COCIDINIS - A pediatric information system

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ABSTRACT

COCIDINIS is an information system which should support the decision making about the type and features of activities needed in successful child's health care. It is based on a numerical index COCIDIN (Computerized cOntinued ChId's Development INdex). COCIDIN is a numeric index founded on observations of important parameters (advised by WHO) concerning child's health status and should reflect an overall impression about the child's health. COCIDINIS supports following main activities: collection, recording and retrieval of data concerned with COCIDIN, management of these activities, generation of statistical, research and other reports, analysis of data, generation of data for other computer systems (i.e. expert systems, neural networks). The main objectives of our work are to enable successful care of whole child populations and the successful care of any individual, to enable fair comparison between various child populations (from different countries, different generations etc.), exchange of information etc.

INTRODUCTION

Two activities are essential for the successful child's health care: adequate trace (measurement, recording, trend and pattern analysis) and control (measurement, comparison and possible mediation) of their development. To enable efficient trace and control we should follow as more as possible various health parameters. The intention of this paper is to present the COCIDIN (Computerized cOntinued ChId's Development INdex), COCIDINIS (COCIDIN Information System) and theirs design. COCIDIN is a numeric index founded on observations of important parameters and can be used as an appropriate base for above activities. COCIDINIS is an information system based on COCIDIN which should support the decision making about the type and features of activities needed in successful child's health care support. It enables following main activities: collection, recording, retrieval and management of data concerned with COCIDIN, management of health care activities, generation of statistical, epidemiological, research and other reports, analysis of data and generation of data for other computer systems (i.e. expert systems, neural networks). The main objectives of our work are to enable successful care of whole child populations and the successful care of any individual, to enable fair comparison between various child
populations (form different countries, different generations etc.), exchange of information etc.

**Information System Design Challenges**
Despite all the advantages of the information technology, we must first at all recognize that its effective use in medical applications is limited by (Brooks\(^1\), Kokol\(^5\)):

- difficulties accompanying doctors, nurses and other medical staff in learning and using it;
- the wide spectrum of medical staff's needs which vary by speciality, practice patterns, research requirements, personality, environment, education background etc.;
- life criticalness of MIS applications; and
- the great semantic gap between medical users and information system (IS) designers.

Taking into account all above limitations, the desire to enable the medical staff to use computers and associate software reliably, easily, and in natural, intuitive fashion as well as the unsuccessfulnes of many existing information systems, not only in medical field, remain us that to made information systems successful we must dedicate a special attention to the paradigms, approaches, methods ... used in the process of their design. To accomplish this goal we have invented a new IS design approach called metaparadigm (Kokol\(^10\)) which has been successfully used in the design of COCIDINIS. The metaparadigm is a paradigm for designing IS design paradigms and it is deep belief that its use can enhance many IS design weakness and as a consequence enlarge productivity, reliability and user satisfaction, reduce design and maintenance costs and result in successful medical information systems design and use.

**Aims and Scope of the Paper**
The main aim of this paper is to

- introduce the COCIDINIS and COCIDIN;
- show the use of the metaparadigm in COCIDINIS design;
- present the applicability of COCIDINIS in practical and research work.

The paper is composed from three main parts. In the first part we introduce the metaparadigm and show its use in designing COCIDINIS. In the second part we briefly present the COCIDIN and COCIDINIS and finally in the third part we present the application of COCIDINIS in the determination of breath feeding influence on the dynamic child's health status.

**RELATED WORK**

**Use of Health Indices in Child's Health Care**
Browsing through recent literature we have noticed some indices about child health status i.e. Apgar index, Rohr's index, Quetelet's index etc. All these indices can be used solely in the limited manner (for the specific life period, merely statical) or consider only a small number of various parameters. Being aware that these just aren't enough, concerning the whole health status we decided to design more complete and accurate models using the information technology.

**A Brief Overview of MIS Design Paradigms**
Our recent Medical Information System (MIS) design literature analysis (Kokol\(^10\)) performed on about 1000 papers from various sources like conferences, journals and newsletters, has shown that despite many published papers, only 14% contain more detailed
MIS design description. Among them, most present the use of simple techniques and methods, and only a few the use of more elaborate approaches and paradigms. 40% of authors have used specific medical design methods, and only one third of them have developed their own ones. The authors have mainly used old structured techniques, ERA approach, organization modeling, prototyping and also the Checklands Soft System Methodology (CSSM). Among recognized specific medical methods MUMPS and HELP were used in most applications. The most interesting new design methods were KALEID (Abul'11) and PRIST (Christia12). According to the above literature overview we can state that only a small part of medical informatics researchers regards the MIS design as a special field and realize its complexity and specificity. These few of them propose original and very interesting solutions, but which are, unfortunately, to specific to be used generally in MIS design.

