

A Requirements Index for Information Processing in Hospitals

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Summary

Objectives: Reference models describing typical information processing requirements in hospitals do not currently exist. This leads to high hospital information system (HIS) management expenses, for example, during tender processes for the acquisition of software application programs. Our aim was, therefore, to develop a comprehensive, lasting, technology-independent, and sufficiently detailed index of requirements for information processing in hospitals in order to reduce respective expenses.

Methods: Two-dozen German experts established an index of requirements for information processing in university hospitals. This was done in a consensus-based, top-down, cyclic manner. Each functional requirement was derived from information processing functions and sub-functions of a hospital.

Results: The result is the first official German version of a requirements index, containing 233 functional requirements and 102 function-independent requirements, focusing on German needs. The functional requirements are structured according to the primary care process from admission to discharge and supplemented by requirements for handling patient records, work organization and resource planning, hospital management, research and education. Both the German version and its English translation are available in the Internet.

Conclusions: The index of requirements contains general information processing requirements in hospitals which are formulated independent of information processing tools, or of HIS architectures. It aims at supporting HIS management, especially HIS strategic planning, HIS evaluation, and tender processes. The index can be regarded as a draft, which must, however, be refined according to the specific aims of a particular project. Although focused on German needs, we expect that it can also be useful in other countries. The high amount of interest shown for the index supports its usefulness.

Keywords

Hospital information system, information management, delivery of health care, needs assessment, quality assurance, process assessment (health care)

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1. Introduction

Hospital information systems (HIS), as defined here, encompass all of the information processing functions, as well as the human and technical actors involved in their information processing roles (1). Based on this definition, both computer-based and conventional information processing tools (such as computers and installed software programs, but also patient records and telephones), as well as the supported information-processing functions (such as patient admission or medical data management) are part of a hospital's information system.

Due to information processing's complexity, high cost, and tremendous relevance to the quality of patient care, a systematic management of HIS is necessary (2). HIS management must deal with core challenges, such as integration and standardization issues, workflow issues, and socio-technical and organizational issues (3).

HIS reference models are useful to support HIS management, especially HIS planning and monitoring. Reference models present a model pattern for a certain class of HIS (4). On the one hand, the model patterns can help derive more specific HIS models using modifications, limitations or add-ons (generic reference models). On the other hand, the model patterns can be used to directly compare HIS models, for example, concerning completeness (non-generic reference models). HIS reference models could focus, for example, on typical information processing structures or on typical business processes in hospitals.

A HIS reference model containing a collection of central HIS requirements, such as quality criteria, could support HIS management. However, such comprehensive, lasting, technology-independent, and sufficiently detailed HIS reference models

are not available. Available HIS reference models primarily focus on other aspects. For example, the 'Hospital Information Model' developed by the Dutch National Hospital Institute in the early 1980's ([5], p. 322 f.) focuses on the information needed for main information processing functions, such as patient registration and food supply. The British National Health Service's 'Common Basic Specification' (6) developed in the early 1990's describes business process activities in hospitals on a rather general level, together with a detailed data model. Within the framework of the European RICHE project (7), a process reference model, the so-called order-and-act-model, describing hospital activities, was established. All of these reference models focus on information processing functions, activities and processes, and data structures, but none contains central requirements and quality criteria for hospital information processing.

We assume that the lack of such reference models causes considerable strategic hospital information systems management expenses. For example, strategic plans for hospital information management require quality criteria. These could be derived from such reference models. The quality criteria would also be very helpful in evaluating hospital information systems. In tender processes for obtaining software application programs, reference models for certain parts of a HIS (e.g., radiological information systems) could offer a guideline for comparison and selection.

Therefore, to support HIS management, it would be helpful to have a reference model that describes a hospital's most important information processing requirements.

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Table 1 Structure of the functional requirements of the requirements index for information processing in hospitals: Each information processing function is described in terms of aims and comments and then divided into sub-functions. For each sub-function, the information processing requirements are then listed. As an example, the division and requirements of the 'order entry' function are presented.

