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EXPERT SYSTEM AS PREVENTION OF FALLS IN MEDICAL CENTERS

EXPERTNÝ SYSTÉM AKO PREVENCIA PÁDOV V ZDRAVOTNÍCKYCH ZARIADENIACH

Abstract

The topic of this work is prevention of patient falls in medical centers focused on risk assessment. In this work we want to introduce some basic terms about falls, define risk of falls focused on qualitative and quantitative risk assessment methods, define the main causes of falls and propose appropriate methods to eliminate the influences acting on the incidence of falls. Based on risk analysis we have designed an expert system, which provides information to healthcare professionals about the potential risk factors affecting the incidence of falls among hospitalized patients, and directly proposes countermeasures to reduce these risk factors. SW implementation was solved using a freeware program EXSYS. This software can be distributed to individual departments in medical centers to facilitate the identification of possible causes of falls in patients.

Abstrakt

Témou tejto práce je prevencia pádov u hospitalizovaných pacientov z pohľadu hodnotenia rizika. V tejto práci by sme chceli predstaviť základnú problematiku pádov, definovať riziko pádov so zameraním na kvalitatívne a kvantitatívne metódy hodnotenia rizika, zistiť hlavné príčiny pádov, analyzovať hlavné príčiny pádov a navrhnúť vhodné metódy na elimináciu vplyvov pôsobiacich na výskyt pádov. Na základe analýzy rizík sme navrhli expertný systém, ktorý poskytuje zdravotníckemu personálu informácie o možných rizikových faktoroch vplývajúcich na výskyt pádu u hospitalizovaného pacienta, pričom priamo navrhuje protiopatrenia na zníženie týchto rizikových faktorov. SW realizáciu podporného expertného systému sme riešili pomocou freewarového programu EXSYS. Tento SW je možné distribuovať na jednotlivé oddelenia v zdravotníckych zariadeniach a tým uľahčiť personálu identifikáciu možných príčin pádov u pacientov.

Keywords

Expert system, Fall, Risk analysis, SW realization, WinExSys.

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1 INTRODUCTION

Nowadays patients' falls are one of the most serious problems in our modern economically developed society. Even though the falls are in the category of reportable undesired events, the risk is currently underestimated. The fall of the patient during his/her hospitalization in the medical center can cause various adverse consequences for his/her health and may also lead to unpleasant litigation. Damage to mental or physical health of the patient may cause adverse harm in social and economic areas of his/her life. In case of children, adolescents or adults in the economically active age under 45, the falls are at the first place as a cause of death, disability and long-time sick leave.

Currently there has been no exact definition of the human being falls estabilshed. Its adoption by professionals and the general public would create the basis for accurate monitoring of stalling situation. Consequently, the results of monitoring of fall incidences could be used for accurate statistics of falls and injuries. Such statistic data would make possible to propose proper methods of falls prevention and assessment of their occurrences. More experts have tried to create a definition of falling but in most cases the result is only a description of the storyline itself.

1.1 Fall and its causes

The fall can be described as an event when a person comes down under the influence of gravity and appears on the ground, or the lower surface. The falling event may occur with or without presence of a witness. The fall may happen as a result of any unintentional movement. So the fall is an event that results in unwanted keeping the patient or parts of his body on the ground or other surface, which is lower than he/she [1]. The fall itself may not be considered a disease but a symptom that should not only lead to a detailed examination of the patient but also to the assessment of the risks of outdoor environment. One should also regard that the fall is more probable in case of women, chronically ill, hospitalized patients and people in long-term institutional care. In case where people have higher age, risk of the fall is influenced by more factors [2]. According to surveys, the falls occur frequently in the early morning, evening and during the night. It is also possible to assume a higher level of risk in certain places, such as bathrooms, toilets, or in certain time intervals when the patient is in movement - getting up, moving from a bed to a chair or armchair [3].

Most common causes of falls are movement disorders, limited mobility or muscle strength, disorders of balance and equilibrium, orthostasis, arterial hypertension, visual disturbances, dementia, confusion, Parkinson's disease, Parkinson syndrome, effects of stroke, stress incontinence, urinary urgency, receiving psychotropic medications, multi medication (more than 4-5 drugs). These causes of falls are a fact of life in approximately 70% of the elderly [4].

The fall of the patient during his/her hospitalization in the medical center may bring various adverse consequences to his/her health and may also lead to unpleasant litigation. Damage to mental or physical health of the patient may cause adverse harm in social and economic areas of his/her life. Complications caused by the fall can be divided into early and late ones. Among the early complications of falls we can include: abrasions, clot, hematoma and fractures. To the category of the late consequences of falls we can include the partial or complete immobilization of the patient or other complications related to his/her immobility.

