Regional disparities in Non-Communicable Disease: Evidence from Kerala and Gujarat

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Abstract:

The study investigates the long-term trends and determinants of the non-communicable disease (NCD) burden in India with a comparative focus on the states of Kerala and Gujarat from 1990 to 2021. Using secondary data from the Global Burden of Disease Study (GBD 2021), the analysis explores key indicators such as Disability-Adjusted Life Years (DALYs), deaths, and Years Lived with Disability (YLDs) per lakh population. The study also examines the influence of environmental/occupational, behavioral, and metabolic risk factors. Descriptive statistics, Kruskal–Wallis tests, and regression analyses with interaction terms were employed to assess regional disparities and temporal changes, particularly before and after the implementation of Sustainable Development Goal 3 (SDG 3) in 2015. Results indicate a consistent rise in the NCD burden across all levels, with Kerala exhibiting higher DALYs and metabolic risk contributions compared to Gujarat and national averages. The findings highlight significant regional disparities and highlight the impact of socio-economic and health system differences in shaping NCD outcomes. The study calls for region-specific, integrated public health strategies to address the growing challenge of chronic diseases in India.

Introduction:

Non-Communicable Diseases (NCDs) have emerged as the leading cause of morbidity and mortality worldwide, replacing communicable diseases in many low- and middle-income countries, including India. NCDs such as cardiovascular diseases, diabetes, cancers, and chronic respiratory illnesses now account for over 70% of all deaths in India (World Health Organization [WHO], 2021). Unlike acute infectious diseases, NCDs are chronic and often lifelong, leading to sustained healthcare demands and significant socio-economic implications for individuals, households, and the nation at large. The burden of NCDs is compounded by India's demographic transition, urbanization, and changing lifestyle patterns, which have heightened exposure to metabolic, behavioral, and environmental risk factors.

Despite numerous national initiatives—such as the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS)—there is limited longitudinal study comparing regional NCD trends within India, particularly at the state level. This gap is crucial, as health outcomes vary significantly across states due to diverse socio-economic conditions, healthcare infrastructure, and demographic profiles. Different states in India are at varying stages of the epidemiological transition, shaped by socio-economic conditions, health infrastructure, cultural practices, and public health priorities. Kerala and Gujarat provide a particularly useful contrast for examining these variations. Kerala is recognized for its high literacy rates, advanced health indicators, and relatively equitable access

to healthcare. However, it faces a higher NCD burden linked to population aging and lifestyle changes (Menon et al., 2020). Gujarat, on the other hand, is economically vibrant and industrially developed but continues to experience inequalities in healthcare access and persistent dual disease burdens—both communicable and non-communicable (Varkey et al., 2020). These contrasting profiles make Kerala and Gujarat ideal for a comparative analysis to understand how regional determinants influence NCD trends.

By examining trends in disease burden along with behavioral, environmental, and metabolic risk factors, the study highlights how social, economic, and policy contexts shape health outcomes. This can help improve evidence-based decision-making and inform targeted public health interventions tailored to local realities. Moreover, by highlighting the impact of urbanization and lifestyle-related factors on disease progression, the study emphasizes the need for integrated approaches that go beyond medical treatment to address the social determinants of health.

The core focus of the study is to analyze how the burden of NCDs has changed over the period 1990 to 2021 in India, with a specific comparative emphasis on Kerala and Gujarat. It explores the evolving patterns of Disability-Adjusted Life Years (DALYs), Years Lived with Disability (YLDs), and NCD-related mortality. It further aims to investigate the influence of risk exposures—namely behavioral (such as tobacco use and physical inactivity), environmental (such as air pollution), and metabolic (such as obesity and high blood pressure)—on the burden of disease. The study seeks to uncover how these factors vary across regions and contribute to different health trajectories over time, thereby enhancing our understanding of the regional dimensions of India's NCD crisis.

Review of Literature

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Scholars have increasingly focused on the burden of disease measured through Disability-Adjusted Life Years (DALYs) and Years Lived with Disability (YLDs) to capture the long-

term impact of NCDs. The Global Burden of Disease Study (IHME, 2020) underscores significant disparities across Indian states. Kerala, known for its high Human Development Index and advanced health infrastructure, has a higher NCD burden due to aging and lifestyle-related factors, while Gujarat, although economically advanced, displays a dual burden of communicable and non-communicable diseases (Sundar et al., 2015).

