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APPLICATIONS OF LOGIC IN MEDICINE

Abstract: This paper presents the importance of logic in the medical field. Efficient and proper medical work is difficult without the knowledge of the rules of logic. Therefore, the paper will consider ways of implementing both classical logic and non-classical approach, e.g. temporal and fuzzy logic. The thesis will be supported by numerous examples illustrating how indispensable is the cognition of logic and showing how applying logic can effectively improve work in medicine.

Introduction

An essential element of the medical profession is making numerous decisions. In this process doctors rely on gained knowledge and experience. However, it seems necessary for them to have the ability to think logically, to use reasoning, to infer, to precisely and clearly express their thoughts and justify the assertions made. Even when their actions are be based on certain algorithms or standards, they have to logically model the situation. Lack of knowledge concerning the rules of logic can lead to dangerous errors and may result in continuous failures in performance flowing from faulty reasoning processes. This paper will present the importance of logic in the medical field. The precursors of this view were Tytus Chałubiński and Edmund Biernacki in the second half of the 19$^{\text{th}}$ century [1]. However, the implementation of logic in medical sciences is ascribed to the Polish general practitioner and philosopher Władysław Biegański (1857–1917). He was the author of an excellent work titled "Logika medycyny". His achievements have been used by equally distinguished professor of history and philosophy of Władysław Szumowski, who lived in the years 1876–1954. W. Szumowski was the autor of such works as "Logika dla medyków", "Filozofia medycyny"

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and “Historia medycyny filozoficznie ujęta”. He deepened the issues raised in the work of W. Biegański putting much more emphasis on the practical approach. Moreover, he discussed the most logical errors in medicine.

Classical Logic

Logic is the science of reasoning, it deals with the formulation of general rules that one may properly carry out by conducting proof, checking or inferring. Its effects are visible in everyday situations. Without logic it is difficult to imagine efficient functioning of the world of medicine. A doctor who is obliged to take decisions arising from many different factors should control his/her actions in accordance with the principles of logical reasoning. Classical logic provides a variety of tools making it possible. The most useful for non mathematical sciences is inference. It consists of identifying the implications arising from available indications and justification of new knowledge on the basic of knowledge already available [2].

There are two types of inferences – certain and uncertain [3]. Among certain inferences are mainly deductive inference. According to it, true reasons always lead to true, uncontested conclusions [4]. Moreover, schemas and relationships, on which it is based, are logical rules. Formerly deductive inference was defined only as a transition from general to specific [5]. The example of such reasoning may be presented as follows:

	All asthmatics are allergic.
	John has asthma.
Therefore:	*John is allergic.*

However, now it is considered that such approach is too narrow [5]. Among the inferences the whole reasoning is contained, such that from the conditions a conclusion results. For example, the entailment which is based on the so-called law of detachment modus ponendo ponens $\frac{\alpha \to \beta, \alpha}{\beta}$ may look as follows:

As per [6]:	*Cervical cancer is the only human organ cancer which if detected at an early stage can be 100% cured.*
	In a patient cervical cancer was detected early in the form of the so-called preinvasive cancer (0 degree).
Therefore:	*This cancer will be cured completely.*

An example of inference based on hypothetical syllogism rule $\dfrac{\alpha \to \beta, \beta \to \gamma}{\alpha \to \gamma}$, which is built according to the law of transitivity, may have the following form:

If during the bacterial infection the temperature of the patient's body rises, then the number of white blood cells in his/her blood will considerably increase.

Increased leucocyte count causes much faster absorption of bacteria by phagocytosis.

Therefore: *Increased temperature in the course of infection is the immune response of the body and prevention of further development of the disease through phagocytosis.*

As an example the inferences based on modus tollendo tollens rule $\dfrac{\alpha \to \beta, \neg\beta}{\neg\alpha}$, which is built on the law of contraposition may be considered as follows:

In accordance with [7]: *If the patient has been infected with varicella virus causing chickenpox then in the period up to three weeks on his/her body will appear blisters surrounded by red border.*

The doctor suspects that the patient who hasn't so far suffered from chickenpox may have had contact with a person infected by varicella virus. He wants to determine whether the patient was infected. After three weeks rash was not visible on the patient's body.

