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Estimation of Diabetes-free Life Expectancy with respect to various Co-morbidities in Northeastern States of India

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ABSTRACT

Examining diabetes-free life expectancy in India, this study, based on Longitudinal Ageing Study in India (LASI) WAVE-1 data, explores demographic and co-morbidity influences, particularly in the Northeast India. Survival functions across five-year age groups reveal distinct patterns in the northeastern states. Results emphasize the crucial role of independent and co-morbidity variables in understanding diabetes dynamics.

The study contributes insights into diabetes-free life expectancy, aiding policy-makers in implementing targeted screening initiatives.

Keywords: Diabetes-free Survival Function, Peto-Pike Test, Prevalence Rate, North-eastern Regions of India.

Introduction

Diabetes mellitus (DM) presents a formidable global health challenge, stemming from dysfunctional insulin and resulting in elevated blood sugar levels. Type 2 Diabetes Mellitus (T2DM) is particularly prevalent, affecting millions worldwide due to a complex interaction of insulin resistance and deficiency.[1] Our research zeroes in on the North-eastern states of India, where an intriguing phenomenon emerges – certain states seemingly devoid of diabetes cases. This study seeks to unravel this divergence, recognizing the Northeast's unique demographic and environmental factors that may contribute to this phenomenon. India, with its vast diversity, harbours a myriad of socioeconomic structures influencing the prevalence of diabetes.[2] The research, inspired by the findings of Singh et al. (2018), delves into states exhibiting superior demographic indicators to understand the dynamics of diabetes-free survival.[3] While diabetes increasingly tightens its grip on a global scale, India, second only to China in incidence rates, faces a pressing challenge.[2] The environment emerges as a critical risk factor, as indicated by a comprehensive study conducted by the Indian Council of Medical Research (ICMR) across North-eastern states from 2010 to 2017[4]. Notably, a significant proportion of diabetes cases in India involve individuals grappling with overweight or obesity, further compounded by a genetic predisposition indicated by 50% having parents with the condition[5].

Methodology

The study utilizes data from the Longitudinal Ageing Study in India (LASI) Wave-1 conducted between 2017 and 2018, Managed by the International Institute for Population Sciences (IIPS) and funded by the Indian Government's Ministry of Health and Family Welfare, ethical approval ensures participant confidentiality[6].

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Focusing on individuals aged 45 and above across 35 states and Union Territories in India (excluding Sikkim), the dataset includes responses from 72,250 participants with an 85% response rate. Analysis includes demographic and co-morbidity factors such as sex, working status, caste, residence area, hypertension, stroke, chronic heart disease, and eye vision problems. Statistical methods like Diabetes-free Survival Function analysis and the Peto-Pike test are employed using SPSS-23 and MS-Excel to calculate probabilities of living without diabetes across age intervals and the methodology used by Singh et al. in 2012 [3]. The study aims to understand diabetes patterns and survival probabilities among India's aging population, guiding tailored public health interventions.

Diabetes–free survival function: In this study, the chances of not getting diabetes are given for different age groups of five years interval. In the dataset, none of the respondents were diagnosed with diabetes before they were 18 years old. The method below shows how to get a survival function from grouped data from a uniform population:

Notation

B_i : The ith interval of width (b_i, b_{i-1}), where $b_0 = 0$, is defined as B_i:[b_{i-1},b_i],(i=1,2,..........n).

T_i : The number of respondents in the beginning of the interval B_i.

A_i : The number of respondents with diabetes in the interval B_i.

${}_nm_i$: Age-specific rates of having diabetes among respondents in the i-th interval.

S_i : Estimated probability of Surviving without diabetes in the interval.

q_i : Estimated conditional probability of finishing the age with diabetes within the interval B_i.

f_i : The percentage of respondents who were diagnosed with diabetes at the start of the interval B_i .

Here the age-specific rates (are given below (n=5),

${}_nm_i = \frac{A_i}{T_i}$, $q_i = 2\times {}_nm_i / (2+ n\times {}_nm_i)$

and $P_i = 1 - q_i$.

The Survival function S_i is calculated by computing the continued products of the P_i.

Thus, $S_1=P_1$,

$S_2 = P_2 P_1$ and so on.

We define $P_0= 1$,so that we have for i[th] interval (i=1,2,……….n).

$S_i = P_0P_1P_2 \cdots\cdots P_{i-1} P_i$,, P_i=1(i) n and $f_i : S_i – S_{i-1}$.

The number of participants who survive divided by the number of patients at risk is the survival probability for each interval. Subjects who have passed away are not deemed to be "at risk"; instead, they are considered "censored" and are excluded from the denominator. The overall probability of survival up to that time interval is computed by multiplying all of the probabilities of survival at all preceding time intervals using the law of probability multiplication (Singh et al. in 2012[3]).

