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An algebraic modeling for tuberculosis disease prognosis and proposed potential treatment methods using fuzzy hypersoft mappings

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ABSTRACT

This study aimed to put forward an Avant-guard mathematical model for assisting the diagnostic process of this Mycobacterium (Tuberculosis (TB) bacterium) based on a novel adaptive fuzzy like structure. It is tough to ascertain the specific type of TB from its seriousness after looking at the symptoms as they overlap with numerous other respiratory infections. This structure, i.e., the fuzzy hypersoft set (FHS), extends the fuzzy soft set used to resolve this issue. The FHS is a more generalized, flexible and reliable algebraic model which is capable of managing the shortcomings of existing fuzzy soft set-like models with the entitlement of multi argument based domain for the approximation of TB patients (alternatives) under examination. It tackles the uncertain observations of medical experts for the approximation of patients with the help of fuzzy membership grade within [0,1]. When the measurements possess sub-values, it is problematic to see refinement in the patient's progression timelines and anticipate the prescription term in a clinical appraisal. This novel fuzzy-like theory categorizes the distinct attributes into corresponding disjoint attribute-valued sets for better interpretation. It is difficult to distinguish a single upper-respiratory infection due to the sheer number of infections that influence the lungs and associated breathing organs. This investigation involves monitoring and constructing a bridge between the presented symptoms and the treatment given to the patient. The FHS-mapping will recognize the severity of the disease and the proposition of adequate treatment for the patient. The presented structure can prove to be an excellent diagnosis aiding tool as it has infinite analysis potential with mathematical interfacing with the patient's condition with time.

1. Introduction

Tuberculosis, a bacterial infection caused by Mycobacterium Tuberculosis. A person suffering from HIV is about 20 times more likely to develop TB as compared to a normal person [1]. The bacterial usually enters the body through inhaled air and makes its way to the lungs, where it spreads to the entire body using the bloodstream and the lymphatic system [2,3]. It is been a severe issue as it is been the cause of millions of deaths around the globe, especially in parts of Asia and Africa where the sanitary conditions are not up to standards [4]. In 2019 alone, 1.4 million people died from TB, out of which 208,000 people were also infected with HIV. It has gained a reputation as one of the top 10 infectious death-causing agents from a single infectious agent resulting in approximately 10.4 million new cases and 1.7 million deaths each year. Regarding all these factors, the disease is treatable and curable, and 60 million people were saved through treatment and diagnosis of TB between the interval of 2000 to 2019 [1]. More than 1 billion people have lost their lives to fight TB during the past 200 years [1]. In addition, a quarter globally, the human population has been affected for a long time, which provides a large reservoir for the future active TB site "ZV". The issue is that it is a 120-year-old microscopy-based diagnostic technology with low sensitivity and efficacy on a 100-year-old vaccination that hindered global TB control (Buckley Kalmet Gorion-BCG) and a large number of drugs that are between 40 and 60 years old [5].

To construct a recommendation infrastructure that can help medical professionals provide an accurate, quick, and outlay assessment of

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tuberculosis, Omisore et al. [6] established a strategy towards cognitive diagnostics of TB adopting the hereditary inferential method. The architecture and technique used to figure out the most common type of TB that an individual may have were proposed by Semogan et al. [7]. Utilizing a prediction model with rules put in place for the multiple TB classes, the classification of tuberculosis is defined. The Adaptive Fuzzy Technique for Mycobacterium Treatment and Diagnosis was introduced by Angbera et al. [8]. The incorporation of ANN as a sensitive diagnostic approach was explained in detail in Dande & Samant [9]. An explanation of the organization of TUBERDIAG was performed by Phuong et al. [10]. The program is being developed in collaboration with healthcare experts from the Hanoi National Institute of Pulmonary and Lung Disease. The software was made using the Desktop Borland Delphi 2.0 software platform for Windows 95.

In the modern era, conventional methods have deprived value as the problems require more complex and tailor-made approaches. Most of the problems incompletely present themselves, giving the problem-solver very little and incomplete data to work with. Incomplete and flawed information can lead to numerous issues that may escalate over time. To tackle such problems, theory on Fuzzy set (FS) Zadeh [11], theory on Rough set Pawlak [12] and mathematics have gained a reputation among the scientific community as resourceful and result oriented tools. Each of these scientific tools requires a predetermination of some parameters, namely, a membership function in the fuzzy set theory (FST), a density function in probability set theory (PST), and a congruence relation in rough set theory (RST). These theories have proven to present the best results while dealing with incomplete data in the fields of machine learning frameworks of different sorts.

The study of images and inverse images of neutrosophic soft expert sets was prompted by the concept of mapping of neutrosophic soft expert sets proposed by Broumi et al. [13]. Heilpern [14] introduced the concept of fuzzy mapping and promoted a converged point theory for fuzzy constrict mappings, which influenced Nadler [15] to construct a fixed point premise for multivalued mappings. Estruch and Vidal [16] presented a linearization theory for fuzzy constriction mapping on a complete topological space that enhanced the convergence point hypothesis established by Heilpern's fixed point premise. The concept of convexity and quasiconvexity of fuzzy mapping by taking into account the ordering due to Goetschel–Voxman [17] was presented by Yan–Xu [18]. The concept of convex and concave fuzzy mapping was put forward by Syau [19]. The notion of summed up convexity and differentiability that includes the terms invexity and pseudoconvexity for fuzzy mappings was put forward by Syau [20].

To deal with impreciseness, Molodtsov [21] created a comprehensive arithmetic technology called a soft set (SS). Due to its diverse products in numerous areas, SS idea is still used in a broad range of technical professions and is one of the most frequently examined mathematical disciplines. Soft sets would be used to aid judgment calls by Maji et al. [22]. So, according to Yang et al. [23], SS and their implementations are meaningful. Maji et al. [24] proposed the notion of fuzzy SS as well as its applications in various fields.

As an enhancement of a soft set, Samarandache [25] presented the hypersoft set (HSS) approach in 2018. In their keynote of the Hypersoft set in text categorization, medical diagnostics, psychiatric condition, and several requirements, Saeed et al. [26–28], Rahman et al. [29–32] and Ahsan et al. [33,34] covered the underlying principles of the HSS and their total configurations in a HSS surrounding.

