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ORIGINAL ARTICLE

THE CAUSE- AND SEX-SPECIFIC BURDEN OF NON-COMMUNICABLE DISEASES AND ATTRIBUTABLE RISK FACTORS IN SUDAN: A POPULATION-LEVEL SECONDARY ANALYSIS FROM GBD 2023.

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Keywords

Non-communicable

Diseases,

Prevalence,

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ABSTRACT

Background: Non-communicable diseases (NCDs) are the leading causes of morbidity and mortality worldwide and represent a growing public health challenge in low- and middle-income countries, including Sudan. Recent estimates suggest that NCDs account for more than half of all deaths in Sudan; however, a comprehensive cause- and sex-specific estimate remains limited.

Methods: This study estimates and analyzes the burden of NCDs and the level-one attributable risk factors in Sudan for both sexes and all age groups, using data from the Global Burden of Diseases, Injuries, and Risk Factors Study 2023 (GBD 2023). A secondary analysis of publicly available data from the GBD platform (<https://ghdx.healthdata.org/gbd-results-tool/>) was conducted. Estimates of prevalence and mortality are presented as absolute counts, age-standardized rates and percentages with 95% confidence intervals (CI), stratified by cause and sex.

Results: In 2023, NCDs accounted for 34.2 million prevalent cases and were responsible for an estimated 170,466 deaths in both sexes in Sudan. Other non-communicable diseases accounted for more than 27 million prevalent cases, while cardiovascular diseases were responsible for more than 60% of all NCD-related mortality in both sexes. Metabolic risk factors contributed to nearly 57% of NCD-related deaths.

Conclusion: Given the current scenario of Sudan, NCDs control and preventive strategies must prioritize feasible, high-impact, gender-based interventions through a primary healthcare approach and effectively implement the WHO-recommended packages such as PEN and mhGAP in Sudan.

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INTRODUCTION

Non-communicable diseases (NCDs) are the leading cause of death worldwide, responsible for about 71% of all global deaths. Among these, cardiovascular diseases account for about 17.9 million deaths, followed by cancers, respiratory diseases and diabetes. NCDs also have become a major public health challenge for both low- and middle-income countries (LMICs), including Sudan and other high-income countries.¹ In LMICs, NCDs are responsible for about 80% of premature deaths, and the economic burden of NCD is expected to exceed US\$ 7 trillion by 2025.² Unhealthy diets and a lack of physical activity show up in people as raised blood pressure, increased blood glucose, elevated blood lipids, and obesity. These metabolic risk factors can lead to cardiovascular diseases, the leading NCD in terms of premature mortality.³

Non-communicable diseases (NCDs) present a growing public health challenge in many developing countries, including Sudan; however, detailed cause- and sex-specific morbidity and mortality data remain limited due to weak surveillance systems and scarce epidemiological evidence.^{4,5} Based on regional patterns in sub-Saharan Africa and other comparable low- and middle-income countries, the major identified NCDs such as cardiovascular diseases, diabetes, cancers, and chronic respiratory diseases are increasing in Sudan due to shared behavioral, metabolic and environmental risk factors.⁶ NCDs policies mainly focus on behavioral and metabolic risk factors, including tobacco control, reducing harmful alcohol consumption, promoting physical activity and improving access to healthy diets as well as strengthening health systems to improve early detection and management of NCDs.^{7,8} Evaluation of policy implementation and effectiveness is critical to address the NCD epidemic in LMICs. Nevertheless, there remains a lack of focused health research and development efforts in many LMICs on NCDs despite repeated calls.⁹ The WHO 2030 Agenda for Sustainable Development recognizes NCDs as a major challenge for sustainable development. As part of the agenda, heads of state and government committed to developing ambitious national responses by 2030 to reduce premature mortality from NCDs by one-third through prevention and treatment (SDG target 3.4).¹⁰ In 2019, the World

Health Assembly extended the WHO Global Action Plan for the Prevention and Control of NCDs 2013–2020 to 2030 and called for the development of an Implementation Roadmap 2023 to 2030 to accelerate progress on preventing and controlling NCDs.¹¹

