# A Computer-Based Guideline Implementation System for Cardiac Rehabilitation Screening

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## Abstract

*The Netherlands Heart Foundation recently released a new Cardiac Rehabilitation guideline. Concurrent with its development, a decision support system (DSS) was built to assist professionals in implementing the guideline in practice. The DSS was evaluated during a 6-week pilot study in four cardiac rehabilitation centers. The number of patients enrolled in the DSS during the pilot study was 134. Adherence to the guidelines on a patient level was 83% for rehabilitation goals, and 68% for rehabilitation therapies. After the pilot study several new functionalities were added to the system while other DSS parts of the system were slightly changed based on user advice. Currently, a large-scale cluster randomized trial is conducted in 38 Dutch hospitals to rigorously assess the effect of the DSS on guideline adherence.*

## 1. Introduction

Cardiac rehabilitation (CR) is a multidisciplinary therapy for cardiac patients that is provided after cardiac events (e.g. myocardial infarctions) and cardiac interventions (e.g. heart surgery). CR is provided by some 100 outpatient clinics in the Netherlands, usually associated with a hospital [1]. In January 2004, the Netherlands Heart Foundation (NHF) released the Dutch CR guideline 2004 [2]. The guideline is a result of the collaboration between the NHF, the Netherlands Society of Cardiology, and a panel of field experts.

Measurements in 1999 revealed that the assessment of patient needs for CR was not always conducted optimally [3]. The CR programme followed was often incomplete, the design was monodisciplinary instead of multidisciplinary, too little attention was paid to secondary prevention, and sometimes no intake interview was held.

With the aim to increase adherence to the new CR guideline, a decision support system (DSS) was built concurrently with the development of the guideline. Systematic reviews on the effects of DSSs have shown that these systems can improve practitioner performance and guideline adherence [4,5]. This paper describes the development of the system and the results from a pilot evaluation study.

## 2. Background

Many different care-providing professionals are involved in CR, including cardiologists, rehabilitation doctors, nurses, dieticians, psychologists, social workers and physiotherapists. CR usually consists of a six- to eight-week programme involving medical evaluation, prescribed exercise, cardiac risk factor modification, education and counseling. These programmes are designed to limit the physiological and psychological effects of cardiac illness, reduce the risk for sudden death or reinfarction and control cardiac symptoms [6]. Economic evaluations suggest that CR is a cost-effective intervention, as it has a beneficial effect on medical consumption [7].

The CR guideline 2004 is an updated and extended version of an older practice guideline that was released in 1995/1996 [8]. A major part of the guideline concerns the needs assessment of new CR patients, referred to as *screening procedure*. This procedure is described with a flow chart which requires 15 to 30 different questions to be answered on the patient's history and current situation. The answers give insight into the objective and subjective reduction of the patient's physical capacity, the psychological and social functioning of the patient, and his or her risk behavior. Several instruments, such as the questionnaire ‘quality of life for cardiac patients’ [9], are used to quantify the various aspects of the patient's condition. Eventually, it is determined whether the patient should be considered for cardiac rehabilitation, and if so, which goals should be set for the patient's rehabilitation programme and which therapies are most appropriate for this purpose. There exist 15 possible rehabilitation goals, and four different therapies.

The way the screening process is organised varies substantially between Dutch CR centres [10]. Most centres perform the screening procedure completely at the

outpatient clinic, while some centres already collect screening information during hospitalisation for the cardiac incident. Also the number of caregivers involved in CR organisation, and the range of their facilities, varies between centres. Not all hospitals provide the complete range of rehabilitation therapies. For instance some hospitals do not have the facilities to provide a lifestyle module. Along with these differences in organisation, there exist substantial differences in adherence to the CR guidelines. All hospitals somehow use the guidelines, but some adjusted it more radically to fit into their working process than others.

## 3. System development

To determine the requirements of the decision support system we visited several hospitals. These visits consisted of consulting professionals involved in CR, observing the screening process, and watching patients attending rehabilitation programmes. Also several meetings of the guideline development committee were attended, during which the new guideline and the requirements for the system were discussed. The following six main functionalities for the system were defined:

- Assist caregivers with screening of patients for rehabilitation goals and therapies.
- Registration of patient information. All information entered and produced needs to be stored so it is available at later times.
- Provide the possibility to evaluate patient rehabilitation progress.
- Functionalities to analyse rehabilitation, patient and population data. Insight should be given in numbers of patients enrolled in CR.
- Provide reporting and presentation functionalities, like printouts and summaries of patient screenings.
- Provide easy access to background documentation. The system should clarify the usefulness of CR screening procedure topics and give insight in the decision logic of recommendations.

These functionalities are in line with the eight information management services defined by Shiffman et al [11] to increase a DSS's probability for success.

It is well known from the literature that a new DSS should be integrated with existing information systems to be accepted by its users [4]. In the field of CR, however, currently no electronic patient record or other information system is used. It was therefore decided to build a stand-alone system which could provide the full range of functionalities described above. Furthermore, the differences in CR organisation between different hospitals (described in Section 2) required a flexible type of system. For instance, at some hospitals the screening procedure is carried out by one caregiver in one session, whereas at other hospitals the procedure is carried out by multiple caregivers, during multiple sessions, and at different locations.

