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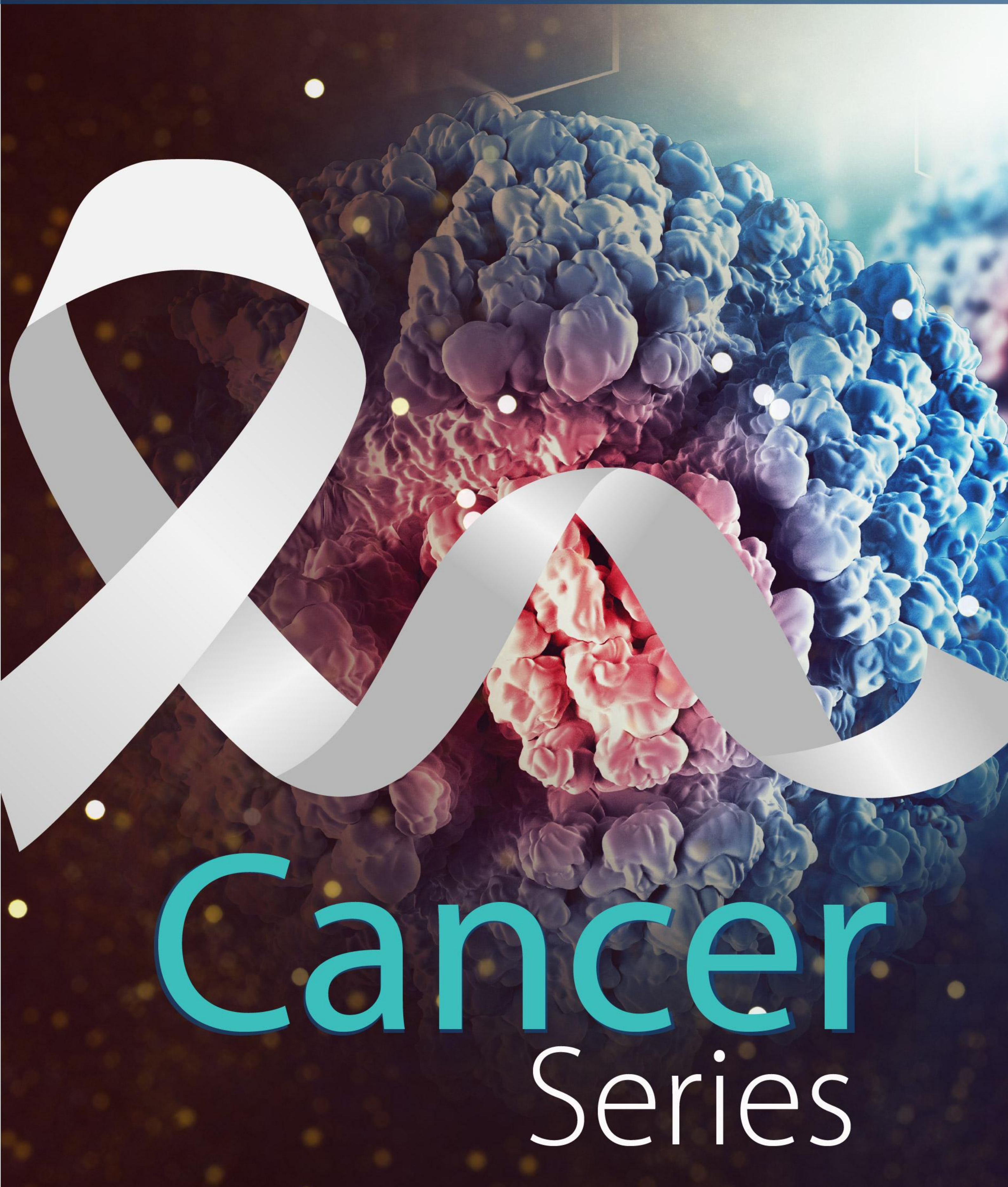

Cancer
Series

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Cancer risk in the workplace: Using mortality data for occupational cancer surveillance

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Summary

Analysis of cause of death in routine mortality records is an important source of information on burden of disease for many countries. Where there is limited surveillance or specific information in other databases, mortality data are the only source of disease burden and trends. Thus, despite the recognised limitations in the quality of some records, analysis of cause of death provides key insights into the health of the population. Occupational health surveillance is particularly limited locally and internationally, and thus mortality data is used to identify occupation-associated diseases, higher-risk occupations or industries, and trends. The methodology of this analysis calculates proportional mortality ratios for each occupation group, or mortality odds ratios. These are used rather than the gold standard, being standardised mortality rates, as there is no information available on the number of people employed in each industry or occupation group in South Africa. The results of these analyses should be interpreted as indications of patterns in cause of death in specific occupation groups. These differences may be due to occupational exposures or lifestyles influenced by their occupation or by chance. The results indicate where further research is warranted in order to use limited resources effectively.

Background

One of the oldest methods in epidemiology is the examination of patterns in cause-specific mortality data. This approach monitors population health over time and within specific groups by using routinely collected mortality data. It provides ongoing information on patterns and trends that require further investigation to identify the underlying risk factors. These data provide an indication of the burden of disease, help prioritise healthcare and research resources, and provide a high-level evaluation of the effects of population-wide interventions. The reporting and analysis of deaths are crucial for effective governance, not only within the health sector but also in various other domains, including the development and maintenance of a healthy workforce.

In South Africa, there is limited population-based occupational health surveillance. Therefore, analysing mortality data can be a cost-effective solution for identifying possible associations between cause of death and occupation that may in turn warrant further investigation and possible health education.[1] Due to limited information from other sources, mortality data analysis is currently employed regularly, even in developed countries, to describe patterns and trends in occupational health. Attributing a disease to occupational exposures can be complicated, and many cases go unreported, and so they are not included in registers of occupational diseases or do not receive compensation. Since occupational exposures can be modified, they are an important consideration in preventing morbidity and mortality in the general population.

In South Africa, it is mandated that Form DHA-1663, the South African Notice of Death/Stillbirth, be completed upon the death of a citizen. This document records essential details, including the age, sex, and date of death of the deceased, as well as information regarding the circumstances and cause of death.

Additionally, Form DHA-1663 contains open-ended questions, such as "What was the usual occupation of the deceased (the type of work done during most of life)?" and "In what type of industry was the deceased employed or working?"

Statistics South Africa (Stats SA), the government bureau responsible for the collection, production, and dissemination of official and other statistics in South Africa, publishes anonymous annual data from death certificates, including information about the cause of death, the underlying cause of death, and the usual occupation and industry as stated on the certificates. However, the quality of this data can be limited due to various biases, such as incomplete death registration forms and poor diagnoses of underlying causes of death. Thus, interpretation of study findings should be approached with caution. Despite these limitations, very few other datasets in South Africa can provide a nationwide perspective on possible occupational exposures and their effects on the health of the working population.

Methods

Vital registry data obtained from Stats SA can be used to identify sub-occupation groups associated with mortality attributed to different cancers for South Africa. The data obtained from Stats SA includes demographic information of the deceased, occupation and industry, and the underlying cause of death. The underlying cause of death is completed by the person certifying the death and is the disease or injury leading to the death and not the mechanism of death. The underlying cause of death is coded using the 10th International Classification of Diseases code (ICD10). Currently, deaths registered with the Department of Home Affairs between 2011 and 2015 among individuals aged 15–69 years can be included in occupation sub-group analysis. A total of 1.5 million deaths were defined using the International Classification of Diseases, 10th Revision (ICD-10) coding for underlying cause of death for the period 2011–2015 in South Africa.

The South African Standard Classification of Occupations (SASCO) is used by Stats SA staff to categorise occupations hierarchically into four groups: major group, sub-major group, minor group, and unit group. The SASCO is based on the United Nations International Standard Classification of Occupations (ISCO) to allow for comparison between countries.[2] There are 10 major groups, including nine occupational groups and one unemployed, unspecified, and armed forces group.[3] These 10 groups combine occupations with very different exposures and thus provide limited information. The major groups are further divided into 41 sub-major occupations and one unclassified group, which contains all the deaths with no occupation information on the death certificate.

The patterns of association between sub-occupation and different types of cancer death can be estimated by calculating the proportional mortality ratios (PMRs). The PMR is the ratio of the proportion of disease-specific deaths out of total deaths in the specific occupation group and the proportion of disease-specific deaths in the total group. This allows for comparison of the proportional ratio of cancer deaths between occupations. PMRs are calculated rather than the gold standard, the standardised mortality rates (SMRs), as denominators are required for their calculation, and other than the Quarterly Labour Force Survey, there are no data in South Africa on the total number of people employed or the sectors and jobs in which they work.

There are statistical methods to calculate the PMRs and their accompanying 95% confidence intervals (CI).[4,5] PMRs range in value from zero to infinity: a value less than one indicates an inverse association, and a value equal to one indicates no association. A value greater than one indicates a positive association between the exposure and the cause of death of interest.[6] PMRs are sometimes multiplied by 100 so that a value less than 100 indicates inverse association, a value equal to 100 indicates no association, and a value greater than 100 indicates a positive association.[7] PMRs can be crude (unadjusted) or indirectly standardised to the standard population (deaths from all causes in a general population) to adjust for potential confounding biases.

$$\text{PMR} = \frac{\text{Proportion of deaths from a specific cancer in a specific group of workers}}{\text{Proportion of deaths from a specific cancer in the general population}} \times 100$$

A limitation of using PMRs for analysis is that cause-specific PMRs are mutually dependent. An increased PMR for one cause of death means that there will be a decreased PMR for another cause of death, and vice versa. PMRs may thus be artificially increased or decreased.[8]

A second method for determining associations and adjusted associations between occupation sub-group and specific cancers is a logistic regression model to calculate adjusted mortality odds ratios (MORs). MORs compare the adjusted odds of death due to one of several cancers between the different sub-occupation groups adjusting for known available confounders and effect-modifiers of cancer such as age at death and sex. Smoking is a known risk factor for a number of cancers and the death certificate has space for this information to be captured. This question is poorly completed in many certificates, with only 57.4% of deaths containing this information. This information still allows some adjustment for smoking, allowing other causes of cancer to drive the MORs. An MOR is considered significant if the 95% CI does not contain one.

$$MOR = \frac{\text{Odds of death from a specific cancer in a specific group of workers}}{\text{Odds of death from a specific cancer in the general population}}$$

Caution should be exercised in interpreting MORs, as the ratios are of odds and not risk and are influenced by the healthy worker effect. Unmeasured confounders may also play a role and be considered. The benefit of using MORs in cancer death is that cancer is a rare outcome, and they are less likely to overestimate the risk.[9]

Advantages of using mortality data

Stats SA mortality data contains useful information on occupations, industries, and causes of death, and covers the entire population. This information does not rely on the individual or employer to report to government bodies and is likely to contain information on more people. The data are collected routinely and are available anonymously at no cost. The information on occupation is phrased as 'usual occupation during life.' This enables identification of the occupation that was most likely to result in long-term exposures. MORs and PMRs are often used in occupational studies when the population at risk is unknown. These values can approximate the cause-specific standardised mortality ratio. These statistics are used in these occupational surveillance reports, as the population employed in South Africa in different sub-occupation groups is unknown, and the proportion of those who were employed that completed the information in the death certificate is also unknown. The description of these statistics also does not rely on a diagnosis of an occupational disease and thus may indicate new associations between specific cancers and occupation, supporting investigations of new exposures that may be related to cancer. Mortality data is used internationally for occupational health trends and burden.[10,11]

Limitations of using mortality data

The quality and amount of data limit the associations of the less commonly reported occupations, industries, and diseases, with minimal reported association with occupational disease. There is often poor completion of the death certificate – in many cases, important questions are left unanswered. The code R99 (unknown or ill-defined cause of death) and R0-99 (group for symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified) is the third most common, broad group recorded as the underlying cause of death, comprising 11% of all deaths. Thus, many cancer deaths may not be diagnosed or recorded. Occupation is also poorly completed on death certificates, although with the unemployment rate at 25.3% in 2015, many people may not be expected to be employed. A large number of elementary occupations are not well captured by the SASCO; thus, occupational associations with cancer are often not clear in this main group. The recent report 'South African National Cause of Death Validation Project' found overall poor agreement between the underlying cause of death in Stats SA and alternative data collected as part of the study. This varied by cause of death; however, for other cancers (including lung cancer), a positive predictive value of 65.2 (95% CI 60.6-69.7) was found, indicating not good but reasonable agreement.[12] These data limitations should be considered when interpreting the findings.

