ORIGINAL ARTICLE

The Burden of Comorbidities in Saudi Arabia: Systemic Disease Patterns and Their Predictive Value for Mortality

Syed Mohammed Basheeruddin Asdaq[1], Syed Imam Rabbani[2], Badr Sami Duwaidi[3], Shaden Abdulrahman Abdullah Almusalam[4], Sami Haran Alenazi[3], Abdullah Mohammad Alabdulsalam[3], Omar Shaffay Alenzy[3], Ibrahim Mohammed Hagawi[3], Majed Farhan Al-harbi[5], A. Alghamdi Raad Mousa[6], Mohammed Ibrahim Alboardi[6], M. Mulia Ghada Mohammedamin[6]

[1]Department of Pharmacy Practice, College of Pharmacy, AlMaarefa University, Dariyah, Riyadh, Saudi Arabia, [2]Department of Pharmacology and Toxicology, College of Pharmacy, Qassim University, Buraydah, Kingdom of Saudi Arabia, [3]Department of Pharmacy, King Abdulaziz Medical City, Riyadh, Saudi Arabia, [4]Department of Pharmacy, National Guard Hospital, Riyadh, Saudi Arabia, [5]Department of Pharmacy, Ministry of National Guard Health Affairs, Saudi Arabia, [6]Department of Pharmacy, King Saud University Medical City, Riyadh, Saudi Arabia

Abstract

Background: Chronic diseases are increasingly straining healthcare systems worldwide, with comorbidities substantially impacting morbidity and mortality in Saudi Arabia. While chronic disease management remains a priority, limited research has explored comorbidity-mortality relationships in the Saudi context. This study examines comorbidity prevalence and its potential mortality associations within the Saudi population. **Materials and Methods:** This retrospective cross-sectional study analyzed electronic health records to examine associations between mortality and demographic/clinical variables (age, gender, marital status, employment, comorbidities). Using both parametric (Analysis of variance) and non-parametric (Mann-Whitney U) tests with 95% confidence intervals (CIs) ($P < 0.05$), we conducted correlation analyses to identify significant mortality predictors. **Results:** The study population encompassed a wide age range, with 52.3% of participants being male, 70.3% married, and 68.3% employed. Approximately 39% of participants had one or more comorbidities. Key predictors of comorbidities included advanced age (34.6%), circulatory system diseases (20.3%), and nervous system disorders (12.1%). Correlation analysis revealed significant associations between age (odds ratio [OR] = 1.15; 95% CI = 1.39–0.83; $P < 0.05$), the presence of comorbidities (OR = 1.33; 95% CI = 1.53–0.72; $P < 0.05$), and the number of comorbidities (OR = 1.63; 95% CI = 1.87–0.93; $P < 0.001$). Comorbid conditions associated with the circulatory system (Rho = 0.62), external causes (Rho = 0.48), and the respiratory system (Rho = 0.41) had a significant ($P < 0.05$) influence on mortality. Furthermore, advanced age was identified as the highest risk factor for mortality (Rho = 0.93, $P < 0.05$). **Conclusion:** Age, the presence of comorbidities, and the number of comorbid conditions were identified as major contributors to mortality in the Saudi population. These findings underscore the importance of addressing these factors in healthcare strategies, with a focus on promoting lifestyle changes, smoking cessation, regular medical screenings, and infection prevention to improve public health outcomes.

Key words: Comorbidities, mortality, population, predictors, Saudi Arabia

INTRODUCTION

In recent years, the global incidence of various diseases has risen significantly. While technological advancements have improved lifestyles, they have also contributed to a more sedentary way of life. Despite remarkable progress in the medical field that has enhanced population health and increased life expectancy,

Address for correspondence:
Syed Mohammed Basheeruddin Asdaq, Department of Pharmacy Practice, College of Pharmacy, AlMaarefa University, Dariyah, Riyadh, Saudi Arabia.
E-mail: sasdaq@gmail.com

Received: 16-05-2025
Revised: 17-06-2025
Accepted: 23-06-2025

there has been a parallel rise in the prevalence of chronic diseases.[1] Metabolic diseases, such as diabetes mellitus, hypertension, and atherosclerosis, have become more widespread, partly due to the increased consumption of unhealthy fast foods. Moreover, industrial pollution, vehicular emissions, and the depletion of the ozone layer have heightened exposure to carcinogens, contributing to a rise in cancer cases.[2,3]

Saudi Arabia, the largest country in the Gulf region, has experienced rapid economic growth driven by oil revenues. This growth has fueled population expansion, which now totals approximately 36.96 million people.[4] Most of the population is young and engaged in non-agricultural industries. The economic boom and westernization of lifestyles have led to the adoption of unhealthy habits such as fast-food consumption, smoking, and sedentary behavior.[5] Over the past few decades, many smaller towns have transformed into large cities, resulting in increased environmental pollution from vehicular exhaust, industrial emissions, and excessive air conditioning use.[6]

