Health Care Performance Indicators
for Health Information Systems

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Abstract. Health Information Systems (HISs) are expected to have a positive impact on quality and efficiency of health care. Rapid investment in and diffusion of HISs has increased the importance of monitoring the adoption and impacts of them in order to learn from the initiatives, and to provide decision makers evidence on the role of HISs in improving health care. However, reliable and comparable data across initiatives in various countries are rarely available. A four-phase approach is used to compare different HIS indicator methodologies in order to move ahead in defining HIS indicators for monitoring effects of HIS on health care performance. Assessed approaches are strong on different aspects, which provide some opportunities for learning across them but also some challenges. As yet, all of the approaches do not define goals for monitoring formally. Most focus on health care structural and process indicators (HIS availability and intensity of use). However, many approaches are generic in description of HIS functionalities and context as well as their impact mechanisms on health care for HIS benchmarking. The conclusion is that, though structural and process indicators of HIS interventions are prerequisites for monitoring HIS impacts on health care outputs and outcomes, more explicit definition is needed of HIS contexts, goals, functionalities and their impact mechanisms in order to move towards common process and outcome indicators. A bottom-up-approach (participation of users) could improve development and use of context-sensitive HIS indicators.

Keywords: Quality indicators, health care, medical informatics applications, health information systems, eHealth, benchmarking.

1   Introduction

Pressures on health care systems across the world to ensure simultaneously access, quality, and affordable care are increasing with the aging population, increased demands for service equity and patient expectations, advances in medicine, and slow economic growth. Health care administrators and policy-makers are faced with major questions regarding the allocation of scarce health care resources to select interventions that support high performance of health systems and increase the quality and efficiency of care and services. [1, 2]

There are big expectations for health information or eHealth Systems (HISs) in improvement of health care system performance. In this contribution, terms HIS and

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eHealth are used as synonyms and defined according to the Medical Subject Headings (MeSH) as "*Integrated set of files, procedures, and equipment for the storage, manipulation, and retrieval of (patient) information*". Health systems performance improvement is defined as "*positive changes in capacity, process and outcomes of public health as practiced in government, private and voluntary sector [health care] organizations*". [3]

Adoption of HISs has grown substantially in the past years [1, 2, 4], including regional and national electronic health record (EHR) systems to capture patient health information and enable the exchange of patient information between organizations. [5] HISs have been seen as key enablers for modern, patient-centred and efficient health care services [6, 7]. Rapid technological diffusion has increased the importance of commonly agreed, reliable and valid indicators to monitor the adoption and impacts of HISs, to learn from past and current initiatives, and provide decision makers with evidence to make informed policy decisions about their HIS. Evidence-based management is a management approach adopting the ideas of evidence-based health care to management, emphasizing that common principles should apply to clinical and non-clinical investment decisions [8, 9]). An "Indicator" is "*a single summary measure, most often expressed in quantitative terms, representing a key dimension of health status, the health care system or related factors*" [10, 11]. "Monitoring" is "*a process aimed at measuring possible change in the indicator values over time (…) to provide (…) the main stakeholders of an intervention with early information on progress, or lack thereof, in the achievement of specific outcomes or objectives. (…) Monitoring must be periodic to pick up change*".[7] For monitoring, impact mechanisms of interventions as well as mediating factors must be clearly specified [12, 13].

In defining what to measure and how for the purpose of evidence-based management of HIS, the viewpoints of different stakeholders (e.g., policy makers, administrators, researchers, citizens or others) have to be taken into account.[2] In addition to improving health, the wider goals of efficiency and equity of access to care are often included in health system performance monitoring. [14] The measurement of HIS-related improvements in health care system performance therefore requires taking into account these various dimensions. The need to translate these dimensions into concrete representations that can be quantified, and the need for a consensus about the most appropriate measures, complicate the definition. Many different measures of equity of access to care can, for example, be used (e.g. waiting time, availability of resources, access of costs), and some may be more sensitive to HIS than others. Measures need to be based on a sound, scientifically validated knowledge foundation, authority, or be derived from the practitioners [13] as well as have a plausible link to HIS.