The Global Burden of Diseases is an ongoing, large-scale study that provides reliable and timely assessments of the epidemiological profiles of diseases, injuries, and risk factors worldwide.¹² GBD 2023 is the most recent publicly available dataset, covering 204 countries and regions from 1990 to 2023.¹³ Despite the availability of estimates from the Global Burden of Disease Study, country-specific evidence for Sudan remains fragmented, with limited synthesis across causes, sexes, and time. Previous Sudan-related analyses based on earlier GBD iterations have primarily reported aggregated national estimates or focused on specific diseases (e.g., malaria burden studies) and regions (e.g., MENA region), with limited emphasis on detailed cause-specific and sex-stratified patterns in Sudan.^{14–16} In the current civil war scenario, Sudan is also experiencing an additional growing burden of NCDs linked to modifiable behavioral risk factors driven by lifestyle transitions such as reduced physical activity, unhealthy diets, and substance use.^{17,18} While recent estimates of NCD morbidity and mortality in Sudan are limited, the burden and risk factors likely mirror those in neighboring sub-Saharan African countries, with a high prevalence of behavioral and metabolic risks.⁶ Recent evidence also indicates that NCD-related mortality in Sudan has risen dramatically from 32% in 2015 to 54% in 2022, highlighting a rapid epidemiological transition and an increasing burden that is not being matched by effective policy implementation, including limited financial resources, shortages of trained healthcare personnel, weak surveillance systems, and poor access to essential medications and preventive services.¹⁹

Since April 2023, Sudan has experienced an ongoing armed conflict that has severely disrupted the health system, leading to widespread displacement, breakdown of healthcare services, and deterioration of routine health information systems. These challenges affect the availability and quality of data, including vital registration and disease surveillance, which are key inputs for the Global Burden of Disease Study.

Table 1: Absolute Count of Cases and Age Standardized Prevalence Rate of NCDs, Sudan, for all Ages, and Both Sexes, 2023.

Causes	Males (95% CI: LL-UL)	Females (95% CI: LL-UL)	Total (95% CI: LL-UL)	ASPR per 100,000 (95% CI: LL-UL)
Total NCDs count	16,827,290 (16,584,349-17,058,713)	17,359,182 (17,190,240– 17,506,251)	34,186,472 (33,799,343– 4,562,613)	92,333 (91,443–93,190)
Other non-communicable diseases	12,085,293 (11,341,161-12,865,874)	15,294,873 (14,818,724– 15,772,030)	27,380,166 (26,265,378– 28,570,912)	74,913 (72,109–77,797)
Neurological disorders	5,888,868 (5,243,545-6,573,432)	6,765,963 (6,094,792–7,456,459)	12,654,831 (11,332,846– 13,896,056)	34,878 (31,457–38,043)
Digestive diseases	5,377,790 (5,071,742-5,707,299)	5,142,049 (4,855,226–5,458,850)	10,519,839 (9,923,148– 11,156,024)	32,826 (31,080–34,595)
Skin and subcutaneous diseases	3,318,237 (3,124,466-3,542,814)	3,741,345 (3,565,023–3,973,910)	7,059,582 (6,700,603–7,510,098)	18,069 (17,217–19,079)
Musculoskeletal disorders	2,375,256 (2,217,049-2,548,888)	3,476,602 (3,231,668–3,724,892)	5,851,859 (5,453,345–6,243,138)	19,382 (18,158–20,545)
Mental disorders	2,838,100 (2,563,565-3,183,455)	2,812,030 (2,504,592–3,160,136)	5,650,130 (5,087,560– 6,282,137)	15,294 (13,849–16,862)
Diabetes and kidney diseases	2,718,482 (2,564,424 -2,886,127)	2,633,125 (2,481,296–2,786,555)	5,351,606 (5,054,772–5,674,270)	17,891 (17,037–18,820)
Cardiovascular diseases	1,395,947 (1,289,042-1,533,606)	1,034,199 (953,682–1,136,127)	2,430,146 (2,254,567 – 2,637,730)	9,106 (8,469–9,916)
Chronic respiratory diseases	1,104,675 (945,952-12,92,988)	1,282,386 (1,107,119–1,524,648)	2,387,061 (2,062,648–2,825,822)	7,364 (6,490–8,436)
Neoplasms	261,180 (219,422-309,034)	518,350 (424,821–633,927)	779,530 (655,838–942,705)	2,460 (2,051–2,984)
Substance use disorders	156,804 (132,987-184,767)	96,824 (83,584–1,11,228)	253,628 (218,578–294,420)	664 (579–762)

