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Supporting Human Interaction and Human Resources Coordination in Distributed Clinical Guidelines

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Abstract

Clinical guidelines (GL) play an important role in medical practice: the one of optimizing the quality of patient care on the basis of the best and most recent evidence based medicine. In order to achieve this goal, the interaction between different actors, who cooperate in the execution of the same GL, is a crucial issue. As a matter of fact, in many cases (e.g. in chronic disease treatment) the GL execution requires that patient treatment is not performed/completed in the hospital, but is continued in different contexts (e.g. at home, or in the general practitioner's ambulatory), under the responsibility of different actors. In this situation, the correct interaction and communication between the actors themselves is critical for the quality of care, and human resources coordination is a key issue to be addressed by the managers of the involved healthcare service. In this paper we describe how computerized GL management can be extended in order to support such needs, and we illustrate our approach by means of a practical case study.

Keywords:
Clinical guidelines, Human interaction and communication, Human resources coordination.

Introduction

Clinical guidelines (GLs) are defined as "systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances" [1]. GLs exploitation is meant to improve the quality and to reduce the cost of healthcare, putting evidence based medicine into practice, and is progressively spreading in several countries. As a matter of fact, a lot of national and international institutions have recently been engaged in developing and disseminating GLs. Moreover, the medical community has started to recognize that a computer-based management of GLs can further increase GL advantages, providing relevant benefits (e.g. automatic connection to the patient databases, and decision making support) to care providers and patients. Many different systems and projects have been developed to this hand (see e.g. [2-4]).

The goals of these systems are mainly the ones of supporting physicians in patient care by representing and executing a GL. However, it is worth noting that some GLs, mainly dealing with chronic diseases, require that patient treatment is not completely performed in a single location (e.g. the hospital), but is continued in time, often in a life-long perspective, and distributed in *different contexts* (e.g. at home, or in the general practitioner's ambulatory), under the responsibility of *different actors*. In this situation, the *correct interaction and communication* between the involved actors is critical for the quality of care, and *human resources coordination* is a key issue to be addressed by the managers of the involved healthcare services. None of the available computerized systems for GL management explicitly addresses these needs, and interaction is nowadays completely demanded to the different actors. Sometimes the responsibility of notification is even demanded to the patient, without a check of communication completeness and correctness. For instance, in Italy, the discharge letter is given to the patient, who has to notify it to her general practitioner.

In this work, we propose an extension of a computerized GL management tool in order to support coordination of multiple actors operating on the same GL. In particular, we first introduce an extension of the GL representation formalism with new dimensions, meant to *color* the GL actions with *context, role* and *competence* information. Then, we describe how human resources coordination and human interaction and communication can be supported through notification and query answering services. The querying facility, in particular, can help both during GL execution and off-line (e.g. before execution, and independently of any specific patient's data). A practical implementation of this work is represented by an extension of the GLARE system, a domain-independent system for GL acquisition and execution [5], that we are developing since 1997. Resorting to the GLARE formalism, we will illustrate the application of our approach to the "Management of harmful drinking and alcohol dependence in primary care" GL developed by the Scottish Intercollegiate Guidelines Network (SIGN) [6], which we have adapted to the Italian context. However, although we have implemented our approach in GLARE, it is worth stressing that the methodology we propose is completely general and application-independent.

The paper is structured as follows: in the next section we describe the extension to the basic GL representation formalism required by our approach, as well as the notification and the query answering service. In the Results section, we exemplify a practical application of our approach considering the alcohol-related disorders treatment GL. Finally in the last section we address some concluding remarks.

Materials and Methods

Colored Guidelines: representation formalism

In the literature, the majority of the GL representation languages share the same basic primitives, from which we will start to describe the extensions we propose in this paper. Obviously this grants for generality: despite the fact that our approach is being integrated with GLARE, all the considerations could be easily adapted to other GL management systems.

In particular, a GL is typically represented by a graph, where nodes are the statements/actions to be executed, and arcs are the control relations linking them. Actions can be *atomic* or *composite*, defined in terms of their atomic components via the has-part relation. Three main types of atomic actions can then be identified[1]: *work actions,* which describe a procedure which must be executed at a given point of the GL; *query actions*, which represent requests of patient data; *decision actions,* which embody the decisional criteria that can be used to select among alternative paths in a GL. *Control* relations establish which actions can be executed next, and in what order: *sequence, parallelism*, *alternative*, and *repetition* constructs are typically available. In some systems (e.g. in GLARE) temporal constraints, such as the delay between two actions in sequence, can also be provided. Such notions will be used in the examples in the Results section.