2   Examples of existing health care performance indicators for HIS

An abundance of HIS indicator domains and measures has been defined for health care structural, process and outcome performance (e.g. [15]). Figure 1 presents a generic (not HIS-specific) representation of the relations between the health care structure, process

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[2] See also: L. Lee et al., Understanding stakeholder interests and perspectives in evaluations of health IT, in: E. Ammenwerth, M. Rigby (eds.), Evidence-Based Health Informatics, Stud Health Technol Inform 222, IOS Press, Amsterdam, 2016.

and outputs/outcomes [16]. Knowledge of structural and process elements is required if outcome impacts are to be understood and evaluated: if the structural elements – e.g. HIS functionalities – are not available, they cannot be used, and if they are not used, they cannot impact health care outputs or outcomes. In general, structural elements are measured by the care capacity using input and resource indicators. HISs and other tools and equipment used in care are one type of resource, availability of which thus form one structural indicator topic. Processes are monitored by indicators measuring care transactions (use of the capacity and resources), outputs by efficiency and volume of services provided, and outcomes by indicators measuring impacts of the care services.
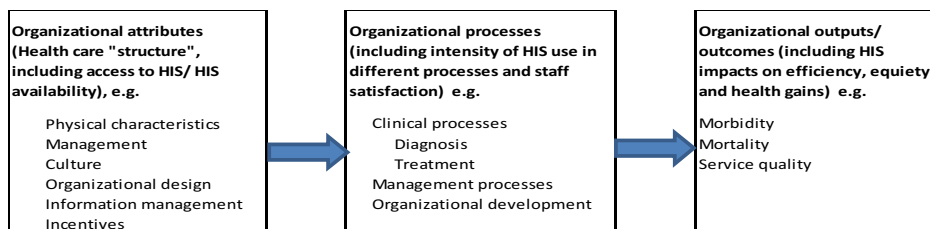
Organizational attributes (Health care "structure", including access to HIS/ HIS availability), e.g.	Organizational processes (including intensity of HIS use in different processes and staff satisfaction) e.g.	Organizational outputs/ outcomes (including HIS impacts on efficiency, equiety and health gains) e.g.
Physical characteristics Management Culture Organizational design Information management Incentives	Clinical processes Diagnosis Treatment Management processes Organizational development	Morbidity Mortality Service quality

Figure 1. The relations between health care structure, process and outcome elements (modified from [16]).

Most of the existing HIS indicators focus on elements of health care structures (e.g. "HIS availability") and processes (e.g. "HIS usage rate"), but also output and outcome indicators have been defined for some specific HIS applications or functionalities and for some health conditions. Many studies have demonstrated a positive association between HIS availability and health care outcomes, but commonly agreed outcome indicators are still rare. The HIS-outcome association is not without controversy, as the variance in outcomes can be attributed to a wide range of factors, for which there are often no ready measures. (We can directly measure EHR adoption, but many factors beyond EHR impact for example patient safety). This is another motivation for the current focus on the structural measures. There is, however, significant policy interest in evaluating the impacts of the implemented HISs and in particular changes in health system performance.

Table 1, while not intended as a comprehensive listing, depicts some examples of current HIS indicator domains and concrete HIS-related health care performance indicators as they apply to one functionality for medication management process.

Superficially, progress on developing measures for "a complete list of prescriptions made to patient" seems good as there are indicators for various aspects of health care performance, not just for structural performance. However, few of these indicators are *internationally agreed, and not all represent reliable and valid* concrete measures for monitoring impacts of a complete prescription list. There is little agreement on *the HIS functionalities* that should be measured nor on the *health care structural, process, output and outcome elements* that matter in order to determine the "value" of specific functionalities [7]. There is also heterogeneity in the methods used to collect data for monitoring. Main methods used are structured surveys, with no agreed definitions and scales. To understand the situation better and to move forward in the national and international HIS indicator work, we need to have a closer look at the different ways in which HIS indicators are developed and used.

