Fuzziness in Diagnosis and Treatment of Urinary Tract Infections

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ABSTRACT

Urinary tract infection is commonly encountered medical problem throughout the world occurring in any age group. If misdiagnosed or untreated, it may develop many life threatening complications. In this paper we focus on vagueness and complexity in diagnosis and treatment of UTI .The paper is organized into three sections. First section does discuss about the symptoms, diagnosis and treatment options for uncomplicated urinary tract infections. Data has been taken from literature available. Second section explains fuzziness and complexity in diagnosis and treatment of UTI and overview of fuzzy logic. Since diagnosis and treatment data is vague and imprecise, there is inherent uncertainty and complexity in the problem. In third section, we propose design of fuzzy algorithm for planning treatment of UTI in women.

General Terms

Soft Computing, Algorithm

Keywords

UTI, symptoms, treatment, complexity, fuzzy

1. INTRODUCTION

Urinary Tract Infection(UTI):

Urinary tract includes organs responsible for filtering blood and removing waste products from body. They include kidneys, bladder, urethra and ureter[1]. Urinary tract infections are bacterial infections that cause disorders of urinary tract functions.

1.1 Classification of UTI

1.1.1 Based on the site of infection, UTIs can be classified as below [2]



Fig. 1. Classification of UTI

1. Urethritis: Infection of urethra.

2. Cystitis: Infection of urinary bladder.

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3. Pyelonephritis: Infection of Kidneys.

- 4. Prostatis: Infection of prostate
- 5. Vaginitis: Infection of vagina

1.1.2 Based on the complications of infection, UTIs can be classified as below.

1. Complicated UTI: There may be functional or structural

abnormalities of urinary tract.

2. Uncomplicated UTI: Absence of structural or anatomical

abnormalities of urinary tract. Symptoms of UTI

1.2 Symptoms of UTI

The symptoms of UTI vary according to age, sex, and location of the infection in the urinary tract. Some individuals may have no symptoms.

Symptoms commonly observed may include following:

- frequent urge to urinate
- pain or burning on urination
- cloudy and dark urine
- Unpleasant urine odor.

Adult female specific Symptoms

- lower abdominal pain
- bloated feeling
- sensation of full bladder
- vaginal discharge

Adult male specific symptoms

- rectal, testicular, penile, or abdominal pain
- pus-like drip or discharge from penis.
- Children specific symptoms:

blood in the urine

- abdominal pain
- fever
- vomiting

Symptoms in Newborns and infants

- fever or hypothermia
- poor feeding
- Jaundice
- vomiting
- diarrhea.

Location based symptoms:

- 1. Urethra: dvsuria
- 2. Bladder: Suprapubic pain
- 3. Ureter and kidney: fever and flank pain

1.3 Treatment Details of UTI

1.3.1 Treatment for UTI in Women

Symptoms: painful urination, urinary frequency, urinary urgency, or suprapubic pain [3]

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Sr. No.	Post- Menopausal	Allergic	Pregnant	Drug
1	yes	Yes	No	Ciprofloxacin (Cipro), 250 mg twice daily for seven days; or nitrofurantoin (Furadantin), 100 mg twice daily for seven days
2	yes	No	No	TMP-SMX, 160/800 Mg twice daily for seven days
3	No		Yes	Nitrofurantoin, 100 mg twice daily for seven days; fosfomycin (Monurol), 3-g single dose; or cephalexin (Keflex), 250 mg four times daily or 500 mg twice daily for seven days
4	No	Yes	No	Ciprofloxacin, 250 mg Twice daily for three days; or nitrofurantoin 100 mg twice daily for seven days
5	no	No	No	TMP-SMX, 160/800 mg, twice daily for three days)

Table 1. Treatment for UTI in Women

1.3.2 Treatment options for UTI in Children aged 2 - 24 Months Table 2. Treatment for UTI in Children

Sr. No.	Drug	Daily Dosage
1	Sulfisoxazole	120-150 mg/kg divided q4-6h 7-14 days
2	Sulfamethoxazole and trimethoprim	6-12 mg/kg TMP, 30-60 mg/kg SMZ divided q12h 7-14 days
3	Amoxicillin and clavulanic acid	20-40 mg/kg divided q8h 7-14 days
4	Cephalexin	20-50 mg/kg divided q6h 7-14 days
5	Cefixime	8 mg/kg divided q12-24h 7-14 days
6	Cefpodoxime	10 mg/kg divided q12h 7-14 days
7	Nitrofurantoin [*]	5-7 mg/kg divided q6h 7-14 days

1.3.3 Treatment options for UTI in Men 1.3.3.1 Treatment of Cystitis

- TMP-SMZ 7-10 days. or
- fluoroquinolone 7-10 days.
- 1.3.3.2 Treatment of urethritis in men
 - If gonococci infection then treat with • ceftriaxone (125 mg intramuscularly single dose) or
 - cefpodoxime (125 mg initialities cutarry single dose) or
 - cerpodoxime (400 mg orally single dose)
 cefixime (400 mg orally single dose)
 - If nongonococcal infection then treat with
 - azithromycin (1 g orally in a single dose) or

• doxycycline (100 mg orally 2 times a day for 7 days).