Therefore: *The patient wasn't infected with the chickenpox virus*

In opposition to the rules presented above, the uncertain inference is that the proposal does not flow logically from the premises; true premises do not prejudge the truth of the conclusion, however it allows for the acceptance of the proposal with some probability. This category includes inductive incomplete inference and reductive inference. The first type relies on drawing conclusions about totality from observations of the details. The inductive incomplete inference is when the trait which was observed in a study group is assigned to the whole community. On the other hand, the reductive inference is applied to explain the experimental facts. It is the opposite to the direction of inference to the previously presented models – it occurs when "proposals result from premises". It is characterized by formulating the causes of some facts and finding the reasons for certain corollaries. For example, if the ECG entry examination presents changes which take the form of a ST segment elevation, forming the so-called Pardee wave, it may be concluded that the patient who has been tested had a heart attack. However, a serious problem is the fact that the evaluation of logical correctness of uncertain inferences is the topic for discussion. A consistent and widely accepted theory which would systematize such reasoning hasn't been yet developed.

The knowledge of the rules of inference is very important in medicine. It is useful both in contact with the patient and during conducting research. It allows one to logically draw final conclusions. Moreover, persons applying it are able to distinguish which of the reasoning is irrefutably correct and which is only probable. In addition, the ability of inference gives the possibility to make some generalizations, to explain the correctness of the decision and enables recognition as true beliefs. Above all, it enables posing hypotheses and thus formulation of the courts and conjecture. Their verification needs a proof, which also inevitably involves the inference. The proof of the theorem is nothing else but a demonstration that the checking argument is true using premises of theorem, axioms, principles of logic and formally carried out reasoning. Broadly speaking, we may distinguished two ways of proof – direct proof and proof by contradiction (indirect proof). Direct proof, also called classic, consist of showing a sentences as a thesis from the available, true premises and initial for the logical systems theorems (axioms) using inference rules. Whereas proof by contradiction is known as ad absurdum proof, by reduction to the absurd. It is based on contradictions between the assumptions and the negation of the thesis. It allows to conclude that if the negation of the thesis is false then that thesis is true [8, 9]. Such reasoning can be carried out in two ways. On the one hand it can take place in accordance with the rules of inference, on the other by showing a counterexample. An example of proof by contradiction may take the following form:

It will be shown that:	*If a man with haemophilia A and healthy woman, so free from hereditary genetic disorders determine by recessive allele, have a daughter then she is a carrier.*
From the human genetics rules, it is known that:	*(∗) Healthy woman is always the child of a healthy man.*

Then suppose that:	*(1) The patient is daughter of healthy woman and a man suffering from haemophilia A.*
	(2) She isn't a carrier. (It is the negation of the thesis)
From (2) under the law (∗) indicates that:	*The patient is daughter of a healthy man.*
It makes contradiction with (1).	
Therefore:	*Daughter of a man with haemophilia A and a healthy woman is a carrier.*

In addition to the previously described, undeniable benefits of using the principles of classical logic in medicine there are now widely developed ways to use also non-classical logic, such as: modal, temporal, epistemic, deontic, multi-valued and fuzzy logic. These which seem to be the most interesting will be presented below.

Temporal logic

The term "temporal logic" is wide. It is used to describe any independent of each other systems which formalize expressions containing time phrases, often in different ways [10]. This subject began to be discussed at the end of the first half of the 20$^{\text{th}}$ century. Currently, as temporal logic we generally consider the Tense Logic. Formally it is derived from modal logic. Its creator was Arthur Norman Prior. Building systems of this logic is an admission of a specific model of physical time. In addition, it is characterized by temporal operators that define different tenses [12]:

- $\mathrm{H}\varphi$ – it has always been the case that φ,
- $\mathrm{P}\varphi$ – it was sometime the case that φ,
- $\mathrm{G}\varphi$ – it will always be the case that φ,
- $\mathrm{F}\varphi$ – it will sometime be the case that φ.

In order to formalize expressions of everyday language Chronological Logic was developed. It was founded by the Polish logician Jerzy Łoś. It contains the following binary functors.