In order to deal with human interaction and human resources management, we propose to extend the semantics of each action by *coloring* it with three new dimensions:

- **context:** it specifies where the action can be executed (e.g. in-patient care, community medicine). Observe that a context is not necessarily a physical place, but it is an operative environment. For instance, community medicine can refer to the patient's home or to the general practitioner's ambulatory;
- **role:** it specifies who can execute the action (e.g. physician, nurse);
- **competence:** it specifies that the action can be executed only by actors with some specific abilities (e.g. pharmacological treatment of abstinence syndrome).

It is worth noticing that not all combinations of values of the three parameters are usually possible. Moreover different actors may share the very same competence. However a competence may assume different meanings according to the role.

[1] In the following, without loss of generality, we will use the GLARE system terminology for action names.

At design time, the specification of a list of possible contexts and of a list of possible roles is mandatory for every action in the *colored* GL; on the other hand the competence dimension specification is not always required. In the case that the competence list is empty, no specific restriction needs to be applied; otherwise, only the actors having the required competences will be allowed to execute the action at hand. Moreover, all dimensions are represented by a list of values, but the interpretation of such lists is different. Context values must be interpreted as alternative ones: in the case that two or more contexts are specified, it means that the action can be executed in any one of the contexts. The same consideration holds for role values: if two or more roles are provided, the action can be executed by any one of the actors. On the other hand, the competence values must be interpreted in conjunction: if two or more competences are specified, the actor responsible for performing the action at hand will need all the abilities.

Example. The action "Brief intervention for hazardous and harmful drinking" (see action 11 in Figure 1, Results section) in the alcohol-related disorders treatment GL [6] is color as follows:

- *context: community medicine, SERT medicine (i.e. an Italian service similar to the Mental Health Service in U.S.A.), in-patient care, hospital care ambulatory;*
- *role: physician, nurse;*
- *competence: psychological support.*

Notification service

As observed in the Introduction, in many real world situations no automatic notification exists to the different actors involved in the execution of a GL on a chronic patient. The issue is particularly critical when an action is followed by another action to be executed in a different context, like, e.g. when a patient is discharged from a hospital, and must be cared by her general practitioner. The absence of an automatic notification exposes the patient to the risk of being "left alone", without any healthcare operator who is formally in charge of her monitoring or treatment procedures; especially when dealing with pathological conditions involving low compliance patients (like e.g. alcohol-addicted ones), it is not really acceptable that the notification to the new responsible actor is up to the patient herself.

Our approach allows to properly deal with this issue, since each action is *colored* with information about context, roles and competences required for its execution. In particular, we have implemented a notification service, which is automatically activated at execution time. By means of this service, as soon as a GL action is completed, all the contexts, roles and competences *coloring* the next action to be executed are collected, and a notification is sent to the proper person or service manager. In this way, the patient is constantly under the responsibility of a proper healthcare operator, and communication with the responsible is always possible for the other people involved in the GL execution.

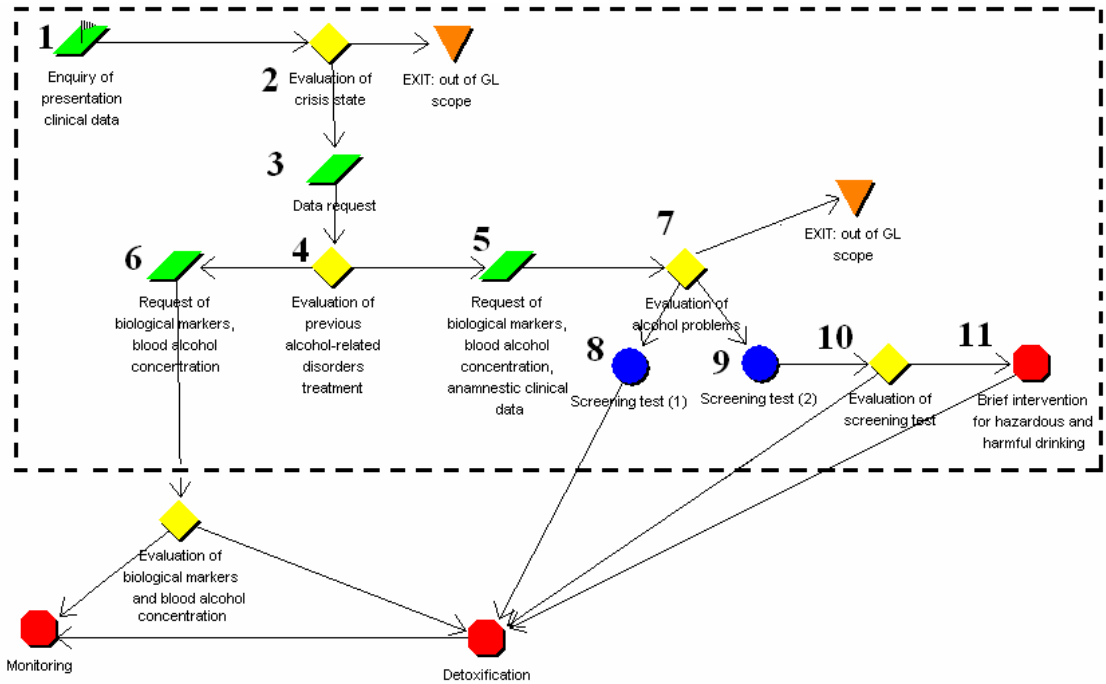

Figure 1 - Part of the alcohol-related disorders treatment GL acquired in GLARE

An example of the notification service use will be provided in the Results section.