<i>General structure</i>	<i>Example</i>
Function A	Order-entry with appointment management
Aim of this function	Order of diagnostic or therapeutic services at a service unit. Includes preparation and transmission of orders.
Comments about the function	Service units often want to make appointments themselves. Thus, a solution, in which the ordering person adds an appointment to the appointment book of the service unit, might not work.
Sub-function A.1	Fill out order form
Requirement A.1.1	<ul style="list-style-type: none"> The requested order can be selected from a structured list of available services.
Requirement A.1.2	<ul style="list-style-type: none"> Already existing data (e.g., patient name) can be inserted into the order form automatically.
.....	<ul style="list-style-type: none"> Formulation of the clinical question and further details are supported. It is possible to enter free-style text. The responsible or authorized person can sign the order.

Sub-function A.2	Arrange appointment
Requirement A.2.1	<ul style="list-style-type: none"> Reservation, acknowledgment, cancellation of appointments is possible.
Requirement A.2.2	<ul style="list-style-type: none"> Urgency and a preferred date can be submitted.
.....	<ul style="list-style-type: none"> Planning aids for recurring appointments exist. All people involved (e.g., on wards, transportation services, service units, and the patient) have access to the relevant dates. All people involved are informed about relevant changes in appointments.

Sub-function A.3	Transmission of orders
Requirement A.3.1	<ul style="list-style-type: none"> Orders can be transmitted from the client unit to the service unit.
Requirement A.3.2	<ul style="list-style-type: none"> The transmission can be conducted within a defined period of time.
.....	<ul style="list-style-type: none"> The order is documented in the patient record.
	...
Function B

sche Forschungsgemeinschaft, DFG), and initiated by its Computing Facilities Committee, we have established a requirements index for information processing in university hospitals.

2. Aim of this Paper

The aim of the 2-year-project was to establish a comprehensive, lasting, techno-

logy independent and sufficient detailed index of requirements for information processing in hospitals. This index should offer a guideline for 'good information processing practices' in hospitals by presenting the main information processing requirements. The requirements index should support the systematic management of HIS by offering a reference model for HIS quality criteria.

In this paper, we will present this requirements index, focussing on its intention, its structure, and its content.

3. Methods

The requirements index is founded on the general consensus of two-dozen university hospital experts in Germany. The experts were selected according to their knowledge regarding different aspects of hospital information systems. The index was created in a cyclic review process.

Initially, we invited all participating experts to a one-day workshop to achieve consensus for the overall structure, the main information processing functions, and the further proceedings.

Following the workshop, communication between the experts was conducted by e-mail. The first drafts of the requirements index were then created by the editorial team in Heidelberg (the authors of this paper), based on literature available on requirements and existing HIS requirements indices.

The first drafts (and following versions) were then sent to the experts, discussed and refined in a four-round process, which finally led to the first official German version of the index. This version was presented to the DFG's Computing Facilities Committee and adopted in February 2001.

4. Results

The first official German version of the requirements index, together with its English translation, is now ready and available through the World Wide Web.

4.1 Structure of the Requirements Index

Initially, it was important to find an overall structure for the index general enough to be adaptable to different HIS architectures and circumstances, but at the same time, easy to understand and practical to use. After thoroughly researching the literature available on requirements engineering, we decided on the following structure and proceedings:

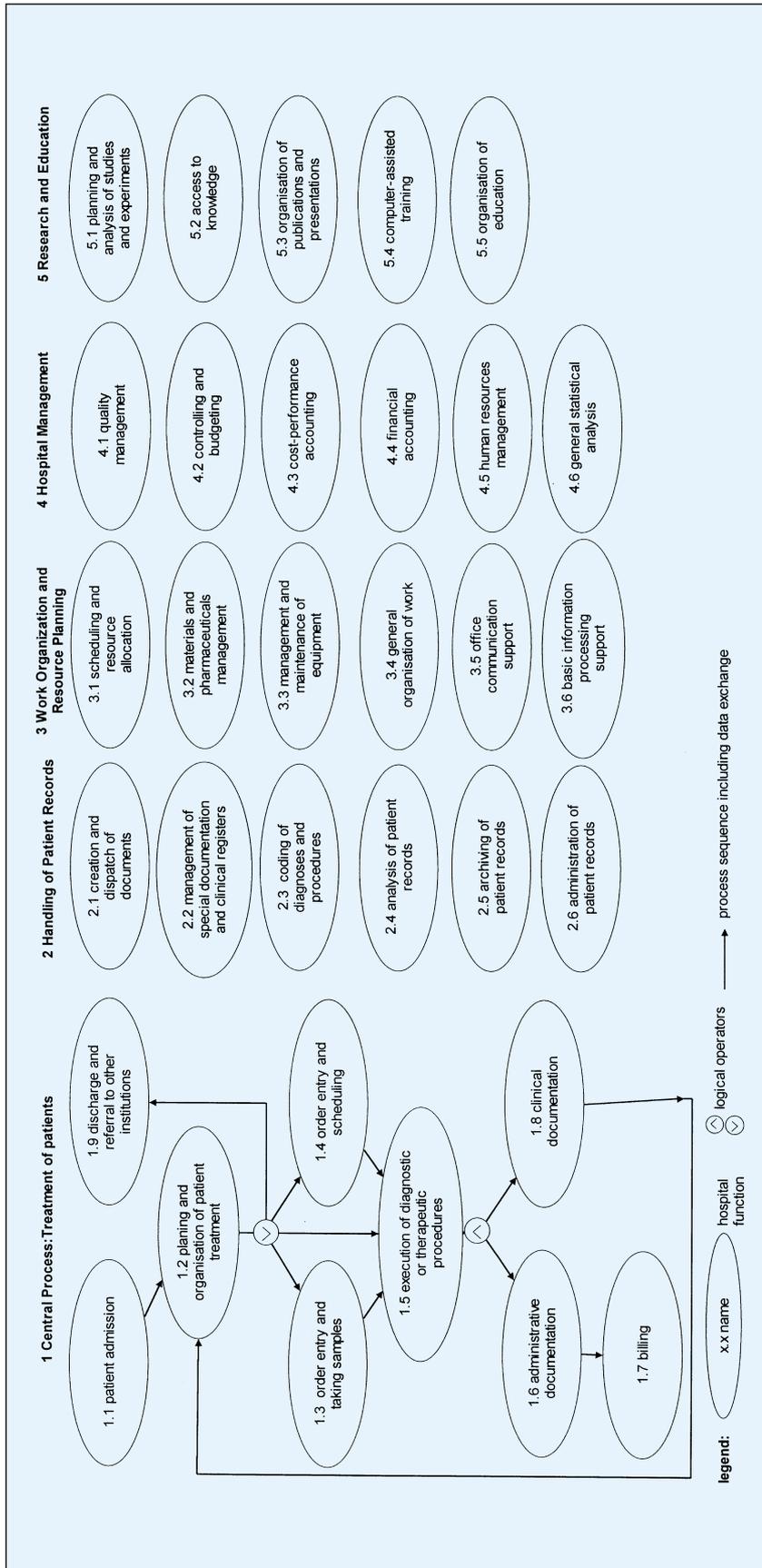


Fig. 1 Information processing functions of a hospital. The top-level information processing functions of the requirements index are presented. On the left, the main functions are ordered according to the primary care process. On the right, the support functions are listed. These top-level functions are broken down further in the requirements index.

The requirements index is intended for use by many different people (e.g., information managers, computer scientists, consultants) and, therefore, should be formulated clearly and understandably (8). Therefore, concise sentences were formulated to describe the requirements (e.g., “New findings should be available to the responsible physician within a pre-defined length of time”). The sentences are formulated in such a way they can be evaluated in a given environment (true, false or a quantitative measure).

Two different types of requirements were identified: **functional requirements and function-independent requirements** (9). Functional requirements can be matched to a specific information processing function (e.g., data management or transmission of findings) directly. For example, one requirement in the context of the transfer of a patient is: “A1.9.d The information needed for continuous care is available in a structured form upon the discharge of a patient and is transferred to the area where care will be continued in a timely fashion and in accordance with data security regulations.”