The goal of this report is to offer an assessment tool for the assessment of TB since this contains common indicators with so many breathing problems. It also advises a treatment strategy. Literature review revealed that the existing theories and methods [35–38] are inadequate for this purpose as they do not utilize data comprehensively and do not propose a treatment strategy relative to the diagnosis. They fail to manage when attributes have their sub-values. The proposed models depend upon the fuzzy hypersoft set defined by Samarandache in 2018 as expansions of the fuzzy soft set. The proposed framework is more versatile in which the attributes may be further sub-divided into sub-attributive values. A mapping correlates between people or more contexts and is based on rules that translate an interrelated attribute to its underlying parametric significance based on spatial and premise similarities. This mapping allows one to deal with parameters of the comparable kind in a single related basic parameter. The study aims to present a tentative diagnosis of TB by mapping the symptoms to the severity of the disease and the proposition of a treatment or medication strategy using the FHS mapping framework. At the initial diagnosis stages of a patient, it is hard for medical staff to diagnose respiratory infections as they have overlapping symptoms, so this tool can be utilized for a prevailing approach of the needs of the patient and come to an overall diagnosis that is backed by the doctor's intuition along with analytical correctness using mathematical tools. The FHS set and FHS mapping with its INM are used to find a solution. This review aims to describe the comparative assessment of chronic conditions and ailments. This design helps bridge the gap between ailments and health care. Finally, vague mapping is created to predict patient growth reports, and if the referenced healing has damaging consequences, the INM should be used to roll back the patients to their starting point and refresh the diagnosis. This urges a doctor to track the patient's condition until the ailment is vanquished.

In order to collect the data for the patients, the programming team first works with the medical professionals to determine the symptoms and their thresholds while considering the timeliness on when the symptoms of each of the diseases occur and at what intensity do they present themselves. Then from there, the patients are monitored in such a way to quantify the intensity of the symptoms based on a particular timelines. This is done by the opinions of doctors and medical professionals supported by lab tested results. Once that is done, the parameters and thresholds are finetuned and tested continuously on newer patients until the results of the model and the diagnosis presented by the doctors start to align. This is how the model patient data is to be collected and utilized in a proper format.

The proposed methodology has the following main contributions and advantages are:

1. The structure developed for the study is considered to be more flexible and detail oriented as compared to similar fuzzy and soft set-based structures as it can address the following restraints:
   (a) During the approximation process, the uncertainty can be dealt with using fuzzy rules.
   (b) The sub-parametric values can be mapped on non-overlapping classes.
   (c) Development of an advanced novel multi-argument approximation function.
2. It takes on the first matter by assigning a fuzzy association degree to every entity of initial universe with respect to attributes. Similarly it deals with the second and third matters by entitling the settings of hypersoft environment. Accordingly it directs to scheming a trustworthy decision support system by tackling with these issues jointly.
3. Due to the complex nature of issues related to medical diagnostic problems, the algorithm allows for the early assortment of the possible alternatives. This process enables it to function as a diagnostic decision-support system.
4. The method endeavors to support as a diagnostic imaging assist for those first treatment plans and for evaluating people with diverging symptomatology. This analysis scientifically links the signs to efficiency and economics and indicates a level of collaboration between them. The framework is structured on reducing FHS set designs that can predict a patient's state of health and estimate medical indicators over time to know how the prescription will affect that person's health. Up until the illness is treated,

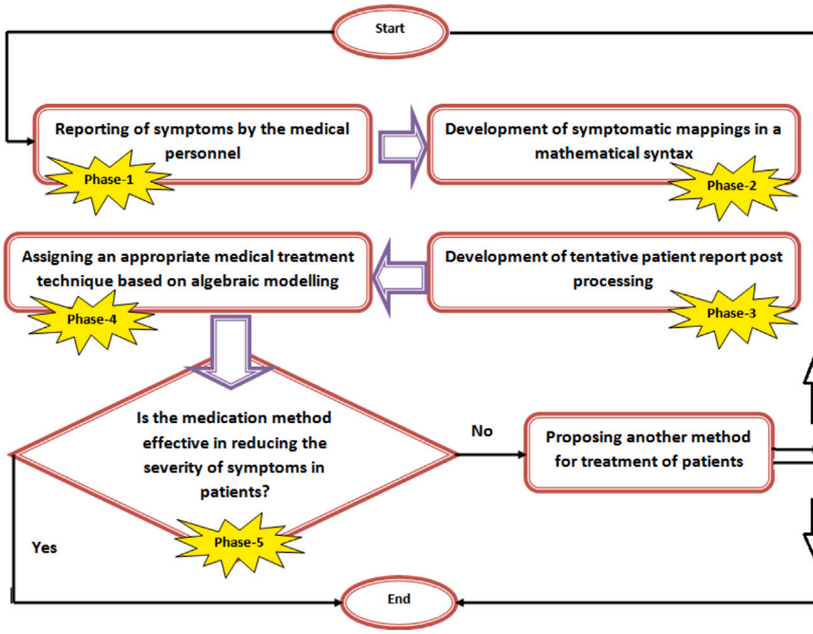

Fig. 1. Brief description of methodology.

it might be done to predict the infection's recovery process. These based classification methods will be developed in the near future to eliminate medication error and yield extraordinary results based on multiple customer conditions.

The following is how the content of the study is structured. Section 2 involves the description of various steps involved in adopted methodology. The comparative analysis, practical application of the method, and demonstration of the method are given in Section 3. The last section will present the much more new revelations.

2. Methodology of the study

This section is aiming to present and elaborate the step-wise methodology of the proposed study. The brief stage-wise description of methodology adopted is presented in Fig. 1.

2.1. Characterization of mappings on fuzzy hypersoft classes

This portion continued to expand on the theory of mapping on FHS classes. FHS sets are put together through FHS classes. Besides that, FHS images and FHS inverse images are described, where $\xi_1 \times \xi_2 \times \xi_3 \times, \ldots, \times \xi_n = J$, $\xi'_1 \times, \xi'_2 \times \xi'_3 \times, \ldots, \times \xi'_n = \mathcal{W}$.

Definition 2.1. Suppose (C, J) and $(\mathcal{E}, \mathcal{W})$ be two sets of FHS classes across C, $\mathcal{E}$ respectively. Let $\delta : C \to \mathcal{E}$ and $\vartheta : J \to \mathcal{W}$ represent the two subpart transformations. The entire translation is then summarized in this sense; $\kappa = (\delta, \vartheta) : (C, J) \to (\mathcal{E}, \mathcal{W})$, for FHS set (ϕ, Ξ) in (C, J) and $\kappa(\phi, \Xi)$ is FHS set incorporated $(\mathcal{E}, \mathcal{W})$ acquired using the same techniques, For $\varsigma \in \vartheta(J) \subseteq \mathcal{E}$ and $q \in \mathcal{E}$, then

$$\kappa(\phi, \Xi)(\varsigma)(q) = \begin{cases} \bigsqcup_{x \in \delta^{-1}(q)} \left(\bigsqcup_{\lambda \in \vartheta^{-1}(\varsigma) \wedge \Xi} \phi(\lambda) \right)(x), \text{ if } \delta^{-1}(q) \neq \emptyset, \\ \qquad \vartheta^{-1}(\varsigma) \wedge \Xi \neq \emptyset \\ (0) \quad \text{if} \quad otherwise \end{cases} \tag{1}$$

$\kappa(\phi, \Xi)$ is the image of FHS set (ϕ, Ξ).

