Implementing Clinical Guidelines in an Organizational Setup

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Outcomes research in healthcare has been a topic much addressed in recent years. Efforts in this direction have been supplemented by work in the areas of guidelines for clinical practice and computer-interpretable workflow and careflow models.In what follows we present the outlines of a framework for understanding the relations between organizations, guidelines, individual patients and patient-related functions. The derived framework provides a means to extract the knowledge contained in the guideline text at different granularities, in ways that can help us to assign tasks within the healthcare organization and to assess clinical performance in realizing the guideline. It does this in a way that preserves the flexibility of the organization in the adoption of the guidelines.

TEAM-ENABLED WORKFLOW

Workflow systems typically employ a tripartite categorization of cases, work-items and resources. A *case* is a specific situation in which the workflow system is applied; a *work-item* is a task to be performed in relation to this case; *resources* are the persons and facilities needed to execute given work-items, their ability to do this being represented as a *role* [1,2].

Classically, work-items have been assigned by available applications to specific workers. An application may in some way recognize that teams exist, but it is pre-selected individual members of teams who are called upon at specific times for the execution of specific work-items. In reality, however, team-work is one of the key resources to be exploited by a workflow system. The teams within healthcare organizations have collective functions and they may be collectively responsible for the execution of these functions in the management of patients. To put it simply: doctors, nurses, technicians, and assistants work in tandem, and current workflow models do not do justice to this fact. We have used this team concept for a framework for the implementation of the task recommendations in clinical guidelines [3].

PARTITIONS AND APPROXIMATION

Different partitions are needed to throw light on different aspects of the organization and of the workflow process at different levels of granularity. At the same time a framework is needed within which these different partitions can be manipulated simultaneouly, for which we employ the Theory of Granular Partitions (TGP) [4,5]. A partition, from the perspective of TGP, consists of a network of cells and subcells, the latter being nested within the former; the cells, in turn, are projectted onto objects.

The hierarchy of available human resources, the functions they perform as well as the physical facilities at the disposal of the organization – all of these determine partitions which we need for the complete representation of team-based workflow. When a particular human resource, for example nurse A, is entitled to carry out a particular function F in a particular location within the physical structure of a hospital, then this means that the cell labelled nurse A in the partition of responsibilities is projected onto function F. When we assess how A exercises this function, then we have a new partition where the cell labelled nurse A is projected onto processes. Functions do not have temporal annotations, while the processes which realize functions exist in specific intervals of time. In this paper, we consider the question of implementation only at the level of the former.

Partitions which determine relevant norms or standards have the capacity to be used as a frame of reference, in a way which allows us to describe the approximate location of actual objects. We call a granular partition which is used in this way a reference partition.

Compare the way we use the reference partition defined by the borders of the fifty states in the USA, in describing, say, an area of high pressure in a weather forecast. The boundaries of the separate states are well defined and we can use this fact to specify the location of the area of higher pressure even though we do not know exactly where it is; for example, by asserting that

it overlaps with Texas and Arizona but not with any other state.

The same idea can be used in giving an account of the way the responsibilities are assigned to the members of a team within a healthcare organization. Here, the *ex ante* boundaries of the functions associated with any given member of the team are vague – that is one of the characteristics of genuine teamwork. The *ex ante* boundaries of the actual healthcare processes which will become associated with the functions mentioned in a clinical practice guideline are also vague. But the complete list of responsibilities in the organization, or the complete list of the functions determined by the guideline text, are crisp and so can be used as reference partitions. The boundaries of the units of the physical structure of the hospital or other places of healthcare delivery are equally crisp, and so is the hierarchy of the human resources in the organization. These can be used to specify the functions of the team of human resources in the organization in a formal way as follows.

Let x be the responsibilities of nurse A within her team, which are projected by partition P onto the collective functions to be exercised by the team as a whole. P does not project crisply onto any single function. Rather it is projected onto P with full overlap (*fo*) to some cells and of partial overlap (*po*) or no overlap (*no*) to others. Some functions are indeed meant to be performed by nurse A only, which implies for those functions a case of full overlap. Some are collective functions executed by nurse A and/or other team members.