Peto-Pike test: Assume that failures occur at intervals $t_1 < t_2 < t_3 <... t_n$ in a pooled sample. Let c_{ij} be the number of failures in the j[th] sample at time t_i, and let n_{ij} be the number of observations in the j[th] sample still at risk before t_i. Let n_{i-}

and c_{i-} be the corresponding numbers in the pooled sample respectively ($n_{i-} = \sum n_{ij}$ and $c_{i-} = \sum c_{ij}$). Assuming that there is no variation among the samples, the conditionally expected frequency of c_{ij}, given n_{ij}, can be computed using the formula $E_{ij} = \frac{C_{i-}}{n_{i-}} \times n_{ij}$ Assume $E_{+i} = \sum E_{ij}$ .Then, $\sum \frac{(E_{+i} - C_{+i})^2}{E_{+i}}$ is the test statistic that Peto and Pike recommend (Singh et al. in 2012[3]). Which given the number of samples (k), is handled as a Chi-square test with (k-1) degree of freedom.

Results and Observations

The prevalence of diabetes across different age groups in northeastern states of India were analysed using data from various states. Generally, diabetes prevalence tends to increase with age. But after a certain age, it either stabilizes or decreases, more specifically in older age groups. Arunachal Pradesh and Assam showed a steady increase in diabetes prevalence until the age group 54-58, after which it slightly declined. Manipur exhibited a sharp rise in prevalence from the age group 44-48 to 59-63, followed by a gradual decrease in older age groups. Meghalaya's prevalence varied considerably, peaking in the age group 64-68, while Mizoram and Nagaland showed peak prevalence in the age group 59-63. Tripura's prevalence fluctuated, peaking in the age group 59-63. Mizoram and Tripura had the highest overall prevalence rates among the north-eastern states analyzed (Table 1).

Table-1: Prevalence of diabetes in the north-eastern states with respect to different Age-groups.

States	Prevalence (in %)										Overall Prevalence of Diabetes
	34-38	39-43	44-48	49-53	54-58	59-63	64-68	69-73	74-78	78+	
Arunachal Pradesh	1.8	5.3	19.3	14.0	15.8	10.5	10.5	15.8	1.8	5.3	4.9
Assam	1.3	6.3	13.3	15.2	17.1	14.6	13.3	7.0	6.3	5.7	6.8
Manipur	0.0	0.8	10.9	16.3	17.8	17.8	13.2	9.3	8.5	5.4	9.5
Meghalaya	3.0	0.0	3.0	6.1	21.2	9.1	24.2	18.2	6.1	9.1	3.5
Mizoram	0.0	2.1	7.3	12.5	12.5	19.8	17.7	7.3	13.5	7.3	7.8
Nagaland	1.7	3.4	5.1	11.9	18.6	8.5	27.1	15.3	3.4	5.1	4.5
Tripura	1.0	4.9	17.6	10.8	15.7	18.6	10.8	12.7	5.9	2.0	8.7
India	0.7	2.5	11.6	14.0	15.4	17.7	16.3	11.2	6.1	4.4	12.2

The data depicts a clear trend of decreasing diabetes-free survival and increasing risk of diabetes with advancing age among different age groups in India. Probability of diabetes-free survival declines gradually from younger to older age groups, while the conditional probability of developing diabetes rises steadily with age. This trend underscores the urgent need for targeted interventions aimed at diabetes prevention and management, particularly among older populations. However, it's important to note that the analysis is limited to individuals up to the age group 74-78, highlighting the necessity for further research to understand diabetes trends among older age groups (Table 2).

Table-2: Trend of Diabetes-free survival in India

Age group	T_i	A_i	m_i	q_i	P_i	S_i	f_i
24-28	**72**	1	0.01	0.01	0.99	1	0.01
29-33	**383**	5	0.01	0.01	0.99	0.99	0.03
34-38	**1744**	64	0.04	0.03	0.97	0.95	0.04
39-43	**4464**	215	0.05	0.04	0.96	0.91	0.06
44-48	**13135**	1008	0.08	0.06	0.94	0.85	0.07
49-53	**10885**	1221	0.11	0.08	0.92	0.78	0.07
54-58	**9980**	1340	0.13	0.09	0.91	0.71	0.07
59-63	**10106**	1543	0.15	0.09	0.91	0.64	0.06
64-68	**8824**	1421	0.16	0.09	0.91	0.58	0.05
69-73	**5723**	977	0.17	0.09	0.91	0.53	0.04
74-78	**3351**	532	0.16	0.08	0.92	0.48	0.03
78+	**3377**	387	0.11	0.07	0.93	0.45	

Table-3 illustrates the pattern of diabetes-free survival among various age groups in north-eastern states and India as a whole. The estimates represent the probability of remaining free from diabetes within specific age interval.