Table 1. Examples of national level health care system performance indicators for a HIS functionality related to medication management.

Notes: a) Specific indicators need to be defined based on local eHealth policy and strategy priorities or stakeholder goals. b) Concrete measures need to be considered from different stakeholder viewpoints and defined for key HIS functionalities c) Many topics (e.g. usability, information quality) require more than one measure, d) There are currently many subjective measures and lack of objective data - only some register-based monitoring measures exist so far.

HIS-related health care structural performance indicators	HIS-related health care process performance indicators	HIS-related health care output indicators	HIS-related health care outcome indicators
HIS availability: Proportion (%) of public organisations where a list of prescriptions made to the patient outside own organization is available for professionals [1-2, (3)]	**Intensity of HIS use:** Proportion of viewings of prescriptions from outside own organisation by professionals/population size [1, (2, 3)]	**Impacts on time saved:** Potential for saved time with ideal system functionality[1]; time to take medication history/patient[3]	**Impacts on patient safety:** No. of medication errors reported during a year/population of the country[1]; no. of adverse drug-related events for high risk patients / all high risk patients, for physicians with and without decision support[3]
HIS technical quality: Experienced satisfaction of physicians with EHR reliability (Mean value, scale 1–5)[1]	**HIS user satisfaction/ attitudes:** Overall satisfaction of physicians with the EHR system (scale 1–5)[1, 3]	**Impacts on no. of contacts:** No. of calls per day received by physicians for refills[3]	**Impacts on continuity of care:** Physicians' experience on IS supporting collaboration between doctors working in different organizations (mean, scale 1–5)[1]
HIS impact on information quality: Proportion (%) of public organisations where nationally agreed information structures are available (implemented)[1]	**Impacts on conformity to care guidelines:** Physicians' experience of impact of HIS on conformity to care guidelines (mean, scale 1–5)[1]	**Impact on Health care costs:** Proportion of ICT-costs of the total budget in public organisations[1]	

Sources: 1) The Nordic eHealth Indicators [17]; 2) The OECD model survey [18]; 3) Canada Health Infoway [19].

3 Methodologies to develop and use Health Care Performance Indicators for HISs

The following sections describe some of the approaches used to develop and assess Health Care Performance Indicators for HIS. We focus on approaches taken at the country or multi-country level. We use the four phase indicator methodology depicted in environmental economics [20] as a common "standard" for comparison in the approaches to look for similarities and differences. The methodology was first adopted in HIS indicator work by the Nordic eHealth Network to make the indicator process transparent:

1. Defining the context (human and environmental) for measurement:
   a. Identifying key stakeholders.
   b. Defining the relevant area or system in question.
2. Defining the goals for measurement.
3. Defining methods for indicator selection and categorization.
4. Defining the data; collecting, analysing and getting feedback.

3.1   Adoption of the 4-phase methodology in the Nordic eHealth Network approach

In 2012, the eHealth group of the Nordic Council of Ministers established a network of organizations responsible for national eHealth monitoring in each of the Nordic countries, to define and test common Nordic eHealth indicators. These were required for monitoring eHealth in the Nordic countries, for use by national and international policy makers and scientific communities to support development of Nordic welfare. [21, 22] The work commenced by searching for a suitable methodology for defining eHealth indicators, and was done in close collaboration with the Nordic council of Ministers and the OECD model survey development.

A review of previous approaches for indicator development proved that a step-by-step methodology is rarely described in connection with eHealth indicator work. In the field of sustainable development, two main approaches for indicator definition have been identified [20]: Expert-led top-down and community-led bottom-up methodologies. Top-down methodology is used in indicator work that focuses on defining measures with which to monitor implementation of policies and their impact on the society level. Top-down approaches rarely define goals formally, as they are pre-determined by funding agencies or Government offices; also they may not reflect or record adequately the effect on the population served. The Bottom-up approach is used especially in the fields where the aim is to monitor policy or strategy implementation and their impacts on the micro level: the indicators are tailored to the needs and resources of the indicator users, but they still remain rooted firmly in the fundamental principles of the policy in question. The Top-down and Bottom-up approaches share four common phases. [20] These were used as a basis of eHealth indicator development in the Nordic Collaboration.

