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RESEARCH ARTICLE

STATISTICAL ASSESSMENT OF RISK FACTORS FOR THE PREVALENCE OF TUBERCULOSIS IN INDIA.

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Abstract

Background:- India is one of major contributor to global burden of tuberculosis which alone accounted for an estimated one quarter (26%) of all tuberculosis cases worldwide. The estimation of disease burden of tuberculosis is a challenge, considering its varied epidemiology and dynamics of transmission. As true disease burden cannot be estimated with count data therefore, statistical modeling techniques have been employed to analyze the disease burden in terms of prevalence of tuberculosis among males and females.

Aim and Objective:- In this article efforts has been made to identify the factors which could be used to segregate the population prone to have higher risk for tuberculosis. Specifically the factors that are responsible for prevalence of tuberculosis in India during 2005 and 2015 have been identified. A comparative study of the factors responsible for prevalence of tuberculosis during these two periods has also been carried out.

Methods:- In our analysis, the binary logistic regression model has been used by considering socioeconomic, demographic, cultural and health factors to know their impact on prevalence of the tuberculosis.

Results:- Some of the variables under socioeconomic factors, demographic factors, cultural factors and health factors have shown decline in their impact on prevalence of tuberculosis in 2015 as compared to 2005. However rest of the variables has the same impact on the prevalence of tuberculosis without any variation.

Conclusion:- The study reveals that there are some factors which were responsible for prevalence of tuberculosis in India during 2005 are also responsible for it in 2015, and these factors are continuously contributing in increasing the prevalence of tuberculosis. Hence it is suggested that there is a need to redesign the policies to minimize the risk factors generated on the part of the factors having same impact on the prevalence of tuberculosis during these two periods. .

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Introduction:-

The international targets for tuberculosis control, framed within the United Nations' Millennium Development Goals, are to ensure that by 2015 the global TB incidence rate is declining and the global TB prevalence and death rates for 1990 are halved .These targets are to be achieved by implementing WHO's Stop TB Strategy (founded on the core DOTS strategy), central to which is the prompt diagnosis of patients with active disease followed by supervised, short-course, combination chemotherapy. The Stop TB Strategy sets the standards for case management today, as it is widely recognized that prompt treatment with the right drug regimens can cure almost all TB patients and save lives. However, Tuberculosis (TB) remains one of the most important causes of infections worldwide, especially in developing countries. The incidence of TB has steadied or declined in most of the regions defined by the World Health Organization (WHO), but the total number of new cases continues to rise slowly due to population growth. According to the WHO in 2010, there were an estimated 8.8 million incident cases of TB (range, 8.5-9.2 million) globally, equivalent to 128 cases per 100 000 population. The five countries with the largest number of incident cases in 2010 were India (2.0-2.5 million), China (0.9-1.2 million), South Africa (0.40-0.59 million), Indonesia (0.37-0.54 million) and Pakistan (0.33-0.48 million). India alone accounted for an estimated one quarter (26%)[6] of all TB cases worldwide, and China and India combined accounted for 38% India is one of the 22 high tuberculosis (TB) burden countries (HBC) in the world. From an estimated population of 35 million people with national HIV prevalence of 7.3%, 45,546 TB patients were diagnosed in the year 2010 of which 54% were HIV-infected. Of these 56% were smear positive, 28% were smear negative and 11% had extra pulmonary TB. Despite implementation of the WHO recommended directly observed therapy short course (DOTS) TB control strategy, the reductions in the incidence of TB have been minimal in HBC. Because of this slow decline of TB incidence there is currently renewed interest in finding new TB control strategies. Focus has been on such strategies as adding to the current arsenal of TB drugs, finding a TB vaccine and designing shorter TB regimens. However, knowledge of what makes some persons develop TB and others not (risk factors) have potential of helping further to refocus the search for novel public health TB control strategies. Whereas tuberculosis is preventable and curable disease if regular and complete treatment is taken in time. Tuberculosis is contagious communicable disease spread through contact with an infected person (Hussain H (2003)), It is a disease poorly significantly associated with poor housing, low literacy and poor nutritional status and lack access to health services (Farmer P(1997)). According to Kallappan (2002), many risk factors such as smoking, use of fuel, poverty, overcrowding and poor housing (socio-economic factors) are known to be associated with the tuberculosis. Hazra (2005) have observed that the household environment affects the health outcomes of women in the northeastern states of India where morbidities such as asthma and tuberculosis are very high. Kaulagekar (2007) have also studied the association of socio- demographic and housing characteristics with tuberculosis using NHFS-2 data.

