission of viruses via this medium is highly unlikely and has not been reported. An advantage over one-dimensional barcodes is that more information can be transmitted (e.g. 1,000 to 2,000 bytes). The 2D barcode can be read by many smartphones; this makes it possible to create suitable applications, such as reminders to take medications at the right time.

The 2D barcode of the medication list does not contain a link, but includes the entire contents of the medication list of the patient. There is therefore no need for a medication server to provide the medication data. As a result, most of the data protection issues that make the electronic health card project so complex do not arise.

The various applications of the medication list are basically as follows: the doctor prescribes medication and prints out an initial medication list for the patient with the assistance of a standardised function in his practice information system. When the patient has his prescriptions filled by a pharmacy, he can have his medication list updated there, and have any other medications entered that he may have purchased himself in the pharmacy. Since there are discount agreements between health care insurers and pharmaceutical manufacturers for most medications, any trade names of medications that have been altered can be updated.

The patient takes his medication list with him to his next visit to the doctor or to the pharmacy where he buys his medications. The doctor and the pharmacist can read the medication list into their IT system via the 2D barcode, so that they have a current list of all medications that the patient should take. If a doctor prescribes a new medication, he prints out the updated medication list for the patient. When the patient gives his medication list to the respective health care professional, all relevant doctors and pharmacists as well as the patient and any nursing staff have access to the current medication list at any time.

f)   Current status and prospects

The uniform patient-related medication list is being tested in four different pilot projects from the beginning of 2015. This involves the use of different solutions for both the medication list and the associated infrastructure.

With the uniform paper-based and patient-oriented medication list, a standardised data structure for medicinal treatment has been achieved, which should make basic interoperability possible.

However, some hurdles still need to be overcome with regard to structuring the data as extensively as possible. This mainly concerns the use of the catalogues from which the software obtains the information required to populate the individual sections of the medication list. The designation of the active substance must still be entered by hand, because there is no freely available and unambiguous classification of active substances for active pharmaceutical substances and their salts. With the classifications that are currently in use (e.g. the official German ATC classification) there is also the problem of re-use of code numbers. A future solution that is not yet available might be use of the German "Arzneimittel-Stoffkatalog" (ASK) [40] or the Global Ingredient Archival System (GINAS) [41] developed and announced by the European Medicines Agency.

The e-Health Act passed end of 2015 entitles the patient to a medication list if he needs to take more than three medications. Service providers should now agree on a uniform concept based on the uniform patient-oriented medication list developed in the Drug Safety Action Plan. The results of the pilot projects will be taken into account in this concept. It will then be possible to incorporate the medication list into the electronic health card, so that the barcode will no longer be necessary in the long term.

e-medication in Switzerland

a)   The health care system in Switzerland

Switzerland is a federation of 26 cantons with 8.2 million inhabitants. Switzerland spends about 10.9% of its GDP on health care. The facilities of the health care system include 298 hospitals (116 general hospitals and 182 specialised clinics), 1,743 pharmacies and 17,554 doctors in the outpatient sector [42] [43]. A significant influence on the Swiss health system is the multilingualism of the resident population (64.9% German-speaking, 22.6% French, 8.3% Italian and 0.5% Romansh) [44].

Responsibilities for health care are divided between the federal government, the cantons and the municipalities. In principle, legislation and its implementation are in the remit of the cantons. The cantons are responsible for the provision of health care and for the planning and partial financing of inpatient facilities. The federal government is responsible for the provision of health insurance in accordance with the Health Insurance Act (KVG). Health insurance is compulsory for the entire population.

Since January 2010, insurance companies must issue an insurance card to all insured persons. Medical data such as blood group and transfusion data, allergies and medications can be stored on the insurance card. Service providers can access these data using card-to-card authentication with their electronic service provider ID (eLENA, Health Professional Card).

b)   Background and motivation: the Swiss eHealth strategy

The "Swiss eHealth Strategy" was developed jointly by the Confederation and the cantons, and was adopted by the Federal Council in 2007. The strategy is focused on the vision that people in Switzerland make data relevant to their treatment accessible to the health care professionals of their choice, regardless of time and place. The health literacy of the Swiss population will be improved by active involvement in their health problems and behaviours [45] [46].