Definition 2.2. Let (C, J), $(\mathcal{E}, \mathcal{W})$ be two sets of FHS classes across C and $\mathcal{E}$ respectively. Assume $\delta : C \to \mathcal{E}$ and $\vartheta : J \to \mathcal{W}$ be mappings. Let (η, δ) be a FHS set in $(\mathcal{E}, \mathcal{W})$, where $\delta \subseteq \mathcal{W}$ then $\kappa^{-1}(\eta, \delta)$ is a FHS set in (C, J) designated as,

$$\kappa^{-1}(\eta, \delta)(\chi)(b) = \begin{cases} \eta\vartheta(\chi)\delta(b) & \text{if } \vartheta(\chi) \in \delta \\ (0) & \text{if } otherwise \end{cases} \tag{2}$$

where $\chi \in \vartheta^{-1}(\delta) \subset J$, then $\kappa^{-1}(\eta, \delta)$ called to be the FHS inverse image of FHS set (η, δ).

2.2. The role of FHS in TB

This section explores TB and its related risks. Indications, symptoms, prognosis, and therapy of tuberculosis patients are all considered. The FHS set is considered as a whole with its relative mapping, or INM. Then it is explained how the offered mathematical formulation is used to generate a treatment strategy for TB patients.

2.2.1. The exploration of tuberculosis and its aspects

The impact of analytic TB research and mathematical modeling in the medical sector is immeasurable. The presented model highlights a theoretical framework that can be trained as a diagnostic support system for Tuberculosis. Based on the severity of the disease and with robust programming of the technique backed by actual patient data, the disease can be indefinitely defined into as many stages as required. The model is based on Fuzzy Hypersoft Set that can quantize the symptoms in a mathematical syntax presented by the patient using its amplitude term while its phase term binds that amplitude term with the time on which the patient presented the symptom. With this method, each of the symptoms can be mapped to a specific disease based on the severity of the symptoms presented at different points in time. Only two types of Tuberculosis for the explanation of the framework in this context that are given below:

(a) Active TB
(b) Miliary TB

2.2.2. Active TB

Active TB is a condition in which Mycobacterium TB causes infection. Usually in the lungs, although many systems can be involved. The World Health Organization estimates that each year, approximately 8 million people worldwide develop TB-activated, and approximately 2 million people die from the disease.

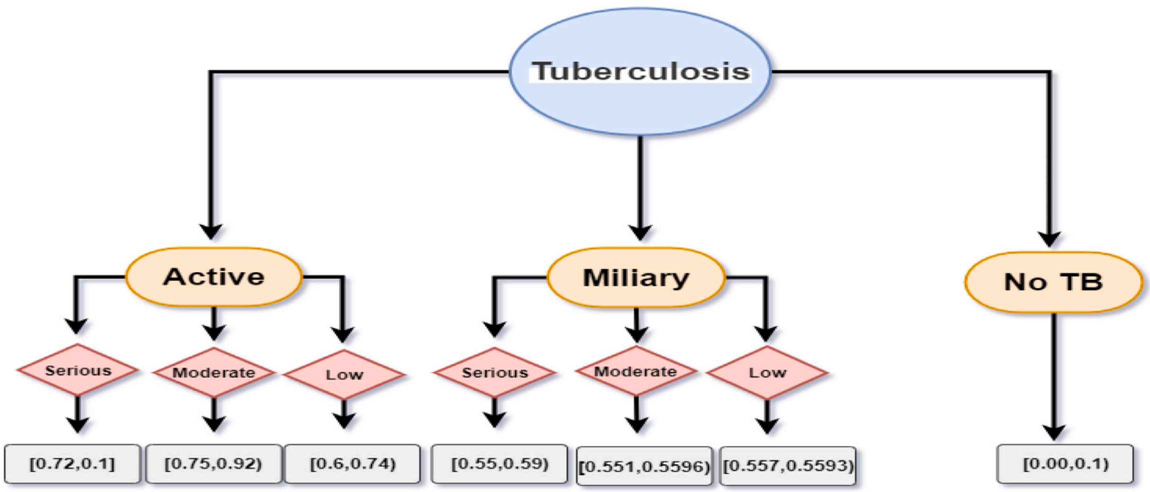

Fig. 2. Flowchart with various ranges pertaining to the TB situations stated.

2.2.3. Miliary TB

Miliary TB is a potentially deadly type of TB that occurs when a large number of bacteria passes through the bloodstream and spread throughout the body. TB is a contagious disease caused by the airborne bacterium Mycobacterium TB. Some of the indicators that go along with these concerns are included.

1. A cough that lasts more than three weeks
2. Loss of appetite
3. Weight loss
4. Fever
5. Chills
6. Night sweats
7. Fever
8. Coughing up blood
9. Chest pain
10. Fatigue

2.2.4. Description of fuzzy rules

The following justification has been provided for the selection of fuzzy rules employed for the study:

1. Linguistic variables are considered and are used as the fuzzy input each corresponding to a fuzzy output.
2. A multi-argument approximation function, novel in nature has been used as the membership function. The novel function takes the cartesian product of the disjoint classes of sub-parametric values corresponding to the parameters with fuzzy sets as their co-domain. It can be thought of as a modified version of the approximation function used in soft sets. It makes sure that the hypersoft environment where the parameters and sub-parameters and in disjoint classes.
3. The fuzzy rules and systems that are to be employed for the construction and computation of relevant processes are designed in this step.
4. The process is concluded by obtaining an optimized fuzzy output in the form of an optimal decision from the set of alternatives. The Fig. 3 presents the pictorial view of the above mentioned fuzzy rules.