Table-3: Pattern of Diabetes-free survival in north-eastern states & India

Age group (yrs)	Diabetes free survivability (S_i)							
	India	**Tripura**	**Assam**	**Meghalaya**	**Manipur**	**Mizoram**	**Arunachal Pradesh**	**Nagaland**
24-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
29-33	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34-38	0.95	0.98	0.98	1.00	1.00	1.00	1.00	1.00
39-43	0.91	0.92	0.93	1.00	0.98	1.00	0.98	0.97
44-48	0.85	0.86	0.89	0.99	0.93	0.96	0.95	0.95
49-53	0.78	0.81	0.84	0.98	0.84	0.91	0.91	0.92
54-58	0.71	0.75	0.78	0.94	0.77	0.86	0.86	0.87
59-63	0.64	0.69	0.73	0.92	0.69	0.78	0.82	0.84
64-68	0.58	0.64	0.69	0.86	0.64	0.72	0.77	0.78
69-73	0.53	0.58	0.65	0.81	0.60	0.67	0.70	0.73
74-78	0.48	0.53	0.61	0.78	0.55	0.60	0.68	0.72
78 +	0.45	0.52	0.57	0.75	0.51	0.55	0.65	0.70

The above analysis shows that the state Meghalaya consistently demonstrates higher probabilities of diabetes-free life compared to other north-eastern states and India. Tripura and Assam are exhibiting similar trends over different age-intervals. Manipur, Mizoram, Arunachal Pradesh, and Nagaland are consistently showing high probabilities of diabetes-free life, particularly in younger age intervals, slightly higher than India's estimates on an average, thus highlighting potential regional variations in diabetes risk and prevention (Table-3).

Table-4: Proportion of individuals identified as diabetic at the commencement of specified age-interval (f_i)

Age group (yrs)	India	Tripura	Assam	Meghalaya	Manipur	Mizoram	Arunachal Pradesh	Nagaland
	%	%	%	%	%	%	%	%
24-28	1	0	0	0	0	0	0	0
29-33	3	2	2	0	0	0	0	0
34-38	4	6	5	0	0	0	2	3
39-43	6	6	4	1	6	4	3	1
44-48	7	5	5	1	8	6	4	3
49-53	7	6	6	4	8	5	5	5
54-58	7	6	5	2	8	8	4	3
59-63	6	5	5	6	5	6	5	6
64-68	5	7	4	6	5	4	7	5
69-73	4	5	4	2	5	7	2	2
74-78	3	1	4	3	3	5	3	2

The data represents the proportion of individuals identified with diabetes at the beginning of specific age interval across various age groups in both India and north-eastern states. Overall, India generally shows moderate proportions of individuals with diabetes, ranging from 0% to 7% across different age groups. Tripura, Assam, Manipur, and Mizoram display similar or slightly lower proportions compared to India, with some fluctuations observed across different age intervals. It is also observed that Meghalaya, Arunachal Pradesh and Nagaland are consistently exhibiting lower proportions of individuals with diabetes, particularly in younger age groups and oldest age-group considered in the present study (Table-4).

Table-5: Prevalence of Co-morbidity factors present in diabetes patients in NE states and India

Co-morbidity	Prevalence in north eastern states (in %)								
	Tripura	**Assam**	**Meghalaya**	**Manipur**	**Mizoram**	**Arunachal Pradesh**	**Nagaland**	**Average of NE**	**India**
Diagnosed Hypertension	69	75	79	52	59	72	58	**66**	61
Diagnosed Heart disease	13	5	3	5	1	4	2	**5**	9
Diagnosed Stroke	8	4	3	5	2	5	8	**5**	4
Eye or Vision Problem	63	56	61	74	50	58	42	**58**	68

Analysis from Table 5 provides the prevalence of co-morbidity factors present in diabetes patients across north-eastern states (NE) and in India.

***Diagnosed Hypertension*:** Tripura, Assam, Meghalaya, Mizoram, Arunachal Pradesh, and Nagaland show relatively high prevalence rates, ranging from 52% to 79%. Manipur exhibits the lowest prevalence rate of 52% compared to other states and national average. The average prevalence of diagnosed hypertension among north-eastern states is 66%, slightly higher than India's average of 61%.