Implementing the strategy involves definition of common organisational, legal and technical guidelines for the development of e-health applications. Since it is not possible to introduce centrally managed e-health applications in Switzerland's federally organised health system, the focus must be on the support of decentralised, regional and strategy-compliant projects as well as their networking. Flexible development of the system appropriate to regional requirements will be taken into account, but this will result in an increased need for coordination.

c)   Objectives of the introduction

In 2013 the Federal Council adopted the health policy agenda "Health 2020", which determines the priorities of Swiss health policy with a total of 36 measures for the next eight years [47] [48] [49]. The "Health 2020" agenda is based on the "Swiss e-Health Strategy" in the corresponding areas, and specifies priority objectives including:

- Introduction and active promotion of an electronic patient record in order to improve the quality of care as well as patient safety, and to support treatment processes and cooperation between health care providers;
- Introduction and active promotion of electronic prescribing by making it possible for health care professionals to obtain electronic access to the medication information of their patients.

The following goals should be achieved by active promotion of electronic prescribing:

- Avoidance of uncoordinated taking of medications;
- Designation of the patient's current medication for all attending health care professionals;
- Avoidance of medication errors by doctors, hospitals, pharmacies and outpatient or inpatient nursing homes.

This measure is closely linked to the introduction of the electronic patient record (EPR), which should support treatment processes (e.g. at discharge from hospital or associated with integrated care processes during a treatment plan).

d)   Organisational and legal framework

The Swiss Federal Council (executive) only has limited responsibilities in the area of health care. However, the cantons do have the necessary authority. But due to their small size, some of them have considerable difficulties in establishing the appropriate objectives and measures at cantonal level. For this reason a framework agreement was concluded in 2007 between the Confederation and

the cantons that declares the intention to implement these objectives jointly. Based on this agreement, a coordinating body between the Confederation and the cantons was established (eHealth Suisse Federal-Cantonal Coordinating Body). The Swiss eHealth strategy provides that the operational and technical work is to be carried out by working groups in the form of individual projects.

1) Federal Act on the electronic patient record

In order to place an important component of the Swiss eHealth Strategy on a firm legal basis, the Federal Act on the Electronic Patient Record (EPR Act) [50] was adopted by Parliament in June 2015. The EPR Act is expected to take effect in 2017.

The EPR Act establishes the legal framework for the processing of data in the EPR. For implementation of the strategy, the legal basis for the nationwide introduction of an electronic patient record is currently being established in the individual cantons.

A key element in the model of the EPR legislation is its voluntary nature: participation is voluntary for both patients (opt-in model) and outpatient service providers. Inpatient service providers, however, must implement an electronic patient file after an appropriate transitional period.

Interoperability will be facilitated by joint guidelines for data processing within and between certified "communities" (associations of health professionals).

2) Revision of the Therapeutic Products Act

The Swiss Therapeutic Products Act is being revised in parallel with the introduction of the electronic patient record. A second revision stage will regulate aspects such as simplified authorisation of medicinal products and provisions governing the prescription, dispensing and use of medicinal products, including dispensing authorities, strengthening of market surveillance, improvement of medicinal therapy in paediatrics, regulation of monetary benefits and the approach to presentation and publication of medicinal product information.

There are currently no minimum requirements for an electronic prescription at the legislative level. However, principles for the prescription and dispensing of medicinal products are laid down in the current version of the Swiss Therapeutic Products Act. The draft revision of the Swiss Therapeutic Products Act will stipulate the contents of the prescription (also refers to the electronic prescription) at the subordinate legislative level. The minimum requirements are based on the European directive on cross-border healthcare (2011/24/EU), which took effect in 2013 [19]. According to Article 11, the Commission issues provisions for the creation of a non-exhaustive list of elements that must be included in prescriptions and which must be clearly visible in all prescription formats.

