Systems Analysis in Health Care: Framework and Example

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Summary

Objectives: Due to the high complexity of structures and processes in health care, thorough systems analyses in health care run the risk of becoming very complex and difficult to handle. Therefore, we aimed to support systematic systems analysis in health care by developing a comprehensive framework that presents and describes potential areas of analysis.

Methods: A framework for systems analysis in health care was developed and applied in a health care setting. To provide a clear structure, the framework describes the potential views and levels of systems analyses in a health care environment.

Results: The framework comprises five views (roles and responsibilities, information processing and tools, communication, business processes, teams structure and cooperation) and five levels of analysis (overall organization, organizational unit, staff member, role, task). The framework was successfully applied in an analysis of the structures and processes of the Department of Child and Adolescent Psychiatry of the University Medical Center Heidelberg.

Conclusions: The proposed comprehensive framework aims to structure the views and levels of systems analysis in the complex health care environment. Our first experiences support the usefulness of such a framework.

1. Introduction: Systems Analysis in Health Care

1.1 Background and Motivation

The complexity of information processing in health care institutions is tremendous due to the high complexity of their structures and processes. Nearly everyone working in a hospital has an enormous demand for information, which must be fulfilled to guarantee excellent and efficient patient care [1, 2]. To achieve high-quality patient care, different professional groups, such as physicians, nurses, and administrative staff, must communicate and cooperate closely [3, 4]. The stakeholders' issue is quite complex [5]. Patient care aims must be discussed, decided upon and revised in treatment teams, which are made up of different members for each patient. Processes are highly variable and flexible, standard 'reference' patient care processes are difficult to define. Patients receive individual treatment – not only in emergency cases that demand immediate care. Decisions must be made quickly and are often based on incomplete information. Therefore, systematic information management is of tremendous importance in order to plan, monitor and direct information processing in such a way that the information needs of the various user groups are fulfilled in any situation and location [6].

The quality of information management can only be assessed by rigorous systems analysis. The general aim of such an analysis is to analyze the current state and weaknesses of organizational structures and processes in a defined area. A thorough systems analysis in a health care institution is the precondition for all activities aiming at improving structures and processes in health care, such as business process reengineering, quality management, or the introduction of new information processing tools [3]. The more precise the analysis, the better the structures and processes of the institution can be redesigned, improved or supported [7, 8].

Due to the high complexity and interconnectivity of workflow, information management, communication and cooperation, thorough health care systems analyses run the risk of becoming very complex and difficult to handle. If relevant parts are overlooked, insufficient systems analyses may even lead to project failures [9, 10]. For example, an insufficient analysis of communication may lead to the failure of a new electronic record system [11].

In our opinion, a description of the possible views and levels of a systems analysis in health care could help clearly define the areas requiring analysis without overlooking relevant parts.

Approaches used in more structured environments do not seem useful in assessing the complexity surrounding health care. For example, available frameworks for computer-based enterprise information systems – such as ARIS (Architecture of Integrated Information Systems) [12], or the Zachmann framework [13], concentrate on the computer-supported part of an information systems, often omitting, for example, an explicit analysis of the specific complexity surrounding health care, such as paper-based information processing, communication and cooperation within the health professional team. Thus, they are not

completely sufficient to describe and evaluate the complex structures and processes surrounding information processing in hospitals.

We feel that a distinctive health care systems analysis framework presenting potential areas for analysis could help define the focus of such an analysis explicitly. This may even improve the quality and completeness of systems analyses.

1.2 Aim of this Paper

The aim of this paper is to present a comprehensive framework to support systems analyses in health care institutions. It describes the potential views and levels of such analyses to support a clear structure of systems analysis.

Developing a health care-specific framework for systems analysis is a challenging task that requires long-term studies and evaluations of its own. In the present paper, we illustrate our first attempt at providing such a framework. A comprehensive systems analysis of the Department of Child and Adolescent Psychiatry of the Heidelberg University Medical Center served as a first application of the framework. We will present the framework and discuss our experiences with its application.

