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EXPERT SYSTEMS FOR DEVELOPING COUNTRIES: HELPING HEALTH WORKERS HELP

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0. Summary

Ambulatory health care in developing countries is often provided by medical or paramedical personnel commonly called rural health workers. Medical problems within their realm of competence include diarrhea, infestation with worms, diseases affecting the eye and the skin, and several kinds of infectious diseases. Also assessment of malnutrition is among the tasks rural health workers have to perform. The hybrid and open knowledge engineering tool VIE-KET is used to construct a modular consultation system that provides decision support for diagnosis, therapy, and drug prescription. Finally, a sample dialogue exemplifies the course of an interaction between a health worker and the consultation system.

1. Introduction

As with food, the main problem in providing adequate health care is not a question of procuring knowledge but a question of the distribution of knowledge. For centuries, tutoring on a personal basis or transfer of knowledge in books were the two salient pillars of knowledge transfer. Personal tutoring correctly performed provides for an active transfer of knowledge as compared to books where written information is presented as a mere passive block of information waiting for the student to act on it.

With the advent of knowledge based systems, the computer seems to emerge as another viable way of transfering knowledge in a more active form prompting medical personnel for appropriate responses. Especially for developing countries, knowledge based decision support systems on rugged and portable personal computers independent of AC supply seem to offer a potential remedy to ease the problem of porting medical knowledge right to the location where it is needed most.

Primary medical care in developing countries is often provided by personnel with a very heterogeneous level of medical training, commonly called village health workers.

The main tasks of a village health worker include (1) to provide a diagnostic classification of a patient's disorder as an easy treatable and not a life threatening disease or as a potentially dangerous disease, (2) if appropriate, to deliver a treatment scheme compatible with his educational level and therapeutic resources, and (3) to refer patients with unclear or potentially dangerous diseases to a professional nurse or doctor.

The availability of professional medical care has a direct bearing on the extent of a health worker's activities. Problems of maintaining an adequate standard of primary medical care include implementing policies to provide for an on-job training to improve efficiency and effectiveness and to provide reference materials easy to consult in unclear cases.

The purpose of this project is (1) to establish a knowledge based decision support system for village health workers covering the most common diseases in developing countries, (2) to implement this knowledge based system on portable microcomputers, and (3) to include tutorial features as well as a reference structure in the design of the system to meet the demands of health workers on the job.

In the following we will present a description of the system specification and design, show the structure of knowledge representation and system implementation, and in the appendix give a sample dialogue between health worker and decision support system.

2. System Design

Ample experience about teaching principles of medical care to health workers has been accumulated through the yea s (Werner, 1980; Werner and Bower, 1982; Abbat and McMahon, 1985). In the design of our system we strived to draw from that vast body of experience as much as possible to avoid common mistakes frequently encountered in intercultural exchange programs. For that purpose, the standard textbook "Where There is no Doctor" by Werner, 1980, served as the primary source of reference. In addition, medical knowledge was also extracted from relevant literature (King et al., 1978; King et al., 1979; Manson, 1982; Upunda et al., 1983).

As a second source we used the experience gained by G. Porenta who, as a member of the Austrian committee for Ethiopia, worked for two months in an ambulatory care center in the Tigre province of northern Ethiopia. Working together with village health workers of different educational levels, he experienced the need for a flexible source of information to cope with problems arising in primary medi al care. Also especially useful in the design phase of the system were health statistics given in Table 1, compiled during a three week period, and showing the actual distribution of diseases within the population treated.

As comments on the data provided in Table 1 two points should be emphasized. Firstly, a small group of diseases accounts for a large percentage of the disorders encountered. Accordingly, treatments of diarrhea, worm infestations, eye diseases, skin afflictions, and malaria made up approximately half of the dai y work. Concentrating on a good quality of health care in t ese areas would significantly improve the overall performance.

Secondly, the disease distribution presented pertains to the situation as it is found in that special geographical area (high country), political context (civil war), social environment (poverty, famine), infrastructure of health care

Table 1. Disease profile of Northern Ethiopia.
Over a three week period diseases as encountered in an ambulatory care center were recorded.