Lifestyle changes in Saudi Arabia have contributed to the rising prevalence of comorbidities, particularly metabolic diseases, such as diabetes mellitus, hypertension, and atherosclerosis.[7] Research indicates that the incidence of diabetes in the country is expected to increase by 40% by 2030, positioning Saudi Arabia as one of the major countries affected by the disease in the Gulf region.[8] In addition, the incidence of malignancies and neurological disorders has risen, likely due to urbanization, exposure to environmental stressors, and the adoption of unhealthy lifestyle choices.[9]

In response, the Saudi government has heavily invested in healthcare infrastructure, establishing primary health centers in neighborhoods and secondary, tertiary, and specialized hospitals across the country. These services are provided free of charge.[10] However, the management of chronic diseases and their complications has placed a substantial burden on both healthcare providers and the general population.[11] This highlights the need for more targeted strategies to address the specific needs of various population groups.[12]

Despite efforts to mitigate the impact of chronic diseases, there remains a lack of comprehensive studies correlating comorbidities with mortality rates in Saudi Arabia. This study aims to fill this gap by evaluating the incidence of comorbidities and their potential association with mortality in the Saudi population. The findings of this research will offer valuable insights for healthcare providers, helping to develop targeted strategies to reduce mortality rates and improve public health outcomes.

MATERIALS AND METHODS

Study design

This investigation employed a retrospective observational approach examining public health data from October 1, 2022, to September 30, 2023. Primary data sources included:

1. Official health statistics from Saudi Arabia's Ministry of Health portal (moh.gov.sa), including:
   - Annual Statistical Yearbooks
   - Epidemiological indicators
   - Disease surveillance reports.
2. Population health metrics from the CDC's Saudi Arabia country profile
3. Peer-reviewed studies documenting disease prevalence across all 13 Saudi administrative regions (Riyadh, Makkah, Eastern Province, etc.).

All disease classifications followed ICD standards to ensure consistent comorbidity analysis.[13] The study compiled and analyzed these diverse datasets to evaluate population health patterns nationwide. Some of the important diseases reported in the Saudi Arabian population are categorized as:[8,11,13]

- Respiratory system: Asthma, chronic obstructive pulmonary disease
- External causes: Microbial infection, trauma
- Skin: Acne, dermatitis
- General: Headache, malaise
- Locomotion: Arthritis, osteoporosis
- Nervous system: Epilepsy, mood disorders
- Genitourinary system: Prostatitis, kidney stones
- Digestive system: Peptic ulcer, irritable bowel syndrome
- Circulatory system: Hypertension, heart diseases.

Further, the study incorporated comprehensive demographic and health indicators obtained from Saudi Arabia's national statistical agency. These included:

- Population demographics (age and gender distribution)
- Household characteristics
- Geographic distribution patterns
- Core health indicators.

All demographic metrics were sourced from the official statistics portal maintained by Saudi Arabia's General Authority for Statistics (stats.gov.sa). This complementary dataset enabled a more robust analysis of health outcomes across different population segments.

Eligibility criteria

Articles in English detailing comorbidities in the population with evidence of informed consent were included. The research focused on cross-sectional studies published between 2022 and 2023 in clinical settings to assess disease prevalence. Eligible studies provided clinical data on disease types, factors influencing comorbidities, complications, predictors, contributors, and recorded mortality. Research and review articles from reputable journals with robust statistical analyses were also considered. Studies were excluded if they failed to meet these criteria, contained duplicate or overlapping data, or provided insufficient information. In addition, terminally ill patients, such as those with cancer, multi-organ failure, or heart attacks, were excluded from the analysis.[14]

Data collection

This study compiled data exclusively from publicly available sources, including official government health reports, peer-reviewed literature, and open-access epidemiological datasets. All information was carefully screened to ensure compliance with ethical standards, excluding any restricted, confidential, or methodologically questionable data. To maintain transparency and reproducibility, only fully documented and properly cited sources were utilized. The collection process followed established research protocols, prioritizing datasets with clear ethical approval and robust statistical methodologies. Stringent measures were implemented to protect privacy, including the use of aggregated, anonymized data and blinded analytical procedures. The Newcastle-Ottawa scale (NOS) was applied to assess data quality, while standardized statistical methods were employed to minimize bias and enhance reliability throughout the analysis.[15]

Quality assessment

The methodological rigor of included cross-sectional studies was evaluated using the NOS, which assesses critical domains including sampling methodology, statistical analysis transparency, and outcome validity.[16] To ensure objective quality appraisal, the primary author conducted blind evaluations, with any discrepancies resolved through consultation with a domain expert. Studies were required to achieve a minimum NOS score of >3 for inclusion, ensuring only methodologically sound publications were incorporated. From an initial pool of 280 identified articles, rigorous screening yielded 12 studies that met all quality criteria and were subsequently included in the final analysis.