As a result, recent estimates rely more heavily on statistical modeling and may not fully capture the acute and indirect health impacts of the conflict, particularly for non-communicable diseases. Therefore, findings from GBD 2023 should be interpreted within this context. By utilizing the most recent estimates from GBD 2023 data base, which incorporates newer datasets and improved modeling approaches when compared to prior GBD publications (<https://ghdx.healthdata.org/gbd-2021>), this study aims to provides a comprehensive and recent estimates on morbidity and mortality burden

of NCDs disease in Sudan for all age groups combined, stratified by cause- and sex- specific for 2023, that have not been fully studied in previous Sudan-focused or regional GBD studies.

METHODS

This is a population-based, descriptive, cross-sectional analysis of secondary data produced in accordance with the Global Burden of Disease 2023 (GBD 2023). study protocol.²⁰ It was conducted in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement.²¹ Details of the GBD 2023

eligibility criteria, the literature search strategy, data selection and extraction, and fatal and non-fatal disease modeling are all described in a previous paper.²²⁻²⁴

For data modeling, GBD 2023 utilizes population based vital registration system and verbal autopsy reports, with the Cause of Death Ensemble model (CODEm) integrating multiple data sources and covariates to estimate mortality in regions or years with sparse data. For non-fatal outcomes, including prevalence and incidence, the DisMod-MR 2.1 Bayesian meta-regression tool ensures internal consistency among epidemiological parameters and provides estimates for locations or time periods lacking direct observations. Missing or incomplete data in the GBD 2023 database are thus addressed through these standardized modeling frameworks.

STUDY VARIABLES AND GBD HIERARCHICAL CLASSIFICATION

This study estimates an absolute count, Age Standardized Prevalent Rates (ASPR), Age Standardized Mortality Rates (ASMR), for all age groups combined, stratified by cause- and sex-specific, with 95% of Confidence Interval (CI); along with death rate and percentages for level 1 attributable risk factors of NCDs in 2023, Sudan. Causes of death (CODs) were classified according to the GBD hierarchical cause list, including Level 1 (non-communicable diseases) and Level 2 categories and can be downloaded from <https://ghdx.healthdata.org/gbd-results-tool>. Level 1 attributable risk factors are categorized into three broad groups: 1. metabolic risks, 2. environmental/occupational risks, and 3. behavioral risks (low physical activity, tobacco use, and dietary risks).²⁵ (details are provided in supplementary tables)

DATA SOURCE, EXTRACTION, AND ANALYSIS:

All the data sets for this study were downloaded from <https://ghdx.healthdata.org/gbd-results-tool>, developed by the Institute for Health Metrics and Evaluation (Seattle, WA, USA), and were analyzed using Microsoft Excel 365. Data from different sources are standardized by using International Classification of Diseases (ICD) codes to ensure accuracy and comparability, and are estimated with sophisticated modeling tools based on the GBD standard population structure (<https://ghdx.healthdata.org/record/ihme-data/gbd-2021-cause-icd-code-mappings>). Data extraction

was performed on 5th January 2026, using the most recent available GBD 2023 dataset release. (see supplementary file for more details on methods)

INCLUSION AND EXCLUSION CRITERIA

Absolute counts of cases, deaths, Age-Standardized Mortality Rate (ASPR), Age-Standardized Mortality Rate (ASMR) of NCDs for all age groups combined, stratified by cause- and sex-specific; along with three major level 1 risk factors as mentioned above in study variables were extracted and included for study in Sudan, while DALYs, YLDs, incidence, age stratified analysis are excluded from the study for the estimated year 2023.

RESULTS

In 2023, Sudan had an estimated population of approximately 50.0 million people, with a slight female majority (50.4%) and a notably younger population, with a median age of about 18.3 years and more than 40% under 15 years. Complete data on the Sudanese population structure are available online: (<https://countryeconomy.com/demography/population-structure/sudan>). Latest estimates on stratified cause- and sex-specific morbidity and mortality burden of NCDs for both sexes and their attributable level 1 risk factors for all age groups combined (from birth to >95 years) in Sudan are presented below.