Function-independent requirements, in contrast, are globally valid for all information processing activities (e.g., requirements on data security or data integration). For example, one information management requirement is: “A.I.1 Goals of the hospital and the hospital information system are described in a strategic information management plan which is update regularly”.

Generally, it should be possible to derive all requirements from the main aims of an information system ([10], [11]). Therefore, the requirements index first states the main aims of a HIS, then determines the requirements in a top-down manner. For functional requirements this means they are derived from the information processing functions and sub-functions of a hospital. This offers a **structure to model the requirements** of each function in a systematic and easy to understand way. An information processing function is decomposed into its sub-function. We then formulated functional requirements for each sub-function. The function-independent requirements are derived from the overall aims of the HIS.

The overall structure of the functional requirements is presented in Table 1. The description of the function “order-entry with appointment management” serves as an example.

4.2 Content of the Requirements Index

The top-level information processing functions upon which the functional requirements of the index are based can be seen in Fig. 1. We have structured the main functions according to the primary care processes from patient admission to discharge. In addition, functions that support the primary care process, such as archiving or scheduling, have been defined. The support functions are extremely important to guarantee high-quality and efficient patient care. They can be found on the right side of Fig. 1 and are divided into three categories: handling of patient records; work organization and resource planning; and hospital management. The main functions are presented on the left side.

In addition to functional requirements, the requirements index also contains the generally valid function-independent requirements. They are derived from the main aims of the HIS and are presented in Fig. 2.

Altogether the requirements index consists of about 50 printed pages, containing 233 functional requirements and 102 function-independent requirements. Table 2 presents the overall content of the requirements index.

4.3 Availability of the Requirements Index

The requirements index is available in German (12) and in English (13) of the Deutsche Forschungsgemeinschaft (www.dfg.de) and of the German Association for Medical Informatics, Biometry and Epidemiology (www.gmds.de) Internet sites, as well as on the main project web site: <http://www.umit.at/reqhis>