- $\mathrm{R}\ t\ \varphi$ – φ is realized at time t,
- $\mathrm{U}\ t_1 t_2$ – time t_1 is before time t_2.

In temporal logic also the von Wright's systems is included – "And Next" and "And Then". These are characterized by the conjunction of binary time operator $\varphi \mathrm{T} \psi$, defined as [11]:

- φ and in the next moment ψ – in "And Next" system (time structure is discrete here),
- φ and later ψ – in "And Then" system (this system involves only the linearity of time).

Quite recently there were formed systems which use the concept of time in computer programs. The authorship of the first of them is assigned to R. M. Burstall and A. Pnueli. They introduced functors relating only to the present and the future:

- $\Box_1\varphi$ – φ is in all conditions,
- $\Diamond_1\varphi$ – φ is in at least one condition,
- $X\varphi$ – the next condition than the present it will have been φ,
- $\varphi U\psi$ – at some point it will have been ψ; by that time there is φ.

Over time, this systems was joined by analogous functors describing the past:

- $\Box_2\varphi$ – φ was in all conditions,
- $\Diamond_2\varphi$ – φ was in at least one condition,
- $X^-\varphi$ – on the previous condition than the present had been φ,
- $\varphi S\psi$ – at some point it happened ψ; previously it had been φ.

The first three of the above mentioned logical systems are used in natural sciences. The last is widely used in computer sciences.

Temporal logics may also be divided taking into account the structure of the time they assume. Then, two groups are distinguished:

- Linear tense logics – depending on the systems; they assume that a preceding relation $<$ is transitive, linear on both sides, without the initial and final time [10],
- Branching tense logics (their authors were N. Rescher and A. Urquhart) assume transitivity and backwards linearity preceding relation (branching of time chain in the future) [10, 13].

The diversity of logics constituting temporal logics is due to the fact that their creation was a response to the need to be used in different fields of knowledge. The most interesting application in medicine has been the so-called bitemporal logic. It defines two types of time [14]:

- VT – the time when the data is valid, the so-called "Valid Time". It is for recording the time when an event takes place in the reality represented by the database.
- TT – the time of the transaction data, the so-called "Transaction Time". It specifies how long the data about an event are held in the database.

Such approach to time allows one to build databases extremely useful for medical purposes. These databases allow storage in addition to the current condition of data also the information relating to both the past and the future. They show how data changes over time. Such databases prevent losing data resulting from certain modifications or upgrades and it is also useful in planning. Now let us consider an example of how the bitemporal database works.

The following Table 1. presents course treatment of patients of the hospital.

Table 1

The example of bitemporal database

	Patient ID	Medicine	VT	TT
1.	1	A	6.04–17.04	5.04–∞
2.	2	C	8.04–∞	8.04–9.04
3.	2	A	11.04–∞	10.04–∞
4.	3	B	10.04–∞	7.04–12.04
5.	3	C	13.04–19.04	13.04–∞
6.	3	A	20.04–22.04	13.04–∞
7.	4	A	17.04–∞	15.04–∞
8.	4	B	20.04–23.04	17.04–∞

The attribute VT represents the duration of validity. In this example, VT is the time when the patient was treated with specific medicine. Transaction Time (TT) is the time when the decision to conduct a specific treatment was stored in the database. This attribute gives information about when the record was inserted and whether it was deleted or not.

This bitemporal database presents numerous information. Firstly, on the 5^{th} of April the doctor using the database decided that Patient 1. will be receiving medicine A from 6 to 17 April. Symbol ∞ indicates that this decision is still in force.

Instead, the patient's 2. course of treatment is as follows: 8.04 the doctor caring for the patient made a decision about the immediate initiation of dosing medicine C. Symbol ∞ informs that he didn't specify how long this treatment will be continued. On 10.04 it turned out that the patient hadn't responded to the treatment. So the doctor decided to apply to him from 11 April medicine A. This has resulted in the relevant entry in the database. Comment requires only the value of TT attribute in row 2, which is "8.04–9.04". It is so because the concept about the start of the treatment with medicine C was made on 10.04 and the previous one, about dosage C, had been stored in the database until 9.04 (included).