3) Coordination of activities by "eHealth Suisse"

The eHealth Suisse Federal-Cantonal Coordinating Body ensures that projects associated with the Swiss eHealth strategy are goal-oriented and strategy-compliant, and that synergies between the projects are exploited. To this end, "eHealth Suisse" is developing recommendations in subprojects that will constitute the legislative principles as well as guidelines for the architecture across the whole of Switzerland. Ten out of twenty-six cantons have already started to implement these recommendations in pilot projects or targeted eHealth projects (particularly for electronic prescribing).

Project organisation in the cantons is carried out individually, and is guided by the cantonal health departments, hospitals or private operators.

e)   Structure, stakeholders and processes

The architecture of "eHealth Suisse" provides a virtual EPR according to the principle of decentralised data storage. Treatment-related data collected in the information systems of service providers such as private practices, pharmacies or hospitals are made available to other service providers after prior authorisation by the patient. Digital support of treatment processes in terms of workflow control is not yet envisioned.

A prerequisite for the collection and provision of data in the EPR is that health professionals join communities that provide the IT infrastructure necessary for the registration, storage and communication of treatment-related data. Interoperability at the interfaces of the communities will be ensured by the use of appropriate IHE profiles, as well as a certification that guarantees data protection and security or certain organisational prerequisites.

With regard to the semantic structure of documents in the EPR, there are currently no particular specifications except for those documents that are made available in the public health sector (notifiable laboratory findings and findings related to the transplantation process). However, in the regions of the pilot projects, exchange formats are already being developed and used, e.g. to store structured medication data or discharge reports in the EPR.

The orientation of the individual projects that are currently underway is varied, and this is reflected by the various project organisations and operators:

- National coordinated strategy-compliant projects in the context of pilot projects.
- Projects that are not strategy-compliant, with and without cantonal coordination.
- Regional projects with public-private partnership.

For the nationally coordinated projects of "eHealth Suisse", semantic standards will be established by an interdisciplinary group of professional associations (IPAG). The working group will develop the technical content of the national exchange format "eMedikation" (e-medication). The results are incorporated into a technical implementation guide, which will be adopted and recommended at national level.

The preliminary results of the IPAG envision the following document types resulting from the prescription process:

- medication list,
- (electronic) prescription,
- dispensing document.

The medication list comprises the planned medication regimen, and also stopped medications with long half-life or long washout period that may be considered problematic. The prescription document fulfils the same purpose as the paper based form but with the benefit of improved prescribing accuracy end efficiency [51].

In some cantonal projects, the prescription can also be a paper document, which can be digitised via a 2D barcode and then updated by the doctor or pharmacist [52]. In such cases, the dataset can

either be used for electronic exchange of information along the treatment chain, or to store information later in the uniform format of the EPR.

The dispensing documentation includes information on possible modifications of the prescription such as information on which service provider validated the prescription.

It is worth noting that the patient's medication history is formed by aggregating the data from the documents mentioned above.

f)   Current status and prospects

The pilot project"MonDossierMedical.ch", developed in the Canton of Geneva, has had a shared medication treatment plan tool (Figure 2, large window) since mid-2013 [53]. This tool enables physicians to plan and prescribe medications - including the generation of the treatment card (Figure 2, small window bottom left) and the production of a prescription (to be printed and signed) [54] [55] [56]. Pharmacists can also contribute to the plan by introducing over-the-counter dispensed as well as patient's reported medications in the plan. Dispensing, and all that is linked to this act like drug substitution, verification of adverse events, etc. is nevertheless not yet implemented. Nurses have also the possibility to document administration-related information, like patient's comments.

This initial version of the shared medication treatment plan therefore supports only the first steps of the medication process: planning, prescription and complementary documentation. Nevertheless, it could be a blueprint for other communities or even a standard for Switzerland.

Figure 2: The Geneva MonDossierMedical.ch's Shared Medication Treatment Plan (large window) and the Geneva Patient's Treatment Card (small window bottom left) (fictional names used).