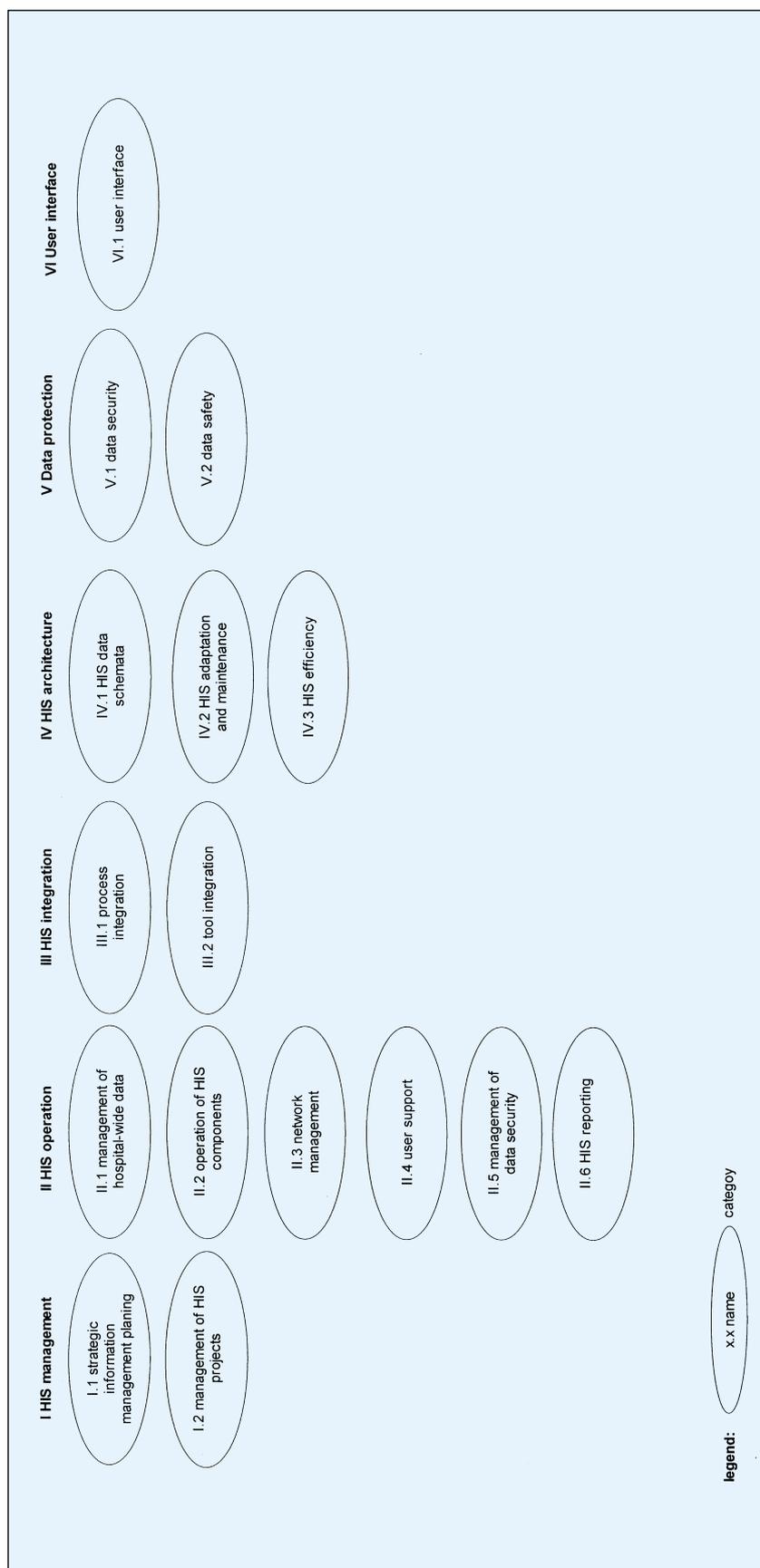


Fig. 2 Top-level structure of the function-independent requirements of the requirements index for information processing in hospitals. The main categories and sub-categories for structuring those requirements are presented. They are broken down further in the requirements index.

1. Introduction
2. Functional requirements (<i>Detailed structure: see Figure 1</i>)
1 Central process: Treatment of patients
2 Handling of patient records
3 Work organization and resource planning
4 Hospital management
5 Research and education
3. Function-independent requirements (<i>Detailed structure: see Figure 2</i>)
I HIS management
II HIS operation
III HIS integration
IV HIS architecture
V Data protection
VI User interface
4. References
5. Index

In addition to a PDF document of the requirements index (compare Table 2), an Excel worksheet is also offered on the German Internet sites, which allows use of various Excel functions while working with the index of requirements. It can also be used to adapt and refine the index according to the specific needs of different users.

5. Discussion

In the paper, we have presented the motivation and the construction of a comprehensive, lasting, technology independent and sufficient detailed index of requirements for information processing in hospitals.

The index was founded on the general consensus of two-dozen university hospital experts in Germany. The experts were selected according to their knowledge regarding different aspects of hospital information systems. The index was created in a cyclic review process. Each expert mostly worked on that part of the index where he felt competent. In addition, in each round, the experts could comment on all other parts of the index. We did not use a structured Delphi approach (as e.g. described in [14]) which seems only possible when all

participants can competently work on all parts of a topic, which is not the case for such a project, covering all areas of information processing. This means that we have no quantitative, but only qualitative proof of consensus. We chose the **consensus-based approach** as it is a well established method to gather requirements, and seemed most appropriate for our aim.

The index is freely available and can now be used in various information management projects, such as HIS strategic planning, HIS evaluation, or in tender processes for the acquisition of software application programs. As with any reference model, the index must be **adapted to the specific needs** of the user. This adaptation should take a selection of necessary information processing functions, a refinement and a quantification of the requirements into account. The information processing functions relevant to a given environment and to a given aim must be chosen. For example, within the context of defining requirements for a documentation system, the function “clinical documentation” may be selected, while functions such as “hospital management” may not. Requirements presented in the requirements index should be refined according to the user’s needs. For example, the requirement “A.1.8.3.c Physicians must be able to document orders for other health care professional groups” could be refined

Table 2

Table of contents of the requirements index for information processing in hospitals. The 233 functional requirements are presented in chapter 2, the 102 function-independent requirements in chapter 3 of the requirements index. The references (chapter 4) contain available requirement indices for specific areas. The index (chapter 5) helps find requirements containing given terms.