ABSOLUTE COUNT OF PREVALENT CASES AND AGE STANDARDIZED PREVALENCE RATE (ASPR)

In 2023, there were an estimated 34.2 million (95% CI: 33,799,343–34,562,613) prevalent cases of NCDs in Sudan, across all age groups and both sexes. The “other non-communicable diseases” category had accounted for approximately 27.4 million (95% CI: 26,265,378–28,570,912) cases, followed by neurological disorders and digestive diseases with 12.7 million (95% CI: 11332846–13896056) and 10.5 million (95% CI: 9923148–11156024) of prevalent cases, respectively. (Table 1)

Among other major chronic diseases, the total number of prevalent cases of diabetes and kidney diseases was about 5.35 million (95% CI: 5054772–5674270), while the cardiovascular diseases (CVDs) and chronic respiratory diseases each accounted for about 2.4 million prevalent cases. The total number of prevalent neoplasms in Sudan accounted for 779,530 (95% CI: 655,838–942,705), while in females and males, it was about

Table 2: Absolute Count of Deaths and Age Standardized Mortality Rate of NCDs, Sudan, for all Ages, and Both Sexes, 2023.

Causes	Males (95% CI: LL-UL)	Females (95% CI: LL-UL)	Total (95% CI: LL-UL)	ASMR per 100,000 (95% CI: LL-UL)
Total NCD's deaths	89,364 (78,556 – 10,1355)	81,103 (70511 – 91,359)	170,466 (155,046 – 185,341)	871.6 (799.4 - 954.8)
Cardiovascular diseases	54,827 (41,658 – 69,570)	51,387 (40,624 – 62,651)	106,213 (87,766 – 122,907)	575 (493.4 - 655.3)
Neoplasms	12,293 (7,235 – 16,420)	10,767 (8,078 – 13,879)	23,060 (18,032 – 29,209)	100.3 (77.6 - 127)
Diabetes and kidney diseases	6,329 (3,918 – 9,206)	7,215 (4,029 – 10,831)	13,543 (9,542 – 17,592)	69.45 (48.9 - 89.6)
Chronic respiratory diseases	4,788 (2,716 – 7,213)	1,776 (1,061 – 2,974)	6,564 (4,301 – 9,167)	37.2 (24.6 - 51.3)
Digestive diseases	4,259 (2,425 – 6,446)	3,378 (2,097 – 5,297)	7,636 (4,992 – 10,497)	35.4 (23.6 - 49.5)
Other non-communicable diseases	4,143 (2,689 – 5,966)	4,012 (2,806 – 5,539)	8,154 (6,282 – 10,515)	22.7 (17.7 - 28.4)
Neurological disorders	2,073 (1,009 – 3,950)	2,160 (970 – 4,621)	4,234 (2,066 – 8,564)	27.6 (12 - 62)
Substance use disorders	487 (233 – 874)	154 (81 – 287)	641 (375 – 1,041)	1.9 (1.2 - 3.1)
Skin and subcutaneous diseases	117 (52 – 228)	120 (58 – 216)	236 (139 – 369)	1.4 (0.8 - 2.2)
Musculoskeletal disorders	49 (22 – 89)	135 (75 – 238)	185 (111 – 300)	0.7 (0.4 - 1.1)
Mental disorders	0	0	0	0

Table 3: Mortality Burden due to Attributable Risk Factors in Sudan, Both Sexes, All ages, 2023

Study Variables	Metabolic risks (95% CI: LL-UL)	Environmental risks, (95% CI: LL-UL)	Behavioral risks, (95% CI: LL-UL)
Total number of deaths	98,709 (83,499-113,867)	60,944 (50,368-71,603)	51,235 (28,102-69,279)
Death Rate/100,000	263 (222-303)	162(134-190)	136 (74-184)
Death (%)	57% (51%-63%)	35% (30%-40%)	30% (15%-40%)

about 518,350 (95% CI: 424,821–633,927), and 261,180 (95% CI: 219,422-309,034), respectively, in 2023. (Table 1)

The Age-Standardized Prevalence Rate (ASPR) was 92,333 per 100,000 population (95% CI: 91,443–93,190) in Sudan in 2023. Most of this burden was attributed to “Other non-communicable diseases,” with an ASPR of 74,913 per 100,000 population (95% CI: 72,109–77,797), followed by neurological disorders and digestive diseases, with

