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Laboratory biosafety and biosecurity are essential to protect laboratory personnel, communities and the environment from accidental exposure, loss, theft, misuse, or intentional release of infectious and harmful agents

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Letters to the editor

المجلة الصحية لشرق المتوسط
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Closing blind spots in laboratory biosafety and biosecurity in the Eastern Mediterranean Region

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Laboratory biosafety and biosecurity have long been regarded as highly technical disciplines focused on containment practices and the safe handling of infectious agents. Their purpose is to protect laboratory personnel, communities, and the environment from accidental exposure, loss, theft, misuse, or intentional release. That framing is no longer sufficient. A biological incident that begins in one laboratory can rapidly become a national emergency, cross borders and threaten global health security.

The accelerating emergence and re-emergence of infectious diseases, coupled with rapid advances in biotechnology and the life sciences, has fundamentally reshaped the biological risk situation (*1*). Risks are no longer confined within laboratory walls; they are increasingly influenced by global mobility, expanding access to powerful technologies, digitised biological information and geopolitical instability.

These pressures are especially amplified in the Eastern Mediterranean Region (EMR). Protracted conflict, fragile health systems, climate-related threats, limited resources, staff turnover and ageing infrastructure all weaken laboratory resilience in the region. Meanwhile, advances in synthetic biology, genetic engineering, genomics and artificial intelligence have outpaced governance and regulatory oversight (*2*). The resulting gap between technological capability and governance preparedness is a regional vulnerability for which the consequences will not respect national borders.

Biosafety and biosecurity are therefore not peripheral laboratory concerns. They are central to resilient health systems, responsible science, public health preparedness and emergency response, and they support implementation of the International Health Regulations (2005). Yet they remain under-prioritised in many countries, constrained by competing demands, limited financing, fragmented responsibilities, and weak regulatory enforcement (*3*).

However, e-SPAR indicator C.4.2 reveals substantial disparities across the 5 performance levels. Among the 20 Member States with available data, all 4 low-income countries reported no or limited capacity (levels 1–2). By contrast, 5 of the 6 high-income countries reported demonstrated or sustainable capacity (levels 4–5), while one reported developed capacity (level 3) (*4*). Progress has been real but uneven, and weakness in one national system can cause vulnerability for the entire region.

Blind spots in laboratory biosafety and biosecurity

Four persistent blind spots continue to weaken the effectiveness, consistency and sustainability of biosafety and biosecurity systems.

Governance and the regulatory systems

Many countries still have limited, fragmented or outdated governance systems (*5*). Existing systems may not adequately address risks arising from modern biotechnology, artificial intelligence, genomic data, dual-use research, cybersecurity and ethical oversight (*6*). Infrastructure and training cannot compensate for weak governance. Countries need clear legislation, defined institutional responsibilities, effective licensing and oversight, and enforceable standards. A regional laboratory biosafety and biosecurity capacity assessment survey was disseminated to EMR Member States in July 2026 to identify national governance, regulatory, operational, and workforce gaps. Its value will depend on whether the findings are translated into funded plans, accountability and measurable action.

Workforce competence and compliance

A resilient system depends on professionals who can assess unfamiliar risks, exercise judgement and adapt procedures as threats evolve (*7*). Training that is based mainly on procedural compliance is no longer enough. The region needs scenario-based learning, competency assessment, incident investigation, interdisciplinary collaboration, and stronger biosafety and biosecurity content in pre-service and continuing education. COVID-19 showed that static guidance cannot be a substitute for institutional learning, supportive leadership and a culture in which safety is routinely practised, assessed and improved (*8*,*9*). Competence must be demonstrated and not assumed by attendance at one-off training programmes.

The hidden infrastructure gap and operational capacity

Safe laboratories require more than advanced equipment. Design, ventilation, workflow, waste management, maintenance, and risk-based spatial planning are frequently overlooked during infrastructure development. A facility can appear technologically advanced while retaining serious weaknesses in containment or occupational safety.

Biosafety cabinet certification remains a major challenge, particularly in low- and middle-income countries, where qualified certifiers, maintenance systems, replacement parts, and financing may be limited. Countries need reliable access, nationally or through regional arrangements, to appropriately designed and quality-assured facilities for high-risk pathogens. A collaboration with the Royal Scientific Society in Jordan is helping to build sustainable regional capacity for biosafety cabinet testing, validation and certification. Such partnerships can strengthen local expertise and reduce dependence on external providers (*10*).

The research gap

Operational research in the region remains scarce, yet practices developed in well-resourced laboratories cannot always be transferred to settings with different infrastructure, staffing, supply chains and disease burdens without modifications (*11*). Locally generated evidence is essential to identify interventions that are effective, affordable and sustainable. A recent publication from Egypt's Central Public Health Laboratory represents the first published account of its kind from the country in the field of laboratory biosafety and biosecurity. The publication provides an important example of emerging regional evidence, demonstrating how locally generated research can document operational experiences, identify context-specific challenges, and offer practical lessons for strengthening biosafety and biosecurity systems across the region (*12*).

A call for action

Biosafety and biosecurity must become permanent features of health security policy, laboratory governance, workforce development, and scientific research – they should not be requirements activated only during outbreaks, inspections or laboratory construction.

The Regional Committee resolution endorsed in October 2025 is an important step towards stronger governance and accountability (*13*). The priority now is implementation. By addressing existing blind spots with urgency and purpose, the EMR can move from vulnerability to resilience, ensuring the safe management of biological materials, safeguarding public health, and enabling scientific progress in an increasingly complex world. This requires coordinated, sustained, and strategic national and regional action.

Governance must be recognised and addressed as a necessity, not a privilege. Countries should update and enforce their regulations in alignment with international standards, assign clear responsibilities and resource national oversight.

Regional cooperation is indispensable. Harmonised standards, cross-border collaboration, and shared learning platforms can strengthen surveillance systems and reduce vulnerabilities associated with transboundary pathogen transmission.

Regional investment in biosafety cabinet certification and laboratory engineering can help reduce reliance on external providers and ensure sustainable maintenance of critical infrastructure.

Workforce development must evolve to empower laboratory professionals to assess risks, develop innovative solutions, and leverage emerging technologies, including artificial intelligence, to enhance biosafety and biosecurity practices.

Operational research must be prioritised and embedded within national laboratory strategies to generate evidence-based solutions that reflect local realities and resource constraints.

The Eastern Mediterranean Region does not lack expertise or commitment; it needs sustained investment, stronger governance, decisive leadership and the political will to translate these strengths into action. Closing existing gaps before they escalate into crises will protect laboratory personnel and communities, strengthen regional health security, and enable scientific progress to advance safely and responsibly.

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The emerging epidemic threat of Crimean-Congo haemorrhagic fever in Pakistan requires global health action

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Background

Crimean-Congo haemorrhagic fever (CCHF) is a life-threatening tick-borne viral infection recognised by the WHO research and development blueprint as a priority disease with epidemic and pandemic potential in emergency context (*1,2*). CCHF is an overlooked, yet intensifying, health threat challenging the fragile health system of Pakistan and other resource-limited countries (*3–5*). It is caused by nairovirus of the Bunyaviridae family and has a case fatality rate (CFR) of 10–40% (*3,5,6*). This disease is geographically among the most widespread and endemic infections and is reported in more than 30 countries across Africa, the Balkans, the Middle East, Asia, and southern Europe, particularly in regions south of the 50th parallel north, which defines the main geographical range of its principal *Hyalomma* tick vector (*5,6*). In Pakistan, insufficient public health measures, evolving ecological dynamics and inadequate surveillance have increased the risk of a widespread CCHF epidemic (3,7–9). This highlights the importance of One Heath approach to its control, recognising the interconnectedness of human, animal and environmental health in shaping CCHF transmission. This commentary outlines the critical factors driving CCHF threat and proposes evidence-based interventions to mitigate its impact.

Critical factors driving CCHF threat in Pakistan

The WHO operational guidance for infection prevention and control (IPC) and water, sanitation and hygiene (WASH) in health care settings for CCHF recommends early case recognition and isolation, appropriate use of personal protective equipment (PPE), strict adherence to standard precautions, safe patient transport, rigorous environmental documentation, and safe burial practices (*6,10*). Currently, there is no vaccine or specific treatment for CCHF, however, ribavirin, an antiviral drug, has been used off-label with uncertain benefits (*11*). Therefore, prevention relies only on risk reduction strategies, IPC and community measures (*5*). These actions, combined with enhanced surveillance and regulation of livestock movement, have been shown to curb transmission in endemic regions such as the Balkans, the Middle East and Asia (*6*). Within this framework, strengthening Pakistan's diagnostic capacity, as well as providing veterinary oversight and community education are critical to reduce the risk of widespread outbreaks (*3,7–9*). However, understanding the current threat requires an understanding of the disease trend in the country.

CCHF is not new to Pakistan; sporadic and intermittent outbreaks have been reported since its first identification in 1976 (*12*). The disease has exhibited persistent zoonotic circulation among both humans and livestock across the country. A nationwide serosurvey conducted in 2017–2018 detected anti-CCHFV antibodies in 2.7% (n = 1872) of human samples and 36.2% (n = 1838) of domestic animals, suggesting possible widespread exposure in buffaloes, camels, cattle, goats, and sheep (*13*). Among animals, camels showed the highest seropositivity (56.7%), followed by cattle (44.3%), sheep (32.6%), buffalo (29.6%) and goats (18.9%). In the same investigation, human seropositivity was markedly higher among livestock farmers (3.2%) than in the general community (0.6%) (*13*). A complementary occupational study reported antibody positivity of 9.52% among animal holders, 6.57% among abattoir workers and 1.78% among milkmen (*14*).

The actual disease burden may be significantly higher due to underreporting and limited diagnostic capacity, particularly in rural and peri-urban regions (*8,9,15*). However, despite the underreporting, more recent data (2012–2023) indicate an alarming increase in CCHF cases in Pakistan each year, with a sustained endemic transmission at the livestock–human interface. Individuals involved in direct contact with animals or their tissues are more vulnerable to the disease than health care personnel or the general population, reflecting a dominant zoonotic transmission in Pakistan (*3,7,9*). This exposure among livestock handlers and related

occupational groups may pose a significant threat to the country's health system (*3,8*). Available evidence indicates a disproportionately high burden of reported cases from Balochistan, Khyber Pakhtunkhwa and Punjab provinces (*3,7,15,16*).

Beyond underreporting, vector ecology further aggravates CCHF threat in Pakistan. Hyalomma ticks thrive in Pakistan's agrarian landscape, putting millions involved in livestock farming at direct risk. A 2020 study reported 2.7% seroprevalence among humans, indicating widespread exposure (*13*). This raises major concerns about zoonotic spillover into human populations, worsened by unregulated livestock movement, lack of vector control management and surveillance (integrated tick surveillance programmes), and limited veterinary monitoring (*13,17*).

The surveillance gaps extend beyond human clinical reporting. Currently, Pakistan faces insufficiency of advanced diagnostic-based and vector surveillance systems to detect viral circulation in livestock or tick populations, which severely limits early warning and management capabilities. This deficit, coupled with ecological and climatic pressures, makes the threat even greater (*6,7,18,19*).

In addition to vector-related risks, CCHF spread in Pakistan is driven by multiple, interlinked factors, including cultural practices, porous cross-border dynamics and weak health infrastructure, further intensified by climate change, which has significantly altered tick habitats and amplified tick activity and disease transmission (*9*). Combined with the fragile health system, insufficient diagnostics, undertrained personnel, and a lack of designated isolation units, these stressors elevate the risk of nosocomial spread in Pakistan (*17*).

Socio-cultural factors also intensify the crisis. Traditional practices such as unregulated livestock markets and mass animal slaughter during *Eid-ul-Adha* significantly increase outbreak risk, particularly in the context of limited public health awareness (*3,8*). Regional dynamics add another layer of complexity, as porous borders with endemic regions such as Afghanistan and Islamic Republic of Iran, allow unregulated movement of livestock, thus intensifying the risk of cross-border transmission (*9*).

The cumulative impact of these determinants results in a 3-fold challenge: an uncontrolled CCHF epidemic that places immense pressure on Pakistan's health system, disrupt livestock trade and increase rural poverty (*8*). The cross-border threat is more alarming and underscores the urgent need for global vigilance to prevent wider transmission. This need is reinforced by the fact that CCHF outbreak dynamics resemble those of other high-consequence pathogens requiring early detection, containment and coordinated response (*2*).

Recommended evidence-based interventions

Recognising and addressing this multifaceted threat requires an equally multifaceted response. Protecting Pakistan from the risk of CCHF requires action on several fronts: comprehensive surveillance, robust vector control, strict livestock movement regulation, community education, and closer international coordination (*5,20,21*). Strengthening laboratory networks and deploying rapid diagnostic tools are essential for timely case detection, while global international organisations can help in preparedness and early response (*5,22,23*). Experience from Turkey, Islamic Republic of Iran and Eastern European countries, where surveillance systems, livestock regulation, vector control, and community awareness campaigns have significantly mitigated CCHF outbreaks, offer actionable models for Pakistan (*5,18–21,24–26*).