Descriptive analysis

The extracted datasets underwent comprehensive analysis through a multi-stage analytical approach,[17] incorporating:

- Demographic characterization - The study population was categorized according to age, gender, marital status, and employment status.
- Prevalence of comorbid conditions - Data on the presence or absence of comorbid conditions as well the number of comorbidities were collected in the population.
- Types of comorbid conditions - Ten major diseased conditions were found to be most common among the population such as cardiovascular diseases, chronic liver diseases, diabetes mellitus, chronic renal diseases, hypertension, skeletal muscle diseases, infectious diseases, cancers, chronic neurological diseases, and chronic respiratory diseases.
- Clinical outcomes - Among the study population, data were collected about the clinical outcome as survival or death.
- Mortality rate - The data about the mortality rate recorded in the population was calculated using the formula.

Mortality rate = Number of deaths due to a particular disease/ Total population.

Data extraction and representation

A pre-structured data extraction form was used to independently retrieve pertinent information. This extracted data comprised various key elements, including study design, characteristics of the study population, and details regarding study outcomes. In addition, other factors such as the language of publication, study location, the number of participants, study design, protocol, drug regimen, diseased duration, ethical approvals, statistical methodologies, and clinical outcome formed essential parameters for assessing the content of the articles.

The study data were systematically organized using Microsoft Excel for comprehensive analysis. All analytical outputs are presented in two formats: (1) Detailed tabular representations of demographic characteristics [Table 1], and (2) graphical visualizations of comorbid condition prevalence [Figure 1].[18] The incidences of survival and deaths recorded in the population according to demographic characteristics were summarized in Table 2. Further, the mortality rate due to different comorbidities recorded in the population is specified in Figure 2. Finally, the correlation between the various variables and mortality in the population is shown in Figure 3 and Table 3.

Statistical analysis

The dataset comprising 3,690 patient records was analyzed using the IBM Statistical Package for the Social Sciences Statistics (Version 25). Following data cleaning procedures, 108 incomplete records were excluded to meet the software's requirements, resulting in a final analytical sample of 3,582 cases. Records were stratified by age groups and analyzed across multiple demographic and clinical variables, including:

- Age distribution
- Gender composition
- Marital status
- Employment status
- Comorbidity profiles
- Mortality-associated comorbidities.

We employed a comprehensive analytical approach incorporating:

1. Parametric tests (one-way analysis of variance) to examine mortality distribution patterns across population groups
2. Non-parametric methods (Mann–Whitney U-test) for disease outcome analysis, independent of population distribution
3. Chi-square tests for assessing variable associations with mortality outcomes

Table 1: Demographic characteristics of the study population

Characteristics	Occurrences (%)
Age	
0–20 years	863 (23.4)
21–40 years	1405 (38.1)
41–60 years	797 (21.6)
>61 years	624 (16.9)
Gender	
Male	1933 (52.3)
Female	1757 (47.7)
Marital status	
Married	2594 (70.3)
Unmarried	1096 (29.7)
Employment	
Employed	2520 (68.3)
Unemployed	1170 (31.7)
Comorbidities	
Yes	1432 (38.8)
No	2258 (61.2)
Number of comorbidities	
0	2258 (61.2)
1	897 (24.3)
≥2	535 (14.5)
Clinical outcome	
Alive	3229 (87.5)
Dead	461 (12.5)

Values are expressed as numbers (percentage), *n*=3690

4. Spearman's correlation analysis to identify mortality determinants.

All analyses maintained a 95% confidence interval (CI) (lower and upper bounds). Statistical significance was established at $P < 0.05$ for all tests.[6,11]

RESULTS

Demographic characteristics of the study population

The demographic characteristics of the study population are summarized in Table 1. The data of a total of 3690 people from different provinces of the country indicated that the maximum number of the study population was aged 21–40 years, and males represented slightly more in number compared to females, with the ratio of 1:0.9.

Most of them are married and employed either in the public or private sectors. The incidences of comorbidities were observed to be 38.8% of the study population and about 15% were found to be sufferers of either 2 or more two comorbidities. The analysis also indicated that 87.5% of the population is alive and the ratio of survival to death was found to be 1:0.4 of the test population.

