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INFORMATION MODEL OF MAJOR DEPRESSION TREATMENT COST –RELEVANCE OF QUALITY MANAGEMENT OF HEALTH SYSTEM

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Abstract: *This paper develops multirelational data base for major depression costs. It lists how data are collected and stored into the fact base and dimension base. Uncertain data is described linguistically and modelled by fuzzy sets. Linguistic expressions are stored in dimension base. Models of major depression treatment costs are developed for each patient and all population. On the basis of this model and multirelational data base MD-OLAP a model for major depression treatment costs is developed.*
Keywords: *major depression costs, data base, information system, fuzzy set*

1. INTRODUCTION

Major depression is a mental disorder characterized by an all-encompassing low mood accompanied by low self-esteem, and loss of interest or pleasure in normally enjoyable activities [9] . Major depression is a disabling condition which adversely affects a person's family, work or school life, sleeping and eating habits, and general health.

In practice, it is known that persons aged between 30 and 40 suffer from major depression, with a later peak between 50 and 60 years. In Serbia, according to the data for the 2000-2005 period, published by the Public Health Care Institute "Dr Milan Jovanović Batut", the number of mental illness patients aged 18 or more is approximately 402,000. Depression's share in mental illnesses is 20% which means that in the Republic of Serbia 80,400 people are being treated for depression. The psychiatric practice shows that the number of people suffering from depression is substantially higher than the number of people being treated for it.Most patients are treated in the community with antidepressant medication and some with psychotherapy or counseling. Ohayon [3] conducted research in the sample which was composed of 6694 individuals aged above 18 within the population of 48 million inhabitants aged 18 or more. According to research results in this study, 28.3% of patients with major depression were taking antidepressants (exclusively or in combination with some other form of psychiatric health care) and 29.4% received psychiatric health care (without antidepressant medication). Depressed individuals have shorter life expectancies than those without depression, in part because of greater susceptibility to medical illness. The treatment cost is very high and it is necessary to take adequate steps to reduce it. In other words, the development and implementation of information system in psychiatric hospitals and primary health care institutions is necessary, primarily in order to provide better quality service for the patients, but also because the implementation of IS allows the cut of treatment cost, which is one of the basic prerogatives of modern medicine.The cut of depression treatment cost is one of the basic imperatives of psychiatric theory and, especially, practice. An adequate solution of the problem at hand can be obtain exclusively through development and implementation of information system.Any expert knows that his medical knowledge consists nearly 70% of uncertain data [5] . According to published data [2] uncertainties in medical problems can well enough be described through the fuzzy sets theory ([7] , [8]). In comparison to other techniques and methods, the advantages of the fuzzy approach in modelling uncertainty are numerous. The advantage recognized as most important is that the knowledge of the experts is represented through natural language, which, having been optimized and adjusted for hundreds of years, represents the most efficient form of communication. In terms of mathematics, the expert knowledge is represented as a linguistic variable which is modelled through the fuzzy set [7] .The paper is organised in the following manner: Section 2 illustrates basic assumptions on account of which we developed the model for assessment of depression treatment costs for each patient, and represents the modelling of all the uncertainties existing in the model; Section 3 briefly presents advantages of multirelational data bases and describes in detail multirelational data base for major depression treatment costs; Section 4 specifies in detail the architecture of MD-OLAP system; Section 5 presents conclusions on importance of development and implementation of information systems when it comes to cutting the cost of major depression treatment in the Republic of Serbia in particular.

2. PROBLEM STATEMENT

The assumptions within which the architecture of MD-OLAP system for determination and optimisation of total cost of major depression treatment are as follows:

-The total cost generated in the process of treatment of depression patients is divided into four groups: (1) Depressed Individual, (2) Family and Friends, (3) Employers, and (4) Society. For the purpose of optimisation of depression treatment cost, the authors have separately examined each group of costs. Depression treatment costs have been indexed ranging from c=1 to c=12 and they are as follows:

1. treatment-prescription fees and therapy costs, expressed in dinars,
2. work disability costs, non-employment costs, unemployment costs, and time off-sick costs, in dinars,
3. costs of anguish, treatment, side effect, suicide and premature mortality, in dinars,
4. informal care-giving costs, in days,
5. time off work costs, in days,
6. carer burden costs, in days
7. employer contributions to treatment care costs,
8. reduced productivity costs,
9. taxation and insurance, in monetary unit,
10. costs of loss of lives, in percentage.