As it is registered in the database, medicine B was administered to Patient 3. from 10.04. The decision about it was taken already on the 7th of April. But on 13.04 the doctor changed the treatment. He planned that the patient will be receiving medicine C from the 13 to the 19 and medicine A in the following days between the 20th and the 22th. TT attribute in rows 5 and 6 has the same value in both cases because decisions were made on 13.04, and from that day are stored in the database.

In addition, on 15th of April the doctor ordered the treatment with medicine A to Patient 4. In this case the end data of treatment hasn't been decided. The concept depended on treatment effects. Moreover on 17.04 the doctor decided additionally on using medicine B to this patient. Thus, patient 4. was treated with two medicines throughout this period.

The database created in such a way gives a wide possibility. First of all, it guarantees that the data will not be lost during update. It allows to view both the current and historical information. It makes it possible to quickly determine the status of data for a specific moment in time – both present and freely chosen [15]. For example, it can be easily seen which records were stored in the database on 9.04. [Table 2].

Table 2

State of data for the day 9.04 of TT

	Patient ID	Medicine	VT	TT
1.	1	A	6.04–20.04	**5.04–∞**
2.	2	C	8.04–∞	**8.04–9.04**
4.	3	B	10.04–∞	**7.04–12.04**

It gives information about treatments taken on 23.04. (which patient is treated and which medicine is used). It is presented in Table 3. (There are both records deleted and stored.).

Table 3

State of data for the day 23.04 of VT

	Patient ID	Medicine	VT	TT
2.	2	C	**8.04–∞**	8.04–9.04
3.	2	A	**11.04–∞**	10.04–∞
4.	3	B	**10.04–∞**	7.04–12.04
7.	4	A	**17.04–∞**	15.04–∞
8.	4	B	**20.04–23.04**	17.04–∞

Moreover, it allows for searching information about treatment taken on 17.04 contained (not deleted) in the database at 21.04. [Table 4.].

Table 4

State of data for the day 17.04 of VT and 21.04 of TT

	Patient ID	Medicine	VT	TT
1.	1	A	**6.04–17.04**	**5.04–∞**
3.	2	A	**11.04–∞**	**10.04–∞**
5.	3	C	**13.04–18.04**	**13.04–∞**
7.	4	A	**17.04–∞**	**15.04–∞**

Data collected in the database may be presented in form of a coordinate system where the axes mean VT and TT [14]. In preceding example this representation is showed on the Figure 1.

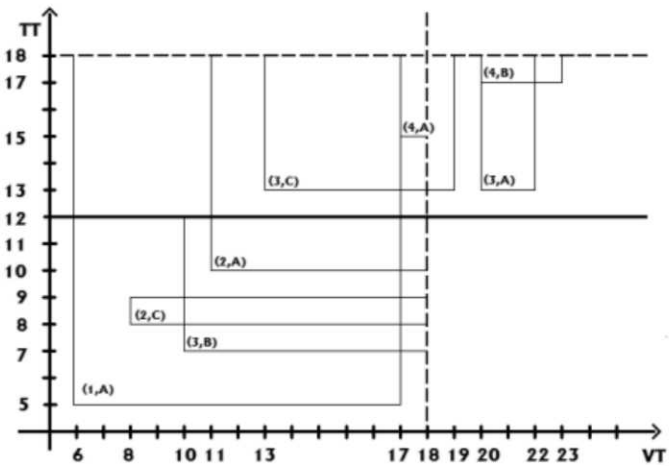

Fig. 1. Graphical representation of bitemporal database from Table 1

As it can be seen it is convenient to represent the database graphically, it gives numerous benefits. Figure 1. is easy to use. It is possible to quickly determine the state of data at any time. For example, the situation for the day 12.04 of TT is marked with a thick solid line on Figure 1. Rectangles, which are in contact with the line or intersect with the line correspond to the records stored in the database on that day. As easy as before it can be read on the Figure 1. which of the patients are treated and which medicine is administered to them on a chosen day. Moreover, assuming that today is the 18th of April, the dashed horizontal line shows data which actually are stored in the bitemporal database and dashed vertical line represents the current events. The place where this dashed lines intersect designates information in the database which is actually taking place, also current with respect to both VT and TT.