In Pakistan, where livestock production is largely poorly managed, acaricide-based tick control is often impractical due to widespread tick resistance to the commonly used chemicals, limited farmer awareness and training, poor farm infrastructure, and the high cost of repeated acaricide application (*9,13,17,27*). This calls for emphasis on practical, context-specific measures such as public awareness campaigns, improved slaughterhouse safety (including mandatory PPE and worker training) and intensified advisories during *Eid-ul-Adha*. Integrated approaches, including pasture modification and livestock delousing, and safer acaricide application, where practical, may provide additional benefits (*24,25,27*). At the same time, stronger regulatory oversight of livestock markets, effective quarantine implementation and routine surveillance can help limit or control zoonotic spillovers (*20,21,25*). Education and outreach among high-risk populations, including farmers, herders and abattoir workers, should be delivered through culturally appropriate and community-led strategies to build trust and ensure adoption (*20,21*).

Strategic integration into the national health policy is critical. CCHF must be embedded within Pakistan's broader health security framework and infectious disease roadmap, supported by dedicated funding and One Health governance structure (*28*). This integration should be reinforced through partnerships with WHO, Food and Agriculture Organization (FAO), the World Organization for Animal Health (WOAH) and the United Nations Environment Program (UNEP). Cross-border data sharing and joint outbreak response are essential to strengthen preparedness (*26*). Together, these measures will enable sustainable resource mobilisation and coordinated implementation of One Health-based disease control efforts (*29,30*).

Conclusion

The increasing threat of a CCHF epidemic in Pakistan is a clear reminder of the intricate links between human, animal and environmental health. Combatting this emerging challenge necessitates the adoption of a One Health approach, which will integrate sectors and strengthen cross-border collaboration. Pakistan should urgently incorporate CCHF preparedness into its national infectious disease roadmap, while international organisations and regional partners recognise the regional and global implications of inaction. Without coordinated and timely measures, a localised epidemic could evolve with consequential wider international health emergency (2,30).

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The implications of *Naegleria fowleri* outbreaks for surveillance and public health preparedness in climate-vulnerable regions

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Epidemiologic patterns of *Naegleria fowleri*

Primary amoebic meningoencephalitis (PAM), caused by *Naegleria fowleri*, is a rare but rapidly progressive and frequently fatal infection of the central nervous system. Unlike other free-living amoebae such as *Acanthamoeba* spp. and *Balamuthia mandrillaris*, which often cause opportunistic infections, *N. fowleri* primarily affects previously healthy children and young adults, following nasal exposure to contaminated freshwater (*1*).

This commentary examines *N. fowleri* outbreak in the broader context of global epidemiology, explores the environmental and climatic determinants, and highlights the urgent need for improved diagnostic awareness and preventive measures in the Global South.

N. fowleri thrives in warm freshwater environments and in soil. It can inhabit swimming pools, water parks, splash pads, and similar recreational facilities if proper disinfection and chlorination are not maintained. Because it grows best at higher temperatures, infections tend to occur more frequently during the summer months (*2*).

Naegleria species were detected in approximately 26.4% of water sources in 35 countries, highlighting their widespread presence worldwide (*3*). The majority of reported primary PAM cases worldwide have originated from such countries as the United States of America (USA), India, Pakistan, Australia, and Mexico. As of 2024, USA had documented approximately 167 cases, of which only 4 patients survived. In Pakistan, the first case was reported in 2008, with 147 cases documented until 2022, while additional 5 cases were reported in 2023 (*4*). India has reported around 26 cases, Australia 22 and Mexico approximately 33 (*5*).

The major outbreak in Kerala, India, in 2025

Over the years, *Naegleria fowleri* infections have been reported in multiple regions of India, including Kerala, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, and West Bengal states (*6*). In 2025, Kerala recorded 69 confirmed cases and 19 deaths, corresponding to a case fatality rate of 27.5%. This was among a wide range of age groups, from a 3-month-old infant to a 92-year-old adult (*7,10*).

In 2025, sporadic cases were reported in the USA and Pakistan. Cases in USA were documented in Missouri and South Carolina, all of which were fatal. The 2 cases reported in Karachi, Pakistan, were also fatal and associated with inadequate chlorination of domestic water (*8,11-12*).

Historically, mortality globally due to primary amoebic meningoencephalitis has exceeded 95% (97–98%). The Kerala cluster suggests comparatively improved survival rate in settings where earlier clinical suspicion and miltefosine-based therapy were implemented (*7*).

Kerala benefits from a well-established public health framework driven by high literacy rates and a community-based primary health care model, which encourages timely medical consultation. However, the warm and humid environment in the state, the heavy monsoons and vast network of backwaters foster the accumulation of stagnant freshwater. Practices like bathing or swimming in ponds, religious nasal cleansing and rapid urban expansion, which outpace drainage systems, heighten exposure risks. The use of untreated private wells further compounds the danger. Climate change may also extend the duration of these high-risk conditions. Notably, infection occurs only when contaminated water enters the nasal passages—swallowing such water does not lead to disease (*9*).

Diagnostic challenges and proposed action plan

Early treatment initiation is critical for improving patient survival. Hence, clinicians should be aware of *Naegleria fowleri* infection, be able to recognise its clinical manifestations and consider it promptly in emergency presentations. Laboratory diagnosis primarily relies on cerebrospinal fluid (CSF) examination, including direct wet mount microscopy and polymerase chain reaction (PCR), which enable early detection when clinical suspicion is high. Culture methods are less useful for timely diagnosis because of their slow turnaround time; however, next-generation sequencing (NGS) offers a rapid and comprehensive but resource-

intensive diagnostic approach (*13*). If the disease is not detected early and treatment is delayed until laboratory confirmation, survival chances decrease markedly. This challenge is further compounded by the absence of an effective curative therapy, as the mortality rate exceeds 95%, particularly when diagnosis and treatment are delayed (*14*).

There is currently no targeted or reliably effective therapy for *Naegleria fowleri* infection. The agents most commonly used, including amphotericin B, miltefosine, fluconazole, and azithromycin, are typically administered in combination regimens; however, evidence of efficacy is largely derived from case reports and small observational series. Treatment outcomes remain inconsistent and therapy may be complicated by drug-related toxicity, as well as challenges in achieving adequate central nervous system penetration. Reported survivors have generally received early, aggressive combination therapy alongside intensive supportive care. These limitations indicate the need for continued research to identify more effective anti-amoebic agents and improved drug delivery strategies capable of achieving therapeutic concentrations within the central nervous system (*15*).

Perspectives for the future

Recent clusters in climate-vulnerable settings highlight the intersection between environmental change, water governance and health system preparedness in curbing the risk of *Naegleria fowleri* infection. Increasing ambient temperatures, inconsistent water treatment practices and cultural or recreational activities that increase nasal exposure to untreated freshwater may collectively contribute to sporadic outbreaks in several regions, including parts of the Eastern Mediterranean.

Persistent diagnostic delays, limited laboratory capacity and constrained therapeutic options continue to impede timely intervention. Strengthening environmental surveillance, standardizing water quality monitoring, enhancing clinician awareness, and expanding access to rapid molecular diagnostics are important components of early detection and response (Table 1). Where feasible, incorporation of molecular typing into surveillance systems may improve understanding of strain distribution and ecologic dynamics.

Equally important is community engagement to promote safe nasal-water practices and improved freshwater hygiene. Primary care physicians, often the first points of contact, play a critical role in early case detection and timely referral, which can reduce diagnostic delays and improve outcomes. Coordinated actions across public health authorities, water and sanitation agencies, clinical services, and the environmental sector—consistent with the One Health framework—is essential to mitigate risk and strengthen preparedness for this rare but devastating infection (*17*).

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Table 1 Key public health actions to prevent and control *Naegleria fowleri* in high-risk regions

Domain	Recommended actions	Purpose/expected impact	Priority level (high/ moderate/long-term)	References
Environmental surveillance	Standardised freshwater sampling Monitor temperature, turbidity, chlorine	Early detection and risk forecasting	High	*(2,3)*
Water safety	Improve chlorination Periodic flushing of wells and pipelines	Reduce environmental contamination	High	*(16)*
Diagnostics	Expand access to microscopy, CSF wet mounts, PCR, and next-generation sequencing	Faster case confirmation and early treatment	High	*(1,5,14,16)*
Clinical awareness	Develop clinician training modules Integrate PAM alerts into emergency protocols	Reduce misdiagnosis and diagnostic delays	High	*(1,14, 15)*
Reporting systems	Make primary amoebic meningoencephalitis a notifiable disease	Improve national data and outbreak response	Moderate	*(1, 16)*
Research	Promote genotyping, strain tracking and novel drug delivery studies	Understand evolution and improve treatment	Long-term	*(5)*
Community education	Safe nasal-water practices Use boiled/filtered water for ablution Avoid submersion	Lower household and community exposure	High	*(2)*

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Assessment of depression, anxiety and predictors of mental health burden among pulmonary tuberculosis patients in Ethiopia

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Abstract

Background: Depression and anxiety are prevalent comorbidities and a major concern for patients with tuberculosis. They are associated with low quality-of-life, poor treatment adherence and increased risk of mortality and morbidity.

Aim: To assess the prevalence of depression and anxiety and their predictors among pulmonary tuberculosis patients in Tigray, Northern Ethiopia.

Methods: Between January and April 2025, we interviewed 360 patients aged ≥ 18 years, who were confirmed to have pulmonary tuberculosis and had been receiving treatment and follow-up for at least 2 weeks in 10 outpatient tuberculosis clinics in Tigray, Ethiopia. We used the Patient Health Questionnaire 9 and Generalized Anxiety Disorder 7 for data collection, and used SPSS version 29 to analyse the data. Binary logistic regression model was used to identify the predictors of depression and anxiety.

Results: Prevalence of depression among the patients was 56.7% while prevalence of anxiety was 54.2%. Multivariable regression analysis revealed that smoking, alcohol consumption, adverse drug effects, and perceived stigma were significant risk factors for depression, while treatment support was a protective factor. Smoking, adverse drug effects, HIV/AIDS coinfection, and perceived stigma were significant risk factors for anxiety.

Conclusion: The prevalence of depression and anxiety among patients with pulmonary tuberculosis in this study was significantly higher than in other studies. Therefore, there is a need to encourage tuberculosis patients with the identified risk factors to undergo screening for depression and anxiety and to incorporate psychological interventions into their treatment plan.

Keywords: anxiety, depression, pulmonary tuberculosis, smoking, alcohol, Ethiopia

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Introduction

Tuberculosis (TB) is a widespread and fatal chronic contagious disease that spreads via airborne droplets when an infected person coughs or sneezes (*1*). TB is still a major health concern worldwide, especially in low- and middle-income countries (*1,2*). Globally, 10.8 million individuals contracted TB in 2023; 6.8% were living with HIV, and 1.25 million deaths occurred (*2*). In Africa, 2.5 million individuals contracted TB and 424 000 died (*3*). Ethiopia remains among the top 30 countries globally for TB (*4*), with 126 cases per year for every 100 000 people, and there were 24 000 deaths in 2022 (*4,5*).

TB is mainly an infectious disease of the respiratory tract; however, it can also cause severe psychological issues (*6,7*). Depression and anxiety are among the most prevalent psychological conditions, with significant public health implications in TB patients (*7*), and they are common among the general population (*8,9*). A cluster of interpersonal, biological and mental interactions enhances the likelihood of developing depression and anxiety in individuals with TB (*10*). TB causes short- and long-term psychological, economic and physical problems (*11*). Depression and anxiety are linked to poor quality of life, low treatment adherence, morbidity and high mortality rates (*12*). How TB patients respond to their illness is influenced by their mental state (*13*).

Numerous research findings reported symptoms of depression and anxiety in individuals with TB. Previous studies have reported that prevalence of depression and anxiety was 18.13% and 18.37%, respectively, in China (*14*), compared with 47.7% and 29.9% in Cameroon (*15*) and 55.9% and 54.6% in Ethiopia (*16*). The prevalence of depression was 45.5% in Nigeria (*17*) and 50.5% in India (*18*). The following factors were predictors of depression and anxiety in TB patients: HIV/AIDS coinfection; educational level; gender; age; financial hardship; family history of mental illness; perceived stigma; inadequate social support; drug adverse effects; previous anti-TB treatment; comorbidity; treatment nonadherence; duration of illness; and residency (*14–18*).

Previous studies in other parts of Ethiopia have focused solely on TB/HIV coinfection or multidrug resistant TB (MDR-TB). Tigray has experienced significant political and economic instability because of armed conflict over the past 2 years, which may have exacerbated the

psychological problems of TB patients. To our knowledge, no previous research has been reported on the prevalence of depression and anxiety among TB patients in the region. This study assessed the prevalence of depression and anxiety and identified the predictors among patients with pulmonary TB in Tigray, northern Ethiopia.

Methods

Study design

This institutional-based, cross-sectional study was conducted in the public hospitals of Tigray, northern Ethiopia from 1 January to 25 April 2025.

All selected adult TB patients attending treatment follow-up were registered under the TB treatment programme. Participants were confirmed to have pulmonary TB, aged ≥ 18 years, currently under treatment and follow-up for at least 2 weeks, and able to read and comprehend the local Tigrigna language. Patients with critical illnesses, chronic mental disorders, congenital abnormalities and physical disabilities were excluded.