The first phase – *context definition* – calls for identification of the HIS functionalities for which indicators are needed, their contexts of use and users, and for whose viewpoint the indicators are developed. In the Nordic countries National eHealth policies were analysed to enable defining the contexts to be monitored [11]. Description of the functional architecture of HIS functionalities was found necessary especially for international comparison. Without this information it is impossible to say "which type of medicine cured the patient". [17]

The second phase – *defining the goals* – includes identification of impact mechanisms of the selected systems in the contexts for different stakeholders, as well as the changes anticipated for health system performance. The eHealth policies in the Nordic countries provided also this information for the Nordic indicators [11, 22].

For the third phase – *indicator selection and categorization* – a longlist of available indicators from the Nordic countries was generated from existing monitoring studies, complemented with indicators from eHealth evaluation studies. The potential measures were grouped with a conceptual framework generated by Ammenwerth and de Keizer [15] under benefits for health care structural, process and outcome quality. To select and

prioritize the measures, the grouped longlist of variables was mapped against the policy goals, stakeholder priorities and the OECD model survey measures.

The fourth phase includes *defining the actual metrics and the data sources, testing the data collection and reporting the results*. For the Nordic work, this was done by comparison of questions in the existing surveys and the OECD model survey as well as national log and register data. The variables were tested by collecting and reporting the data for each of the defined variables [11, 22]. The lessons learned have been used to refine the indicators further as a basis for a permanent system for Nordic eHealth benchmarking. [17]

3.2   The Canadian approach

Canada Health Infoway is the primary lead in Canada for eHealth-related activities. In 2006 Canada Health Infoway published their Benefits Evaluation framework. A consulting team managed the Benefits Evaluation (BE) Plan development process and compiled the report. Subject matter experts developed the programme specific plans, and an Expert Advisory Panel provided guidance in the development of the BE Plan [19]. It included HIS-specific benefits indicators for six national eHealth programmes: diagnostic imaging, drug information system, laboratory information system, public health surveillance system, interoperable electronic health record and telehealth programmes. Selection of indicators was based on the following criteria:

• Importance: The indicator reflects aspects of health system functioning that matter to users and are linked to a Strategy Map priority area. Six strategy-relevant HIS functionalities are selected for monitoring: radiology, medication, laboratory, public health (immunizations), interoperable EHR (Health information exchange and personal health records), telehealth.
• Relevance: The indicator provides information that advances the understanding of population health and the health system, and can be used to monitor and measure health system performance over an extended period of time.
• Feasibility: Data required for the indicator are readily available for the areas and time periods indicated, and there are no unreasonable obstacles or constraints on access to the information collected, nor restrictions on its use.
• Reliability: The indicator produces consistent results in repeated measurements of the same condition or event.
• Validity: There is consensus on the part of users and experts that the indicator is related to the dimension it is supposed to assess (face validity), covers the whole dimension it is supposed to assess (content validity), is related to other indicators measuring the same dimension (construct validity), and has predictive power (criterion validity). [19]

The Delone & McLean Information System Success Model [23], which is based on wide review of eHealth literature, was used as a basis for conceptual grouping of the eHealth indicators. For each of the six selected HIS functionalities, separate indicators were developed.

Assessed against the 4-phase approach, the Canadian approach includes phases 1-2, even if the policy analysis is not published as part of the framework definition: the first and second bullet points anchor the definition of the HIS functionalities and goals to be monitored firmly to the national eHealth strategy. The three consequent bullet points

refer to phases 3-4. The Canadian approach uses both literature and analysis of availability of data to select the indicators, which focus on HIS-related impacts on all aspects of health care system performance, including outcomes. Most of the data are provided with individual evaluations, and indicators for continuous performance monitoring with survey, log or register data are less common [19].