Material and Methods:-

The main data source for this paper is collected from National Health Family Survey (NHFS) - 3 and 4, which was conducted in 2005 and 2015 respectively. The main purpose of this paper is to identify the socioeconomic, demographic, cultural and health factors for tuberculosis by using the logistic regression technique. To identify the underlying determinants which have significant effect on the transmission of Tuberculosis, a statistical model is employed. Therefore, due to the binary nature of the outcome variable in this study, being suffered from Tuberculosis or not, a binary logistic regression model is employed for the given data. One of the main applications of logistic regression is to determine or forecast the chance of the occurrence of a particular outcome of the response variable on the basis of independent or explanatory variables by fitting a given data to Logit function. Based on the number of categories of the outcome variable, a logistic regression model can be classified as binary or multinomial. The dependent (outcome) variables which are binary in nature are classified under binary logistic regression whereas outcome variables which have more than one category are categorized under multinomial logistic regression. In the cross sectional data there are some missing values. To deal with the problem, the randomness of the missing values has been checked, to do this in each group the percentage distribution of the non missing values to the total number of observation is calculated which shows that missing values are not distributed systematically i.e. the missing values are completely random in the given data which reveals that in every respect missing values are similar to non missing values. To reduce the biasness of regression coefficients and to deal with the problem, case wise deletion method of missing value is used.

Binary Logistic Regression for Continuous Explanatory Variables:-

For a binary response Y_j and quantitative explanatory variable X_{ij}, i=1,2,….,m and j=1,2,…..,n, where m is the number of variables included in the model and n is the number of observations, let $\pi_j = P(X_{ij})$ represents the

"success probability" when X_{ij} takes the values x_{ij}. The problem with a linear model is that the probability model $E(Y) = X\beta$ (where β is the vector of parameters to be estimated) is used to approximate a probability value, $\pi_j = P(Y_j=1)$ within the interval 0 and 1, while $E(Y_j)$ is not so constrained. Therefore, the logit transformation where the transformed quantity $\log(\pi_j/(1-\pi_j))$ lies in the interval $(-\infty, \infty)$ and is modeled as

$$\text{Logit}(\pi_j) = \log\frac{\pi j}{1-\pi j} = \beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_m X_{mj} \quad \text{----------(1)}$$

Through algebraic manipulation

$$\frac{\exp(\beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_m X_{mj})}{1 + \exp(\beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_m X_{mj})} \quad \ldots\ldots\ldots\ldots(2)$$

where the parameter β_i represents the coefficient of parameter to be estimated.

Binary Logistic Regression Model for Categorical Predictors:-

Suppose the model has a binary response Y and m predictors, X_i=1,2…m, the predictors may have more than 2 categories (levels).