Sample size was determined using a single-proportion formula, based on a prevalence of depression in TB patients of 31.1% in a previous study (*19*), a 95% confidence interval (CI) and a 5% margin of error.

$$n = \frac{(Z_{\alpha/2})^2 \cdot pq}{d^2} = \frac{(1.96)^2 * .31 * .69}{(0.05)^2}$$

where n is the sample size, p = proportion of depression level, q = 1 - p, Z = standard normal distribution, 95% CI and 5% level of significance = ± 1.96, and d = 5%, then n = 328. After adding 10% contingency rates, the final total sample size was 360.

Hospitals were used as study sites in health facilities that provided TB treatment services. Among the total hospitals in the study area, around 30% used the lottery method. The number of samples was assigned to study sites based on patient load. Study subjects were chosen using systematic random sampling from TB patients attending outpatient follow-up treatment. Ten hospitals were selected as study sites. A total of 31, 26, 57, 29, 18, 44, 42, 30, 47 and 36 participants were included from Abiadi, Adihaqi, Ayder, Dr Tsegay, Endabaguna, Mekelle, Lemlemkarl, Quiha, Suhul and Wukro Hospitals, respectively.

Data collection

Data were collected using a structured questionnaire administered by an interviewer in the outpatient TB clinic. The questionnaire was adopted from previous studies (*20–22*). The required data were collected by nurses with bachelor's degrees. Nurses with a master's degree and a researcher supervised the data collection process. One data collector was assigned to each selected hospital. These professionals were experienced in TB case management and received a 1-day training session focused on the purpose and importance of the research, as well as how to interview participants and complete the questionnaire. The researchers were checked daily to ensure the completeness of the collected data.

Outcome variables

Depression was measured using the Patient Health Questionnaire 9 (PHQ-9). This tool comprises 9 items, with 3 3-point responses for each item. It has a maximum total score of 27, and 10 indicates depressive symptoms. The severity of depression can be classified by scores of 0–4, 5–9, 10–14, 15–19 and 20–27, corresponding to none, mild, moderate, moderately severe and severe, respectively (*20*). This questionnaire is reliable, with Cronbach's α = 0.78 (*23*). Depression status was categorized into 2 groups for logistic regression: PHQ-9 score ≥ 10 indicated depression, while < 10 indicated no depressive symptoms. Anxiety was assessed with Generalized Anxiety Disorder 7 (GAD-7) scale, which has 7 items. The tool has a maximum score of 21, and a score of 10 indicates anxiety symptoms. Anxiety can be categorized by scores of 0–4, 5–9, 10–14 and ≥15, signifying none, mild, moderate and severe, respectively (*21*). GAD-7 is reliable and valid in the Ethiopian language, with a Cronbach's α of 0.81 (*24*). Anxiety status was categorized into 2 groups for logistic regression: GAD-7 score ≥ 10 indicated anxiety, while < 10 indicated no anxiety symptoms. Perceived stigma was measured using a 12-item stigma questionnaire with Likert-scale responses. The scores for each item were summed to classify TB patients as having perceived stigma, using an average mean value as the cut-off point (*22*).

Data quality assurance

The questionnaires were pretested among 5% of the total sample before the actual data collection period. The pretest guided modification and correction of the measures to evaluate the desired outcomes. Data were collected in the local language, Tigrigna, using prepared questionnaires. Data collectors and supervisors received training to maintain data quality. The researcher and supervisor verified the completeness of the collected data daily as they were being collected.

Data analysis

Data were processed and analysed using SPSS version 29. Sociodemographic and clinical characteristics, depression and anxiety levels of participants were displayed with frequency tables, percentages and figures. A binary logistic regression model was used to identify predictors. The assumptions of the model were assessed using the Hosmer–Lemeshow goodness-of-fit test and checked for multicollinearity. The model assumptions were satisfied, as indicated by $P > 0.05$ and the absence of perfect multicollinearity among the predictors. Bivariate logistic regression was performed for each explanatory variable; accordingly, those with $P < 0.02$ and 95% CIs were selected for inclusion in the multivariable regression analysis. In this analysis, $P \leq 0.05$ was considered statistically significant. The study

used adjusted odds ratios (AORs) with 95% CIs and $P \leq 0.05$ to determine statistical significance.

Ethics approval

Ethics approval was granted by the Institutional Review Boards of Zhengzhou University and Mekelle University, with reference numbers ZZUIRB 2025-78 and MU-IRB 2464/2025, respectively. Written informed consent was obtained from participants. Confidentiality was guaranteed for all the information submitted.

Results

Sociodemographic and clinical characteristics of participants

We enrolled 360 participants, resulting in a 100% response rate. Sixty-five (18.1%) participants were aged ≤ 24 years, with a mean of 37.37 ± 11.94 years (Table 1). Regarding the clinical features of participants, 138 (38.3%) were in the intensive phase of TB follow-up treatment and 318 (88.3%) were new TB patients. One hundred and sixty-seven (6.4%) participants reported experiencing perceived stigma symptoms.

Depression and anxiety levels of participants

The overall prevalence of depression among TB patients was 56.7% (95% CI: 52.3–61.1%) (n = 204) (Figure 1). The severity of depression was classified as moderate (26.4%, n = 95), moderate-to-severe (23.1%, n = 83) and severe (7.2%, n = 26). The overall prevalence of anxiety was 54.2% (95% CI: 49.8–58.6%) (n = 195), and its severity was classified as moderate (28.4%, n = 102) and severe (25.8%, n = 93).

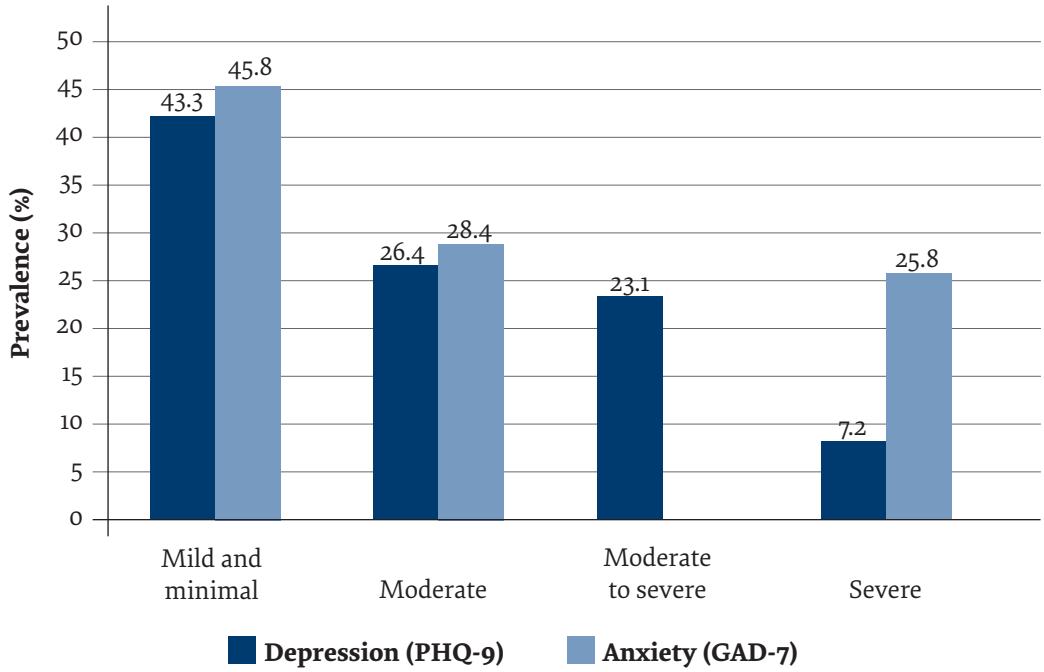
Predictors of depression and anxiety

Cigarette-smoking TB patients were 84% more likely to exhibit symptoms of depression (AOR = 0.16; 95% CI: 0.04–0.69) (Table 2). Among participants, 62% of those who did not consume alcohol were less likely to manifest

Table 1Sociodemographic and clinical characteristics of patients with pulmonary tuberculosis

Variables	Category	Number (%)
Age (years)	≤24 years	65 (18.1)
	25–34	101 (28.1)
	35–44	90 (25.0)
	≥45	104 (28.9)
Sex	Male	210 (58.3)
	Female	150 (41.7)
Residence	Rural	242 (67.2)
	Urban	118 (32.8)
Marital status	Married	275 (76.4)
	Single	67 (18.6)
	Divorced	15 (4.2)
	Widowed	3 (0.8)
Level of education	No formal education	103 (28.6)
	Primary education	114 (31.7)
	Secondary education	93 (25.8)
	College and above	50 (13.9)
Occupation	Employed	70 (19.4)
	Farmer	157 (43.6)
	Merchant	63 (17.5)
	Unemployed	70 (19.4)
Monthly income (Ethiopian birr)	≤2000	147 (40.8)
	2000–3500	104 (28.9)
	≥3500	109 (30.3)
Phase of treatment	Intensive phase	138 (38.3)
	Continuous phase	222 (61.7)
Type of patient	New case	318 (88.3)
	Retreatment	42 (11.7)
Comorbidity	HIV	7 (1.9)
	Other chronic disease	37 (10.3)
	None	316 (87.8)
Cigarette smoking	Yes	52 (14.4)
Alcohol use	Yes	109 (30.3)
Treatment supporter	Yes	275 (76.4)
Experienced drug side effect	Yes	146 (40.6)
Any difficulty in taking drugs	Yes	133 (36.9)
Health education received	Yes	264 (73.3)
Family history of depression	Yes	21 (5.8)

Figure 1 Prevalence of depression and anxiety among pulmonary tuberculosis patients



symptoms of depression (AOR = 0.38; 95% CI: 0.18–0.84). Among TB patients who reported anti-TB drug adverse effects, 95% had a high probability of depressive symptoms (AOR = 0.05; 95% CI: 0.02–0.16). Patients who had treatment support were 2.02 times less likely to show symptoms of depression (AOR = 2.02; 95% CI: 1.01–5.05). Sixty-eight percent of participants with perceived stigma had a higher probability of manifesting symptoms of depression (AOR = 0.32;95% CI: 0.14–0.75). TB patients who smoked cigarettes had an 85% probability of anxiety symptoms (AOR = 0.15; 95% CI: 0.03–0.68) (Table 2). The 96% of TB patients who had experienced anti-TB drug adverse effects were highly likely to develop anxiety symptoms (AOR = 0.04; 95% CI: 0.01–0.12). Among TB patients who had coinfection with HIV/AIDS, 33% were likely to experience anxiety symptoms (AOR = 1.67; 95% CI: 1.24–2.89). Among TB patients who reported perceived stigma, 67% were likely to experience anxiety symptoms (AOR = 0.33;95% CI: 0.14–0.82).

Discussion

Depression and anxiety were the most common psychological disorders that have serious public health consequences among patients with TB. In this study, the overall prevalence of depression and anxiety among patients with pulmonary TB was 56.7% and 54.2%, respectively. Multivariate logistic regression analysis showed that smoking cigarettes, alcohol consumption, treatment support, perceived stigma, and experiencing adverse drug effects were significant predictors of depression. Similarly, smoking cigarettes, adverse drug effects, perceived stigma, and comorbidity with HIV/AIDS were predictors of anxiety among patients with pulmonary TB.

Our results are consistent with those in other areas of Ethiopia, where prevalence of depression and anxiety was 55.9% and 54.6%, respectively (*16*). Similarly, prevalence of depression was 56% in Pakistan (*25*). However, our results were higher than in other countries: prevalence of depression and anxiety was 18.13% and 18.37%, respectively, in China (*14*); 47.7% and 29.9% in Cameroon (*15*); 45.5% and 13.4% in Nigeria (*17*); and 31.4% and 38.4% in Brazil (*26*). Prevalence of depression was 50.5% in India (*18*), prevalence of anxiety was 26% in Türkiye (*27*) and prevalence of depression and anxiety was 29.94% and 29.34%, respectively, in northern China (*28*), and 47.9% and 42.6%, respectively, in Southwest China (*29*). In contrast, our results were lower than in Pakistan, where 65% of TB patients had anxiety (*25*), and in Türkiye, where 60.5% had depression (*27*).

There are several possible reasons for these discrepancies. Consistent findings are likely due to similar socioeconomic development in the countries because TB is closely related to the patient's economic status (*2,10*). The lower results in China, Nigeria, Brazil and other countries might have been due to inclusion of studies that used different measurement tools and cut-off points. Although most of the studies used PHQ-9 for depression (*14,18*) and GAD-7 tool for anxiety, many studies used other tools (*15,17,26,28*). The integration of mental health interventions with the usual TB treatment programme (*14,26,27*) might have resulted in a difference in prevalence. Some studies excluded MDR-TB; however, our study included all TB cases, including MDR-TB. The lower rates than in Pakistan and Türkiye could have been related to differences in the study population. The other studies might have included more hospitalized patients (*27*) and participants with other comorbid diseases.