***Diagnosed Heart Disease*:** Tripura, Assam, Meghalaya, Manipur, Arunachal Pradesh, and Nagaland show prevalence rates ranging from 1% to 13%. Mizoram has the lowest prevalence rate of diagnosed heart disease (1%) and Tripura has the highest prevalence rate (13%). The average prevalence of diagnosed heart disease among north-eastern states is 5%, slightly lower than India's average of 9%.

***Diagnosed Stroke*:** Tripura, Assam, Meghalaya, Manipur, Arunachal Pradesh, and Nagaland exhibit prevalence rates ranging from 2% to 8%. Mizoram has the lowest prevalence rate of diagnosed stroke at 2%.The average prevalence of diagnosed stroke among north-eastern states is 4%, slightly lower than National average.

***Eye or Vision Problem*:** Manipur has the highest prevalence rate of eye or vision problem among the north-eastern states (74%). Nagaland has the lowest prevalence rate of eye or vision problem (42%). The average prevalence of eye or vision problem among north-eastern states is 58%, lower than India's average of 68%.

Table-6: Pattern of diabetes-free survival with various Co-morbidity present

Age groups (yrs)	Diabetes free survival (S_i)			
	Hypertension	**Stroke**	**Heart disease**	**Eye Problem**
24-28	1.00	1.00	1.00	1.00
29-33	0.92	1.00	1.00	1.00
34-38	0.86	1.00	1.00	0.95
39-43	0.77	0.86	0.86	0.89
44-48	0.67	0.72	0.74	0.81
49-53	0.58	0.61	0.62	0.73
54-58	0.50	0.51	0.52	0.64
59-63	0.43	0.44	0.44	0.57
64-68	0.37	0.38	0.38	0.51
69-73	0.33	0.33	0.33	0.45
74-78	0.29	0.29	0.28	0.41
78+	0.26	0.26	0.25	0.38
Average	**0.58**	**0.61**	**0.62**	**0.69**

The table-6 depicts the pattern of diabetes-free survival with various co-morbidities present across different age groups. There is an overall gradual decline in diabetes-free survival rates as age advances, indicating a diminishing likelihood of remaining free from diabetes with age. In the youngest age groups (24-28 and 29-33), all co-morbidities show almost 100% survival rates. However, as age increases, diabetes-free survival rates decrease across all age groups and co-morbidities. Specifically, the presence of hypertension, stroke, and heart disease leads to lower survival rates, with averages ranging from 58% to 62%. Notably, eye problems have the highest impact on diabetes-free survival, with an average survival rate of 69%. The decline in survival rates is more pronounced in older age groups, emphasizing the cumulative effect of age and co-morbidities on diabetes-free survival.

Table-7:- P-values of Peto-pike test for different important independent variables and co-morbidities in India

Independent Variable	P-Value	Remarks
Sex (Male vs. Female)	0.02	Significant
Working Status	<0.00001	Significant
Hypertension	<0.00001	Significant
Stroke	<0.00001	Significant
Area of Residence	<0.00001	Significant
Caste	<0.05	Significant
Chronic heart Disease	0.01	Significant
Vision problem-free Survivals (Dia. Vs Non-Diabetic)	<0.00001	Significant
HTN-free Survivals (Dia. Vs Non-Diabetic)	<0.05	Significant
Stroke-free Survivals (Dia. Vs Non-Diabetic)	<0.01	Significant
CHD-free Survivals (Dia. Vs Non-Diabetic)	<0.05	Significant

The Peto-Pike test was conducted to evaluate the significance of various independent variables and co-morbidities in India concerning diabetes-free survival. The results indicate significant associations of comorbidities with several factors: sex ($p = 0.02$) (Fig-1), working status ($p<0.00001$) (Fig-2), hypertension ($p<0.00001$) (Fig-3), stroke ($p<0.00001$) (Fig-4), area of residence ($p <0.00001$), caste ($p< 0.05$), chronic heart disease ($p = 0.01$)(Fig.-5), and vision problem-free survival ($p<0.00001$). Additionally, significant differences were observed in diabetes-free survival concerning hypertension ($p< 0.05$), stroke ($p< 0.01$), and chronic heart disease ($p< 0.05$) compared to non-diabetic individuals. These findings underscore the importance of these factors in influencing diabetes-free survival rates and highlight the need for targeted interventions to address disparities and improve outcomes in diabetes management (Table7).