2. A Framework for System Analysis

A framework is a supportive structure or frame [14]. A framework for systems analysis should, therefore, structure an analysis in health care. Our framework will focus on the question: "What can be analyzed?" To answer this question, we differentiate between:

- views of systems analysis in health care and
- levels of systems analysis in health care.

2.1 Views of Systems Analysis in Health Care

The theory of systems analysis proposes different views on a complex object and supports the selection of one or more of these views depending on the question of interest. It is helpful to find main views for systems analysis that may then be refined to fit a concrete analysis.

Most often information systems analysis focuses on views relevant for software engineering, such as data flow, workflow, and the information processing tools used [7]. Health care-specific aspects, such as responsibilities, decision-making processes,

as well as communication and, especially, cooperation within the health care professional team have often been overlooked, although information processing in health care institutions often suffers from weaknesses in these areas [15, 16].

In order to include these important aspects, we propose the following five main views for systems analysis in health care institutions:

Roles and responsibilities: Analysis of the roles of health care professionals, their activity profiles, their responsibilities, and the organizational hierarchies and decision structures. Weaknesses that may be found during systems analysis include unclear responsibilities, or conflicting roles.

Information processing and information processing tools: Representation of the information processing functions, such as registering, storing and archiving information, as well as the used information processing tools (paper or computer-based). Weaknesses that may be found include redundant documentation, insufficient number of information processing tools, or violation of data integration.

Communication between health care professionals: Representation of the communication processes taking place between the various roles, both indirect and direct information exchange, including meetings, briefings, postings, etc. Weaknesses that may be found include redundant communication or communication breaches.

Business processes: Representation of the logical and temporal sequences of activities. Weaknesses that may be found include redundant work routines, unclear process definitions, waiting times, or missing feedback of process results.

Team structure and cooperation within the teams: Representation of the structures of the multi-professional health care team, description of the cooperation between team members, and teams. Weaknesses that may be found include a high effort for cooperation, insufficient definition of team aims, and an unclear team structure for a particular patient.

Each view favors a particular perspective and emphasizes certain aspects of information processing in health care. Each view represents a cluster of more refined

View \ Level	Overall organization	Organizational unit	Staff member	Role	Task
Roles and responsibilities				example 1	
Information processing and tools	example 2				example 2
Communication			example 3		
Business processes					example 4
Team structure and cooperation					

Fig. 1 Framework for systems analysis in health care: A systems analysis project can be described by the view of analysis (roles and responsibilities, ... teams and cooperation) and by the level of analysis (overall organization, ..., task). The gray boxes point out the examples of our project, which are described in Chapter 3.

systems analysis questions. Any systems analysis may focus on one or more of the views depending on the aims of the respective systems analysis project.

2.2 Levels of Systems Analysis in Health Care

Occupational psychology proposes analyzing an organization on different levels using a stepwise approach: beginning with the level of the overall organization, and ending with the analysis on each task [17]. This approach is also useful for analyzing systems in health care. However, we propose adding the level of a role, as staff members in health care will often fill different roles simultaneously (e.g., a doctor who is senior physician, director of a department, and a researcher). Thus, five different levels of systems analysis can be identified:

- the *overall organization* (e.g., a department);
- an *organizational unit* (e.g. a ward or an outpatient unit of a department);
- an *individual staff member* (e.g. a nurse or a physician);
- a *role* (e.g. the role of senior physician or the role of a patient);
- a *task* (e.g. patient admission or clinical documentation).

These five levels can be used in each of the five views of systems analysis described earlier.

2.3 A Framework for Systems Analysis in Health Care

By combining the five views and the five levels, 25 areas of systems analysis can be defined. Figure 1 shows the potential areas of systems analysis proposed by this framework.

The optimal combination of views and levels must be chosen for each systems analysis according to the project aims. Each combination of view and level must then be further refined to derive the concrete study questions for certain aspects (e.g., only the computer-based information processing tools may be of interest for one project).

Often, several views and/or levels will be combined.

Of course, some of the weaknesses of the health care institution will appear in several views. For example, frequently missing information during physician rounds may be reflected in the business process view, as well as in the information processing view.