Table 2: Predictors of mortality in the study population according to demographic characteristics

Characteristics	Survivals (%)	Deaths (%)	P-value
Age			
0–20 years	860 (26.6)	3 (0.6)	0.001
21–40 years	1341 (41.5)	64 (13.9)	0.001
41–60 years	835 (25.9)	144 (22.6)	0.001
>61 years	221 (6.8)	403 (62.9)	0.012
Gender			
Male	1650 (51.1)	283 (61.3)	0.001
Female	1579 (48.9)	178 (38.7)	0.001
Marital status			
Married	1853 (57.4)	380 (82.4)	0.001
Unmarried	1376 (42.6)	81 (17.6)	0.001
Employment			
Employed	1908 (59.1)	306 (66.4)	0.001
Unemployed	1321 (40.9)	155 (33.6)	0.001
Comorbidities			
Yes	1282 (39.7)	406 (88.1)	0.001
No	1947 (60.3)	55 (11.9)	0.001
Number of comorbidities			
0	1947 (60.3)	53 (11.6)	0.001
1	849 (26.3)	137 (29.8)	0.001
≥2	433 (13.4)	271 (58.6)	0.016
Examples of comorbidities			
Circulatory system	656 (20.3)	89 (19.3)	0.001
Old age	1120 (34.6)	150 (32.5)	0.001
Digestive system	181 (5.6)	19 (4.1)	0.015
Genito-urinary system	138 (4.3)	12 (2.6)	0.001
Nervous system	388 (12.1)	41 (8.9)	0.001
Locomotor system	194 (6.1)	9 (1.9)	0.001
General diseases	236 (7.3)	22 (4.8)	0.001
Skin	108 (3.3)	3 (0.6)	0.001
External causes	156 (4.8)	65 (14.2)	0.001
Respiratory system	164 (5.1)	51 (11.1)	0.001

Values are expressed as numbers (percentages). *n*=3229 for the surviving population. *n*=461 for deaths. Statistics: One-way analysis of variance followed by non-parametric test. A *P*<0.05 is considered significant

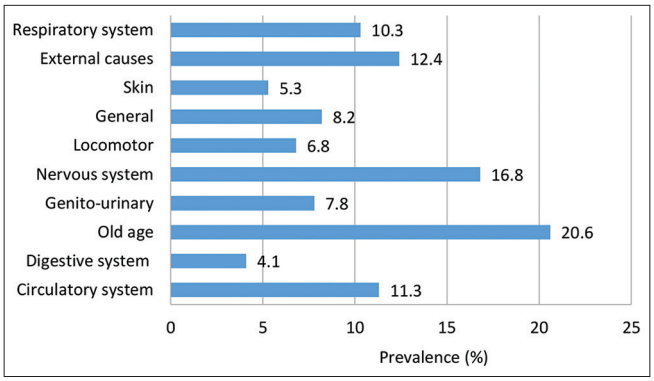

Figure 1: Predictors or risk factors of comorbidities in the study population. Values are expressed as percentages, *n* = 1432

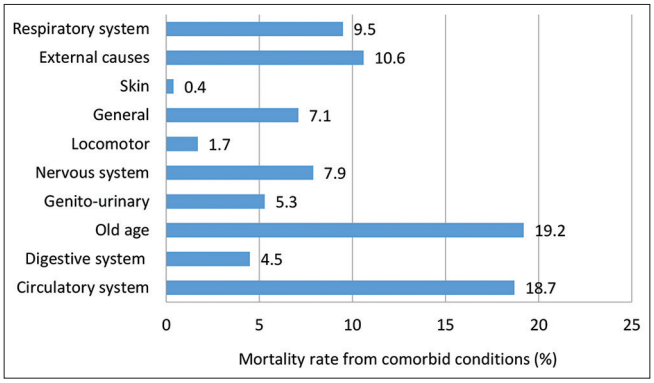

Figure 2: Mortality rate recorded in the population. Values are expressed as a percentage

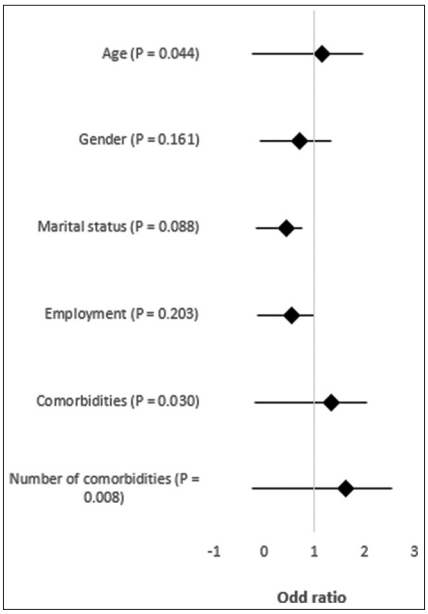

Figure 3: Forest plot for the predictors of mortality in the study population by using multivariable logistic regression. Statistics: One-way analysis of variance and Chi-square test. A $P < 0.05$ is considered significant

Table 3: Determinants of mortality in the study population

Types of diseases	Spearman correlation analysis		
	Rho value	95% CI (Lower - Upper)	*P*-value
Circulatory system	0.62	0.44–0.70	0.036*
Old age	0.93	0.73–1.21	0.009**
Digestive system	0.21	0.14–0.30	0.152
Genitourinary system	0.19	0.10–0.26	0.069
Nervous system	0.35	0.22–0.42	0.208
Locomotor system	0.14	0.08–0.19	0.088
General diseases	0.17	0.11–0.25	0.332
Skin	0.11	0.06–0.16	0.098
External causes	0.48	0.32–0.51	0.024*
Respiratory system	0.41	0.29–0.47	0.030*

Statistics: One-way analysis of variance and Chi-square tests. *$P<0.05$, **$P<0.01$ compared between groups. CI: Confidence interval

Prevalence of comorbidities in the study population

The prevalence of comorbidities in the study population indicated that old age is the major contributor to disease states found in the population. This group of people had a 20.6% diseased prevalence followed by the nervous system (16.8%), external causes (12.4%), circulatory system (11.3%), and respiratory system (10.3).