ASPRs of 34,878.43 (95% CI: 31457-38043) and 32,825.62 (95% CI: 31080-34595) per 100,000 population, respectively. (Table 1)

ABSOLUTE COUNT OF MORTALITY AND AGE STANDARDIZED MORTALITY RATE (ASMR)

In 2023, there were about 170,466 (95% CI: 55,046–185,341) NCD-related deaths in Sudan, of which cardiovascular diseases (CVDs) were

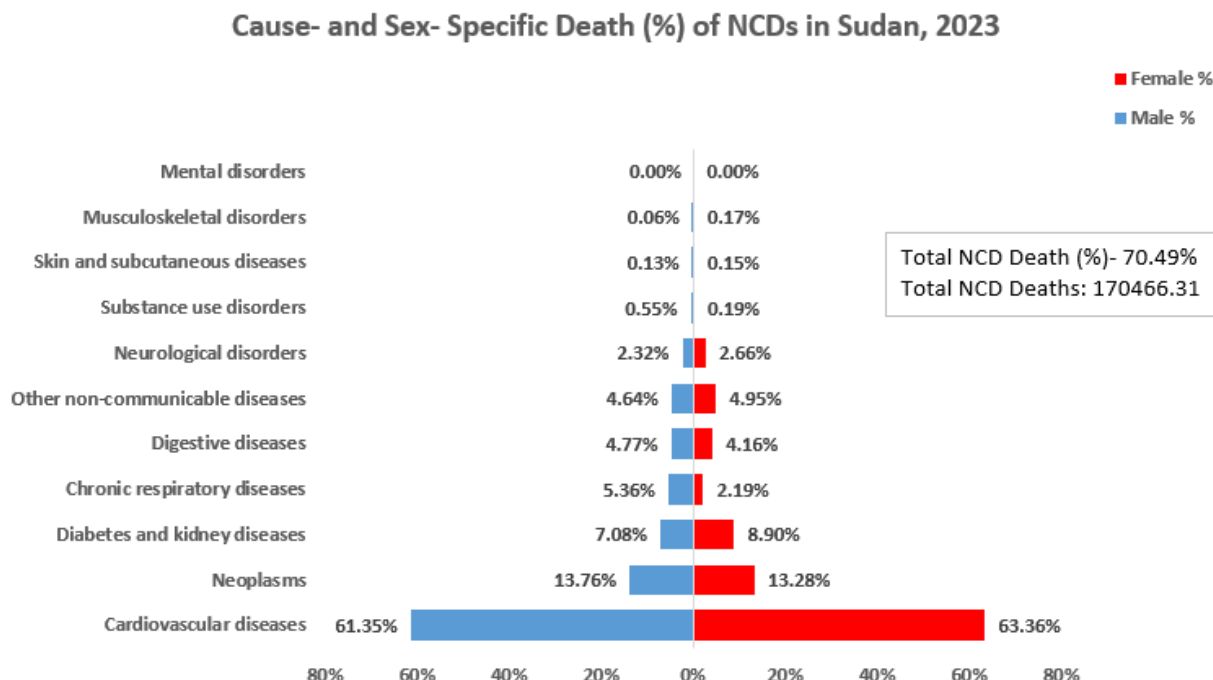


Figure 1: Cause and Sex-specific Deaths in percentages among both male and female, 2023

responsible for 106,213 (95% CI: 87,766–122,907) deaths. After cardiovascular diseases, neoplasms accounted for 23,060 deaths (95% CI: 18,032–29,209), while diabetes and kidney diseases caused 13,543 deaths (95% CI: 9,542–17,592). Overall, the total number of deaths in males was 89,364 (95% CI: 78,556–10,1355) when compared with females, 81,103 (95% CI: 70511–91,359) in Sudan. (Table 2)

In Sudan, the Age-Standardized Mortality Rate (ASMR) due to NCDs was 871.62 (95% CI: 799.35–954.79) per 100,000 population for all ages, both sexes combined, in 2023. Cardiovascular diseases accounted for an ASMR of 575.0 (95% CI: 493.4 - 655.3) per 100,000 population among all NCD-related mortality. This was followed by neoplasms (cancers), diabetes, and kidney diseases, with an ASMR of 100.26 (95% CI: 77.6 - 127), and 69.45 (95% CI: 48.9 - 89.6) per 100,000 population, respectively, in 2023. (Table 2)