For each view and level, specific analytical methods and descriptions may be useful and should be selected carefully before carrying out the analysis. Some examples are: Roles and responsibilities could be described using organigrams or UML use cases [18], information processing and information processing tools using the 3LGM [19], communication using speech act models [16], business processes using event-driven process chains or petri-nets, and cooperation using action workflow models [20].

3. Example: Application of the Framework in a System Analysis

In the following example, we will present the use of the framework in a systems analysis in a health care environment, and report some of the results. The aim is to demonstrate, how the framework helped to structure an actual systems analysis project in health care.

3.1 Project Description

We used the proposed framework to structure a broad systems analysis within an ongoing reorganization project within the Department of Child and Adolescent Psychiatry of the Heidelberg University Medical Center. The aim of the project was to find main weaknesses and to propose solutions for a reorganization of the treatment process. In a first step, a detailed systems analysis of the current state and weaknesses in the organization of patient care was conducted, which was structured with the help of the framework.

Systems analysis was performed by combining standardized questionnaires, partially standardized interviews, and observations. The overall project began in October 1999. Over a time period of 8 months, approx. 60 interviews with nearly all of the staff members and observations of 20 meetings were conducted. 30 questionnaires were answered (return rate was approx. 60%) and around 135 types of paper-based forms were analyzed.

3.2 Analysis Examples and Results

In the next paragraphs, we will present different aspects of the project. We will focus on distinct areas of analysis. For each area, we will briefly describe the aims and means, and present some examples of the results to illustrate how our analysis fits into certain parts of the proposed framework (cp. also Fig. 1). A detailed presentation and discussion of methods used in the analysis and of the results are described in [21] (study plan) and [22] (study results).

Example 1: Analysis of Roles and Responsibilities

One part of this analysis described the roles in the department, together with their responsibilities, and the typical activity profiles of the staff members. The analysis of the activity profiles was carried out on a role level in form of interviews. The aggregated activity profiles of some roles are presented in Table 1.

Time expended for coordinating care was found to be very high. A further analysis of the daily activities of some roles showed extremely fragmented time schedules due to firmly scheduled meetings and frequent disturbances due to telephone calls.

The overall results of a more detailed analysis led to a proposal to reorganize the meetings in order to optimize free time for patient treatment.

Example 2: Analysis of Information Processing and its Tools

For an analysis of this view, we focused on the purpose and content of documentation,

Table 1 Proportion of time spent during a typical week by the different roles on activities regarding patient treatment in the Dept. of Child and Adolescent Psychiatry Heidelberg. The percentages and hours are mean estimates based on interviews. Only the activities regarding patient treatment are included, others (e.g. research) are not included.

Role / Activities	Physician	Nurse	Co-therapist	Psychologist
Interventions with direct patient contact	30-40%	40-50%	40-50%	30-40%
Coordination of treatment inside the department	40-50%	40-50%	40-50%	40-50%
Documentation	*(5 h per week)*	*(5 h per week)*	*(5 h per week)*	*(5-10 h per week)*
Meetings with team members	*(12 h per week)*	*(10 h per week)*	*(7 h per week)*	*(15h per week)*
Telephone calls	*(5-10 times per day)*	*(1-5 times per day)*	*(1-5 times per day)*	*(5-10 times per day)*
Coordination of treatment with external units	5-10%	10-15%	0-5%	5-10%

the forms and information processing tools used, the structure of patient records and how they were archived, since some weaknesses were expected in this area. This analysis was conducted both on the overall organizational level (e.g., which forms and IT-tools are generally used) and on the task level (e.g., which forms are used for a given task). Our results showed that a complete computer-based patient record is currently not available in the department. While part of the documentation is conducted electronically, most is still paper-based. Differ-

ent professional groups use their own documentation systems. Information is spread over several media and over several main patient records, hindering fast access and resulting in high time losses during the search for necessary information.

As an example of our results, Table 2 shows the overall number of different types of paper-based forms available to support patient care. Many forms are primarily specific to this department, whereas the administrative forms and order entry forms are mostly standardized hospital-wide.

