Open Peer Review on Qeios

Tobacco Smoking-Attributable Mortality in Kenya: 2012 – 2021

Lazarus Odeny[1], Gladwell Gathecha[2], Valerian Mwenda[2], Anne Kendagor[2], Samuel Cheburet[2], Beatrice Mugi[3], Caroline Mithi[4], Florence Jaguga[5], Kennedy Okinda[3], Shukri Mohamed[6], Jane Rahedi Ong'ang'o[7]

1 Amref Health Africa
2 Ministry of Health
3 Kenyatta National Hospital
4 Kenyatta University
5 Moi Teaching And Referral Hospital
6 African Population and Health Research Center
7 Kenya Medical Research Institute

Funding: This study was funded by the Tobacco Control Data Initiative (TCDI), a comprehensive program spanning six African countries: The Democratic Republic of Congo, Ethiopia, Kenya, Nigeria, South Africa, and Zambia. The TCDI aims to discern the tobacco-related data needs of these nations, identify existing datasets, address data gaps, and develop tools to empower policymakers in formulating effective tobacco policies. The initiative is spearheaded by Development Gateway, a global non-profit organization specializing in data for development, in collaboration with the University of Cape Town's Research Unit on the Economics of Excisable Products (REEP), operating as an IREX Venture.

Potential competing interests: No potential competing interests to declare.

Abstract

Background: Tobacco smoking poses a significant risk for various diseases, including cardiovascular diseases, chronic respiratory diseases, and cancers. In Kenya, tobacco-related deaths contribute substantially to non-communicable disease mortality. This study aims to quantify the mortality attributed to tobacco smoking in Kenya from 2012 to 2021.

Methods: Employing a prevalence-based analysis model, the study utilized Population Attributable Fraction to estimate age-specific Smoke Attributable Mortality (SAM) rates for individuals aged 35 years and older. Causes of death associated with tobacco use, including cancers, cardiovascular diseases, respiratory diseases, tuberculosis, and diabetes, were analyzed based on age, sex, and death records between 2012 and 2021.

Results: Over the study period, 60,228 deaths were attributed to tobacco-related diseases, with an annual increase observed until 2016 and subsequent fluctuations. Respiratory diseases, diabetes mellitus, malignant cancers, tuberculosis, and cardiovascular diseases collectively accounted for 16.5% of deaths among individuals aged 35 and older. Notable contributors were pneumonia and influenza (respiratory diseases), oesophageal cancer (cancers), and cerebrovascular diseases (cardiovascular diseases).

Smoking Prevalence: Smoking prevalence in Kenya indicated 17.4% of men, 0.9% of women, and 9% overall as current smokers. Former smokers constituted 10.6% of men, 1.4% of women, and 5.9% overall.

Smoking-Attributable Mortality: Out of observed deaths, 16.5% were attributed to smoking, with respiratory diseases (40.5%), malignant cancers (31.4%), tuberculosis (13%), cardiovascular diseases (8.9%), and diabetes mellitus (6.1%)

contributing. Pneumonia and influenza, oesophageal cancer, chronic airway obstruction, and tuberculosis were primary causes, comprising 70% of all Smoking-Attributable Mortality (SAM).

Discussion: The study underscores smoking's substantial impact on mortality in Kenya, emphasizing the urgency of preventive measures and tobacco control strategies. The findings highlight the differential contributions of smoking to various diseases, indicating the need for targeted interventions tailored to specific health outcomes.

Conclusion: Tobacco-related mortality is a significant public health concern in Kenya. Efforts should focus on preventing tobacco use and managing associated disease burdens. Smoking cessation initiatives and comprehensive tobacco control measures are imperative to mitigate the impact on population health.

Lazarus Odeny[1,*], **Gladwell Gathecha**[2], **Valerian Mwenda**[2], **Anne Kendagor**[2], **Samuel Cheburet**[2], **Beatrice Mugi**[3], **Caroline Mithi**[4], **Florence Jaguga**[5], **Kennedy Okinda**[6], **Shukri Mohamed**[7], **Jane Rahedi Ong'ang'o**[1,**]

[1] *Kenya Medical Research Institute, Centre for Respiratory Diseases Research*

[2] *Department of Non-Communicable Diseases, Ministry of Health Kenya*

[3] *Kenyatta National Hospital, Nairobi*

[4] *Kenyatta University Teaching, Referral and Research Hospital*

[5] *Moi Teaching and Research Hospital*

[6] *Kenyatta National Hospital, Othaya*

[7] *African Population and Health Research Center*

[*]Corresponding author:

Lazarus Odeny, P. O. Box 3589 Kisumu, 40100 (E-mail:LazarusOdeny@gmail.com)

**Alternative corresponding author:

Jane Rahedi Ong'ang'o, P. O. Box 74775 Nairobi, 00200 (E-mail:jrnabongo@gmail.com)

Keywords: Tobacco smoking, Smoking - attributable mortality, population-attributable fraction.

Introduction

Tobacco smoking is a significant risk factor for a spectrum of illnesses, including cardiovascular diseases (CVD), chronic respiratory conditions, and various cancers affecting the lungs and other organs [1][2][3][4]. This habit contributes to a staggering toll of 7.69 million deaths and 200 million disability-adjusted life-years (DALYs) [5] worldwide. Notably, in 2019, the leading causes of mortality linked to tobacco use globally were ischaemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), tracheal and bronchus cancers, lung cancers, and stroke, collectively responsible for

approximately 72% of tobacco-related deaths [5].

Examining the situation in Kenya, findings from the 2015 STEPs-survey and the Kenya Global Adults Tobacco Survey (GATS) [6][7][8] underscore the prominence of cardiovascular diseases as the primary cause of death associated with tobacco use, followed by cancers, respiratory diseases, and diabetes. Together, these ailments account for 82% of all non-communicable disease (NCD) deaths attributable to tobacco use. The surveys report an overall tobacco use prevalence in Kenya of 13.5%, with significantly higher rates among males (23%) compared to females (4%).

Despite the substantial impact of tobacco on public health, there is a dearth of studies investigating the mortality burden of tobacco smoking in Kenya. Notable among these limited studies is a retrospective analysis by Ogeng'o in 2010, utilizing data from Kenyatta National Hospital, which found a 12.5% increase in the risk of myocardial infarction associated with smoking [9]. Additionally, research by Macigo et al. revealed that smokers of filter cigarettes had a relative risk of 9.1 for oral leukoplakia, while non-filter cigarette smokers had a risk of 9.8 [10].

