Original Study

Open Access

Tobacco Burden in Pakistan (1990–2021): Join point and Forecast Analysis

Z. Ahsan[1], M.Ahsan[2]

[1]Agha Khan University
[2]Dow University of Health sciences

Introduction:
Tobacco use remains a major global health concern and a leading cause of preventable morbidity and mortality. Despite national control measures, Pakistan continues to experience substantial health losses attributable to smoking, chewing tobacco, and secondhand smoke exposure.

Objective:
This study aimed to assess the burden of age-standardized mortality rates (ASMR) and disability-adjusted life years (dalys) associated with tobacco use in Pakistan from 1990 to 2021 using Global Burden of Disease (GBD) data, and to forecast future trends through 2031 using the Autoregressive Integrated Moving Average (ARIMA) model.

Methods:
Data on tobacco-related ASMR and dalys were extracted from the GBD 2021 dataset for the period 1990–2021. Joinpoint regression analysis was employed to identify significant changes in temporal trends, with statistical significance set at $p < 0.05$. Forecasting of mortality trends up to 2031 was performed using the ARIMA (1,1,2) model, selected based on optimal fit determined by the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Results:
Between 2004 and 2014, both ASMR and dalys showed significant declines, with reductions of −2.59% and −2.56%, respectively ($p < 0.05$), corresponding to the implementation of comprehensive tobacco control policies. Forecasts indicate continued downward trends through 2031, with projected reductions in ASMR of 96.17 (71.61–131.83) for overall tobacco use, 73.13 (61.96–85.22) for smoking, and 17.19 (6.84–17.46) for secondhand smoke exposure. Regional analysis demonstrated the greatest improvements in Sindh and Balochistan provinces.

Conclusion:
This study reveals a substantial decline in ASMR and dalys attributable to tobacco use in Pakistan over the past three decades, particularly following stricter tobacco control measures. Projections suggest continued progress through 2031, though regional disparities persist. Limited improvement in chewing tobacco-related mortality highlights the need for targeted interventions. Sustained, region-specific tobacco control strategies remain crucial to further reducing the national disease burden.

Keywords: Tobacco, Smoking, Chewing Tobacco, Secondhand Smoke, Pakistan, Global Burden of Disease, ARIMA Forecasting

Introduction

Tobacco use remains one of the world's most serious public health issues, causing significant morbidity and mortality across a wide range of populations.(1). The World Health Organization (WHO) estimates that tobacco use causes more than eight million fatalities per year, with over seven million from direct tobacco use and around 1.2 million from secondhand smoke exposure (2). Tobacco use has far-reaching health implications, including cardiovascular diseases, chronic respiratory disorders, and many types of cancer (3).

Tobacco use continues to be a major public health concern in South Asia, with high prevalence rates reported in India, Bangladesh, Nepal, and Sri Lanka. The region bears a significant percentage of the worldwide tobacco burden as a result of widespread use of both smoked and smokeless tobacco products, deeply ingrained cultural habits, and socioeconomic conditions. The Global Adult Tobacco Survey (GATS) reports that tobacco usage among adults in South Asia ranges from 20% to 35%, with considerable gender disparities and rural-urban differences (4, 5). Despite several tobacco control programs under the WHO Framework Convention

on Tobacco Control (FCTC), enforcement loopholes and low public knowledge continue to impede effective reductions in tobacco-related morbidity and mortality (6, 7).

In Pakistan, the burden of tobacco-related diseases is a complicated public health issue driven by socioeconomic disparities, cultural traditions, and variable levels of policy enforcement among provinces. Despite the adoption of tobacco control measures in 2002, such as the Prohibition of Smoking and Protection of Nonsmokers' Health Ordinance (8)Tobacco use remains widespread, posing major public health hazards. According to the Global Adult Tobacco Survey (GATS), over 19% of Pakistani adults currently use tobacco, with significant exposure to secondhand smoke in households and public places(9).

Understanding changes in tobacco-related health outcomes is critical for developing public health policies and interventions. The Global Burden of Disease (GBD) research collects extensive data on tobacco-related mortality and disability-adjusted life years (dalys), providing important insights on temporal patterns and regional disparities (10). Join-point regression analysis, a powerful statistical approach for detecting significant shifts in trend data, allows for the examination of changes in age-standardized mortality rates (ASMR) and dalys across time(11).

Subnational studies reveal regional disparities in tobacco use. For instance, a study published in the National Tobacco Control Cell's report found that tobacco use prevalence in rural areas is 21.1%, which is 5.2 percentage points higher than in urban areas (15.9%). Additionally, research indicates that smokeless tobacco products, such as naswar and paan, are widely consumed across Pakistan, with a study highlighting that 85.86% of participants had heard of smokeless tobacco products (12, 13)

Despite the implementation of tobacco control measures over the years, tobacco-related diseases continue to burden the healthcare system, with regional disparities in the prevalence of smoking and smokeless tobacco products. Understanding the trends in tobacco-related health outcomes is crucial for developing effective public health interventions. This study is novel in its application of both Join-point regression and ARIMA models to analyze and forecast tobacco-related health trends in Pakistan from 1990 to 2021. While Join-point regression has been used in various studies to identify significant shifts in health trends, and ARIMA models have been employed for forecasting, this is the first study to combine these two methodologies specifically for tobacco-related mortality and disability-adjusted life years (dalys) in Pakistan. Join-point regression allows for the identification of key turning points in tobacco-related health trends, while ARIMA models provide a powerful tool for projecting future health burdens based on historical data.

This study aimed to assess the burden of ASMR and dalys associated with tobacco use, including chewing tobacco, smoking, and secondhand smoke exposure, in Pakistan from 1990 to 2021 using GBD data. Additionally, it seeks to predict future trends in tobacco-related health burdens through 2031 using the Autoregressive Integrated Moving Average (ARIMA) model. By elucidating these trends, the study aimed to provide evidence-based recommendations for strengthening tobacco control policies and reducing the health burden associated with tobacco use in Pakistan.

Method:

Study Design: This study employed an ecological study design to analyze national and provincial tobacco-related health outcomes in Pakistan over 31 years (1990–2021). The analysis primarily focused on trends in age-standardized mortality rates (ASMR) and age-standardized disability-adjusted life years (ASDR) attributed to tobacco consumption, including smoking, chewing tobacco, and secondhand smoke exposure.

Data Source: The data for this study were extracted from the Global Burden of Disease (GBD) 2021 dataset, which is managed by the Institute for Health Metrics and Evaluation (IHME). The GBD dataset provides comprehensive information on diseases, injuries, and risk factors impacting different countries and regions globally. The variables

Corresponding Author:

Name: Zeeshan Ahsan

Affiliation: Agha Khan University

Email: zeeshanallana@gmail.com

Date of Receiving: July 16, 2025

Date of Revision: August 8, 2025

Date of Acceptance: October 8, 2025

DOI: https://doi.org/10.69491/i2v2ajfr

included in this study were the ASMR and ASDR for all-cause tobacco-related risk factors, including tobacco use, smoking, chewing tobacco, and secondhand smoke exposure, from 1990 to 2021. Subnational data for Sindh, Punjab, Balochistan, Khyber Pakhtunkhwa, Islamabad, Gilgit Baltistan, and Azad Jammu Kashmir were also included. The dataset was accessed through the IHME GBD visualization hub (https://vizhub.healthdata.org/gbd-results/).