Altogether, approximately 135 different types of paper-based forms are available; while many are rarely used, others have even become obsolete. Some main documentation (e.g., therapeutic documentation) is conducted using an unstructured, hand-written manuscript instead of using forms. The overall results of a more detailed analysis led to a proposal to introduce a multi-professional electronic patient record, which should minimize paper-based forms and improve the availability of information.

Example 3: Analysis of Communication

For a communication analysis, we focused on the communication between roles, their structure, purpose and the tools used for communication. Analysis was mainly conducted on the role and staff member level by observing meetings, conducting interviews, and using questionnaires. Overall, we found that much inter- and intra-professional communication is needed inside the multi-professional health care team. Staff members in different roles judge the relevance of communication as very high. However, no clear communication concept is available for how and when to use the different communication types and media, such as synchronous telephone communication, pagers and mobile phones, meetings and seminars, as well as asynchronous communication by voice mailbox, fax, and conventional and electronic mail. The amount of written communication was analyzed for the most important roles. Figure 2 presents some examples of the results.

This detailed analysis of the communication behavior of individual staff members in their roles led to a proposal to restructure the communication media, and to introduce workflow management facilities within the planned electronic patient record in order to better support communication.

Usage / Treatment process phase	Used only in Dept. of Psychiatry	Also used in other departments	Total number
Patient administration (admission and discharge)	4	11	15
Patient treatment (diagnostics and therapy)	80	40	120
Order entry and results	*5*	*31*	
Clinical documentation	*48*	*5*	
Organizational support	*27*	*4*	
Total number	84	51	135

Table 2 Number of different types of paper-based forms available in the Dept. of Child and Adolescent Psychiatry Heidelberg, sorted by main patient treatment tasks.

Example 4: Analysis of Business Processes

The aim of the business process analysis was to define and describe the most important business processes of the department. The analysis was carried out on the task
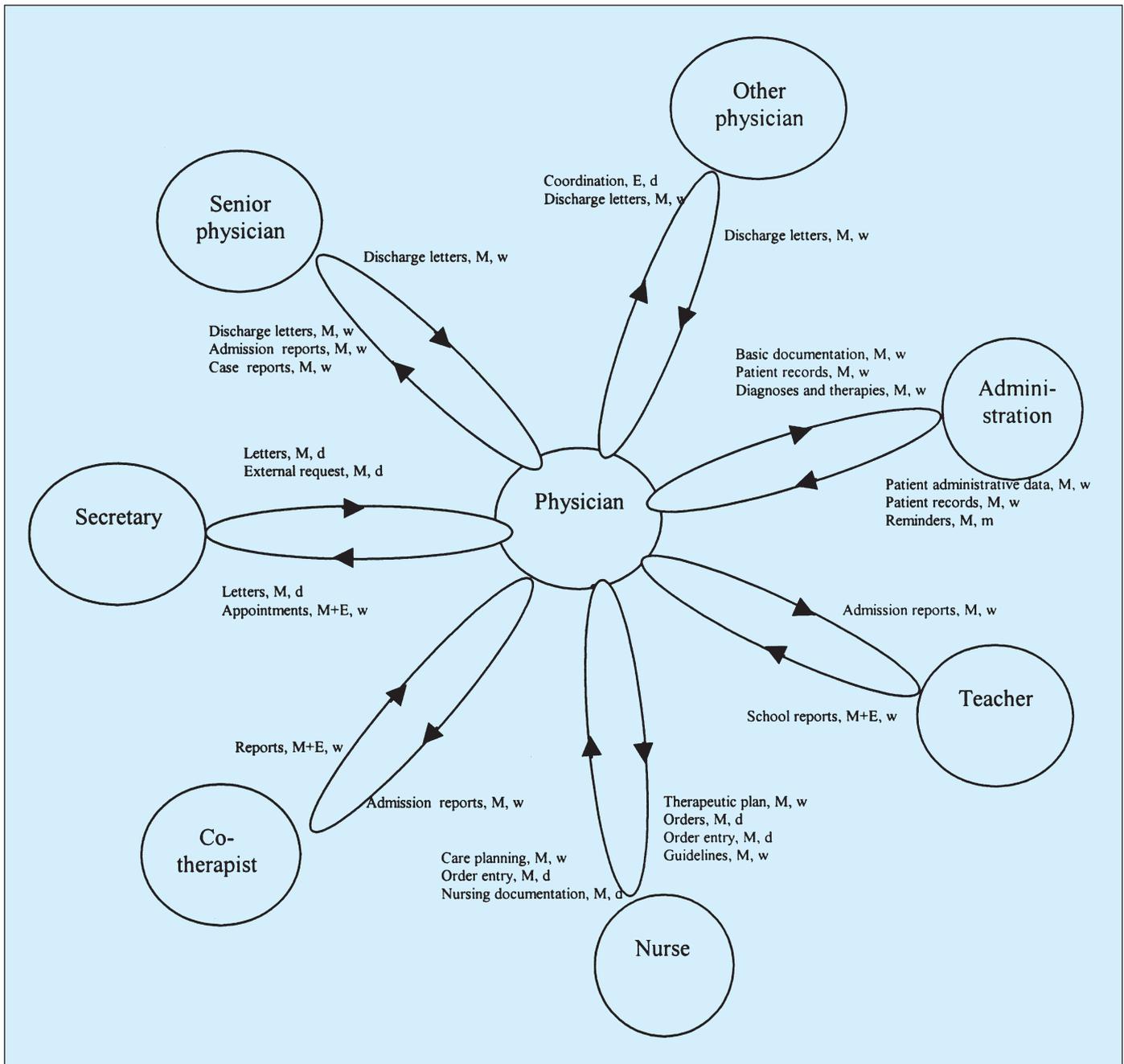
Fig. 2 Content, frequency and media of the main written communication between different roles involved in patient care in the Dept. of Child and Adolescent Psychiatry Heidelberg. The communication is described from one distinct physician's point of view. The communication media used is indicated by: M = by conventional mail, E = by e-mail. The frequency of communication is indicated by: m = monthly, w = weekly, d = daily.