Metaparadigm and Related Research
In a more general view the metaparadigm is related to domain analysis (Diaz6), metamodeling (Osterveil3), megaprogramming (Tracz13), system factory (Scacchi7), Metaview system (Sorrensen9) and CASE - integration (Norma17). However, domain analysis and megaprogramming are limited to the reuse of information, system factory to the large-scale development, metamodeling to the analysis of software design process, and Metaview system and CASE - integration to the generation of CASE environments. But nevertheless, all above or any related approaches can be used as a part of the metaparadigm or opposite.

THE METAPARADIGM

The metaparadigm is based on following assumptions that the information system design:

- is a human activity system (Checkland2);

- is a process (Kokol5) performed in a specific design situation, according to a specific design paradigm;

- is a goal-oriented decision making exploration and learning activity;

- occurs in two contexts: the context within which the designer operates and the context produced by the designing design itself.

Analyzing design processes, design situations, design paradigms and relations between them we found that:

- there are no absolute good or bad design paradigms, they perform good or bad only in specific design situations;

- there are design situations for which no known design paradigm is appropriate.

Congruent to above findings we contend that to enable successful information system design in any design situation we must first design an appropriate design paradigm. This activity was called the metadesign and a metadesign paradigm a metaparadigm (Kokol10).

The metaparadigm is defined as a pattern for executing actual design actions in designing real world-design paradigms and the IS design paradigm is a pattern for executing actual IS design actions in designing real-world IS applications. An adequate metaparadigm should permit the following minimal set of activities:

- formal description of design paradigms, design process and design situations;

- formal evaluation and comparison of design paradigms;
- metadesign of design paradigms, where metadesign is treated in a very broad sense as invention of new design paradigms, adoption of known design paradigms, composition of known design paradigms, selection between design paradigms etc.; and

- learning and accumulation of new knowledge.

Emphasizing above arguments and respecting recent scientific findings (Checkland\(^2\), Geoffrion\(^16\), Koko\(^{10}\)) we decided that a metaparadigm should be composed out of a suitable framework, theory and a metadesign methodology and philosophy (Koko\(^{10}\)). Currently we have selected the idea of a process (Ostervei\(^3\)) as the framework, the Checklands Soft System Methodology (CSSM) (Checkland\(^2\)) as the methodology and philosophy, and the process formalization (metamodelling) (Ostervei\(^3\), Koko\(^{14}\)) as the theory.

**ESSMP: THE COCIDINIS DESIGN PARADIGM**

According to the specific design situation found in designing COCIDINIS we have constructed a new design paradigm called ESSMP (Extended Structured Spreadsheet Modeling Paradigm) which is based on the following design paradigm's root definition:

A paradigm defining an iterative, multilingual, multidimensional and multiaspect process performed by a design group with the participation of medical users concerned with user's requirements learning, conflict solving, requirements implementation, maintenance and engineering communications so that the process results in a successful ambulatory MIS.

![Diagram](image)

Figure 1. The model of ESSMP. MU are the medical users and D is the design group. Bold boxes represent artifacts, arrows represent actions, normal boxes represent agents and dotted boxes represent attributes.
In the first phase of the model presented in Fig. 1 we try to motivate the user's participation (user participation is important because they have the right to control their environment and they are experts in their domain and valuable knowledge resources) with education, building, exercising and using prototypes and data-entry routines. In the second phase we try to learn the users requirements with proper communications and the extended operational specification approach (Koko). In this phase we first construct the formal operational specification, transform it into an executable prototype which is then exercised and if required adapted. After the changes are made on the prototype we must also tailor the operational specification according to the modification made on the prototype. To resolve conflicts the second phase is made on more instances - one instance for every conflicting party. When all the parties are satisfied with the specifications we use the consensus techniques to construct a common understanding and as a result the common specification. These specifications are then transformed during the implementation phase into the final IS. The main characteristic of the maintenance phase is, contrary to the current practice, that the maintenance is performed directly on requirements and not on the code. During all phases the engineering on communications is made to enable successful design without communication's conflicts.

Two methodologies were used while design the COCIDINIS. First was the JSD (Cameron) and second the SSM (Koko). The JSD was used in specification and implementation of more general parts of COCIDINIS, and SSM was used in modeling activities concerned with COCIDIN.

COCIDIN AND COCIDINIS

COCIDIN

The idea for our research work came from our previous research where we developed some decision models concerning children's development. The results we got really did encouraged us that we continued with our work using a much more extensive framework. We selected ten parameters for COCIDIN: weight, height, measurement of head circumference, ricketiness, hip development, Hb-status, motorical development, psychological development, development of teeth and immunization program. As it is shown quite a diverse and unmatched parameters, but we had to regard them as a system (whole) to completely determine the child's development. Concerning the diversity and the inexperience of medical staff in both modeling and use of computers it was not easy to build an appropriate model. Thus we applied a new methodology called Structured Spreadsheet Modelling (SSM) for this purpose. A part of the COCIDIN's structured spreadsheet model concerning the DBD index (Static Body Development Index) which determines the child's body development during the specific period of time is shown on Fig. 2.