In light of this gap in knowledge, our study sought to comprehensively investigate and quantify the mortality attributed to tobacco smoking in Kenya over the period from 2012 to 2021.

Methods

Study Design

Our study employed a prevalence-based analysis model [11][12], as recommended by Pérez-Ríos et al. (2008, 2022), for estimating attributable mortality related to tobacco smoking. This model relies on the Population Attributable Fraction (PAF), quantifying the proportion of deaths in the population attributed to a specific risk factor, such as tobacco smoking. Specifically, it calculates age-specific Smoke Attributable Mortality (SAM) rates for individuals aged 35 or older, factoring in age, sex, and cause-specific mortality rates. This method, widely acknowledged for SAM calculations, was deliberately chosen due to the absence of cancer mortality data among never smokers in Kenya, ensuring a robust estimation of mortality attributable to tobacco smoking.

The prevalence-based approach proves effective in situations where detailed cancer mortality data for non-smokers is unavailable. By employing this model, we could confidently estimate the mortality linked to tobacco smoking in Kenya. The model's consideration of age-specific SAM rates, along with demographic and cause-specific factors, enhances the precision of our estimations.

This methodological choice offers notable advantages. Firstly, it allows the computation of SAM rates even when comprehensive cancer mortality data for non-smokers is lacking. Secondly, it adheres to international standards for estimating tobacco-related mortality [12]. Thirdly, it facilitates meaningful comparisons with other studies utilizing similar prevalence-based models, thereby enhancing the generalizability of our findings.

By consciously selecting the prevalence-based analysis model, our objective was to furnish a comprehensive and

dependable assessment of the mortality burden attributed to tobacco smoking in Kenya, thereby contributing to a broader understanding of the impact of tobacco use on public health..

Non-Communicable Disease Causes of Death

Tobacco use has been linked to non-communicable diseases such as cancers, cardiovascular diseases, chronic respiratory diseases, tuberculosis [13][14][15], and diabetes [16]. We adopted a similar disaggregation by sex and age-group in our study. Recognizing that the effects of tobacco use manifest later after smoking initiation, we focused on causes of deaths observed in individuals aged 35 and older in Kenya between 2012 and 2021. Causes of deaths were stratified into two age groups: 35 to 64 years and 65 years and above. Additionally, causes of deaths were stratified by sex.

Observed All-Cause Mortality

To determine all-cause mortality, we utilized data from the United Nations website[17] for annual population estimates. Crude death rates for tobacco-related diseases were calculated against national population projections. Joinpoint regression analysis using Joinpoint software 4.9.1.0-April 2022 (Statistic Research and Application Branch, National Cancer Institute) was applied to identify changes in mortality rate trends for every age and sex group. This method determines the year(s) when a trend change occurs based on crude mortality rates. We integrated population data with all-cause mortality data to model deaths attributable to tobacco smoking in Kenya between 2012 and 2021. The mortality data was extracted from the Kenya Health Information System (KHIS), encompassing de-identified, case-based data from health facility-based deaths in Kenya.

All-cause mortality data between 2012 and 2021 was systematically reviewed from hospital medical records. A total of 500 facilities were sampled, including 3 national teaching and referral hospitals and a stratified sample of sub-county and faith-based hospitals. Recertification of the cause of death was performed using WHO-recommended forms, and data was coded using the 10th International Classification of Diseases (ICD-10).

Smoking Prevalence in Kenya - Mid-Year Analysis

Data on smoking prevalence was obtained from the STEPS survey 2015[6], a national cross-sectional household survey covering individuals aged 18-69 years. The GATS survey 2014 [7] was also utilized, which used multistage stratified cluster sampling of 5,376 households. Both surveys provided insights into tobacco use and measures of interest. Relative risks of death among smokers and ex-smokers compared to non-smokers were derived from recent systematic reviews and the Cancer Prevention Study II of 1982-1988. For our research, we used the relative risks proposed by the Cancer Prevention Study II and the Royal College of Physicians in 2020 [18].

Calculation of Smoking Attributable Mortality

The study calculated Smoking Attributable Mortality (SAM) for each cause of mortality using the formula SAM = OM ×

PAF, where OM represented observed mortality, and PAF denoted the Population Attributable Fraction. PAF was determined by the formula {[p0 + p1RR1 + p2RR2] - 1} / [p0 + p1RR1 + p2RR2], with p0, p1, and p2 representing the prevalence of non-smokers, current smokers, and former-smokers, respectively. RR1 and RR2 denoted the risks of dying from any cause for current smokers and ex-smokers, respectively. The SAM formula encapsulated a comprehensive estimation of mortality associated with tobacco smoking, considering the prevalence and risks of different smoking categories. The calculation allowed for the determination of the proportion of deaths attributed to smoking, providing a quantifiable measure of the mortality burden associated with tobacco smoking in the studied population. The methodology integrated data from multiple sources and employed statistical analysis techniques to estimate tobacco-related mortality in Kenya, considering age, sex, and specific causes of death. Ethical considerations, data reliability, and the use of established models contributed to the robustness of the study's methodology [11][12][19].

Results

Observed Mortality

Between 2012 and 2021, Kenya experienced 60,228 deaths attributed to tobacco-related diseases among adults aged 35 years and older. Median age was 65; interquartile range of 50-77. Males accounted for the majority at 56% [Table 1]. The observed mortality demonstrated an annual increase across all cohorts (males 35-64 years, males 65 years and above, females 35-64 years, and females 65 years and above) until 2016, with a notable decline in 2017 due to a health-workers strike affecting record-keeping. Subsequently, mortality rates fluctuated, reaching a sharp increase after 2018 [Figure 1-2]. Joinpoint regression analysis revealed a decline in mortality rates until 2018, followed by a substantial rise.