IMPLEMENTATION FORMALISM

The above-mentioned approach can now be applied to the creation, implementation and application of computer-interpretable guideline models. This requires not only that one is able to interpret the guideline text and models based thereon, but also that one has to find a way to understand the actual workflow within a given organization implementing the guideline.

The functions are divided into recommended and actualized functions; into homogenized and dehomogenized functions and into functions before and after approximation.

Recommended vs. Actualized Functions. The former are the idealized functions, mentioned in the guidelines, providing the best-practice approach in a specific clinical situation. The latter are the functions actually implemented within a particular organization.

Homogenized vs. Dehomogenized Functions. Homogenized functions provide a complete list of functions mentioned in either the recommended or actualized functions, while dehomogenized functions are the functions which have a built-in ontology, which reflects a hierarchical organization among the functions. Dehomogenization could occur in the idealized condition depicted in guidelines in the form of task-hierarchy, that is, by identification of tasks and their subtasks; or it could occur in the actualized functions present within a organization by making a task-hierarchy based on the existent hierarchy of human resources in the organization.

Unapproximated vs. Approximated Functions. Approximation describes the overlaps which can occur between different functions, it could be partial, full or no overlap; again either between the idealized functions in the guidelines or between the functions which can be carried out by the human resources in the organization. The functions which are present before the approximation are unapproximated functions, while the functions existing after the approximation are approximated functions.

Unapproximated (U) Recommended (R)

Homogenized functions f(H,R,U): The partition of recommended homogenized functions contain the complete list of functions which are related to the management of a given pathology mentioned in the guideline without any relationship between the functions, which are presented as a list.

Dehomogenized functions f(D,R,U): This partition provides information about the complexity of functions. It records which functions are a part of which other functions. If function C is a part of function D, then the implementation of function C will be within the context of function D, thus, determining the context within which a particular function is to be executed.

Unapproximated (U) Actualized (Ac)

Homogenized functions f(H,Ac,U): The partition of actualized homogenized function of a healthcare organization is the list of all the functions which can be carried out within the organization, irrespective of the agent executing the function.

Dehomogenized functions f(D,Ac,U): The functions mentioned in f(H,R,U) are assigned to the different agents in the healthcare organization.

Different agents can perform the same function or part of function and different functions can be performed by the same agent. Therefore, this partition will describe that echocardiography is a function of a cardiologist; while blood pressure determination can be done by a cardiologist or a staff nurse or a general practitioner. But this partition does not do justice to the existence of team-work, where the allocation of functions can be joint or vague.

Approximated(A) Recommended (R)

Homogenized functions f(H,R,A): The boundaries of the homogenized functions recommended for a pathology do not change after applying the concept of approximation to the partition of homogenized recommended functions. This is in line with the assumption that the knowledge mentioned in the guideline is considered to be the standard for further steps. However, the functions present can stand to each other in complete, partial or no overlap relations. If there is no overlap within the functions, then their representations are not modified at this stage. The functions with complete overlap are considered as the same function. Functions with partial overlap are depicted with a connection.

Dehomogenized functions f(D,R,A): The overlaps present in the f(H,R,A) are also present in the this partition. The connection is strengthened if the overlapping functions are present within the same context. The context and task hierarchy are related, because if a subfunction is a part-of another funtion, then the subfunction is carried out within the context of the first.

Approximated (A) Actualized (Ac)

Homogenized functions f(H,Ac,A): The list of functions remains the same in this partition as in f(H,Ac,U). The functions with no overlap are designated to be carried by single team members, while the functions with partial overlap are carried out by team members jointly.

Dehomogenized functions f(D,Ac,A): This partition brings to prominence the fact that the functions carried out in the organization can involve different human agents jointly in a team or the allocation of the functions to the members of such a team is vague, that is, the overlap between the functions is projected onto the team in the organization.

Using these definitions, we can designate the functional (F) level at which the organization stands in implementing a guideline or further steps it might take towards a more complete implementation of the guideline.

PARTITIONS CONSIDERED

The WHO Hypertension Guideline deals with the different tasks performed in diagnosis, classification, investigation and management of hypertensive patients [6]. We take the examples of the tasks mentioned in this guideline to demonstrate the working of the framework sketched above.

Considering all the many definitions within the context of a guideline such as that of hypertension, we can deal here only with some sample partitions, which will help to create an overall picture. The different levels are created within this setup by connecting the different partitions and using approximation.

