**ORAL CANCER SUSCEPTIBILITY ASSESSMENT USING PYTHON**

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**Abstract -** A type of cancer that affects the lining of the lips, mouth, or upper throat is called oral cancer. It is estimated that people who use alcohol and tobacco both have a 15 times higher risk of developing oral cancer than those who do not use them. Using statistical application techniques, susceptibility assessment has been done for a selected population based on oral health and habit questionnaire. Methodically collected data has been initially divided into age based small subgroups. A processed data based on If-Then rules with cer- tain conditions has been used to investigate patients’ susceptibility to oral pre- cancers and squamous cell carcinoma. To achieve a more accurate prediction of the disease outcome and the associated condition, similarity measures using the Jaccard similarity coefficient has been incorporated. Based on age, gender, demographics, and oral health hygiene, the data set have been clustered in to various groups having different degree of susceptibility to oral cancer. As a result, strategies for policy making via real-life questionnaire data handling will be developed using this analytical approach.

**Introduction:**

One of the most prevalent cancers is oral cancer, especially in Asia, where it accounts for around 66% of all instances of oral cancer (OC), with an estimated 248,360 new cases and 131,610 fatalities each year. The prevalence of OC is highest among Indian men, and it looks to be spreading around the world [1]. The overall 5-year survival rate of OC patients is between 50 and 60%, despite improvements in surgical techniques, adjuvant radiation, and chemotherapy. Interdisciplinary therapy and early detection can increase the success rates of OC treatment [2]. The most well-known risk factors for OC are HPV-16/18, betel nut use, cigarette smoking, drinking alcohol, and chewing tobacco [3,4,5]. With over 100 million users in India and Pakistan alone, Southeast Asia is thought to account for over 90% of the world's smokeless

tobacco usage burden [6]. Annually, nearly 2–3 percent of oral lesions show diseased conversion. Long term effect studies clinically imply that OLK accompanying harsh dysplasia is more liable until revolution into OSCC [7]. Additionally, it has been demonstrated that a person's risk of developing oral cancer is increased when they smoke, consume alcohol, and practise poor oral hygiene because these behaviours affect the resident microbiota that is necessary for maintaining the environment's homeostasis in the mouth . Chronic inflammation and infection are the main factors in cancer pathogenesis [8,9] .

**Literature review:**

Intake of tobacco is the essential reason of demise and disability worldwide. it’s miles acquired from Nicotiana tabacum. When extensively classified, to- bacco is both smoked or smoke less tobacco “a big type of commercially or non-commercially available merchandise and combinations that include tobacco because the principal constituent and are used both orally or nasally with out combustion” [10]. The amount, frequency, and length of smoke less tobacoo exposure are inversely correlated with the occur- rence and severity of tobacco-related oral lesions. Symptomatic exposure may result in OLK [11]. A dosages relationship has been observed between Smoke less tobacco use and an elevated chance of oral cancer across the USA [12]. The roles of Betel quid and Smoke less tobacco in the Indian people are widely understood [13]. In a meta - analytic review, bidi smoking showed a higher odds ratio (OR) than smoking cigarettes when tobacco use is taken into account [14]. A person was thought to have the highest risk of developing cancer if they were subjected to each smoking agents on a regular basis due to their synergistic effects. A study reported that betel nut use could prevent oropharynx and esophageal cancer without consuming cigarettes. We assessed chewing as a possible carcinogen when OSCC was taken into account. An oral pre-cancer (OSF) may develop even without tobacco usage, according to a research, if irritation from frequent chewing causes it [15]. The intensity and severity of chewing betel nut without tobacco was found to have a dosages relation that raised the risk of OSF [16]. Chewing betel nut, whether with or without cigarettes, is regarded as a standalone cancer-causing risk [17]. There are numerous activities you can engage in to campaign of oral health in India [18]. Repeatedly, it was discovered that the Indian population’s good oral healthcare awareness, attitude, and sanitary measures practise were directly related to their economic factors. Although poor oral hygiene was thought to be a separate OSCC-causing disease [19,20] . Fuzzy logic is frequently used to interpret ambiguous knowledge that is contained in a system and incorporates hazy human judgement in issues that are not taken into account by any traditional computing techniques. The precision in the meaning of an output and gaining an understanding of a complicated system with tolerance for imprecision are what make fuzzy logic's practical applications so beautiful [21]. By using fuzzy numbers, complex systems can be modelled utilising a higher level of abstraction based on known information and experience [22]. When considering real-life situations, it is frequently observed that the number of addictive products consumed daily is not always fixed, and that people who are illiterate or who lack proper knowledge frequently are unable to provide precise information on the year in which an addictive habit first developed [23].