Our findings show that pulmonary TB patients who smoked cigarettes were more likely to experience symptoms of depression and anxiety. This is similar

Table 2 Bivariate and multivariable regression analysis to identify predictors of depression and anxiety among patients with pulmonary tuberculosis

Variable	Depression				Anxiety			
	Yes	No	COR (95% CI)	AOR (95% CI)	Yes	No	COR (95% CI)	AOR (95% CI)
Sex								
Male	137	73	2.32 (1.51–3.57)	2.43 (0.97–4.65)	139	71	3.28 (2.12–5.08)	5.69 (0.94–9.22)
Female	67	83	1	1	56	94	1	1
Residence								
Rural	143	99	0.74 (0.47–1.15)	1.15 (0.59–2.24)	141	101	0.60 (0.38–0.94)	0.82 (0.40–1.69)
Urban	61	57	1	1	54	64	1	1
Phase of treatment								
Continuous	101	121	0.28 (0.17–0.45)	0.43 (0.22–1.04)	91	131	0.23 (0.14–0.36)	0.68 (0.15–1.63)
Intensive	103	35	1	1	104	34	1	1
Type of patient								
New case	171	147	1	1	162	156	1	1
Retreatment	33	9	3.15 (1.46–6.80)	1.36 (0.39–4.65)	33	9	3.52 (1.63–7.61)	2.08 (0.57–7.54)
Comorbidity								
HIV	5	2	0.27 (0.12–0.57)	1.604 (0.97–2.67)	5	2	0.28 (0.14–0.58)	1.67 (1.24–2.89)*
Other disease	33	4	0.67 (0.26–1.33)	1.03 (0.41–3.66)	32	5	0.74 (0.35–1.44)	1.43 (0.62–4.74)
None	166	150	1	1	158	158	1	1
Cigarette smoking								
No	155	153	0.06 (0.01–0.20)	0.16 (0.04–0.69)*	147	161	0.07 (0.02–0.22)	0.15 (0.03–0.68)*
Yes	49	3	1	1	48	4	1	1
Alcohol use								
No	117	134	0.22 (0.13–0.37)	0.38 (0.18–0.84)*	108	143	0.19 (0.11–0.32)	0.26 (0.11–1.01)
Yes	87	22	1		87	22	1	
Treatment support								
Yes	133	142	1	1	125	150	1	1
No	71	14	5.41 (2.91–9.06)	2.02 (1.01–5.05)*	70	15	5.60 (3.05–9.06)	2.24 (0.83–6.10)
Drug side effects								
No	64	150	0.03 (0.01–0.44)	0.05 (0.02–0.16)*	57	157	0.02 (0.01–0.04)	0.04 (0.01–0.12)*
Yes	140	6	1	1	138	8	1	1
Perceived stigma								
Yes	58	135	0.06 (0.03–0.10)	0.32 (0.14–0.75)*	53	140	0.07 (0.04–0.11)	0.33 (0.14–0.82)*
No	146	21	1	1	142	25	1	1

*Significant at $P \leq 0.05$; AOR = adjusted odds ratio; COR = crude odds ratio

to Brazil, where smokers had depression but were not associated with anxiety (*26*), Nepal (*30*) and different parts of Ethiopia (*31*). Smoking impairs immunity, making a person more vulnerable to contracting TB. Smokers who have TB are more likely to experience recurrence, unsuccessful treatment and chronic breathing problems. Smoking is a common coping strategy for depression, anxiety and stress. Smokers with TB are more likely to suffer from acute anxiety and sadness as a result of their impaired health. TB patients may find it more challenging to stop smoking due to despair and worry, which can lead to a vicious cycle.

Patients with pulmonary TB who consumed alcohol were more likely to exhibit symptoms of depression. This is in agreement with a report from Nepal (*30*). However, a study in China reported that patients who were alcohol drinkers had reduced anxiety levels (*14*). Drinking alcohol compromises immunity, worsening the seriousness of TB and lengthening its healing period, which can exacerbate feeling of depression and hopelessness. Alcohol affects mood-regulating neurotransmitters, including dopamine and serotonin, which may cause or intensify symptoms of depression, overwhelm coping mechanisms and increase stress. Alcohol and anti-TB drugs might interact negatively, aggravating adverse reactions such as exhaustion or neuropathy that can lead to depression. Alcohol, depression and TB interact in a negative and perpetuating manner.

This study indicated that patients who experienced adverse effects from anti-TB medication were more prone to symptoms of depression and anxiety. Our findings are consistent with reports from Nepal (*30*) and China (*32*). Anti-TB medication adverse effects and several other psychological disorders can directly cause depression and anxiety for TB patients. Adverse effects, including neuropsychiatric symptoms, depression, anxiety, mood swings, dissatisfaction, sleep disruption and psychosis, can occur directly and indirectly. Frequent adverse effects of anti-TB drugs worsen the quality of life and exacerbate symptoms of depression. The lengthy months-long course of TB therapy causes mental discomfort, frustration and pessimism. TB medication may aggravate symptoms in patients who already have anxiety or depression.

The findings revealed that patients with family and social support during treatment were less likely to develop depressive symptoms, which is consistent with studies in Cameroon (*15*) and Ethiopia (*31,33,34*). Family and social support for TB patients is essential in reducing depression and anxiety. This sort of support assists TB patients to overcome their condition by promoting acceptance, normalizing the illness, and lessening feelings of stigma and isolation. Support from family members enhances treatment adherence through medication reminders and escorting patients to clinics, which in turn speeds up healing and indirectly reduces depression and anxiety and lowers feelings of hopelessness.

This study found that pulmonary TB patients who perceived stigma were more likely to exhibit symptoms of depression and anxiety, which is similar to other studies (*16,34*); one study reported that perceived stigma was associated with anxiety only (*35*). Depression and anxiety are closely linked to TB patients' perceptions of stigma. Self-blame, disclosure, discrimination and social isolation are some ways that stigma can appear. TB patients face isolation from relatives, close friends and society at large due to misunderstandings about their illness. Patients who perceive stigma may have feelings of guilt or shame because of their illness, which can result in symptoms of depression. Stress caused by stigma may deter patients from obtaining medical attention or adhering to their medication.

This study showed that pulmonary TB patients coinfected with HIV/AIDS were significantly more likely to experience anxiety, which is consistent with other studies in Ethiopia and Cameroon (*15,34,35*). In addition to increasing anxiety caused by multidrug resistance and weakened immunity, comorbid patients are more susceptible to worry about disease progression. Also, worry about premature mortality is a significant psychological burden that may result in panic attacks, persistent anxiety and even depression. Patients with TB and HIV/AIDS sometimes lose their employment as a result of their frequent hospital stays.

Study limitations

This study had several potential limitations, including social desirability and recall biases associated with the use of the PHQ-9 and GAD-7 tools, as well as the cross-sectional study design. Hence, it will be beneficial to conduct follow-up and interventional studies in the future.

Conclusion

This study revealed high prevalence of depression and anxiety among patients with pulmonary TB, with 56.7% of patients experiencing depression and 54.2% experiencing anxiety. Smoking, alcohol consumption, perceived stigma and adverse drug effects were significant risk factors for depression, while having treatment support was a protective factor. Smoking, adverse drug effects, perceived stigma and HIV/AIDS coinfection were predictors of anxiety among patients with pulmonary TB. This study demonstrates the importance of reducing depression and anxiety with an emphasis on patients' identified factors. Health professionals should focus on developing psychosocial therapies that alleviate symptoms such as depression and anxiety, including: support for reducing cigarette smoking and alcohol consumption; providing patient support and encouragement for managing comorbidity; closely monitoring adverse drug effects; raising awareness of stigma; and establishing treatment support groups for individuals lacking such resources.

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Five-year analysis of needlestick and sharps injuries among health care workers in Croatia

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Abstract

Background: Needlestick and sharps injuries are common occupational hazards among health care workers and may result in exposure to bloodborne pathogens.

Aim: To assess reported needlestick and sharps injuries among health care workers at 2 university hospitals in Croatia.

Methods: We collated and analysed national surveillance and hospital data of needlestick and sharps injuries among health workers in 2 university hospitals in Croatia for the period 2018–2022. We compared the pre-COVID-19 pandemic period (2018–2019) with the pandemic period (2020–2022) using descriptive statistics and chi-square tests. $P < 0.05$ was considered statistically significant.

Results: Between 2018 and 2022, a total of 3554 needlestick and sharps injuries were reported among the health care workers. Needles accounted for 2373 (68.6%) of 3458 reports with complete data on injury type. Nurses and medical technicians were the most affected group, accounting for 2358 of the national reports (51.4%; 95% confidence interval 49.7–53.0). Injury reports were higher during the COVID-19 pandemic than before the pandemic (1930 vs 1624). The difference between the 2 hospitals was not statistically significant ($P = 0.41$).

Conclusion: Needlestick and sharps injuries remain an important occupational risk among health care workers in Croatia, particularly among nurses and medical technicians. Safer handling of sharps, better reporting compliance and targeted education can help reduce this occupational exposure.

Keywords: needlestick injury, sharps injury, occupational exposure, health care worker, bloodborne pathogen, infection control, Croatia

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Introduction

Needlestick and sharps injuries are a persistent occupational risk during routine patient care and diagnostic, therapeutic, surgical and rehabilitative procedures. Although not every exposure incident leads to infection, contaminated sharps may result in exposure to bloodborne pathogens (*1*). Globally, an estimated 3 million health care workers are exposed to needlestick or sharps injuries each year (*2*).

The risk is not limited to physicians and nurses. Laboratory personnel, waste handlers, cleaning staff, students and trainees may also be exposed through contact with patients, contaminated instruments and medical waste (*3,4*). Surgical teams are particularly vulnerable because of their frequent exposure to blood, body fluids and sharp instruments, and the risk is higher in low- and middle-income countries (*5*).

In Croatia, exposure incidents were not officially recorded until 2010. The framework agreement on preventing injuries from sharp objects in the healthcare sector was later incorporated into Croatian law through the regulation on protective measures to prevent sharp object injuries. This regulation came into force in 2013, establishing safety measures for health care workers at risk of exposure incidents (*6*). However, formal reporting systems do not capture all injuries, and underreporting of needlestick and sharps injuries is common, especially among medical students (*7*).

The regulation aims to improve workplace safety through preventive measures, risk assessment and elimination strategies. It also promotes an integrated approach to preventing hospital-acquired infections and health care-associated infections through training, awareness programmes, monitoring and regulatory compliance. It establishes procedures for reporting and managing exposure incidents, including post-exposure prophylaxis when required (*6,8*). The cost of treating occupationally acquired hepatitis B, hepatitis C and human immunodeficiency virus infection is high worldwide (*9*). After implementation of the regulation, reported exposure incidents increased substantially, reaching a peak of 827 reports in 2018 (*6*).

Effective post-exposure management is crucial for reducing the risk of bloodborne infections following needlestick and sharps injuries among health care workers (*10*). Prompt evaluation, risk assessment, appropriate prophylaxis, reporting and follow-up help

prevent disease transmission and support workplace safety (*11*).

This study assessed reported needlestick and sharps injuries among health care workers from 2018 to 2022, with emphasis on 2 university hospitals, affected occupational groups, injury types and COVID-19-related reporting patterns.

Methods

Study design

We conducted a retrospective analysis of reported needlestick and sharps injuries among employees of University Hospital Centre (UHC) Zagreb and UHC Sestre Milosrdnice between 1 January 2018 and 31 December 2022. Both hospitals are tertiary referral centres with diverse medical and surgical specialties and approximately 6000 and 2470 health care workers, respectively. The 2 hospitals were selected because they are the largest university clinical centres in Croatia, with comprehensive specialty coverage and large health care workforces, providing a broad institutional dataset on occupational needlestick and sharps injuries.

National data on needlestick and sharps injuries were obtained from the Croatian Institute for Public Health reports, while hospital data were collected from annual reports of the hospital infection committees of both hospitals. The study period was divided into pre-pandemic (2018–2019) and pandemic (2020–2022) periods, according to the COVID-19 outbreak timeline in Croatia.

Minor discrepancies between the national total and the numbers presented in Tables 1 and 2 were due to differences in data completeness and variable availability. The national dataset included 3554 reported injuries, whereas the institutional datasets used for detailed analyses included only records with complete information for specific variables. Table 1 summarises injuries by the type of object that caused the injury, while Table 2 categorises them by occupation of the injured worker. Not all reports included both variables. These variations are expected in retrospective surveillance data and do not affect the overall trends or conclusions of the study.

Data analysis

Data were analysed using descriptive statistics, and chi-square tests were used to assess differences in the distribution of needlestick and sharps injuries. Statistical significance was set at $P < 0.05$. We calculated 95% confidence intervals for key proportions and rates using standard binomial methods.