A) **Partition of the Physical Structure of a Hospital**: This has cells corresponding to the Departments of Internal Medicine, of Surgery, of Cardiology and so on; the Department of Internal Medicine will itself have parts: Inpatient Unit, Procedure Room, Outpatient Unit, and so on.

B) **Partition of Healthcare Professionals**: This has cells corresponding to: Physicians, Nurses, Technicians and so on; the cell Physicians has subcells: Physician internists, cardiologists etc.; the cell Nurses has subcells: nursing staff internal medicine, specialized nurse emergency, junior nurse staff etc.

C) **Partition of Recommended Functions:** This gives a complete list of functions mentioned in guidelines, for example, "Measurement of Blood Pressure", "Advice: Change Dietary Intake" etc.

GUIDELINE IMPLEMENTATION

F1. The guideline text has been used to manually extract the recommended functions as two distinct partitions, in two steps – f(H,R,U) and f(D,R,U). Fulfilment on this level with respect to a particular guideline would mean that all the functions mentioned in the guideline are presented as a list in the first partition and then a hierarchy is established among them as by identifying the tasks and their subtasks from the list.

Example of f(H,R,U) – This consists of a list of functions without a hierarchy: (Therapeutic or Preventive Procedures; Advice: Lifestyle Changes;

Advice: Change Dietary Intake; Advice: Change Fiber Intake; Advice: Change Fat Intake; Advice: Change Potassium Intake; Advice: Increased Magnesium Intake; Advice: Salt Intake Reduction; Advice: Encourage Intake of Calcium)

Example of f(D,R,U) – This consists of a hierarchical representation based on the parthood relationships. (Advice: Change Fiber Intake; Advice: Change Fat Intake; Advice: Change Potassium Intake; Advice: Increased Magnesium Intake; Advice: Salt Intake Reduction; Advice: Encourage Intake of Calcium) *is part-of* (Advice: Change Dietary Intake) *is part-of* (Advice: Lifestyle Changes) *is part-of* (Therapeutic or Preventive Procedures)

F2. The functions carried out in a healthcare organization are modelled as two distinct partitions, in two steps – f(H,Ac,U) and f(D,Ac,U). Fulfilment on this level would mean that the functions performed by the organization as a whole or its parts, for example a particular department are mentioned as a list and then the different tasks are assigned to the different human agents in the organization. At this level, the concept of approximation has not been applied and thus the existence of teams has not been acknowledged.

Example of f(H,Ac,U) – (Measurement of Blood Pressure; *Echocardiography*; *Risk assessment of Hypertensive Patients*; Advice: Change Fiber Intake; Advice: Change Fat Intake; Advice: Change Potassium Intake; Advice: Increased Magnesium Intake; Advice: Salt Intake Reduction; Advice: Encourage Intake of Calcium)

Example of (D,Ac,U) for an Internist – (Measurement of Blood Pressue; Advice: Change Fiber Intake; Advice: Change Fat Intake; Advice: Change Potassium Intake; Advice: Increased Magnesium Intake; Advice: Salt Intake Reduction; Advice: Encourage Intake of Calcium)

Example of f(H,Ac,U) for a junior nurse staff – (*Measurement of Blood Pressure*)

F3. Approximated functions are created. Fulfilment on this level would mean that the vagueness between the recommended functions has been taken into account in the guideline text based functions; and the team-based functions have been accounted for in the organizational set-up. For example, DASH or Dietary Approaches to Stop Hypertension, as promoted by the National Institute of Health [7]. The WHO guideline text employs the functions mentioned in DASH but does not mention DASH explicitly. However, one DASH diet does *not* include all the recommendations mentioned under "Advice: Change Dietary Intake" in the WHO guideline. For example, the DASH recommendation of "Have a 1/2 cup serving of lowfat frozen yogurt instead of a 11/2-ounce milk chocolate bar. You'll save about 110 calories" does not include a recommendation to decrease sodium intake though it has overlaps with reduction in cholesterol. On the other hand, implementation of *all* the DASH recommendations will include *all* the functions in the hypertension guideline regarding Advice to Change Dietary Intake. Thus, if we consider all the DASH recomendations together, the boundary of collective DASH-related functions is within the boundary of "Advice: Lifestyle Changes" and fully overlaps with "Advice: Change Dietary Intake". However, individual DASH-related functions are in partial overlap with the individual functions mentioned under "Advice: Change Dietary Intake".