The major contributors to mortality included respiratory diseases (36%), diabetes mellitus (18%), malignant cancers (17%), tuberculosis (16%), and cardiovascular diseases (13%). Among respiratory infections, pneumonia and influenza (86%) predominated, surpassing COPD (13%) and bronchitis/emphysema (1%). The year 2020 witnessed a significant twofold increase in pneumonia and influenza deaths, attributed to COVID-19. Noteworthy cancer causes included oesophagus cancer (37%), cervical cancer (19%), stomach cancer (16%), and pancreatic cancer (9%). Cerebrovascular diseases (87%) emerged as the primary cardiovascular cause of death, followed by ischemic heart diseases (10%) and other arterial diseases (3%) [Table 1].

Tobacco-related diseases	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total (%)
1. Malignant cancers (Cancer)	**930 (16%)***	**848 (15%)**	**866 (15%)**	**921 (14%)**	**1,200 (15%)**	**609 (20%)**	**880 (17%)**	**1,118 (22%)**	**1,287 (20%)**	**1,380 (15%)**	**10,039 (17%)**
Esophagus C15	326 (35%)**	300 (35%)	344 (40%)	346 (38%)	484 (40%)	240 (39%)	351 (40%)	429 (38%)	441 (34%)	438 (32%)	3,699 (37%)
Kidney and renal pelvis C64-C65	6 (1%)	5 (1%)	7 (1%)	11 (1%)	6 (1%)	5 (1%)	9 (1%)	12 (1%)	12 (1%)	17 (1%)	90 (1%)
Larynx C32	17 (2%)	11 (1%)	10 (1%)	12 (1%)	16 (1%)	10 (2%)	6 (1%)	18 (2%)	21 (2%)	49 (4%)	170 (2%)
Lips, oral cavity, pharynx C00–C14	41 (4%)	47 (6%)	48 (6%)	55 (6%)	55 (5%)	48 (8%)	53 (6%)	60 (5%)	105 (8%)	122 (9%)	634 (6%)
The neck of the uterus C53	186 (20%)	187 (22%)	177 (20%)	163 (18%)	224 (19%)	115 (19%)	170 (19%)	179 (16%)	236 (18%)	277 (20%)	1,914 (19%)
Pancreas C25	94 (10%)	84 (10%)	58 (7%)	79 (9%)	105 (9%)	37 (6%)	81 (9%)	94 (8%)	122 (9%)	135 (10%)	889 (9%)
Stomach C16	178 (19%)	150 (18%)	150 (17%)	169 (18%)	195 (16%)	102 (17%)	122 (14%)	203 (18%)	186 (14%)	196 (14%)	1,651 (16%)
Trachea, lungs, bronchi C33–C34	52 (6%)	41 (5%)	44 (5%)	55 (6%)	79 (7%)	34 (6%)	73 (8%)	98 (9%)	136 (11%)	118 (9%)	730 (7%)
Urinary bladder C67	30 (3%)	23 (3%)	28 (3%)	31 (3%)	36 (3%)	18 (3%)	15 (2%)	25 (2%)	28 (2%)	28 (2%)	262 (3%)
2. Cardiovascular diseases (CVD)	**612 (11%)**	**628 (11%)**	**685 (12%)**	**844 (13%)**	**1,087 (14%)**	**392 (13%)**	**762 (15%)**	**751 (15%)**	**980 (15%)**	**1,171 (13%)**	**7,912 (13%)**
Cerebrovascular disease I60–I69	518 (85%)	570 (91%)	609 (89%)	735 (87%)	968 (89%)	343 (88%)	657 (86%)	647 (86%)	826 (84%)	997 (85%)	6,870 (87%)
Ischemic heart disease I20-I25	70 (11%)	46 (7%)	63 (9%)	91 (11%)	92 (8%)	37 (9%)	77 (10%)	74 (10%)	118 (12%)	131 (11%)	799 (10%)
Other arterial diseases I72-I78	24 (4%)	12 (2%)	13 (2%)	18 (2%)	27 (2%)	12 (3%)	28 (4%)	30 (4%)	36 (4%)	43 (4%)	243 (3%)
3. Respiratory diseases (CRD)	**1,953 (34%)**	**1,943 (35%)**	**2,122 (36%)**	**2,485 (37%)**	**2,794 (36%)**	**977 (33%)**	**1,698 (33%)**	**1,553 (31%)**	**2,071 (33%)**	**4,075 (45%)**	**21,671 (36%)**
Bronchitis, Emphysema J40-J43	19 (1%)	14 (1%)	23 (1%)	16 (1%)	23 (1%)	8 (1%)	6 (0%)	12 (1%)	11 (1%)	13 (0%)	145 (1%)
Chronic airway obstruction J44–J46	290 (15%)	279 (14%)	260 (12%)	313 (13%)	409 (15%)	155 (16%)	256 (15%)	225 (14%)	268 (13%)	362 (9%)	2,817 (13%)
Pneumonia, Influenza J10-J18	1,644 (84%)	1,650 (85%)	1,839 (87%)	2,156 (87%)	2,362 (85%)	814 (83%)	1,436 (85%)	1,316 (85%)	1,792 (87%)	3,700 (91%)	18,709 (86%)
4. Tuberculosis (TB)	**1,232 (22%)**	**1,220 (22%)**	**1,269 (21%)**	**1,230 (18%)**	**1,417 (18%)**	**485 (16%)**	**793 (15%)**	**694 (14%)**	**714 (11%)**	**599 (7%)**	**9,653 (16%)**
5. Diabetes mellitus	**967 (17%)**	**947 (17%)**	**986 (17%)**	**1,247 (19%)**	**1,317 (17%)**	**538 (18%)**	**984 (19%)**	**889 (18%)**	**1,274 (20%)**	**1,804 (20%)**	**10,953 (18%)**
Total	**5,694 (100%)**	**5,586 (100%)**	**5,928 (100%)**	**6,727 (100%)**	**7,815 (100%)**	**3,001 (100%)**	**5,117 (100%)**	**5,005 (100%)**	**6,326 (100%)**	**9,029 (100%)**	**60,228 (100%)**
	*% is of subgroup over total deaths (i.e., 16% Cancer deaths in the year 2012= 930/5,694) and **disease specific percentage (%) is over the subgroup; i.e., 35% of Esophagus C15 deaths for year 2012=Esophagus C15 deaths over all Cancer deaths (326/930)										

Table 1. Absolute numbers of recorded deaths of 35 years and above who died due to tobacco related diseases in Kenya between 2012-2021