**Proposed method:**

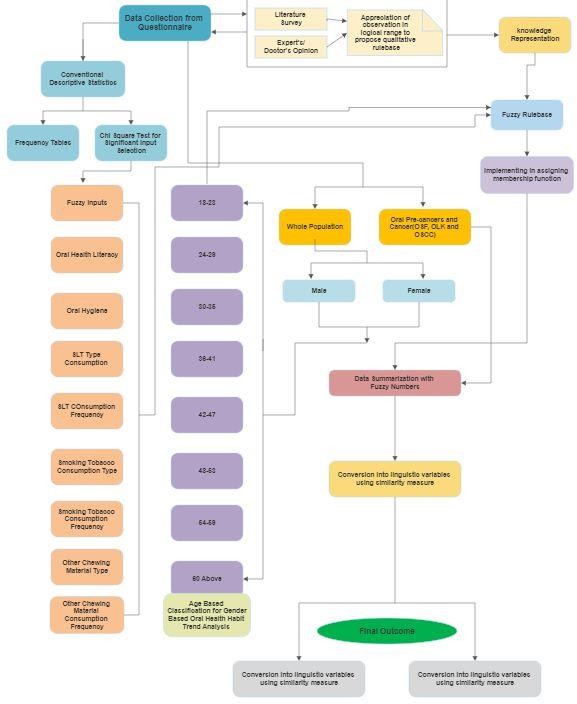
The proposed method is demonstrated schematically (Figure. 1) and represented by the following steps:

**Subject selection**

A study of the rural population in Tamil Nadu,vIndia, was chosen for this study. In spite of its cultural diversity, this population has not received much attention as far as their oral health is concerned. Although this group is well renowned for the variety of cultures represented in the area, limited data recognized about their oral health.

**Data collection strategy**

A number of variables were collected, including age, gender, education level, oral cancer, alcohol consumption, tobacco smoking, tobacco chewing, chewing of betal nuts and leaves, and brushing habits. Erstwhile written informed consent from all patients and from the concerned authorities was taken. An oral health habit-related questionnaire was used to interview 359 patients (201 males and 158 females) who attended the hospital’s outpatient department for oral health treatments.



**Figure 1 Proposed methodology on application of fuzzy consensus in assessing oral cancer susceptibility**

**Data Analysis Strategy**

**Conventional statistical analysis**

In order to estimate risk and to select primary features for use in the risk assessment, clinical-epidemiological data from the study subjects were analyzed statistically using Python version 3.0 and scipy module. Pearson’s chi-square test was used to compare each input variable between patients with and without oral lesions. and the cutoff significance was established at pi 0.01.The degree of freedom is 1.

**Defining fuzzy numbers and If-Then rule base creation**

To map linguistic variables from numeric data for fuzzy reasoning, a fuzzy inference rule and membership function must be defined. Eight parameters were considered during the fuzzy rulebase generation. health literacy (X1), Brushing (X2), Smokeless tobacco type (X3), Smokeless tobacco frequency (X4), smoking type (X5), smoking frequency (X6), chewing habit type (X7) and chewing habit frequency (X8). Using physician intuition and literature review information, the rulebase was compiled[11-25] and few example rules can be found below[Appendix A & B]. Each gender was then again separated into eight age groups in years i.e., 18–23 years, 24–29 years, 30–35 years, 36–41 years,42–47 years, 48–53 years, 54–59 years and >= 60 years for age associated trend analysis. A fuzzy scale of 0–1 was used to describe input variables quantitatively through intuition in Table 1.