level by conducting interviews and observations. Major processes were then analyzed on a more detailed level. Figure 3 presents an example of a modeling excerpt of the first steps of the admission process.

One of the results of business process analysis was that no clear agreement was defined in regard to some important processes, such as therapy planning. This became apparent, for example, in different views mentioned by the respondents on how certain processes should flow. The analysis of activities and business processes led to a proposal to define and then reorganize some of the main business processes, such as admission and therapy planning.

4. Discussion

We presented a framework for systems analysis in health care, which offers five views and five levels of analysis. In our opinion, this framework can support systems analysis projects by suggesting a
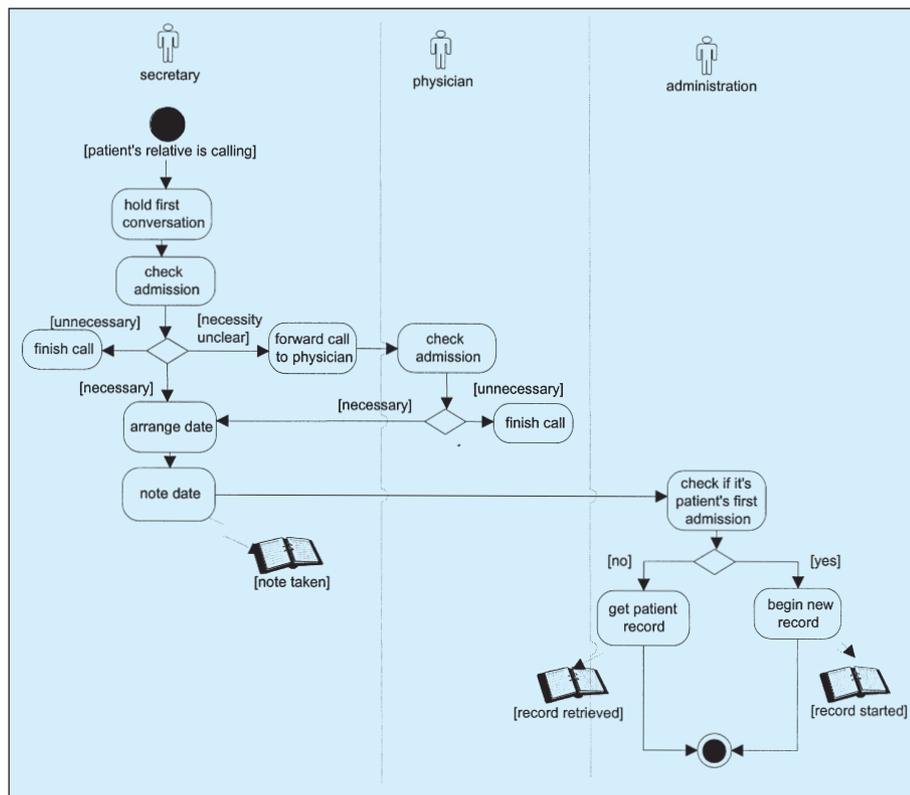
Fig. 3 Example of a business process: the first steps of the admission process in the Dept. of Child and Adolescent Psychiatry Heidelberg, modeled using an UML activity diagram.