To implement guidelines within a DSS, a paper based guideline needs to be converted into a format that can be interpreted by computers: guideline formalization. In this project the CR guideline was formalized concurrently with its development, which ensured that the decision logic in the DSS and the paper guideline are the same. For our system the GASTON framework [12] was used as the basis to provide decision support. This framework contains a set of tools that make it possible to formalize a guideline and execute it. Using this framework we formalized the CR screening flow chart and all other necessary guideline information. The GASTON framework contains an execution engine that can interactively provide client applications with the required guideline information and documentation. However most functionalities defined in the requirement analyses, such as registration, documentation, evaluation and data analysis can not be provided by the framework. Therefore we developed a system ourselves which embeds Gaston's execution engine (GEE) to provide guideline logic. All other functionalities are handled by the system we named CARDSS (CArdiac Rehabilitation Decision Support System). CARDSS was developed in Microsoft's programming language C# and uses a SQL-server database for data storage.

Whenever screening for a patient is initiated, the GEE provides CARDSS with the appropriate guideline information. This information is based on the state of the patient's screening and the answers to questions, passed through to the GEE by CARDSS. During the screening procedure, the GEE provides patient specific guideline recommendations and advices which are collected by CARDSS and presented to the user at the end of the screening procedure.

The user is always allowed to override guideline recommendations, since valid reasons for disagreement are possible. However the user is always obliged to motivate this action. This can be done by choosing from a standard list of reasons or by entering free text. The standard reasons include 'refusal/request of patient', 'patient is too sick', 'lack of facilities' and more. All screening information and documentation can be printed out in a report, so it can be added to a paper chart.

## 4. Pilot study

Technical problems and acceptance by users are critical issues that determine whether or not the implementation of a new DSS into clinical practice is successful [13]. To evaluate the CARDSS software we performed a pilot study in four hospitals. These hospitals were selected because they well represented the variation in organisation of CR in the Netherlands. All caregivers

from the participating hospitals agreed on actively using the CARDSS for every CR patient during the pilot study.

## 4.1 Methods

Two types of data on system functionality and performance were collected in the pilot study: (i) data that was automatically collected by the DSS during its usage, and (ii) answers to questionnaires by the participating caregivers, filled in after the pilot study.

Data automatically collected by the system was primarily used to keep track of usage statistics and technical anomalies like system crashes. Furthermore, clinical characteristics and CR goals and therapies were stored in the system's database for each patient that was screened with the DSS during the pilot study.

Questionnaires were given to the caregivers at the end of the pilot study. They were divided into three sections: (i) questions about the guideline, (ii) questions about the software, and (iii) questions about the guideline integrated in the software. The questions were partly based on the questionnaires developed by Trivedi et al [13] but the questions were translated and adapted to our situation. During personal interviews caregivers were asked to clarify some answers and provide suggestions for system improvements.

## 4.2. Results

The number of patients enrolled in the DSS during the pilot study was 134 as shown in Table 1. A total of 1024 rehabilitation goals (on average 7.6 per patient) was recommended by the system. For 22 patients, one or more goals were rejected by the user, and for 6 patients, one or more goals were added to the ones recommended. Similarly, a total of 415 therapies (on average 3.1 per patient) was recommended. For 40 patients, one or more recommended therapies were rejected, and in three cases a therapy was added. In sum, adherence to the guidelines on a patient level was 83% for rehabilitation goals, and 68% for rehabilitation therapies. It appeared however that in most cases where a goal or therapy recommendation was rejected, this was due to a lack of facilities in the hospital concerned; two hospitals were structurally unable to offer certain goals and therapies during the pilot. When discarding these rejections guideline adherence for both goals and therapies was over 95%.

Divided over the four hospitals a total of 11 caregivers used CARDSS during a period of eight weeks. The users found several bugs in the system, each of which could be fixed within one day. The bugs varied from not being able to enter text with an apostrophe (which is a typical SQL error) to not being able to go back several question to alter earlier answers. In some situations a bug led to a crash, but patient information was never lost.

Table 1. Information about the use of the software during the pilot study.

| | hospital | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | Total |
| #patients screened | 35 | 46 | 30 | 23 | 134 |
| #caregivers | 2 | 3 | 5 | 1 | 11 |
| #bugs found | 3 | 1 | 1 | 2 | 5 |
| #times help needed | 5 | 3 | 2 | 2 | 12 |

At the end of the pilot study, seven of the eleven questionnaires were returned. One CR team returned a joint questionnaire, while two other professionals felt they were too inexperienced with the software to fill in the questionnaire. The majority of caregivers (5/7) found that the new CR guideline is an improvement to the 1995/1996 guideline. The system itself was received very positive. Response times were fast enough (7/7) and it was easy to use (7/7) even though some caregivers indicated that they had hardly any experience with computers before the pilot study (3/7). The graphics made the software attractive (7/7) and the interfaces were logical and complete. The software was fun to use (5/7). Most caregivers agreed that the software makes the decision tree more comprehensive than the paper version (5/7). Although not every one used the possibility to disagree with recommendations by the guideline (2/7), the possibility to override guideline recommendations was judged to be very important (6/7). Caregivers found the explanatory information provided with questions and recommendations helpful (5/7).