Disease	Cases	%	Sum %
Diarrhea	386	14.8%	14.8%
Worms	371	14.2%	29.0%
Eye disease	297	11.4%	40.4%
Skin disease	203	7.8%	48.2%
Infectious diseases			
Malaria	157	6.0%	54.2%
Bronchitis	146	5.6%	59.8%
Ear infection	102	3.9%	63.7%
Urinary tract	75	2.9%	66.6%
Throat	57	2.2%	68.8%
Pneumonia	50	1.9%	70.7%
Tuberculosis	46	1.8%	72.5%
Bilharzia	3	0.1%	72.6%
Others	714	27.4%	

(rural health centers closed, two town hospitals) and other factors. It is not possible to devise a detailed generic general purpose knowledge based system suited for rural health workers in different countries. For proper function and acceptance, the system has to be tailored towards the region where it is used and the people using it. Therefore, the system presented in this study is a specific instance applying to the northern part of Ethiopia, although general principles as outlined in the book by Werner, 1980, are included.

In the design of the system, we identified five problem areas to be represented in the system (diarrhea, infestation with worms, eye diseases, skin diseases, common infectious diseases) and three different entry points into the system (diagnosis, therapy, posology).

On the topmost level, the system is set up to start on a question-answer strategy to find an appropriate diagnosis, suggest a treatment plan, and give detailed advice about drug prescription if necessary. At this level we assume that the village health worker is familiar with the most common medical terms so that he can answer each question with yes, no or unknown.

The diagnostic strategy is structured around the five kernel areas of disease as mentioned above. In a first step, the system tries to ascertain that the medical problem as presented by the patient is not dangerous and falls within the competence of the village health worker. If none of the danger criteria is met, the system then goes on to ask questions about diseases ranked by their frequency of occurance in an ambulatory care center.

After deciding on the main complaint, the village health worker is prompted to answer questions posed by the system. A choice to enter a set of symptoms in free order is not offered. With this strategy, we attempted to elucidate the diagnostic pathways of the system in a tutorial context. In following a predetermined sequence of questions that is to a very high degree independent of the user's input, a village health worker should get acquainted with and understand a standard way of efficiently taking the history and performing a physical examination.

In the present stage, questions are asked by printing out text on the screen using the terminology of Werner, 1980. Clearly, this is not the most appropriate form of an user-friendly interface. An icon-based dialogue using symbols instead of text with a touch sensitive screen for the user input might be more appropriate for a broader range of audience and might also feature language independence. In developing our prototype, however, we concentrated on the proper representation of the knowledge and at this first attempt set aside the problem area of adequate user interface.

At the second level, the system will use the diagnosis established in the first level to work out an adequate treatment plan consisting of general advice and drug prescription if deemed necessary. It also provides the opportunity to start with a diagnosis independent of a pass through the first level. While working on a treatment plan, questions about contraindications and, if yet unknown, about general patient data (e.g. age, weight) have to be answered. A suggestion of treatment is presented as a final result.

While determining the adequate treatment scheme, the system evaluates its knowledge about contraindications, side effects, treatments of choice, and price information pertaining to the drugs in its knowledge base. User access to this module of the system is also available for personnel that might be interested in a specific drug regimen. So for drug posology, the system provides a third entry point to be used independently of the diagnosis and treatment branches.

3. Discussion

Several other attempts have also been launched to provide decision support for health care in developing countries, one of them being TROPICAID. This is a joint project between Medecins Sans Frontieres and the University Pitie Salpetriere, Paris, designed for being used in the Tchad (Auvert et al., 1986). Field tests of that system are well under way and additional projects are in a planning phase. A preliminary evaluation provided evidence that this system can support the daily work of medical personnel in an useful way.

For the knowledge based system presented in this study, several aspects have to be worked out in more detail before eventually field tests can take place. The main and yet unsolved problem is still the task to develop a user-friendly interface tailored towards the educational level of rural health workers. An icon-based approach seems to be promising but is obviously difficult to achieve. Also, before a field test takes

place a disease profile has to be established to provide guidance in the ajustment of the knowledge base towards the specific situation.

Finally, the system presented in this study should serve as a starting point for discussions and considerations on how knowledge based systems might help to bridge the gap of quality of health care in developing and industrialized countries.

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covering the problem area "skin". Ms. Glatzer provided valuable comments from a nurse's perspective.