Table 1 Reported needlestick and sharps injuries by object or mode of exposure, Croatia, 2018–2022

Type of exposure	UHC Zagreb		UHC Sestre Milosrdnice		Croatia	
	N	%	N	%	N	%
Needle	677	76.8	309	83.1	2373	68.6
Scalpel	73	8.3	19	5.1	232	6.7
Other instruments	58	6.6	40	10.8	564	16.3
Mucosal splash	72	8.2	2	0.5	249	7.2
Other, including human bite or broken ampoule	2	0.2	2	0.5	40	1.2
Total	882		372		3458	

χ^2 (4, n = 1254), $P < 0.001$

Table 2 Distribution of needlestick and sharps injuries by occupation of injured worker, Croatia, 2018–2022

	UHC Zagreb		UHC Sestre Milosrdnice		Croatia	
	N	%	N	%	N	%
Nurses and medical technicians	411	46.6	203	56.2	1708	49.2
Physicians	320	36.3	94	26.0	850	24.5
Cleaning staff	52	5.9	28	7.8	308	8.9
Students	41	4.7	16	4.4	115	3.3
Laboratory technicians	20	2.3	15	4.2	131	3.8
Other health care workers (e.g. dentists, dental nurses, midwives)	38	4.3	5	1.4	362	10.4
Total					3474	

χ^2 (5, n = 1254), $P < 0.0001$

Results

UHC Zagreb and UHC Sestre Milosrdnice had approximately 6000 and 2470 health care workers, respectively. The mean annual reported rate of needlestick and sharps injuries was 2.94% (95% confidence interval 2.69–3.20%) at UHC Zagreb and 3.01% (95% confidence interval 2.65–3.41%) at UHC Sestre Milosrdnice. Between 1 January 2018 and 31 December 2022, 3474 needlestick and sharps injuries were reported in Croatia. The highest number was recorded in 2019, with 797 reports, and the lowest in 2020, with 613.

At UHC Zagreb, the highest number of incidents was reported in 2018 (201 cases), and the lowest in 2022 (144 cases). At UHC Sestre Milosrdnice, the highest number was recorded in 2019 (92 cases), and the lowest in 2020 (51 cases) (Figure 1).

The distribution of exposure types differed significantly between the 2 hospitals [χ^2 (4, N = 1254), $P < 0.001$]. Needlestick injuries were the most common exposure type, accounting for 2373 cases nationally (68.62%), including 677 cases at UHC Zagreb (76.76%) and 309 at UHC Sestre Milosrdnice (83.06%). The least frequent exposures were classified as "other", including human bites and broken ampoules, which accounted for 40 reports nationally (1.16%) and 4 reports across the 2 hospitals. Categories with low expected frequencies were combined for statistical analysis.

The distribution of reported needlestick and sharps injuries by occupation differed significantly between the 2 hospitals [χ^2 (5, N = 1254) = 23.85, $P < 0.001$]. Nurses and medical technicians were the most affected group, accounting for 1708 cases nationally (49.17%), followed by physicians (850 cases; 24.47%) and other health care workers (362 cases; 10.42%). Students and laboratory technicians each accounted for less than 5% of reported injuries nationally. Categories with very low or zero counts were merged into a single category named "other health care workers" to satisfy chi-square test assumptions for the between-hospital comparison.

The totals differ between Tables 1 and 2 because some national reports lacked data on either exposure type or occupation; therefore, each table includes only records with complete data for the variable analysed.

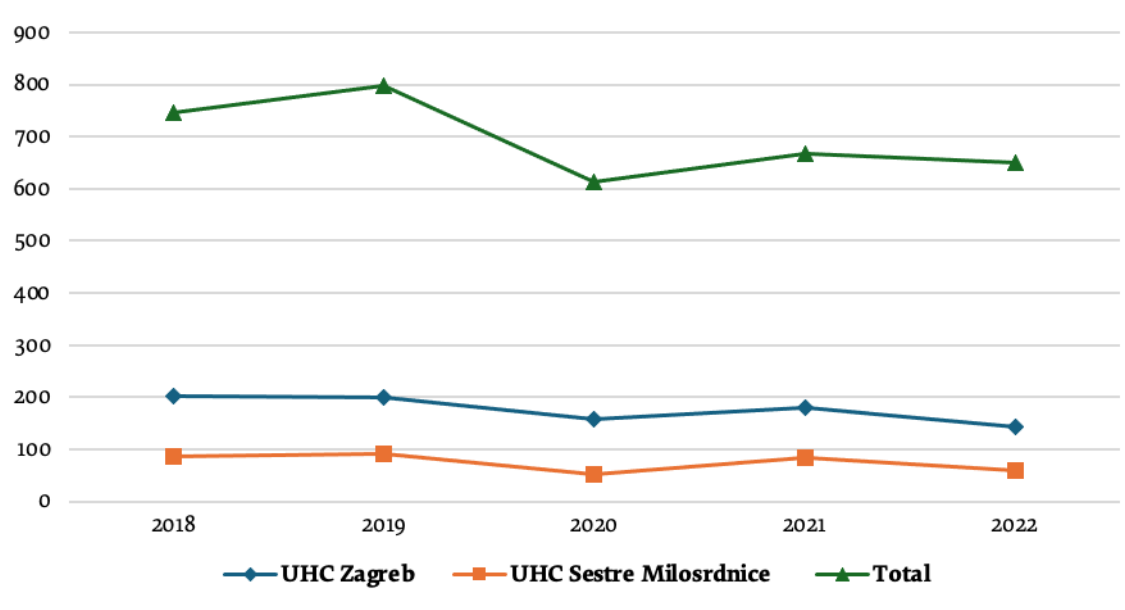
Reported needlestick and sharps injuries were compared between the pre-pandemic period (2018–2019) and the COVID-19 pandemic period (2020–2022). There was no statistically significant difference between the 2 hospitals in the distribution of reports by period [χ^2 (1, N = 1254) = 0.67, $P = 0.41$]. During the pandemic, 1930 needlestick and sharps injuries were reported nationally, including 482 at UHC Zagreb and 194 at UHC Sestre Milosrdnice.

Discussion

This study examined 882 reported needlestick and sharps injuries at UHC Zagreb and 372 at UHC Sestre Milosrdnice from January 2018 to December 2022. The mean annual reported rates were 2.94% and 3.01%, respectively. These rates were lower than those reported in a meta-analysis that found higher prevalence in North Africa (49.7%), East Asia (47.2%), Eastern Europe (47.3%) and the Middle East (43.8%), and lower rates in Singapore (3.5%), Hong Kong (5.9%), Brazil (7.7%) and New Zealand (9.1%). These differences may reflect variations in awareness, reporting practices, workforce distribution, availability of protective equipment, occupational safety policies and perceived infection risk (5).

The distribution of injury types and affected health care workers was broadly consistent with global patterns (5,13). Needles were the leading cause of injury in both Croatian centres, accounting for 76.76% of injuries at

Figure 1 Reported needlestick and sharps injuries, Croatia, 2018–2022



UHC Zagreb and 83.06% at UHC Sestre Milosrdnice. At UHC Zagreb, scalpel-related injuries were the second most frequent exposure type (8.28%), while at UHC Sestre Milosrdnice, injuries involving other instruments ranked second (10.75%). These instruments included sharp hooks, stylets, forceps, scissors, bone fragments and cautery needles. The distribution of injury-causing objects differed significantly between the 2 hospitals.

Although reported rates of needlestick and sharps injuries were lower in Croatia than in some other settings, the types of injuries and the occupational groups most frequently affected were consistent with previous studies (*13*,*14*). A 2016 survey at the Zenica Health Centre in Bosnia and Herzegovina reported that 69.6% of 184 health care workers experienced needlestick injuries, but only 16.4% reported them to their superiors. Needles were the most common cause of injury. Unpredictable patient reactions, haste and neglect of protective measures were cited as the main reasons. Injection procedures, needle recapping attempts, blood cleanup and contaminated waste disposal were common injury scenarios (*15*).

As of May 2023, there were 32 440 nurses in Croatia, representing 43% of the health care workforce. Nurses and medical technicians accounted for over half of reported needlestick and sharps injuries across the country (49.17%), consistent with previous evidence from Poland (*13*). At UHC Zagreb and UHC Sestre Milosrdnice, they accounted for 46.60% and 56.23% of reports, respectively. A 7-year study at the King Hussein Cancer Center in Jordan similarly found that nurses were the most affected group (61.97%), followed by cleaning staff (16.62%) and physicians (12.68%). Staff shortages, heavy workloads, poor organisational practices and shift patterns may have contributed to the higher proportion of injuries among nurses. In Jordan, alternating between day and night shifts was found to double the risk of errors or incidents compared with consistent shift patterns (*16*).

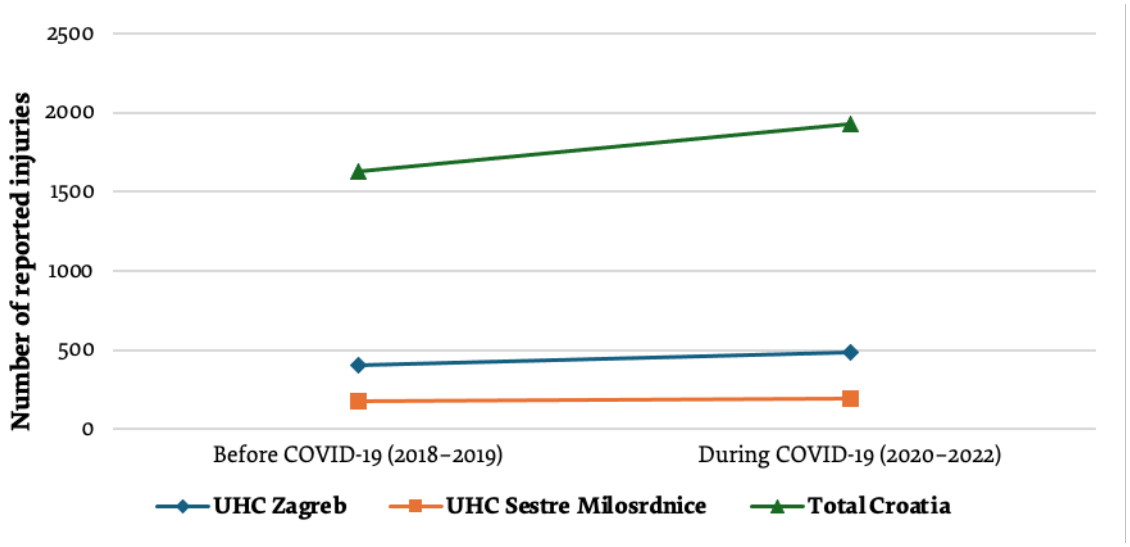
In Croatian health care centres, cleaning staff ranked third, accounting for 5.9% of reports at UHC Zagreb and 7.8% at UHC Sestre Milosrdnice. This proportion was lower than that reported in a 9-year retrospective study, in which cleaning staff accounted for 19.8% of injuries (*17*). This difference may reflect underreporting among cleaning staff in Croatia.

Students also experienced needlestick and sharps injuries during clinical practice. They ranked fourth at UHC Zagreb and UHC Sestre Milosrdnice, accounting for 4.6% and 4.4% of reports, respectively, and fifth nationally, accounting for 3.31%. A study in Germany found that 27.4% of postgraduate medical students had experienced at least one needlestick injury, with 18.8% not reporting it because of fear of repercussions, perception that the injury was minor, or advice from mentors not to report it (*18*). Similar underreporting among Croatian students may mean that the true burden of injury is underestimated.

There was no significant difference in reported needlestick and sharps injuries before and during the COVID-19 pandemic in Croatia. Nationally, 1544 cases were reported in 2018–2019 and 1930 in 2020–2022. The corresponding numbers were 400 and 482 at UHC Zagreb, and 178 and 194 at UHC Sestre Milosrdnice.

This finding is consistent with a study from a Croatian COVID-19 hospital, which found that the absolute number of injuries remained stable during the pandemic, although the rate of injuries per hospital activity increased (*19*). This suggests that infection control measures and reporting systems remained largely intact despite the pressures of the pandemic. Changes in hospital workload, greater use of personal protective equipment, and shifts in patient care may have affected exposure risks and reporting. These findings highlight

Figure 2 Reported needlestick and sharps injuries before and during the COVID-19 pandemic, Croatia, 2018–2022



the need for stronger prevention policies and continuous monitoring to protect health care workers, especially during health crises.

Study strengths and limitations

Using national surveillance data and institutional records from 2 of the largest hospital centres in Croatia, this analysis provides important evidence on reported needlestick and sharps injuries over a 5-year period. Its main strength is the combined assessment of national trends and detailed institutional data by exposure type, occupational group and pandemic period. As one of the first Croatian analyses of reported needlestick and sharps injuries, it helps identify priority groups and exposure patterns for prevention.

Several limitations should be considered. The retrospective design means that the findings depend on the completeness and accuracy of routine reporting. Some professional groups, particularly students and cleaning staff, may have underreported their injuries. Although data were collected from 2 major hospital centres, the results may not be generalisable to all health care facilities in Croatia. Information on age, sex, duration of employment and department was not available in the institutional records, limiting assessment of individual and workplace risk factors. Differences in reporting protocols and varying levels of awareness among health care workers may have affected the observed injury rates. Minor inconsistencies between table totals likely reflect variations in data completeness and classification within national and institutional reporting systems.

Conclusion

Needlestick and sharps injuries remain a significant occupational risk in Croatian health care settings, particularly among nurses and medical technicians. Injury patterns were consistent with global trends, and reporting remained broadly stable during the COVID-19 pandemic. Strengthening prevention strategies, education, safer sharps handling and reporting systems are essential to reduce occupational exposure among health care workers in Croatia.