2.2.5. Initial move

The consistency of the complaints makes recognizing TB complicated for healthcare workers. Several of these classification involve peculiarities that are harder to decipher. It means that uncertainties and ambivalence contribute in these situations and that the FHS is the perfect tool for the endeavor. Different kinds of TB are devised for an imprecise region [0,1] to interpret auditory data into information language. To consider multiple forms of infective TB, a database is created. Please see Table 1. Since each issue has a varied concentration over time, the paper will accumulate more crucial data about a health history; for a proper diagnosis, each expert needs to review at least 2–3 sets of questionnaires comparable to the getting noticed negative consequences. Additional graphs are generated for monitoring the TB medical symptoms and their day-to-day synchronization with the algorithm. The daily stability of patients' ailments and distinct ranges related to specified TB conditions are represented in Table 2 and Fig. 2. Each kind of tuberculosis has 3 phases: severe, moderate, and mild. A flow chart (Fig. 2) is also offered to indicate the broad range assigned to these restrictions.

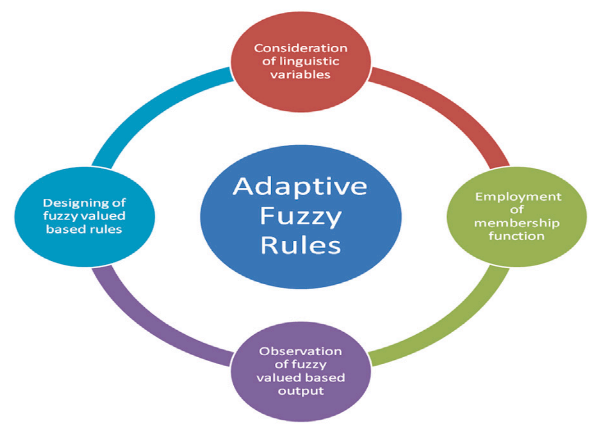

Fig. 3. Brief description of fuzzy rules based components.

Table 1
TB diagnostics chart.

Sorts of TB	Different ranges of [0, 1]
Active TB	[0.6, 1]
Miliary TB	[0.1, 0.6)
No TB	[0, 0.1)

2.2.6. Proposal of algorithm

Now an algorithm is being proposed which will assist the medical physicians to diagnose and treatment TB with great ease.

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Table 2
To analyze tuberculosis, chronic conditions and their day-to-day synchronization.

Settings	1st day	2nd day	3rd day
Serious Active TB (SAT)	[0.72, 0.8)	[0.8, 1)	= 1
Moderate Active TB (MAT)	[0.75, 0.82)	[0.82, 0.87)	[0.87, 0.92)
Low Active TB (LAT)	[0.2, 0.21)	[0.21, 0.22)	[0.22, 0.24)
Serious Miliary TB (SMT)	[0.24, 0.25)	[0.25, 0.31)	[0.31, 0.33)
Moderate Miliary TB (MMT)	[0.1, 0.13)	[0.13, 0.14)	[0.14, 0.19)
Low Miliary TB (LMT)	[0.02, 0.07)	[0.07, 0.08)	[0.08, 0.099)
No TB (NT)	[0.00, 0.001)	[0.001, 0.008)	[0.008, 0.009)

Algorithm 2.3. Following the procedural steps of proposed algorithm:
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Step 1. TB needs to be discriminated from these other disorders in terms of health care, let $Q = \{k_1, k_2, k_3, ..., k_n\}$ be the ones who are regarded to have TB indications and $A = \{t_1, t_2, t_3, ..., t_v\}$ be the reported maladies and their accompanying remedies are S_i's, where $V = \prod_{i=1}^{v} V_i$. Following a careful examination, the consultants prepared the FHS set chart at εth spots might be adjusted as per:
$z_V^\varepsilon = \{z_p^\varepsilon = \{k, \langle T_p^\varepsilon(k)\rangle\} : k \in Q, p \in V\}$, where $T_p^\varepsilon(k)$ is membership grade of Active TB and Miliary TB. The FHS confederation of all knowledge diagrams to assemble the patient majority's original information.

Step 2. It is believed that $B = \{t_1', t_2', t_3', ..., t_w'\}$ be a group of interlinked indicators (introductory indications encompass connecting core diseases), matching sets are V_i''s, where $V' = \prod_{i=1}^{w} | V_i' |$. Consider is a combination of FHS factors that the clinical experts established after bringing the patient history state into reference during the length of ε.

Step 3. Maps are regarded as $\phi : Q \to Q$ and $\omega : V \to V'$ being classified as follows $\phi(k_l) = k_l$, $\omega(p_k) = (p'_{k'})$ (relying as to how the clinical manifestations correlate). Let FHS-mapping $\psi = (\phi, \omega) : FHS(Q) \to FHS(Q)$ represented as
$T_{\psi(z_V)}(p')(k)$

$$=| T_{p'_{k'}} | \begin{cases} \max_{k\in\phi^{-1}(k)}\left(\max_{p\in\omega^{-1}(p')\cap V} T_{z_s}\right)(k) \text{ if} \\ \qquad \phi^{-1}(k) \neq \emptyset, \omega^{-1}(p') \cap V \neq \emptyset, \\ 0 \text{ if } otherwise \end{cases} \quad (3)$$

wherein connecting factors from zV' make up $Tp'k'$. Using the mappings ψ and marked as $z'V'$, acquire the representation of $\sqcup z^\varepsilon V$.

Step 4. Furthermore, generate the after consequences set and consolidate the pre-diagnosis table to use the values from Table 2 so that the accuracy of the research study can be retrieved.

Step 5. Calculate of each total scores that refers to symptomatology from the learned FHS group. Take our overall product and had used Table 1 as a standard.

Step 6. Assuming various indicators, $B = \{t_1', t_2', t_3', ..., t_w'\}$ which are attached simultaneously time, where $k = \prod_{i=1}^{w} | V_i' |$ and $I = \{i_1, i_2, i_3, ..., i_x\}$ is a list of potential medicines. From there, $\chi_{V'}$. can be generated, where χ from V' to $P(I)$ is a function.

Step 7. Get Q_I^1 by using union over $z'_{V'}$ and $\chi_{V'}$.

Step 8. Adopt medication that strategy is applied while often getting serious side effects. The participant's prognosis is estimated by taking the maximum score values.

Step 9. Evaluate the following mappings: $\phi' : Q^{q-1} \to Q^q$, $\omega' : I^{q-1} \to I^q$ such that $\phi'(k_l) = k_l$ and $\omega'(i_x) = i_x$. Furthermore, FHS-mapping might potentially be established in this style $\psi' = (\phi', \omega') : Q_I^{q-1} \to Q_I^q$ and is analogous to:
$Q_I^q = \psi'(Q_I^{q-1})(f)(k)$

$$= \frac{1}{q} \begin{cases} \sqcup_{\pi\in\phi'^{-1}(k)}(\sqcup_{\varsigma\in\omega'^{-1}(f)\cap I} Q_I^{q-1}(\pi) \text{ if} \\ \qquad \phi'^{-1}(k) \neq \emptyset, \omega'^{-1}(f) \cap I \neq \emptyset, \\ 0 \text{ if } otherwise \end{cases}, \quad (4)$$

for $q \geq 2$ and $f \in \omega'(I) \subseteq I$, $k \in Q^q$, $\pi \in Q^{q-1}$, $\varsigma \in I^{q-1}$.