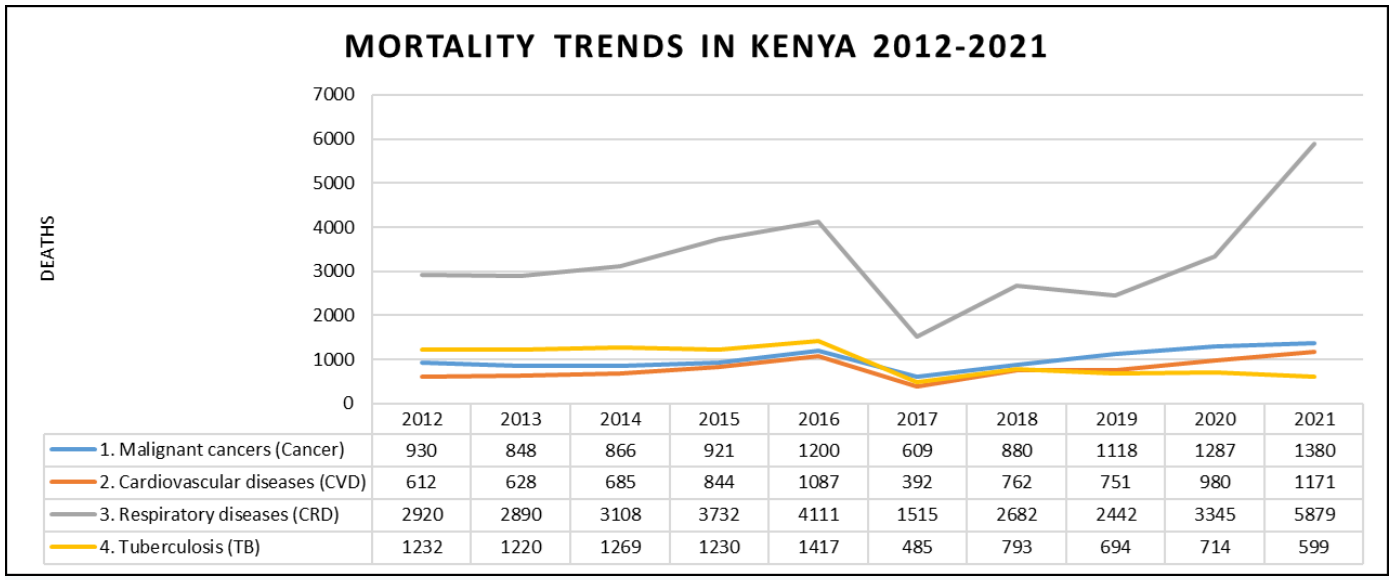

Figure 1. Absolute mortality numbers from medical records of persons aged 35+ years who died due to smoking related diseases in Kenya 2012-2021.

CVD = Cardiovascular Diseases

CRD = Chronic Respiratory Diseases

TB = Tuberculosis Diseases

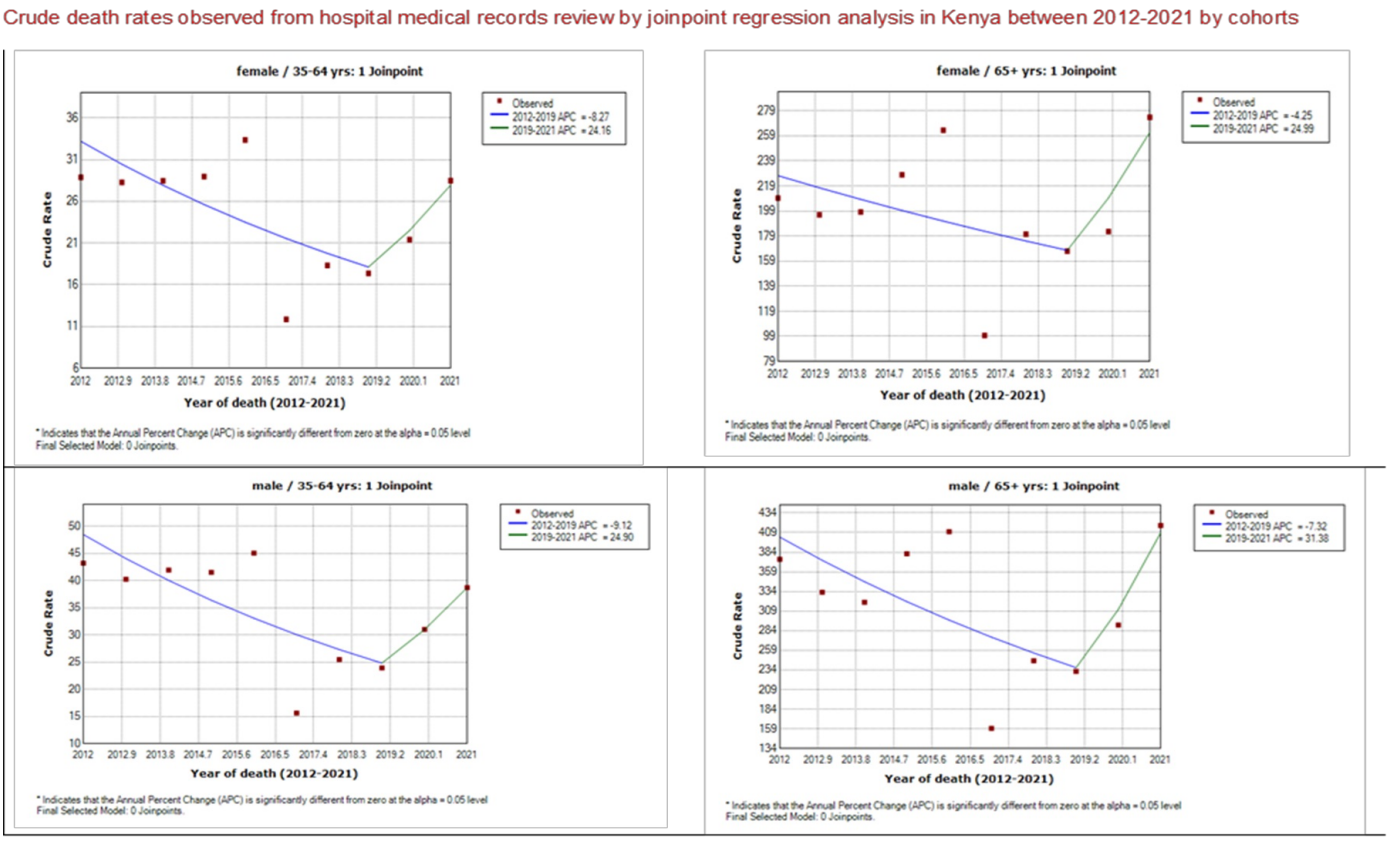

Figure 2. Mortality rate trends for 60,228 persons age 35 and above who died due to tobacco related diseases in Kenya between 2012-2021