Fig.-1: Diabetes –free survival Curves according to different Sex category

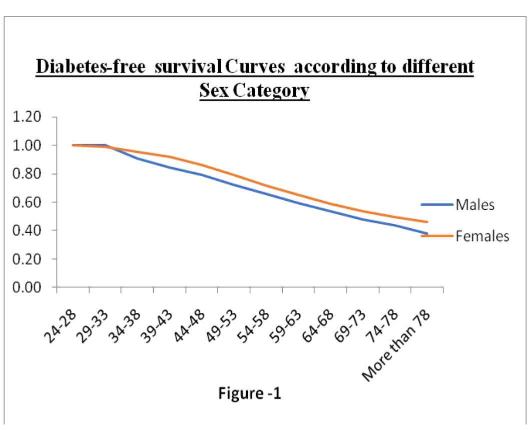

Fig.-2: Diabetes –free survival Curves with respect to working status.

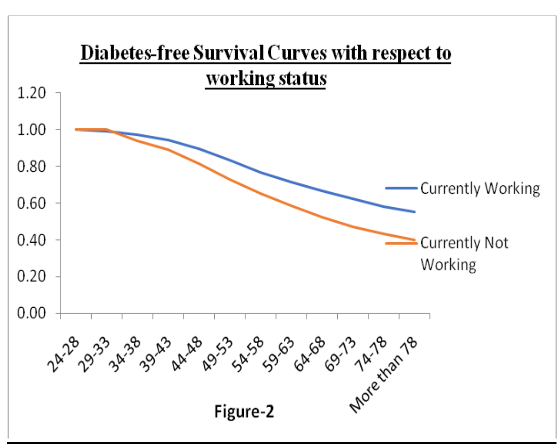

Fig.-3: Diabetes –free survival Curves with and without hypertension.

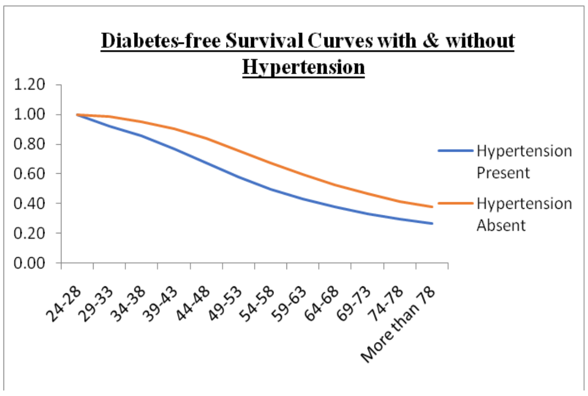

Fig.-4: Diabetes –free survival Curves with and without stroke

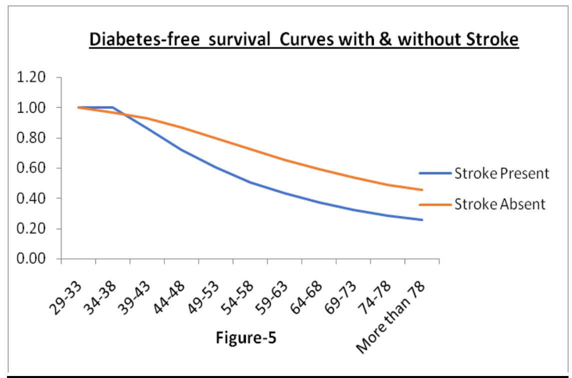

Fig.5: Diabetes –free survival Curves with and without chronic heart disease (CHD)

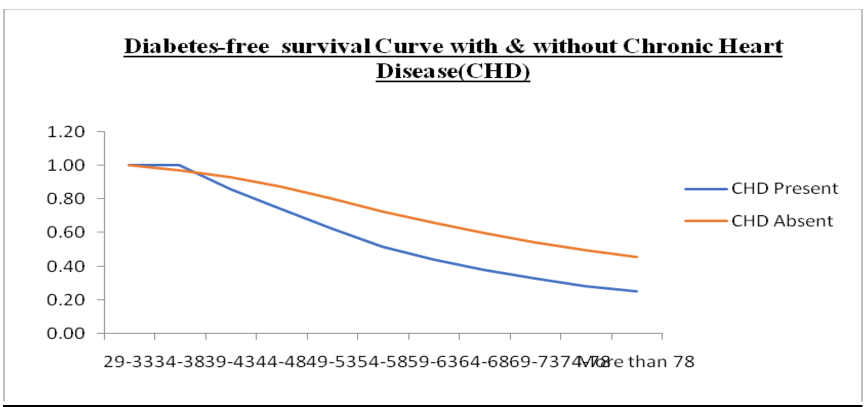

Table-8:-Pattern of diabetes-free survival in India by different demographic variables