**Summarization of data**

Based on age and gender, the data were summarized according to frequencies. In order to summarize the data, the frequency of patients for each Age between and gender was sorted out in accordance with each rule, then the relative frequency of each type was multiplied by the corresponding fuzzy scale. To get the final fuzzy number which summarizes the condition of each group quantitatively, each fuzzy number was then added for each group. The data from 36 patients diagnosed with OSF, OSLK and OSCC were used to construct a fuzzy disease expert system for patients with oral pre-cancers and cancers. The generated fuzzy numbers were then used for further decision making. In some cases, linguistic interpretation of the mid value of the generated fuzzy set was ambiguous, therefore similarity measures were introduced. Tables 4, 5 for males, females respectively, show the linguistic outputs that were discovered to have changed after taking similarity measures into consideration. These outputs are where If-Then rules to predict disease susceptibility in specific conditions were ultimately obtained.

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| --- | --- | --- |
| Table | **Fuzzy scale(in 0-1)** | |
| Variable | Linguistic scale | Fuzzy scale |
| Oral health literacy (X1) | poor | (0, 0, 0.50) |
| [based on schooling level in | Satisfactory | (0, 0.50, 1) |
| Indian education system] | Good | (0.50, 1, 1) |
| Oral hygiene (X2) [assessed on | poor | (0, 0, 0.50) |
| brushing habit with toothpaste, powder, | Satisfactory | (0, 0.50, 1) |
| kala-manjan, lal-manjan,daantan, etc,] | Good | (0.50, 1, 1) |
| SLT type (X3) [based on | Low | (0, 0, 0.50) |
| materials used like tambaku,Gudaku and related products) | Moderate | (0, 0.50, 1) |
| High | (0.50, 1, 1) |
| SLT frequency (X4) | High | (0, 0, 0.50) |
| [frequency of consumption Of products divided into type | Moderate | (0, 0.50, 1) |
| i,e, occasional, less than 2/day,less than 2-5/day, more than 10/day | Low | (0.50, 1, 1) |
| Smoking type (X5) [based | Low | (0, 0, 0.50) |
| on materials used like Beedi and cigarette] | Medium | (0, 0.50, 1) |
|  | High | (0.50, 1, 1) |
| Smoking frequency (X6) | Low | (0, 0, 0.50) |
| [frequency of consumption of products divided into | Moderate | (0, 0.50, 1) |
| type, i.e. occasional,less than 2/day, 2-5/day, 5-10/day and more than 10 day] | High | (0.50, 1, 1) |
| Chewing habit type (X7) | Low | (0, 0, 0.50) |
| [based on the product used | Medium | (0, 0.50,1) |
| like betel quid and others consumption) | High | (0.50, 1, 1) |
| Chewing habit frequency(X8) | Low | (0, 0, 0.50) |
| [frequency of | Moderate | (0, 0.50, 1) |
| consumption of products | High | (0.50, 1, 1) |
| divided into few types. i.e.occasional, less than 2/day,less than 5/day,and more than 10/days |  |  |
| **Table 1: Fuzzy values for the input variables (in 0–1).** | | |

**Result and discussion**

**Descriptive statistics of the whole data:**

Table 2 contains specific observations made when evaluating the addictions that respondents claimed to have a connection to oral carcinogenesis. Table 3 shows the variables that were further taken into account when determining overall clinical outcomes and have confidence intervals. In the whole population, there is substantial evidence of a relationship between daily smoking tobacco (Pearson chi square 2.86), use of SLT (Pearson chi square 0.00143), betel nut chewing (Pearson chi square 1.35) and the presence of oral lesions. Low literacy rates (52.37) people were with education up to 8th standard of Indian education system) in conjunction with debilitating addictive habits were also found to be associated with oral precancers and OSCC occurrence in this area.Brushing daily and good education level showed a defensive effect on oral cancer occurrence.

**Analysis of the precised data**

The majority of recent research focuses on institutional studies that examine the frequency and distribution of various oral diseases and perform risk estimation for each particular possible causes . This investigation hence sought to identify a significant relationship between a number of clinico-epidemiological characteristics related to oral literacy