These four conditions were found to have prevalence in more than 10% of the study population. Among the list of co-morbidities identified, the digestive system was found to be the least prevalent observed in the population. The incidences of this ailment were found to be 4.1% [Figure 1].

Possible predictors of mortality according to demographic characteristics

The predictors of mortality according to demographic characteristics indicated that the maximum surviving group of the population is aged 20–40 years, while maximum mortality was observed in people aged above 60 years. The mortality in this group was 62.9%. In the gender, although much variation was not found in the surviving population in terms of mortality, more deaths were recorded in males compared to females. The analysis of marital status and employment data suggested that the population who were married as well as employed showed more mortality compared to unmarried and unemployed. On the other hand, higher incidences of mortality were observed in those groups of people diagnosed with a comorbid condition. Further, the occurrences of mortality in the population increased with an

increase in the number of comorbid states, as a population with 2 or more was found to have the highest mortality (58.6%).

The predictors of mortality suggested that as old age caused the highest percentage (32.5%) of deaths in the population. The other contributors that caused mortality in the population were circulatory (19.3%), external causes (14.2%), respiratory (11.1%), and nervous system (8.9%). The comparison of data between the incidences of life and death among the population suggested a significant ($P < 0.01$) variation for all the groups [Table 2].

Mortality rate in the population of the country

Figure 2 summarizes the mortality rate among the population of the country. The analysis of ten major diseases recorded in the population indicated that old age has the highest mortality rate (19.2%), followed by diseases of the circulatory system (18.7%) and external causes (10.6%).

The other two most frequently occurring diseases responsible for mortality were found to be respiratory (8.5%) and general disease (7.1%). Furthermore, it was observed that skin diseases have caused the lowest mortality rate (0.4%) in the group of people studied in this research.

Correlation analysis between variables and mortality in the study population

The forest plot of multivariable regression analysis used to predict the mortality in the population suggested that several comorbidities have the highest odd ratio value (OR = 1.63; ± 95% CI = 1.87/0.93). This variable was also found to be significant ($P < 0.001$) when groups were compared. In addition, the presence of comorbid conditions in the population was observed to be the second highest odd ratio value (OR = 1.33; ± 95% CI = 1.53/0.72), which was found to be significant ($P < 0.05$) when groups were compared.

The other variable whose odd ratio was found to be above 1 (OR = 1.15; ± 95% CI = 1.39/0.83) was age and this variable too indicated a significant ($P < 0.05$) difference upon comparison with different groups. The rest of the other variables, such as gender, marital status, and employment were found to have odd ratio values <1 and were also non-significant ($P > 0.05$) when group comparison was performed [Figure 3].

The Spearman correlation analysis suggested that old age had the highest Rho value (0.93; ± 95% CI = 1.21/0.73; $P < 0.05$). The other three systems that had a Rho value above 0.4 are the circulatory system (0.62; ± 95% CI = 0.70/0.44; $P < 0.05$), external causes (0.48; ± 95% CI = 0.51/0.32; $P < 0.05$), and respiratory system (0.41; ± 95% CI = 0.47/0.29; $P < 0.05$). These four causes were observed to have significant variation, where the P-value was <0.05 in comparison with different groups. The lowest Rho value was found to be for skin (0.11; ± 95% CI = 0.16/0.06; $P > 0.05$) [Table 3].

DISCUSSION

The present study analyzed the incidence of mortality among a population in Saudi Arabia, with a focus on demographic characteristics and the occurrence of comorbidities. Various types of comorbidities were assessed, and their association with observed deaths was evaluated to identify potential predictors of mortality [Tables 1-3 and Figures 1-3].