Smoking Prevalence

Mid-decade prevalence of tobacco smoking (2012-2021), including under 35 years old, indicated that 17.4% of men, 0.9% of women, and 9% overall were current smokers; former smokers constituted 10.6% of men, 1.4% of women, and 5.9% overall. Among individuals aged 35 or older (our study population), 24.1% of men, 1.4% of women, and 12.9% overall were current smokers, while 17.3% of men, 2.4% of women, and 10% were former smokers [Table 2].

Table 2. Smoking mid-decade (between 2012-2021) prevalence estimates in Kenya by gender and age-group

	Proportion of Smokers and None-smokers by Smoking Category (row%)		
	Current	Former	Never
Total	12.9	10.0	77.2
Age 35-64 years	13.5	9.4	77.2
Age 65+ years	8.1	14.0	78.0
Male	24.1	17.3	58.7
Age 35-64 years	24.8	16.3	59.0
Age 65+ years	18.5	24.8	56.7
Female	1.4	2.4	96.3
Age 35-64 years	1.5	1.9	96.7
Age 65+ years	0.7	6.1	93.3

Smoking-Attributable Mortality

Out of the 60,228 observed deaths from respiratory diseases, diabetes mellitus, malignant cancers, tuberculosis, and cardiovascular diseases between 2012 and 2021, 16.5% (9,943) were attributed to tobacco smoking [Table 3]. This included 40.5% from respiratory diseases, 31.4% from malignant cancers, 13% from tuberculosis, 8.9% from cardiovascular diseases, and 6.1% from diabetes mellitus. Within respiratory diseases, pneumonia and influenza contributed 59%, while chronic airway obstruction accounted for 39%. Noteworthy cancer causes included oesophageal cancer (56%) and trachea, lungs, and bronchi combined cancers (14%). Of the cardiovascular tobacco-attributable deaths, 83% were from cerebrovascular diseases, with a notable distribution of 58% and 25% among 35-64 and 65+ year-olds, respectively. The primary causes for smoking-attributable deaths were pneumonia and influenza (24%), oesophagus (18%), chronic airway obstruction (16%), and tuberculosis (13%), constituting 70% of all Smoking Attributable Mortality (SAM) (6,987/9,943).

TRI and ICD10 codes	Observed mortality			Age adjusted relative risk CPS-II (1982-1988)				Prevalence estimate (mid decade 2012-2021 GATS & STEPS) {%}						PAR			Smoking Attributable Mortality (SAM)			
	Female	Male	Total	Female		Male		Female			Male			Female	Male	Total	Female	Male	Total	Cause
				CS	FS	CS	FS	CS	FS	Never	CS	FS	Never							Specific
	n (%)	n (%)	n	RR	RR	RR	RR	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	n (%)	n (%)	n	(%)
1. Malignant cancers (Cancer)	**4,990 (49.7%)**	**5,049 (50.3%)**	**10,039**													**31.1%**	**279 (8.9%)**	**2,847 (91.1%)**	**3,126**	**31.4%**
Esophagus C15	1,288 (34.8%)	2,411 (65.2%)	3,699	7.8	2.8	6.8	4.5	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	11.8%	66.7%	47.6%	152 (8.7%)	1,607 (91.3%)	1,759	17.7%
Kidney and renal pelvis C64-C65	46 (51.1%)	44 (48.9%)	90	1.3	1.1	2.7	1.7	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	0.6%	34.6%	17.3%	0 (1.9%)	15 (98.1%)	16	0.2%
Larynx C32	29 (17.1%)	141 (82.9%)	170	13	5.2	14.6	6.3	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	20.7%	80.7%	70.5%	6 (5.0%)	114 (95.0%)	120	1.2%
Lips, oral cavity, pharynx C00–C14	223 (35.2%)	411 (64.8%)	634	5.1	2.3	10.9	3.4	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	7.9%	73.6%	50.5%	18 (5.5%)	303 (94.5%)	320	3.2%
The neck of the uterus C53	1,914 (100.0%)	0 (0.0%)	1,914	1.6	1.1			1.4%	2.4%	96.3%				1.0%		1.0%	20 (100.0%)	0 (0.0%)	20	0.2%
Pancreas C25	463 (52.1%)	426 (47.9%)	889	2.3	1.6	2.3	1.2	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	3.1%	25.8%	13.9%	14 (11.5%)	110 (88.5%)	124	1.2%
Stomach C16	637 (38.6%)	1,014 (61.4%)	1,651	1.4	1.3	2	1.5	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	1.2%	24.6%	15.6%	8 (3.0%)	250 (97.0%)	258	2.6%
Trachea, lungs, bronchi C33–C34	296 (40.5%)	434 (59.5%)	730	12.7	4.5	23.3	8.7	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	19.4%	87.0%	59.6%	57 (13.2%)	378 (86.8%)	435	4.4%
Urinary bladder C67	94 (35.9%)	168 (64.1%)	262	2.2	1.9	3.3	2.1	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	3.6%	42.6%	28.6%	3 (4.5%)	72 (95.5%)	75	0.8%
2. Cardiovascular diseases (CVD)	**3,907 (49.4%)**	**4,005 (50.6%)**	**7,912**													**11.2%**	**66 (7.4%)**	**818 (92.6%)**	**884**	**8.9%**
Cerebrovascular disease I60–I69 {35-64 years}	1,026 (44.4%)	1,283 (55.6%)	2,309	4	1.3	3.3	1	1.5%	1.9%	96.65%	24.8%	16.3%	58.95%	4.7%	36.3%	22.3%	48 (9.4%)	466 (90.6%)	514	5.2%
Cerebrovascular disease I60–I69 {≥65 years}	2,431 (53.3%)	2,130 (46.7%)	4,561	1.5	1	1.6	1	0.7%	6.1%	93.25%	18.5%	24.8%	56.7%	0.3%	10.0%	4.8%	8 (3.6%)	213 (96.4%)	221	2.2%
Ischemic heart disease (IHD) I20-I25 {35-64 years}	126 (34.7%)	237 (65.3%)	363	3.1	1.3	2.8	1.6	1.5%	1.9%	96.65%	24.8%	16.3%	58.95%	3.5%	35.2%	24.2%	4 (5.0%)	83 (95.0%)	88	0.9%
Ischemic heart disease (IHD) I20-I25 {≥65 years}	218 (50.0%)	218 (50.0%)	436	1.6	1.2	1.5	1.2	0.7%	6.1%	93.25%	18.5%	24.8%	56.7%	1.6%	12.4%	7.0%	3 (11.3%)	27 (88.7%)	31	0.3%
Other arterial disease I72-I78	106 (43.6%)	137 (56.4%)	243	2.2	1.1	2.1	1	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	1.8%	20.9%	12.6%	2 (6.3%)	29 (93.7%)	31	0.3%
3. Respiratory diseases (CRD)	**9,178 (42.4%)**	**12,493 (57.6%)**	**21,671**													**18.6%**	**413 (10.2%)**	**3,617 (89.8%)**	**4,030**	**40.5%**
Bronchitis, Emphysema J40-J43	46 (31.7%)	99 (68.3%)	145	12	11.8	17.1	15.6	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	28.7%	86.5%	68.1%	13 (13.4%)	86 (86.6%)	99	1.0%
Chronic airway obstruction J44–J46*	1,099 (39.0%)	1,718 (61.0%)	2,817	13.1	6.8	10.6	6.8	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	23.1%	76.8%	55.8%	253 (16.1%)	1,319 (83.9%)	1,573	15.8%
Pneumonia, Influenza J10-J18	8,033 (42.9%)	10,676 (57.1%)	18,709	2.2	1.1	1.8	1.4	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	1.8%	20.7%	12.6%	146 (6.2%)	2,212 (93.8%)	2,359	23.7%
4. Diabetes mellitus	5,428 (49.6%)	5,525 (50.4%)	10,953	1.37	1.14	1.37	1.14	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	0.8%	10.2%	5.5%	45 (7.4%)	562 (92.6%)	606	6.1%
5. Tuberculosis (TB)*	3,194 (33.1%)	6,459 (66.9%)	9,653	1.57	1.57	1.57	1.57	1.4%	2.4%	96.3%	24.05%	17.3%	58.7%	2.1%	19.1%	13.4%	66 (5.1%)	1,231 (94.9%)	1,297	13.0%
All deaths	**26,697 (44.3%)**	**33,531 (55.7%)**	**60,228**													**16.5%**	**868 (8.7%)**	**9,075 (91.3%)**	**9,943**	**100.0%**