If infection not confirmed then treat with combination of gonococci and nongonococcal treatments.

2. FUZZINESS AND COMPLEXITY IN DIAGNOSIS AND TREATMENT OF UTI

- 1. Disease symptoms vary significantly as per age, sex and patient specific characteristics. Some patients may not experience any symptom at all. Thus diagnosis data is uncertain and inadequate. Fuzzy logic may be used to model such uncertainty.
- 2. Frequency of occurrence of symptoms, their severity, amount of drug dose, treatment duration are generally expressed in natural language such as often, frequently, usually, mild,moderate, severe, high, low etc.Since thinking and judgement of doctors vary significantly, there is no sharp boundary between often and usually or mild and moderate. Also accuracy of measuring devices and methods of measurement contribute to vagueness in data[5]. This vagueness and inexact boundary can be modelled by using fuzzy logic flexibility
- 3. Multiple treatment options are available for a particular disease or situation. Various factors such as age, sex, drug allergies must be considered for the selection of appropriate antibiotic and duration of therapy[6] Thus treatment planning requires combinatorial analysis of many decision variables which makes it a complex task that may be simplified using fuzzy logic.

2.10verview of Fuzzy Logic:

Fuzzy logic is a multi-valued logic that deals with approximate reasoning and allows the use of linguistic terms. In contrast with binary logic having only two values true and false, it handles partial truth by using degree of truth ness. Also it allows overlapping of data sets which is not possible in crisp logic.

Due to the flexibility offered by fuzzy logic, it has large number of applications in various fields. The structure of a typical fuzzy inference system is given below [7]



Fig. 2. Block Diagram of Fuzzy Inference System

3. PROPOSED FUZZY APPROACH

Treatment of a disease includes determination of amount of drug dose, frequency of dose and duration of treatment. Treatment is decided based on severity of disease, age and weight of the patient and some other patient specific characteristics.

We propose fuzzy algorithm for planning drug dose of Nitrofurantoin for treatment of UTI in women.

3.1 Input and Output for the algorithm

We consider three input and three output variables for the proposed algorithm.

Fuzzy sets for Input variables:

1. Age

Table3. Fuzzy Sets for Age

Sr.	Range (in yrs)	Fuzzy set
No.		
1	15-25	young
2	20-50	adult
3	45-60	Old
4	>60	Very old

2. Severity

Table 4. Fuzzy Sets for severity

Sr. No.	Range	Fuzzy set
1	30-40	Very low
2	40-60	low
3	55-75	medium
4	70-85	gh
5	>85	Very high

3. pregnacy_status

This variable has only two possible values, yes or no and has non overlapping fuzzy sets.

Table5. Fuzzy Sets for pregnancy_status

Sr. No.	value	Fuzzy set
1	0	no
2	1	yes

Fuzzy sets for Output variables:

1. Quantity (amount of drug dose) Table6. Fuzzy Sets for quantity

Sr. No.	Range	Fuzzy set
1	50-100	low
2	75-125	medium
3	100-150	high
4	150-200	Very high

2. Frequency (daily frequency)

Table7. Fuzzy Sets for frequency

Sr. No.	Range	Fuzzy set
1	1-2	low
2	2-3	medium
3	3-4	high

3. Duration (duration of treatment in days)

Table8. Fuzzy Sets for duration

Sr. No.	Range	Fuzzy set
1	1	Very low
2	1-3	low
	3-5	medium
3	5-7	high
4	7-10	Very high

3.2 Fuzzy Rulebase

Following table shows some sample fuzzy rules for the proposed algorithm

Table9. Fuzzy Rulebase

Sr.	Rule
No.	
1	If Age is young and severity is very low and
	pregnancy_status is no then quantity is low and
	frequency is low and duration is low.
2	If Age is young and severity is low and
	pregnancy_status is no then quantity is low and
	frequency is low and duration is low.
3	If Age is young and severity is medium and
	pregnancy_status is no then quantity is medium and
	frequency is low and duration is medium.

3.3 Defuzzification

In defuzzififcation, fuzzy output is converted to crisp output. A well known centroid method can be used for defuzzification.

4. CONCLUSION

It is seen that vagueness and complexity is inherent to problem of treatment planning and is best suitable for application of fuzzy logic. The future work aims at development of proposed fuzzy algorithm and to test its performance.

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