X^r_{ij} ,i=1,2,….,m , j=1,2,…..,n, r=1,2…, K_i -1

Where X^r_{ij} refers to the r^{th} level of a factor
m is the number of variables (factors),
n is the number of observations and

Let us also assume that one level of each factor is taken as a reference category, therefore the model will have (K_i-1) dummies as shown below

$$\begin{aligned} P(Y=1) = \beta_0 &+ \{\beta_1^1 X_{1j}^1 + \beta_1^2 X_{1j}^2 + \ldots + \beta_1^{k_1-1} X_{1j}^{k_1-1}\} \\ &+ \{\beta_1^1 X_{2j}^1 + \beta_1^2 X_{2j}^2 + \ldots + \beta_1^{k_2-1} X_{2j}^{k_2-1}\} \\ &+ \ldots + \beta_1^1 X_{mj}^1 + \beta_1^2 X_{mj}^2 + \ldots + \beta_1^{k_m-1} X_{mj}^{k_m-1}\} \quad ---(3) \end{aligned}$$

On the basis of equation (3) partial logistic regression models by each factor and its levels are built and analyzed for cross sectional data of 2005 and 2015 respectively. In all models the first group is taken as a reference. Partial logistic regressions are considered on the basis of socioeconomic, demographic, cultural and health variables. In the socioeconomic model, the explanatory variables are education level, wealth index, respondent occupation, literacy, types of place of residence and respondent caste.

Socioeconomic model:-

$$\text{Logit}(\pi_j) = \beta_0 + \beta_1 X_{1(\text{Occupation})} + \beta_2 X_{2(\text{Education})} + \beta_3 X_{3(\text{Wealth})} + \beta_4 X_{4(\text{Literacy})} + \beta_5 X_{5(\text{Caste})} + \beta_6 X_{6(\text{Place})}$$

Demographic model:-

Age and the marital status have been considered the main explanatory variables and the probability of beinginfected by the epidemic is predicted.

$$\text{Logit}(\pi_j) = \beta_0 + \beta_1 X_{1(\text{Age})} + \beta_2 X_{2(\text{Marital Status})}$$

Cultural model:-

The three explanatory variables that are included in the model are Knowledge about TB Transmission, Desire for discretion about TB infection, Trouble procuring funds for medical treatment. On the basis of these three explanatory variables, the statistical equation for the cultural model is:

$$\text{Logit}(\pi_j) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Where X_1= Knowledge about TB Transmission, X_2 = Desire for discretion about TB infection, X_3= Trouble procuring funds for medical treatment.

Health model:-
The probability of being infected by the epidemic is predicted by the respondent Body mass index level, Anemia level, smoking status and use of the type of fuel.

$$\text{Logit}(\pi_j) = \beta_0 + \beta_1 X_{1(\text{Body Mass Index})} + \beta_2 X_{2(\text{Anemia Level})} + \beta_3 X_{3(\text{Smoking})} + \beta_4 X_{4(\text{Fuel Used})}$$

All the data with respect to constructed model is analyzed in SPSS 20.0 software and interpreted accordingly.

Results and Discussion:-

The output of the logistic regression employed to measure the relationship between the prevalence of tuberculosis and the key independent variables are discussed at 5%, and 1% level of significance accordingly. Some of the estimated coefficients of specific models show that some predicting variables and their corresponding levels are matched as it is expected theoretically and hypothetically at least at 5 % level of significance.

Place of living, caste, literacy, wealth, education and occupation are the socio-economic factors which are associated with tuberculosis significantly in both the years. The output of table of 2015 shows that better occupation has significantly reduced their epidemic of disease. Males and females who are engaged in agriculture and those who are unemployed are at 0.18, 1.83 and 0.85, 1.49 times less risk of being infected with tuberculosis. The number has however reduced significantly in case of females. The risk of acquiring the tuberculosis disease for males and females who has primary and secondary education is about 1.23, 1.19 and 1.29, 1.27 times higher. The poor's had reduced significantly their vulnerability of being affected with tuberculosis as the males and females had 0.76 and 1.11 times less chances of being epidemic to disease. The odds of acquiring tuberculosis are higher among illiterates as male and female illiterate had 0.41 and 0.12 times more risk. Both schedule caste and others shows significant results of being affected by the tuberculosis. These are significant both in case of males as well as females but the risk of being affected by tuberculosis is more among schedule caste females as they shows highly significant results with level of significance of 1%. The individual who are residing in rural areas are at more odds of being epidemic with disease as the chances of acquiring tuberculosis for rural male and female were 1.05 and 1.17 times more. The output table of 2005 reveals that males in service and those who are unemployed have 2.59 and 1.63 times less risk of being infected while females in all occupations are at less risk of acquiring the disease due to better treatment at the medical hospitals. For the variable education and wealth the results are same as in 2015. In the literacy factor, only illiterate males have 0.52 times more risk. Similar to 2015 both males and females of schedule caste and others caste have more chances of getting tuberculosis.