3.3   The European Commission approach

An important contribution of the European Commission to improvement of public health services is benchmarking ICTs. Wide differences across health care systems at both national and regional level and the absence of commonly agreed indicators led the Commission to launch a series of eHealth benchmarking studies, e.g. [2, 4, 24, 25]. This research has also developed an indicator framework to support and guide the development of, and agreement on, a comprehensive set of key global indicators and procedures for data gathering on eHealth. [25].

The report on the methodology identifies three user groups: patients, health-service providers and payment institutions, and four types of applications: clinical information systems, telemedicine, home care and personalized health systems, integrated regional-national networks and systems and secondary use systems. The methodology included a search for eHealth monitoring and benchmarking activities in the EU, Iceland, Norway, Canada and the United States of America. The priority areas were identified using the European Union eHealth policy analysis reports. Four dimensions of indicators were defined [25]:

- Basis indicators, covering respondent demographics and basic ICT infrastructure.
- Activity-dependent indicators, covering eHealth-related health care activities.
- Attitude indicators, covering general and specific attitudes towards ICT as well as perception of ICT-related impacts.
- Horizontal issues, including IT investment, IT support, Data protection/security, Interoperability, IT skills.

Reference to several EU-level policy analysis documents is presented as sources for additional priority areas, including the eHealth action plan as a source for selecting the systems to be monitored. It is stated in the document that policies have also been used for restructuring the activity dimension based on the expertise and understanding of the eHealth domain developed in a number of projects. [25]

A matrix with stakeholders as rows and indicator categories as columns is presented in the methodology, filled from the pool of more than 4,400 indicators identified from analysis of national studies. For missing data, new indicators were generated. The European Union has conducted primary and specialized care surveys based on the defined methodology in 2009 and 2013.

Compared with the 4-phase approach, the Commission framework has identified the key stakeholders and functionalities or applications as is done in the first phase of the 4-phase approach. Also EU-level policy studies have been referred to in the methodology as is done in phase 2 of the 4-phase approach. How policy priorities (applications and goals) in each country have been mapped against the indicators to be selected remains unclear. The third phase, indicator selection and grouping, has been conducted using the existing studies. Data were collected with a survey instrument defined by the Commission projects.

3.4   The OECD approach

The OECD has led an effort to provide countries with reliable statistics to compare ICT development and policies in the health sector [6], to assist governments in understanding the barriers and incentives to ICT use and to realize the far-reaching economic and social benefits from their application. In 2010, an OECD survey of countries identified four core objectives for ICT implementation: Increase the quality and efficiency of care; reduce the operating costs of clinical services; reduce the administrative costs of running the health care system; and enable entirely new models of health care delivery [26].

In 2012, the OECD established a group of national and international experts representing seventeen OECD countries and four non-OECD countries to agree on a core set of survey indicators and an approach to measurement. Its work has been guided by three overarching principles. First, measures needed to respond to policy and information needs of countries along a continuum, starting from ICT availability, moving towards effective use, and ending with measuring outcomes and impact on population health. This helps in accommodating countries that are at different levels of maturity and progress towards achieving their e-health goals. For example, advanced countries are unlikely to devote substantial resources to collecting data on availability of ICTs if their policy needs are focused on effective use and better outcomes.

The second principle was to use the OECD "model survey" framework, which takes a staged approach in moving international measurement work forward. The model survey is composed of separate, self-contained modules for flexibility and adaptability to a rapidly changing context. Core modules can be added-on to existing national surveys or administered as a stand-alone survey while supplemental modules can be used as needed by countries.

The third principle was to use a functionality-based approach to defining key types of health ICTs to ensure that the terminology has comparable meaning across different countries. For example, while many OECD countries use the terms electronic medical record (EMR) and electronic health record (EHR) interchangeably, in Canada, EMRs refer to systems used by a healthcare professional to manage patient health information in a specific medical setting, whereas the EHR involves pooling data from multiple different clinical settings, allowing access to a more comprehensive patient record. If a core module question asked physicians about EHR use, the answers from Canada and the U.S. would, for example, mean very different things. This approach also supports technology-neutrality (i.e., the questions neither require nor assume a particular technology) and is forward looking (i.e., does not hinder the use or development of technologies in the future).