F4. f(H,R,A) is compared with f(H,Ac,A). In order for all the guideline-recommended functions to be realizable within the healthcare organizational set-up, all the functions in f(H,R,A) must be a part of f(H,Ac,A); that is, the boundary of the former must be within the boundary of the latter.

F5. f(D,R,A) is compared to f(D,Ac,A). If F4 is satisfied and the functions within the same context in the guideline are carried out by the team as partially overlapping functions, then the team functions *with interaction* and is *compliant* with the guideline at the functional level. If F4 is satisfied and the functions within the same context in the guideline are carried out by the team members as fully overlapping or non-overlapping functions, then the team functions *without interaction* but is *compliant* with the guideline at the functional level. For example, the physician P with dietician D and nurse A could be involved in implementing the function of "Advice to Change Dietary Intake". Thus, the referral to D by P, the giving of advice to A by D and the supervision of A by P within the context of this function describes an interactive team design which preserves the context mentioned in the guideline, and is thus compliant with it. That is, if 'Measurement of blood pressure' is carried out as a part-of the task 'Risk assessment of hypertensive patients', then, the parthood relationship also
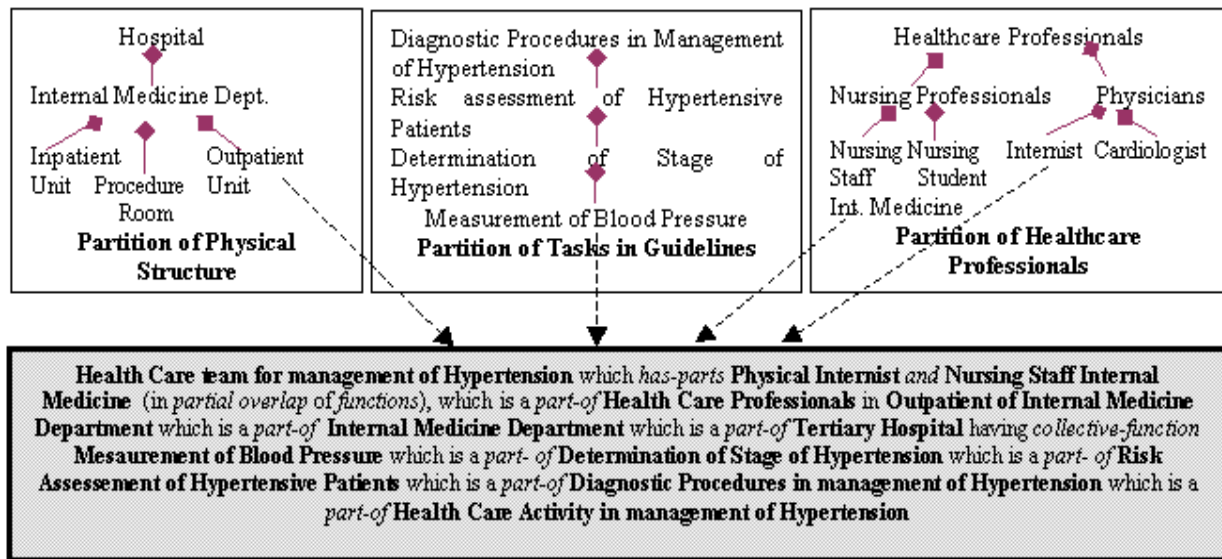
Fig 1 Sample of different partitions used to describe the implementation of tasks recommended in guidelines in a healthcare organization (◆━ = *is-part-of*)

implies that the former is carried out within the context of carrying out the latter. If all the functions mentioned within a particular context are perfomed by the same agent, for example if only D is involved in the implementation of "Advice to Change Dietary Intake" without any role for P or A, then the team is overall compliant with the guideline recommendations but it is not interactive.

CONCLUSION

This paper describes the different levels of guideline implementation, considering the tasks as functions and defining successive levels of granularity of functional assignment or representation. These functions are executed as processes or clinical activities in real-time, for which we will describe corresponding granularity levels in further work, where we will take into consideration also the sequence of execution of the workflow tasks.

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