Query answering service

In addition to the notification service, we have also defined a query answering service, which may help both individual actors involved in the GL and healthcare service managers.

An individual actor (e.g. a physician, a nurse) represents one instantiation of the three dimensions used to *color* a GL: she works in a context, covers a specific role, and has (or can have) a set of competences (actually the instantiation may be partial, since specific competences may be absent).

By means of our approach, given her "*colors*" the actor is allowed to issue some queries, with the aims of:

- focusing on **what** actions she will **necessarily/potentially** be asked to be responsible of; this type of query can be issued both during GL execution, referring to future actions, or off-line, considering the overall set of actions composing the GL;
- scheduling **when** she will **necessarily/potentially** be involved in the GL execution, and referring to what actions; this kind of query will obviously be issued at execution time;
- discovering **with whom** she will **necessarily/potentially** be involved, i.e. who are the actors responsible for the actions to be executed before/after the ones she is in charge of. This type of query, which can be useful both at execution time and off-line, strongly facilitates interaction and communication.

On the other hand, healthcare service managers (like e.g. hospital administrators, or social services directors) may be interested in issuing queries with the aim of:

- verifying **what human resources** are **necessarily/potentially** involved in a GL execution, and **when**; this type of query, which is useful off-line, allows the manager to properly coordinate and allocate human resources themselves. The information about the list of people covering the same role or having the same competences helps the manager to optimize human resource allocation also when people in the context she manages are involved in different distributed GLs at the same time.

Note that temporal queries are answered resorting to advanced AI techniques integrated in GLARE [7]. Examples of the different query types will be provided in the Results section.

Results

As an example, we present an application of our approach to a GL for alcohol-related problems [6], adapted to the Italian context. We have acquired and *colored* such GL in GLARE. The possible values of the three dimensions used to *color* all GL actions are the following:

- context: Community medicine (C1), SERT medicine (C2), in-patient care (C3), hospital ambulatory care (C4), social services (C5), social voluntary work (C6), family (C7);
- role: physician (R1), nurse (R2), healthcare assistant (R3), social assistant (R4), social worker (R5), patient (R6), relative (R7);
- competence: pharmacological treatment of abstinence syndrome (CO1), psychological support (CO2), family and group approach (CO3).

For the sake of brevity, we will focus on a subpart of the GL, shown in the dashed box in Figure 1. The GL starts with a request of some clinical data (query action 1), used in the following decision action (decision action 2), which is meant to diagnose if the patient is currently experiencing a crisis state. Alcohol-related crisis is outside the GL scope. If, on the other hand, the patient is not experiencing a crisis, her history is collected (query action 3), in order to distinguish whether it is the first time that the patient is in treatment for alcohol-related problems, or not (decision action 4). New patients require the collection of biological markers, blood alcohol concentration and anamnestic data (data request 5), while anamnestic data collection is not needed for patients who were already cared for alcohol related disorders (data request 6). Focusing on new patients, a diagnosis about alcohol-dependence is performed (decision action 7), on the basis of the collected information. In the case that the patient does not show alcohol-dependence, the GL execution is ended. Otherwise, two different treatments can be applied, on the basis of the severity of alcohol-dependence; both start with a screening test (work actions 8 and 9 respectively). Focusing on patients who show a mild alcohol-dependence (work action 9), evaluating the screening test results (decision action 10), the patient can be selected for the brief intervention for hazardous and harmful drinking (composite action 11), which basically consists in a set of motivational interviews. Actions 1 to 11 in Figure 1 are *colored* as described in Table 1.

We now provide an example of the notification service use. Suppose that, during a specific GL execution on a new patient X, the "Evaluation of previous alcohol-related disorders treatment" action (action 4) is performed by actor Y, being Y a social assistant (R4), who is employed in social services S (C5). Being X a new patient, action "Request of biological markers, blood alcohol concentration, anamnestic clinical data" (action 5) will be scheduled for execution next. All the possible responsibles for action 5 (i.e. all physicians (R1) in contexts C1-C4) are notified by the GLARE facility about the fact that one of them should take care of the patient for the needed data collection. If temporal constraints about the action execution are specified in the GL (e.g. if data collection must start as soon as possible, for instance within one day from the completion of action 4) such constraints are provided in the notification message as well. As a matter of fact, they can be of help for the potential actors in scheduling their commitments.