MonDossierMedical.ch – as part of the national eHealth strategy – is committed to using well established standards. However the existing standards (IHE Pharmacy profiles) were not covering the whole process – both planning and administration phase being missing. Work was therefore performed to extend IHE profiles in order to be able to describe the planning phase (IHE MTP Profile [57]), followed by the definition of a national extension (MTPS – Medication Treatment Plan Sharing). The MTPS was then submitted in June 2015 to the IPAG interdisciplinary work group in order to harmonise the proposals of the ongoing projects and to prepare a national specification. The MTPS should finally become a national exchange format for the EPR in fall 2016.

Implementation of the MTPS and integration of at least the University Hospitals of Geneva's prescription system, several pharmacy applications and healthcare professional applications are planned to be ready in spring 2016. This strong integration will progressively make the shared treatment plan in the MonDossierMedical.ch more and more complete, becoming then the main source of information about current and past patient's medication. The shared treatment plan aiming at containing all medications of a patient, it will be the source of information for inter cantonal as well as international cross-border communication like e.g. what has been implemented in epSOS / EXPAND European projects (Patient Summary and ePrescription / eDispensation services). Integration of drug interaction information sources is also considered as an added value service to prescribers, but for a future extension.

The last step of the medication process – the administration one – is currently not considered, as the process leading to a reliable documentation is not clear.

The EPR Act in Switzerland [50] as well as Geneva's cantonal law [58] do support this patient's right by allowing him to choose the level of confidentiality for each document – including medication related ones - meaning that the patient can prohibit the access to some prescriptions. For example, the patient has the possibility to hide all actions performed by a specific healthcare provider, leading thus to a partial medication plan. The computerized medication plan will therefore never replace the dialog between the healthcare provider and the patient – it is a tool supporting the continuity of care with a high added value if used properly taking its limits in consideration.

The Austrian eMedikation

a)   The health care system in Austria

Austria is a landlocked country with nine federal states and 8.5 million inhabitants. Austria spends about 10.6% of its GDP on health care. Its healthcare facilities include approximately 280 hospitals, 2,300 pharmacies (including commercial and hospital pharmacies) and 19,300 doctors in private practice [59]. About 50% of physicians are doctors not affiliated with any of the state health insurance funds ("Wahlärzte"). All insured persons in Austria have an e-card (which is also valid as a European Health Insurance Card). The e-card is only used for identification purposes and does not contain any medical data. The e-card is used approximately 500,000 times per day.

b)   Background and motivation for eMedikation

In 1995, the Austrian Minister of Health set up the STRING Commission, an advisory panel of experts to address the issue of electronic exchange of patient data between health care institutions. This

expert committee published the MAGDA-LENA framework for nationwide electronic sharing of patient data in 1998 [60]. This framework was the starting point for the Austrian eHealth strategy. The MAGDA-LENA framework outlined the technical and organisational aspects that govern development of an Austrian healthcare information network that will enable the contents of electronic health records (EHRs) to be shared.

Between 1999 and 2005, an electronic social security card (the e-card) was introduced for all Austrian citizens, containing information on the insurance status of the holder. In 2005, the Ministry of Health issued the Healthcare Reform Act that involved the introduction of a lifelong electronic health record ("ELGA") in Austria [61]. "eMedikation" is an ELGA service introduced in addition to discharge letter, laboratory findings and radiology records [62].

c)   Objectives of the introduction of eMedikation

eMedikation is a service that provides information on the patient's medication in the course of prescribing, dispensing and administering. The key element is a database of the medications that have been prescribed and dispensed. This database has interfaces to the existing IT infrastructure (such as software systems for medical practices and pharmacies as well as hospital information systems). eMedikation is based on the ELGA infrastructure [63].

The main objectives of eMedikation are to increase drug safety, prevent multiple prescriptions, achieve economic savings, involve patients and enhance the networking of healthcare service providers. Purely electronic prescribing (e-prescribing) is not planned at this stage; the patient will continue to receive a paper prescription.

d)   Organisational and legal framework

The ELGA project is managed by ELGA GmbH. The umbrella organisation of social insurance companies is responsible for the establishment and operation of this information system.