Comparative studies between Indian states are relatively limited but growing. Balarajan et al. (2011) emphasized that disparities in healthcare access, socio-economic status, and education contribute significantly to variations in disease prevalence and outcomes. Kerala's strong public healthcare system facilitates early detection and treatment, whereas Gujarat faces challenges in healthcare delivery across rural and urban divides (Rao et al., 2011).

Environmental, behavioral, and metabolic risk factors are critical determinants of NCD prevalence. Prabhakaran et al. (2016) found that dietary patterns, physical inactivity, tobacco use, and air pollution are significantly associated with rising NCD rates in both urban and rural India. The variations in risk factor distribution are influenced by social determinants such as income, education, and occupational structure (Marmot & Wilkinson, 2005). These determinants also affect healthcare utilization and financial coping mechanisms among affected households (Bloom et al., 2012).

Economic analyses have shown that the financial burden of NCDs can be catastrophic, particularly for low-income families. Gupta et al. (2016) found that out-of-pocket expenditures for chronic disease treatment lead to indebtedness, loss of income, and reduced spending on essential needs. Such burdens exacerbate existing inequalities and reduce the quality of life for NCD patients and their families.

Policy responses at the national level, such as the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), aim to integrate prevention, screening, and treatment. However, the effectiveness of these programs varies widely across states due to differences in implementation capacity and resource allocation (Sundararaman & Muraleedharan, 2015). A context-specific approach that addresses regional disparities and focuses on socio-economic determinants is essential for achieving Sustainable Development Goals related to health and well-being (United Nations, 2015).

These literature survey shows the the urgency of addressing NCDs not only from a clinical perspective but also from a socio-economic and policy lens. Comparative regional studies like the one proposed between Kerala and Gujarat are necessary to understand the diverse determinants and impacts of NCDs, and to formulate more equitable and effective interventions.

Methodology

This study employs a quantitative longitudinal research design to analyze and compare trends and determinants of Non-Communicable Disease (NCD) burden in India, with a specific focus on Kerala and Gujarat, over the period 1990–2021. The analysis uses secondary data obtained from the Global Burden of Disease Study 2021 (GBD 2021), published by the Institute for Health Metrics and Evaluation (IHME). The dataset includes annual estimates of key indicators such as Disability-Adjusted Life Years (DALYs), Years Lived with Disability (YLDs), deaths due to NCDs per lakh population, and risk factors including environmental/occupational, behavioral, and metabolic determinants. These variables were analyzed globally, at the national level (India), and sub-nationally (Kerala and Gujarat). The study is grounded in the Social Determinants of Health (SDH) and epidemiological transition theories, which provide the conceptual framework for understanding how socio-economic and demographic changes influence health outcomes. These frameworks support the investigation of both structural (e.g., healthcare access, economic status) and individual-level factors (e.g., lifestyle, environmental exposures) influencing the burden of NCDs.

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Kruskal–Wallis H tests were conducted to test for statistically significant differences in NCD indicators and risk factor contributions across regions (Global, India, Kerala, Gujarat). The non-parametric Kruskal-Wallis test was chosen due to the ordinal nature of the region variable and potential non-normality of the data. To assess temporal trends, segmented linear regression (also known as piecewise or joinpoint regression) was implemented to examine structural

changes in the trends before and after the launch of Sustainable Development Goal 3 (SDG 3) in 2015. Additionally, regression with interaction terms was applied to explore the differential impact of the "period" variable (pre- and post-SDG 3) and "year" on the dependent variables (DALYs, deaths, and YLDs).