2 RISK ANALYSIS OF FALL

The analytical part of our work is established on the elaboration of risk analysis of falls. When analyzing this issue, we have chosen the method Failure Tree Analysis (FTA). For lack of relevant information on the frequency and causes of falls, we focused on a qualitative assessment of the risk of falling, but this does not exclude the use of the proposed structure for later quantitative evaluation of the risk of the fall. The FTA begins with definition of the undesired top event and continues to lower causes that give rise to the event. Relations between individual causes for the emergence of the top event are expressed using the "and", and "or" gates. Thus each situation that could cause the effect (top event) is added to the tree as a series of logic expressions. The process of analysis is continued

and the tree further developed until we have reached the primary causes which can not be further developed or their quantitative statement would be more costly than the level of expression of the events above [5].

In our particular work we have started with definition of the fall as the undesired top event. Consequently, we may analyze and identify four main contributors (categories of causes) whose occurrence may lead to the top event, namely:

- Clinical condition: we grouped here all the crashes caused by medical conditions,
- Slipping: this category includes all types of slipping, which may occur in the hospital,
- Stumbling: this category includes all types of stumbling that may occur in the hospital,
- Falling or slipping: this category includes all other types of falling or slipping, which may occur in the hospital [5].

When analyzing the relationships we have found that occurrence of the fall may be caused by any of specified single events. This implies use gate "OR" between events. The result of the first step of our analysis is shown in Figure 1.

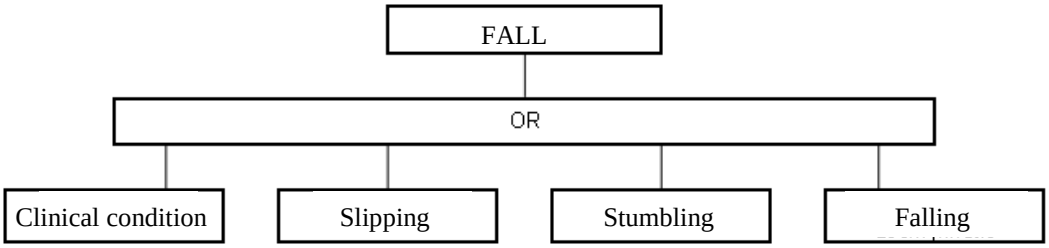

Fig. 1 Defining of top event contributors [5]

In the next step of our analysis our attention has been paid to development of the "Clinical condition" event. We can analyze all the basic events that can cause a fall. For better understanding these events have been divided into five categories, depending on the disease causing them: diabetes mellitus (DM), myocardial infarction (MI), stroke (STR), dizziness (DIZ), or high blood pressure (HBP). The sub-tree resulting from this step is shown in Figure 2.

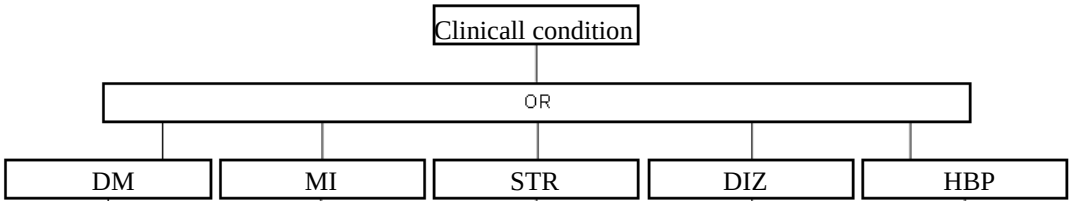

Fig. 2 Analysis of the causes affecting the Clinical condition [5]

The same methodology has been used to develop events that influence the fall due to the influence of diabetes mellitus. We have found that the patient should be mobile or partially immobile and obviously he/she must have diabetes mellitus. Relationships between events and using proper gates in the tree structure depend on this finding. Results of this step can be seen in Figure 3. Other sub-causes (diseases) indicated in Figure 2 may be developed in the same way.

The same procedure has been applied when developing the event "Slipping". Its primary events have been divided for better understanding into two categories depending on what could potentially cause their occurrence: slipping on the wet floor and slipping on objects stored on the floor.

The third event analyzed in the tree in Figure 1 has been "Stumbling". All potential causes leading to Stumbling event have been divided into ten categories depending on the stumbling blocks potentially causing in the hospital environment: luggage, door threshold, bed, cable, chair, shoes, mobility aids, laundry, cleaning trolley or structural parts of buildings.