Conclusion

Despite the limitations inherent in South African death certificate data, they are an important source of information on associations between occupation and cancer in the South African population. Cancer is rare and often has a long latency, making it difficult to clearly measure an occupational exposure as the cause of cancer death. As a result, cancer is less likely to be reported as an occupational disease (to the Department of Employment and Labour) or to be compensated. With this in mind, cause of death data provides a unique source for investigating patterns and trends between occupation and several cancers. Significantly increased or decreased PMRs or MORs are seen as indicators of a possible relationship, and the absolute amounts are considered with caution. The associations indicated may not always be directly related to occupational exposures but provide an opportunity to target health education and evaluate known and new associations to improve the health and safety of workers in South Africa.

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Conflicts of interest

The authors declare no conflicts of interest.

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Occupation groups associated with an increased risk of lung cancer mortality in South Africa

Occupation groups associated with an increased risk of lung cancer mortality in South Africa

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Summary

Lung cancer is the commonest cause of cancer death globally and in South Africa. While smoking is the main cause of lung cancer, occupational exposures have also been shown to cause or increase the risk of lung cancer. Yet, little is known about occupational lung cancer in South Africa. This study used vital registry data from Statistics South Africa (Stats SA) to describe patterns of lung cancer mortality in South Africa by occupation group and industry type, adjusting for non-occupational factors where possible. This analysis utilised data from 2011 to 2015, during which occupational sub-group information was made available by Stats SA. There were 17 112 lung cancer deaths between 2011 and 2015 in South Africa, with 71% (12 150) in men and 25% (4 187) in people between the ages of 60–64 years. Smoking history is poorly completed, with information provided for only 57% of working-age deaths. After adjustment for available risk factors, mortality odds ratios (MORs) were calculated. A number of sub-occupation groups showed increased odds of lung cancer mortality compared to the general population (all deaths without occupation information). Significantly increased mortality odds for men and women were seen in all management occupations, science and engineering, business and administration professionals, as well as science and engineering associate professionals. Both male and female clerks in general and customer services showed increased MORs. Men and women employed in metal machinery and trades, along with stationary plant and machine operators (miners), also showed significantly increased odds of lung cancer death. In men only, electrical and electronic trades, forestry and fishery skilled workers, construction workers, and subsistence farmers showed increased odds. In women only, health, education, legal and social professionals, and business and admin associate professionals showed increased odds along with sales workers, protective services and armed forces, agricultural, forestry and fishery labourers, and other elementary workers. The occupations with increased odds of lung cancer death should be investigated for exposure to carcinogens, as some cases of lung cancer in these groups may be due to exposures at work. Continued monitoring of the implementation of the Occupational Health and Safety Act (OSH Act) 85 of 1993 and the Tobacco Products Control Amendment Act of 1999 by companies and the government is important.

Introduction

Lung cancer is the malignant transformation of epithelial cells in the lung or bronchus, forming tumours. These tumours develop from various genetic and epigenetic alterations, driven by exposure to carcinogens and host susceptibility. These changes are linked to the activation of growth-promoting pathways and the inhibition of tumour suppressor pathways.[1] Genetic and epigenetic changes accumulate over time when regulatory mechanisms and signals from other cells are ignored.[1] Exposures to carcinogens in the workplace may act as initiators or promoters of lung cancer. The International Agency for Research on Cancer (IARC) has produced monographs evaluating carcinogenic risks to humans. Since 1971, critical reviews have been conducted on epidemiological and experimental data on the carcinogenicity of chemicals, groups, mixtures, industrial processes, and biological agents. The identified agents with sufficient evidence of carcinogenicity in humans were then considered from an occupational exposure point of view in publications and lists of occupational carcinogens, along with the cancers with which they are associated.[2] A total of 28 definite occupational carcinogens were identified in 2004, with many being associated with lung cancer.[2] In an update in 2018, 47 occupational carcinogens were listed as sufficient evidence in humans, with lung cancer being the most common agent-cancer association.[3]

A summary of case reports and studies in the early 1930s recognising lung cancer associated with occupational exposures, particularly in mining, was published in 1935.[4] Recent studies demonstrating associations between occupational exposure and lung cancer include a meta-analysis by Wan *et al*. (2024), who found a pooled relative risk (RR) of 1.14, 95% (confidence interval (CI) 1.03–1.27) for workers occupationally exposed to benzene.[5] An IARC study on occupational exposure to pairs of five lung carcinogens found that the pairwise joint effects increased the risk of lung cancer in men above that of exposure to the individual agents.[6] A recent study of workers at an active asbestos mine in Russia found a significantly increased risk of lung cancer in men exposed to 65–150 mg/m^3 years of dust (RR 1.37, 95% CI 1.04–1.80) and in men exposed to dust levels greater than 150 mg/m^3 years (RR 1.40, 95% CI 1.03–1.90).[7]

The 2021 Global Burden of Disease (GBD) study indicated that lung cancer remained the main cancer cause of death globally, accounting for 2.97% of deaths. In South Africa, 1.26% of deaths were due to lung cancer.[8] In 2022, lung cancer in South Africa accounted for 3.84% of all incident cancers in men, down from 5% in 2001, and 2.25% in women, up from 2.12% in 2001.[9,10] Lung cancer was attributed to smoking in 59.1% of lung cancer deaths in the USA, 66.8% in China, 51.5% in Botswana, and 47.5% in South Africa. In South Africa, 17.3% of lung cancer deaths were attributed to occupational exposures in 2021.[8] Recognised occupational carcinogens are asbestos, silica, diesel exhaust fumes, some heavy metals, benzene, wood dust, and some manufacturing chemicals, such as vinyl chloride and acrylonitrile, amongst others.[11,12] A global study on the burden of lung cancer attributable to occupational carcinogens found that, between 1990 and 2019, the age-standardised mortality rate of lung cancer increased in middle- to lower-sustainable development index (SDI) regions.[4] South Africa is included in the low SDI group. The study also found that occupational lung cancer deaths increased globally during the same period.[11]

Globally, trends in lung cancer deaths closely follow the incidence of lung cancer because of a high fatality rate, with age-standardised rates varying by country. Even in developed countries, there have been only small improvements in the five-year survival of lung cancer patients.[12] The mortality data thus provide valuable information on incidence. Lung cancer is identified by International Classification of Diseases 10 (ICD-10) codes C33 and C34, which encompass malignant neoplasms of the lung, bronchus, and trachea. This study aimed to identify occupational groups associated with an increased risk of lung cancer mortality in South Africa.

Methods

Statistics South Africa (Stats SA) publishes the anonymised annual death certificate data for South Africa, which includes data on cause of death and underlying cause of death, along with usual occupation and usual industry. Therefore, it is possible to examine lung cancer-related deaths by occupation in the absence of a national occupational health surveillance system. Usual occupation is grouped into 10 large non-specific major groups, but occupations are also presented in much more specific detail in sub-major groups; for instance, technicians and associate professionals contain the sub-groups science and engineering associate professionals, health associate professionals, business and administration and legal, and social and cultural associate professionals. For this study, we used Stats SA mortality data from 2011 to 2015 and limited the analysis to persons aged 15–69 years as working age.

In this analysis, lung cancer was coded in the underlying cause of death as ICD-10 codes C33 (a malignant neoplasm of the trachea) and C34 (a malignant neoplasm of the bronchus and lung). These were combined into a new variable coded as 0 for no lung cancer and 1 for lung cancer present. The 42 sub-major occupation groups were used to provide statistics for occupations with different possible exposures.

Statistical analysis

We conducted a descriptive analysis using the socio-demographic characteristics of persons whose deaths were due to lung cancer. Proportional mortality ratios (PMRs) were calculated as the proportion of men or women in a specific occupational group who died from lung cancer, divided by the proportion of men or women overall who died from lung cancer. A PMR above 100 was interpreted as indicating an increased prevalence of lung cancer in that specific occupational group compared to the general population. If the 95% CI contained 100, the PMR was considered non-significant (data not presented; however, the figures are bolded to indicate significance).

Lastly, we estimated the associations between occupation and lung cancer death by mortality odds ratios (MORs), which were calculated as the odds of lung cancer death in an adjusted logistic regression model.

A p-value of <0.05 was considered significant. The odds of lung cancer death in sub-occupation groups were adjusted for significant factors, such as age, sex, province of residence, year of death, education level, smoking, and next of kin being a smoker. This information is captured from the notification of death form of the Department of Home Affairs by Stats SA. The question specifies next of kin and does not include data from roommates or colleagues. All statistical analyses were conducted with Stata version 16 (Stata Corporation, Texas, USA) and Microsoft Excel (Microsoft Corporation, Washington, USA).

Results

The distribution of lung cancer deaths in people of working age (15–69 years) from 2011 to 2015 shows a steady increase in lung cancer as a proportion of total deaths (Figure 1a). Figure 1b shows that 71% (12 150/17 088) of lung cancer deaths at working age were in men. Twice as many smokers (n = 5 499; 32.1%) died from lung cancer compared to non-smokers (n = 2 631; 15.4%). Unfortunately, 52.5% (n = 8 982) did not have information on smoking.

a b

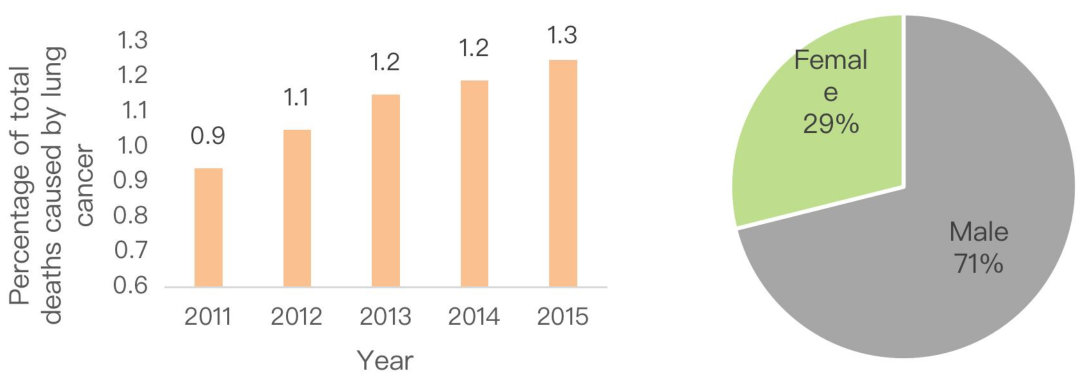

Figure 1. a. Percentage of total deaths caused by lung cancer by year among people of working age (15–69 years), South Africa. **b**. Distribution of lung cancer deaths by sex, South Africa, 2011–2015.