Fuzzy logic

Classical logic assumes that each sentence is either true or false. But this standard creates a problem when describing ambiguous, inexact phenomena and formalizing the intermediate situations. For example, let us consider RBC – the index which means the number of red blood cells in blood morphology. How can it be determined whether the value of RBC, which is 6,4 mln/mm^3, is high? If the person who has been tested is an adult woman then this situation is evident – the value of RBC is high. For a 30-year-old man who every day does hard physical work it is a value classified as standard. By contrast, if the patient is an infant, it arises doubts. Then it is a problem to say what we think about it. It would be the safest to use an expression that this ratio is rather below standard. Interpretation is dependent on the specific situation and its context. Such problem was observed by Plato, who lived in the years 427–327 BC. First attempt to resolve it was taken by the Polish scientist Jan Łukasiewicz, who formed three-valued logic. In this system a value is formulated "possible" between true and false.

However, the real breakthrough was the work of Lotfi A. Zadeh entitled "Fuzzy sets" published in 1965. Here it was defined that fuzzy sets differ from classical approach, which assume that an item belongs to the set or not. They do not have sharp, clearly defined border. Each element belongs to the fuzzy set to a certain extent and their attachment may be expressed as a number in the range [0,1]. Such classification is like the human process of thinking, reasoning and interpreting occurrence. It allows an individual approach to each circumstance as well as formalized situation described in a natural language in which are the determinations of the type: little, medium, small, very, quite [18]. Such vision, although seeming to be simple, has revolutionized the approach to sets [16]. So Lotfi A. Zadeh proposed in 1973 a fuzzy logic. Some statements in this system may be false (0), true (1) or in some part true. There are concepts of half-truths, almost false and practically true and there are admissible logical values in the range [0,1]

Fuzzy sets are found whenever there is some ambiguity or subjectivity, and thus imprecisely worded conditions to belong to the set. Degree of belonging of item x to set A specifies the so-called membership function which will be recorded as $\mu_A(x)$. It is defined in an arbitrary way, but the image of function has to be from the interval [0,1] [17]. Its shape or model may be decided by expert knowledge, or a neural network.

For example, let us consider the problem presented earlier, "Is the value of RBC equal 6.4 mln/mm^3 high?". Then membership function may take the form as in Figure 2.

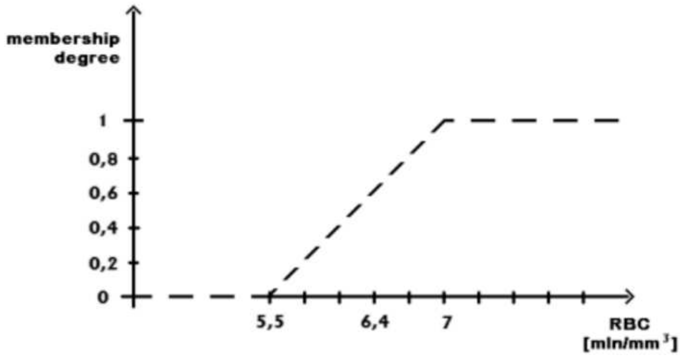

Fig. 2. The membership function of measurement results RBC belonging to a set of indicators of high

or like that:

$$\mu(x) = \begin{cases} 0 & \text{for } x \leq 5,5 \text{ mln/mm}^3 \\ \dfrac{x-5,5}{1,5} & \text{for 5,5 mln/mm}^3 < x \leq 7 \text{ mln/mm}^3 \\ 1 & \text{for } x > 7 \text{ mln/mm}^3 \end{cases}$$

Thus, in this interpretation, the number of red blood cells of 6,4 as being 0,6 high value is defined. Furthermore, the indicator which is 5,5 mln/mm^3, does not belong to the set of high values because membership degree is 0. On the other hand, each of the results of over 7 mln/mm^3 is blindly recognized for the high – membership degree is 1. The membership function gives twofold information. It designates areas where there is no doubt with assigning certain element to a particular set but also shows how to define the degree of fulfilled criteria of belonging to the set in the interval in which there is some confusion.