As it shown in the demographic model, in the year 2015, the odds of being infected by tuberculosis in the middle age groups are significantly less as compared to very young age groups in general terms. For example as it is shown in the demographic models that the odds of being infected by tuberculosis in the age group 35-49 are less for male as compared to the very young age groups (15-24). However, unlike for male respondents, the odds of acquiring of tuberculosis for female respondents in the age group 35-49 are significant and higher than their younger counterpart as those females have 0.54 times more risk. The coefficient estimates of marital status has shown significant results of the odds of being affected by the epidemic, however widowed/divorced have reduced their chances of being infected by tuberculosis significantly over time. The males who are married have 1.37 times less risk while females who are married and widowed/divorced have 1.80 and 1.65 times more chances of acquiring tuberculosis.

Regression output of demographic model of 2005 reveals that odds of acquiring tuberculosis is significant for age group of 35-49 both for males and females like that in output of 2015 model. Male of the age group (35-49) has 0.07 more risk while the females have 0.27 times less risk. The older age group shows significant results both at 1% and 5% level of significance. Marital status significantly affected the odds of being likelihood to tuberculosis as both males and females whether married or widowed/divorced shows significant results of being epidemic to the disease however the number is more significant in case of females.

The output table of cultural model shows that there is hardly any improvement in the situation. Those who have more odds of being infected by tuberculosis in 2005 have remained their position intact in 2015 as well. The males who have knowledge about tuberculosis transmission and those who do not have any such knowledge has

significantly reduced their likelihood of acquiring the disease while in case of females those who have the knowledge are at 0.20 times more risk instead those females who do not have much knowledge about the transmission of tuberculosis has significantly reduced their risk. The risk was 0.92 times higher among males those who have no desire for discretion about tuberculosis infection. The individuals who have the funds for medical treatment are less epidemic to disease while male who have trouble procuring funds for medical treatment are at 0.07 times more risk of being affected by tuberculosis.

Health variables like Body mass index (BMI) level, Anemia level and smoking had overall significant effect in both cross sectional years 2015 and 2005 respectively on the prevalence on tuberculosis. However fuel used has significant impact upon tuberculosis in 2005 but it has successfully reduced its impact in 2015. The output table of health model shows that in 2015, BMI level, Anemia level and smoking are significant for both males and females at 5 % level of significance while low anemia level among females is highly significant with the significance level of 1 % showing females with low anemia are more vulnerable to tuberculosis. The output table of 2005 showed that all four health variables BMI level, Anemia level, smoking, and fuel used had significant impact upon the likelihood of being infected with tuberculosis with significance level of 5 %. These health variables also showed significant result in case of females with 5 % level of significance but anemia level and fuel used are highly significant in case of females with 1 % level of significance.

The summarizations of findings are as follows:

- Among the socioeconomic factor males and females who are engaged in service and business sector have reduced their chances of acquiring tuberculosis in 2015 as compared to 2005. Similarly, the individuals residing in urban areas and illiterate females have reduced their impact on prevalence of tuberculosis in 2015 while rests of variables have same impact upon prevalence of tuberculosis.
- The impact of the demographic factors remains intact in both the years the only difference is that the males who are widowed/divorced have reduced their odds of acquiring tuberculosis.
- Females who have the knowledge about TB transmission are now significantly affecting the prevalence of tuberculosis in 2015 while in 2005 they do not have any such significant impact.
- Among the health factor the male who uses solid fuels have reduced their odds of acquiring tuberculosis in 2015 and the remaining variable have same impact in 2015 as they are having in 2005.