The demographic analysis indicated that individuals aged 21–40 years represented the largest group, which aligns with data from previous studies.[5] Gender distribution revealed a slightly higher proportion of males compared to females, and most individuals were married and employed. This finding is consistent with earlier reports, which note that Saudi Arabia's rapid economic growth has been driven by a large young workforce in both public and private sectors, contributing significantly to the country's economic development.[19]

The study revealed that 38.8% of the population suffers from comorbidities, with 12.5% of deaths occurring among those affected. These findings align with data from countries with established healthcare systems, where similar trends in comorbidity-related mortality have been reported.[20] Saudi Arabia has invested heavily in healthcare, with a significant portion of its annual budget allocated to public health. Primary healthcare centers are available in neighborhoods, supplemented by secondary, tertiary, and specialty hospitals across the provinces.[21]

The prevalence of comorbidities in the study population showed that old age accounted for 30.1% of cases, followed by diseases of the nervous system (16.8%), external causes (12.4%), circulatory system diseases (11.3%), and respiratory system conditions (10.3%). This distribution is consistent with earlier studies, which report a global increase in these comorbidities, particularly in developed countries.[22] Technological advances and the westernization of dietary habits have been linked to the rising prevalence of metabolic diseases, with sedentary lifestyles and fast-food consumption negatively impacting public health.[23]

Analysis of mortality data indicated that individuals aged over 60 years with more than two comorbidities had a higher mortality rate. This finding is consistent with previous studies conducted in the region, where aging and the presence of multiple comorbidities have been shown to exacerbate health complications. While medical advancements have increased life expectancy, the aging population faces a higher burden of comorbidities, leading to increased complications and mortality rates.[24] The male population exhibited higher mortality rates than females, likely due to increased exposure

to risk factors, such as smoking, environmental pollutants, and occupational hazards.[25] In addition, genetic factors, particularly the susceptibility of Y-chromosomes to certain morbidities, may contribute to the higher mortality in men.[26] Marital and employment status were also found to influence mortality, as most individuals in these categories are likely to be in older age groups, a well-established risk factor for both morbidity and mortality.[24]

The five major predictors of mortality identified in the study were old age (32.5%), circulatory system diseases (19.3%), external causes (14.2%), respiratory diseases (11.1%), and nervous system disorders (8.9%). These findings are consistent with mortality statistics in the country, where cancer, diabetes mellitus, and cardiovascular diseases are leading causes of death, particularly in older age groups. Cancer-related deaths are often attributed to the depletion of nutrients in tissues as cancer cells consume a disproportionate amount of energy.[27] Cardiovascular complications and multi-organ failure are major causes of death in diabetic patients, with ischemia leading to heart attacks and strokes being the primary contributors to mortality in cardiovascular disease. In hypertensive patients, left ventricular thickening increases the risk of myocardial infarction and heart failure.[28] Furthermore, cardiovascular complications can lead to sepsis and infection, which are significant causes of death in chronic renal disease patients.[29]

Correlation analysis revealed several key predictors of mortality in the study population [Figure 3]. The results indicated that age (OR = 1.15), the presence of comorbidities (odds ratio [OR] = 1.33), and the number of comorbidities (OR = 1.63) were associated with increased mortality, contributing 15%, 33%, and 63%, respectively. A strong correlation was found between advanced age and mortality, with circulatory system diseases showing a moderate correlation. External causes and respiratory diseases showed mild correlations with mortality. External causes primarily refer to diseases caused by microorganisms, a category that gained prominence after the coronavirus pandemic.[30] Studies have indicated that microbial infections increase the mortality rate among the elderly and those with comorbid conditions.[31]

Existing literature supports the notion that advancing age and the presence of multiple comorbidities impair normal body function and increase complications that ultimately lead to death.[32] The findings from this study provide valuable insights into the epidemiology of comorbidities and their association with mortality in Saudi Arabia. These results can help inform healthcare policy, enabling the design of targeted preventive or intervention strategies for specific population groups. Tailored approaches, in line with international and World Health Organization guidelines, could effectively reduce mortality rates and improve public health outcomes in the country.[33]

Strengths, limitations, and policy implications

For the 1st time, the findings of the study provide critical insights into the major determinants of mortality within the Saudi population. Older individuals with circulatory disorders, such as atherosclerosis, are at heightened risk of ischemia affecting vital organs, such as the brain, heart, lungs, and kidneys. These complications, exacerbated by impaired circulation, can significantly increase susceptibility to microbial infections due to diminished immune function.[34] To mitigate atherosclerotic complications, it is essential to emphasize medical interventions, a balanced and nutritious diet, regular physical activity, avoidance of cigarette smoke, and routine medical check-ups. Identifying this at-risk group, raising awareness, and promoting preventive measures, such as seasonal vaccinations – are crucial steps that healthcare authorities can adopt to reduce mortality rates and improve health outcomes.[35]

This study analyzed retrospective data from a specific cohort, and the findings may be reflective of the observations recorded within the selected population group. To establish a more precise and generalized association between comorbidities and mortality rates, a larger, more diverse study involving individuals from various ethnic backgrounds is necessary.[36] Further research should explore the type, severity, duration, and treatment of comorbidities, as well as the impact of socioeconomic and environmental factors. Such data would help develop targeted strategies for preventing and managing disease states within the population. In addition, incorporating methods to minimize bias, such as randomization techniques and more robust statistical analyses, will enhance the credibility and accuracy of future studies.