Age-group	Sex		Working Status		Residence		Caste		
	Males	**Females**	**Currently Working**	**Currently Not Working**	**Rural**	**Urban**	**SC & OBC**	**ST**	**General**
24-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
29-33	1.00	0.99	0.99	1.00	0.99	0.98	0.98	1.00	1.00
34-38	0.91	0.96	0.97	0.94	0.97	0.94	0.95	0.97	0.96
39-43	0.85	0.92	0.94	0.89	0.94	0.88	0.91	0.95	0.91
44-48	0.79	0.86	0.89	0.81	0.90	0.80	0.85	0.92	0.85
49-53	0.72	0.79	0.83	0.73	0.85	0.71	0.78	0.87	0.77
54-58	0.66	0.72	0.77	0.65	0.79	0.63	0.71	0.83	0.69
59-63	0.59	0.65	0.71	0.58	0.73	0.55	0.64	0.78	0.61
64-68	0.53	0.59	0.67	0.52	0.68	0.48	0.58	0.73	0.55
69-73	0.48	0.54	0.62	0.47	0.63	0.43	0.52	0.68	0.49
74-78	0.44	0.50	0.58	0.43	0.59	0.38	0.48	0.64	0.45
78 +	0.38	0.46	0.55	0.40	0.56	0.35	0.44	0.62	0.41

Table-8 illustrates the pattern of diabetes-free survival in India across various demographic variables. Overall, males generally exhibit higher survival rates compared to females across all age groups. Individuals currently working tends to have higher survival rate than those not working, and urban residents slightly outperform rural residents. Among different caste groups, SC & OBC show slightly lower rates compared to ST and Unreserved categories.

Table-9: Pattern of different Co-morbidity factors-free survival among diabetes patients

Age-group	Vision-Problem Free	Hypertension-Free	Stroke-Free	Chronic Heart Disease Free
24-28	1.00	1.00	1.00	1.00
29-33	1.00	0.67	1.00	1.00
34-38	0.77	0.54	1.00	1.00
39-43	0.58	0.41	0.98	0.96
44-48	0.44	0.32	0.96	0.92
49-53	0.35	0.26	0.94	0.88
54-58	0.28	0.21	0.91	0.83
59-63	0.23	0.17	0.89	0.77
64-68	0.19	0.14	0.85	0.72
69-73	0.16	0.12	0.81	0.67
74-78	0.13	0.10	0.77	0.61
78 +	0.12	0.09	0.74	0.57
Average	**0.44**	**0.34**	**0.90**	**0.83**

Table 9 reveals the pattern of co-morbidity factors-free survival among diabetes patients across different age groups. In younger age groups (24-33), the rates of being free from vision problems, hypertension, stroke, and chronic heart disease are generally higher, but gradually decline as age increases. For vision problems and hypertension, the rates start at 100% and gradually decrease to 12% and 9%, respectively, in the 78+ age group. Similarly, for stroke and chronic heart disease, rates begin at 100% and decreases to 74% and 57%, respectively, in the 78+ age group.

Discussion

The data highlights significant regional variations in diabetes prevalence within India, with it North-eastern states showing varying levels of prevalence. Manipur, Tripura, and Mizoram exhibit higher prevalence rates compared to Meghalaya, suggesting potential differences in lifestyle, genetic predispositions, or healthcare access among these states. Previous research indicates a significant genetic inclination towards diabetes among individuals of Indian descent, particularly noticeable in challenging environmental circumstances. Studies have proposed that Asian Indians tend to develop diabetes at earlier stages of life compared to other ethnic groups globally. Research has firmly established age as a prominent predictor of diabetes within the Indian population, with the prevalence of the disease exhibiting distinct patterns across different age cohorts.[7] The concentration of diabetes patients within the age range of 44-63 underscores the importance of age as a significant factor in diabetes prevalence. The data also reveals varying age distributions of diabetes risk across different states, indicating the need for targeted interventions and healthcare strategies tailored to specific age groups within each region.

Their study findings on diabetes prevalence in rural areas was comparable to urban studies by Goswami et al. in 2016, and Singh et al. in 2012 undertaken in the various geographic locations in India.[8,9,10] The survival function analysis provides valuable insights into the probability of remaining diabetes-free within specific age intervals, aiding in understanding the trajectory of diabetes risk over time. The declining risk of developing diabetes after certain age thresholds (e.g., after age 53 nationally) suggests potential age-related factors influencing diabetes onset. The global prevalence of prediabetes is on the rise, with projections indicating that over 470 million individuals will have prediabetes by the year 2030. Lifestyle changes are fundamental for preventing diabetes in individuals with prediabetes, with research showing a relative risk reduction of 40%–70%. Additionally, emerging evidence suggests potential advantages of pharmacological interventions in managing prediabetes.[11]