The model questionnaire was completed and published in 2013 [18] and is structured as shown in Table 2. Part I of the survey is addressed to general/primary care/family practitioners in ambulatory settings, Part II, to Chief Information Officers and administrators in the acute care settings.

Since 2013, several countries have begun piloting the model survey and/or mapping information from existing surveys and administrative data sources to indicators that would be derived from the model survey.

Assessed against the 4-step approach, phase 1 is strongly present in specification of the functionalities to be monitored. Phase 2 – how selected indicators reflect the national eHealth goals – is not explicitly reported, but becomes evident in national selection of variables to be monitored. Phases 3 and 4, where actual indicators are selected, defined and tested, are conducted nationally. Data are collected by the member states in their

national HIS surveys, where the OECD model survey variables are integrated to the extent possible.

Table 2. Structure of the OECD Model Survey.

Part I GENERAL PRACTITIONERS/ PRIMARY CARE PHYSICIANS	Part II CHIEF INFORMATION OFFICERS/ IT ADMINISTRATORS
Section A: Contextual Indicators (i.e., basic demographic data about respondents and their practice setting)	Section A: Contextual indicators (i.e., basic demographic data about respondents and their organisation)
Section B: Availability and use of electronic records and health information exchange	Section B: Availability and use of electronic records and health information exchange
Section C: Availability and use of functionalities that support patient engagement	Section C: Availability and use of functionalities that support patient engagement
Section D: Availability and use of telecommunications technologies to support health care delivery	Section D: Availability and use of telecommunications technologies to support health care delivery

3.5   The World Health Organization (WHO) framework

The eHealth strategy for the World Health Organization (WHO) was established in 2005. The WHA58.28 resolution urged Member States to plan for appropriate eHealth services in their countries. That same year WHO launched the Global Observatory for eHealth, an initiative dedicated to the study of eHealth, its evolution and impact on health in individual countries. [7] The WHO Global Observatory eHealth survey has been conducted from 2005 between 4-year intervals for three times. The latest report is a survey-based baseline review of eHealth and innovation focusing on the first four recommendations of the Commission in Information and Accountability for Women's and Children's Health (CoIA). The survey instrument was developed to monitor attainment of the CoIA recommendations. Of particular significance to the survey was Recommendation 3 on eHealth and innovation: "by 2015, all countries have integrated the use of Information and Communication Technologies in their national health information systems and health infrastructure".

The survey instrument enquires about eHealth programmes for monitoring of women's and children's health for 1) health service delivery (call centres, education, reminders, health promotion, feedback, telemedicine); 2) health and health problems monitoring and surveillance; 3) access to information for health professionals (publications, decision support systems, patient records) and 4) other eHealth programmes. There are also questions about eHealth implementation barriers, knowledge base for eHealth, internet safety, social media etc. [27]

Compared to the 4-phase approach, the WHO framework is very strong in phases 1 - 2. The survey instrument queries about availability of national eHealth policies, and lists various eHealth programmes. The selection of functionalities in the list originates from current programmes in the countries (phase 1) [27]. eHealth policy or literature analysis for identification of applications and functionalities and their impact mechanisms to match the CoIA recommendations is not reported in the documents. It is also not clearly documented how the indicators have been selected. The main data source was a survey.

3.6   The ISO health informatics and health indicators conceptual framework

The International Standardization Organisation's (ISO) standard on Health Informatics and Health Indicators Conceptual Framework (21667:2010) is intended to foster a common vocabulary and conceptual definitions for the resultant framework. The framework defines the dimensions and sub-dimensions required to describe the health of the population and performance of a health care system. The conceptual framework is broad (high-level) to accommodate a variety of health care systems, and it encapsulates all of the factors related to health outcomes and health system performance and utilization, as well as regional and national variations.