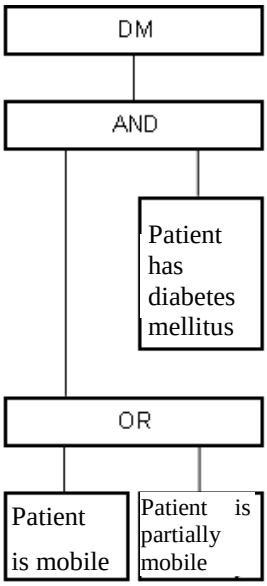

Fig. 3 Analysis of the diabetes mellitus [5]

The last analyzed event has been "Falling or slipping". Its causes have been divided into nine categories depending on the primary effect causing the event of falling or slipping (where or from where the fall might happen): from a mobile toilet, a chair platform, a wheel-char, a bench, a bed, down the stairs, a chair, a armchair, or in the elevator shaft.

Totally 27 possible primary causes of the fall have been analyzed. Based on risk analysis we have proposed the following remedy measures to reduce risk of falling in the hospital.

For the sake of illustration example, we could mention remedies for one particular situation when patient suffers from diabetes mellitus:

Assumption: The patient is likely to fall due to his/her medical condition - diabetes mellitus.

Remedy to reduce the risk of falling: control blood sugar, regular meals, monitoring the state of consciousness, monitor side effects, monitoring hydration, education.

3 EXPERT SYSTEM IMPLEMENTATION

We have decided to use a developer program environment EXSYS Professional (expert system shell) for design and implementation of an evaluation tool which could be used by nurses in hospital departments.

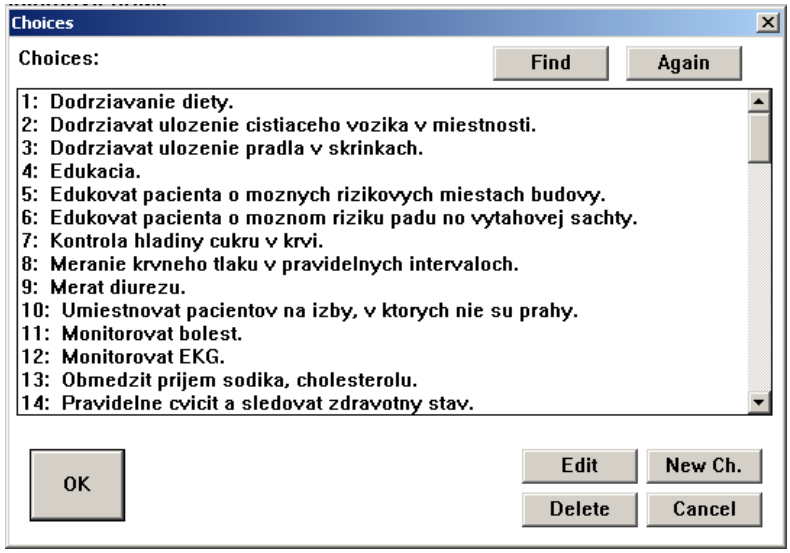

Fig. 4 A part of the list of results [5]

This program has been developed for design of expert systems in various domains. Since we have created a system that assesses the risk of falling, we have chosen a qualitative evaluation of the possibility based on using two-state logic „Yes/No“(with no uncertainty mechanisms applied). One of the first steps in the process of making the expert system problem oriented is definition of “Choices” which represent final solutions (see Figure 4).

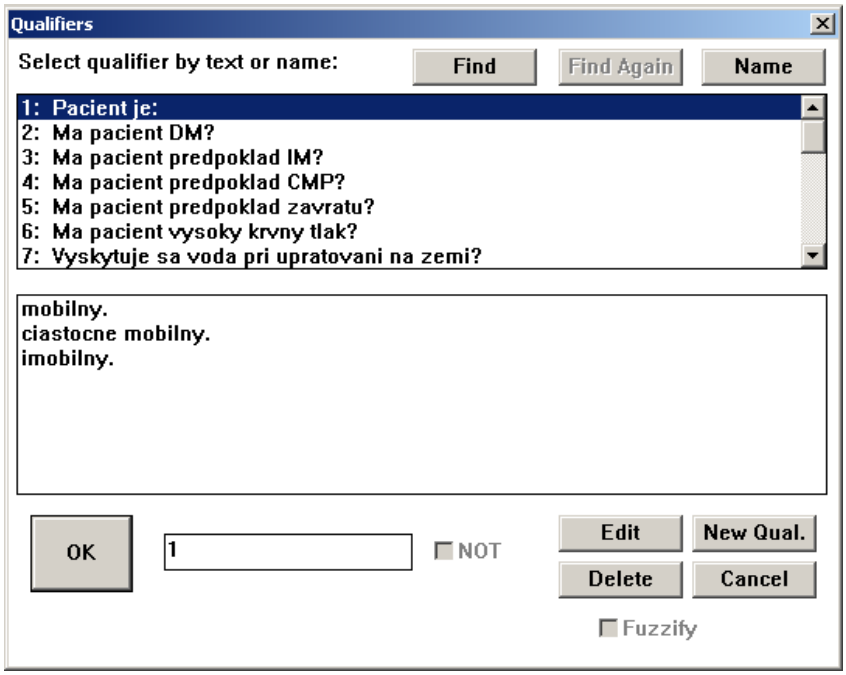

Fig. 5 Example of definition of the list of questions and answers [5]