Statistical Analysis:

The statistical analysis includes both Joinpoint regression and ARIMA (Autoregressive Integrated Moving Average) models to assess temporal trends and forecast future tobacco-related health outcomes in Pakistan. Joinpoint regression, conducted using the Joinpoint Regression Program (Version 5.2.0) from the National Cancer Institute, was employed to detect significant shifts, or "joinpoints," in the age-standardized mortality rates (ASMR) and age-standardized disability-adjusted life years (ASDR) associated with tobacco consumption. This method identifies periods where the trend changes significantly, allowing for the analysis of non-linear trends. The permutation method was applied with a significance level of $p < 0.05$ to assess the changes in trends, and a constant variance method for correlated errors ensured robust trend assessments by maintaining consistent variance across the data points. These methods enabled the identification of key turning points in tobacco-related health trends, which provided insights into the effects of tobacco control policies implemented in Pakistan.

In addition to Joinpoint regression, the ARIMA model was used to forecast future trends in tobacco-related ASMR. ARIMA is a time series forecasting model that predicts future values based on historical data. Using STATA Version 17.0, historical ASMR data from 1990 to 2021 were utilized to forecast trends up to 2031. The ARIMA (1,1,2) model was selected based on three parameters: p (autoregressive order), d (degree of differencing), and q (moving average order). The parameter $d = 1$ was used to achieve stationarity by applying a second-order differencing, while $q = 2$ was included to account for forecast errors from the previous two periods. The model's performance was evaluated using both the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to identify the best-fitting model, ensuring the robustness of the forecasts. The results from the Joinpoint regression analysis were presented using apcs, which indicated the rate of change in ASMR and ASDR for each period.

Results

Table 1 shows the results from the joinpoint analysis of the Age-Standardized Mortality Rate (ASMR) and Age-Standardized dalys Rate (ASDR) for tobacco-related risk factors across Pakistan from 1990 to 2021. The ASMR showed a consistent decreasing trend from 1990 onwards, with a significant decline observed from 2004 to 2014 at an annual percentage change (APC) of -2.59% (-2.73% to -2.51%), followed by a continued decrease from 2014 to 2021 at -2.45% (-2.54% to -2.17%). All provinces demonstrated decreasing trends in ASMR, with the most significant decline recorded in Balochistan at -2.66% (-2.77% to -2.56%), followed closely by Punjab at -2.59% (-2.61% to -2.57%), and Sindh at -2.39% (-2.46% to -2.34%). Similarly, the ASDR for tobacco-related diseases showed a significant decrease between 2018 and 2021 at -2.97% (-3.51% to -2.64%). This decrease was consistent across provinces, with Sindh showing the most significant reduction at -3.16% (-3.53% to -2.91%), followed by Khyber Pakhtunkhwa (KPK) at -2.93% (-3.66% to -2.55%), Punjab at -2.85% (-3.13% to -2.72%), and Balochistan at -2.78% (-2.85% to -2.72%). These findings highlight significant regional variations, with the most considerable improvements in provinces like Balochistan and Punjab, emphasizing the importance of localized tobacco control interventions.

Table 1: Join-point Analysis of Age-Standardized Mortality and dalys Rate of Tobacco Risk Exposure among all causes in Pakistan from 1990 till 2021

Countries	**Age-Standardized Mortality Rate**		**Age-Standardized dalys Rate**	
	Year	**APC (95% CI)**	**Year**	**APC (95% CI)**
Pakistan	1990-1992	1.08* (0.72 - 1.48)	1990-	0.92* (0.46 - 1.43)

			1992	
	1992 - 1995	2.82* (2.60 - 3.06)	1992-1995	2.56* (2.23 - 2.86)
	1995 - 1998	0.55* (0.32 - 0.74)	1995-1998	0.41 (-0.05 - 0.66)
	1998 - 2004	-1.08* (-1.17 - -0.99)	1998-2004	-1.25* (-1.46 - -1.15)
	2004 - 2014	-2.59* (-2.73 - -2.51)	2004-2018	-2.56* (-2.60 - -2.33)
	2014 - 2021	-2.45* (-2.54 - -2.17)	2018-2021	-2.97* (-3.51 - -2.64)
Sindh	1990 - 1992	1.08* (0.70 - 1.50	1990-1992	0.88* (0.40 - 1.40)
	1992 - 1995	2.87* (2.63 - 3.13	1992-1995	2.59* (2.24 - 2.90)
	1995 - 1998	0.81* (0.45 - 1.03	1995-1998	0.62* (0.02 - 0.88)
	1998 - 2003	-0.71* (-0.92 - -0.58	1998-2003	-0.85* (-1.16 - -0.73)
	2003 - 2010	-2.09* (-2.19 - -1.93	2003-2017	-2.27* (-2.32 - -2.22)
	2010 - 2021	-2.39*	2017-	-3.16* (-3.53 - -2.91)

		(-2.46 - -2.34	2021	
Punjab	1990 - 1992	0.90* (0.53 - 1.30	1990-1992	0.74* (0.38 - 1.14)
	1992 - 1995	2.63* (2.40 - 2.88	1992-1995	2.40* (2.17 - 2.64)
	1995 - 1998	0.34* (0.01 - 0.53	1995-1998	0.15 (-0.18 - 0.35)
	1998 - 2004	-1.20* (-1.30 - -1.14	1998-2004	-1.34* (-1.48 - -1.26)
	2004 - 2021	-2.59* (-2.61 - -2.57	2004-2016	-2.54* (-2.58 - -2.48)
			2016-2021	-2.85* (-3.13 - -2.72)
Baluchistan	1990 - 1992	2.20* (1.77 - 2.63	1990-1997	2.53* (2.29 - 2.76)
	1992 - 1995	3.64* (3.38 - 3.91	1997-2004	-0.69* (-0.98 - -0.44)
	1995 - 1998	1.10* (0.76 - 1.35	2004-2021	-2.78* (-2.85 - -2.72)
	1998 - 2001	-0.25* (-0.86 - -0.03		
	2001 - 2004	-0.93* (-2.84 - -0.79		