Step 10. Whenever it is necessary to assess the outcomes, keep going with step 9.

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2.2.7. Limitation of the method

The major issues need to be considered before setting the system to use on individual care and clinical information:

1. It is important to capture these qualities and identify their underlying normative parameters since such appearance and premise of these factors are analogous.
2. The combinations must be distinctive from the others and be part of the very same organizational classroom . in order for modeling or syntheses to be defined (FHS).
3. As per a doctor's note, the effective treatments for indications relies on the history from a certain individuals.
4. A doctor's advice should be sought while developing a handful of categories.
5. If the algorithm's prescribed prescription schedule becomes inadequate, INM would be deployed to reset the individual to his pre-treatment form, at which juncture a clean medication course might just be commenced.

2.2.8. Study proposal with a numerical illustration

This portion involves the research that seeks to apply the successfully participated to a hospital setting. The approach's strongest comparison is that, by also including basic truths in the model, this may be calculated to assess the actual course of disease. The technique may be used to prescribe a treatment course for that same ailment. It is daunting to properly treat each service user due to the complex nature of the health assessment and the greater amount of psychiatric nurse practitioner empiricism necessary; data is gathered from numerous terminally stupid individual citizens for the application's narrative idea sculpting and quantitative inference. Four patients with acute breathing disease that require a prognosis from a clinician are the topics of a research study. Although most ailments have conflicting indications, it is tricky to distinguish only the one. The medical team rules out specific aspects dependent on the physician's behaviors, previous and present emotional effects, the physician's biography, heredity and physiological physical stress, and many other aspects. In order to collect the data for the patients, the programming team first works with the medical professionals to determine the symptoms and their thresholds while considering the timelines on when the symptoms of each of the diseases occur and at what intensity do they present themselves. From there, the patients are monitored in such a way to quantify the intensity of the symptoms based on a particular timeline. This is done by the opinions of doctors. Once that is done, the parameters and thresholds are finetuned and tested continuously on newer patients until the results of the model and the diagnosis presented by the doctors start to align. This is how the model patient data is to be collected and utilized in a proper format.

Table 3
Tabulation of z^1_V.

Symptoms/patients	k_1	k_2	k_3	k_4
(t_{11}, t_{21}, t_{31})	0.4	0.1	0.5	0.3
(t_{11}, t_{21}, t_{32})	0.1	0.8	0.4	0.1
(t_{12}, t_{21}, t_{31})	0.4	0.8	0.7	0.1
(t_{12}, t_{21}, t_{32})	0.3	0.1	0.2	0.6

Table 4
Tabulation of z^2_V.

Symptoms/patients	k_1	k_2	k_3	k_4
(t_{11}, t_{21}, t_{31})	0.2	0.2	0.1	0.2
(t_{11}, t_{21}, t_{32})	0.2	0.2	0.6	0.2
(t_{12}, t_{21}, t_{31})	0.4	0.8	0.7	0.1
(t_{12}, t_{21}, t_{32})	0.5	0.3	0.6	0.8

Table 5
Tabulation of $\sqcup z^{\epsilon}_V$.

Symptoms/patients	k_1	k_2	k_3	k_4
(t_{11}, t_{21}, t_{31})	0.4	0.2	0.5	0.3
(t_{11}, t_{21}, t_{32})	0.2	0.8	0.6	0.2
(t_{12}, t_{21}, t_{31})	0.4	0.8	0.7	0.1
(t_{12}, t_{21}, t_{32})	0.5	0.1	0.6	0.8

Table 6
Tabulation of $z_{V'}$.

Symptoms/patients	k_1	k_2	k_3	k_4
$(t'_{11}, t'_{21}, t'_{31})$	0.2	0.8	0.6	0.2
$(t'_{11}, t'_{21}, t'_{32})$	0.4	0.8	0.7	0.1
$(t'_{12}, t'_{21}, t'_{31})$	0.4	0.2	0.5	0.3
$(t'_{12}, t'_{21}, t'_{32})$	0.5	0.1	0.6	0.8

Step 1. Assume $Q = \{k_1, k_2, k_3, k_4\}$ a quintet of patients. Let t_1 =Fever, t_2 =Chills and t_3 =Cough, be the features from each requirement with accompanying subvalues that are valid for the collections V_1, V_2, V_3. Let $V_1 = \{t_{11}$ =High, t_{12} =Low$\}$, $V_2 = \{t_{21}$ =Low blood sugar$\}$, $V_3 = \{t_{31}$ =Coughing up blood, t_{32} =Coughing that lasts three or more weeks$\}$, Upon extensive investigation, a doctor can confirm this. With the physician's details available as $z^{\epsilon}_V \in FHS(Q)$ and the first, second-day record foundation as 3 and 4 separately, which are both in FHS, one may produce the two days chart z^1_V and z^1_V. The underlying FHS $\sqcup z^{\epsilon} V$ is found in Table 5.

Step 2. Let t'_1 =Night sweats, t'_2 =Appetite, t'_3 =Fever, be distinctive characteristics of combined TB manifestations, along their corresponding sub-values constituting the groupings V'_1, V'_2, V'_3. Let $V'_1 = \{t'_{11}$ =Endocarditis, t'_{12} =Osteomyelitis$\}$, $V'_2 = \{t'_{21}$ =Loss of appetite and unintentional weight loss$\}$, $V'_3 = \{t'_{31}$ =intermittent, t'_{32} =remittent$\}$. Specialists ascribe weights to diagnoses depending on patient details, and use the FHS $z_{V'}$ type to generate qualitative information to quantifiable transcription, as shown in Table 6.

Step 3. Define two transformations in this form; $\phi : Q \to Q$, $\omega : V \to V'$ such that $\phi(k_1) = k_1$, $\phi(k_2) = k_2$, $\phi(k_3) = k_3$, $\phi(k_4) = k_4$, and
$\omega(t_{11}, t_{21}, t_{31}) = (t'_{11}, t'_{21}, t'_{31})$,
$\omega(t_{11}, t_{21}, t_{32}) = (t'_{11}, t'_{21}, t'_{32})$,
$\omega(t_{12}, t_{21}, t_{31}) = (t'_{12}, t'_{21}, t'_{31})$,
$\omega(t_{12}, t_{21}, t_{32}) = (t'_{12}, t'_{21}, t'_{32})$.