* SAM is calculated based on p0, p1 and p2; CS=Current Smoker; FS=Former Smoker; CPS-II=The second Cancer Prevention Study; PAR=Population Attributable Risk; SAM=Smoking Attributable Mortality

Table 3. Tobacco Smoking Attributable deaths of 35 years and above who died due to tobacco related diseases in Kenya between 2012-2021

To address the significant impact of tobacco-related diseases on mortality in Kenya, a multifaceted approach to intervention is warranted. Comprehensive public awareness campaigns should be launched, utilizing various media channels to emphasize the association between tobacco use and diseases highlighted in the study findings. School-based programs should educate the younger population about the dangers of tobacco, aiming to deter initiation. Healthcare providers need training to offer effective smoking cessation counseling during routine visits, and access to cessation resources should be improved. Implementing higher tobacco taxes and enforcing smoke-free policies in public spaces can create environments discouraging tobacco use. Youth prevention programs and community engagement initiatives, linked to the study's findings on prevalent causes of mortality, are crucial. Additionally, ongoing research and surveillance efforts will help tailor interventions to evolving patterns of tobacco use. Overall, a collaborative and sustained effort involving government, healthcare providers, educators, and the community is essential for the success of these interventions, ultimately reducing the burden of tobacco-attributable deaths in Kenya.

Discussion

Magnitude of Smoking-Attributable Mortality

In this study, the examination of all-cause mortality data between 2012 and 2021 revealed a substantial impact of smoking, contributing to 16.5% of deaths among adults aged 35 and over in Kenya. These findings align with a growing body of evidence underscoring the profound health implications associated with smoking [18].

Trends in Mortality and Global Comparisons

The observed trend of escalating mortality across the studied conditions throughout the decade mirrors patterns observed in analogous studies. Comparable trends were noted in a study in China examining cancer mortality attributable to tobacco smoking over a ten-year span [20]. However, disparities emerge when comparing our findings with a study in Morocco [21], where 9.7% of all deaths were attributed to tobacco smoking, notably lower than the 16.5% observed in Kenya.

Disease-Specific Contributions to Smoking-Attributable Deaths

Respiratory Diseases

Respiratory diseases, particularly pneumonia and influenza, emerged as the predominant contributors to deaths attributable to tobacco smoking, followed closely by malignant cancers. Although local data on lung cancer were limited, the similarities with Australia's 2018 observations reinforce the consistency of these findings [10][22].

Chronic Respiratory Diseases

Chronic respiratory diseases showcased a distinctive pattern in our study, with pneumonia and influenza overshadowing chronic obstructive pulmonary disease (COPD). This contrasts with the Global Burden of Disease (GBD) Study 2019 [5], which highlighted COPD as the primary cause of death in chronic respiratory diseases (CRDs).

Cancers

Cancer-related deaths attributed to smoking revealed oesophageal cancer as the leading cause, consistent with Chinese findings where lung, liver, oesophageal, and stomach cancers were frequently associated with smoking-associated cancer mortality [23][24].

Cardiovascular Diseases

Within cardiovascular deaths, cerebrovascular diseases dominated among men, followed by ischemic heart diseases, aligning with established evidence of tobacco smoking's pervasive impact across the cardiovascular system [25]. Males exhibited a higher risk of cardiovascular disease (CVD) mortality than females.

Diabetes

The study also unveiled the association between smoking and diabetes-related mortality, consistent with existing epidemiological studies [26]. This underscores the importance of addressing smoking cessation as a crucial aspect of managing diabetes-associated mortality risks [27][28][29].