Appendix

The following dialogue exemplifies the course of an interaction between the system and a health worker. User inputs are designated with '**'. Comments on the dialogue will appear in parentheses.

```
 ------------------------------
I                              I
I    What is your problem:     I
I                              I
I    **  Skin  **              I
I        Eye                   I
I        Worms                 I
I        Diarrhea              I
I        Cough                 I
I        Fever                 I
I        Headache              I
I        Painful Urination     I
I        Urine reddish         I
I                              I
 ------------------------------
```

(After the problem area "skin" has been selected, another menu is presented:)

```
 ------------------------------------------
I                                          I
I   What is your major skin problem:       I
I                                          I
I ** Small or pimple-like sores **         I
I    Open sores or skin ulcer              I
I    Lumps under the skin                  I
I    Large Spots or Patches                I
I    Warts                                 I
I    Rings (spots with raised or red edges)I
I    Blisters                              I
I                                          I
 ------------------------------------------
```

(After the heading 'Small or pimple-like sores' has been chosen, the system generates a hypothesis about the disease and tries to prove it by asking about additional relevant symptoms:)

```
Do you have the following symptom:

itchiness/scratching ?  ** Yes

Do you have the following symptom:

itchiness_at_night ?  ** Yes
```

Are the symptoms located on the:

head ? ** ?

(A question mark as an answer to the preceding question prompts the system to display information about the disease currently in focus:)

PRESENT p ABSENT a UNKNOWN u NOT-ASKED n

Scabies Believe: 640

	itchiness/scratching	400	-400	p
	itchiness_at_night	400	0	p
##	loc_head	-700	200	n
	loc_face	-700	200	n
	Combination:	600	-200	n
	loc_genitals	400	0	n
	loc_between_fingers	400	0	n
	loc_body	400	0	n

('Scabies' is the disease hypothesis presently active. 'Itchiness/scratching' and 'itchiness_at_night' are known as being PRESENT and are flagged with a 'p'. Both of these symptoms have a certainty factor of 400 associated with them yielding a combined value of 640 ('Believe: 640''. The symptom 'loc_head' is presently being asked ('##') and like all the other symptoms is designated as not yet asked ('n'). The system repeats the question:)

Are the symptoms located on the:

head ? ** No

Are the symptoms located on the:

face ? ** No

Are the symptoms located on the:

genitals ? ** No

Are the symptoms located on the:

between_fingers ? ** Yes

(At this time, the diagnosis `Scabies` is confirmed.)

Diagnosis: Scabies

Do you have the following symptom:

yellow_crusts ? ** ?

(Now questions concerning the treatment scheme therapy are asked and explained on prompting the system with '?':)

yellow_crusts is a DANGER SIGN of Scabies

(Yellow crusts indicate a super infection, which in turn would require some kind of a drug treatment.)

Do you have the following symptom:

yellow_crusts ? ** Yes

(Penicillin is one of the drugs, that can be used. So contraindications of penicillin will be checked:)

Checking contraindications for Penicillin:

Do you have the following symptom:

penicillin_allergy ? ** Yes

Penicillin cannot be used

(As penicillin cannot be used, sulfadiazine is considered as an alternativ treatment plan:)

Checking contraindications for Sulfadiazine:

Do you have the following symptom:

allergic ? ** No

Enter AGE in years (in case of babies you can use months as a unit, e.g.: 4 m(onths)) Age: ** 23

(As babies should not be treated with sulfadiazine, the patient's age was requested. The next question concerns pregnancy:)

Is the patient

female ? ** Yes

Is she

pregnant ? ** No

Do you have the following symptom:

dehydration ? ** No

(As the patient is not dehydrated either, sulfadiazine can be used. To compute the dosage, the weight or the age of the patient is used:)

Enter WEIGHT in kg (or U if unknown): ** U

(No weight was given, but as the age is already known, a therapy is now presented:)

Therapy

Scabies

- Everyone in the family should be treated.

- Bath and change clothes daily.

- Ointment lindane/vaseline:

lindane 1 part (of 15% solution)
vaseline (or body oil) 15 parts:

Wash the whole body with soap and hot water;
heat the vaseline and the lindane and stir well;
smear the ointment on the whole body,
but except the face,
leave for one day and then bath well;
After treatment, put on clean clothes and
use clean bedding.
Repeat this treatment one week later.

- WARNING: Can cause poisoning if used too often.

(To treat the super infection an appropriate dosage for Sulfadiazine plus warnings is displayed:)

Sulfadiazine: 1000mg, 4 time(s) a day

Warnings(Side effects):

Take it with lots of water
If there are rash, itching after tablets, then
stop taking it and drink lots of water!

May cause: vomitimg, diarrhea.