Results and Discussion

Table 1 presents a comparative analysis of the non-communicable disease (NCD) burden globally, in India, and in the states of Kerala and Gujarat from 1990 to 2021, using three key indicators: Disability-Adjusted Life Years (DALYs), deaths per lakh, and Years Lived with Disability (YLDs). The data reveals that while the global burden of NCDs has remained relatively stable in terms of DALYs and deaths, YLDs have steadily increased, indicating a rise in chronic conditions causing prolonged disability. In India, all three indicators show a gradual upward trend, with DALYs rising from 18,527 in 1990 to over 20,465 in 2021 and deaths increasing by approximately 35%, reflecting the country's ongoing epidemiological transition and changing lifestyle patterns. Kerala exhibits the highest NCD burden among the four units, with significantly higher DALYs and death rates, likely due to its aging population and advanced demographic profile. Gujarat, on the other hand, started with a lower burden but shows a consistent rise across all indicators, pointing to the growing influence of urbanization and lifestyle-related risk factors. The coefficients of variation for Kerala and Gujarat, especially in mortality rates, indicate more fluctuation in NCD impact over time compared to national and global levels. This comparative analysis reveals that while NCD burdens are increasing across all levels, the intensity and trends vary significantly by region. Kerala faces the highest overall burden, aligning with its demographic profile and disease transition stage. Gujarat, while lower, is catching up rapidly.

Table 1: Comparative Trends in Non-Communicable Disease Burden (DALYs, Deaths, and YLDs) Globally, in India, Kerala, and Gujarat (1990-2021)

	Year	DALYs per lakh	Deaths per lakh	YLDs per lakh
Global	1990	21,565.6	502.01	7,611.51
	2000	21,366.8	512.87	7,982.59
	2010	21,138.8	518.72	8,423.08
	2020	21,780.2	551.26	9,185.11
	2021	21,887.1	554.63	9,273.45
	Average	21,403.5	520.91	8,275.11
	SD	201.94	13.93	471.10

	CV	0.94	2.67	5.69
India	1990	18,527.35	337.60	7,030.18
	2000	18,416.71	345.71	7,245.50
	2010	18,858.38	389.02	7,713.34
	2020	20,429.61	458.85	8,557.49
	2021	20,465.66	457.51	8,654.00
	Average	19,017.39	385.00	7,618.81
	SD	662.99	41.002	459.42
	CV	3.49	10.65	6.03
Kerala	1990	18,454	388	7,793.5
	2000	20,022.8	453.9	8,375.8
	2010	21,664	528.9	9,355.4
	2020	24,966.1	674.7	10,353.7
	2021	25,105.2	669.5	10,597.7
	Average	21,069.0	503.3	8,993.0
	SD	2005.1	85.4	811.5
	CV	9.5	17.0	9.0
Gujarat	1990	17,113.8	299	6,889.7
	2000	17,750.4	332	7,207.4
	2010	18,836.2	389.5	7,718.9
	2020	21,745.7	508.5	8,638.8
	2021	21,905.9	515.4	8,697.3
	Average	18,745.5	379.6	7,608.2
	SD	1,434.0	64.8	522
	CV	7.6	17.1	6.9

Source: Estimated from Global Burden of Disease Collaborative Network, Global Burden of Disease Study 2021 (GBD 2021) Results, Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2022.

Table 3 presents the results of three regression models analyzing the impact of the implementation of Sustainable Development Goal (SDG) 3: Good Health and Well-being—adopted in 2015—on key indicators of the non-communicable disease (NCD) burden: Disability-Adjusted Life Years (DALYs), Deaths, and Years Lived with Disability (YLDs).

The analysis uses an interaction term (Period × Year) to determine whether the trends in these health indicators changed significantly after 2015. All three models show statistically significant F-values for both the corrected models and interaction terms, with p-values less than 0.001, indicating strong evidence that the time period before and after SDG 3 had a differential impact on NCD outcomes. The adjusted R^2 values for the models indicate that the explanatory power is modest to substantial: 30.6% for DALYs, 31.2% for Deaths, and 45.3% for YLDs. This means that the regression models explain a considerable portion of the variation in NCD outcomes across time. Importantly, the average values before and after the adoption of SDG 3 show an increase across all indicators: DALYs rose from 19,650.2 to 21,829.6 per lakh, deaths increased from 427.8 to 531.3 per lakh, and YLDs rose from 7,924.3 to 8,988.3 per lakh population. These findings suggest a rising burden of NCDs in the post-SDG period, possibly due to increased life expectancy, lifestyle-related risk factors, and improved diagnosis and reporting. At the same time, it raises critical questions about the effectiveness of current interventions and the need for more aggressive, targeted policies to curb the growing impact of NCDs. The statistically significant interaction terms further emphasize that SDG 3 has had a measurable influence on the trajectory of NCD burden, though the direction indicates a rising trend that requires urgent public health attention.