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Three-year analysis of suspected child abuse and neglect at a regional hospital in Oman

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Abstract

Background: Evidence on the patterns and sociodemographic characteristics of suspected child abuse and neglect in Oman remains limited, particularly outside the national capital region.

Aim: To assess the patterns and sociodemographic characteristics of suspected child abuse and neglect cases at a regional hospital in Oman.

Methods: We collated and analysed data on suspected child abuse and neglect cases among children aged 0–18 years from Rustaq Hospital, Oman, for the period August 2020 to August 2023. Descriptive statistics and chi-square tests were used to assess associations between abuse type, age, sex and parental marital status. $P < 0.05$ was considered statistically significant.

Results: Neglect was most frequently reported (58.2%) among the 256 suspected cases, especially among children aged 0–4 years. Physical and sexual abuse were more frequent among older children, and emotional abuse among children from single-parent households. Neglect was higher among boys than girls (69.2% vs 48.9%; $P = 0.001$), while sexual abuse was more common among girls (34.5% vs 11.1%; $P < 0.001$). Overall, abuse type was significantly associated with age, sex and parental marital status.

Conclusion: Age, sex and parental marital status were associated with patterns of suspected child abuse and neglect in this regional hospital. Strengthening early detection, family support and targeted prevention may help improve child protection in this setting.

Keywords: child abuse, child neglect, child protection, sexual abuse, family support, Oman

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Background

Child abuse and neglect are major global public health and child protection concerns that can have long-term physical, psychological and social consequences for affected children. WHO estimates that up to one billion children worldwide experience neglect or physical, sexual or emotional violence each year (*1*). Ending abuse, exploitation, trafficking and all forms of violence against, and torture of, children is a specific target of the 2030 Agenda for Sustainable Development (*2*).

Child maltreatment was historically treated as a private family matter and was often hidden from public scrutiny. The description of the "battered child syndrome" in 1962 helped establish child abuse as a clinical and public health concern (*3*). In Euro-American societies, the increasing recognition that followed led to more stringent child protection legislation (*4*). The United Nations adopted the Convention on the Rights of the Child (CRC) in 1989, establishing a global legal framework for child protection. Oman and other Gulf Cooperation Council (GCC) countries have ratified the Convention (*5*).

Oman strengthened its child protection framework through Royal Decree No. 22/2014, which established a new Child Law (*6*). Child protection committees now operate at national, governorate and hospital levels, and a toll-free 24-hour helpline is available for emergency reporting. National guidelines require health care workers to notify suspected cases within 48 hours, and trained child protection delegates have quasi-judicial powers to intervene. A recent assessment against the WHO INSPIRE framework found that Oman's child protection system reflected all 7 strategic pillars, but recommended stronger intersectoral coordination and a unified electronic case-management platform to improve child safety (*7*).

Child abuse and neglect may remain difficult to identify and report, even in settings with established child protection systems (*8*). Reporting barriers are more pronounced in collectivist and honour-based societies, including GCC countries such as Oman, where family privacy and reputation are highly valued (*9*). These cultural and social barriers may contribute to the limited research on child abuse and neglect in Gulf Cooperation Council countries. Similar reluctance to disclose and report abuse has also been described in Asian settings (*10*).

Social attitudes in Middle Eastern societies are gradually changing, and child abuse and neglect are increasingly recognised as health and social protection issues. Recent studies from Oman have begun to document child protection capacities, child maltreatment, adverse childhood experiences and severe injuries associated with neglect (*11*,*12*). However, empirical data on the patterns and sociodemographic factors associated with child maltreatment in the country remain limited. The relatively recent development of support services for vulnerable children highlights the need for evidence to inform prevention, detection and referral pathways.

Understanding the types of abuse reported and the sociodemographic characteristics of affected children and their families is essential for designing targeted interventions. Recent studies from Oman have begun to document the prevalence, nature and long-term consequences of child abuse and neglect (*11*–*14*). However, most available evidence comes from urban and more cosmopolitan populations, while data from less urbanised regions remain scarce. Hospital-based evidence is also limited (*13*).

This study therefore examined the patterns of child abuse and neglect and their association with sociodemographic characteristics among cases identified by a dedicated service at a regional hospital outside the national capital region of Oman. The findings may inform child protection policy, health care practice and social services.

Methods

Study design

We conducted a retrospective descriptive study at Rustaq Hospital, a secondary care centre in South Al Batinah governorate, Oman, from August 2020 to August 2023. Rustaq Hospital receives referrals for child, adolescent and adult health services from primary health care centres across the governorate, which accounts for 10% of Oman's population. The study was conducted within the framework of the hospital's Suspected Child Abuse and Neglect (SCAN) service. The service conducts awareness activities on child abuse and neglect through workshops, lectures and online sessions for government and social institutions, which may have contributed to an increase in referrals during the study period.

The study included children aged 0–18 years who were referred to the SCAN service at Rustaq Hospital because of suspected abuse or neglect. The upper age limit was based on Oman's child law definition of a child. Referrals came from health care professionals, educators, law enforcement officers and representatives of the Ministry of Social Development. Established in 2020, this was Oman's first specialised hospital-based programme for suspected child abuse and neglect and follows international assessment standards.

Data collection

Data were extracted retrospectively from the electronic database maintained by the SCAN service. Each case underwent comprehensive evaluation by a senior paediatrician trained in the assessment of child abuse and neglect cases according to international standards. The evaluation included non-leading interviews, detailed history-taking and thorough physical examination. Information was documented and stored securely in the database. Extracted variables included the child's sex, age at presentation, type(s) of abuse, perpetrator details, and parental marital status. Reported abuse types were classified as neglect, physical, sexual, emotional or other. The "other" category included high-risk behaviours or child protection concerns that did not fit the main categories.

Data analysis

Data were analysed using the R statistical software (*15*). Categorical variables, including abuse type, sex, age group and parental marital status, were summarised as frequencies and percentages. Continuous variables, such as age and number of abuse types per child, were summarised using means, standard deviations, minimums and maximums. Associations between abuse type and sociodemographic variables were assessed using chi-square tests. $P < 0.05$ was considered statistically significant.

Ethics considerations

This study was approved by the Research and Ethical Review and Approval Committee of South Al Batinah governorate, Oman (MoH/CSR/24/28844; 5 September 2024). All data were de-identified to protect participant confidentiality and anonymity. The requirement for informed consent was waived because the study used retrospective anonymised data.

Results

Over the 3-year study period, 256 suspected child abuse and neglect cases involving children and adolescents aged 0–18 years were identified and included in the analysis. Table 1 shows the distribution of abuse by sex, age group and family structure, and the results of tests of association. Girls accounted for a slight majority of cases (139/256; 54.3%). Some children had more than one reported abuse type.

More than one-third of the cases (37.5%) were among children aged 5–12 years, followed by those aged 1–4 years (31.6%), < 1 year (19.5%) and > 12 years (11.3%). All abuse types were significantly associated with age. The age-group-specific proportions of physical, sexual, emotional and other abuse increased in older age groups, whereas neglect decreased from 70.0% among children aged < 1 year to 41.4% among those aged >12 years. Neglect was significantly more frequent among boys than girls (69.2% vs. 48.9%; $P = 0.001$), while sexual abuse was higher among girls than boys (34.5% vs. 11.1%; $P < 0.001$).

Family structure was significantly associated with the type of abuse reported (χ^2 = 61.2039, P < 0.001). Emotional abuse was more common among children from single-parent households than among those from two-parent households (52.5% vs 12.0%). Although the number of neglect and "other" cases was higher among children from two-parent households, this may reflect their greater representation in the sample (n = 216 vs n = 40). Physical and sexual abuse varied significantly by family structure, with higher proportions reported among children from single-parent homes (Table 1). More than half of the children (57.3%) had one reported abuse type, while 23.9% had 2, 8.6% had 3, 7.8% had 4 and 2.4% had 5. Concerns classified as "other" were recorded for 45.3% of the cases (Table 1).

The details of reported sexual abuse are presented in Table 2. Nearly a quarter of the cases (23.8%) involved sexual abuse, with significantly higher rates among girls than boys (34.5% vs 11.1%). In most cases, the perpetrator was a close/trusted relative (60.7%) and most victims were girls, followed by a friend or schoolmate (23.0%). Cases involving friends were reported among older children, and most involved online contacts (93%). Girls were more commonly affected than boys (Table 2).

The children were aged 0.1–18 years, with a mean age of 5.6 ± 4.9 years. Each child had a mean of 1.7 ± 1.1 reported abuse types, ranging from 1 to 5. The mean number of reported abuse types increased with age, from 1.2 ± 0.4 among infants aged < 1 year to 1.5 ± 0.9 among children aged 1–4 years, 1.9 ± 1.1 among those aged 5–12 years, and 2.9 ± 1.1 among those aged > 12 years.

Discussion

This study examined 256 reported cases of suspected child abuse and neglect over 3 years at a regional hospital in Oman, adding to the limited evidence from outside the national capital region. The findings showed that some cases involved multiple overlapping forms, underscoring the need for a multifaceted and context-specific approach to child protection in Oman.

Neglect

Neglect was the most frequently reported form of abuse in this study and was most common among children aged 0–4 years, similar to global findings (*16*). In our study, neglect was more common among boys than girls. This contrasts with reports from many non-Western settings, including India and parts of Africa and South-East Asia, where girls are more likely to experience neglect (*17,18*). However, a similar pattern has been reported in Saudi Arabia, where neglect was slightly more common among boys than girls (*19*). Further research is required to understand why this pattern is observed in GCC countries, including the possible role of cultural norms.

Child sexual abuse

Child sexual abuse was reported in nearly a quarter of the cases. In addition to psychological trauma, sexual

Table 1 Distribution of suspected child abuse and neglect type by sex, age group and family structure, Oman, 2020–2023 (N = 256)

Type of abuse	Sex of child				Age group					Family structure		
	Cases, n (%)	Girls n (%)	Boys n (%)	χ^2 (*P* value)	< 1 year n (%)	1–4 years n (%)	5–12 years n (%)	> 12 years n (%)	χ^2 (*P* value)	Single-parent household n (%)	Two-parent household n(%)	χ^2 (*P* value)
Neglect	149 (58.2%)	68 (48.9%)	81 (69.2%)	10.772 (0.001)*	35 (70.0%)	51 (63.0%)	51 (53.1%)	12 (41.4%)	8.006 (0.046)*	28 (70.0%)	121 (56.0%)	2.712 (0.100)
Physical abuse	72 (28.1%)	39 (28.1%)	33 (28.2%)	0.001 (0.979)	7 (14.0%)	14 (17.3%)	31 (32.3%)	20 (69.0%)	34.397 (<0.001)*	20 (50.0%)	52 (24.1%)	11.222 (0.001)*
Sexual abuse	61 (23.8%)	48 (34.5%)	13 (11.1%)	19.200 (<0.001)*	2 (4.0%)	18 (22.2%)	24 (25.0%)	17 (58.6%)	30.360 (<0.001)*	15 (37.5%)	46 (21.3%)	4.882 (0.027)*
Emotional abuse	47 (18.4%)	27 (19.4%)	20 (17.1%)	0.230 (0.631)	0 (0.0%)	10 (12.3%)	25 (26.0%)	12 (41.4%)	27.231 (<0.001)*	21 (52.5%)	26 (12.0%)	36.866 (<0.001)*
Other	116 (45.3%)	68 (48.9%)	48 (41.0%)	1.598 (0.206)	16 (32.0%)	29 (35.8%)	47 (49.0%)	24 (82.8%)	23.457 (<0.001)*	33 (82.5%)	83 (38.4%)	26.457 (<0.001)*
All reported abuse types†	445 (173.8%)†	250 (179.9%)†	195 (166.7%)†	—	60 (120.0%)†	122 (150.6%)†	178 (185.4%)†	85 (293.1%)†	—	117 (292.5%)†	328 (151.9%)†	—
Total cases	256	139	117	—	50	81	96	29	—	40	216	—

**Significant at P < 0.05*

Other = high-risk behaviours or child protection concerns that did not fit the main categories, including reckless driving, dysfunctional romantic relationships, suicide ideation or attempts, truancy or absenteeism from school, running away from home, and unusual or extreme religious ideation

†Totals and percentages exceed 100% because some children experienced more than one type of abuse

Chi-square values and corresponding P values assess the association between each abuse type and the relevant sociodemographic variable.

Table 2 Details of reported child sexual abuse cases, Oman

	Perpetrator		Affected children		
	Male	Female	Total cases	Girls	Boys
Close/trusted relative	33	4	37	33	4
Friend/ schoolmate	15	0	15	12	3
Offline friend	1	0	1	0	1
Online friend (OSCE)	14	0	14	12	2
Neighbour	4	0	4	0	4
Housemaid	0	1	1	1	0
Stranger	Unknown	Unknown	4	2	2
Total	52	5	61	48	13

OSCE = online sexual child exploitation

abuse may cause serious physical injuries, especially among infants and young children. Internationally, approximately 30% of child sexual abuse is perpetrated by family members, around 60% by known and trusted individuals, and only 10% by strangers (*20*). Most perpetrators identified in this study were male, and many were close relatives or trusted individuals, similar to reports from other settings (*21*). Although reports of child sexual abuse perpetrated by female relatives are rare, underreporting is possible and should be considered when assessing suspected cases.