-Individual Depression costs are measured in monetary units, Family and Friends costs are expressed in days, Employer costs are non-dimensional and, finally Society costs are expressed in percentage.

- Each of the defined Depression cost groups is considered individually, independently of any other.

-Values of defined kinds of depression costs can be cardinal and/or uncertain. Cardinal depression costs are given by evidence data. Values of uncertain depression costs are modelled by subjective judgments of doctors.

-For each patient p, p=1,..,P the overall cost of every kind has been calculated as well as the total cost generated in the process of depression treatment of the patient p, p=1,..,P.

2.2. Notation

c_1^p - treatment-prescription fees costs and therapy costs for patient p, p=1,..,P,

c_2^p - work disability costs, non-employment costs, unemployment costs, and time off-sick costs for patient p, p=1,..,P,

c_3^p - costs of anguish, treatment, side effect, suicide and premature mortality for patient p, p=1,..,P,

2.1. Basic Assumptions

$\sim^p c_4$ - informal care-giving costs for patient p, p=1,..,P,

c_5^p - time off work cost for patient p, p=1,..,P,

$\sim^p c_6$ -carer burden costs for patient p, p=1,..,P,

$\sim^p c_7$ - employer contributions to treatment care costs for patient p, p=1,..,P,

$\sim^p c_8$ -reduced productivity for patient p, p=1,..,P,

c_9^p -taxation and insurance for patient p, p=1,..,P,

c_{10} - costs of loss of lives,

C_I^p -the total cost of depression for individual patient p, p=1,..,P,

$\sim^p C_F$ -total costs of family&friends for patient p, p=1,..,P,

$\sim^p C_E$ -the total employers costs for patient p, p=1,...,P,

$\sim^p C_S$ -the total society costs for patient p, p=1,..,P,

C_I -the total cost of depression individual for a region,

$\sim C_F$ -total costs of family&friends for a region,

$\sim C_E$ -the total employers costs for a region,

$\sim C_S$ -the total society costs for a region.

2.3. Modelling of Uncertainties

In this Section, modelling of all uncertainties existing in the model is given.

Informal care-giving and carer burden costs

Iinformal care-giving costs can be described by two linguistic expressions: ‘the need for informal care is not greater than other person’s 30 days’ and ‘the need for other person’s informal care is greater than 30 days’. The carer burden cost values can be described by the following linguistic expressions: ‘not smaller then 5 days’, ‘about 30 days’, ‘not greater then 60 days’. These

linguistic descriptions are modelled by discrete fuzzy numbers.

The domain of each discrete fuzzy number is defined on the set of natural numbers. The authors suggest that the discretisation step of the domain should be 5 days.

In the literature, there are six classes of experimental methods which are used for determination of membership functions [4]. In accordance with the problem analysed in this paper, the authors have used the horizontal method of membership estimation.

Employers costs and reduced job productivity cost

In this paper, five linguistic expressions are defined for employer costs: 'very small', 'small', 'medium', 'high', and 'very high'. They are modelled by triangular fuzzy numbers.

Values in domain of each defined fuzzy numbers are defined in scale belonging to the interval of [0,10].

Value 0 marks the lowest employer's costs, or the maximum reduced work productivity respectively. Value 10 marks maximum employer's costs, meaning that the employer is actively involved in the treatment process of a patient with depression, which implies minimal reduction in job productivity, respectively.

The values of membership function of each of the defined triangular fuzzy numbers are determined by judgments of experts (andragogues, psychiatrists, industrial psychologists,...)

2.4. Model Costs of Major Depression

Total depression costs for patient p, p=1,..,P can be calculated by following expressions:

1) Depression individual costs, $C_I^p, p = 1,.., P$

$$C_I^p = c_1^p + c_2^p + c_3^p$$

Values of this type of depression costs are crisp, expressed in dinars.

2) Family and friends costs, $\sim^p C_F, p = 1,.., P$

$$\sim^p C_F = \sim^p c_4 + \sim^p c_5 + \sim^p c_6$$

Values of this type of depression costs are described by discrete fuzzy number, in days.