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| --- | --- | --- |
| **Variables** | **Frequency** | **Percentage** |
| **Gender** |  |  |
| Male | 201 | 55.99 |
| Female | 158 | 44.01 |
| **Education** |  |  |
| Illiterate | 77 | 21.45 |
| Primary | 27 | 7.52 |
| Medium | 84 | 23.40 |
| Secondary | 61 | 16.99 |
| Higher Secondary | 52 | 14.48 |
| Graduate | 50 | 13.93 |
| Higher than Graduate | 8 | 2.23 |
| **Brushing** |  |  |
| Yes | 347 | 96.66 |
| No | 12 | 3.34 |
| **Smoking Tobacco** |  |  |
| Yes | 65 | 18.11 |
| No | 294 | 81.89 |
| **Smokeless Tobacco** |  |  |
| Yes | 122 | 33.98 |
| No | 237 | 66.02 |
| **Betel Nut** |  |  |
| Yes | 103 | 28.69 |
| No | 256 | 71.31 |
| **Alcohol** |  |  |
| Yes | 111 | 30.92 |
| No | 248 | 69.08 |

Table 2: Table of variables, frequency, and percentage

levels, oral habits, and hygiene, as well as oral genetic susceptibility in various ages.This method merely employed a traditional risk estimation technique to extract the basic features. For the purpose of understanding such correlations via trend analysis of the dataset, the systematic fuzzy mapping of characteristics and linguistic transformation of allocated membership functions shown in tables (Tables 4, 5), were employed. Thus, disease risk was evaluated under certain settings utilising built-in If-Then rules. In addition to predicting oral pre-cancers and malignancies (OTH),the guidelines were also inferred to predict oral problems. Tables 4, 5were created by the linguistic transformation of fuzzy numbers for male, female respectively, in the framework of appraising characteristic summary towards the disease conditions. The eight characteristics (X1–X8) all were combined. The regulations are written in a way that one of them can be described as follows : Considering oral hygiene literacy and very good oral hygiene, males between 18 and 23 were more likely to experience oral complications other than pre-cancers and cancers (OTH), as well as very low Smokeless tobacco consumption and low smokeless tobacco consumption frequency, and low smoking tobacco type and low smoking tobacco consumption frequency as well as low chewing material type and low chewing material frequency.The perspective was found to be significantly different when the trend between the male and female population of various Age betweens was evaluated (Tables 4 and 5). Additionally, it more clearly illustrated age-based feature segmentation. Only women between the ages of 18 and 23, 30 and 41, and 54 and 59 showed greater oral health literacy than men, whereas in the Indian community, men are

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| --- | --- | --- | --- | --- | --- | --- |
| Variable | Type of variable | Meaning of variable | χ2 value | d.o.f | p- value |  |
| Age | bifurcated (0/1) | age  more/less  than 40 | 23.31 | 1 | 0.00 | Null Hypothesis  Is rejected. |
| Education | bifurcated (0/1) | Education </> than  standard 8th | 14.45 | 1 | 0.00 | Null Hypothesis is |
|  |  |  |  |  | rejected. |
| smoking  Tobacco | bifurcated (0/1) | yes/no | 2.86 | 1 | 0.09 | Failed to reject the  null hypothesis |
|  |  |  |  |  |
| smokless  tobacco | bifurcated (0/1) | yes/no | 0.00143 | 1 | 0.97 | Failed to reject the  null hypothesis |
|  |  |  |  |  |
| Betal Nut chewing | bifurcated (0/1) | yes/no | 1.35 | 1 | 0.24 | Failed to  Reject the  null hypothesis |
| Brushing | bifurcated (0/1) | yes/no | 0.68 | 1 | 0.41 | Failed to  reject the  null  hypothesis |
| **Table 3: Variables Selected after performing chi-square**  **test** | | | | | | |
|  | | | | | | |

thought to have higher education than women.smokeless tobacco type and

consuming frequency were significantly lower in females in this cohort than in males, which is

is consistent with other studies. The addiction of tobacco smoking was found to be extremely rare in girls, including both terms of types and frequency, but in males there was an increase from age 42 years (Table 4). Again, it is well recognised that OLK and cigarette use are related [10]. The current research has also shown new data to support the If-Then fuzzy rule for the development of such precancer from 40 years, when male smokers’ smoking habit and type started to rise from 36 years (Tables 4). Increased

prevalence of harmful oral behaviours, such as Smokeless tobacco use, was also observed in males in the 36-year-old Age between (Table 5). The findings of the other studies can be confirmed by the results of the present investigation, which showed a relationship between high smoking tobacco use and Smokeless tobacco intake,

poor oral hygiene, low oral health literacy, and high age in the case of OSCC prevalence.