ISO 21667:2010 does not identify or describe individual indicators or specific data elements for the health indicators conceptual framework; nor does it address needs analysis, demand analysis or the range of activities that need to be supported for health system management. The framework identifies four categories or indicator domains: 1) health status (the overall health of the population served, how it compares to other regions in the jurisdiction and how it is changing over time); 2) non-medical determinants of health; 3) health system performance (the health services received by the region's residents); 4) and community and health system characteristics (characteristics of the community and the health system that provide useful contextual information). These categories have been adopted by many countries (including Canada) and have sub-domains with associated indicators.

Compared to the 4-phase model, the ISO framework focuses in phase 3, definition of the actual indicators and measures. The origins for contextual definitions (stakeholders and systems) as well as groundings to the national eHealth policy goals are not explicitly described in the framework.

4   Utilising HIS indicators

Continuous measuring of progress in HIS success in a comparable manner supports evidence-based management in order to promote successful implementation of HIS, policy learning, decision making and the on-going policy processes. It provides benchmark information of actual HIS adoption, its progress and eventually impacts in different contexts [4]. Figure 2 presents an example of the varied emphasis on eHealth policy goals in the individual Nordic countries (2010) [21], and variation in two indicators: 1) adoption rate of one key functionality in 2010-2014: proportion of public health care organisations where sending a prescription electronically to be dispensed in any pharmacy is available, and 2) number of yearly reported medication errors per resident population (2014) [17].

There are several observations that can be made from Figure 2: 1) Denmark, Sweden and Norway have all had clinical infrastructure and business support as a high policy priority (Icelandic eHealth policy was not assessed in 2010). 2) Denmark and Iceland have progressed most rapidly in deployment of one indicator impacting business processes. 3) Finland and Norway have had more focus on IT architecture, security and standards, which may explain the slower start in adoption of the functionality. 4) Medication errors can be used as one indicator measuring ePrescribing success, but we would need to have data from a longer monitoring period to show change that has happened in this indicator after implementation of the HIS functionality. Still, we could show correlation and odds ratio at most, since there may be several other parallel

interventions impacting medication errors, statistics may be defined differently in different countries and also the architectures and use settings of the functionality vary from country to country.

Combining selected health care performance indicators e.g. medication errors, with information on availability and use of specific policy-relevant HIS-interventions could thus provide one source of information that is on high demand by the decision-makers about efficiency and effects of eHealth policies and particular HIS interventions, but as the case above shows, results are far from straight-forward.
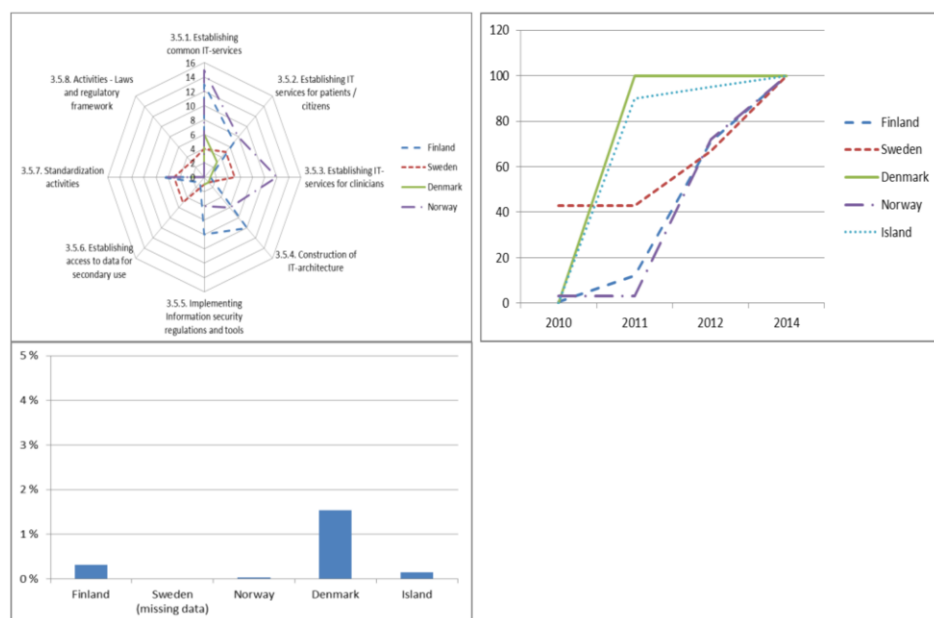

Figure 2. Examples of Benchmarking Indicators in use in the Nordic Countries: (a) Varied emphasis in eHealth policy goals in the Nordic countries in 2010 [21], (b) varied adoption rate of national ePrescribing 2010-2014 and (c) number of medication errors per resident population in 2014 [17].