The next step consists in definition of so called "Qualifiers" (attributes with discrete values) which help us to formulate questions and answers to a user. Figure 5 illustrates a part of that definition process. Finally, based on risk analysis and using pre-defined “Choices” and “Qualifiers” we have designed the rule-based knowledge base. Example of consultation results is in Figure 6.

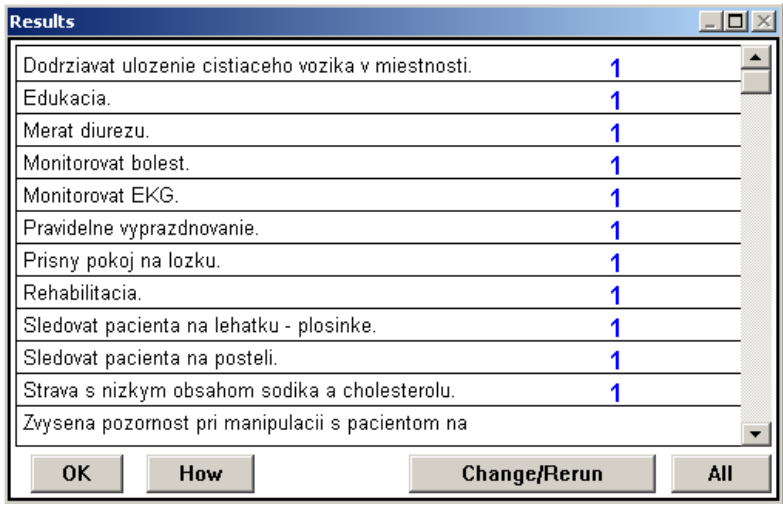

Fig. 6 Example of results from the particular consultation with the expert system [5]

4 CONCLUSIONS

In our work we have dealt with the problem of risk assessment of patients' falls in medical centers. When analysing the issue, we have focused on qualitative analysis and qualitative evaluation of the risk of falling. As the main method the Fault Tree Analysis (FTA) has been successfully applied which has made possible to design and create a tree structure suitable for risk analysis. We have also proposed a method to reduce the impact of the root causes that affect potential occurrence of the patient's fall.

All these obtained findings have helped us to create and implement a rule-based expert system for medical personnel. Thus it is possible to specify what kinds of falls might endanger particular patients based e.g. on diseases they suffer from and to propose the appropriate countermeasures to reduce risk of the falls.

When writing this paper, our motivation was to show a complex and comprehensive view at the problem in question. The practical implementation of the proposed and presented methods have been realized using the demonstration version of the freeware expert system shell WINEXSYS (having full functionality but limited a maximum number of rules to be stored in the knowledge base). If necessary, the knowledge base has potential to be further developed and extended and/or the implementation formalism (rules) transformed to other needed formalisms (e.g. BBNs - Bayesian Belief Nets) to enable utilization by other kinds of expert systems.

The finally created domain-oriented expert system can be distributed to individual departments in medical facilities and help personnel to facilitate identification of possible causes of falls of their patients.

REFERENCES

[1] KRAJČÍK, Š. 2006. Pády a ich príčiny v starobe. Via pract., Vol. 3, 2006, No. 7/8, pp. 344-346, ISSN 1335-9444.

[2] NÉMETH, F. et al. 2009. Geriatria a geriatrické ošetrovateľstvo. Martin: Osveta, 2009. 193 pp. ISBN 978-80-8063-314-1.

[3] GESENHEUR, S. – ZIECHE, R 2003. Vademekum lékaře – všeobecné praktické lekařství. 1. české vyd. 2003. 812 pp. ISBN 80-7262-444-X.

[4] HEGYI, L. KRAJČÍK, Š. 2010. Geriatria. 1. vyd. Bratislava: Herba s.r.o. 2010, 608 pp. ISBN 978-80-89171-73-6

[5] ZELENÁKOVÁ, L. Pády v zdravotníckom zariadení. MSc. thesis, Department of Nursing, Constantine the Philosopher University in Nitra, Slovakia, 107 pp. (2013)