# Conclusion

In order to add value to the results from traditional statistical methods, fuzzy

rule-base methods have been used to define specific associations between important clinic epidemiological

characteristics and their conceivable effects on disease output in a given dataset. Oral pre-cancers and OSCC

were found to be common in the investigated community for a variety of causes, including low literacy rates and

crippling addictions. Additionally, a fuzzy If-Then rule trend analysis of oral

health and habits revealed disparities in awareness attitude across Age betweens based on gender.The suggested

methodology can also predict the likelihood of illness susceptibility in specific conditions. In contrast to conventional statistical methods that predict disease chances in rigid quantitative values, the novelty of the proposed approach relies on consideration of the uncertainty of circumstances involved in disease incidence and incorporation of physician’s intuition in real-life situations. The population of a particular demographic was involved in the new dimension of questionnaire data management, and the same methodology can be used for other demographic circumstances as well. Additionally, it is the first of its kind and can assist physicians and decision-makers in implementing therapies and habit-preventing techniques.

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| Age between | Oral health literacy | Oral hy- giene | SLT  types con- sump- tion | SLT  con- sump- tion fre- quency | Smoking tobacco type | Smoking tobacco con- sump- tion  fre- quency | chewing material type | chewing material fre- quency | Disease Chances |
| 18–23 | Satis- | Good | Low | Low | Low | Low | Low | Low | OTH |
|  | factory |  |  |  |  |  |  |  |  |
| 24–29 | Satis- | Good | Low | Low | Low | Low | Low | Low | OTH |
|  | factory |  |  |  |  |  |  |  |  |
| 30–35 | Poor | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |  |  |  |  |
| 36–41 | Poor | Good | Low | Low | Medium | Moderate | Low | Low | OTH |
| 42–47 | Poor | Good | Low | Moderate | Low | Low | Medium | Low | OTH |
| 48–53 | Poor | Good | Moderate | Moderate | Medium | Moderate | Low | Low | OTH |
| 54–59 | Poor | Good | Moderate | Moderate | Low | Low | Medium | Low | OTH |
| 60 | Poor | Good | Moderate | Moderate | Medium | Moderate | Low | Low | OSF |
| Above |  |  |  |  |  |  |  |  |  |
| **Table 4: Oral health and habit trend acquired through linguistic conversion of fuzzy numbers in male** | | | | | | | | | |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Oral health literacy | Oral  hygiene | SLT  types con- sump- tion | SLT  con- sump- tion fre- quency | Smoking to- bacco type | Smoking tobacco con- sump- tion  fre- quency | chewing material type | chewing material frequency | Disease  Chances |
| 18–23 | Good | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |
| 24–29 | Poor | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |
| 30–35 | Poor | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |
| 36–41 | Poor | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |
| 42–47 | Poor | Good | Low | Low | Low | Low | Medium | Low | OTH |
|  |  |  |  |  |  |  |
| 48–53 | Poor | Good | Low | Low | Low | Low | Low | Low | OTH |
|  |  |  |  |  |  |  |  |
| 54–59 | Poor | Good | Low | Low | Low | Low | Medium | Low | OTH |
|  |  |  |  |  |  |  |  |
| 60 | Poor | Poor | Low | Low | Low | Low | Medium | Moderate | OTH |
| above |  |  |  |  |  |  |  |
| **Table 5: Oral health and habit trend acquired through linguistic conversion of fuzzy numbers in female.** | | | | | | | | | |