	2004-2021	-2.66* (-2.77 - -2.56)		
Khyber Pakhtunkhwa (KPK)	1990-1992	2.05* (1.59 - 2.91	1990-1996	2.69* (2.48 - 2.94)
	1992-1996	3.15 (-0.16 - 3.49	1996-2001	-0.17 (-0.39 - 1.67)
	1996-2001	-0.22* (-1.67 - -0.03	2001-2005	-1.63* (-2.13 - -0.44)
	2001-2005	-1.64* (-3.34 - -1.36	2005-2011	-3.48* (-3.96 - -1.97)
	2005-2012	-3.28* (-3.49 - -2.48	2011-2017	-2.28* (-3.40 - -1.67)
	2012-2021	-2.32* (-2.44 - -2.19	2017-2021	-2.93* (-3.66 - -2.55)
Islamabad	1990-1992	0.18 (-0.14 - 0.61	1990-1992	-0.16 (-0.49 - 0.42)
	1992-1996	1.63* (1.49 - 1.87	1992-1997	0.93* (0.80 - 1.20)
	1996-2000	-0.22* (-0.41 - -0.02	1997-2004	-1.54* (-1.67 - -1.45)
	2000-2004	-1.36* (-1.59 - -1.15	2004-2011	-2.69* (-2.84 - -2.57)
	2004-2012	-2.25* (-2.36 - -2.18	2011-2021	-1.65* (-1.72 - -1.59)
	2012-2021	-1.44* (-1.50 - -1.37		
Gilgit Baltistan	1990-1992	0.86* (0.41 - 1.49	1990-1997	1.60* (1.45 - 1.77)
	1992-1996	2.45* (2.25 - 2.79	1997-2003	-1.15* (-1.38 - -0.94)
	1996-2001	-0.51* (-0.68 - -0.32	2003-2012	-3.25* (-3.44 - -3.13)
	2001-2004	-1.87* (-2.52 - -1.28	2012-2021	-2.36* (-2.49 - -2.20)
	2004-2013	-2.97* (-3.11 - -2.89		
	2013-2021	-2.06* (-2.18 - -1.93		
Azad Jammu Kashmir	1990-1992	0.15 (-0.23 - 0.53	1990-1997	0.46* (0.29 - 0.65)
	1992-1995	1.66* (1.43 - 1.91	1997-2003	-1.92* (-2.15 - -1.58)
	1995-1998	-0.39* (-0.71 - -0.18	2003-2010	-2.99* (-3.41 - -2.80)

	1998 - 2003	- 1.65* (-1.86 - -1.52	2010- 2021	-2.02* (-2.13 - -1.90)
	2003 - 2012	- 2.67* (-2.76 - -2.61		
	2012 - 2021	- 1.77* (-1.84 - -1.69		
*Indicate the annual percentage change (APC) is significantly different from zero at the 0.05 level of significance (Empirical Quantile Method)				

Table 2 shows the findings of the joinpoint analysis of the Age-Standardized Mortality Rate (ASMR) and Age-Standardized dalys Rate (ASDR) for chewing tobacco-related risk factors across Pakistan from 1990 to 2021. While the ASMR of chewing tobacco shows an overall decreasing trend, no statistically significant difference was found after 2000. However, there was a slight increase in the Annual Percentage Change (APC) from 2014 to 2021, with a value of 0.04 (-0.10 to 0.23). Notably, some regions such as Islamabad (0.15* [-0.31 to 0.42]) and Azad Jammu Kashmir (0.12* [0.06 to 0.18]) reported increases in ASMR during certain periods, with KPK also showing a small increase (0.08 [-0.04 to 0.22]). For the Age-Standardized dalys Rate (ASDR), a consistent decrease in the national level was observed, with the most significant reduction occurring between 2003 and 2014, at -0.81 (-0.89 to -0.77). In addition, while most provinces showed a decreasing trend in ASDR, Islamabad demonstrated a significant increase of 0.24 (0.10 to 0.45) between 2012 and 2021. These findings suggest region-specific patterns in the burden of chewing tobacco use, with Islamabad exhibiting a particularly notable increase in both ASMR and ASDR in more recent years. These results highlight both regional disparities and temporal trends in the health impact of chewing tobacco in Pakistan, emphasizing the need for tailored public health interventions in regions such as Islamabad, where increases in chewing tobacco-related morbidity and mortality were observed.

Table 2: Join-point Analysis of Age Standardized Mortality and dalys Rate of Chewing Tobacco Risk Among All Causes in Pakistan from 1990 till 2021

Countries	**Age Standardized Mortality Rate**		**Age Standardized dalys Rate**	
	Year	**APC (95% CI)**	**Year**	**APC (95% CI)**
Pakistan	1990-1995	2.86* (2.71 - 3.02)	1990-1995	2.87* (2.71 - 3.03)
	1995-2000	1.28* (1.18 - 2.80)	1995-2000	1.46* (1.33 - 1.68)
	2000-2003	0.22 (-0.18 - 1.24)	2000-2003	0.17 (-0.33 - 0.65)
	2003-2009	-0.59 (-0.73 - 0.14)	2003-2014	-0.81* (-0.89 - -0.77)
	2009-2014	-0.83 (-1.11 - 0.08)	2014-2021	-0.09 (-0.20 - 0.05)
	2014-2021	0.04 (-0.10 - 0.23)		
Sindh	1990-1995	2.87* (2.65 - 3.08)	1990-1995	2.87* (2.62 - 3.13)
	1995-2000	1.49* (1.34 - 2.73)	1995-2000	1.71* (1.56 - 2.94)
	2000-2003	0.04 (-0.31 - 1.48)	2000-2003	-0.04 (-0.36 - 1.74)
	2003-2009	-0.42* (-1.15 - -0.23)	2003-2009	-0.50* (-1.13 - -0.21)
	2009-2012	-1.12 (-1.28 - 0.12)	2009-2012	-1.09 (-1.26 - 0.16)
	2012-2021	-0.04 (-0.21 - 0.13)	2012-2021	-0.08 (-0.35 - 0.13)
Punjab	1990-1995	2.84* (2.74 - 2.96)	1990-1995	2.88* (2.73 - 3.05)
	1995-1999	1.18* (1.03 - 1.40)	1995-2000	1.16* (1.03 - 1.42)
	1999-2003	0.33* (0.08 - 0.57)	2000-2003	0.08 (-0.53 - 0.61)
	2003-2009	-0.64* (-0.74 - -0.45)	2003-2016	-0.96* (-1.02 - -0.92)
	2009-2015	-0.93* (-1.15 - -0.84)	2016-2021	-0.09 (-0.27 - 0.17)