Lung cancer deaths peaked in the 60–64-year age group in both men and women, while few deaths were seen in those younger than 40 years (Figure 2). The Western Cape reported the largest percentage of lung cancer deaths in men, at 5% (4 349/85 918), followed by the Northern Cape at 2% (556/26 212) (Figure 3).

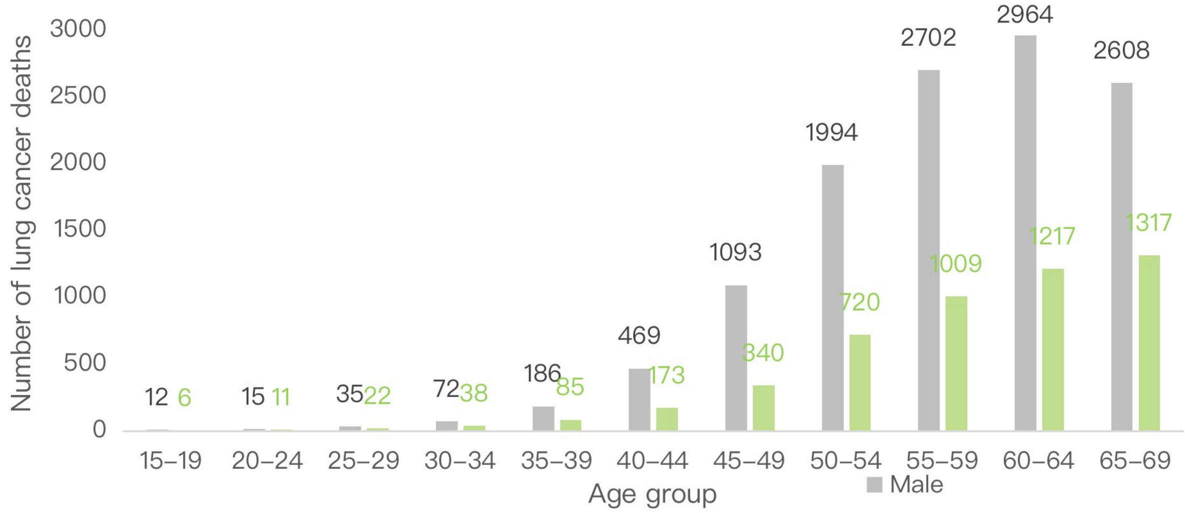

Figure 2. Lung cancer deaths by sex and working age group, South Africa, 2011–2015.

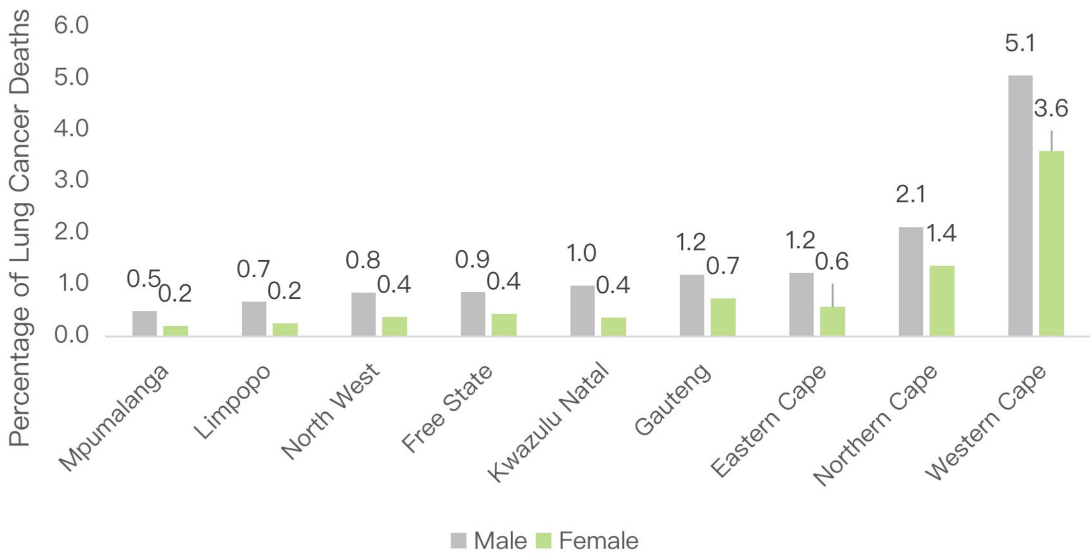

Figure 3. Percentage of lung cancer deaths of total deaths by province, South Africa, 2011–2015.

Association of lung cancer death with sub-occupation group

Increased adjusted MORs indicate higher odds of lung cancer death compared to the general South African population, after adjusting for sex, age, and other limited significant factors in South Africa (Table 1).

Table 1. Lung cancer PMRs and adjusted MORs for sub-occupations in South Africa, 2011–2015.

Sub-occupation	N lung cancer deaths male	PMR males	Adjusted * MOR	N lung cancer deaths female	PMR females	Adjusted * MOR
Occupations unspecified	8 573	95,0	ref	3 311	85,2	ref
Economically inactive persons	1 091	**123,9**	0.98	733	**159,8**	**1.20**
Chief executives & senior officials	17	124,3	1.02	7	**277,0**	**3.14**
Administrative & commercial managers	24	**248,5**	**2.32**	13	**569,7**	**5.54**
Production & specialised services managers	23	**191,2**	**1.69**	7	**514,6**	**5.19**
Hospitality & retail services managers	79	**190,0**	**1.68**	20	**278,2**	**2.66**
Science & engineering professionals	61	**205,3**	**1.80**	5	**292,4**	**3.62**
Health professionals	14	83,9	0.83	58	**236,4**	**1.90**
Teaching professionals	55	95,4	0.91	58	**139,6**	**1.44**
Business & administration professionals	83	**158,7**	**1.31**	40	**359,7**	**3.03**
Information & communication professionals	3[†]	-	-	2[†]	-	-
Legal, social & cultural professionals	22	130,1	1.10	14	**361,5**	**3.31**
Science & engineering associate professionals	46	**142,0**	**1.53**	5	**268,0**	**2.77**
Health associate professionals	9	151,6	1.87	9	189,8	1.72

Sub-occupation	N lung cancer deaths males	PMR males	Adjusted * MOR	N lung cancer deaths female	PMR females	Adjusted * MOR
Business & administration associate professionals	33	135,5	1.39	46	**520,5**	**3.70**
Legal, social, and cultural associate professionals	12	99,5	1.12	8	179,1	1.93
Information & communications technician	5	114,3	1.20	0	-	-
General & keyboard clerks	56	**158,8**	**1.58**	84	**282,1**	**2.42**
Customer services clerks	12	**195,7**	**2.49**	14	162,8	**1.94**
Numerical & material recording clerks	8	159,5	1.87	4	-	**-**
Other clerical support workers	6	**272,5**	**2.83**	4	-	**-**
Personal services workers	26	101,1	1.18	31	**143,6**	1.33
Sales workers	44	85,0	1.18	25	96,9	**1.78**
Personal care workers	2	79,7	0.92	6	93,4	1.65
Protective service workers & armed forces	107	**52,2**	0.96	11	**55,3**	**2.30**
Market-orientated skilled agricultural workers	24	93,3	1.02	2	-	-
Market-orientated skilled forestry and fishery workers	129	**149,4**	**1.33**	18	134,8	1.22
Subsistence farmers	49	**198,6**	**1.44**	3	174,0	1.94
Building & related trades workers	238	**155,2**	**1.42**	0	-	-

Sub-occupation	N lung cancer deaths males	PMR males	Adjusted * MOR	N lung cancer deaths female	PMR females	Adjusted * MOR
Metal, machinery & related trades workers	153	**147,5**	**1.51**	26	**400,2**	**1.93**
Handicraft & printing workers	8	107,5	0.74	2	-	-
Electrical & electronic trades worker	55	124,3	**1.40**	1	-	-
Food processing, woodworking workers	19	142,0	1.41	8	110,7	1.27
Stationary plant & machine operators	196	110,7	**1.39**	11	160,0	**2.04**
Assemblers	4	**-**		0	-	-
Drivers & mobile plant operators	200	**71,9**	0.99	2	-	-
Cleaners & helpers	33	**67,8**	0.86	212	99,6	1.12
Agricultural, forestry & fishery labourers	96	**133,1**	1.07	24	**263,6**	**1.71**
Labourers in mining, construction & manufacturing	54	92,8	1.09	4	-	-
Food preparation assistants	0	-	-	2	-	-
Street & related sales workers	4	-	-	1	-	-
Refuse workers & other elementary workers	477	99,3	1.07	107	**122,2**	**1.26**

Bold numbers indicate a p-value <0.05.
*Adjusted for age group, year of death, smoking status, education, province of residence, and next of kin smoking. Sub-occupation groups with less than five lung cancer deaths were not included in the calculations.

Several sub-occupation groups in men showed significant increases in lung cancer PMRs as well as significantly increased MORs adjusted for available risk factors for lung cancer. The sub-occupation groups with significant MORs compared to the general population in men were administration (MOR 2.3), production (MOR 1.7), and hospitality and retail services managers (MOR 1.7).

Among male professionals only, science and engineering (MOR 1.8) and business and administration professionals (MOR 1.3) had raised risks, along with science and engineering associate professionals (MOR 1.5). Clerks, including general and keyboard (MOR 1.6) and customer services (2.5), showed significantly increased MORs. Among the more labour-intensive occupations with significantly increased odds of lung cancer were skilled forestry and fishery workers (MOR 1.3) and subsistence farmers (MOR 1.4), building (construction) workers (MOR 1.4), metal and machinery (1.5), electrical and electronic trades workers (MOR 1.4), and plant and machine operators, including miners (MOR 1.4). None of the sub-occupations with significantly reduced PMRs had significant MORs. Unemployed men did not have increased MORs for lung cancer (MOR 0.98).

More sub-occupation groups among women showed significantly increased MORs compared to men. All management sub-occupations in women showed increased MORs compared to the general population (MORs 2.7–5.5). Women chief executive officers also had increased MORs (MOR 3.1). Among women, all professional occupations showed significantly increased MORs (MOR 1.4–3.6), except information and communication professionals, which was not determined due to too few registered cases. Similar to men, women clerks showed significantly increased MORs (MOR 1.9–2.4). Sales workers (MOR 1.8) and armed and protective service workers (MOR 2.3) had increased MORs in women but not in men. Metal machinery and related trades (MOR 1.9) and plant and machine operators (MOR 2.0) also showed significantly increased MORs in women. Refuse and other elementary workers showed an increased MOR in women, but not in men (MOR 1.3). Unemployed women had increased MORs for lung cancer (MOR 1.2).

Discussion

Lung cancer accounted for an average of 1.11% of all deaths recorded in South Africa between 2011 and 2015, with a consistent increase over this period. This percentage is close to the 1.31% to 1.61% of lung cancer deaths in South Africa modelled using Bayesian meta-regression in the GBD database for 2011–2015. The GBD database also suggests that 17% of lung cancer deaths were due to occupational carcinogen exposure in South Africa.[8]

We described lung cancer deaths in the working-age population of South Africa (15–69 years of age) by sub-occupation group, adjusting for available known non-occupational risk factors. Men accounted for approximately 2.5 times the reported lung cancer deaths in women overall. The relationship between sex and lung cancer has been well described since cancer statistics became available and has mostly been attributed to exposure differences, with more men smoking and working in hazardous occupations.[13] However, more recently, focus has been placed on the role of biological sex, independent of exposures, in lung cancer.[13] Our results showed more occupations with increased MORs in women than in men, possibly due to differences in smoking by sex.