**Appendix A. If-Then Rules for oral health literacy**

|  |
| --- |
| If Age between 18–23 and Education level is Il or Med Then Oral health literacy is Poor |
| If Age between 18–23 and Education level is Pr or S or HS Then Oral health literacy is Satisfactory |
| If Age between 18–23 and Education level is G or HG Then Oral health literacy is Good |
| If Age between 24–29 and Education level is Il or Med or Pr Then Oral health literacy is Poor |
| If Age between 24–29 and Education level is S or HS Then Oral health literacy is Satisfactory |
| If Age between 24–29 and Education level is G or HG Then Oral health literacy is Good |
| If Age between 30–35 and Education level is Il or Pr or M or S Then Oral health literacy is Poor |
| If Age between 30–35 and Education level is HS or G Then Oral health literacy is Satisfactory |
| If Age between 30–35 and Education level is HG Then Oral health literacy is Good |
| If Age between 36–41 and Education level is Il or Pr or M or S or HS Then Oral health literacy is Poor |
| If Age between 36–41 and Education level is G Then Oral health literacy is Satisfactory |
| If Age between 36–41 and Education level is HG Then Oral health literacy is Good |
| If Age between 42–47 and Education level is Il or Pr or M or S or HS Then Oral health literacy is Poor |
| If Age between 42–47 and Education level is G Then Oral health literacy is Satisfactory |
| If Age between 42–47 and Education level is HG Then Oral health literacy is Good |
| If Age between 48–53 and Education level is Il or Pr or M or S Then Oral health literacy is Poor |
| If Age between 48–53 and Education level is HS Then Oral health literacy is Satisfactory |
| If Age between 48–53 and Education level is G or HG Then Oral health literacy is Good |
| If Age between 53–59 and Education level is Il or Pr or M or S Then Oral health literacy is Poor |
| If Age between 53–59 and Education level is HS Then Oral health literacy is Satisfactory |
| If Age between 53–59 and Education level is G or HG Then Oral health literacy is Good |
| If Age between >60 and Education level is Il or Pr or M or S Then Oral health literacy is Poor |
| If Age between >60 and Education level is HS Then Oral health literacy is Satisfactory |
| If Age between >60 and Education level is G or HG Then Oral health literacy is Good |