	2015-2021	-0.04 (-0.14 - 0.09)		
Baluchistan	1990-1995	2.79* (2.34 - 3.25)	1990-1994	3.08* (2.70 - 3.75)
	1995-2000	1.44* (1.15 - 3.03)	1994-2000	1.88* (1.56 - 2.16)
	2000-2004	0.29 (-0.16 - 1.47)	2000-2004	0.21 (-0.42 - 0.77)
	2004-2007	-1.39 (-1.68 - 0.27)	2004-2012	-1.21* (-1.49 - -1.05)
	2007-2014	-0.92 (-1.15 - 0.33)	2012-2021	-0.16 (-0.30 - 0.00)
	2014-2021	0.02 (-0.49 - 0.49)		
Khyber Pakhtunkhwa (KPK)	1990-1995	2.75* (2.50 - 3.03)	1990-1995	2.76* (2.52 - 3.12)
	1995-2001	1.17* (0.97 - 1.42)	1995-2000	1.57* (1.22 - 1.90)
	2001-2005	-0.36 (-0.80 - 0.20)	2000-2004	0.03 (-0.49 - 0.47)
	2005-2012	-1.11* (-1.49 - -0.94)	2004-2012	-1.29* (-1.52 - -1.15)
	2012-2021	0.08 (-0.04 - 0.22)	2012-2021	-0.07 (-0.19 - 0.07)
Islamabad	1990-1995	2.19* (2.01 - 2.48)	1990-1995	2.19* (1.90 - 2.70)
	1995-2000	1.50* (1.24 - 1.75)	1995-2000	1.59 (-0.09 - 1.81)
	2000-2004	0.28 (-0.05 - 0.69)	2000-2004	-0.02 (-1.24 - 0.34)
	2004-2012	-0.83* (-1.05 - -0.56)	2004-2012	-1.11 (-1.37 - 0.15)
	2012-2017	0.59 (-0.81 - 0.96)	2012-2021	0.24* (0.10 - 0.45)
	2017-2021	0.15 (-0.31 - 0.42)		
Gilgit Baltistan	1990-1992	2.11* (1.72 - 2.78)	1990-1995	2.79* (2.61 - 3.03)
	1992-1995	3.06* (1.39 - 3.31)	1995-2000	1.83* (1.60 - 2.02)
	1995-2000	1.42 (-0.20 - 1.54)	2000-2004	-0.20 (-0.44 - 0.12)
	2000-2004	-0.16 (-1.13 - 0.11)	2004-2013	-1.15* (-1.27 - -1.07)
	2004-2013	-1.07* (-1.18 - -0.32)	2013-2021	-0.20* (-0.31 - -0.09)
	2013-2021	-0.22* (-0.34 - -0.09)		
Azad Jammu Kashmir	1990-1995	2.57* (2.47 - 2.68)	1990-1995	2.53* (2.34 - 2.73)
	1995-2000	1.12* (1.03 - 1.28)	1995-2000	1.23* (1.04 - 1.44)
	2000-2003	0.25 (-0.18 - 0.67)	2000-2004	-0.08 (-0.35 - 0.19)
	2003-2010	-0.65* (-0.73 - -0.57)	2004-2013	-1.01* (-1.15 - -0.93)
	2010-2013	-1.21* (-1.34 - -0.98)	2013-2021	-0.02 (-0.12 - 0.13)
	2013-2021	0.12* (0.06 - 0.18)		

Table 3 presents the joinpoint analysis of Age-Standardized Mortality Rate (ASMR) and Age-Standardized dalys Rate (ASDR) for smoking-related risk factors across Pakistan from 1990 to 2021. The data reveals a significant national decline in ASMR, with a notable decrease from 2004 to 2018 of -2.80 (-2.86 to -2.78) and from 2018 to 2021 of -2.36 (- 2.65 to -1.98). These findings highlight a consistent downward trend in smoking-related mortality across all provinces and regions. Among the provinces, Sindh exhibited the most significant decline in ASMR (-2.68 [-2.74 to -2.64]), followed by Balochistan (-2.62 [-2.89 to -2.08]) and Khyber Pakhtunkhwa (KPK) (-2.57 [-2.73 to -2.36]). For ASDR, a similar pattern was observed, with a significant reduction in Pakistan from -2.83 (-2.89 to -2.80) from 2004 to 2018, and -2.40 (-2.71 to -2.03) from 2018 to 2021. Notably, Sindh demonstrated the most significant decline in ASDR (-2.74 [-2.80 to -2.70]), while Punjab showed a smaller but still significant reduction (-2.25 [-2.71 to -1.99]). These results suggest that while all regions experienced decreases in smoking-related disease burden, Sindh stands out for the largest reductions in both mortality and disease-adjusted life years, underlining the

effectiveness of tobacco control measures in that region.

Table 3: Join-point Analysis of Age Standardized Mortality and dalys Rate of Smoking in Pakistan from 1990 to 2021

Countries	Age Standardized Mortality Rate		Age Standardized dalys Rate	
	Year	APC (95% CI)	Year	APC (95% CI)
Pakistan	1990-1992	0.90* (0.53 - 1.30)	1990-1992	1.06* (0.68 - 1.47)
	1992-1995	2.79* (2.57 - 3.03)	1992-1995	2.81* (2.59 - 3.06)
	1995-1998	0.53* (0.32 - 0.72)	1995-1998	0.61* (0.40 - 0.81)
	1998-2004	-1.23* (-1.32 - -1.16)	1998-2004	-1.26* (-1.35 - -1.18)
	2004-2018	-2.80* (-2.86 - -2.78)	2004-2018	-2.83* (-2.89 - -2.80)
	2018-2021	-2.36* (-2.65 - -1.98)	2018-2021	-2.40* (-2.71 - -2.03)
Sindh	1990-1992	1.14* (0.79 - 1.64)	1990-1992	1.30* (0.92 - 1.81)
	1992-1996	2.59* (2.43 - 2.89)	1992-1996	2.61* (2.45 - 2.91)
	1996-1999	-0.05 (-0.34 - 0.17)	1996-1999	0.00 (-0.31 - 0.23)
	1999-2003	-0.91* (-1.32 - -0.77)	1999-2003	-0.98* (-1.38 - -0.82)
	2003-2009	-2.22* (-2.37 - -2.08)	2003-2009	-2.30* (-2.45 - -2.13)
	2009-2021	-2.68* (-2.74 - -2.64)	2009-2021	-2.74* (-2.80 - -2.70)
Punjab	1990-1992	0.74* (0.35 - 1.13)	1990-1992	0.90* (0.56 - 1.26)
	1992-1995	2.59* (2.36 - 2.84)	1992-1995	2.65* (2.45 - 2.87)
	1995-1998	0.32 (0.00 - 0.51)	1995-1998	0.41* (0.21 - 0.59)
	1998-2004	-1.30* (-1.41 - -1.22)	1998-2004	-1.32* (-1.40 - -1.25)
	2004-2018	-2.77* (-2.85 - -2.74)	2004-2019	-2.75* (-2.81 - -2.73)
	2018-2021	-2.42* (-2.72 - -2.03)	2019-2021	-2.25* (-2.71 - -1.99)
Baluchistan	1990-1992	2.05* (1.57 - 2.59)	1990-1992	2.04* (1.49 - 2.97)
	1992-1995	3.68* (3.36 - 3.99)	1992-1995	3.45* (1.37 - 3.82)
	1995-1998	1.37* (1.01 - 1.63)	1995-1998	1.20 (-1.15 - 1.48)
	1998-2004	-0.96* (-1.08 - -0.86)	1998-2004	-1.11* (-3.33 - -1.00)
	2004-2017	-3.24* (-3.31 - -3.20)	2004-2017	-3.40* (-3.51 - -3.35)
	2017-2021	-2.62* (-2.89 - -2.08)	2017-2021	-2.68* (-3.00 - -2.05)
Khyber Pakhtunkhwa (KPK)	1990-1992	1.73* (1.16 - 2.78)	1990-1992	1.87* (1.33 - 2.85)
	1992-1996	3.14 (-0.27 - 3.60)	1992-1996	3.14 (-0.24 - 3.55)
	1996-2001	-0.39* (-1.85 - -0.15)	1996-2001	-0.33* (-1.86 - -0.12)
	2001-2005	-1.88* (-3.51 - -1.52)	2001-2005	-1.85* (-3.70 - -1.54)
	2005-2013	-3.48* (-3.72 - -3.04)	2005-2012	-3.67* (-3.89 - -2.96)
	2013-2021	-2.57* (-2.73 - -2.36)	2012 - 2021	-2.70* (-2.83 - -2.55)
Islamabad	1990-1992	0.30 (0.00 - 0.78)	1990 - 1992	-0.48* (0.14 - 0.96)
	1992-1997	1.47* (1.36 - 1.66)	1992-1997	1.41* (1.29 - 1.64)
	1997-2001	-0.80* (-0.95 - -0.59)	1997-2001	-1.21* (-1.42 - -1.00)
	2001-2004	-1.71* (-2.22 - -1.28)	2001-2004	-1.89* (-2.68 - -1.56)
	2004-2014	-2.36* (-2.45 - -2.31)	2004-2013	-2.66* (-2.78 - -1.75)
	2014-2021	-1.55* (-1.65 - -1.44)	2013-2021	-1.68* (-1.78 - -1.57)