Conclusion:-

In this article efforts have been made to identify the easily identifiable factors, which could be used to segregate the population prone to have higher risk for tuberculosis. It has been found that all demographic variables have revealed a significant effect on the prevalence of the tuberculosis. Age and marital status of the individuals have a significant effect on the prevalence of tuberculosis for both female and male individuals in both cross-sectional years of 2005 and 2015. Besides it have been found from both surveys that the chances of suffering from tuberculosis are higher among the adults as compared to the younger group.

The chances of suffering from TB are higher among the illiterates as compared to literates. Schedule caste or Schedule tribe population are more likely to have higher number of tuberculosis cases in both surveys. It has been seen that the prevalence of tuberculosis is higher in rural and urban in 2005 whereas in 2015 it had reduced in urban areas. Body mass index level, Anemia level and smoking remain constantly effective variables for prevalence of tuberculosis in both the cross sectional years. In short, it has been observed that the most of the variables responsible for disease in 2005 are also responsible in 2015 and continue to contribute in increasing the prevalence of tuberculosis. So, it is suggestive that those who are involved in the planning intervention should have to target these risk factors.

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Appendices:-

Table 1:- Socioeconomic model 2015 and 2005

		Male			Female		
Socioeconomic factors 2015		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Occupation	Service	-3.597	0.023	0.071	-1.242	0.008	0.298
	Business	0.123	0.700	1.131	-0.770	0.007	0.263
	Agriculture	-0.182	0.168*	0.834	-0.854	0.000**	0.726
	Unemployed	-1.832	0.000*	0.156	-1.496	0.000**	0.574
Education	Primary	1.233	0.006*	0.431	1.297	0.001**	0.659
	Secondary	1.119	0.006*	1.061	1.274	0.000**	1.575
	Higher	1.124	0.006	1.176	1.170	0.002	2.221
Wealth	Low	-0.768	0.054*	0.464	-1.117	0.000**	0.327
	Middle/High	0.242	0.491	1.274	-0.629	0.014	0.533
Literacy	Literate	0.261	0.761	1.461	0.361	0.044	0.644
	Illiterate	0.419	0.063*	1.521	0.012	0.028*	0.636
	Almost everyday(1)						
Caste	Others	0.862	0.012*	1.523	1.012	0.006**	0.423
	Schedule tribe/caste	1.052	0.009**	2.864	-0.823	0.000**	0.439
	Female(1)						
Place	Urban	1.871	0.118	1.243	1.734	0.003	2.339
	Rural	1.052	0.000**	2.863	1.171	0.000**	3.224
		Male			**Female**		
Socioeconomic factors 2005		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Occupation	Service	-2.597	0.023*	0.171	-1.242	0.000**	0.798
	Business	0.123	0.700	1.236	-0.770	0.007**	0.463
	Agriculture	-0.182	0.468	0.604	-0.854	0.000**	0.326
	Unemployed	-1.632	0.000**	0.196	-1.296	0.000**	0.271
Education	Primary	1.233	0.006*	2.631	1.297	0.001**	3.658
	Secondary	1.119	0.006*	3.761	1.274	0.000**	3.571
	Higher	1.124	0.006	3.146	1.170	0.002	3.224
Wealth	Low	-0.768	0.054*	0.464	-1.117	0.000**	0.327
	Middle/High	0.242	0.491	1.274	-0.629	0.014*	0.533
Literacy	Literate	0.345	0.126	1.121	0.098	0.745	1.031
	Illiterate	0.521	0.083**	1.821	0.112	0.828	1.241
	Almost everyday(1)						
Caste	Others	1.234	0.021*	1.432	0.076	0.000**	0.356
	Schedule tribe/caste	1.052	0.009**	2.864	-0.823	0.000**	0.439
	Female(1)						
Place	Urban	0.856	0.007**	1.087	0.925	0.019**	1.342
	Rural	1.052	0.000**	2.863	1.171	0.000**	2.024