COCIDINIS

Using ESSMP we obtain an information system called COCIDINIS. (COCIDIN Information System). COCIDINIS support following main activities:

- collection;
- recording of data concerned with COCIDIN;
- retrieval of data concerned with COCIDIN;
- management of activities involved with COCIDIN;
- generation of statistical, research and other reports;
- analysis of data;
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- generation of data files for other computer systems (i.e. expert systems, neural networks).

&DBD-INDEX

&BASIC ELEM BASIC ELEMENTS
INFANT /pe/ ::String 20 There is a list of INFANTS.
EXAMINATION /pe/ Size of {EXAMINATION} is 5::Int+ There is a list of EXAMINATIONS.

&MEASURED DATA MEASURED DATA
MEASURE(INFANT, EXAMINATION) /ce/ {INFANT} x {EXAMINATION} For each INFANT-EXAMINATION combination there is a MEASURE
HEIGHT(MEASUREi) /a/ {INFANT} x {EXAMINATION} :R+ At each MEASURE a HEIGHT (in cm) is measured.
WEIGHT(MEASUREi) /a/ {INFANT} x {EXAMINATION} :R+ At each MEASURE a WEIGHT (in kp) is measured.

&LIMITING CONSTANT LIMITING PERCENTIL CONSTANTS
L_P_CONST /pe/ There is a LIMITING PERCENTIL CONSTANT
L(L_P_CONST) /a/ :R+ There is a PERCENTIL DELIMITING VALUE which delimits normal developed children from unnormal ones.

&AVERAGE AVERAGED MEASURES
AVG_HEIGHT(HEIGHTij) /f/ {EXAMINATION}; AVG(HEIGHTi) There is an AVERAGE HEIGHT for every EXAMINATION.
AVG_WEIGHT(WEIGHTij) /f/ {EXAMINATION}; AVG(WEIGHTi) There is an AVERAGE WEIGHT for every EXAMINATION.

Figure 2. A part of the textual schemata for the DBD-index determination model. The first paragraph simply says that there is a module named &DBD-INDEX and indentation reveals that it consists out of submodules. The third paragraph says that there is a self indexed (indexed by i) primitive entity named INFANT. It doesn’t say anything about the number of elements in it but its domain statement "::String 20" indicates that elements are strings of characters with maximal length of 20. The fourth paragraph is a primitive entity EXAMINATION. It is self indexed by the index j and its index set statement "Size of {EXAMINATION} is 5" and domain statement "::Int+" say that there are exactly five positive integer elements in the genera. The seventh paragraph says that there is a compound entity MEASURE. It is externally indexed by i and j and its typical element MEASUREij calls INFANTi and EXAMINATIONj. The index set statement "{INFANT} x {EXAMINATION}" says that MEASURE has an element for every INFANT - EXAMINATION combination. The paragraph for externally indexed attribute genera says that it has an element for every MEASURE and the range statement :R+ says that all elements have nonnegative real values. The function genus AVG_HEIGHT has a generic rule that says that AVG_HEIGHT is calculated with equation AVG_HEIGHTj = AVG(HEIGHTi).

THE APPLICATION OF COCIDINIS

In one of more interesting applications of COCIDINIS we used COCIDIN in a research study in which we try to analyze the influence of breath-feeding on the dynamic child body development during theirs first year of life. To determine the dynamic COCIDIN we have to use the static COCIDIN defined previously. Using grades of static COCIDIN during the period of interest we can calculate the dynamic COCIDIN which has 26 grades representing 26 different curves of child’s dynamic body development (chaotic, statically normal, bad to normal, normal to bad etc.). These curves are grouped into six classes: I- unchaotic into normal, II-unchaotic into accelerated, III-unchaotic into small for date, IV-unchaotic into thin, V-unchaotic into obese, VI-chaotic.

Using above method we’ve used COCIDINIS to gather and store data for 470 boys and girls during their first year of life. Five static COCIDINs were calculated for each of them (birth, 3, 6, 9 and 12 months). Children were divided into four groups: A-lactated until first month,
B-lactated until third months, C-lactated until sixth months, D lactated over sixth months. After grouping into classes we've got the results shown in Table 1. According to them we observe that there's not a great difference between classes B and C, but there's a big difference between classes B, C and classes A, D. Because there are significantly more normal representatives in classes B and C we conclude that lactation is mostly recommended in the duration from at least 3 to at most 6 months.

CONCLUSION

The big aid of the metaparadigm was that it entitled us to design a specific information system design paradigm called ESSMP which was successfully used in the design of a child's development determination model called COCIDIN and a supporting information system COCIDINIS. Indeed it has been shown that the ESSMP is an user friendly paradigm which has been efficiently used also by nontrained medical users without greater troubles. Thus it is our deepest belief that using the metaparadigm can enhance many IS design weaknesses and as a consequence result in successful medical information systems design and use.

REFERENCES