In this study, sexual abuse was reported more often among girls than boys, consistent with global literature (*16*,*22*). However, some research in the Middle East and China suggests underreporting of sexual abuse among girls due to social restrictions and a culture of silence (*10*,*23*). These findings underscore the importance of culturally sensitive methods for eliciting accurate disclosures and providing effective support.

Online sexual exploitation was reported in 14 cases, including 12 involving girls. Although internet controls and firewalls are used in Oman and other Gulf Cooperation Council countries to block sexual content, these measures may not adequately protect children from risks associated with social media and smartphone use. This finding is notable because evidence on online sexual exploitation of children remains limited in the Middle East and North Africa (*24*). Prevention efforts should include guidance for parents and caregivers on monitoring children's online activities, including smartphone use.

Age, sex and family structure

Abuse type differed significantly by age, consistent with global evidence (*16*). Physical and sexual abuse were more frequent among older children, whereas neglect was more common among younger children. Emotional abuse increased with age, particularly among adolescents. Younger children, especially those aged 0–4 years, were more likely to experience one type of abuse, which may reflect their dependence on primary caregivers and limited interactions outside the home. Children aged > 12 years had the highest mean number of reported abuse types. This may reflect greater exposure to social environments and greater ability to recognise and disclose various forms of abuse, as described in the wider literature (*25*).

Patterns differed by sex. In this study, neglect was reported more often among boys, while sexual abuse was more common among girls. These differences may reflect sex-related patterns of risk, care-seeking or reporting, and should be interpreted in light of cultural norms and stigma. Social expectations could explain why boys may receive less supervision, while concerns about sexual abuse of girls may be more likely to prompt formal reporting (*26*). Non-offending parents, often mothers, may face pressure to remain silent, a phenomenon reported globally, including in the Middle East (*27*). This highlights the need to support non-offending parents, especially mothers, to recognise abuse, seek help and report concerns safely.

Family structure was another relevant factor. Children from single-parent households experienced emotional, physical and sexual abuse more often than those from two-parent households, suggesting that family structure may shape patterns of suspected child abuse and neglect in this hospital sample. Additional social or economic stressors may increase vulnerability to maltreatment in some single-parent households (*12*). A retrospective review of 220 child abuse and neglect cases in Saudi Arabia found that children living in single- or step-parent households were 4 times more likely to experience physical abuse than those from two-parent households (*28*). Although the Saudi study focused on physical abuse, its findings align with ours in indicating the need for family-centred strategies, including social, financial and mental health support for single-parent households.

Implications for practice and policy

Although most children experienced one form of abuse, many had 2 or more. The overlap between neglect, physical abuse, sexual abuse, emotional abuse

Table 3 **Age distribution and number of reported abuse types per case, Oman**

Age group	Number of children, n (%)	Mean age ± SD; range (years)	Number of reported abuse types per child, mean ± SD; range
< 1 year	50 (19.5)	0.4 ± 0.2; 0.1–0.9	1.2 ± 0.4; 1–2
1–4 years	81 (31.6)	2.37 ± 1.1; 1.0–4.0	1.5 ± 0.9; 1–4
5–12 years	96 (37.5)	8.15 ± 2.2; 5.0–12.0	1.9 ± 1.1; 1–5
> 12 years	29 (11.3)	15.1 ± 1.7; 13.0–18.0	2.9 ± 1.10; 1–5
Total	256 (100.0)	5.6 ± 4.9; 0.1–18.0	1.7 ± 1.1; 1–5

SD = standard deviation

and other safeguarding concerns underscores the need for integrated child protection interventions as recommended by UNICEF (*5*). Health care and social service providers should be trained to recognise less clearly defined abuse types including those classified as "other" in this study, and to ensure appropriate referral, follow-up and support.

The number of cases identified by the SCAN service highlights the value of dedicated hospital-based SCAN teams for identifying, documenting and referring suspected cases. The service conducts awareness activities on child abuse and neglect through workshops, lectures and online sessions targeting various government and social institutions, which may have contributed to the increase in referrals during the study period. Health care professionals including doctors, nurses and social workers play a pivotal role in identifying child abuse, as shown in studies from Saudi Arabia and Oman (*29,30*). Early recognition, clear documentation and timely referral can improve outcomes for vulnerable children (*31*). Systematic screening protocols in hospitals and emergency departments may be especially useful for detecting cases that may otherwise remain hidden.

Compared with settings where legal sanctions, child education and help-seeking mechanisms for child sexual abuse are more established, many Middle Eastern and Asian settings have only recently begun to address these issues and continue to face barriers related to cultural taboos (*24,32,33*).

The SCAN service in this study encountered considerable resistance to disclosure and reporting from the families and victims, reflecting a persistent culture of silence and concerns about family honour. Child protection efforts in Oman should therefore include community-wide education initiatives, particularly for mothers, robust legislative measures, and culturally sensitive mechanisms for reporting and intervention. Parents should receive guidance on monitoring their children's online social activities.

Study limitations

Although this study adds to the limited evidence on suspected child abuse and neglect outside the national capital region of Oman, it was conducted in a single regional hospital, which may limit the generalisability of findings to other regions of the country. Unreported cases were not captured, and stigma associated with certain forms of abuse may have influenced disclosure, reporting and the observed distribution of cases.

Conclusion

During the 3 year review period, neglect was the most frequently reported form of suspected child abuse and neglect, followed by physical, sexual and emotional abuse. The findings highlight the value of dedicated hospital-based child protection services for early identification, documentation and referral, particularly in settings where cultural barriers may limit disclosure and reporting. They support the consideration of establishing similar teams in all health centres in Oman and other GCC countries.

Many cases involved multiple overlapping abuse types. Neglect was reported more often among boys, whereas girls accounted for a larger share of sexual abuse cases, including online sexual exploitation. Emotional abuse was more common among children from single-parent households. Addressing these issues requires prevention, early detection and coordinated action by health care providers, social services and legal authorities. Future research should focus on underreported abuse types, underlying risk factors, cultural barriers to disclosure and reporting, and the development of culturally sensitive interventions, while fostering collaboration among schools, health care providers, religious authorities and law enforcement agencies to create safer environments for children.

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Socioeconomic inequalities in noncommunicable disease mortality in Islamic Republic of Iran

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Abstract

Background: Limited evidence on the socioeconomic inequalities in mortality due to noncommunicable disease hampers the development and implementation of policies to improve health equity in Islamic Republic of Iran.

Aim: To assess the socioeconomic inequalities in mortality caused by major noncommunicable diseases across provinces and districts in Islamic Republic of Iran.

Methods: We obtained data for all deaths attributed to noncommunicable disease (1 105 000) for the period 2016–2018 across 429 districts in 31 provinces of Islamic Republic of Iran. We also obtained aggregated household income and expenditure data from the statistical centre. We analysed the data with R version 4.5.1, using the index of disparity to measure inequality and regression-based relative index of inequality to measure socioeconomic inequalities in noncommunicable disease mortality.

Results: The average noncommunicable disease mortality ranged from 36.02 per 100 000 population in Kohgiluyeh and Boyer-Ahmad to 73.06 per 100 000 in Golestan. The index of disparity was >40% in Chaharmahal and Bakhtiari, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad, and <20% in Semnan and Qazvin. Cardiovascular disease mortality showed the highest difference between adjacent socioeconomic groups, decreasing from 144.1 to 118.5 per 100 000 population between the first and second groups.

Conclusion: Noncommunicable disease mortality varied across provinces and socioeconomic groups, particularly for cardiovascular disease mortality. To reduce inequalities in mortality due to noncommunicable disease within and between the provinces, there is a need to strengthen health inequality monitoring using evidence on the causes of death, risk factors and the social determinants of health.

Keywords: noncommunicable disease, mortality, cardiovascular disease, diabetes, chronic respiratory disease, socioeconomic inequality, social determinants of health, health equity, health policy, Iran

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Background

The increasing burden of noncommunicable diseases (NCDs) is a major global health challenge and an important driver of inequalities between countries and within societies. NCDs cause an estimated 35 million of the 53 million deaths worldwide each year and, by 2030, are projected to be responsible for 8 of every 10 deaths (1,2). More than 75% of these deaths occur in low- and middle-income countries (LMICs), disproportionately affecting people of lower socioeconomic status (3,4). WHO has therefore identified NCD prevention and control as a global health priority, particularly in the LMICs (3).

Most evidence on socioeconomic inequalities in NCDs comes from high-income countries, where incidence and mortality are often higher among disadvantaged and marginalized populations than among higher socioeconomic groups (*3,5,6*). Evidence on subnational NCD inequalities in LMICs remains limited, making it difficult to plan, implement and evaluate strategies to reduce the NCD burden. Health equity has therefore become an important policy concern, with increasing emphasis on the role of socioeconomic inequalities in shaping health outcomes (*7–10*).

Socioeconomic status affects health indirectly, especially through access to health care (*11,12*). This makes health inequities particularly important for lower socioeconomic groups, whose access to and use of health services may be constrained by financial and social circumstances (*3,13,14*). People living with NCDs are particularly vulnerable to health inequalities because they often need long-term costly care, and illness may reduce their capacity to work and earn income (*15*). Monitoring health equity is therefore both a public health priority and a human rights obligation, and has become increasingly important in many countries (*16*).

In Islamic Republic of Iran, as in many other settings, NCDs, including cardiovascular diseases (CVDs), cancer,

chronic respiratory diseases and diabetes, are the leading causes of death and account for 78·1% of disability-adjusted life years (*17*). Their prevention and control have therefore become a major political commitment, reflected in the establishment of the multisectoral Iranian Noncommunicable Diseases Committee (INCDC) within the Ministry of Health and Medical Education (MOHME) (*18*). However, despite efforts to measure the NCD burden, little is known about inequalities across socioeconomic groups. This evidence gap is important because reducing socioeconomic inequalities is a national policy priority (*19–22*). Interpreting inequalities in NCDs differs from interpreting other health outcomes because NCD risk factors, incidence, prevalence and mortality vary across socioeconomic groups and contexts (*23*).

Previous studies in Islamic Republic of Iran have not fully assessed inequalities in NCD mortality across the country (*20,24–26*). Several of these studies have examined regional differences in mortality from specific diseases or geographical variation in NCD mortality alone (*4,18,25,26*). Analyses that do not consider socioeconomic inequalities may underestimate the true burden of NCD mortality. People with NCDs often require long-term care but may delay or avoid seeking services when facing financial hardship, thus increasing their risk of death. Because NCD risk factors and disease patterns are complex, NCD management systems should be tailored to disease characteristics, service setting, perceived needs and available resources (*27*). Given the remaining evidence gaps, applied research is needed to support equitable access and efficient use of resources. This study assessed subnational inequalities in mortality caused by major NCDs, including neoplasms, cardiovascular diseases, diabetes and chronic respiratory diseases, in Islamic Republic of Iran.

Methods

Data sources

The National Organization for Civil Registration (NOCR) is legally responsible for registering civil events in Islamic Republic of Iran, including births, marriages, divorces, and deaths. However, because cause-of-death data from civil registration may be incomplete or inaccurate, MOHME established a parallel death registration and classification system to improve mortality data.

The MOHME death registration system was piloted in a few provinces in the late 1990s and progressively expanded nationwide, reaching all provinces, including Tehran, by 2015. The system collects and cross-verifies cause-of-death data from hospitals, cemeteries, and the NOCR to ensure completeness and validity.

We used individual death records from the MOHME death registration system for all deaths attributed to NCDs across 31 provinces and 429 districts during 2016–2018 (N = 1 105 000). We obtained aggregated household income and expenditure data at city and provincial levels from the Statistical Center of Iran and used model-based clustering to classify districts according to socioeconomic status indicators. Districts were then grouped into 4 quartiles from poorest to richest.

Classification of NCD subtypes

We categorised NCD mortality into 4 major groups using ICD-10 codes and the classification systems of MOHME and the Global Burden of Disease study: neoplasms (C00–D48); cardiovascular diseases, including ischaemic heart disease, cerebrovascular disease, hypertensive heart disease and other cardiovascular conditions; diabetes mellitus (E10–E14); and chronic respiratory diseases, including chronic obstructive pulmonary disease, asthma and other chronic lower respiratory diseases (J40–J47).

Covariates

Covariates in the multilevel mixed-effects model were district population, illiteracy rate, proportion of the population with university education, number of households with more than 5 members, and urban population, based on the 2016 Census. To reduce the effect of annual fluctuations in reported NCD deaths, particularly in smaller districts, we calculated the average NCD mortality rate for 2016–2018.

Data quality assurance

Data quality in the MOHME death registration system is supported through cross-verification with hospital and cemetery records and civil registration data. Trained coders review duplicate and inconsistent records at the provincial level, and causes of death are classified using ICD-10 codes with periodic audits to reduce misclassification. We used data that had undergone these quality-control procedures and averaged district-level mortality rates over 2016–2018 to reduce random fluctuations and reporting errors.