structure to describe and organize an analysis in a health care environment. The framework was used to plan a systems analysis in a department of the University Medical Center of Heidelberg. We presented some results of this analysis to show how the proposed framework reflects different aspects of such an analysis. Only some results have been presented, the overall analysis included more analysis aspects of the selected views and levels than could be presented here.

Our examples illustrate that our first experiences have been positive in using this framework in a structured systems analysis of a cooperative health care environment. Identifying five views helped us find a better structure for various aspects of systems analysis. Of course, selecting an adequate view(s) is only the first step towards a more detailed study plan which further describes the study aims and study questions. The five levels we proposed helped us select the correct level of analysis. From our experience, a predefined order of analysis, beginning with the area 'roles and responsibilities',

and ending with 'teams and cooperation', seemed useful. We did not overlook any views or levels in the framework during our project. However, the framework was developed for a specific project, thus its application in our project is no proof of its completeness. The framework must now be used to structure future systems analysis projects to further evaluate its usefulness and completeness.

The proposed framework focuses on views and levels of an analysis, not on the methods and procedures that can be applied. We did not recommend special methods on *how* to analyze a specific level or a specific view in the best way. The focus of a systems analysis and which methods are applied depend on the specific questions of interest and the basic project aims. However, presenting possible methods would be helpful when planning a systems analysis. Thus, further work in this area may be very interesting and may lead to a systematic guideline for planning and executing systems analyses in health care.

In using the suggested framework, it became clear that certain weaknesses may occur in different views. For example, unclear decision structures occur in the roles and responsibilities view and again in the detailed view of individual business processes. This does not question the framework, but rather reinforces the need for a clear definition of the aims targeted by the analysis. In any systems analysis project, the views and levels most important to the project must be determined. A broad analysis, covering all 25 aspects, will rarely be of use.

Our work was based on the assumption that the complexity in health care organizations requires a distinct analysis framework. While this assumption can be discussed, we found the stronger focus on non-technical aspects of roles and communication and cooperation, in contrast to 'traditional' systems analysis frameworks, as very useful to our project.

Of what use could the presented framework be? First, it can support the preparation of systems analysis projects by helping to find adequate views and levels of the analysis, and to structure it. Second, the framework can help compare analysis projects by illustrating the views and levels of analysis used in each. This may help, for example, to find similar projects and learn from their methods or procedures. Third, the framework may be used to arrange specific methods of analysis for certain views or levels, which may help the project manager select suitable methods.

5. Conclusion

In this paper, we presented a framework for systems analysis by combining five views and five levels of investigation. Our first experiences support the usefulness of this framework. It is important to stress that our proposed framework does not represent a guideline for an overall systems analysis. Depending on the research aims, separate analysis areas should be defined and appropriate parts of the framework selected and further refined.

The framework should now be verified in other cooperative health care institu-

tions. We hope that this framework will also help focus on communication and cooperation in light of the rising demand placed on multi-professional treatment teams.

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