The analysis of co-morbidities such as hypertension, eye problems, heart disease, and stroke highlights their significant association with diabetes prevalence. Individuals with hypertension show the highest predictor for diabetes, suggesting the need for integrated management strategies targeting both conditions. Cardiovascular disease stands as a leading cause of illness and death among individuals with diabetes, a condition further aggravated by hypertension. Diabetes and hypertension share common risk factors, such as endothelial dysfunction, inflammation of blood vessels, arterial restructuring, and plaque build-up in arteries, abnormal blood lipid levels, and obesity. Moreover, both conditions exhibit significant overlap in cardiovascular complications, primarily affecting small and large blood vessels. Common physiological pathways, like the activation of the renin-angiotensin-aldosterone system, oxidative stress, inflammation, and immune system activation, contribute to the close association between diabetes and hypertension. Many of the underlying biological mechanisms responsible for micro-vascular and macro-vascular complications in diabetes, such as oxidative stress, inflammation, and tissue scarring, also contribute to blood vessel restructuring and dysfunction in hypertension. Therefore, managing concurrent conditions, particularly hypertensions, and implementing strategies to enhance vascular health are crucial for reducing the risk of complications stemming from both diabetes and hypertension.[12]

Gender disparities in diabetes risk, with women showing a higher likelihood of avoiding diabetes compared to men, raise questions about potential biological and socio-cultural factors influencing disease susceptibility. Socioeconomic factors, including caste and employment status, also play a role, with SC or OBC respondents and working individuals showing a higher likelihood of avoiding diabetes. The higher likelihood of avoiding diabetes among rural residents compared to urban residents underscores the importance of addressing urbanization-related lifestyle changes and access to healthcare in urban areas. Sex and gender disparities in diabetes risk and outcomes stem from a combination of biological and psychosocial factors. Psychosocial stress tends to have a more pronounced effect on women compared to men. Gender variations play a significant role in various aspects of diabetes, including its development, detection, symptoms, diagnosis, treatment, and prevention, especially concerning lifestyle-related factors. However, disease awareness and the perceived severity of complications are not solely determined by gender; they also hinge on individual experiences, level of education, income, access to quality healthcare services, social support, and lifestyle choices. Therefore, distinguishing between the influence of gender and external factors or lifestyle differences can be challenging due to the intricate interplay and interaction of these multifaceted factors throughout an individual's life.[13]

The analysis revealing the risk of developing hypertension, stroke, eye disease, and heart disease among individuals with diabetes underscores the intricate interconnection between these health conditions. Hypertension is a common co-morbidity in individuals with diabetes. Both conditions share similar risk factors such as obesity, unhealthy diet, physical inactivity, and genetic predisposition. Moreover, diabetes can lead to vascular damage, impairing blood vessel function and contributing to elevated blood pressure. Conversely, hypertension can exacerbate diabetes-related complications by further compromising blood vessel integrity and increasing the risk of cardiovascular events.[14]

Diabetes significantly increases the risk of stroke by promoting atherosclerosis (plaque build-up in arteries) and causing vascular damage, which can lead to blood clots or ruptured blood vessels in the brain. Additionally, hypertension, a common complication of diabetes, further elevates the risk of stroke by putting additional strain on blood vessels and increasing the likelihood of vessel rupture or blockage.[15] Eye Disease (Diabetic Retinopathy): Diabetic retinopathy is a common complication of diabetes and a leading cause of blindness in adults. Elevated blood sugar levels can damage the small blood vessels in the retina, leading to vision impairment or loss. Hypertension can exacerbate diabetic retinopathy by increasing vascular damage and impairing blood flow to the retina, further compromising vision.[16] Diabetes significantly increases the risk of developing heart disease, including coronary artery disease, heart attack, and heart failure. Both diabetes and hypertension contribute to the development of atherosclerosis and arterial stiffness, leading to reduced blood flow to the heart and increased risk of cardiovascular events. Additionally, diabetes can cause abnormal heart rhythms and weaken the heart muscle, further increasing the risk of heart-related complications.[12]

Given the interconnected nature of these health conditions, comprehensive management approaches are essential. This includes not only controlling blood sugar levels and blood pressure through medication, but also adopting healthy lifestyle habits such as regular exercise, a balanced diet, weight management, and smoking cessation. Additionally, regular monitoring and early intervention for complications such as diabetic retinopathy and cardiovascular disease are crucial for preserving overall health and reducing the risk of long-term complications in individuals with diabetes. Overall, the data provides valuable insights into the complex interplay of demographic factors, co-morbidities, and regional variations in diabetes prevalence within India, offering important implications for healthcare policymaking, public health interventions, and targeted disease management strategies.