Tuberculosis

Moreover, our study illuminated the role of smoking in tuberculosis (TB) mortality in Kenya. While our findings are consistent with Bates et al.'s meta-analysis [13], attributing 31% of TB cases and deaths to smoking, the percentage in our study was lower (13.4%). The gender disparity in TB deaths attributable to smoking mirrored findings from South Korea, India, and Bangladesh [30][31][32][33], with higher proportions in males.

Conclusion

In conclusion, our study establishes smoking-attributable mortality as a critical health concern in Kenya. Urgent and concerted efforts are needed to prevent tobacco use and address the associated disease burden. Immediate tobacco control imperatives should focus on facilitating smoking cessation among existing smokers. Continuous monitoring, public awareness campaigns, and targeted interventions are vital components of a comprehensive strategy to mitigate the impact of smoking-attributable deaths in Kenya.

Ethical Approval

Ethical approval was not sought since our study utilized data from existing medical records rather than human subjects. However, administrative approval was obtained from the Principal Secretary of the Ministry of Health, the Director of Civil Registration Services, and County Directors of Health to permit the use of records.

Limitations and Recommendations

Despite these valuable insights, the study has limitations. It focused exclusively on smoking, neglecting other forms of tobacco use, such as smokeless tobacco, which may contribute significantly to morbidity and mortality. The challenge of ill-defined causes of death and the need for improved death certification processes highlight the study's limitations. Efforts to enhance the quality of cause-of-death certification, including periodic reviews and training for healthcare providers, are imperative.

Strengths and Implications

The study utilized nationally representative datasets that directly measured smoking status to determine tobacco smoking prevalence averaged over a decade. This robust approach provides a comprehensive overview despite potential fluctuations in smoking prevalence due to various interventions. The adoption of revised relative risks from recent systematic reviews and meta-analyses enhances the accuracy of the prevalence-based model, overcoming previous inconsistencies.

Acknowledgements

This study was conducted as an integral part of the Tobacco Control Data Initiative (TCDI), a comprehensive program spanning six African countries: The Democratic Republic of Congo, Ethiopia, Kenya, Nigeria, South Africa, and Zambia. The TCDI aims to discern the tobacco-related data needs of these nations, identify existing datasets, address data gaps, and develop tools to empower policymakers in formulating effective tobacco policies. The initiative is spearheaded by Development Gateway, a global non-profit organization specializing in data for development, in collaboration with the University of Cape Town's Research Unit on the Economics of Excisable Products (REEP), operating as an IREX Venture.

Our heartfelt gratitude extends to the dedicated clinicians at Kenya's Ministry of Health, whose meticulous coding of death data at various facilities played a pivotal role in this research. We express our appreciation to the data collectors from the Civil Registration Services of the Kenya Bureau of Statistics for their invaluable contributions in collecting and providing access to critical mortality data. Special acknowledgment is extended to the teams involved in the Global Adult Tobacco Survey (GATS) and the WHO Stepwise Approach to Surveillance (STEPS) survey for their diligent management and

provision of essential data on tobacco smoking. Lastly, we convey our thanks to the Royal College of Physicians for their invaluable efforts in revising relative risks, enhancing the robustness of our research outcomes.

References

1. ^*World Health Organization. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. World Health Organization; Geneva, Switzerland: 2009.*
2. ^*Office of the Surgeon General (US); Office on Smoking and Health (US). The Health Consequences of Smoking: A Report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention (US); 2004. PMID: 20669512.*
3. ^*Centers for Disease Control. The Surgeon General's 1989 Report on Reducing the Health Consequences of Smoking: 25 Years of Progress. MMWR Suppl. 1989;38:1–32.*
4. ^*IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. World Health Organization. International Agency for Research on Cancer. Tobacco Smoke and Involuntary Smoking. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans; Lyon, France: 2004. pp. 1–14383.*
5. a, b, c*Reitsma MB, Kendrick PJ, Ababneh E, Abbafati C, Abbasi-Kangevari M, Abdoli A, Abedi A, Abhilash ES, Abila DB, Aboyans V, Abu-Rmeileh NM. 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 (GBD) Study 2019. The Lancet. 2021 Jun 19;397(10292):2337-60.*
6. a, b*Kenya Ministry of Health. "Kenya Stepwise Survey for Noncommunicable Diseases Risk Factors 2015 Report." (2015). https://aphrc.org/publication/kenya-stepwise-survey-for-non-communicable-diseases-risk-factors-2015-report/ [Accessed 11 March 2021].*
7. a, b*Global Adult Tobacco Survey (GATS). Kenya Report, 2014. https://extranet.who.int/ncdsmicrodata/index.php/catalog/249 Accessed 11 March 2021*
8. ^*Ngaruiya, C., Abubakar, H., Kiptui, D. et al. Tobacco use and its determinants in the 2015 Kenya WHO STEPS survey. BMC Public Health 18, 1223 (2018). https://doi.org/10.1186/s12889-018-6058-5*
9. ^*Ogeng'o JA, Olabu BO, Ong'era D, Sinkeet SR. Pattern of acute myocardial infarction in an African country. Acta Cardiol. 2010 Dec;65(6):613-8.*
10. a, b*Macigo FG, Mwaniki DL, Guthua SW, Njeru EK. Influence of cigarette filters on the risk of developing oral leukoplakia in a Kenyan population. Oral Dis. 2001 Mar;7(2):101-5*
11. a, b*Pérez-Ríos M, Montes A. Methodologies used to estimate tobacco-attributable mortality: a review. BMC public health. 2008 Dec;8(1):1-1.*
12. a, b, c*Pérez-Ríos M, Rey-Brandariz J, Galán I, Fernández E, Montes A, Santiago-Pérez MI, Giraldo-Osorio A, Ruano-Raviña A. Methodological guidelines for the estimation of attributable mortality using a prevalence-based method: the STREAMS-P tool. J Clin Epidemiol. 2022 Jul;147:101-110. doi: 10.1016/j.jclinepi.2022.03.016. Epub 2022 Mar 25. PMID: 35341948.*
13. a, b*Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco*

smoke: a systematic review and meta-analysis. Arch Intern Med. 2007 Feb 26;167(4):335-42. doi: 10.1001/archinte.167.4.335. PMID: 17325294.