to “Physician must be able to document medication orders, examination requests, as well as general patient care instructions for an individual patient. These orders can be directed at nurses, physiotherapists, social workers or other professional groups”. Finally, certain requirements may need quantification. For example, the requirement “A.1.3.3.b: A service request must be transmitted to the service unit within a defined period of time” should be quantified according to the user’s needs, for example: “A service request must be transmitted to the service unit within a defined period of time. This means: a radiological order should be transmitted within 10 minutes, a laboratory order within 5 minutes, and a physiotherapist order within 30 minutes”. In addition to the functional requirements, the generally valid function-independent requirements must be included.

In order to ensure a patient-centered view of information processing, we have **focused on the primary care process** and have stepped away from the (often used) departmental view (e.g., radiology information system, laboratory information systems). This means that the requirements index does not contain detailed departmental requirements, for example for a radiology information system. Instead, the index user must find the information processing functions relevant to a radiology unit and refine them according to the required needs. The means that users will not be able to directly find specific requirements for a given area. However, we are convinced that our way is useful, as the presented requirements are valid in any given areas (e.g., the presented general requirements for order entry are valid in radiology, laboratory, and other areas). This motivated us to abstract away from the different areas and to find more general requirements. Detailed requirements (e.g., order entry with or without sample), which will surely differ between areas, must be derived according to the specific user needs. Adding detailed requirements of any given department or area to the index would cause not only an explosion in size, but also high amounts of overlapping requirements. Also, detailed requirements are being published by several different institutions and working groups

across Germany (e.g., [15]). Therefore, the index is not an assembly of available detailed requirements indices, specific to a given area, but rather a structure to be used and refined according to own tasks and surroundings. However, the suitability of this approach remains to be evaluated in detail in actual projects.

The index is based on the idea that formulating information processing requirements should be **independent of the information processing tools** (computer-based or conventional) used. For example, the requirement "transmission of new findings to the ward should take place within a defined period of time" can be fulfilled with different types of transmission media (e.g., electronic network or conventional mail). Of interest in this case are only results, such as: Can the physician or the nurse access the new findings within a pre-defined time period? Therefore, the requirements in the index have been formulated independent of the tools used, or of the architecture found in a given hospital. This may lead to protest, since users will have problems finding requirements applying to customizing software; however, the index will contain requirements about the adaptation of information processing components, which are valid both for software and for paper-based tools. The requirements index can, thus, be used in any surrounding, after being refined according to the user's needs. This approach must also be evaluated.

The first official German version of the index was finished and published broadly in February 2001. The English translation is available since February 2002. The requirements index is now open for discussion and **evaluation**. In order to access its usefulness, the index should be used in different hospital information management tasks and evaluated in a trial. This would allow assessment, for example, of whether the index can really speed up tender processes, support HIS evaluation, or facilitate the development of strategic information management plans. Following such an evaluation, we should also be able to answer the following questions:

- Is the requirements index complete for the mentioned tasks?

- Is the granularity of the index suitable for the mentioned tasks?

In our opinion, the requirement index is quite unique, as it concentrates on general quality criteria for information processing, it encompasses all areas of information processing, not only specific parts (such as radiology), and it is formulated independent of a specific HIS architecture and independent of the tools used, thus encompassing both computer-supported and conventional information processing. The requirements index should therefore be of interest for other researchers, both as an example for general quality criteria of hospital information systems, and as a draft to be refined and used in information management and selection project in hospitals.

So far we have seen a considerable amount of interest in the index by researchers, information managers, computer scientists, and health care consultants across Germany and abroad. Our German website has been accessed more than 1300 times between March and July 2001. The medium access rate was 80 times per week between May and July 2001. We now plan to use the index in different projects for further evaluation in case studies.

6. Conclusion

The index contains general requirements for information processing in hospitals. It aims to support HIS management, especially HIS strategic planning, HIS evaluation and tender processes. The requirements index can be regarded as a reference model, which must, however, be refined according to the specific aims of a particular project. Depending on the level of detail required, this may take some effort. However, we feel that the requirements index can be a useful tool in supporting hospital information management, and that efforts can be reduced. This may be difficult to prove and must be analyzed in further detail. In general, the high interest in the requirements index supports its usefulness.