CONCLUSION

This study analyzed retrospective data from 3,690 individuals across different provinces of Saudi Arabia. The analysis revealed that certain demographic groups, particularly those based on age and the presence and number of comorbidities are at a higher risk of mortality. Saudi healthcare authorities allocate substantial resources to safeguarding public health, and the findings of this study can be used to identify common microbial infections at various times of the year. By implementing proactive measures, both the public and healthcare providers can work together to reduce the incidence of these diseases. However, this study is limited by its focus on a specific population, and further research is needed to validate and expand upon these findings.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This retrospective study was approved by the Institutional Review Board of AlMaarefa University, Riyadh, Saudi Arabia

(Protocol #IRB22-025). The research utilized exclusively de-identified, secondary data from electronic sources, which qualified for exemption from informed consent requirements under institutional guidelines for retrospective analyses.

REFERENCES

1. Doody P, Lord JM, Greig CA, Whittaker AC. Frailty: Pathophysiology, theoretical and operational definition(s), impact, prevalence, management and prevention, in an increasingly economically developed and ageing world. Gerontology 2023;69:927-45.
2. Yun JS, Jung SH, Shivakumar M, Xiao B, Khera AV, Won HH, *et al*. Polygenic risk for type 2 diabetes, lifestyle, metabolic health, and cardiovascular disease: A prospective UK biobank study. Cardiovasc Diabetol 2022;21:131.
3. Gao M, Lv J, Yu C, Guo Y, Bian Z, Yang R, *et al*. China kadoorie biobank (CKB) collaborative group. Metabolically healthytransition to unhealthy metabolic status, and vascular disease in Chinese adults: A cohort study. PLoS Med 2020;17:e1003351.
4. Aldubikhi A. Obesity management in the Saudi population. Saudi Med J 2023;44:725-31.
5. AlTamimi JZ, Alagal RI, AlKehayez NM, Alshwaiyat NM, Al-Jamal HA, AlFaris NA. Physical activity levels of a multi-ethnic population of young men living in Saudi Arabia and factors associated with physical inactivity. Front Public Health 2022;9:734968.
6. Asdaq SM, Rabbani SI, Alshammari MK, Alshammari RS, Kamal M, Imran M, *et al*. Burden of COVID-19: A preliminary analysis in the population of Saudi Arabia. PeerJ 2022;10:e13219.
7. Robert AA, Al Dawish MA. Cardiovascular disease among patients with diabetes: The current scenario in Saudi Arabia. Curr Diabetes Rev 2021;17:180-5.
8. Abdelwahab SI, Taha MM, Kaabi YA. Diabetes mellitus research in Saudi Arabia: A bibliometric study (2010-2021). J Family Med Prim Care 2023;12:1038-49.
9. Aseafan M, Devol E, AlAhwal M, Souissi R, Sindi R, AlEid H, *et al*. Population-based survival for cancer patients in Saudi Arabia for the years 2005-2009. Sci Rep 2022;12:235.
10. Yousef L, AlAngari D, AlShehri R, AlSharif B, Bayameen O, Alnemer Z. Healthcare transformation journey in the eastern REGION of Saudi Arabia: An overview, challenges and lessons learned. J Med Life 2023;16:583-92.
11. Alharbi AM, Rabbani SI, Halim Mohamed AA, Almushayti BK, Aldhwayan NI, *et al*. Analysis of potential risk factors associated with COVID-19 and hospitalization. Front Public Health 2022;10:921953.
12. Al-Omar HA, Alshehri A, Abanumay A, Alabdulkarim H, Alrumaih A, Eldin MS, *et al*. The impact of obesity in Saudi Arabia: Healthcare resource use and costs associated with obesity-related complications. Adv Ther 2023;40:1430-43.
13. Alwadeai KS, Alhammad SA. Prevalence of type 2 diabetes mellitus and related factors among the general adult population in Saudi Arabia between 2016-2022: A systematic review and meta-analysis of the cross-sectional studies. Medicine (Baltimore) 2023;102:e34021.
14. Al-Sofiani ME, Batais MA, Aldhafiri E, Alzaid A. Pharmacological treatment of type 2 diabetes in Saudi Arabia: A consensus statement from the Saudi society of endocrinology and metabolism (SSEM). Diabetes Metab Syndr 2021;15:891-9.
15. Gliniecka M. The ethics of publicly available data research: A situated ethics framework for reddit. Sage J Social Media Soc 2023;23:1-11.
16. Belay GM, Lam KK, Liu Q, Wu CS, Mak YW, Ho KY. Magnitude and determinants of alcohol use disorder among adult population in East Asian countries: A systematic review and meta-analysis. Front Public Health 2023;11:1144012.
17. Anweigi L, Aldegheishem A, Azam A, Alromaih Y, Alkeait F, Alhaimy L, *et al*. Oral-health-related self-efficacy among the elderly population in Riyadh, Saudi Arabia. Int J Environ Res Public Health 2022;19:15900.
18. Al-Yamani MJ, Rabbani SI, Basheeruddin Asdaq SM, Imran M, Alshammari MK, Al-Shammari NA, *et al*. Epidemiological determinants for the spread of COVID-19 in Riyadh Province of Saudi Arabia. Saudi J Biol Sci 2022;29:1306-12.
19. Alesawi A, Malaka A, Abuzenada M, Alsaywid B, Badawood H, Aldawsari M, *et al*. Employment rate of newly certified healthcare specialists in Saudi Arabia: A survey-based study. Cureus 2023;15:e40898.
20. Alasiri AA, Mohammed V. Healthcare transformation in Saudi Arabia: An overview since the launch of vision 2030. Health Serv Insights 2022;15:11786329221121214.
21. Al-Sheddi A, Kamel S, Almeshal AS, Assiri AM. Distribution of primary healthcare centers between 2017 and 2021 across Saudi Arabia. Cureus 2023;15:e41932.
22. Gosadi IM, Abualgasem MM, Sultan YA, Bakri MY, Ageeli AM, Kaal AA, *et al*. Body mass index profile and its association with social determinants among adolescents from Jazan, Saudi Arabia. Int J Gen Med 2023;16:6151-62.
23. Salem V, AlHusseini N, Abdul Razack HI, Naoum A, Sims OT, Alqahtani SA. Prevalence, risk factors, and interventions for obesity in Saudi Arabia: A systematic review. Obes Rev 2022;23:e13448.
24. Cui J, Guo X, Yuan X, Wu H, Yu G, Li B, *et al*. Analysis of rheumatic heart disease mortality in the Chinese population: A joinpoint and age-period-cohort study. Int J Environ Res Public Health 2022;19:9872.
25. Kim Y, Kim YJ, Cho WK. Effect of multiple comorbidities on mortality in chronic obstructive pulmonary disease among Korean population: A nationwide cohort study. BMC Pulm Med 2021;21:56.
26. Wren G, Davies W. Sex-linked genetic mechanisms and