A telematics act (ELGA Act) was adopted in 2012 for the introduction of the electronic health record [64]. §16 of this Act is the legal basis of eMedikation.

e)   Structure, stakeholders and processes

The key component of eMedikation is a list of medications that have been prescribed or dispensed to a given patient. This list is available to patients, physicians and pharmacists. Figure 3 shows how the medication list will be structured [65].

The technical basis of ELGA is the IHE Framework. Its basic components include a central patient index and an index of health service providers. The document standard HL7 CDA is used for sharing patient data. The CDA implementation guide for eMedikation [63], as well as sample documents and supporting documents for implementation of aspects such as value sets, can be found on the ELGA homepage.

A typical process within the eMedikation system proceeds as follows: after authentication of the patient with the e-card and the doctor with the o-card, the doctor can read the centrally stored medication list into his information system. The interaction test is carried out locally. When a new prescription is saved in the central database, an eMedikation identification number (eMedID) is generated and printed on the paper prescription. The patient takes the paper prescription to the

pharmacy. The pharmacist reads the open prescriptions in from the medication list via the eMedID and saves the dispensing record in the medication database.

Abgabe(n)										
			Dosierung							
	Arzneimittel ⬇	**Einnahme**	morgens	mittags	abends	nachts	**Hinweis**	**Zusatzinformation**	**Abgabe am** ⬇
[+] [3]	Zithromax 500 mg Filmtabletten	täglich					1 Tablette		06.05.2013
[-] [2]	Diazepam Actavis 10 mg Tabletten	täglich	0	0	1	0	Darf nicht mit Milch eingenommen werden	Einnahmestart: 07.05.2013 Einnahmeende: 29.05.2013	05.05.2013
	Packung(en), Menge/art								
[+]	3 x 10 Stück	täglich	0	0	1	0	Darf nicht mit Milch eingenommen werden	Einnahmestart: 07.05.2013 Einnahmeende: 29.05.2013 Art der Anwendung: zum Einnehmen	05.05.2013
[-]	2 x 30 Stück		1	0	1	0	Darf nicht mit Milch eingenommen werden	Art der Anwendung: zum Einnehmen	03.03.2013

Verordnet am 02.03.2013 von

	Titel	Vorname	Nachname	Fachgebiet	Adresse
	Dr.	Max	Arzt	Allgemein	Musterstraße 27/1, 1010 Wien

Abgegeben am 03.03.2013 von

	Name	Adresse
	Wald Apotheke	Apothekenstraße 10, 1010 Wien

[+] [3]	Concor plus- Filmtabletten								06.05.2013
[+] [1]	Erythromycin, Hydrocortison, Ultrasicc ad 50.0	Mo, Mi, Sa							03.03.2013

Figure 3: Structure of the Austrian medication list, indicating drug name, strength, form, intake recommendations, prescribing physician, dispensing date and dispensing pharmacy.

Further details of the system are: (i) Storage of medications administered in hospital wards is not currently foreseen. (ii) A selection of over-the-counter (OTC) medicinal products with significant interactions will be stored centrally. (iii) Records of medication dispensing are stored for one year in the eMedikation database. (iv) Access by health service providers to information from the eMedikation database is possible one month after authentication of the patient. (v) Central drug-drug interaction testing is not provided, meaning that responses to interaction warnings by health service providers are not stored centrally and are therefore not available to subsequent providers.

f)   Current status and prospects

In 2011, a pilot project on eMedikation was carried out in three test regions. The project was delayed by a refusal to cooperate on the part of the medical professionals. The evaluation [66] resulted in an overall view that was basically positive, but a re-design was also requested.