Gilgit Baltistan	1990-1992	0.68* (0.25 - 1.29)	1990-1992	1.09* (0.61 - 1.81)
	1992-1996	2.46* (2.26 - 2.80)	1992-1996	2.65* (2.41 - 3.06)
	1996-2000	-0.42* (-0.67 - -0.13)	1996-2000	-0.38* (-0.68 - -0.04)
	2000-2004	-1.72* (-2.07 - -1.47)	2000-2004	-1.72* (-2.25 - -1.46)
	2004-2014	-3.04* (-3.14 - -2.98)	2004-2014	-3.26* (-3.37 - -3.18)
	2014-2021	-2.20* (-2.33 - -2.04)	2014-2021	-2.27* (-2.42 - -2.09)
Azad Jammu Kashmir	1990-1992	-0.04 (-0.43 - 0.36)	1990-1997	0.87* (0.74 - 1.01)
	1992-1995	1.66* (1.42 - 1.91)	1997-2003	-1.89* (-2.07 - -1.67)
	1995-1998	-0.38* (-0.74 - -0.18)	2003-2013	-3.01* (-3.15 - -2.91)
	1998-2003	-1.89* (-2.09 - -1.72)	2013-2021	-1.95* (-2.10 - -1.79)
	2003-2013	-2.84* (-2.92 - -2.79)		
	2013-2021	-1.96* (-2.05 - -1.86)		

Table 4 shows the join point analysis of Age-Standardized Mortality Rate (ASMR) and Age-Standardized Daly's Rate (ASDR) for secondhand smoke exposure among all causes in Pakistan from 1990 to 2021. The data reveals a significant decrease in ASMR from 2019 to 2021, with an annual percentage change (APC) of -3.15 (-3.68 to -2.35). This decline was observed across all provinces and regions, with Sindh showing the most significant reduction -3.03 (-3.56 to -2.67), followed by Gilgit Baltistan -2.97 (-3.68 to -1.88) and Balochistan -2.88 (-3.32 to -2.53). Similarly, the ASDR also exhibited a significant decrease in Pakistan from 2018 to 2021 -5.29 (-6.00 to -4.35). Among the provinces, Sindh showed the most substantial reduction in ASDR -5.90 (-6.98 to -4.69), followed by Gilgit Baltistan -5.53 (-6.73 to -4.09) and Azad Jammu Kashmir -5.72 (-7.25 to -4.05). These findings indicate that secondhand smoke exposure has declined significantly in recent years, with the greatest improvements observed in Sindh and Gilgit Baltistan. The results suggest that tobacco control policies related to secondhand smoke, particularly in Sindh and Gilgit Baltistan, have been effective in reducing both mortality and disease burden. The regional disparities highlight the importance of continued and targeted interventions in areas with slower progress, such as Azad Jammu Kashmir and Khyber Pakhtunkhwa (KPK), to achieve further reductions in secondhand smoke exposure-related health outcomes.

Table 4: Join-point Analysis of Age-Standardized Mortality and dalys Rate of Second-Hand Smoke Exposure in Pakistan from 1990 till 2021

Countries	**Age-Standardized Mortality Rate**		**Age-Standardized dalys Rate**	
	Year	**APC (95% CI)**	**Year**	**APC (95% CI)**
Pakistan	1990-1996	2.48* (2.33 - 2.65)	1990-1996	1.26* (0.91 - 1.66)
	1996-2003	-0.29* (-0.42 - -0.17)	1996-2003	-1.02* (-1.35 - -0.64)
	2003-2019	-2.17* (-2.21 - -2.08)	2003-2018	-2.06* (-2.17 - -1.97)
	2019-2021	-3.15* (-3.68 - -2.35)	2018-2021	-5.29* (-6.00 - -4.35)
Sindh	1990-1997	2.02* (1.81 - 2.22)	1990-1996	0.98* (0.53 - 1.80)
	1997-2003	-0.31 (-0.56 - 0.16)	1996-2001	-0.63 (-1.67 - 0.17)
	2003-2012	-1.92* (-2.31 - -1.24)	2001-2018	-1.82* (-1.99 - -1.71)
	2012-2017	-1.41* (-1.74 - -0.91)	2018-2021	-5.90* (-6.98 - -4.69)
	2017-2021	-3.03* (-3.56 - -2.67)		
Punjab	1990-1996	2.31* (2.18 - 2.46)	1990-1996	1.03* (0.68 - 1.54)

	1996-2003	-0.53* (-0.63 - -0.43)	1996-2003	-1.3038* (-1.65 - -0.71)
	2003-2014	-2.28* (-2.36 - -2.18)	2003-2017	-2.12* (-2.27 - -2.01)
	2014-2021	-2.67* (-2.91 - -2.55)	2017-2021	-4.67* (-5.53 - -4.05)
Baluchistan	1990-1995	3.36* (3.18 - 3.56)	1990-1995	2.64* (2.15 - 3.30)
	1995-2004	0.85* (0.77 - 0.93)	1995-2004	0.43* (0.19 - 0.70)
	2004-2017	-1.45* (-1.51 - -1.40)	2004-2017	-1.31* (-1.44 - -1.17)
	2017-2021	-2.88* (-3.32 - -2.53)	2017-2021	-4.55* (-5.28 - -3.86)
Khyber Pakhtunkhwa (KPK)	1990-1995	3.67* (3.47 - 3.90)		
	1995-2000	0.71* (0.50 - 1.03)	1990-1996	2.52* (2.21 - 2.85)
	2000-2004	-0.46* (-0.99 - -0.19)	1996-2004	-0.28* (-0.51 - -0.07)
	2004-2011	-2.93* (-3.15 - -2.79)	2004-2011	-3.03* (-3.35 - -2.77)
	2011-2017	-1.53* (-1.73 - -1.13)	2011-2017	-1.07* (-1.39 - -0.60)
	2017-2021	-2.44* (-2.97 - -2.16)	2017-2021	-4.31* (-4.86 - -3.78)
Islamabad	1990-1997	0.96* (0.80 - 1.11)	1990-1992	-1.54* (-2.05 - -0.72)
	1997-2001	-0.38 (-0.59 - 1.13)	1992-1997	-0.59* (-2.08 - -0.12)
	2001-2004	-0.87* (-2.29 - -0.58)	1997-2005	-1.91* (-2.82 - -1.67)
	2004-2011	-2.09* (-2.25 - -1.14)	2005-2011	-2.61* (-3.05 - -1.23)
	2011-2018	-0.85* (-0.95 - -0.61)	2011-2017	-0.96* (-1.22 - -0.55)
	2018-2021	-1.56* (-2.03 - -1.27)	2017-2021	-2.27* (-2.70 - -1.97)
Gilgit Baltistan	1990-1996	2.14* (1.94 - 2.36)	1990-1997	0.44* (0.16 - 0.78)
	1996-2003	-0.57* (-0.74 - -0.38)	1997-2003	-1.48* (-1.93 - -1.09)
	2003-2012	-3.15* (-3.32 - -2.93)	2003-2011	-3.65* (-4.08 - -3.40)
	2012-2019	-1.59* (-3.05 - -1.18)	2011-2019	-1.99* (-2.19 - -1.60)
	2019-2021	-2.97* (-3.68 - -1.88)	2019-2021	-5.53* (-6.73 - -4.09)
Azad Jammu Kashmir	1990-1996	1.12* (0.91 - 1.32)	1990-1996	-0.45 (-0.86 - 0.23)
	1996-2003	-1.06* (-1.25 - -0.86)	1996-2003	-2.13* (-2.54 - -1.52)
	2003-2011	-2.53* (-2.74 - -2.37)	2003-2008	-3.40* (-4.53 - -2.68)
	2011-2019	-1.20* (-1.32 - -0.96)	2008-2019	-1.58* (-1.75 - -1.22)
	2019-2021	-2.58* (-3.21 - -1.78)	2019-2021	-5.72* (-7.25 - -4.05)