3) Employer costs, $\sim^p C_E, p = 1,.., P$

$$\sim^p C_E = \sim^p c_7 + \sim^p c_8$$

Value of employer costs for patient p, p=1,..,P is described by fuzzy number.

4) Society costs, $C_S^p, p = 1,.., P$

$$\sim^p C_S = (c_9^p)^n$$

Where:

$\left(c_9^p\right)^n = \dfrac{c_9^p}{c_9^{max}}$, and c_9^{max} is maximum monthly value of health insurance in the state.

Values of society cost for patient p, p=1,..,P is defined in the set of real numbers.

Values of total major depression cost in a region are calculated according to following expressions:

1) Total Individual Depression Costs:

$$C_I = \frac{1}{P}\sum_{p=1}^{P} C_I^p$$

2) Total Family and Friends Costs:

$$\sim C_F = \frac{1}{P}\sum_{p=1}^{P} \sim^p C_F$$

3) Total Employer Costs:

$$\sim C_E = \frac{1}{P}\sum_{p=1}^{P} \sim^p C_E$$

4) Total Society Costs:

$$C_S = \frac{1}{P}\sum_{p=1}^{P} C_S^p + c_{10}$$

3. REALISATION OF MULTIDIMENSIONAL DATA BASES

Modern processes in the area of development of information-communication technologies allow to the generation of such solutions which would unify the functions of collection, processing, visualisation, analysis and presentation of the data relating to the depression treatment cost into a unique software (information) solution ([1] , [6]).

The development of the multidimensional data model has been realised through separation of business entities and attributes into tables of facts and dimensions. The tables of facts (represent main tables) contain quantitative of factual data. The tables of dimensions (represent supporting tables) are smaller in size and contain descriptive data on the information given in the table of facts.

The concept of the multidimensional model of data bases of the depression treatment cost can be graphically represented as star-shaped.

The traditional (conventional) data-models and data-bases, if applied consistently, ensure the integrity of the data, protection from error and stability in data-changing applications. These models are applied in systems for On-Line Transaction Processing in the area of data generation and represent a conceptual and physical basis of DB facts of the described model.

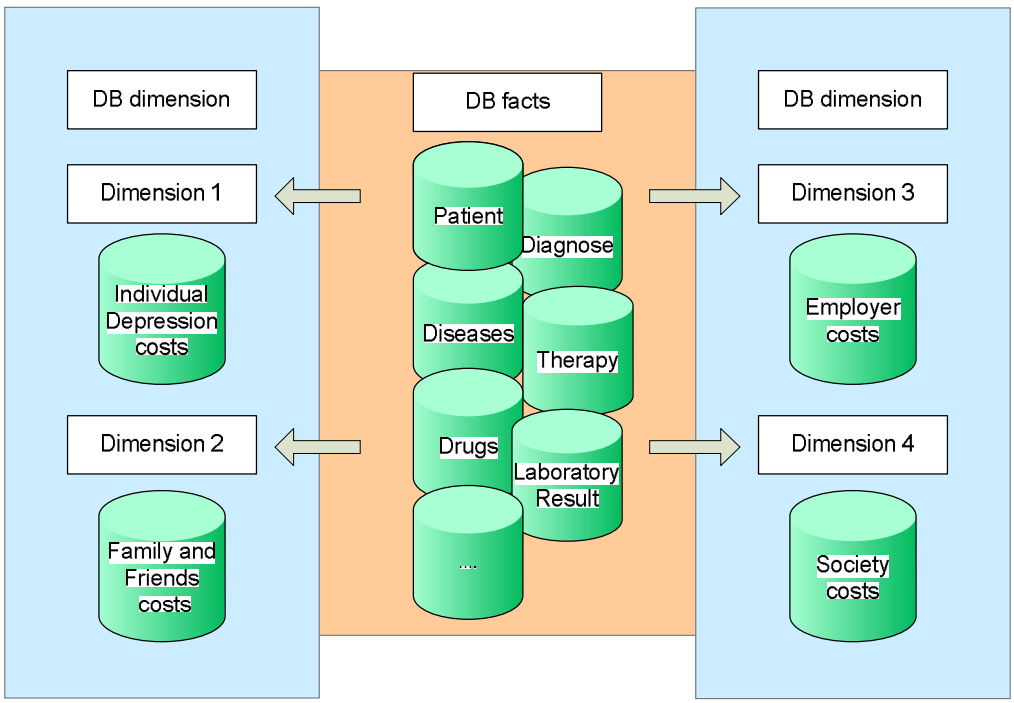

Figure 1. The star-shaped scheme of multidimensional model of data base on major depression treatment costs