If the task would be to qualify the results of red blood cells measurement to one of three groups: high, normal or low, the membership function as presented in Figure 3 may be used.

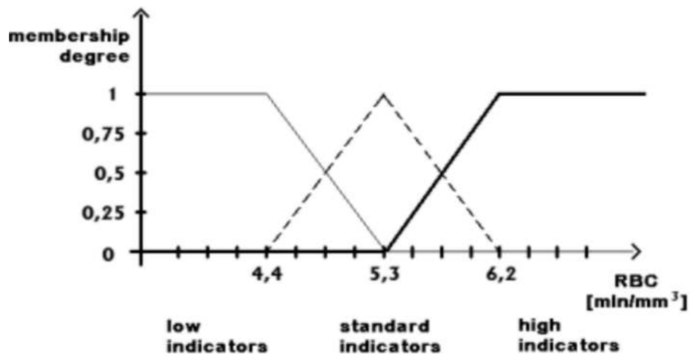

Fig. 3. Membership functions to sets of different types of RBC measurement

Then, as Figure 3. shows, the value of rate which is 5,525 mln/mm^3 belongs to high indicators in 0,25 and at the same time it belongs to the set of standard indicators in 0,75. On the other hand, it isn't contained in the set of low indicators as evidenced by the zero membership degree.

LA Zadeh also defined operations on fuzzy sets, analogously like it was done in classical logic, and the corresponding degrees of membership [18]:

- by the sum of the fuzzy sets A and B, it is meant the smallest fuzzy set containing both set A and set B. Membership degree to the set $A \cup B$ is defined as follows:

$$\mu_{A\cup B}(x) = \max(\mu_A(x), \mu_B(x))$$

- intersection of fuzzy sets A and B is the largest fuzzy set belonging simultaneously to both sets. Membership degree to the set $A \cap B$ is modeled as:

$$\mu_{A\cap B}(x) = \min(\mu_A(x), \mu_B(x))$$

- complement of the fuzzy set A is defined as the maximum fuzzy set of elements does not belong to set A. Membership degree to the set $\neg A$ is given by formula:

$$\mu_{\neg A}(x) = 1 - \mu_A(x)$$

Let us consider membership functions presented in Figure 3. which allocate RBC measurement into 3 categories according to the value.

– Membership degrees to the sum of set of low indicators and set of standard indicators are specified by the function from Figure 4.
  It shows how much the item belongs to one of the sets – low indicators or standard indicators.

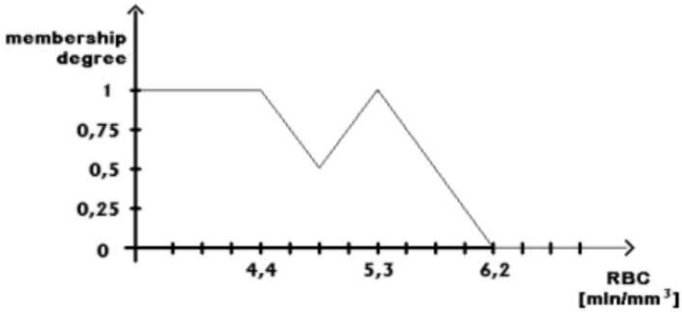

Fig. 4. The membership function of the sum of set of low indicators and set of standard indicators

– Membership degrees to intersection of sets of red blood cells measurement in standard and high are presented by the Figure 5.

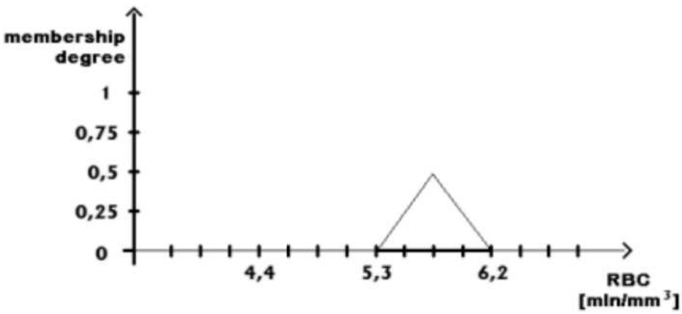

Fig. 5. The membership function of the intersection of set of standard indicators and set of high indicators

This function demonstrates how much the item belongs to both sets simultaneously.