Table 5 shows the average annual percentage change (AAPC) of Age-Standardized Mortality Rates (ASMR) and Age-Standardized dalys Rates (ASDR) for tobacco, smoking, chewing tobacco, and secondhand smoke exposure across different regions of Pakistan from 1990 to 2021. The overall trend in Pakistan shows a significant decrease in tobacco-related ASMR -1.22* (-1.23 to -1.19), smoking-related ASMR -1.37* (-1.39 to -1.35), and secondhand smoke exposure-related ASMR -0.92* (-0.97 to -0.89). However, there was an increase in chewing tobacco-related ASMR +0.44* (0.42 to 0.46). Regionally, Azad Jammu Kashmir showed the most significant decrease in tobacco-related ASMR -1.43* (-1.45 to -1.41) and smoking-related ASMR (-1.61* [-1.64 to -1.60]), with similar trends for secondhand smoke exposure (-2.05* [-2.15 to -1.98]). Punjab also demonstrated a substantial reduction in tobacco-related ASMR (-1.32* [-1.34 to -1.30]) and smoking-related ASMR -1.42* (-1.45 to -1.40), while Sindh exhibited the largest increase in chewing tobacco-related ASMR +0.50* (0.48 to 0.52). For ASDR, there was a similar decreasing trend across tobacco -1.35* (-1.39 to -1.33), smoking -1.37* (-1.40 to -1.35), and secondhand smoke exposure -1.51* (-1.58 to -1.46) across Pakistan. Azad Jammu Kashmir had the most significant reduction in tobacco-related ASDR -1.67* (-1.70 to -1.64) and smoking-related ASDR (-1.65* [-1.69 to -1.63]). Sindh saw the highest increase in chewing tobacco-related ASDR (+0.50* [0.48 to 0.53]), while Gilgit Baltistan and Azad

Jammu Kashmir had significant reductions in secondhand smoke exposure-related ASDR (-2.01* [-2.09 to -1.96] and -2.05* [-2.15 to -1.98], respectively.

These results highlight the regional disparities in tobacco-related health outcomes, with some provinces experiencing significant reductions in mortality and disease burden, while others, particularly about chewing tobacco, show increases. The findings underscore the importance of implementing targeted tobacco control policies that address specific regional needs and risk factors.

Table 5: Average Annual Percentage Change of Age Standardized Mortality and Daly's Rate of Secondhand Smoke Exposure in Pakistan from 1990 to 2021 (Join-point Analysis)

Risk Factor	Countries	Age Standardized Mortality Rate	Age Standardized Daly's Rate
		AAPC (95% CI)	AAPC (95% CI)
Tobacco	Pakistan	-1.22* (-1.23 - -1.19)	-1.35* (-1.39 - -1.33)
	Sindh	-1.02* (-1.05 - -1.00	-1.19* (-1.23 - -1.16)
	Punjab	-1.32* (-1.34 - -1.30	-1.42* (-1.45 - -1.40)
	Balochistan	-1.00* (-1.02 - -0.98	-1.13* (-1.17 - -1.10)
	Khyber Pakhtunkhwa (KPK)	-1.14* (-1.17 - -1.11	-1.23* (-1.28 - -1.20)
	Islamabad	-0.99* (-1.01 - -0.97	-1.35* (-1.38 - -1.33)
	Gilgit Baltistan	-1.30* (-1.33 - -1.28	-1.51* (-1.54 - -1.48)
	Azad Jammu Kashmir	-1.43* (-1.45 - -1.41	-1.67* (-1.70 - -1.64)
Chewing Tobacco	Pakistan	0.44* (0.42 - 0.46)	0.39* (0.38 - 0.42)
	Sindh	0.50* (0.48 - 0.52)	0.50* (0.48 - 0.53)
	Punjab	0.33* (0.32 - 0.35)	0.23* (0.21 - 0.25)
	Balochistan	0.37* (0.34 - 0.41)	0.41* (0.39 - 0.46)
	Khyber Pakhtunkhwa (KPK)	0.38* (0.36 - 0.42)	0.34* (0.31 - 0.37)
	Islamabad	0.52* (0.50 - 0.56)	0.38* (0.35 - 0.42)
	Gilgit Baltistan	0.26* (0.24 - 0.29)	0.32* (0.30 - 0.34)
	Azad Jammu Kashmir	0.37* (0.36 - 0.39)	0.29* (0.27 - 0.32)
Smoking	Pakistan	-1.37* (-1.39 - -1.35)	-1.37* (-1.40 - -1.35)
	Sindh	-1.20* (-1.22 - -1.18)	-1.23* (-1.25 - -1.21)
	Punjab	-1.42* (-1.45 - -1.40)	-1.39* (-1.42 - -1.37)
	Balochistan	-1.29* (-1.32 - -1.26)	-1.43* (-1.47 - -1.40)
	Khyber Pakhtunkhwa (KPK)	-1.38* (-1.41 - -1.33)	-1.40* (-1.44 - -1.37)
	Islamabad	-1.13* (-1.15 - -1.11)	-1.30* (-1.32 - -1.28)
	Gilgit Baltistan	-1.41* (-1.44 - -1.38)	-1.44* (-1.47 - -1.41)