Accordingly, FHS-mapping may be described in this approach: $\psi = (\phi, \omega) : FHS(Q) \to FHS(Q)$. Now, seek to introduce the method provided here in Step 3 and the translating mechanism mentioned here to calculate the image of $\sqcup z^{\epsilon}_V$ represented as $\sqcup z'_{V'}$ in Table 7.

Table 7
Tabulation of $z'_{V'}$.

Symptoms/patients	k_1	k_2	k_3	k_4
$(t'_{11}, t'_{21}, t'_{31})$	0.22	0.12	0.24	0.2
$(t'_{11}, t'_{21}, t'_{32})$	0.2	0.18	0.24	0.1
$(t'_{12}, t'_{21}, t'_{31})$	0.1	0.18	0.32	0.09
$(t'_{12}, t'_{21}, t'_{32})$	0.22	0.08	0.12	0.2

Table 8
An initially assessment table's tabulated explanation has been used to analyze the outcomes' credibility.

Symptoms/patients	k_1	k_2	k_3	k_4
$(t'_{11}, t'_{21}, t'_{31})$	LAT	MMT	SMT	LAT
$(t'_{11}, t'_{21}, t'_{32})$	LAT	MMT	SMT	MMT
$(t'_{12}, t'_{21}, t'_{31})$	MMT	MMT	SMT	LMT
$(t'_{12}, t'_{21}, t'_{32})$	LAT	LMT	MMT	LAT

Table 9
Input about auxiliary ailments should be included in the clinical assessment.

Patients	Total average score
k_1	0.74
k_2	0.56
k_3	0.92
k_4	0.509

Table 10
Tabulation of $\chi_{V'}$.

Treatments/symptoms	$(t'_{11}, t'_{21}, t'_{31})$	$(t'_{11}, t'_{21}, t'_{32})$	$(t'_{12}, t'_{21}, t'_{31})$	$(t'_{12}, t'_{21}, t'_{32})$
d_1	0.2	0.3	0.1	0.5
d_2	0.6	0.4	0.6	0.6
d_3	0.6	0.5	0.3	0.2
d_4	0.5	0.3	0.4	0.7

Step 4. Examine Table 7 with Table 2 for the first prognosis Table 8 in this procedure. This can then be used to examine the integrity of the simulation result.

Step 5. The function then calculates the average of all values for each patient. The additional patients are drawn in Table 9 in a similar manner. A comparison of the findings with the TB diagnostic parameter chart shown in Table 1 may be made using Table 9. Patients k_1, k_3 were found to have active TB, but patients k_2, k_4 were found to have mild TB.

Step 6. Considering a management of acute of each clinical assessment, the doctor may suggest a treatment regimen. According with particular prescription, an unique FHS schedule is generated, and a possible particular strategy is presented in line with the supplied assessment. Let

$$V' = \left\{ \begin{array}{c} (t'_{11}, t'_{21}, t'_{31}), (t'_{11}, t'_{21}, t'_{32}), \\ (t'_{12}, t'_{21}, t'_{31}), (t'_{12}, t'_{21}, t'_{32}) \end{array} \right\}$$

be a cluster of TB-related ailments. Suppose, $D = \{d_1$ = Rifampin, d_2 = Pyrazinamide, d_3 = Ethambutol (RIF), d_4 =Isoniazid$\}$ be a combination of remedies the practitioner suggests. The $\chi V' \in FHS(Q)$ function has already been established and is provided as a Table 10. Relying on each person, the options in Table 10 are updated. Rankings for membership consider in both the benefit of medicines for each variety of TB and their justification.

Step 7. In attempt to decide the relationship amongst prescription medications and certain patients, the combination of the FHS set is analyzed between $\chi_{V'}$ and $z'_{V'}$, as shown in Table 11.

Table 11
Q_D^1: composition within $\chi_{V'}$ and $z'_{V'}$.

Patients/treatments	d_1	d_2	d_3	d_4
k_1	0.22	0.3	0.24	0.5
k_2	0.6	0.4	0.6	0.6
k_3	0.6	0.5	0.32	0.2
k_4	0.5	0.3	0.4	0.7

Table 12
Chart illustrating clinical manifestations and potential therapies.

Patients/treatments	d_1	d_2	d_3	d_4	Maximum esteems	Selected treatment
k_1	0.22	0.3	0.24	0.5	0.5	d_4
k_2	0.6	0.4	0.6	0.6	0.6	d_1 or d_3 or d_4
k_3	0.6	0.5	0.32	0.2	0.6	d_1
k_4	0.5	0.3	0.4	0.7	0.7	d_4

Table 13
Tabular representation of Q_D^2.

Patients/treatments	d_1	d_2	d_3	d_4
k_1	0.25	0.4	0.3	0.52
k_2	0.65	0.5	0.68	0.63
k_3	0.7	0.4	0.2	0.1
k_4	0.4	0.2	0.1	0.3

Table 14
Tabular representation of Q_D^3.

Patients/treatments	d_1	d_2	d_3	d_4
k_1	0.1	0.3	0.1	0.2
k_2	0.1	0.36	0.51	0.2
k_3	0.2	0.2	0.3	0.03
k_4	0.3	0.02	0.3	0.12

Step 8. The prescription is optimum for the person, offering one of most effectiveness with the minimal detrimental consequences. The physician's prognosis is considered in determining the utmost score values, as seen in the Table 12. Table 12 demonstrates that drugs $d1$ are superior for the individual. The best combination for k_3, d_4 is best for k_1, k_2 and k_4 and d_1 and d_3 is better for k_2 respectively. The ultimate decision is made primarily on the participant's existing condition, health history, and really disease. The patient's present state, his examination, and the sort of condition all have a part in defining his aspects of the construction.

Step 9. Each individuals maintains a various positions according on their symptom severity and their experiences. Before the sickness is adequately healed, anyone can reproduce incidents. The FHS-mapping tool would be used to analyze each clinical management. Now, identify two mappings: $\phi' : Q^{q-1} \to Q^q$, $\omega' : I^{q-1} \to I^q$ such that $\phi'(k_1) = k_1$, $\phi'(k_2) = k_2$, $\phi'(k_3) = k_3$, $\phi'(k_4) = k_4$, and $\omega'(i_1) = i_1, \omega'(i_2) = i_2, \omega'(i_3) = i_3$.