Lung cancer deaths increased with age in both men and women, which is commonly reported in other studies.[14] When describing the province of residence of lung cancer deaths, we found that 37% (6 347/ 17 112) of all cases resided in the Western Cape. The Western Cape also had the highest proportion of lung cancer deaths out of all-cause mortality, followed by the Northern Cape. Little literature is available on regional variations in lung cancer, highlighting the need for further exploration of regional and occupational risk factors for this disease, as well as access to healthcare in South Africa. Smoking is accepted as the main cause of lung cancer,[11] and our study found twice as many lung cancer deaths in smokers compared to non-smokers. Unfortunately, 52% (8 982/17 112) of individuals in the database did not have smoking status information, limiting adjustment for smoking in the final model.

There are well-recognised occupational carcinogens associated with lung cancer, including asbestos, silica, diesel exhaust, some metals, and manufacturing chemicals.[11,12] Silica exposure was found to increase the odds of lung cancer to an odds ratio (OR) of 1.67 (95% CI 1.21–2.31) with substantial silica exposure and OR 1.31 for any silica exposure in two Canadian case-control studies.[15] In an analysis of 11 case-control studies, workers exposed in the highest quintile to diesel exhaust had increased odds of 1.31 (95% CI 1.19–1.43).[16] In another similar pooled analysis, occupational exposure to nickel and hexavalent chromium was found to increase the odds of lung cancer in men: OR 1.29 (95% CI 1.15–1.45) for nickel and OR 1.32 (95% CI 1.19–1.47) for hexavalent chromium.[17] These exposures may increase the odds of lung cancer death in specific exposed occupations.

In our study, many occupation sub-groups showed increased PMRs, and when adjusting for other significant risk factors in the dataset, many retained significant MORs. In both men and women, management positions were associated with increased odds of lung cancer mortality. Professionals also had increased odds of lung cancer death in women, with some professional groups showing significantly higher odds in men. The increased odds in these higher-income occupational levels may reflect the effect of income on smoking in South Africa.[18] They may also reflect the possible effect of more diagnoses with increased access to healthcare that comes with higher socio-economic status.[19] Women teachers had increased odds of lung cancer, possibly due to asbestos in school buildings. This is supported by the increased risk of mesothelioma observed globally in teachers.[20]

Among associate professionals, men showed increased MORs in science and engineering, while women had increased MORs in science, engineering, and business. Clerks showed significantly increased MORs in both men and women. Women sales workers also showed significantly increased MORs. Second-hand smoke, or environmental tobacco smoke, found in offices before 2001 may account for some of the increase in cases among office workers, such as managers, professionals, clerks, and sales workers.

Among men, forestry and fishery skilled workers and subsistence farmers had significantly increased odds of lung cancer death. Occupational exposure to cumulative wood dust is associated with lung cancer in two Canadian case-control studies – OR 1.4 (95% CI 1.0–2.0) and OR 1.7 (95% CI 1.1–2.7)[21] – as well as a study on pesticide exposure.[22] Men in construction showed increased odds of lung cancer death, which was expected due to possible exposure to silica and asbestos, among other carcinogens.[23] Metal machinery and related trades were associated with increased MORs in both men and women, as were men in electrical trades, who may have been exposed to carcinogenic metals.[11] Mining is not directly recognised as an occupation, but most skilled miners are coded as stationary plant and machine operators. In this occupation group, both men and women showed increased MORs. A recent Swiss study, with more complete data on lung cancer mortality in the working population, also found that occupations in mining, construction, metalworking, and electrical and electronic trades were at higher risk of lung cancer mortality.[24] Occupational exposure to radon is recognised in the mining industry, particularly in uranium and ore mines.[25] South Africa has both uranium mines and ore mines, which likely increases the risk of occupational lung cancer in the mining industry. Women working in agriculture and forestry and fishery, as well as other elementary workers, were also at increased risk of lung cancer mortality in our study.

This study was conducted using Stats SA mortality data, which have limitations: incomplete information, particularly regarding occupation and industry, reduces the records available for analysis in this study. Incomplete smoking history is also a major limitation in the adjustment of the analysis of lung cancer. A large group of deaths do not have a cause of death provided, and the effect of stigmas, such as those associated with HIV and TB, may affect the correct identification of the underlying cause of death. Using five years of mortality data allowed some of these limitations to be mitigated, but underlying bias cannot be entirely eliminated. Despite this, previous analyses of pneumoconiosis mortality confirmed the correct attribution of occupation to this occupational disease.

Identifying the effect of occupational exposure is complicated in mortality surveillance, as other risk factors may vary by occupation group. In this study, the adjusted model attempted to account for demographic risk factors and smoking to increase the likelihood of identifying occupations with increased odds of lung cancer mortality as a consequence of workplace exposures. However, the results require cautious interpretation due to potential bias in death registration and diagnosis and highlight areas where future research is required.

Conclusion

The information provided in this surveillance analysis highlights the increased odds of lung cancer mortality in a number of occupation groups, including skilled forestry and fishery workers; building trades; metal, machinery and electrical and electronic trades; stationary plant operators; and female forestry and fishery labourers. This demonstrates the importance of surveillance and monitoring to improve management of workplace health. These findings can be used to support the updating of compensation for work-related lung cancer in South Africa and investigations into carcinogen exposure in the workplace.

Recommendations

- Academics and labour officials should investigate the occupations with significantly increased lung cancer MORs, including those where second-hand smoke exposure is a likely cause in the short term. Scientific confirmation of occupations with increased risk is required, and inspection to ensure exposures in the identified industries are well controlled.
- Improved reporting by next of kin and health care workers of smoking, usual occupation and industry on death certificates, alongside reducing reporting of unknown causes of death, is necessary to receive the full value of the money spent in collecting the data. Home affairs officials receiving the death notification forms can also play a role in ensuring the completeness of the information provided.
- Smoking cessation needs to be aggressively promoted by employers and unions in all workplaces to reduce lung cancer risk and improve productivity at work.
- Industries with known exposure to less-recognised occupational carcinogens need to improve their policies and practices to reduce lung cancer risk in employees. Continued monitoring of exposure to carcinogens and maintenance of control measures are required in these workplaces.
- The national government needs to establish occupational health surveillance to provide more complete exposure and outcome information in possible cases of occupational lung cancer. This will support prevention activities and compensation when prevention fails.
- The health sector needs to investigate means of increasing identification of occupational lung cancer or the contribution of occupation to the cancer so that compensation for lung cancer can be provided. Compensation helps mitigate the impact of the disease on families and, by increasing company contributions, may encourage replacement or reduction in harmful exposures.

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Ethical considerations

An ethics waiver has been provided for this analysis, as the data is available in the public domain and is anonymous.

Conflicts of interest

No conflicts of interest were reported by any of the authors of this manuscript.

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Bladder cancer mortality by major occupational category in South Africa, 2011–2015

Bladder cancer mortality by major occupational category in South Africa, 2011–2015

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Summary

Bladder cancer is common in South Africa, with approximately 2 600 new cases and 1 000 deaths each year. Men are affected more commonly than women. An increased risk of bladder cancer has been associated with occupational exposures. This study aimed to identify occupations associated with an increased risk of bladder cancer mortality. We conducted a cross-sectional study using Statistics South Africa mortality data to describe the sociodemographic characteristics of persons aged 15–69 years whose death was due to bladder cancer, and estimated proportional mortality ratios (PMRs) to identify occupations associated with increased risk of bladder cancer mortality in South Africa. Participants aged 15–69 years whose underlying cause of death was bladder cancer and whose occupations were recorded were included in the study. PMRs were calculated to estimate where excess mortality by occupation occurred. Confidence intervals that do not include 100 indicate that a PMR is significant. From 2011 to 2015, a total of 1 541 488 deaths was recorded among individuals aged 15–69 years in South Africa, of which 1 363 (0.09%) were bladder cancer deaths. Males accounted for the most bladder cancer deaths at 886 (65%) compared to females at 474 (35%). Gauteng province reported the highest mortality, with (377; 27.7%). Men in the manufacturing, construction, wholesale, retail, motor repair, accommodation and food, and transport industries had increased PMRs. For women, high PMRs were reported in construction and educational services. Bladder cancer morbidity and mortality have adverse effects on individuals, families, businesses, institutions, and the economy in general. Interventions and preventative measures, such as policies to reduce occupational exposure and raising awareness, are therefore required in the high-risk industries to reduce the burden of deaths due to bladder cancer.

Introduction

Cancer is a major societal, public health, and economic problem in the 21st century, responsible for almost one in six deaths worldwide (16.8%) and one in four deaths from non-communicable diseases worldwide (22.8%).[1] Bladder cancer is one of the commonest urological cancers and a leading cause of cancer-related mortality globally.[2] Bladder cancer is the ninth commonest cancer in the world, with 613 791 new cases per year, and is ranked 13th in terms of mortality rate, with 220 349 deaths reported in 2020.[1] The burden and rates are considerably higher in men than in women. There are three main histological subtypes of bladder cancer: squamous cell carcinoma (SCC), transitional cell carcinoma (TCC) (also known as urothelial carcinoma (UC)), and adenocarcinoma. Across the world, there are variations in bladder cancer incidence, histological subtypes, and risk factors. Transitional cell carcinoma/UC predominates in developed countries and is strongly associated with smoking and occupational exposure to carcinogens. In Africa, the commonest subtype is SCC and is mostly schistosoma-related.[3] With increasing industrialisation and urbanisation, and efforts to control schistosomiasis in Africa, a gradual decrease in bladder cancer incidence has been reported.[3,4]

The main risk factors for bladder cancer are tobacco smoking and occupational exposures (including working with aniline dye, aromatic amines, cables, and rubber in the electrical and glass manufacturing industries). Other risk factors include arsenic in drinking water, dietary supplements containing aristolochic acid,[5,6] increasing age, family history, obesity, chronic urinary bladder inflammation, and bladder birth defects.[7]

Generally, studies of bladder cancer in South Africa are limited and sometimes outdated. Studies from KwaZulu-Natal province (endemic for schistosomiasis) conducted between the 1970s and 1980s suggested the following distribution of histological subtypes: 62% TCC, 56% SCC, and 10% adenocarcinoma or undifferentiated bladder cancer cases. In the Western Cape (non-endemic for schistosomiasis), a study conducted between 1978 and 1989 reported that TCC and SCC constituted 83% and 9%, respectively, of 112 cystectomy cases.[8] Similarly, a recent analysis of secondary data from 115 patients treated in the radiation oncology unit of an academic hospital in Johannesburg (non-endemic for schistosomiasis) from 2010 to 2020 showed that TCC was the most prevalent histological subtype, compared to SCC.[2] While most TCC cases were among Black patients, White patients were four times more likely to present with TCC than SCC (OR: 4.22, 95% CI: 1.43–12.48, p=0.009).[2]

This study aimed to identify occupations associated with an increased risk of bladder cancer mortality in South Africa.