## 5. Discussion

This paper describes the development of a DSS based on the Dutch CR guideline and a pilot study that was performed to evaluate the DSS. Results on guideline adherence were very encouraging, with adherence of 83% for CR goals and 68% for CR therapies on a patient level. Adjusted for structural reasons (e.g. lack of facilities), adherence is even above 95%, which is much higher than expected based on earlier measurements [3].

Several factors may bias our results. Although all caregivers indicated they had accurately specified in CARDSS which goals and therapies were offered to patients, this information was not checked with an independent source (e.g. paper record). So, it is possible that recommendations of the system were not followed, without this fact being recorded in the system's database. Furthermore, guideline adherence may have been positively influenced by the 'volunteer' and Hawthorne effects [14]. Finally, perceptions on the effect of CARDSS are limited by the fact that we used no control group to determine the adherence level without the

system or to measure the role of the 'checklist effect'. [14].

Currently, a large-scale cluster randomized trial is conducted in 38 Dutch CR centers to rigorously assess the effect of the DSS on guideline adherence, while adjusting for these potential sources of bias. The participating CR centers will either work with an intervention version of the DSS, having full functionality, or with a control version, which comprises patient records and information management services but provides no decision support. Both versions of the DSS record patient data, guideline-based recommendations, and rehabilitation goals and therapies that are actually pursued in each patient's programme. After a period of six months, the effect of receiving guideline-based recommendations on guideline adherence is assessed by comparing the data that have been recorded in the two arms of the trial. If the DSS does enhance adherence, then future costs for maintaining and updating CARDSS are justified by more effective rehabilitation programmes.

## 6. Conclusion

In this project we have successfully developed and implemented a DSS based on the Dutch Cardiac Rehabilitation guidelines. The pilot evaluation study results show that the system meets the requirements of daily practice and that caregivers involved in CR are satisfied with the system's functionalities. Furthermore, the results provide indications that the systems has a beneficial effect on guideline adherence.

One particular success factor in this project was the fact that renewal of the paper guideline, and development of CARDSS, were conducted simultaneously. As a result, the DSS completely mimics the decision logic of the paper guideline and *vice versa*. CARDSS was recommended for usage to all Dutch CR professionals when the new guideline was published and disseminated by the Netherlands Heart Foundation. Nearly 50 Dutch CR centres are now using the DSS along with the paper guideline. From this experience we believe that computer-based guideline implementation strategies are most viable when accompany the paper guideline development and implementation process.

## References


[1] Strijbis AM, Franke B, Boxtel EPE van, Duiker MEC. Cardiac rehabilitation in numbers. Hart Bulletin 2005;36(4):94-9.

[2] Rehabilitation Committee NHS/NVVC. Guidelines for Cardiac Rehabilitation 2004. The Hague: Netherlands Heart Foundation; 2004.

[3] Netherlands Heartfoundation. Cardiovascular disease in the Netherlands 2001. The Hague: Netherlands Heartfoundation; 2001.

[4] Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA 2005;293(10):1223-38.

[5] Johnston ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. A critical appraisal of research. Ann Intern Med 1994;120(2):135-42.

[6] Feigenbaum E, Carter E. Rehabilitation Services. Health technology assessment report 1987, no. 6 Rockville MD: US Department of Health and Human Services, Public Health Service, National Center for Health Services Research and Health Care Technology Assessment; 1988.

[7] Oldridge NB. Comprehensive cardiac rehabilitation: is it cost-effective? Eur Heart J 1998;19 Suppl O:O42-O50.

[8] Rehabilitation Committee NHS/NVVC. Guidelines for Cardiac Rehabilitation 1995/1996. The Hague: Netherlands Heartfoundation; 1996.

[9] Hillers TK, Guyatt GH, Oldridge N, Crowe J, Willan A, Griffith L, et al. Quality of life after myocardial infarction. J Clin Epidemiol 1994;47(11):1287-96.

[10] Goud R. Decision support in cardiac rehabilitation: An effort to improve guideline compliance among professionals 2004. Accessible through http://dare.uva.nl/document/16221

[11] Shiffman RN, Liaw Y, Brandt CA, Corb GJ. Computer-based guideline implementation systems: a systematic review of functionality and effectiveness. J Am Med Inform Assoc 1999;6(2):104-14.

[12] de Clercq PA, Hasman A, Blom JA, Korsten HH. Design and implementation of a framework to support the development of clinical guidelines. Int J Med Inform 2001;64(2-3):285-318.

[13] Trivedi MH, Kern JK, Marcee A, Grannemann B, Kleiber B, Bettinger T, et al. Development and implementation of computerized clinical guidelines: barriers and solutions. Methods Inf Med 2002;41(5):435-42.

[14] Friedman CP, Wyatt JC. Evaluation Methods in medical informatics. New York: Springer-Verlag 1997



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