The FHS-mapping is $\psi' = (\phi', \omega') : Q_I^{q-1} \to Q_I^q$. The FHS-mapping is given as $Q_I^q = \psi'(Q_I^{q-1})(f)(k)$

$$= \frac{1}{q}\begin{cases} \sqcup_{\pi\in\phi'^{-1}(k)}(\sqcup_{\varsigma\in\omega'^{-1}(f)\cap I} Q_I^{q-1}(\pi)) & \text{if } \phi'^{-1}(k) \neq \emptyset, \\ \qquad \omega'^{-1}(f) \cap I \neq \emptyset & \\ (0,0) & \text{if } otherwise \end{cases} \tag{5}$$

for $q \geq 2$ indicates the total number of sessions and $f \in \omega'(I) \subseteq I$, $k \in Q$, $\pi \in Q^{q-1}$, $\varsigma \in I^{q-1}$ and specialized individual therapy are provided in Table 13, Table 14, Tables 15 and 16 for q.

Step 10. Step 9 is followed till it patient understands restored and cured of their sickness. Fig. 4, Fig. 5, Fig. 6, and Fig. 7 indicates the participant's update on the progress.

Table 15
Tabular representation of Q_D^4.

Patients/treatments	d_1	d_2	d_3	d_4
k_1	0.02	0.04	0.04	0.05
k_2	0.06	0.04	0.07	0.06
k_3	0.06	0.05	0.03	0.02
k_4	0.05	0.03	0.4	0.07

Table 16
Tabular representation of Q_D^5.

Patients/treatments	d_1	d_2	d_3	d_4
k_1	0.0025	0.001	0.02	0.004
k_2	0.07	0.04	0.007	0.008
k_3	0.064	0.003	0.004	0.005
k_4	0.002	0.04	0.005	0.007

3. Comparative assessment and comments

The presented model highlights a theoretical framework that can be trained as a diagnostic support system for Tuberculosis. With TB causing over 1.4 million deaths alone in 2014, it is essential to develop a system that can correctly help diagnose the ailment so timely countermeasures can be taken. The model is based on Fuzzy Hypersoft Set that can quantize the symptoms in a mathematical syntax presented by the patient using its amplitude term while its phase term binds that amplitude term with the time on which the patient presented the symptom. With this method, each of the symptoms can be mapped to a specific disease based on the severity of the symptoms presented at different points in time. This model is superior to the ones already presented in literature as it can individually quantize each symptom in time and develop a mapping to the disease. As each disease presents numerous symptoms at the same time but the severity differs at different points in time, this pattern can be programmed to develop a decision support system that can help doctors diagnose Tuberculosis. The current limitations of the method are that initial gathering and quantizing of symptom thresholds as they need to be properly adjusted and finetuned using expertise of medical professionals for individual diseases that present that same set of symptoms so a mapping can be developed. Also, this methodology can be used for checking the efficiency of medical treatments as intensity of symptoms is being monitored with time and processed through the mapping system based on a fuzzy hypersoft set. The lowering of intensity of symptoms with time means that the medication is effective while adverse factors can be monitored as well. The FHS mapping paradigm is comprehensive and effective for a number of environments. Although they have limitations (see Table 17), theoretical concepts cannot be intended to address and examine the difficulties. Because of such boundaries, incapable or unwilling to gather all of a physician's initial information. The presented method is able to transform the patient condition into a quantitative style without gaps or overlaps, permitting us to secure the best findings for diagnosis and treatment. The presented approach is compared to existing theories on structural and computational basis in Table 17. All currently used procedures are inadequate when features would be further divided into input variables. These shortcomings are remedied by the specified mapping. It demonstrates that our approach is more reliable and successful at overcoming such difficulties than traditional methods. Now, the recommended plan is discussed along with its comprehensive nature.

1. TB, due to its diagnostic complication during the first assessment of the patient, the algorithm adds additional days to the initial approximation in the form of FHS to get a general idea of the pattern corresponding to the symptoms to determine the severity of the disease.

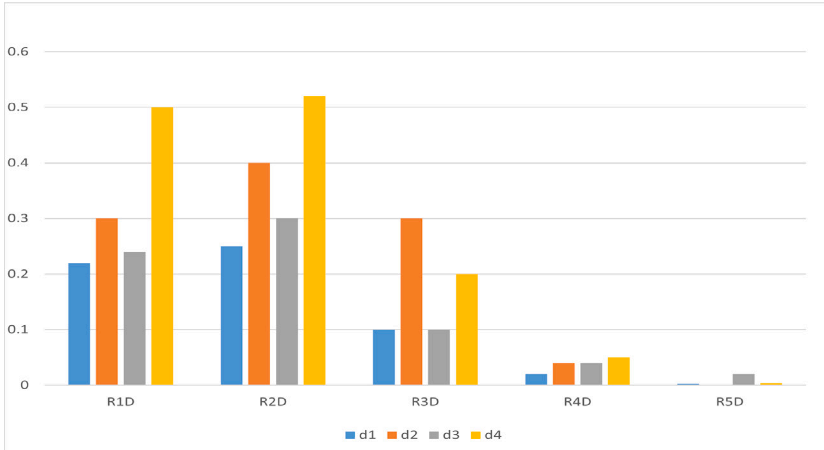

Fig. 4. Patient's success record k_1.

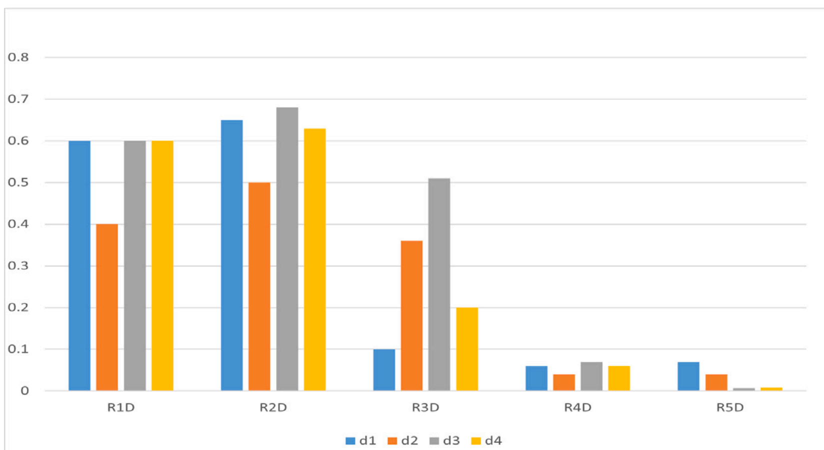

Fig. 5. Patient's success record k_2.