In 2013, ELGA put the ELGA patient portal into operation [67] – at that time without any documents contained yet. However, patients were already able to configure some functions of their own ELGA records. For example, they could exclude individual health service providers or medications, or they could cancel their ELGA registration altogether ("opt out"). In 2015, ELGA services started with the discharge letters from hospitals in two regions (Vienna and Styria). The roll-out of eMedikation is planned for 2016.

The success of eMedikation will be determined by the extent of participation by patients and healthcare providers as well as the completeness of the prescription and dispensing records. One problem is that "Wahlärzte" (doctors not affiliated with any of the state health insurance funds) are not required to participate in eMedikation. It would be important to have comprehensive participation of all health service providers and acquisition of non-prescription medications with relevant interactions, since about 80% of all medications are not prescribed by doctors (OTC products) [68, p. 26]. Austria's situation as a landlocked country and a tourist destination means that harmonisation of medication data with neighbouring countries would be particularly worthwhile.

Overview of the e-medication approaches in Austria, Germany and Switzerland

Table 1 summarizes the most important similarities and differences of the three countries.

Table 1: Overview of the e-medication approaches in Germany, Switzerland and Austria

	Austria	Germany	Switzerland
National eHealth strategy available?	"MAGDA-LENA" framework as basis; Federal states have regional eHealth strategies.	Strategy is contained in basic concept for the telematics infrastructure and in eHealth law.	"Swiss eHealth Strategy", 2007.
National strategy to improve medication safety available?	Reflected in telematics act (ELGA-law) from 2012.	"Action plan AMTS", since 2008.	"Gesundheit 2020", 2013.
e-prescription available?	Only paper-based prescriptions are issued to the patient.	Only paper-based prescriptions are issued to the patient.	Only paper-based prescriptions are issued to the patient.
Name of project to achieve national medication list?	"eMedikation" as part of ELGA (national electronic health record).	"Medikationsplan", not yet integrated in eGK (elektronische Gesundheitskarte).	Currently, different names in regional projects; "eMedikation" will be part of the Swiss EPR (electronic patient record).
Objectives of project for national medication list?	Inform all providers on recent medication of a patient. Increase medication safety. Reduce double prescriptions. Economic savings.	Remind patient on reasons for drug therapy and give intake recommendations. Increase patient adherence Coordination of drug therapy between providers.	Prevent uncoordinated drug intake; Inform all providers on recent medication. Prevent medication errors. Increase patient adherence.

	Increase patient empowerment.		
Legal basis for national medication list?	Telematics act (ELGA-law) from 2012.	eHealth law (passed December 2015).	Federal law on the electronic patient record (to become applicable in 2017).
Organizational project architecture?	Project initiated and conducted centrally (by ELGA GmbH); introduction starts 2016.	Project initiated centrally (by DCGMA Drug Commission of the German Medical Association);

pilots with different scope at the moment running in various regions. | Project initiated regionally by Swiss cantons; pilots with different scope running in various regions. |
| Technical project architecture? | Central prescription and dispensing database with interface to IT systems at doctors' offices and pharmacies; eMedikation is part of ELGA, the national electronic health record. | No central storage of medication plan information; information is contained in barcode and in local IT systems at doctors' offices and pharmacies.

Medication list is planned to be later included as service in the telematics infrastructure. | Decentral architecture of a virtual electronic patient record that also contains medication information. |
| Is participation voluntary? | All health care providers have to participate. Patients are automatically participating, but can decide to opt-out. Doctors in private practice do not participate. | Patient with more than three prescribed drugs have the right to get a printed medication plan from his health care provider. | Patients and out-patient service provider participate voluntarily. Patients have the option to opt-in. For inpatient service provider participation is compulsory after a defined transitional period. |
| Standards used? | IHE-XDS;

HL7 CDA. | 2D-Barcode;

Drug catalogue still under discussion. | IHE XDS;

IHE Pharmacy Profiles;

National standard based on IHE Pharmacy; Medication List (Medication Treatment Plan Sharing). |

Discussion

The description of e-medication initiatives in Germany, Switzerland and Austria can only highlight major developments and is not an in-depth analysis of the success criteria for e-medication in each country. However, the structured description highlights some similarity, but also several differences in the way the countries handle the challenge of a national medication list.