TOTAL MORTALITY, DEATH RATES & PERCENTAGES DUE TO ATTRIBUTABLE LEVEL 1 RISK FACTORS

In 2023, metabolic risk factors accounted for 98,709 (95% CI: 83,499–113,867) NCD-related mortality, followed by Environmental and occupational risks with 60,944 (95% CI: 50,368–71,603) deaths, which are equivalent to 57% (95%

CI: 51%-63%) and 35% (95% CI: 30%-40%) death percentages, respectively. Behavioral risk factors accounted for 51,235 deaths (95% CI: 28,102–69,279), equivalent to 30% (95% CI: 15%-40%). In terms of death rates, metabolic risk factors had reported a death rate of 263 per 100,000 population, followed by environmental/occupational risks and behavioral risks with 162 per 100,000 and 136 per 100,000 population, respectively, in Sudan, 2023. (Table 3)

CAUSE- AND SEX- SPECIFIC MORTALITY BURDEN OF NCDS IN 2023

In Sudan, cardiovascular disease was responsible for approximately 61.4% and 63.4% of all NCD-related mortality in males and females, respectively. Neoplasms had accounted for about 13–14% of all NCD-related mortality in both sexes. Mortality due to diabetes and kidney diseases had contributed to 7-9% each in both sexes. While with respect to chronic respiratory diseases, mortality among males and females were 5.4% and 2.2%, respectively. Digestive diseases, other non-communicable diseases, and neurological disorders each had a limited share of NCD-related mortality, with about 2–5% deaths. Skin and subcutaneous diseases (0.13-0.15%) and musculoskeletal disorders (0.02-0.06%) contributed minimally to

overall mortality. Mental disorders were not recorded as direct causes of mortality. (Figure 1)

DISCUSSION

The study found that non-communicable diseases (NCDs) represented a significant health burden across both sexes, with an estimated total of over 34 million prevalent cases in Sudan as of 2023. This highlights the widespread impact of NCDs on the Sudanese population. The largest share of these estimated NCDs prevalent burden was attributed to Other non-communicable diseases and Neurological disorders, which are more prevalent in females when compared to males in Sudan.

Also, the ASPR pattern in Sudan, indicates that non-fatal, chronic conditions such as other non-communicable diseases, neurological, skin and subcutaneous, musculoskeletal, and mental disorders dominate the morbidity burden, which are more female predominantly skewed, while other traditionally high-mortality conditions such as cardiovascular diseases and neoplasms (cancers) contribute relatively less to prevalent cases, but remain a critical from a mortality perspective (male predominantly skewed). This might be due to a substantial unmet need for accessible, community-based care for women in society.

Integrating NCD services into maternal and child health (MCH) programs and expanding the role of female community health workers (CHWs) might improve access and decrease the burden of NCDs for females in Sudan. In contrast, the relatively higher NCD-related mortality burden due to cardiovascular diseases, chronic respiratory diseases and substance use disorders among males highlights the need for selected targeted risk-reduction strategies, including workplace-based screening and behavioral interventions addressing tobacco use and diet.

When compared with previous GBD 2019 and 2021 estimates, the present study findings from GBD 2023 estimates, reveals a clear epidemiological shift from mortality-dominated NCDs (cardiovascular diseases and neoplasms), towards a high-morbidity, disability-driven burden characterized by neurological, digestive, musculoskeletal, and mental disorders (chronic morbidity burden), alongside an increasing contribution of metabolic risk factors from the previous predominantly behavioral and environmental risk factors.¹²⁻¹⁴

The findings from this study also showed that NCDs had remained the leading contributors to mortality in Sudan, particularly driven by CVDs, which had accounted for more than half of all NCD-related mortality and remained the primary cause of death in both sexes separately. It was observed that mortality due to neoplasms, digestive and chronic respiratory diseases are male-dominated, while deaths due to diabetic and kidney disease and musculoskeletal diseases, among others, appeared to be more female-dominated. This mortality burden was further reflected in the persistently high probability of premature death (ages 30–70 years) from major NCDs, estimated at approximately 23% in recent reports, indicating that nearly one in four adults in Sudan is at risk of dying before the age of 70 due to these conditions.²⁶