On the other hand, the dimensional data base models should allow for a more efficient manner of reporting or analyzing the data with a structure that has to be user-friendly. These models are applied in the systems for On-Line Analytical Processing and represent the basis of dimensions 1, 2, 3 and 4 of the model described.

3.1. Multirelational data-bases for major depression treatment cost

In Fig. 1 the star-shaped scheme is a representation of DB of facts (Patient, Diagnosis, Illness, Therapy, Medication, Laboratory Result etc.) in the centre of the star which is a surrounded DB dimension (Individual Depression Costs, Family and Friends Costs, Employer Costs, Society Costs

Cutting of treatment costs for patients with major depression primarily implies development of separate data bases for each patient with major depression. The data base contains all the relevant patient data such as: the date when major depression was diagnosed, the medications the patient is on, the change of medication (if any), patient's reaction to medication in previous periods, the accompanying illnesses (if any), etc. In medical practice, a data base of patient-related facts defined in this way is known as electronic bill of health. Even when the patient makes appearance in different health-care institutions (which are generally dislocated), the necessary data are obtainable quickly and easily.

The data contained in the Individual Depression Costs DB are primarily obtained from the data records or through direct measurement. This DB contains data on therapy costs, laboratory results costs, various specialist examination costs, hospitalization costs etc. The values of costs contained in the Individual Depression Costs DB are expressed in monetary units.

The Data Base entitled Family and Friends Costs contains data on the costs of family and friend's involvement in the process of treatment of patients suffering from major depression. In medical practice these costs are called informal care-giving costs and carer burden costs. Generally, values of these costs differ for each patient with major depression. Values of these costs are described by linguistic expressions. Modelling of these costs is shown in Section 2.3.

DB Employers contains data regarding the manner

and degree of employer involvement in the process of treatment of patients with major depression as well as work productivity data for each patient. These data can be obtained in different manners; for example, through evidence data, angragogue expert opinion, a team of psychiatrists expert opinion, etc. Generally, for each patient treated for different disease these values can be different. Employer involvement, as well as reduced job productivity generate certain cost which represents a part of the total cost generated in the process of treatment of the patient with major depression. As these costs are almost impossible to quantify, it is the opinion of the authors of this paper that it is only fitting for them to be described through linguistic expressions. This base contains linguistic expressions describing the value of employer costs and reduced productivity costs. Determination of the number and type of these linguistic expressions can be discussed separately. Modelling of linguistic expressions by which Employer costs are expressed is represented in Section 2.3.DB Society contains data concerning amount of taxation and insurance for a patient, as well as data regarding risk of suicide (we assume that loss of lives occurs through suicide). These costs do not depend on the patient.

4. THE ARCHITECTURE OF THE MD-OLAP SYSTEMS

MD-OLAP (MultiDimensional On-Line Analitycal Processing) – are systems for multidimensional on-line analytical data processing.

Methodological support for the integrated processing of the presented data base model is realized through two system: transactional and analytical information system whose architecture is shown in Fig. 2.