	Azad Jammu Kashmir	-1.61* (-1.64 - -1.60)	-1.65* (-1.69 - -1.63)
Secondhand Smoke Exposure	**Pakistan**	-0.92* (-0.97 - -0.89)	-1.51* (-1.58 - -1.46)
	Sindh	-0.79* (-0.83 - -0.76)	-1.49* (-1.58 - -1.42)
	Punjab	-1.10* (-1.13 - -1.08)	-1.67* (-1.73 - -1.61)
	Baluchistan	-0.21* (-0.24 - -0.18)	-0.60* (-0.67 - -0.54)
	Khyber Pakhtunkhwa (KPK)	-0.65* (-0.69 - -0.62)	-1.06* (-1.11 - -1.01)
	Islamabad	-0.73* (-0.76 - -0.72)	-1.67* (-1.71 - -1.64)
	Gilgit Baltistan	-1.20* (-1.24 - -1.16)	-2.01* (-2.09 - -1.96)
	Azad Jammu Kashmir	-1.16* (-1.20 - -1.13)	-2.05* (-2.15 - -1.98)
*Indicate the average annual percentage change (AAPC) is significantly different from zero at an alpha less than 0.05 Empirical Quantile Method			

Table 6 presents the predicted Age-Standardized Mortality Rate (ASMR) for tobacco, chewing tobacco, smoking, and secondhand smoke exposure risk factors in Pakistan from 2022 to 2031. The data shows that overall tobacco-related ASMR is predicted to decrease significantly by 96.17 (71.61 - 131.83). Smoking-related ASMR shows a substantial reduction of 73.13 (61.96 – 85.22), and secondhand smoke exposure is expected to decrease by 17.19 (6.84 – 17.46). In contrast, the ASMR for chewing tobacco shows only a minor decrease of 5.67 (3.54 – 5.82). The projected trends suggest a steady decline in tobacco-related mortality rates, particularly due to smoking, with significant reductions expected through 2031. However, chewing tobacco shows a comparatively smaller decrease, indicating the need for continued attention and intervention in this area. The predicted decline in secondhand smoke exposure mortality reflects the impact of ongoing public health policies aimed at reducing passive smoking risks. These projections underscore the effectiveness of tobacco control measures in driving down mortality rates over the next decade.

Table 6: Predicted Age Standardized Mortality Rate of Tobacco, chewing tobacco, smoking, and Secondhand Smoke Exposure Risk among all causes in Pakistan (2022 - 2032)

Year	**Tobacco**	**Chewing Tobacco**	**Smoking**	**Second-Hand Smoke Exposure**
2022	113.46 (83.07 - 149.46)	4.84 (3.60 - 6.44)	89.04 (66.55 - 117.54)	24.32 (12.83 - 36.26)
2023	111.19 (81.49 - 147.14)	4.84 (3.60 - 6.38)	86.97 (66.13 - 114.70)	23.74 (12.42 - 34.15)
2024	109.04 (80.00 - 145.48)	4.83 (3.61 - 6.33)	85.01 (65.68 - 111.72)	23.00 (11.70 - 32.75)
2025	106.99 (78.60 - 143.36)	4.81 (3.61 - 6.26)	83.13 (65.20 - 108.57)	22.28 (11.17 - 30.44)
2026	105.03 (77.27 - 141.55)	4.80 (3.61 - 6.21)	81.33 (64.70 - 105.22)	21.51 (10.44 - 28.94)
2027	103.15 (76.02 - 139.54)	4.78 (3.60 - 6.13)	79.59 (64.18 - 101.67)	20.71 (9.83 - 26.42)
2028	101.33 (74.83 - 137.66)	4.76 (3.59 - 6.07)	77.91 (63.65 - 97.91)	19.88 (9.08 - 24.83)
2029	99.57 (73.70 - 135.69)	4.73 (3.58 - 5.99)	76.28 (63.10 - 93.91)	19.02 (8.38 - 22.09)
2030	97.85 (72.63 - 133.79)	4.71 (3.56 - 5.91)	74.69 (62.54 - 89.69)	18.12 (7.60 - 20.42)
2031	96.17 (71.61 - 131.83)	4.67 (3.54 - 5.82)	73.13 (61.96 - 85.22)	17.19 (6.84 - 17.46)

Discussion:

This longitudinal analysis elucidates a significant downward trajectory in age-standardized mortality

rates (ASMR) and disability-adjusted life years (dalys) attributable to tobacco use in Pakistan over a period spanning three decades. The data not only affirm a global downtrend in tobacco consumption, but the World Health Organization (2021)(14, 15) corroborates and highlights Pakistan's relatively accelerated pace of decline compared to its regional counterparts. This variance underscores the substantial influence of socio-economic, cultural, and policy-oriented factors in shaping regional tobacco consumption patterns.

The pronounced reduction in tobacco-related health burdens observed between 2004 and 2014 coincides with rigorous tobacco control policies, particularly the Prohibition of Smoking and Protection of Non-smokers Health Ordinance enacted by the Pakistani government in 2002 (8). This temporal alignment strongly indicates the profound impact of proactive legislative frameworks on public health outcomes. The economic implications of these health improvements are significant, as detailed by Memon et al. (2024)(16), who delineate the considerable financial benefits derived from reduced tobacco use, underscoring the fiscal prudence of stringent tobacco control measures.

Predictive modeling using an ARIMA framework projects a sustained decline in tobacco-related mortality and dalys through 2031, offering a foundation for optimistic long-term health policy planning. However, the persistence of regional disparities, notably in provinces like Balochistan and Sindh, highlights the imperative for customized public health strategies that accommodate specific regional dynamics influencing tobacco use.

The synthesis of global perspectives provided by Chugh et al. (2023)(17) and Siddiqi et al. (2020)(18), along with Hou et al.'s (2024) (19) specific focus on ischemic stroke risks associated with tobacco use, enriches the broader narrative on the multifaceted impacts of tobacco. These comprehensive analyses underscore the global health imperative for robust tobacco control policies and spotlight the international community's collective responsibility in tackling this preventable health crisis.

The study has some limitations that should be considered when interpreting the findings. This was an ecological study, which assesses population-level data and does not control for potential confounders, such as socioeconomic factors, which may not be fully accounted for. . Additionally, the study does not control for unmeasured confounders like tobacco control policies, public health interventions, or changes in smoking behavior that could influence mortality and disease burden (20). Regional disparities were highlighted, but local socio-economic and cultural factors that affect tobacco consumption may not have been fully captured. The use of the ARIMA model for future predictions assumes that past trends will continue, which may not fully account for sudden shifts in tobacco use or healthcare advancements (21). Moreover, the generalizability of findings to all regions in Pakistan may be limited, especially in rural or underreported areas. Finally, the study may not fully capture the short-term effects of recent tobacco control policies, as these interventions typically take time to impact population health. Acknowledging these limitations allows for a more nuanced understanding of the study's results and identifies areas for future research (22).

Given these findings, it is evident that while considerable strides have been made in mitigating the public health impact of tobacco use, the journey towards the eradication of tobacco-related morbidity and mortality requires unwavering commitment to and enhancement of existing control measures 23,24). Future research should focus on exploring the social, cultural, and economic factors influencing tobacco use in Pakistan through qualitative studies, such as interviews and focus groups. Intervention-specific evaluations are needed to assess the effectiveness of tobacco control measures, including smoking cessation programs, public bans, and taxation policies. Longitudinal studies could track the impact of these interventions on smoking rates and health outcomes. Additionally, region-specific studies should examine geographic disparities and the role of regional policies and healthcare access in tobacco-related mortality (25). Research on emerging tobacco products, like e-cigarettes, is also crucial to understand their impact on tobacco use patterns in Pakistan.