Materials and Methods

Data sources and management

The South African Standard Classification of Occupations (SASCO) categorises occupations hierarchically into four groups, namely major group, sub-major group, minor group, and unit group. There are 10 major groups, which are the broadest level of job classification.[9] For this analysis, major occupation group and sub-major occupation group data from the Statistics South Africa (StatsSA) mortality dataset were used. Data collected from the working-age population (15–69 years of age) for the period 2011–2015 were included in this analysis. Deaths were classified using the International Classification of Diseases, 10th Revision (ICD-10). Deaths due to bladder cancer included cases in which the underlying cause of death was coded as ICD-10 code: C67. All persons whose cause of death was bladder cancer, with a death date before 2011 or after 2015, were excluded. Furthermore, all bladder cancer deaths recorded for persons whose usual occupation status was unknown or unspecified were excluded.

Statistical analysis

Descriptive analysis was used to describe the sociodemographic characteristics of bladder cancer mortality using frequencies and proportions. To estimate the prevalence of bladder cancer mortality in South Africa for the study period 2011 to 2015, the following equation was used:

$$\text{Prevalence} = \frac{\text{Number of people in all occupation groups who died from bladder cancer}}{\text{Total number of people in all occupation groups who died 2011–2015}} \text{ x } 100$$

We calculated proportional mortality ratios (PMRs) to estimate where excess mortality by occupation was found, using the following equation:

$$\text{PMR} = \frac{\text{Proportion of deaths from bladder cancer in a specific group of workers}}{\text{Proportion of deaths from bladder cancer in the general population}} \text{ x } 100$$

PMR is a simple and potentially useful way of portraying the burden of a specific disease within a population. A PMR above 100 was interpreted as indicating the increased prevalence of bladder cancer in that specific occupational group compared to the general population. A PMR with confidence intervals that did not include 100 was considered significant.

Results

Bladder cancer mortality

From 2011 to 2015, a total of 1 363 bladder cancer deaths was recorded in South Africa, accounting for 0.09% of the total deaths (1 363/1 541 488). Males accounted for the majority of bladder cancer deaths at 886 (65%) compared with females at 474 (35%) (Figure 1). The highest proportional bladder cancer mortalities were recorded among those aged 50–69 years (Figure 2). The mean age of death due to bladder cancer was 58.2 years in men and 54.5 years in women. The highest proportional bladder cancer deaths were reported from Gauteng (267 (30.14%) males and 110 (23.21%) females), Western Cape (230 (25.96%) males and 81 (17.09%) females), and KwaZulu-Natal (142 (16.03%) males and 112 (23.63%) females) (Figure 3).

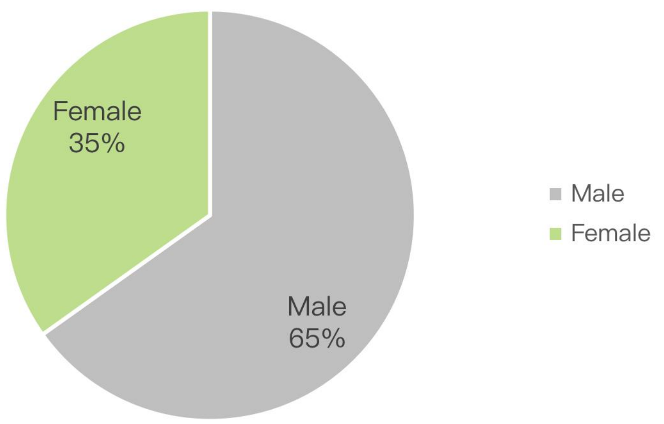

Figure 1. Bladder cancer mortality among persons aged 15–69 years by sex, South Africa, 2011–2015.

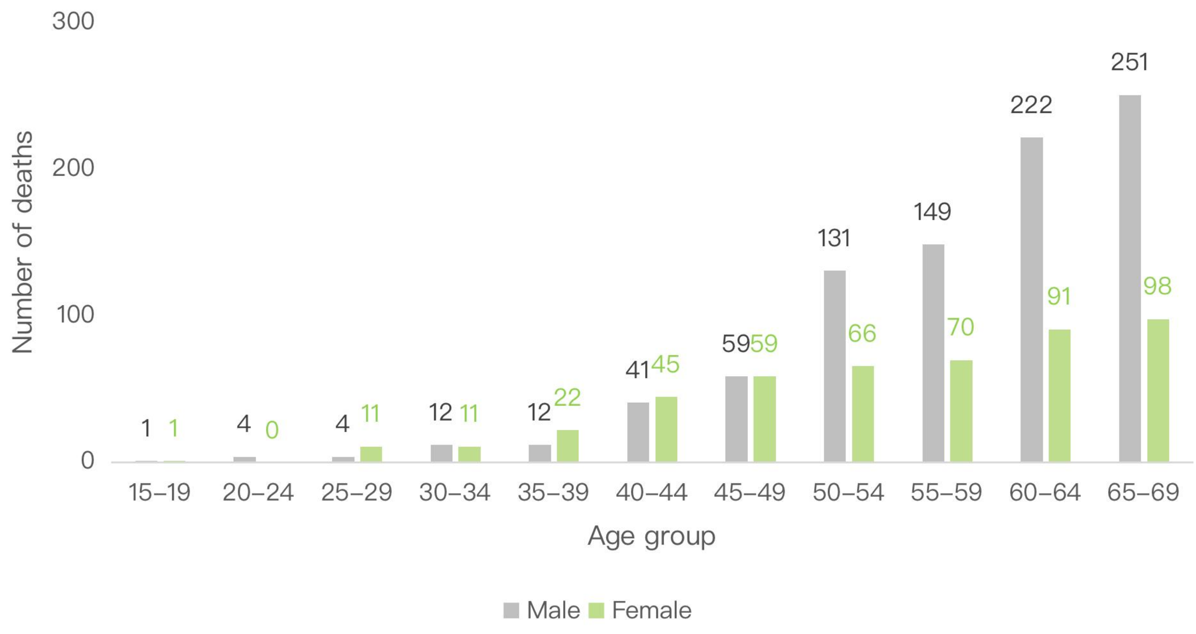

Figure 2. Bladder cancer deaths among persons aged 15–69 years by age group and sex, South Africa, 2011–2015.

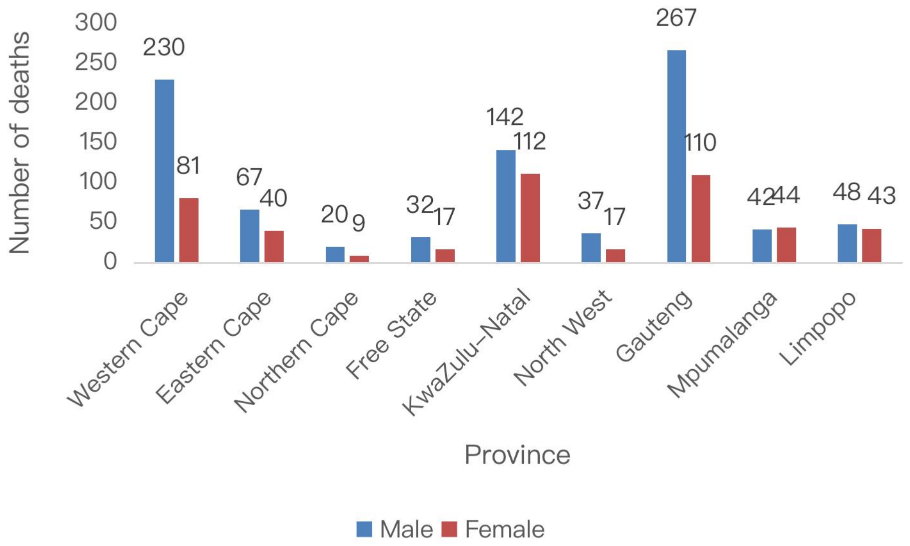

Figure 3. Bladder cancer deaths among persons aged 15–69 years by province and sex, South Africa, 2011–2015.

For men, the main industries with significantly elevated PMRs for bladder cancer-related deaths compared with the general population were manufacturing (PMR: 181.64, 95% CI: 126.23-261.39); construction (PMR: 143.78, 95% CI: 100.53-205.65); wholesale, retail, motor repair, accommodation, and food (PMR: 195.85, 95% CI: 138.50-276.95); transport (PMR: 151.71, 95% CI: 102.51-224.53); and other service activities (PMR: 229.31, 95% CI: 140.48-374.30). For women, construction (PMR: 343.78, 95% CI: 110.87-1,065.93) and educational services (PMR: 202.01, 95% CI: 101.03-403.95) had elevated PMRs for bladder cancer-related deaths compared with the general population (Table 1).

Table 1. Bladder cancer-related deaths by industry, stratified by sex, South Africa, 2011–2015.

Industry	**Men**			**Women**		
	n	**Total deaths**	**PMR (95% CI)**	**n**	**Total deaths**	**PMR (95% CI)**
Not economically active and unspecified activities	694	733 993	93.04 (86.37-100.23)	433	618 321	98.14 (89.32-107.84)
Agriculture	21	21 634	95.52 (62.28-146.50)	3	6 557	64.12 (20.68-198.82)
Mining	10	18 064	54.47 (29.31-101.24)	2	1 067	262.69 (65.70-1050.39)
Manufacturing	29	15 710	**181.64 (126.23-261.39)**	0	3 936	-
Construction	30	20 531	**143.78 (100.53-205.65)**	3	1 223	**343.78 (110.87-1065.93)**
Wholesale, retail, motor repair, accommodation, and food	32	16 078	**195.85 (138.50-276.95)**	4	9 064	61.85 (23.21-164.79)
Transport	25	16 215	**151.71 (102.51-224.53)**	2	1 106	253.43 (63.38-1013.35)

Industry	Men			Women		
	n	Total deaths	PMR (95% CI)	n	Total deaths	PMR (95% CI)
Health and social services	2	1 588	123.93 (30.99-495.54)	3	4 108	102.35 (33.01-317.34)
Educational services	8	4 439	177.34 (88.69-354.61)	8	5 550	**202.01 (101.03-403.95)**
Waste and recycling	0	105	0 (-)	0	88	-
Business, finance, legal, politics, and entertainment	19	16 612	112.55 (71.79-176.45)	9	7 748	162.79 (84.70-312.88)
Other service activities	16	6 866	**229.31 (140.48-374.30)**	7	5 529	177.43 (84.59-372.19)
Total	**886**	**871 835**		**474**	**664 297**	

CI=confidence interval.

Bolded PMRs were statitistically significant: A PMR with confidence intervals that did not include 100 were considered significant.

In terms of major occupation, men working as legislators, senior officials and managers (PMR: 429.01, 95% CI: 287.55-640.06), professionals (PMR: 227.09, 95% CI: 157.81-326.78), technicians and associate professionals (PMR: 295.43, 95% CI: 183.65-475.23), and in craft and related trades (PMR: 175.01, 95% CI: 128.86-237.69) had significant excess mortality due to bladder cancer compared with the general population. Working in elementary occupations was protective among men (PMR: 49.70, 95% CI: 33.31-74.14). Among women, working as clerks (PMR: 283.29, 95% CI: 156.89-511.55) had significant excess mortality due to bladder cancer compared with the general population (Table 2).

Table 2: Bladder cancer-related deaths, South Africa, 2011–2015, by sex and major occupation.