Table 3: Impact of SDG Implementation Period on Trends in NCD Burden (DALYs, Deaths) through Interaction Effects (per lakh)

	Model 1		**Model 2**		**Model 3**	
Dependent Variable	**DALYs**		**Death**		**YLDs**	
	F	**p**	**F**	**p**	**F**	**p**
Corrected Model	28.989	.000	29.859	.000	53.604	.000
Intercept	10.190	.002	17.477	.000	39.442	.000
Period * Year	28.989	.000	29.859	.000	53.604	.000
R Square	0.317		0.323		0.462	
Adjusted R Squared	0.306		0.312		0.453	
Average Before SDG 3	19650.2		427.8		7924.3	
Average After SDG 3	21829.6		531.3		8988.3	

Note: Period: 0= Before SDG 3, Good Health and Well-being (2015), 1= After SDG 3, Good Health and Well-being (2015); Source: Estimated from Global Burden of Disease

Collaborative Network, Global Burden of Disease Study 2021 (GBD 2021) Results, Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2022

Table 4 presents a comparative analysis of deaths per lakh population attributed to three major categories of risk factors—environmental/occupational, behavioural, and metabolic—from 1990 to 2021. At the global level, deaths linked to metabolic risk factors (e.g., high blood pressure, high blood sugar, obesity) have shown a consistent increase over the three decades, from 186.6 in 1990 to 227.5 in 2021, indicating a growing influence of metabolic conditions on NCD mortality. Behavioural risk-related deaths (e.g., due to poor diet, smoking, inactivity) remained relatively stable, while deaths due to environmental/occupational causes (e.g., pollution, workplace hazards) declined slightly. The coefficient of variation (CV) highlights this trend, showing greater variability for metabolic risks (CV = 5.5%) compared to behavioural (1.5%) and environmental risks (2.6%). In India, all three categories of risk factors showed increasing death rates over time, with the most significant rise observed in metabolic risk-related deaths, which jumped from 102.4 in 1990 to 177 in 2021, with a high variability (CV = 18.1%). Behavioural and environmental risk-related deaths also increased steadily, reflecting lifestyle transitions, urbanization, and environmental degradation. Notably, behavioural risks had the highest average mortality contribution among the three, underlining the urgency of preventive health strategies. Kerala, despite its strong health indicators, exhibited significantly high and rising mortality due to metabolic risk factors, escalating from 171.3 in 1990 to 340.7 in 2021, the highest among all compared regions. This trend underscores the "disease of affluence" pattern, where improved longevity and lifestyle shifts contribute to chronic conditions. Behavioural risks also climbed substantially, particularly after 2010, reflecting changing food habits and reduced physical activity. In contrast, Gujarat demonstrated lower initial values but a sharper rise over time in all three risk categories. Metabolic deaths more than doubled, from 102.9 in 1990 to 212.5 in 2021, and behavioural risk deaths rose from 115.1 to 197.4. The high coefficients of variation (CV = 19–22%) for Gujarat reflect significant year-to-year fluctuations and possibly disparities in health awareness and healthcare access. So, metabolic and behavioural factors emerging as dominant drivers of NCD-related deaths in both national and sub-national contexts. This trend calls for urgent, targeted interventions in public health policy, emphasizing lifestyle modifications, early screening, and better management of metabolic conditions, particularly in fast-developing regions like Gujarat and high-risk zones like Kerala.