– Membership degrees to complement of set of RBC measurement in standard are presented on Figure 6.

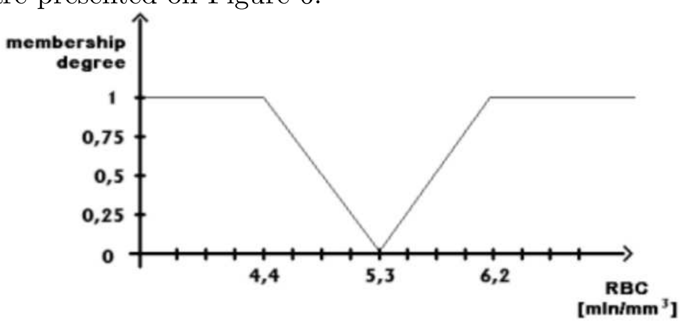

Fig. 6. The membership function of complement of set of standard indicators

It defines how much the item does not belong to the set.

Let us now imagine the situation of a doctor who has to make a decision of starting treatment with a specified antibiotic. This medicine has a number of restrictions to apply. It can be used only to patients over 12 years of age whose weight is at least 40 kg.

The doctor after conducting an appropriate interview obtains all the necessary information. Suppose that he is guided by the logic of the classical meaning. Then the decision made by him is categorical and immediate – if the patient fulfills all required conditions, the treatment is started; but if at least one of the requirements does not occur, the treatment with this antibiotic is no longer taken into account. Fuzzy logic gives the doctor many more opportunities. It allows an individual approach to each patient and it gives a chance to take a subjective decision requiring consideration of several and sometimes many factors. Moreover, it determines the degree in which the patient meets each criterion separately but also both together.

Let us suppose the membership function to set of people aged 12 years looks like it is presented in Figure 7.

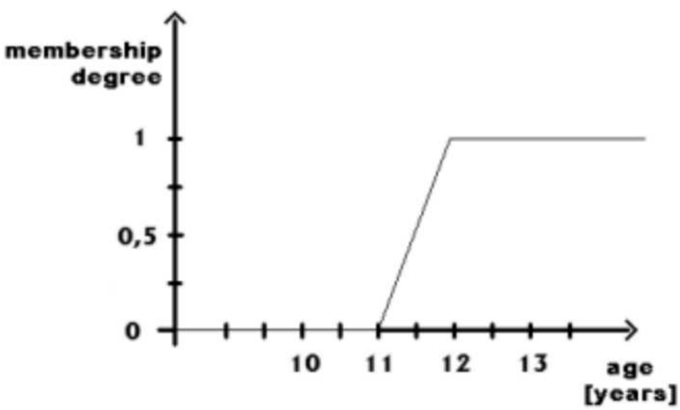

Fig. 7. The membership function to set of people aged 12 years

Furthermore, membership degree to set of people weighing at least 40 kg can be read from the graph in Figure 8. Now, if the patient is a 12 year old boy weighing 38.5 kg then, in accordance with the classical approach, one of requirements to apply specified antibiotic isn't fulfilled and the doctor admittedly rejects the possibility to treat with it. Fuzzy logic allows the doctor to determine the extent to which there are satisfied criteria previously formulated. Let A be the set of those over 12 years and B be the set of

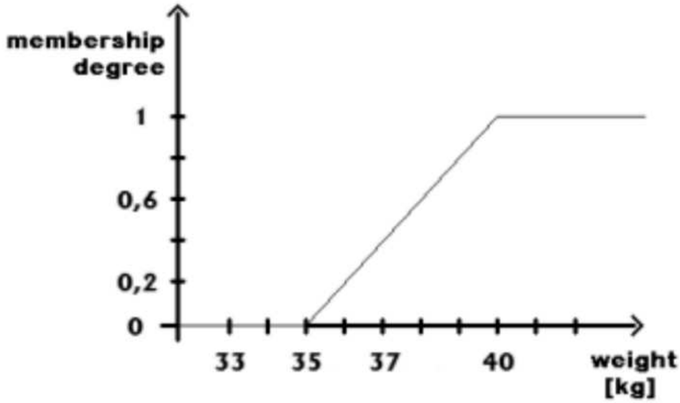

Fig. 8. The membership function to set of people weighing at least 40 kg

people who weigh is at least 40 kg. Then, in pursuance of functions shown in Figures 7 and 8 it is:

$$\mu_A(x) = 1$$
$$\mu_B(x) = 0,7$$

Moreover:

$$\mu_{A\cap B}(x) = \min(1; 0,7) = 0,7$$

It means that in the case of this patient the restriction on the use of the medicine are met in a relatively high degree of at 0.7. It allows the doctor a personal assessment whether this value is sufficient to decide about starting the treatment. Also it gives an opportunity to consider whether, in this situation, the benefits of cure outweigh the risk of possible adverse effects.

Fuzzy logic opens up the possibility for users to formalize the rules of everyday life, as described in colloquial language, which could not be expressed in the framework of the classical approach. What is more, it gives a chance of reasoning consistent with human process of thinking. It is available through the so-called fuzzy inference. This operation consists of a series of stages that can be carried out in many different ways. There are processes such as defuzzyficaton (blurring), inference, fuzzyfication (sharpening) [19, 20]. Furthermore, numerous fuzzy models were created to increase the accuracy of fuzzy reasoning or its simplification as, for example such models as: Mamdani, Takagi-Sugeno, relational, local, global, multimodels [19]. In order to use a fuzzy inference it has to be known, defined by an expert, membership functions of input values to fuzzy sets, base of rules of the form "If ... then ... " and there should be chosen the inference mechanism. An excellent way to cope with these restrictions is to use neural networks [20, 21]. They select all relevant indicators in the way of learning "under the supervision" and they model the necessary functions or solve various problems of estimation. These are currently one of the fastest developing methods of artificial intelligence.

Fuzzy logic enables to model in a formal way the surrounding world and it is used especially to describe vague and subjective situations. It is an alternative wherever classical logic is no longer sufficient, where this logic is not able to contrive with certain ambiguities. Thus, it has an extremely wide applications. It serves mainly to choose the method of action. It is also used to solve various decision problems. There are systems based on fuzzy logic applied in economics, sociology, electronics, technology, industry, informatics, meteorology, ecology and spatial economy. They are used in refrigeration, air-conditioning equipment and car driving control systems, in image processing systems and water treatment devices, in elevators, cameras with auto focus and household appliances like kitchen dishwashers, washing machines, refrigerators, in decision-making processes relating to trading activities of enterprises, to credit risk assessment, in systems controlling the rolling stock or ventilation of underground tunnels, to solve the problem of traffic jams, and even in the production of Japanese sake alcohol. Above all, fuzzy logic has numerous medical applications, among others, in fields such as cardiology, oncology, endocrinology, pediatrics, intensive care, anesthesiology. It supports the processes of making diagnoses or determining the dose of medicine. It participates in decisions concerning treatment and arising from a number of factors, it may be used also to predict patient length of stay in hospital. It is used in many medical devices, for example, in systems controlling pacemakers or blood pressure and blood sugar, in cancer diagnostics, equipment for insulin dosage, warning systems for heart disease, osteoporosis and arthritis.

Conclusion

Learning, understanding and applying the laws of logic, both classical and non-classical, is necessary to work efficiently in the world of medicine. It allows one to effectively, consistently and without mistakes carry out all the reasoning and to prove the hypothesis in a formal way. It causes that we see the need to justify opinions through the means of argumentation. It gives certainty to the correctness of the formulated views. It informs how to recognize which of the justifications are indisputably certain and which are only to some extent likely. Thus, logic is useful both in the contact with the patient, in the process of diagnosis and therapy planning as well as in laboratory studies. In addition, its principles are the basis of the activity numerous machinery, application, technologies, systems and computer programs which improve work. So actually, logic is applied in each aspect of medical action. Simultaneously, intensive work on developing ways to use more "alternative logics" for the purposes of the medical field is carried out. Applications of fuzzy logic and bitemporal logic presented in the paper shows areas in which it can be expected beyond these studies. It is believed that the scope of using logic in medicine will soon expand.

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