**Appendix B. If-Then Rules for oral hygiene**

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| --- |
| If Age between 18–23 and Brushing with ToothPaste or Powder Then Oral Hygiene Good |
| If Age between 18–23 and Brushing with KM or LM or Dantan Then Oral Hygiene Satisfactory |
| If Age between 18–23 and Brushing with Others Then Oral Hygiene Poor |
| If Age between 24–29 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 24–29 and Brushing with Powder or KM or LM Then Oral Hygiene Satisfactory |
| If Age between 24–29 and Brushing with Others or Dantan Then Oral Hygiene Poor |
| If Age between 30–35 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 30–35 and Brushing with Powder Then Oral Hygiene Satisfactory |
| If Age between 30–35 and Brushing with KM or LM or Dantan or Others Then Oral Hygiene Poor |
| If Age between 36–41 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 36–41 and Brushing with Powder or KM or LM or Dantan Then Oral Hygiene Satisfactory |
| If Age between 36–41 and Brushing with Others Then Oral Hygiene Poor |
| If Age between 42–47 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 42–47 and Brushing with Powder or KM or LM or Dantan Then Oral Hygiene Satisfactory |
| If Age between 42–47 and Brushing with Others Then Oral Hygiene Poor |
| If Age between 48–53 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 48–53 and Brushing with Powder or KM or LM or Dantan or Others Then Oral Hygiene Poor |
| If Age between 54–59 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between 54–59 and Brushing with Powder or KM or LM or Dantan or Others Then Oral Hygiene Poor |
| If Age between >60 and Brushing with ToothPaste Then Oral Hygiene Good |
| If Age between >60 and Brushing with Powder or KM or LM or Dantan or Others Then Oral Hygiene Poor |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Age group | Oral health literacy | SLT types cousurnption | SLT consumption frequency | Smoking tobacco type | Smoking tobacco consumption frequency | chewing material type | chewing material frequency | Oral hygiene | Y (disease chance) |
| 18-23 | 0.3, 0.518,  0.73 | 0.006, 0.05,  0.097 | 0.037, 0.081,  0.147 | 0.013, 0.081,  0.147 | 0.031,0.065,  0.116 | 0.088,0.206,  0.238 | 0.022, 0.072, 0.131 | 0.738  0.988, 1 | 0.004,  0.016,  0.349 |
| (M) |  |
|  |  |  |  |  |  |  |  |  |
| 24-29 | 0.304,  0.533,0.764 | 0.056, 0.110,  0.164 | 0.061,0.117,  0.168 | 0.009,0.028,  0.131 | 0.056, 0.112,  0.205 | 0.103,0.224,  0.252 | 0.040, 0.100, 0.159 | 0.493,  0.743,  0.995 | 0.006,  0.009,  0.34 |
| (M) |  |
|  |  |  |  |  |  |  |  |
| 30-35 | 0.081,  0.190, 0.440 | 0.089, 0.177,  0.262 | 0.097, 0.185,  0.259 | 0.016, 0.113,  0.194 | 0.060, 0.073,  0.153 | 0.113,0.234,  0.242 | 0.044, 0.105, 0.161 | 0.484,  0.734,0984 | 0.011,  0.027,  0.354 |
| (M) |  |
|  |  |  |  |  |  |  |  |  |
| 36-41 | 0.055,  0.161,0.411 | 0.136, 0.25,  0.356 | 0.225, 0.331,  0.394 | 0.060, 0.305,  0.492 | 0.301, 0.441,  0.475 | 0.093, 0.237,  0.288 | 0.102, 0.174, 0.288 | 0.483,  0.725,  0.975 | 0,0.005,  0.339 |
| (M) |  |
|  |  |  |  |  |  |  |  |  |
| 42-47 | 0.008,  0.084,0.360 | 0.242, 0.358, | 0.258, 0.373, | 0.023, 0.2, | 0.192, 0.281, | 0.170, 0.362, | 0.204, 0.3,0.384 | 0.462,  0.731,  0.962 | 0.15,  0.026,  0.348 |
| (M) | 0.454 | 0.462 | 0.354 | 0.354 | 0.385 |  |
|  |  |  |  |  |  |  |  |
| 48-53 | 0.034,  0.097,0.347 | 0.278, 0.420, | 0.313, 0.455, | 0.057, 0.318, | 0.290, 0.420, | 0.136,0.318, | 0.193,0.284, 0.364 | 0.42,  0.631,  0.881 | 0.038,  0.068,  0.386 |
| (M) | 0.557 | 0.568 | 0.523 | 0.523 | 0.364 |  |
|  |  |  |  |  |  |  |  |
| 54-59 | 0.043,  0.091,0.341 | 0.256, 0.378, | 0.262, 0.384, | 0.085, 0.293, | 0.232,0.335, | 0.195,0.402, | 0.207,0.311, 0.415 | 0.463,  0.695,  0.945 | 0.041,  0.073,  0.394 |
| (M) | 0.469 | 0.488 | 0.415 | 0.415 | 0.414 |  |
|  |  |  |  |  |  |  |  |
| 60  above | 0.019,  0.055,0.305 | 0.310, 0.454, | 0.319, 0.463, | 0.231, 0.518, | 0.287, 0.430, | 0.148,0.305, | 0.162,0.240, 0.315 | 0.481,  0.722,  0.972 | 0.123,  0.191,  0.468 |
| 0.565 | 0.574 | 0.574 | 0.574 | 0.315 |  |
| (M) |  |  |  |  |  |  |  |
| 18-23 | 0.383,  0.657,0.901 | 0, 0.003,0.009 | 0,0.003, 0.009 | 0, 0, 0 | 0, 0, 0 | 0.043,0.136  0.191 | 0.018,0.049, 0.099 | 0.741,  0.987, 0.991 | 0,0,0.333 |
| (f) |  |  |  |  |  |  |
| 24-29 | 0.223,  0.443,0.696 | 0.024, 0.048,  0.072 | 0.036, 0.066,  0.09 | 0, 0, 0 | 0, 0, 0 | 0.060,0.157,  0.205 | 0.033,0.087, 0.139 | 0.463,  0.696,  0.946 | 0,0,0.333 |
| (f) |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 30-35  (f) | 0.013,0.16 0.303 | 0.025, 0.053,  0.081 | 0.01, 0.06, 0.200 | 0, 0, 0 | 0, 0, 0 | 0.075,0.188,  0.256 | 0.038, 0.109, 0.178 | 0.444,  0.675,  0.925 | 0.004,  0.008,  0.341 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| 36-41 | 0.019,  0.051, 0.301 | 0.051, 0.106,  0.162 | 0.102, 0.157,  0.204 | 0, 0, 0 | 0, 0, 0 | 0.093,0.231,  0.278 | 0.111, 0.181, 0.241 | 0.50,0.75,1 | 0.006,  0.012,0.345 |
| (f) |  |  |  |  |
| 42-47 | 0.026,  0.057, 0.302 | 0.188, 0.281, | 0.193, 0.286, | 0, 0.02 1, | 0.021, 0.031, | 0.156, 0.365, | 0.219,0.323, 0.417 | 0.427,  0.666, 0.917 | 0.014,  0.028,0.361 |
| (f) | 0.365 | 0.375 | 0.042 | 0.042 | 0.417 |  |
| 48-53 | 0.006,  0.020,0.270 | 0.090, 0.167, | 0.153, 0.230, | 0, 0.070, | 0.069, 0.104, | 0.083, 0.181, | 0.097,0.146, 0.194 | 0.458,  0.688,  0.938 | 0.009,  0.019,  0.361 |
| ( F) | 0.243 | 0.306 | 0.138 | 0.138 | 0.194 |  |
|  |  |  |  |  |  |  |  |
| 54-59 | 0, 0.026,  0.276 | 0.145, 0.211,  0.263 | 0.132, 0.197,  0.263 | 0, 0, 0 | 0, 0, 0 | 0.184, 0.395,  0.421 | 0.210, 0.316, 0.421 | 0.421,  0.632,0.880 | 0.018  0.053,0.881,0.368 |
| (f) |  |  |  |
| 60  above(f) | 0.01, 0.03,  0.28 | 0.23, 0.34,0.43 | 0.23, 0.33,0.40 | 0.03, 0.04,  0.04 | 0.02, 0.03,  0.04 | 0.2, 0.42, 0.44 | 0.26, 0.38,0.48 | 0.19, 0.38,  0.63 | 0.053, 0.08,  0.386 |
|  |  |  |  |