Major occupation	**Men**			**Women**		
	n	**Total deaths**	**PMR (95% CI)**	**n**	**Total deaths**	**PMR (95% CI)**
Armed forces, unspecified occupations, and unemployed	676	710 203	93.92 (87.10-101.27)	405	584 122	97.10 (88.09-107.04)
Legislators, senior officials, and managers	24	5 520	**429.01 (287.55-640.06)**	2	1 797	155.87 (38.98-623.25)
Professionals	29	12 601	**227.09 (157.81-326.78)**	11	11 172	137.89 (76.36-245.00)
Technicians and associate professionals	17	5 678	**295.43 (183.65-475.23)**	3	2 714	154.81 (49.93-480.00)
Clerks	5	3 488	141.45 (58.87-339.83)	11	5 438	**283.29 (156.89-511.55)**
Service and sales workers	25	20 458	120.58 (81.48-339.83)	8	9 915	113.00 (56.51-225.96)
Skilled agricultural and fishery workers	13	9 812	130.73 (75.91-225.15)	2	2 163	129.50 (32.39-517.79)
Craft and related trade workers	41	23 116	**175.01 (128.86-237.69)**	1	2 255	62.11 (8.75-440.91)
Plant and machine operators	29	32 749	87.38 (60.72-125.74)	0	1 183	-
Elementary occupations	24	47 653	**49.70 (33.31-74.14)**	31	43 074	100.79 (70.88-143.32)
Total	883	**871 278**		474	**663 833**	

Men and women who were not economically active had significantly increased PMRs of 137.08 (95% CI: 111.24–168.94) and 134.01 (95% CI: 103.83–172.96), respectively. Men employed in the following sub-major occupation groups had excess mortality due to bladder cancer compared with the general population: chief executives and senior officials (PMR: 601.83, 95% CI: 270.37–1339.61); production and specialised service managers (PMR: 456.08, 95% CI: 171.17–1215.20); hospitality and retail workers (PMR: 395.84, 95% CI: 224.80–697.01); business and administration professionals (PMR: 288.40, 95% CI: 159.72–520.78); science and engineering associate professionals (PMR: 253.93, 95%CI: 114.08–565.23); legal, social, and cultural associate professionals (PMR: 568.78, 95% CI: 236.74–1,366.53); personal services workers (PMR: 266.66, 95%CI: 110.99–640.67); sales workers (PMR: 291.35, 95% CI: 161.35–526.11); and subsistence farmers (PMR: 333.55, 95% CI: 149.85–742.46). Women professionals employed in science and engineering (PMR: 1218.66, 95% CI: 304.78–4872.88), business and administration associate professionals (PMR: 353.61, 95% CI: 114.04–1096.410), and general and keyboard clerks (PMR: 314.86, 95% CI: 163.82–605.14) had significant excess mortality due to bladder cancer compared to the general population (Figure 4).

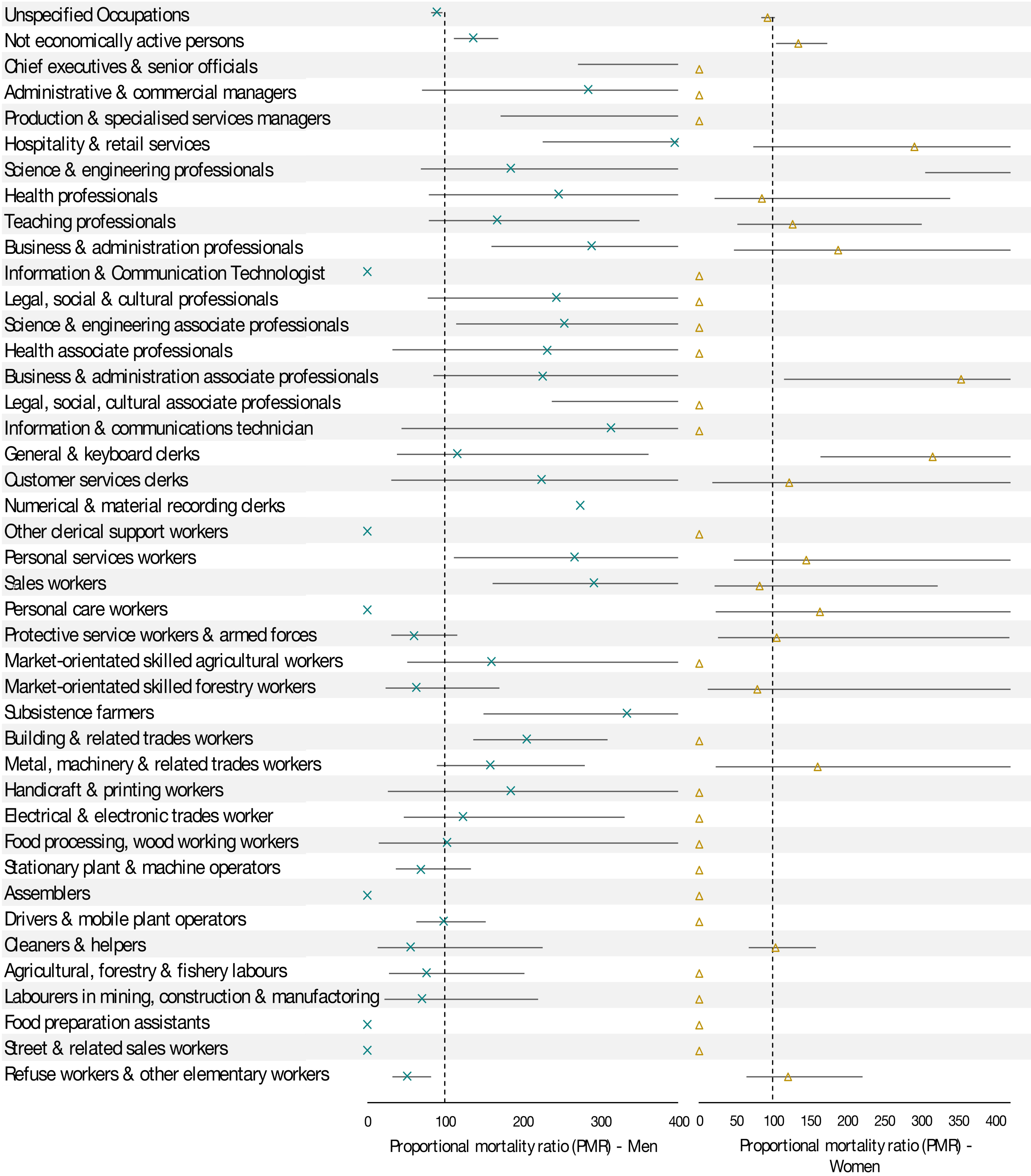

Figure 4. Bladder cancer-related mortality by sex and sub-major occupation, South Africa, 2011–2015.

Discussion

In South Africa, bladder cancer accounted for 0.09% of all deaths among individuals aged 15–69 years for the period between 2011 and 2015. The majority of deaths (65%) occurred in males. The highest proportional bladder cancer mortalities were recorded among those aged 50–69 years, with a mean age of death of 58.2 years for men and 54.5 years for women. Bladder cancer is known to disproportionately affect males, and its risk increases with increasing age.[7]

In this study, the main industries with significantly elevated PMRs for bladder cancer-related deaths were manufacturing, construction, wholesale, retail, motor repair, accommodation and food, and transport in men; and construction and educational services in women, compared with the general population. Men working as legislators, senior officials and managers, professionals, technicians and associate professionals, and craft and related trades also had significant excess mortality due to bladder cancer compared with the general population. Possible confounding due to race, socioeconomic status, and smoking status could not be ruled out. However, working in elementary occupations was protective among men. Among women, working as clerks had significant excess mortality due to bladder cancer compared with the general population. Men and women who were not economically active had significantly increased PMRs. Individuals with lower socioeconomic status are more likely to be diagnosed with bladder cancer, present at later stages, and have poorer survival rates.[3]

Some of the main industries and occupations with increased PMRs, such as construction and manufacturing, could be directly or indirectly linked to the already established occupational exposures, such as aniline dye, aromatic amines, cables, and rubber in the electrical and glass manufacturing industries, as well as exposure to arsenic in drinking water and the use of dietary supplements containing aristolochic acid.[5,6] However, for other industries with high PMRs, such as educational services, clerical work, and business and administration professionals, there is no obvious link to known occupational exposures.

Professions with prolonged exposure to high-risk carcinogens may be at an increased risk of developing and dying from occupational bladder cancer. These professions include manufacturing and industrial-processing workers in the rubber, textiles, plastics, mining, and metals industries, because they can be exposed to carcinogens such as aromatic amines.[10] There is evidence suggesting that painters, hairdressers, and barbers have an increased risk of developing bladder cancer compared to the general population because they work with dyes, including hair dyes.[11] Truck drivers, bus drivers, and other individuals in the transport industry who are exposed to high levels of diesel fumes may also have a higher risk of bladder cancer.[12]

Limitations

As there is no population-based occupational health surveillance programme in South Africa, our study utilised mortality data, and the limitations of such data are discussed in detail elsewhere.[13] Another limitation of our study is that many key variables relevant to bladder cancer risk were either completely missing or largely incomplete. These include, but are not limited to, exposures to occupational hazards and duration of employment in high-risk industries, as well as demographic and behavioural factors, such as the worker's tobacco smoking status, schistosomiasis diagnosis, body mass index, alcohol consumption, physical activity, family history of bladder cancer, and information on histological subtypes of bladder cancer. Approximately 50% of bladder cancer cases are caused by tobacco smoking, but information on smoking was missing for more than 70% of the data.[14] Schistosomiasis is endemic in South Africa and is mainly found in the Limpopo and Mpumalanga provinces, the north and east of Gauteng, the lower-altitude areas of KwaZulu-Natal, and along the east coast into the Eastern Cape province as far south as Gqeberha. All countries bordering South Africa, except Lesotho, have transmission areas.[15]

Future South African studies investigating the association between occupation and bladder cancer should adjust for sociodemographic and behavioural factors to allow for a comprehensive and nuanced investigation of this association.

Conclusion

Most deaths due to bladder cancer in South Africa during the period 2011–2015 were in males. The highest proportional bladder cancer mortalities were recorded among those aged 50–69 years. The main industries with significantly elevated PMRs for bladder cancer-related deaths were manufacturing, construction, wholesale, retail, motor repair, accommodation and food, and transport in men; and construction and educational services in women, compared with the general population. There is a need for policies and practices to reduce occupational risk factors. In addition, it is important to raise awareness of lifestyle and occupational risk factors for bladder cancer among workers in high-risk industries.

Recommendations

We recommend that workplaces, in collaboration with the Department of Health (DoH):

- Raise awareness of bladder cancer risk in the workplace, encourage workers to stop smoking and avoid exposure to second-hand tobacco smoke, and provide education on healthy diets and maintaining a healthy weight to reduce the risk of bladder cancer and other non-communicable diseases;

- Support programmes and awareness campaigns on health and the prevention of non-communicable diseases, such as bladder cancer;
- Implement awareness programmes and specific policies through the DoH to prevent workplace exposure to the already-established workplace carcinogens, for example, by providing protective clothing; and
- Implement policies and practices to reduce bladder cancer risk, for example, periodic physical activity, providing smoking cessation support groups, seeking timely medical help, and creating a supportive, healthy working environment.
- The DoH should provide training for healthcare workers to improve the completion of usual occupation, industry, and cause of death on death certificates.
- Ongoing research is needed to identify avoidable risk factors that could reduce the number of people who develop bladder cancer.

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Ethical considerations

Statistics South Africa publishes mortality data in the public domain in accordance with the Statistics Act no. 6 of 1999, which provides for the use of the data by government, other sectors of society, and the public at large. (http://www.statssa.gov.za/?page_id=830).