Conclusion

The analysis of diabetes prevalence, co-morbidities, and regional differences in India offers crucial insights into the complexity of the disease and its complications. Key factors such as demographics, lifestyle, genetics, and healthcare access significantly influence diabetes risk and outcomes. Regional variations underscore the necessity for tailored healthcare strategies, considering differences in lifestyle, genetics, and healthcare infrastructure among states. Addressing co-morbidities like hypertension, stroke, eye disease, and heart disease requires comprehensive management, including blood sugar and pressure control, lifestyle changes, and early intervention. Gender and socioeconomic disparities further highlight the need for holistic diabetes management approaches, addressing both biological and psychosocial factors. Overall, the findings provide valuable guidance for policymakers, public health professionals, and healthcare providers to develop targeted interventions and improve diabetes care nationwide.

Declarations

Ethical Approval: The secondary dataset serves as the basis for the research, and no personal information about survey respondents is included. The Ministry of Health and Family Welfare carried out the LASI (WAVE-1) Survey, which was organized by the International Institute for Population Sciences in Mumbai. The Institutional Ethical Review Board authorized all of the survey protocols used in the LASI (WAVE-1) Survey.

Data Availability: The data is available on the Institutional Website & can be easily downloaded forthe research purpose by the students, faculty & other researchers in India.

References

1. Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, Ostolaza H, Martín C. Pathophysiology of Type 2 Diabetes Mellitus. Int J Mol Sci. 2020; 21 (17):6275. doi:10.3390/ijms 21176275
2. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021; 69 (11) : 2932-2938. doi:10.4103/ ijo.IJO_1627_21
3. Singh SK, Pedgaonkar S, Puri P, Gupta J. Diabetes-free life in India: Application of survival function analysis. J Soc Health Diabetes. 2018; 6: 48-55. doi:10.1055/s-0038-1676192
4. Behera SK, Das S, Xavier AS, Selvarajan S, Anandabaskar N. Indian Council of Medical Research's National Ethical Guidelines for biomedical and health research involving human participants: The way forward from 2006 to 2017. Perspect Clin Res. 2019; 10 (3):108-114. doi:10.4103/picr.PICR_10_18
5. Kaveeshwar SA, Cornwall J. The current state of diabetes mellitus in India. Australas Med J. 2014;7(1):45-48. doi:10.4066/AMJ.2013.1979
6. International Institute for Population Sciences (IIPS), National Programme for Health Care of Elderly (NPHCE), Ministry of Health and Family Welfare (MoHFW), Harvard T.H. Chan School of Public Health (HSPH), University of Southern California (USC). Longitudinal Ageing Study in India (LASI), Wave 1 2017–18. India National Report. Mumbai, India: International Institute for Population Sciences; 2020.
7. Ramachandran A, Mary S, Yamuna A, Murugesan N, Snehalatha C. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. Diabetes Care. 2008;31:893-8.
8. Thankappan KR. Diabetes and cardiovascular risk factors associated with urbanization in India. Department of Public Health and Community Medicine, Central University Kerala, Kasaragod, Kerala, India.
9. Arlappa N. Diabetes and cardiovascular risk factors associated with urbanization in India. Division of Community Studies, Indian Council of Medical Research–National Institute of Nutrition, Hyderabad, Telangana, India.
10. Mahanta TG. Diabetes and cardiovascular risk factors associated with urbanization in India. Department of Community Medicine/Prevention and Social Medicine, Tezpur Medical College, Tezpur, Assam, India.
11. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. Prediabetes: a high-risk state for diabetes development. Lancet. 2012; 379 (9833):2279-2290. doi:10.1016/S0140-6736(12)60283-9
12. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Can J Cardiol. 2018; 34 (5):575-584. doi:10.1016/j.cjca.2017.12.005
13. Ciarambino T, Crispino P, Leto G, Mastrolorenzo E, Para O, Giordano M. Influence of Gender in Diabetes Mellitus and Its Complication. Int J Mol Sci. 2022; 23 (16):8850. doi:10.3390/ijms23168850
14. Long AN, Dagogo-Jack S. Comorbidities of diabetes and hypertension: mechanisms and approach to target organ protection. J Clin Hypertens (Greenwich). 2011; 13 (4):244-251. doi:10.1111/j.1751-7176.2011. 00434.x
15. Chen R, Ovbiagele B, Feng W. Diabetes and Stroke: Epidemiology, Pathophysiology, Pharmaceuticals and Outcomes. Am J Med Sci. 2016; 351 (4):380-386. doi:10.1016/j.amjms.2016.01.011
16. Kropp M, Golubnitschaja O, Mazurakova A, et al. Diabetic retinopathy as the leading cause of blindness and early predictor of cascading complications-risks and mitigation. EPMA J. 2023;14 (1):21-42. doi:10.1007/ s13167-023-00314-8.

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