**Appendix C. Assigned membership functions for the fuzzy set**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Age between | Education | smokeless type | smokeless frequency | Smoking type | Smoking frequency | Chewing type | Chewing frequency | Oral hygiene | Y (disease chance) |
| 18–23 (M) | 0.945 | 0.962 | 0.966 | 0.902 | 0.963 | 0.888 | 0.976 | 0.988 | 0.964 |
| 24–29 (M) | 0.976 | 0.966 | 0.955 | 0.903 | 0.962 | 0.881 | 0.962 | 0.984 | 0.964 |
| 30–35 (M) | 0.969 | 0.955 | 0.935 | 0.916 | 0.965 | 0.869 | 0.96 | 0.985 | 0.964 |
| 36–41 (M) | 0.963 | 0.961 | 0.925 | 0.722 | 0.946 | 0.886 | 0.951 | 0.985 | 0.964 |
| 42–47 (M) | 0.956 | 0.96 | 0.912 | 0.917 | 0.956 | 0.821 | 0.956 | 0.983 | 0.965 |
| 48–53 (M) | 0.956 | 0.959 | 0.966 | 0.864 | 0.96 | 0.841 | 0.956 | 0.965 | 0.968 |
| 54–59 (M) | 0.958 | 0.926 | 0.953 | 0.864 | 0.946 | 0.836 | 0.958 | 0.982 | 0.966 |
| 60 above (M) | 0.97 | 0.964 | 0.966 | 0.886 | 0.963 | 0.836 | 0.955 | 0.984 | 0.936 |
| 18–23 (F) | 0.956 | 0.932 | 0.952 | 0.84 | 0.936 | 0.906 | 0.962 | 0.988 | 0.963 |
| 24–29 (F) | 0.971 | 0.952 | 0.954 | 0.822 | 0.936 | 0.903 | 0.963 | 0.982 | 0.963 |
| 30–35 (F) | 0.971 | 0.955 | 0.978 | 0.822 | 0.936 | 0.906 | 0.962 | 0.966 | 0.964 |
| 36–41 (F) | 0.971 | 0.959 | 0.934 | 0.822 | 0.936 | 0.886 | 0.935 | 0.985 | 0.964 |
| 42–47 (F) | 0.97 | 0.949 | 0.949 | 0.847 | 0.953 | 0.838 | 0.953 | 0.964 | 0.963 |
| 48–53 (F) | 0.966 | 0.934 | 0.941 | 0.902 | 0.962 | 0.884 | 0.949 | 0.98 | 0.961 |
| 54–59 (F) | 0.942 | 0.94 | 0.935 | 0.822 | 0.936 | 0.84 | 0.956 | 0.949 | 0.964 |
| 60 above (F) | 0.975 | 0.937 | 0.918 | 0.841 | 0.952 | 0.849 | 0.94 | 0.943 | 0.966 |
| **Appendix D. Jaccard similarity measure for linguistic output selection** | | | | | | | | | |

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