Conflicts of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Oesophageal cancer mortality by occupation in South Africa: A five-year review from 2011 to 2015

Oesophageal cancer mortality by occupation in South Africa: A five-year review from 2011 to 2015

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Summary

Oesophageal cancer is the 11th most commonly diagnosed cancer globally and the second leading cause of cancer-related deaths in South Africa. The two main histological types, adenocarcinoma and squamous cell carcinoma, have been linked to lifestyle factors, such as tobacco use, alcohol consumption, and obesity. Occupation also plays a significant role in oesophageal cancer risk, with higher risks observed in specific job categories globally. However, research on these associations in South Africa is lacking. To address this gap, we used Statistics South Africa (Stats SA) data for deaths registered between 2011 and 2015 among individuals aged 15–69 years to identify high-risk occupations associated with oesophageal cancer mortality. We used this data to describe the sociodemographic characteristics of persons who died from oesophageal cancer. We estimated the associations between major and sub-occupation groups and oesophageal cancer death by calculating the proportionate mortality ratios (PMRs). The proportion of oesophageal cancer deaths was consistent over the five-year period (between 0.5 and 0.6% of all deaths). Males had a higher proportion of oesophageal cancer mortality (5 987/872 346; 0.7%) compared to females (3 001/664 701; 0.5%), while individuals aged 55 years and older were the most affected (6 052/494 791; 1.2%). The Eastern Cape province had the highest proportional mortality of oesophageal cancer deaths (2 186/218 819; 1.0%). Males in the following sub-occupations had a significantly elevated risk of oesophageal cancer mortality: skilled forestry workers, building and related trade workers, and stationary plant and machine operators. For females, the sub-occupations associated with elevated risks of oesophageal cancer mortality were cleaners and helpers. This study highlights certain occupations as high risk for oesophageal cancer. It underscores the importance of targeted interventions and workplace safety measures to reduce the incidence and mortality of oesophageal cancer. We recommend that the South African Department of Employment and Labour partner with local employers to host workshops about occupational risk factors for oesophageal cancer. In collaboration with the National Department of Health (NDoH), efforts must target high-mortality regions such as the Eastern Cape while investigating contributing factors. Employers and unions should advocate for restorative reforms, including mandatory breaks, ergonomic practices, and regular screenings. Additionally, the NDoH and Stats SA should train personnel responsible for completing death certificates and collecting data to improve the accuracy of occupation-related data.

Introduction

Oesophageal cancer ranks as the 11th most commonly diagnosed cancer and the seventh leading cause of cancer-related deaths globally.[1] The number/proportion of deaths from oesophageal cancer is notably higher in South Africa, making it the second leading cause of cancer-related fatalities in the country.[2] Using data from the Global Cancer Observatory (GLOBOCAN), it has been estimated that worldwide incident cases and deaths related to oesophagus cancer are likely to rise by 63.5% and 68% by 2040, respectively.[3] Despite its high prevalence and expected rise in incident cases, research on oesophageal cancer in South Africa is scarce.[4]

There are certain lifestyle risk factors for the two main histological types of oesophageal cancer: adenocarcinoma (AC) and squamous cell carcinoma (SSC). The two histological subtypes have distinct incidence patterns and risk factor profiles. Tobacco use is associated with an increased risk of oesophageal SSC and oesophageal AC, whereas alcohol consumption is a significant risk factor for oesophageal SSC but not for oesophageal AC.[5] Obesity has also been identified as a strong risk factor for oesophageal AC.[6]

There is increasing evidence that specific occupations present a higher risk of oesophageal cancer-related morbidity and mortality. Using data from the Nordic Occupational Cancer Study – a large population-based prospective cohort – Jansson *et al.* showed between 24% (standardised incidence ratio [SIR]: 1.24) and over two-fold (SIR: 2.58) increased risk of oesophageal cancer among waiters, cooks and stewards, seamen, food workers, miscellaneous construction workers, and drivers. The same study found a decreased risk among religious workers, teachers, and physicians.[7] In India, evidence suggests an association between strenuous occupational physical activity (OPA) and increased oesophageal cancer risk, as compared to workers with moderate OPA.[8]

Studies investigating the association between occupation and oesophageal cancer are lacking in South Africa. To address this gap, we investigated the associations between occupation and oesophageal cancer mortality, leveraging occupation data from vital registration records to identify high-risk occupations.

Materials and methods

Data sources and management

We used Statistics South Africa (StatsSA) data for deaths registered between 2011 and 2015. Deaths due to oesophageal cancer were identified as the underlying cause if they were coded as C15 according to the 10th version of the International Classification of Diseases (ICD-10). The usual occupation of the deceased was identified by the type of work done for the majority of their working life. These occupations are classified into 10 major occupations and 42 sub-occupation groups by StatsSA, based on the South African Standard Classification of Occupations. We used nine of the 10 major occupations and 40 of the 42 sub-occupations to test for associations between oesophageal cancer mortality and occupation. The

major occupation groups titled 'armed forces,' 'occupations unspecified,' 'not elsewhere classified," and "not economically active persons' and sub-occupation groups titled 'occupations unspecified' and "not economically active' were excluded from the analysis as they contained unemployed persons or those with unspecified occupations. Lastly, we restricted our analysis to the working-age population of 15–69 years.

Statistical analysis

We conducted a descriptive analysis of the sociodemographic characteristics of persons whose death was due to oesophageal cancer. We stratified oesophageal cancer deaths by sociodemographic factors, namely year of death, age, sex, educational attainment, province of death, and smoking status. Lastly, we estimated the associations between occupation and oesophageal cancer death by calculating the PMR with 95% confidence intervals. All statistical analyses were conducted with Stata version 18 (Stata Corporation, College Station, Texas, USA) and Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA).

Results

Characteristics of all-cause deaths and oesophageal cancer deaths

There were 1 541 488 recorded deaths among persons aged 15–69 years between 2011 and 2015 in South Africa. Less than one per cent were due to oesophageal cancer (8 995/1 541 488; 0.6%). The proportion of oesophageal cancer deaths remained consistent over the five-year surveillance period (0.5% to 0.6%). There was a higher proportion of oesophageal cancer deaths among males (5 987/872 346; 0.7%), while individuals aged 55 years and older were most affected, with mortality proportions of 1.2% to 1.3% (6 052/494 791). Among educational attainment levels, the highest mortality proportions were among those with primary education (1 998/271 334; 0.7%). Notably, the Eastern Cape province reported the highest mortality proportion of oesophageal cancer deaths at 1% (2 186/218 819) compared to other provinces. The mortality proportion of oesophageal cancer among smokers (0.8%; 2 653/314 330) was double that of non-smokers (0.4%; 2 389/571 041) (Table 1).

Table 1. Distribution of total deaths and oesophageal cancer deaths among persons aged 15–69 years by sociodemographic characteristics, South Africa, 2011–2015.

Characteristic	Total deaths (n=1 541 488)	Oesophageal cancer deaths (n=8 995)	%
Year of death			
2011	337 790	1 819	0.5
2012	315 066	1 808	0.6
2013	298 822	1 709	0.6
2014	292 768	1 806	0.6
2015	297 042	1 853	0.6
Age group			
15-19 years	35 807	4	0.0
20-24 years	76 000	15	0.0
25-29 years	129 895	26	0.0
30-34 years	159 832	64	0.0
35-39 years	166 105	148	0.1
40-44 years	160 167	334	0.2
45-49 years	156 123	805	0.5
50-54 years	162 768	1 547	1.0
55-59 years	164 621	1 971	1.2
60-64 years	173 291	2 207	1.3
65-69 years	156 879	1 874	1.2
Sex of deceased			
Male	872 346	5 987	0.7
Female	664 701	3 001	0.5
Unspecified	4 441	7	0.2
Educational attainment			
None	88 220	772	0.9
Primary education	271 334	1 998	0.7
Secondary education	423 102	1 411	0.3
Tertiary education	29 183	143	0.5
Unknown	57 076	491	0.9
Unspecified	672 573	4 180	0.6
Province of death occurrence			
Western Cape	146 856	1 379	0.9
Eastern Cape	218 819	2 186	1.0
Northern Cape	47 318	318	0.7
Free State	118 043	565	0.5
KwaZulu-Natal	296 541	1 517	0.5
North West	116 412	663	0.6
Gauteng	325 455	1 405	0.4
Mpumalanga	122 152	398	0.3
Limpopo	142 226	543	0.4
Unknown	3 153	9	0.3
Outside South Africa	2 433	3	0.1

Characteristic	Total deaths (n=1 541 488)	Oesophageal cancer deaths (n=8 995)	%
Unspecified	2 080	9	0.4
Smoking status of the deceased			
Smoker	314 330	2 653	0.8
Non-smoker	571 041	2 389	0.4
Unknown	82 710	652	0.8
Unspecified	573 407	3 301	0.6

Proportionate mortality ratio of oesophageal cancer deaths by major occupation

We calculated PMRs to estimate the risk of oesophageal cancer death associated with each occupation compared with the general population (i.e., those that did not die from oesophageal cancer) (Table 2). Among males, there was a statistically significant elevated risk of oesophageal cancer death in professionals (PMR: 128.55, 95% confidence interval (CI): 106.27–155.51) and skilled agricultural and fishery workers (PMR: 127.72, 95% CI: 102.86–158.58) compared with the general population. Male service and sales workers showed lower proportionate mortality from oesophageal cancer (PMR: 58.27, 95% CI: 46.67–72.74), indicating a decreased association with oesophageal cancer relative to the general population. Among females, oesophageal cancer mortality was significantly higher (PMR: 117.12, 95% CI: 101.24–135.48) in elementary occupations.

Table 2. PMR of oesophageal cancer deaths among persons aged 15–69 years by major occupation, South Africa, 2011–2015.

Major occupation	Male			Female		
	n	Total deaths	PMR (95% CI)	n	Total deaths	PMR (95% CI)
Legislators, senior officials, and managers	37	5 520	102.44 (74.22–141.38)	4	1 797	62.04 (23.28–165.3)
Professionals	106	12 601	**128.55 (106.27–155.51)**	37	11 172	92.3 (66.88–127.4)
Technicians and associate professionals	32	5 678	86.13 (60.91–121.79)	4	2 714	41.08 (15.42–109.45)
Clerks	28	3 488	122.68 (84.7–177.68)	18	5 438	92.25 (58.12–146.43)
Service and sales workers	78	20 458	**58.27 (46.67–72.74)**	25	9 915	70.27 (47.48 – 104.00)
Skilled agricultural and fishery workers	82	9 812	**127.72 (102.86–158.58)**	8	2 163	103.08 (51.55–206.13)
Craft and related trade workers	166	23 116	109.74 (94.26–127.78)	7	2 255	86.52 (41.25–181.48)
Plant and machine operators	196	32 749	91.46 (79.51–105.21)	2	1 183	47.12 (11.78–188.41)
Elementary occupations	329	47 653	105.51 (94.7–117.55)	181	43 074	**117.12 (101.24–135.48)**
Total	1 054	161 075		286	79 711	

Statistically significant PMRs are bolded

Proportionate mortality ratio of oesophageal cancer deaths by sub-occupations

We calculated PMRs to estimate the risk of oesophageal cancer death associated with each sub-occupation compared with the general population (i.e., those who did not die from oesophageal cancer) (Table 3). Among females, a statistically significant elevated risk of oesophageal cancer mortality was noted among information and communications technicians (PMR: 796.28, 95% CI: 112.16–5 653.08) and cleaners and helpers (PMR: 125.53, 95% CI: 105.63–149.17). For males, those who were in the sub-occupations of science and engineering professionals (PMR: 186.34, 95% CI: 126.87–273.68), teaching professionals (PMR: 162.55, 95% CI: 120.97–218.43), customer service clerks (PMR: 277.82, 95% CI: 138.93–555.53), market-orientated skilled forestry workers (PMR: 133.17, 95% CI: 101.99–173.88), building and related trades workers (PMR: 123.56, 95% CI: 100.38–152.09), and stationary plant and machine operators (PMR: 135.88, 95% CI: 113–163.39) had an increased risk of oesophageal cancer mortality compared with the general population.