Table 4: Trends in Deaths Attributable to Environmental, Behavioural, and Metabolic Risk Factors per Lakh Population

	Year	Environmental/ occupational Risk Factors	Behavioural Risk Factors	Metabolic Risk Factors
Global	1990	129.94	189.16	186.61
	2000	132.83	190.04	197.72
	2010	128.38	186.23	206.57
	2020	122.75	189.99	225.9
	2021	126.32	191.11	227.54
	Average	129.9	189.1	204.4
	SD	3.4	2.9	11.3
	CV	2.6	1.5	5.5
India	1990	106.08	119.29	102.44
	2000	111.75	121.76	112.95
	2010	132.04	139.39	137.78
	2020	152.4	162.72	176.65
	2021	155.6	162.68	176.96
	Average	128.9	136.5	133.1
	SD	17.6	15.0	24.1
	CV	13.6	11.0	18.1
Kerala	1990	129.5	152.3	171.3
	2000	150.7	174.3	215.3
	2010	153.8	191.8	261
	2020	137.3	229.1	342.8
	2021	147	227.5	340.7
	Average	147.3	184.3	243.1
	SD	7.6	22.3	50.1
	CV	5.2	12.1	20.6
Gujarat	1990	99	115.1	102.9
	2000	115.1	125.1	122.1
	2010	138.6	150	146.6
	2020	173.8	194.8	208.9

	2021	181.9	197.4	212.5
	Average	133.7	145.3	143.6
	SD	25.4	25.4	31.9
	CV	19.0	17.5	22.2

Source: Estimated from Global Burden of Disease Collaborative Network, Global Burden of Disease Study 2021 (GBD 2021) Results, Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2022.

Table 5 presents a comparative analysis of deaths per lakh population attributable to environmental/occupational, behavioural, and metabolic risk factors associated with non-communicable diseases (NCDs) across regions. For environmental/occupational risk factors, the mean death rate is highest in Kerala (147.3 per lakh), followed by Gujarat (133.7), Global average (129.9), and India (128.9). Despite relatively small standard deviations globally (SD = 3.4), India and Gujarat show higher variability. The Kruskal-Wallis test result ($\chi^2 = 28.721$, $p = 0.000$) confirms significant regional differences, likely reflecting disparities in pollution exposure, workplace safety, and urban planning. In terms of behavioural risk factors, which include tobacco use, alcohol consumption, unhealthy diets, and physical inactivity, the global average mortality stands at 189.1 per lakh. Kerala closely mirrors this at 184.3, indicating lifestyle-related health burdens. However, India and Gujarat lag behind, with averages of 136.5 and 145.3 respectively, suggesting under-reporting or regional variation in behaviour-driven NCD outcomes. The high Kruskal-Wallis value ($\chi^2 = 74.385$, $p = 0.000$) highlights significant variation, pointing to different behavioural patterns and health awareness levels. The most striking disparity appears in metabolic risk factors, such as obesity, high blood pressure, and diabetes. Kerala records an exceptionally high average of 243.1 deaths per lakh, far above the global average of 204.4 and significantly higher than both Gujarat (143.6) and India as a whole (133.1). The standard deviations are also large (e.g., SD = 50.1 in Kerala), indicating considerable annual variation. The Kruskal-Wallis test ($\chi^2 = 88.111$, $p = 0.000$) strongly affirms that metabolic risk-based mortality differs significantly by region, emphasizing Kerala's advanced epidemiological transition and high lifestyle disease burden. It shows pronounced regional disparities in NCD mortality across different risk factor domains. Kerala consistently records higher mortality for all risk types, reflecting both advanced demographic aging and lifestyle shifts, while India and Gujarat remain lower but show rising trends.

Table 5: Regional Comparison of Deaths Attributable to NCD Risk Factors per Lakh Population

Indicators	Region	N	Mean per lakh	Std. Deviation	Std. Error	Kruskal Wallis Test
Environmental/ occupational Risk Factors	Global	32	129.9	3.4	0.6	Chi-Square (3) = 28.721 p=0.000
	India	32	128.9	17.6	3.1	
	Kerala	32	147.3	7.6	1.4	
	Gujarat	32	133.7	25.4	4.5	
	Total	128	135.0	17.4	1.5	
Behavioural Risk Factors	Global	32	189.1	2.9	0.5	Chi-Square (3) = 74.385 p=0.000
	India	32	136.5	15.0	2.6	
	Kerala	32	184.3	22.3	3.9	
	Gujarat	32	145.3	25.4	4.5	
	Total	128	163.8	29.6	2.6	
Metabolic Risk Factors	Global	32	204.4	11.3	2.0	Chi-Square (3) = 88.111 p=0.000
	India	32	133.1	24.1	4.3	
	Kerala	32	243.1	50.1	8.8	
	Gujarat	32	143.6	31.9	5.6	
	Total	128	181.1	55.4	4.9	

Source: Estimated from Global Burden of Disease Collaborative Network, Global Burden of Disease Study 2021 (GBD 2021) Results, Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2022.