14. ^*Sitas F, Egger S, Bradshaw D, Groenewald P, Laubscher R, Kielkowski D, Peto R. Differences among the coloured, white, black, and other South African populations in smoking-attributed mortality at ages 35-74 years: a case-control study of 481,640 deaths. Lancet. 2013 Aug 24;382(9893):685-93. doi: 10.1016/S0140-6736(13)61610-4. PMID: 23972813.*
15. ^*Groenewald P, Pacella R, Sitas F, Awotiwon OF, Vellios N, Van Rensburg CJ, Manda S, Laubscher R, Nojilana B, Joubert JD, Labadarios D, Ayo-Yusuf L, Roomaney RA, Turawa EB, Neethling I, Abdelatif N, Pillay-van Wyk V, Bradshaw D. Estimating the changing disease burden attributable to smoking in South Africa for 2000, 2006 and 2012. S Afr Med J. 2022 Sep 30;112(8b):649-661. doi: 10.7196/SAMJ.2022.v112i8b.16492. PMID: 36458348.*
16. ^*Giraldo-Osorio A, Pérez-Ríos M, Rey-Brandariz J, Varela-Lema L, Montes A, Rodríguez-R A, Mourino N, Ruano-Ravina A. Smoking-attributable mortality in South America: A systematic review. J Glob Health. 2021 Mar 27;11:04014. doi: 10.7189/jogh.11.04014. PMID: 33828844; PMCID: PMC8005314.*
17. ^*United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition. Link World Population Prospects - Population Division - United Nations. [Accessed on 04 April 2023]*
18. [a, b]*Tobacco Advisory Group of the Royal College of Physicians Hiding in Plain Sight: Treating Tobacco Dependency in the NHS2018 31/07/2018. [(Accessed 7 July 2022)]. Available online from https://www.rcplondon.ac.uk/file/10116/download?token=K05kvT-7*
19. ^*LEVIN ML. The occurrence of lung cancer in man. Acta Unio Int Contra Cancrum. 1953;9(3):531-41. PMID: 13124110.*
20. ^*Xu Z, Qi F, Wang Y, Jia X, Lin P, Geng M, et al. (2018) Cancer mortality attributable to cigarette smoking in 2005, 2010 and 2015 in Qingdao, China. PLoS ONE 13(9): e0204221. https://doi.org/10.1371/journal.pone.0204221.*
21. ^*Tachfouti N, Raherison C, Najdi A, Obtel M, Rguig A, Azami AI, Nejjari C. Smoking-attributable mortality in Morocco: results of a prevalence-based study in Casablanca. Arch Public Health. 2014 Jul 1;72(1):23. doi: 10.1186/2049-3258-72-23. PMID: 25126418; PMCID: PMC4128604.*
22. ^*Greenhalgh, EM & Winnall, W. 3.30 Total burden of death and disease attributable to tobacco by disease category. In Greenhalgh, EM, Scollo, MM and Winstanley, MH [editors]. Tobacco in Australia: Facts and issues. Melbourne: Cancer Council Victoria; 2021. Available from https://www.tobaccoinaustralia.org.au/chapter-3-health-effects/3-30-total-burden-of-death-and-disease-attributable-to-tobacco-by-disease-category*
23. ^*Islami F, Torre LA, Jemal A. Global trends of lung cancer mortality and smoking prevalence. Transl Lung Cancer Res. 2015; 4(4):327±38. https://doi.org/10.3978/j.issn.2218-6751.2015.08.04 PMID:26380174.), Bonneux 2011; International Agency for Research on Cancer 2004; U.S. DHHS 2014.*
24. ^*Lariscy, J.T., Hummer, R.A. & Rogers, R.G. Cigarette Smoking and All-Cause and Cause-Specific Adult Mortality in the United States. Demography 55, 1855–1885 (2018). https://doi.org/10.1007/s13524-018-0707-2.*
25. ^*Banks et al.Tobacco smoking and risk of 36 cardiovascular disease subtypes: fatal and non-fatal outcomes in a large prospective Australian study; BMC Medicine (2019) 17:128 https://doi.org/10.1186/s12916-019-1351-4.*

26. ^*GBD 2019, Szwarcbard N, Villani M, Earnest A, Flack J, Andrikopoulos S, Wischer N, et al. The Association of Smoking Status With Glycemic Control, Metabolic Profile and Diabetic Complications- Results of the Australian National Diabetes Audit (ANDA). J Diabetes Complicat (2020) 34:107626. doi: 10.1016/j.jdiacomp.2020.107626.*
27. ^*Anan F, Takahashi N, Shinohara T, Nakagawa M, Masaki T, Katsuragi I, Tanaka K, Kakuma T, Yonemochi H, Eshima N, Saikawa T, Yoshimatsu H. Smoking is associated with insulin resistance and cardiovascular autonomic dysfunction in type 2 diabetic patients. Eur J Clin Investig. 2006;36:459–65.*
28. ^*Pirie K, Peto R, Reeves GK, Green J, Beral V, Million Women Study Collaborators. The 21st century hazards of smoking and benefits of stopping: a prospective study of one million women in the UK. Lancet. 2013;381:133–41.*
29. ^*Jha P, Ramasundarahettige C, Landsman V, Rostron B, Thun M, Anderson RN, McAfee T, Peto R. 21st-century hazards of smoking and benefits of cessation in the United States. N Engl J Med. 2013;368:341–50.*
30. ^*Jee SH, Golub JE, Jo J, et al. smoking and risk of tuberculosis incidence, mortality, and recurrence in South Korean men and women. Am J Epidemiol. 2009;170(12):1478–1485.*
31. ^*Pednekar MS, Gupta PC. Prospective study of smoking and tuberculosis in India. Prev Med. 2007;44(6):496–498.*
32. ^*Alam DS, Jha P, Ramasundarahettige C, et al. Smokingattributable mortality in Bangladesh: proportional mortality study. Bull World Health Organ. 2013;91(10):757–764.*
33. ^*Ere GA, Nayak P, Salindri AD, Narayan KMV, Magee MJ. Contribution of Smoking to Tuberculosis Incidence and Mortality in High-Tuberculosis-Burden Countries. Am J Epidemiol. 2018 Sep 1;187(9):1846-1855. DOI: 10.1093/aje/kwy081. PMID: 29635332; PMCID: PMC6888026.*