A recent systematic review showed a high prevalence of behavioral risk factors in Sudan, ranging from 1–25% and 10–47.5% among adolescents and adults, respectively.²⁷ While another study also reported that obesity and unhealthy dietary habits among young students in Sudan are a growing public health concern.²⁸ In addition, a more recent research study showed that more than 40% of young medical students have a low level of physical activity in Sudan.²⁹ While another study conducted in Sudan reported that the increase in NCDs attributable risk factors could also be due to low levels of health awareness in Sudan, as many individuals do not know the risk factors associated with NCD, which may be due to delayed diagnosis, lack of preventive behavior, and insufficient management of NCD.³⁰ This lack of awareness also affects healthcare-seeking behaviors, causing late-stage diagnoses and the development of early onset of complications.³¹

Financial strains could also have an impact on the NCD epidemic burden in Sudan. The overall health budget in Sudan is comparatively low, and NCD prevention and control programs received less priority in terms of resource allocation.³² Additionally, the healthcare system in Sudan has suffered a severe shortage of trained health personnel, particularly in rural areas, due to the current civil war conflicts.³³

The present study had a few limitations that should be noted. Firstly, in Sudan, due to insufficient resources, potential misdiagnoses, and loss of literature, reduce the quality and availability of data. Although the application of data processing

and statistical modeling methods by GBD collaborators can effectively help address this issue to some extent, it introduces some uncertainty into the data analysis results. Secondly, it should be noted that there is a delay in GBD data updates. The burden of NCDs is calculated using available data from 1990 to 2023 and cannot fully reflect the current situation. Thirdly, due to manuscript word limitations, detailed estimates of DALYs, YLDs, incidence rates, prevalence, and age-stratified indicators were not included in the current version. However, we acknowledge that incorporating these indicators would further improve the robustness and comprehensiveness of the analysis and will consider their inclusion in future studies. Finally, due to the absence of primary data and limitations in GBD 2023 estimates stem from ongoing war conflicts, disrupting health data collection, vital registration, and surveys in Sudan, possibly leading to underreported information and limiting causal inference.

The study findings hold significant implications for NCDs in public health and clinical practice in Sudan. Firstly, the study provides a comprehensive national-level assessment of NCDs burden in Sudan, using recent 2023 estimates, across all age groups and both sexes. Secondly, it estimates the prevalence, mortality, age-standardized rates, and attributable risk factors, which offers a multidimensional understanding of the NCD burden in Sudan. Thirdly, the inclusion of sex- and cause-specific analyses for major NCD categories enhances the identification of disease patterns and gender disparities. Fourthly, the use of standardized epidemiological indicators with 95% confidence intervals improves the comparability, reliability, and robustness of the findings. By highlighting, the epidemiological transition, the dominant contribution of cardiovascular diseases and metabolic risk factors, the study provides valuable reliable evidence for public health planning and policy prioritization. Finally, given the limited epidemiological data available from Sudan, this study contributes important baseline evidence for future research, surveillance, and NCD control strategies.

CONCLUSION

Considering Sudan's fragile healthcare system and ongoing conflicts, NCD control strategies should focus on practical, high-impact interventions implemented via the primary healthcare (PHC) approach. Scalable approaches include integrating chronic disease management into PHC services, incorporating rehabilitation services, and adopting evidence-based WHO-recommended packages such as PEN and mhGAP. Effective implementation will require coordinated actions from the MOH, PHC providers, and community-based health workers, supported by international partners such as WHO and the World Bank for technical and financial assistance. A gender-responsive approach is also essential to effectively reduce NCD inequalities in both sexes in Sudan.

CONFLICT OF INTEREST

There was no conflict of interest.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

No ethical approval was required for this study, as it used the GBD database—a publicly available dataset containing anonymized data from voluntary participants for secondary analysis.

ROLE OF THE FUNDING SOURCE

There was no funding for this study. The corresponding author had full access to the data and final decision for publication.

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AUTHORS' CONTRIBUTIONS

Dr. Mohd Shanawaz is the sole, single author who had extracted the data, conceptualized, designed the study, analyzed and revised the manuscript for its intellectual content.

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