We hope that the requirements index supports the systematic management of information processing, the communication between hospitals and vendors, as well as between hospitals and accreditation institutions, and supports high-quality information processing and patient care.

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References

1. Winter A, Brigl B, Buchauer A, Dujat C, Gräber S, Grosse A, et al. Purpose and Structure of Strategic Plans for Information Management in Hospitals. In: Hasman A, Blobel B, Dudeck J, Engelbrecht R, Gell G, Prokosch H, eds. Medical Infobahn for Europe - Proceedings of MIE2000 and GMDS 2000. Amsterdam: IOS Press; 2000. p. 880-884.
2. Winter A, Ammenwerth E, Bott O, Brigl B, Buchauer A, Gräber S, et al. Strategic Information Management Plans: The Basis for systematic Information Management in Hospitals. *Int J Med Inform* 2001; 64 (2-3): 99-109.
3. Kuhn K, Guise D. From Hospital Information Systems to Health Information Systems - Problems, Challenges, Perspectives. *Methods Inf Med* 2000; 40: 275-86.
4. Winter A, Winter A, Becker K, Bott O, Brigl B, Gräber S, et al. Referenzmodelle für die Unterstützung des Managements von Krankenhausinformationssystemen (Reference models to support the management of hospital information systems; in German). *Informatik, Biometrie und Epidemiologie in Medizin und Biologie* 1999; 30 (4): 173-89.
5. van Bemmel JH, Musen MA, editors. *Handbook of Medical Informatics*. Houten/Diegem: Springer; 1997.
6. Herbert I. The Common Basic Specification (version 4.4), Information Management Group

- (IMG), United Kingdom National Health Service (NHS), 1993.
7. Frandji B. Open architecture for health care systems: the European RICHE experience. In: Dudeck J, Blobel B, Lordieck W, Bürkle T, eds. *New technologies in hospital information systems*. Amsterdam: IOS Press; 1997. p. 11-23.
 8. Greenes RA, Collen M, Shannon RH. Functional requirements as an integral part of the design and development process: summary and recommendations. *Int J Biomed Comput* 1994; 34: 59-76.
 9. Mylopoulos J, Chung L, Yu E. Requirements Analysis. *Commun ACM* 1999; 42 (1): 31-7.
 10. Dardenne A, van Lamsweerde A, Fickas S. Goal-directed requirements acquisition. *Sci Comput Program* 1993; 20: 3-50.
 11. Ammenwerth E. Modellierung von Anforderungen an die Informationsverarbeitung im Krankenhaus (Requirement modeling for information processing in hospitals; in German; abstract in English). Heidelberg, Dept. of Med. Informatik, University of Heidelberg. <http://www.ub.uni-heidelberg.de/archiv/1101>.
 12. Haux R, Ammenwerth E, Buchauer A. Anforderungskatalog für die Informationsverarbeitung im Krankenhaus, Version 1.0b, Report No. 1/2001, Dept. of Medical Informatics, Heidelberg, 2001. <http://www.anforderungskatalog.uni-hd.de>.
 13. Haux R, Ammenwerth E, Buchauer A. Requirements Index for Information Processing in Hospitals, Version 1.0b, Report No. 1/2001, Dept. of Medical Informatics, Heidelberg, 2001. <http://www.umat.at/reghis>.
 14. Chocholik J, Bouchard S, Tan J, Ostrow D. The Determination of Relevant Goals and Criteria Used to Select an Automated Patient Care Information System: A Delphi Approach. *JAMIA* 1999; 6 (3): 219-33.
 15. Herrmann G, Müller I, Stausberg J. Anforderungskatalog für ein Anwendungssoftwareprodukt für die OP-Dokumentation (Requirements Index for an OR-data management system), University Hospitals of Leipzig. Last accessed: Febr. 2002. http://www.uni-essen.de/~tmi030/ak_chirurgie/info/auswahl.htm.

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