atrial fibrillation risk. Eur J Med Genet 2022;65:104459.
27. Rumgay H, Arnold M, Ferlay J, Lesi O, Cabasag CJ, Vignat J, *et al*. Global burden of primary liver cancer in 2020 and predictions to 2040. J Hepatol 2022;77:1598-6.
28. Tu CL, Sue SP, Hsu WH, Huang HY, Wen WL, Lin IT, *et al*. Causes of in-hospital death in patients with type 2 diabetes with microvascular and macrovascular complications in Taiwan. Int J Clin Pract 2021;75:e14491.
29. Yen FS, Wei JC, Shih YH, Hsu CC, Hwu CM. Metformin use and the risk of bacterial pneumonia in patients with type 2 diabetes. Sci Rep 2022;12:3270.
30. Hamada S, Nakajima M, Kaszynski RH, Otaka S, Goto H, Matsui H, *et al*. Association between adjunct clindamycin and in-hospital mortality in patients with necrotizing soft tissue infection due to group A Streptococcus: A nationwide cohort study. Eur J Clin Microbiol Infect Dis 2022;41:263-70.
31. Chen Y, Huang HB, Peng JM, Weng L, Du B. Efficacy and safety of ceftazidime-avibactam for the treatment of carbapenem-resistant enterobacterales bloodstream infection: A systematic review and meta-analysis. Microbiol Spectr 2022;10:e0260321.
32. Brunetti VC, Reynier P, Azoulay L, Yu OH, Ernst P, Platt RW, *et al*. SGLT-2 inhibitors and the risk of hospitalization for community-acquired pneumonia: A population-based cohort study. Pharmacoepidemiol Drug Saf 2021;30:740-8.
33. Kang E, Kim S, Rhee YE, Lee J, Yun YH. Self-management strategies and comorbidities in chronic disease patients: Associations with quality of life and depression. Psychol Health Med 2021;26:1031-43.
34. Abdalla SM, Mohamed EY, Almehmadi BA, Alanazi MA, Elsabagh HM. Stroke prevention: Knowledge of the general population in Riyadh Region, Saudi Arabia. Eur Rev Med Pharmacol Sci 2021;25:5424-8.
35. Alhomoud IS, Talasaz A, Mehta A, Kelly MS, Sisson EM, Bucheit JD, *et al*. Role of lipoprotein (a) in atherosclerotic cardiovascular disease: A review of current and emerging therapies. Pharmacotherapy 2023;43:1051-63.
36. Alkhamees M, Alasqah I. Patient-physician communication in intercultural settings: An integrative review. Heliyon 2023;9:e22667.

Source of Support: Nil. **Conflicts of Interest:** None declared.