The findings of this study reveal important trends and regional disparities in the burden of Non-Communicable Diseases (NCDs) in India, particularly in Kerala and Gujarat, over the period from 1990 to 2021. The increase in Disability-Adjusted Life Years (DALYs), deaths, and Years Lived with Disability (YLDs) aligns with previous research that underscores the growing public health threat of NCDs in low- and middle-income countries undergoing rapid epidemiological transition. Prior studies (e.g., Prabhakaran et al., 2016; IHME, 2021) have similarly noted that states like Kerala are experiencing higher NCD burdens due to aging populations, sedentary lifestyles, and urbanization — a trend that this study confirms through longitudinal data analysis.

From a theoretical standpoint, the findings support frameworks such as the Social Determinants of Health (SDH) and the Epidemiological Transition Model. These models predict that as societies progress economically and socially, health burdens shift from infectious diseases to chronic, lifestyle-related illnesses. Kerala, with its high Human Development Index (HDI), early demographic transition, and relatively advanced healthcare infrastructure, exemplifies this shift. The elevated DALYs and metabolic risk-related deaths in Kerala reflect not only biological aging but also the health consequences of affluence and urban living. In contrast, Gujarat represents a state with a mixed health profile—marked by industrial development and economic growth but also wide disparities in health access and awareness, which may explain its lower but rising NCD burden.

The divergence between Kerala and Gujarat also points to significant socio-economic and health system differences. Kerala's public health system, characterized by better outreach and coverage, may enable more thorough detection and reporting of NCDs, possibly inflating the measured burden relative to under-reported figures in Gujarat. Additionally, Kerala's aging population contributes to higher YLDs and DALYs due to longer life expectancy but poorer health in later years. Meanwhile, Gujarat's younger demographic and variable healthcare access may delay diagnosis and lead to underestimation of disease prevalence. These differences emphasize that a "one-size-fits-all" approach to NCD policy in India is inadequate. Instead, state-specific strategies, accounting for demographic, economic, and health infrastructure characteristics, are crucial for effective NCD control.

Conclusion

This study has analyzed the emerging trends and determinants of the burden of Non-Communicable Diseases (NCD) in India between Kerala and Gujarat on detailed data from 1990 to 2021. The findings strongly suggest a rising trend in the Disability-Adjusted Life Years (DALYs), mortality, and Years Lived with Disability (YLDs) from NCDs in all of the states, though with impressive regional variations. Kerala, with its well-established healthcare system, is seen to have significantly higher burden in the metabolic and behavioural risk factors, which is attributed to the effect of demographic aging, transition in lifestyle, and premature epidemiological transition. Gujarat, though economically advanced, shows stable but comparatively lower burden, which may be suggestive of differences in access to healthcare, awareness, and reporting.

The statistical tests, such as Kruskal-Wallis tests and regression models, validate that the post-2015 period following the adoption of SDG 3 saw an accelerated increase in NCD burden, especially in metabolic risk, which points to loopholes in existing prevention and control

strategies. The research also emphasizes the role of environmental and behavioural determinants and lays the ground for the fact that public health interventions need to extend beyond the clinical care to lifestyle and socio-environmental determinants. The study suggests the imperative need for state-specific plans and convergent policy intervention for prevention, early detection, risk factor modification, and socio-economic support. It also emphasizes the need for regional comparative evaluation for health planning for any country as heterogeneous as India. In pointing towards the intricate interconnection of demographic, behavioral, and metabolic risk factors leading to NCDs, the study contributes to the discussion on equitable and sustainable health systems for India.

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