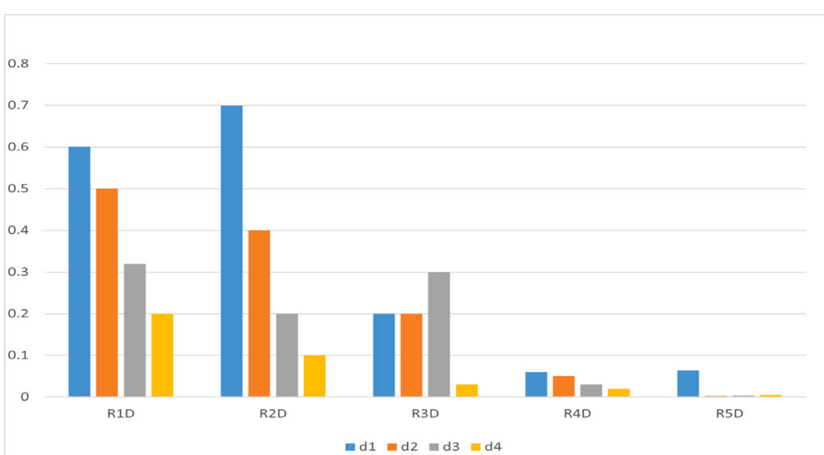

Fig. 6. Patient's success record k_3.

2. The patient is regularly monitored to develop a relationship between the severity of the disease with its critical indications along with the symptoms (weighed analysis). The analysis would be incomplete if only the initial symptoms recorded at the first assessment are to be always accessed.
3. Based on the results obtained from the mapping, a treatment method based on the type of TB that was diagnosed by the algorithm is suggested.
4. Continuous monitoring of the patient's condition is done over the course of their recovery. If the patient responds well to the

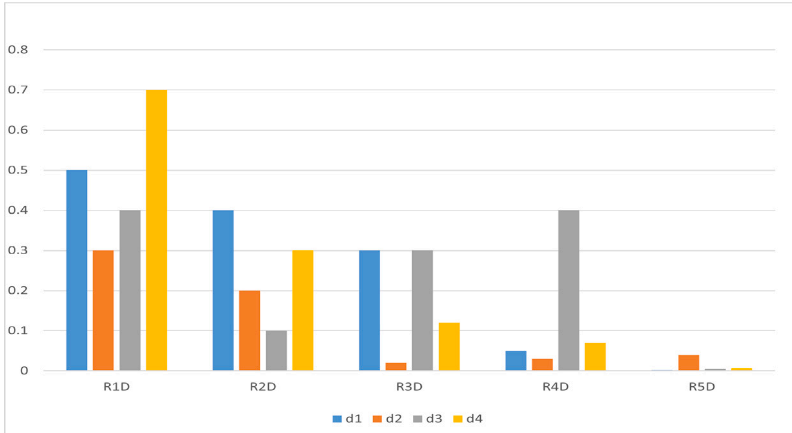

Fig. 7. Patient's success record k_4.

Table 17
The suggested FHS is compared to scientific theories.

References	COFMG	EOMA	COM	COSAV	RBTBDT
Zadeh [11]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$
Heilpern [14]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$
Kharal and Ahmad [35]	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$
Kharal and Ahmad [36]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$
Riaz and Hashmi [37]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$
Karaaslan [39]	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$
Zhang and Zhang [40]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$
Chen et al. [41]	$\hat{\Delta}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$	$\hat{\nabla}$
Proposed model	$\hat{\Delta}$	$\hat{\Delta}$	$\hat{\Delta}$	$\hat{\Delta}$	$\hat{\Delta}$

medication, continue the medication. If not, record the conditions again to reassess the approach and start another treatment method.

5. Fuzzy hypersoft mapping due to its ability to deal with sub-parameters in a comprehensive and coherent manner, can be employed for the analysis of timeline of various diseases to develop mappings that can be used for diagnostic support systems.
6. Based on the degree of matching of the mapping to the disease, a degree between 0 and 1 is given after processing using FHS indicating which disease most likely corresponds to the patient's condition.
7. The scientific prototype provided in this article tends to develop a quantitative relationship between the symptoms and disease as each disease follows a specific pattern with the passage of time. The calculation is entirely based on FHS-mapping that can be used as a diagnostic support system if tested with real data and finetuned for diseases with similar indicators. Another advantage of the system is that medication procedures can be programmed alongside the mappings that allow it to suggest optimal treatment methods corresponding to each disease.

In Table 17, the abbreviations COFMG, EOMA, COM, COSAV and RBTBDT stand for "Consideration of fuzzy membership grade", "Entitlement of multi arguments", "Consideration of mapping", "Consideration of sub-attribute values" and "Ranking based on TB-diagnosis and treatment" respectively. Similarly the symbols $\hat{\Delta}$ and $\hat{\nabla}$ are meant for "Yes" and "No" respectively.

4. Conclusions

The primary objective of this research seems to be to act as a framework for clinical diagnosis for the assessment of tuberculosis and indeed the issues related with it. Integrating FHS-mapping and INM, the section will analyze the client's good area on current observations. There have been 3 stages to the approach. The intensity of the condition of the patient is appraised in the very first stage predicated on the malady. The second process incorporates the prescription of prescription, which is mapped through FHS mapping in keeping with the patient's illness and prognosis as described in process one amongst the protocol. The third step is to construct a comprehensive FHS structure and make use of the medical reports and anticipated prescription distribution whenever the patient's restoration appears within standard range of tests and treatments. This procedure would be used to assess and assess a wide range of conditions, which affords it a multitude of uses. The findings obtained by linking this procedure only with literature are comprehensive, accessible, and have excellent adaptability to investigate multi-criteria ruling issues. This technique's future opportunities here include adaptation of the presented techniques' domains into a variety of additional frameworks, namely Neutrosophic Hypersoft Set, Plithogenic Hypersoft Set, Plithogenic Intuitionistic Fuzzy Hypersoft Set, and its combination frameworks. Extensions of the proposed method are included under keywords of signal processing, machine learning research, and diagnostic medical challenges.

CRediT authorship contribution statement

Muhammad Saeed: Conceptualization, Methodology, Formal analysis, Investigation, Writing – review & editing, Visualization, Supervision. **Muhammad Ahsan:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Muhammad Haris Saeed:** Conceptualization, Methodology, Software, Validation, Data curation, Writing – original draft, Visualization. **Atiqe Ur Rahman:** Software, Validation, Data curation, Writing – original draft, Visualization. **Mazin Abed Mohammed:** Conceptualization, Software, Data curation, Writing – review & editing, Supervision, Project administration. **Jan Nedoma:** Writing and editing, Funding acquisition. **Radek Martinek:** Writing and editing, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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