Table 3. PMR of oesophageal cancer deaths among persons aged 15 to 69 years by sub-occupation, South Africa, 2011 – 2015.

Sub-occupation	Male			Female		
	n	Total deaths	PMR (95% CI)	n	Total deaths	PMR (95% CI)
Chief executives & senior officials	9	981	140.18 (72.94–269.42)	0	340	-
Administrative & commercial managers	6	693	132.29 (59.43–294.48)	1	307	90.78 (12.79–644.49)
Production & specialised services managers	5	863	88.53 (36.85–212.7)	0	183	-
Hospitality & retail services	17	2 983	87.08 (54.13–140.08)	3	967	86.46 (27.89–268.09)
Science & engineering professionals	26	2 132	**186.34 (126.87–273.68)**	1	230	121.17 (17.07–860.25)
Health professionals	8	1 198	102.04 (51.03–204.04)	9	3 301	75.99 (39.54–146.04)
Teaching professionals	44	4 136	**162.55 (120.97–218.43)**	17	5 590	84.76 (52.69–136.34)
Business & administration professionals	23	3 753	93.64 (62.23–140.92)	7	1 496	130.41 (62.17–273.55)
Information & Communication technologist (NQF level 7, 8 or 9)	0	169	-	0	34	-
Legal, social & cultural professionals	5	1 213	62.98 (26.22–151.32)	3	521	160.48 (51.76–497.59)
Science & engineering associate professionals	13	2 325	85.44 (49.61–147.14)	0	251	-
Health associate professionals	3	426	107.61 (34.7–333.65)	2	638	87.37 (21.85–349.34)
Business & administration associate professionals	6	1 748	52.45 (23.56–116.75)	1	1 189	23.44 (3.3–166.41)
Legal, social, cultural associate professionals	7	865	123.65 (58.95–259.38)	0	601	-
Information & communications technician (NQF level 5 or 6)	3	314	145.99 (47.08–452.65)	1	35	**796.28 (112.16–5653.08)**
General & keyboard clerks	18	2 530	108.71 (68.49–172.55)	15	4 006	104.36 (62.91–173.1)
Customer services clerks	8	440	**277.82 (138.93–555.53)**	3	1 157	72.26 (23.31–224.07)
Numerical & material recording clerks	0	360	-	0	136	-
Other clerical support workers	2	158	193.42 (48.37–773.39)	0	139	-
Personal services workers	9	1 845	74.54 (38.78–143.25)	13	2 904	124.76 (72.44–214.87)
Sales workers	17	3 715	69.92 (43.47–112.48)	6	3 472	48.16 (21.64–107.21)
Personal care workers	0	180	-	3	864	96.77 (31.21–300.05)
Protective service workers & armed forces	52	14 718	**53.99 (41.14–70.85)**	3	2 675	31.26 (10.08–96.91)
Market-orientated skilled agricultural workers	14	1 846	115.88 (68.63–195.67)	0	135	-
Market-orientated skilled forestry workers	54	6 196	**133.17 (101.99–173.88)**	8	1 796	124.14 (62.08–248.24)

Subsistence farmers	14	1 770	120.86 (71.58–204.07)	0	232	-
Building & related trades workers	89	11 006	**123.56 (100.38–152.09)**	1	230	121.17 (17.07–860.25)
Metal, machinery & related trades workers	52	7 441	106.78 (81.37–140.13)	4	874	127.55 (47.87–339.85)
Handicraft & printing workers	5	534	143.07 (59.55–343.74)	0	100	-
Electrical & electronic trades workers	16	3 175	77 (47.17–125.69)	1	79	352.78 (49.69–2504.53)
Food processing, woodworking workers	4	960	63.67 (23.89–169.64)	1	972	28.67 (4.04–203.56)
Stationary plant & machine operators	113	12 707	**135.88 (113–163.39)**	1	925	30.13 (4.24–213.9)
Assemblers	1	69	221.45 (31.19–1572.14)	0	17	-
Drivers & mobile plant operators	82	19 973	62.73 (50.52–77.89)	1	241	115.64 (16.29–820.99)
Cleaners & helpers	28	3 492	122.52 (84.59–177.45)	129	28 641	**125.53 (105.63–149.17)**
Agricultural, forestry & fishery labours	33	5 176	97.42 (69.26–137.03)	6	1 225	136.51 (61.33–303.85)
Labourers in mining, construction & manufacturing	31	4 177	113.4 (79.75–161.25)	4	1 006	110.81 (41.59–295.26)
Food preparation assistants	0	29	-	0	77	-
Street & related sales workers	1	275	55.56 (7.83–394.46)	0	347	-
Refuse workers & other elementary workers	236	34 480	104.58 (92.06–118.82)	42	11 775	99.41 (73.46–134.51)
Total	1054	161 075		286	79 708	

Statistically significant PMRs are bolded

Discussion

To our knowledge, this is the first study investigating associations between occupation groups and oesophageal cancer mortality in South Africa. In the absence of a national occupational surveillance programme in South Africa, this study leveraged existing vital registration data to identify occupations associated with an increased risk of oesophageal cancer mortality.

It is important to note that the data provided by StatsSA do not differentiate between the histological types of oesophageal cancer when reporting underlying causes of death. Instead, all histological types are aggregated under a single category. Existing literature, however, indicates that in South Africa, SCC is the predominant histological subtype, accounting for over 95% of oesophageal cancer cases.[9] It can consequently be inferred that the vast majority of oesophageal cancer-related mortality cases reported by StatsSA are attributable to SCC.

Our study found a small proportion of oesophageal cancer-related deaths (0.6%) among the total recorded deaths in South Africa during the period 2011 to 2015. Although the results are limited to the review period, this figure is consistent with the prevalence of oesophageal cancer reported in other

South African studies.[10] Males had a higher proportion of oesophageal cancer mortality compared with females. Although the reasons for the gender differences in oesophageal cancer cases are not known, it is considered more common in males, with a reported male-to-female ratio of 2:1 in sub-Saharan Africa – similar to our findings.[9] This study found that the proportion of deaths from oesophageal cancer is higher in the Eastern Cape than in other provinces. Studies from the Eastern Cape suggest that the consumption of home-brewed maize beer, contaminated with *Fusarium verticillioides*, may be a contributing factor to the high prevalence of oesophageal cancer in the region.[11–13] This highlights the need for further exploration of regional and demographic risk factors for this disease. Smoking is a recognised risk factor for oesophageal cancer; a recent meta-analysis of 52 studies found that current smokers in Western countries face about a fivefold higher risk of developing oesophageal SCC compared with non-smokers, while in Asia and South America, the risk is approximately three times greater,[5,14] in keeping with our findings that the proportionate mortality from oesophageal cancer is twice as high among smokers compared with non-smokers.

In analysing the risk of major occupation group-specific oesophageal cancer mortality, we observed an elevated risk of oesophageal cancer death among male skilled agricultural and fishery workers (e.g., gardeners and fishers) and females in elementary occupations (e.g., cleaners and helpers). When considering sub-occupation groups, which are more occupation-specific, this study found an elevated risk of oesophageal cancer mortality among female cleaners and helpers and among male skilled forestry workers, building and related trades workers, and stationary plant and machine operators. These findings align with results from a large population-based cohort epidemiological study that reported an increased risk of oesophageal cancer among what the authors termed 'low socioeconomic status (SES) occupations', such as seamen, waiters, and miscellaneous construction workers.[7] It is hypothesised that this link might be due to exposures associated with low SES, such as excessive alcohol consumption, tobacco smoking, and obesity, rather than occupational exposures alone.[7] Further, strenuous work has been reported as a risk factor for oesophageal cancer, possibly due to oxidative stress.[8] The occupational groups with an elevated risk of oesophageal cancer death in our study are relatively strenuous compared to other occupations, such as service and sales workers – which was found to be protective against oesophageal cancer death among males in our study. Interestingly, males in the sub-occupations of science and engineering professionals, teaching professionals, and customer service clerks, and females who were information and communication technicians also faced significantly higher mortality rates. This contrasts with earlier studies showing that people in less physically demanding jobs and those with higher education levels have a lower risk of oesophageal cancer.[7, 8]

In the absence of a population-based occupational health surveillance programme in South Africa, our study utilised national mortality data. The limitations of such data are discussed in detail elsewhere.[15] Specific to this study, on average, only 16.3% of death notifications provided information on usual occupation despite an employment rate of approximately 42% between 2011 and 2015.[15]

The risk of death may differ between employed and unemployed. In our analysis, we excluded observations with missing occupation information. Another limitation of our study was that many key variables concerning association with oesophageal cancer were either completely missing or largely incomplete and therefore were not adjusted for. These include, but are not limited to, exposures to occupational hazards and demographic and behavioural factors, such as body mass index, alcohol consumption, and physical activity – none of which are included on the death notification form and therefore missing from the datasets. Future South African studies investigating the association between occupation and oesophageal cancer should adjust for sociodemographic and behavioural factors to allow for a comprehensive and nuanced investigation of this association.

Conclusion

This study shows that oesophageal cancer accounted for 0.6% of deaths in South Africa between 2011 and 2015, with marked occupational and gender disparities. Males in skilled agriculture, fishery and forestry, building trades, and machine operation faced elevated mortality related to oesophageal cancer. Females in elementary roles – particularly cleaners and information and communications technicians – faced high risk. Eastern Cape residents and smokers bore a heavier burden. These findings highlight occupation as a critical factor in oesophageal cancer mortality and signal an urgent need for targeted interventions, enhanced workplace safety measures, and robust future research that adjusts for key sociodemographic and behavioural risk factors.

Recommendations

- The South African Department of Employment and Labour (DEL) should partner with local employers to implement workshops that educate both employers and employees about lifestyle and occupational risk factors for oesophageal cancer.
- The DEL and National Department of Health (NDoH) should focus efforts on regions with elevated oesophageal cancer mortality rates, such as the Eastern Cape, and conduct further research on factors associated with increased oesophageal cancer-related mortality in these regions.
- Employers and workers' unions should advocate for workplace reforms that mitigate risks associated with strenuous labour, including introducing mandatory rest breaks, ergonomic practices, and health screenings, especially for industries identified with higher proportional mortality rates for oesophageal cancer.
- The National Institute for Occupational Health and universities with public health programmes should secure grants and lead investigations of occupational and environmental contributors to oesophageal cancer to identify trends, develop preventative measures, and inform public health policies.

- The NDoH and StatsSA implement training for personnel completing death certificates and data-capture staff to improve understanding of the questions on occupation and the importance of completing all sections of the DHA-1663 death notification form.

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Ethical considerations

Statistics South Africa makes mortality data publicly accessible under the provisions of the Statistics Act No. 6 of 1999, enabling its use by the government, various societal sectors, and the general public.

Conflict of interest

The authors declare no conflicts of interest.

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