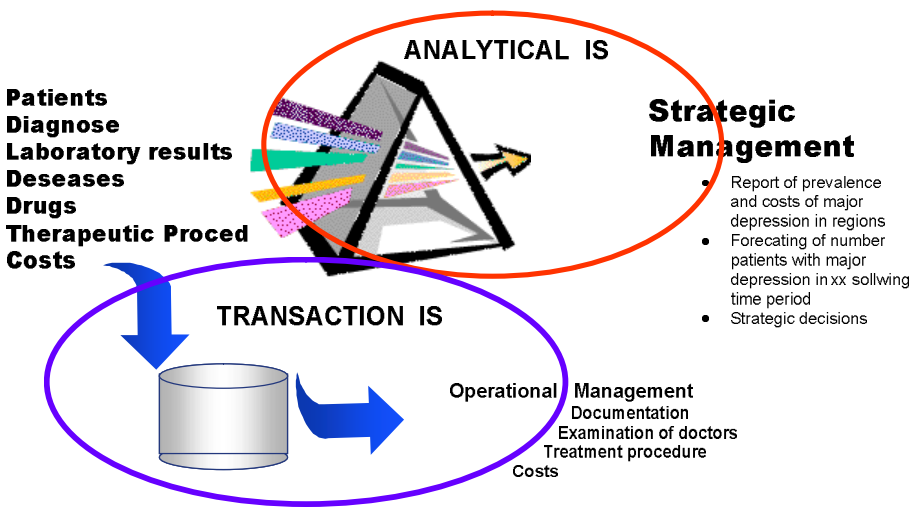

Figure 2 Architecture of MD-OLAP system for major depression treatment costs

Transactional IT system allows for the operative data to be housed in the DB of Facts. The characteristics related to operative data are: applicationally and transactionally oriented, detailed, changeable, continual execution, processing tasks known in advance, totality of maintenance, non-redundant, stative in structure, dynamic in content, smaller quantity of data used for processing, referring to a shorter period of time. Also, it is possible to trace consumption of different types of medications used to treat the patients with major depression in a shorter period of time, which is very important from the perspective of medicine stock management.

The analytical IT system is related to analytical, i.e. dimensional bases, which are smaller in size and contain descriptive data about the data from the Table of Facts.

Dimensional bases contain data which are generated or calculated in some other manner. Basic characteristics of the derivative data are: object and analytically oriented, sum and redefined, unchangeable, with heuristic execution, processing tasks are not known in advance, maintenance divided into sub sets, redundant, flexible in structure, huge quantity of data used for processing, no time-limitation and tracing the data history within the system. By means of these data, by application of the developed model (Section 2.4), it is possible to calculate the cost of each category for an individual patient, to trace the change of the value of costs for each category in a period of time which represents an indirect indication of adequacy of certain treatment. On account of the results obtained, the doctor takes appropriate preventative measures aimed at

improvement of treatment success on one, and reduction of individual treatment costs on the other side. It is possible to calculate total cost for each category for any administrative area (a region, a state), as well as to track the change of these costs in time. These results should enable making of the right decision regarding allocation of the amount of financial means for health care of patients with major depression.

It is also possible, in the presented analytical data bases, to realize data mining concepts and techniques such as: statistic methods (variance analysis), cluster analysis, neuron network, fuzzy sets and fuzzy logic, genetic algorhytms, advanced visualisation etc, which depending on the task at hand, have their advantages and drawbacks in each individual case.

5. CONCLUSION

Major depression is a mass non-contagious disease that affects large portion of working population of each country. As the treatment of patients suffering from this disease requires substantial involvement of family, friends, employers and society as a whole, it can be concluded that the costs generated in the process of treatment of this disease are quite large. Development and application of IT systems such as MD-OLAP system for major depression treatment costs would allow for rationalisation of costs generated during treatment of major depression. Rationalisation is achieved through introduction of electronic bill of health which provides better patient registry and tracking of their disease, as well as of medication prescribed over time. Electronic bill of health enables us to determine the prevalence of major depression, which has not only economic, but importance for the society as a whole. Rationalisation of costs of major depression treatment costs is obtained through reduction of value of costs in each category by taking appropriate preventative measures at the right moment. MD-OLAP system allows for tracking of patient's condition on daily basis, updating of data and their analytical processing whose result enables the doctor to make the right decision. On the other hand, IT system allows for the standardization of preventative measures, which makes it possible to track their efficiency. MD-OLAP system should allow the doctor to make a better decision when it comes to all the aspects of treatment of the patient with major depression.

The development of MD-OLAP system as a support in the process of solving the problem of optimisation of major depression treatment costs is entirely in accordance with aspirations of Serbian Ministry of Health, which has, in association with the World Bank and EU, initiated a project aimed at development of IT and telecommunication technologies in the area of health care in the Republic of Serbia.

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