Table 1 – GL actions in dashed box of Figure 1 and their "colors".

Action number	Action description	Context	Role	Competence
1	Enquiry of presentation clinical data	C1, C2, C3, C4, C5	R1, R2, R4	-
2	Evaluation of crisis state	C1, C2, C3, C4, C5	R1, R2, R4	-
3	Data Request	C1, C2, C3, C4, C5	R1, R2	-
4	Evaluation of previous alcohol-related disorders treatment	C1, C2, C3, C4, C5	R1, R2	-
5	Request of biological markers, blood alcohol concentration, anamnestic clinical data	C1, C2, C3, C4	R1	-
6	Request of biological markers, blood alcohol concentration	C1, C2, C3, C4	R1	-
7	Evaluation of alcohol problems	C1, C2, C3, C4	R1	-
8	Screening test (1)	C1, C2, C3, C4	R1, R2	-
9	Screening test (2)	C1, C2, C3, C4	R1, R2	-
10	Evaluation of screening test	C1, C2, C3, C4	R1, R2	-
11	Brief intervention for hazardous and harmful drinking	C1, C2, C3, C4	R1, R2	CO2

Observe that the patient is free to choose among different contexts for being visited and for taking her lab exams, as requested by action 5: she can go to the hospital (C3 and C4), as well as to the general practitioner (C1), or to the SERT centre (C2). The added value of our facility is that all contexts know that the patient is meant to contact one of them; as soon as one context is chosen by the patient, one physician employed there will explicitly accept the responsibility of action 5, and all her

colleagues in the same as well as in the other contexts will be automatically contacted and properly informed by GLARE. It is also worth noting that, if the patient does not contact any context, the notification service can work as a reminder for all potential responsibles. In this way, one of them will then proactively contact the patient, and finally accept the responsibility of action 5.

A set of queries, of the types introduced in the previous section, are now provided as an example of the query answering service use.

Query1: social assistant *Y* (R4) asks off-line **what** actions she will **necessarily/potentially** be required to be responsible of in the alcohol-related GL.

Answer1: she will be potentially involved in the following actions: "Enquiry of presentation clinical data" (action 1), "Evaluation of crisis state" (action 2).

Query2: during a specific GL execution, social assistant *Y* (R4), who has determined that the treatment path will start with "Request of biological markers, blood alcohol concentration, anamnestic clinical data" (action 5) asks for information on the actions to be executed next, in order to verify **with whom** she will **necessarily/potentially** be involved.

Answer2: "Evaluation of alcohol problems" (action 7) is the next, mandatory action to be executed, and can be performed by a physician (R1), in any of the contexts C1, C2, C3 and C4. Depending on the evaluation results, "Screening test (1)" or "Screening test (2)" (action 8 and 9) which are mutually exclusive, will be executed next. Both can be performed by a physician (R1) or by a nurse (R2) in C1, C2, C3, or C4 contexts.

Query3: the responsible of a hospital ambulatory care (C4) asks for information concerning the execution of the "Brief intervention for hazardous and harmful drinking" (action 11) in order to discover what **human resources** are **necessarily/potentially** involved in its execution (take from the GL colors), and **when** (inferred by temporal reasoning [7] on the constrains in the GL).

Answer3: The action is not mandatory during the GL execution, it has a minimum duration of 1 day and a maximum duration of 3 days, and in the case that it will be performed, its execution will be done by a physician (R1), who has the competence of alcohol-related disorders management (CO1), within the 9th day from GL start.

Conclusion

In this paper we have presented an extension of the basic computerized GL management support, meant to deal with human interaction and communication. Such extension is strongly needed when dealing with distributed GLs, which ask for a continuous patient monitoring and treatment, operated in different contexts, under the responsibilities of actors covering different roles and having different competences.

To the best of our knowledge, the existing GL management systems have not explicitly considered this issue yet. It is just worth noting that Fox's group has recently proposed an extension of the PROforma representation formalism [8] in order to specify who will execute an action. However their goal is not the one of managing actor interactions in different contexts: they exploit actor information for better contextualizing GLs taking into account local human resources, and for flexibly adjusting them through delegation.

Our approach is currently integrated in the GLARE system - even though it is general enough to be easily transferred to other GL management systems as well. In the future, we will complete the implementation, and add further facilities. First, we will structure the available contexts, roles and competences information in a hierarchical fashion, by acquiring the needed knowledge from domain experts. This will allow us to better structure the *color* information in the GL actions. Moreover, we have implemented a user-friendly graphical interface, in order to allow the different actors involved in a distributed GL execution to easily and quickly obtain the answers to their typical queries, and to properly deal with communication and resources coordination needs.

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