Table 2:- Demographic model 2015 and 2005

Demographic factors 2015							
		Male			**Female**		
variables	category	**B**	**Sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Age	25-34	-1.656	0.009	0.090	2.176	0.026	0.808
	35-49	-0.485	0.001*	0.604	0.545	0.000**	1.673
Marital Status	Married	-1.717	0.000*	0.247	1.803	0.000**	0.169
	Widowed/divorced	-1.629	0.004	0.265	1.653	0.000**	0.193
Demographic factors 2005							
		Male			**Female**		
variables	category	**B**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Age	25-34	-1.373	0.047	0.262	-0.504	0.067	0.604
	35-49	0.072	0.820*	1.075	-0.277	0.241*	0.758
Marital Status	Married	-1.373	0.063*	0.253	1.932	0.000**	0.145
	Widowed/divorced	-0.895	0.078*	0.409	1.386	0.000**	0.250

Table 3:- Cultural model 2015 and 2005.

		Male			Female		
Cultural factors 2015		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Knowledge about TB Transmission	No	-0.754	0.035*	0.471	-0.154	0.023*	0.857
	Yes	-0.689	0.015	0.502	0.202	0.851*	1.224
Desire for discretion about TB Infection	No	0.929	0.039*	2.533	-1.226	0.000**	0.293
	Yes	-0.336	0.375	0.715	-2.801	0.000**	0.061
Trouble procuring funds for Medical Treatment	No	-1.373	0.047	0.262	-0.504	0.067	0.604
	Yes	0.072	0.820*	1.075	-0.277	0.241*	0.758
		Male			**Female**		
Cultural factors 2015		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
Knowledge about TB Transmission	No	-0.477	0.115*	0.379	-0.274	0.035*	0.857
	Yes	-0.623	0.781	0.502	0.289	0.021	1.224
Desire for discretion about TB Infection	No	0.734	0.024*	1.233	-1.246	0.000**	0.193
	Yes	-0.536	0.175	0.935	-2.401	0.000**	0.161
Trouble procuring funds for Medical Treatment	No	-0.173	0.147	0.292	-0.804	0.167	0.304
	Yes	0.372	0.420*	1.015	-0.677	0.221*	0.258

Table 4:- Health model 2015 and 2005.

		Male			Female		
Health factors 2015		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
BMI Level	Normal	-0.754	0.035*	0.471	-0.154	0.851*	0.857
	Low	-0.689	0.015*	0.502	0.202	0.806*	1.224
Anemia Level	Normal	0.929	0.039	2.533	-1.226	0.008	0.293
	Low	-0.336	0.075*	0.715	-2.801	0.000**	0.061
Smoking	No	0.234	1.226	1.233	0.112	0.459*	1.211
	Yes	0.115	0.815*	0.556	0.562	1.233*	1.341
Fuel used	Others	0.843	0.007	1.008	-0.211	0.000**	0.613
	Solid	0.911	0.012	0.971	0.129	0.000**	0.433
		Male			**Female**		
Health factors 2005		**β**	**sig**	**Exp(β)**	**B**	**sig**	**Exp(β)**
BMI Level	Normal	0.354	0.185*	0.871	-0.484	0.451*	0.457
	Low	0.679	0.315*	0.902	0.702	0.006*	1.424
Anemia Level	Normal	0.501	0.139	0.717	-0.926	0.000**	0.187
	Low	0.736	0.075*	0.705	-1.301	0.000**	0.095
Smoking	No	0.564	0.236	1.023	0.132	0.419*	1.016
	Yes	0.115	0.115*	0.857	0.232	0.705*	0.921
Fuel used	Others	1.143	0.003	0.508	-0.254	0.000**	0.944
	Solid	0.784	0.121*	0.331	0.148	0.000**	0.636