Conclusion:

This study reveals a significant decline in tobacco-related mortality and disability-adjusted life years (dalys) in Pakistan from 1990 to 2021, especially after the implementation of stricter tobacco control policies. However, regional disparities persist, with areas like Islamabad and Sindh showing increases in chewing tobacco-related health burdens. The predicted trends suggest continued reductions in

smoking and secondhand smoke exposure through 2031. The findings highlight the effectiveness of tobacco control measures and the need for region-specific interventions. Future research should focus on targeted strategies for high-risk areas and emerging tobacco products. Continued enforcement of policies and monitoring are essential for sustaining progress. Equitable health outcomes require tailored, localized interventions to address regional variations in tobacco use.

Declarations:

Ethics Approval and Consent to Participate: Ethical approval was not required as this was a secondary study using publicly available data from the Global Burden of Disease (GBD) database.

Consent for Publication: Not applicable.

Availability of Data and Materials: The data used in this study are available upon reasonable request from the corresponding author and can also be easily downloaded from the GBD website.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgments: None

References

1. West R. Tobacco smoking: Health impact, prevalence, correlates and interventions. Psychol Health. 2017;32(8):1018-36.
2. (WHO) WHO. WHO global report on trends in prevalence of tobacco use 2000-2025, fourth edition 2021 [cited 2025. Available from: https://www.who.int/publications-detail-redirect/9789240039322.
3. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2024;403(10440):2162-203.
4. Saqib MAN, Rafique I, Qureshi H, Munir MA, Bashir R, Arif BW, et al. Burden of tobacco in Pakistan: findings from global adult tobacco survey 2014. Nicotine and Tobacco Research. 2018;20(9):1138-43.
5. Palipudi K, Rizwan SA, Sinha DN, Andes LJ, Amarchand R, Krishnan A, Asma S. Prevalence and sociodemographic determinants of tobacco use in four countries of the World Health Organization: South-East Asia region: findings from the Global Adult Tobacco Survey. Indian J Cancer. 2014;51 Suppl 1:S24-32.
6. Mann N, Spencer G, Hutchinson B, Ngongo C, Tarlton D, Webb D, et al. Interpreting results, impacts and implications from WHO FCTC tobacco control investment cases in 21 low-income and middle-income countries. Tobacco Control. 2024;33(Suppl 1):s17-s26.
7. Organization WH. Tobacco Control in South-East Asia Region 2020 [cited 2025. Available from: https://www.who.int/southeastasia/health-topics/tobacco/tobacco-control-in-the-south-east-asia-region.
8. Pakistan. Go. Prohibition of Smoking and Protection of Non-smokers Health Ordinance. Islamabad. 2002 [Available from: http://www.tcc.gov.pk/Downloads/Prohibition%20of%20Smoking%20and%20Protection%20of%20Non-Smokers%20Ordinance%20%202002.pdf.
9. Saqib MAN, Rafique I, Qureshi H, Munir MA, Bashir R, Arif BW, et al. Burden of Tobacco in Pakistan: Findings From Global Adult Tobacco Survey 2014. Nicotine Tob Res. 2018;20(9):1138-43.
10. Brauer M, Roth GA, Aravkin AY, Zheng P, Abate KH, Abate YH, et al. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet. 2024;403(10440):2162-203.
11. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med. 2000;19(3):335-51.
12. Abdullah S, Ansaari S, Boeckmann M, Khan A, Siddiqi K. The extent of illicit cigarette sales in five rural districts of Pakistan: a cross-sectional study. Nicotine and Tobacco Research. 2025;27(1):143-7.
13. Irshad HA, Raja S, Jehanzeb H, Shaikh WA, Saleem U, Malik SAR, et al. Smokeless tobacco: knowledge, attitudes and usage in Pakistan. J Health Popul Nutr. 2025;44(1):19.
14. Razzaq S, Nagi MLF, Athar U, Kazmi T, Alslamah T, Naz S, Abalkhail A. Prevalence of tobacco consumption and the associated factors among the adults in an urban slum: Findings from the WHO stepwise survey. Tob Induc Dis. 2022;90:91.
15. Organization WH. Tobacco use declines despite tobacco industry efforts to jeopardize progress 2024 [Available from:

https://www.who.int/news/item/16-01-2024-tobacco-use-declines-despite-tobacco-industry-efforts-to-jeopardize-progress.
16. Memon JA, Nasir M, Nayab D, Siddique O, Kishwar S. Economic burden of tobacco use in Pakistan. Tobacco control. 2024;33(Suppl 2):s101-s7.
17. Chugh A, Arora M, Jain N, Vidyasagaran A, Readshaw A, Sheikh A, et al. The global impact of tobacco control policies on smokeless tobacco use: a systematic review. Lancet Glob Health. 2023;11(6):e953-e68.
18. Siddiqi K, Siddiqui F, Boeckmann M, Islam Z, Khan A, Dobbie F, et al. Attitudes of smokers towards tobacco control policies: findings from the Studying Tobacco users of Pakistan (STOP) survey. Tobacco Control. 2022;31(1):112-6.
19. Wang H, Lu F, Tian Y, Zhang S, Han S, Fu Y, et al. Evaluation of toxicity of heated tobacco products aerosol and cigarette smoke to BEAS-2B cells based on 3D biomimetic chip model. Toxicology in Vitro. 2024;94:105708.
20. GBD 2019 Tobacco Collaborators. Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. Lancet (London, England). 2021 Jun 19;397(10292):2337.
21. Masud H. *Reducing the affordability of tobacco products in Pakistan: a political economy analysis* (Doctoral dissertation, University of Warwick).
22. Coyle K, Singh PK, Kaushik R, Huque R, Khan Z, Mehrotra R, Siddiqi K, Pokhrel S. The lifetime health and economic burden of smokeless tobacco use in Bangladesh, India, and Pakistan: Results from ASTRAMOD. Nicotine & tobacco research. 2025 Mar 24;27(4):684-92.
23. Glozah FN. Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019.
24. Liao J, Zeng L, Huang X, Huang H, Shen C, Li J, Zhan Y. Burden of Chronic Obstructive Pulmonary Disease in China: A Global Burden of Disease Study on Temporal Trends, Risk Factor Contributions, and Projected Disease Burden from 1990 to 2030. COPD: Journal of Chronic Obstructive Pulmonary Disease. 2025 Jul 7;22(1):2531016.
25. Jalbani NB, Solangi SH, Bhutto S, Min HS, Khan H, Nawaz HR, Bhatti M, Imad S. Health risk assessment and trace element analysis in tobacco products and user blood samples from urban and rural Karachi. Scientific Reports. 2025 Oct 1;15(1):34229

Conflict of interest: Author declares no conflict of interest.
Funding Disclosure: Nil

Author's Contribution:

Zeeshan Ahsan: Conception or design of the work, write-up, and review
Mehak Ahsan: Conception or design of the work, write-up, and review