5   Discussion

This contribution provides a summary overview of progress in HIS measurement by countries or multi-country coalitions – not individual health systems. The evidence presented indicates good progress in the development of internationally comparable HIS-related indicators for health care structures. A range of different approaches are in use - which creates opportunities for fruitful comparative assessment and learning. The Top-down approach appears to prevail, and goals for monitoring are rarely defined formally, as Reed et al. also found [20]. The WHO, Canadian and the Nordic approaches are among the most explicit in grounding the key HIS functionalities for HIS indicators in national health or eHealth policy goals. HIS-related indicators are targeted to policy makers, HIS managers and other stakeholders to inform decision-making related to HIS and their further development. Hence, the quality of the indicators can also be assessed against their utility for different stakeholders. Transparency of the goals and involving

stakeholders more closely in indicator development (the Bottom-up approach) is essential if the aim is to deliver information useful at different levels of decision making.

Few (international) approaches seem concerned about the comparability of ways HIS functionalities are realized across different countries and contexts. Yet, the way the HIS is structured and functions may have a strong impact in HIS usage rate, usability and thereby outcomes. Different countries are also in different stages of HIS implementation, and process and outcome measurements may vary depending on the maturity of the system, showing the importance of adequate definition, even "maturity index" of the HISs to be monitored.

The approaches differ also in indicator selection: the WHO approach is outcome- and condition-oriented, the ISO-framework is outcome- but not condition-oriented. The national Canadian approach has the widest scope with HIS-related indicators for health care inputs, processes, outputs and outcomes for six specified HIS functionalities. The OECD approach focuses on structural and process indicators. Methods of indicator selection and clustering are seldom explicitly stated.

Many methodologies (e.g. the EU, OECD and WHO) rely solely on data collection through stand-alone surveys, the Nordic and Canadian approach use also other types of data sources. The OECD and the Nordic approach use survey data collected as part of the national monitoring activities, the EU and WHO collect data themselves. The latter may be more costly but may result in more consistent and timely data collections across countries, whereas the former is a more economical option, but inevitably depends on national monitoring priorities and timelines. Moreover, achieving harmonization of the variables and data collection methodologies for cross-country benchmarking has been a challenge, which the OECD model survey and the ISO standard are helping to address. Also the organisation and funding of the national monitoring activities remain issues to be solved.

In conclusion, more explicit definition of systems, stakeholders and their goals, methods for indicator selection and categorization as well as stakeholder participation could help in moving towards stakeholder- and HIS-specific health care performance indicators for Health Information Systems that support evidence-based decision making on HIS approaches.

Recommended further readings

1. Hyppönen H, Kangas M, Reponen J, Nøhr C, Villumsen S, Koch S, et al., *Nordic eHealth Benchmarking. Status 2014*, Nordic Council of Ministers, Copenhagen, 2015, Report No. TemaNord 2015:539. http://norden.diva-portal.org/smash/get/diva2:821230/FULLTEXT01.pdf, last access 11 February 2016.
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Food for thought

1. In your country / in your health system, what indicators would be most important in determining the best focus for HIS investment?
2. Which terms in the following indicator can be defined in various ways in different countries, and what metrics are required to calculate the indicator value? "Proportion of public hospitals providing clinicians access to electronic storing of patient data"
3. What are the pros and cons of using the indicator "Time to take medication history per patient" for monitoring health care process improvement after implementing access to all prescriptions made to the patient from outside own organization?

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