In all three countries, the major objective is to inform health care providers on the medication that is taken by a patient, to improve medication safety. Additional objectives have a partly different focus: Austria also strives to reduce double prescriptions, to allow economic savings;, Germany wants to improve patient adherence with the medication list. Switzerland, and especially Geneva, wants to provide healthcare providers with the most accurate knowledge of the medications taken by the patient in order to secure the prescription of drugs. Improving patient adherence through a comprehensive and up to date medication list is also part of the main objectives.

All three countries started their national eHealth activities in the 1990[s] or 2000[s]. In all three countries, a comprehensive national electronic infrastructure for exchange of health data is planned, but not yet or only partly available. Switzerland with a strong federal organization has chosen a decentralized approach with strong focus on voluntary participation. Austria and Germany have chosen a more centralized approach to establish a national electronic infrastructure for data exchange. Austria and Switzerland base their solutions on international standards such as IHE-XDS, while Germany uses a 2D-Barcode for information transmission.

Switzerland allows a high degree of voluntariness for outpatient health care providers and an opt-in for patients. Only inpatient providers must participate after a transitional period. In Germany, participation in the medication list is mandatory for health care providers and is offered as a right to patients. In Austria, participation in eMedikation is mandatory for all, but patient can opt-out. The argument for mandatory participation is that only when all health care providers participate, the medication list of a patient can be as complete as possible and thus be helpful. However, in Austria, certain doctors ("Wahlärzte") are not obliged to participate, which will lead to an incomplete medication list for patients.

In general, in order to fully support the medication process, all medication-related applications have to communicate, that is they have to support semantic interoperability. Indeed many applications manage medication data and contribute and update medication information, such as electronic patient records from hospitals and healthcare professionals, dispensing software from pharmacies as well as nursing documentation systems. Combining the information from these applications will allow establishing a comprehensive patient's medication list.

However, in all countries the patient has the possibility to hide medication-related information from health care providers. Thus to guarantee the completeness of the medication list is not possible. Indeed when discussing with his/her physician, the patient always has the possibility to omit mentioning medications he/she is taking. It is however expected that a trusting relationship between the patient and the physician is the best way to limit if not avoid such situations that can lead to medication problems.

Austria plans to start with the exchange of medication data in 2016 as part of the ELGA introduction. In Germany, integration of medication information in the national infrastructure (eGK) is planned for

the next years. Yet, to avoid delays, a work-around with a paper-based medication plan is piloted at the moment. In Switzerland, regional pilot projects are starting now.

In all countries, the process of developing solutions for e-medication was slower than expected. All countries have seen challenges such as acceptance among health care professionals, concerns regarding data security or complex political negotiations, all this delaying the start of e-medication. In Austria, the evaluation study of the pilot project showed that the success factors are different for physicians and pharmacists [69]; each group therefore needs individual support.

One further reason for the long phasing-in periods is the need to adapt national legislation to form a legal basis for eHealth and medication systems in all countries.

We are living in a mobile world with many travelling tourists, professionals and students. To support cross-border healthcare, the project epSOS [17] draws the requirements on interoperability frameworks. Therefore, taking a look into the future, the technical and semantical harmonisation of the three national approaches will also be an overarching objective as well.

Conclusion

Nationwide e-medication systems and cross-border harmonization are acknowledged as important goals towards medication safety. In Germany, Switzerland and Austria e-medication is a primary objective in their eHealth strategies. However the e-medication systems are developing slowly, mainly due to privacy and security requirements, the need of law amendments and last but not least political interests.

Authors' contribution

All authors participated in the design of the paper. AA contributed the information about the activities in Germany, RS and SS of Switzerland and EA and WG of Austria. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare no conflicts of interest.

Amin-Farid Aly, who contributed the information about Germany and is currently working for the Institute for Quality Assurance and Transparency in the Health Sector (IQTIG), was previously employed at the Drug Commission of the German Medical Association (DCGMA).

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