Data analysis

We fitted a multilevel mixed-effects Poisson regression to the observed NCD death counts in each district, using a log link and the log of district population as an offset. This allowed the model to estimate mortality rates rather than raw counts. The model was specified as follows:

$$Y\_pd \sim \text{Poisson}(mu\_pd)$$

$$\log(mu\_pd) = beta\_0 + b\_p + \sum_{k=1}^{K} beta\_k\, X\_pd,k + \log(N\_pd)$$

where Y_pd is the number of deaths in district d of province p, μ_pd is the expected number of deaths, N_pd is the district population, β_0 the fixed intercept, $b_p \sim N(0,\sigma_p^2)$ is the province-level random effect, $X_pd,_k$ represents K district-level covariates, and β_k represents their regression coefficients.

We applied Cook distance to identify influential outliers, using a threshold of 4/n. Districts exceeding this threshold were excluded from the final model (*28*). The multilevel structure accounted for clustering of district-level observations within provinces and reduced underestimation of standard errors.

We used the index of disparity to measure inequality in NCD mortality across districts within each province. The index was calculated as follows:

IDisp = [sum(i = 1 to J - 1) |r_i - r_ref| / r_ref] x 100

where r_j is the conditional mean mortality rate for district j, r_{ref} is the mortality rate for the corresponding province and J is the number of districts in that province.

We used the regression-based relative index of inequality (RII) to measure socioeconomic inequalities in NCD mortality. Concentration curves were used to assess whether NCD mortality was concentrated among poorer or wealthier districts after ranking districts by economic status. Greater deviation from the 45-degree line indicated greater equality. Curves above the line showed concentration of mortality among lower socioeconomic groups.

Data management, analysis and graphing were performed using R version 4.5.1 with the lme4 package for mixed-effect models and the ineq package for inequality analysis, including the concentration index and concentration curves (*29*).

The concentration index was calculated as follows:

C = [2 / (N x mu)] sum(i = 1 to N) h_i r_i - 1

where h_i is the health variable value, defined here as the district-level NCD mortality rate for district r; r_i is the fractional socioeconomic rank of each district, ordered from poorest to richest; N is the total number of districts, and μ is the mean mortality rate.

Confidentiality and data protection

We used fully anonymised secondary mortality data from the MOHME death registration system, with no personal identifiers. Analyses were conducted at district or provincial levels, and data access was limited to the research team in accordance with MOHME and Tehran University of Medical Sciences ethics requirements.

Figure 1 Estimated average mortality rates due to major noncommunicable diseases by district

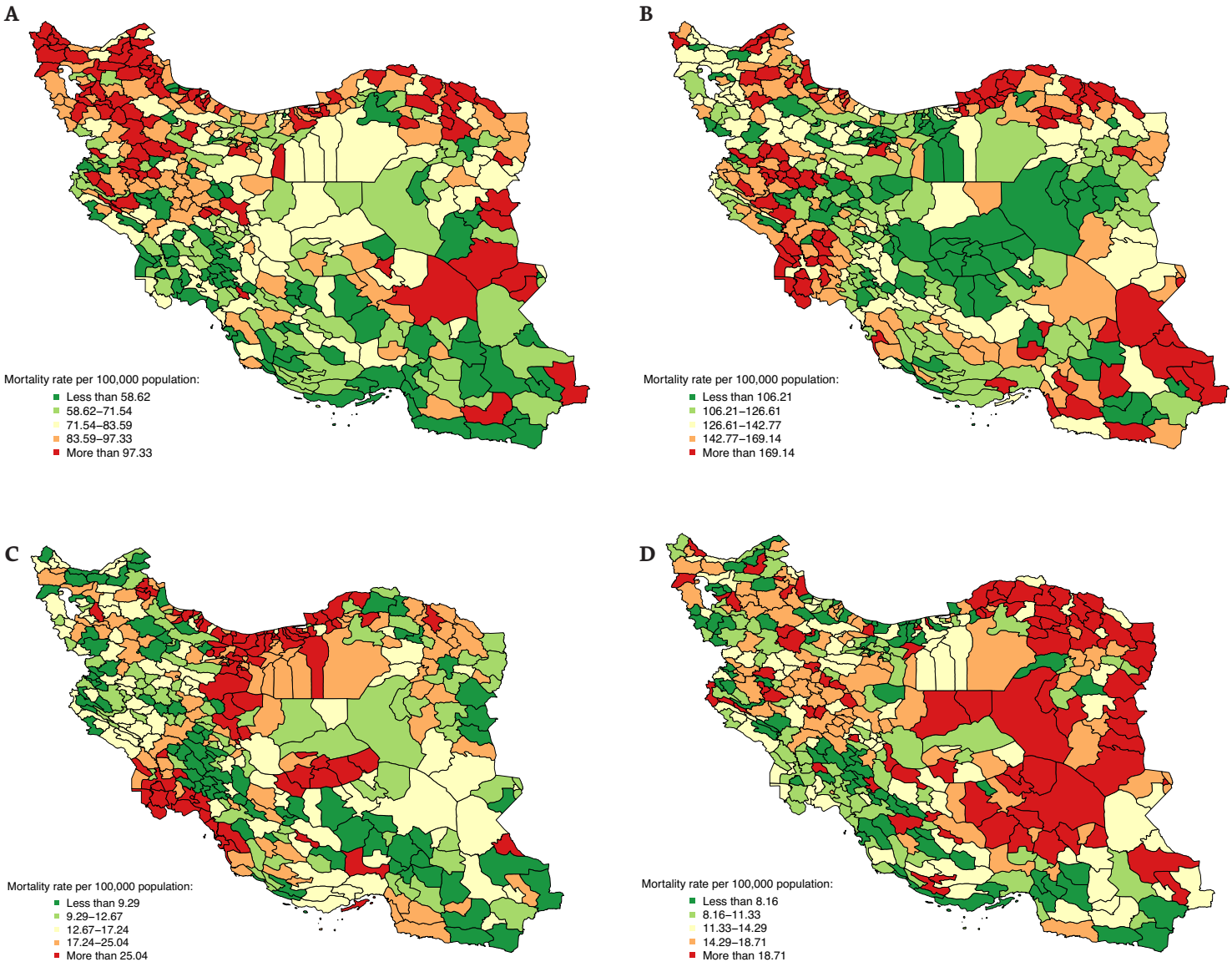


Table 1 Average mortality rates (per 100 000 population) due to major noncommunicable diseases, and inequality indices by province, 2016–2018

Province	Mortality rate per 100 000 population				Relative index of inequality				Index of disparity (%)			
	Neoplasms	Cardiovascular diseases	Diabetes	Chronic respiratory disease	Neoplasms	Cardiovascular diseases	Diabetes mellitus	Chronic respiratory disease	Neoplasms	Cardiovascular diseases	Diabetes mellitus	Chronic respiratory disease
Alborz	66.38	98.88	22.75	8.00	2.24	1.60	2.68	1.98	15.13	16.14	24.84	34.17
Ardabil	99.19	126.65	17.77	12.24	1.71	1.68	7.48	12.02	10.79	13.92	43.15	45.08
East Azerbaijan	93.02	128.38	15.60	12.98	2.12	3.64	6.80	6.35	12.48	22.68	29.84	42.21
West Azerbaijan	94.85	113.52	13.32	11.00	1.82	1.69	4.72	7.40	16.67	13.82	24.81	36.57
Bushehr	56.33	112.44	23.41	6.95	3.14	2.97	7.93	3.06	29.71	28.87	36.02	30.33
Chaharmahal and Bakhtiari	50.26	98.21	5.37	7.69	2.15	1.53	5.04	12.86	17.65	13.68	89.79	62.24
Fars	65.57	115.20	13.09	12.57	2.93	1.67	12.98	10.82	20.16	11.79	35.30	37.65
Gilan	88.35	146.74	27.00	11.44	2.94	3.29	7.50	7.66	16.67	14.65	42.55	33.15
Golestan	81.02	173.97	21.27	15.99	2.17	1.47	3.83	6.71	14.53	10.91	27.05	39.50
Hamedan	76.79	138.39	11.73	13.96	2.17	2.07	2.98	2.55	16.19	21.17	25.52	17.69
Hormozgan	40.57	104.64	13.46	7.05	6.99	2.91	4.87	3.08	29.32	23.34	31.61	32.93
Ilam	64.63	107.67	12.02	9.68	3.16	1.87	3.44	4.16	22.22	16.05	20.13	42.15
Isfahan	69.69	94.98	16.97	10.02	1.80	2.03	7.87	3.61	12.91	15.13	39.12	36.14
Kerman	63.50	106.11	8.67	30.46	3.06	3.71	7.08	13.45	22.55	23.51	36.65	50.00
Kermanshah	83.08	145.51	9.00	12.75	2.14	1.82	4.54	8.93	22.01	14.40	37.86	49.26
North Khorasan	79.95	142.78	11.14	22.12	3.02	1.96	7.00	2.63	19.13	14.14	66.49	29.46
Razavi Khorasan	78.50	121.36	18.76	18.86	2.73	3.00	9.68	6.06	19.36	20.97	34.88	29.78
South Khorasan	59.93	96.76	10.38	19.10	2.55	2.18	3.69	4.61	27.21	18.59	30.36	41.81
Khuzestan	61.33	146.14	31.65	9.17	3.15	2.57	22.45	24.64	19.00	20.94	45.71	45.18
Kohgiluyeh and Boyer-Ahmad	44.43	85.59	6.53	7.53	4.69	1.88	5.70	2.67	38.04	24.28	46.77	57.91
Kurdestan	70.51	115.77	9.35	10.09	1.76	2.02	3.23	4.54	17.39	20.06	36.29	27.39
Lorestan	64.61	107.83	11.74	14.87	2.93	2.94	2.15	6.73	25.40	29.75	20.04	36.57
Markazi	74.47	99.12	13.39	13.74	2.42	2.06	2.82	3.78	17.17	19.32	28.11	24.65
Mazandaran	79.14	104.82	34.89	9.37	2.68	1.90	7.43	4.43	12.81	16.01	32.40	45.64
Qazvin	75.36	110.15	12.25	12.09	1.57	1.38	2.78	1.79	11.72	14.41	23.87	13.25
Qom*	72.10	100.59	24.99	16.64	-	-	-	-	-	-	-	-
Semnan	69.17	104.20	19.21	11.39	2.12	1.63	2.79	1.62	13.21	16.98	17.92	16.01
Sistan and Baluchistan	49.79	158.74	10.15	14.89	9.80	5.26	4.85	26.06	45.57	30.44	41.84	50.60
Tehran	79.70	90.69	27.24	9.19	3.51	2.62	7.55	5.79	26.05	27.39	38.38	34.46
Yazd	68.16	68.07	29.05	9.87	2.80	1.48	6.29	2.70	14.91	6.67	35.49	36.78
Zanjan	68.48	96.77	8.30	13.27	2.02	1.42	3.07	3.79	20.46	14.07	35.32	39.37

*Qom has only one city, therefore, inequality indices could not be calculated

Ethics approval

This study used licensed secondary data from the Ministry of Health and Medical Education. Ethics approval and waiver of consent were granted by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.VCR.REC.1397.230).

Results

For 2016–2018, the average neoplasm mortality rate at the city level was lowest in Jask (12.49 per 100 000) and highest in Khash (283.44 per 100 000) (Figure 1A). At the provincial level, Hormozgan had the lowest rate (40.57 per 100 000) and Ardabil the highest (99.19 per 100 000) (Table 1). The average CVD mortality rate at the city level was lowest in Nikshahr (53.93 per 100 000) and highest in Malayer (213.07 per 100 000) (Figure 1B). At the provincial level, Yazd had the lowest rate (68.07 per 100 000) and Golestan the highest (173.97 per 100 000) (Table 1).

The diabetes mellitus mortality rate at the city level was lowest in Kahnuj (4.68 per 100 000) and highest in Karun (101.67 per 100 000) (Figure 1C). At the provincial level, Chaharmahal and Bakhtiari had the lowest rate (5.37 per 100 000) and Mazandaran the highest (34.89 per 100 000) (Table 1). The average chronic respiratory disease mortality rate at the city level was lowest in Kazeroon (2.31 per 100 000) and highest in Haftgel (70.35 per 100 000) (Figure 1D). At the provincial level, Bushehr had the lowest rate (6.95 per 100 000) and Kerman the highest (30.46 per 100 000) (Table 1).

Sistan and Baluchestan had the highest inequality in neoplasm mortality (ID = 45.57%; RII = 9.80) while Qazvin had the lowest (ID = 11.72%; RII = 1.57). For CVD mortality, inequality was highest in Sistan and Baluchestan (ID = 30.44%; RII = 5.26) and lowest in Yazd (ID = 6.67%; RII = 1.48). For diabetes mellitus mortality, inequality was highest in Chaharmahal and Bakhtiari (ID = 89.79%; RII = 5.04), and lowest in Semnan (ID = 17.92%; RII = 2.79). For chronic respiratory disease mortality, inequality was highest in Chaharmahal and Bakhtiari (ID = 62.24%; RII = 12.86) and lowest in Qazvin (ID = 13.25%; RII = 1.79) (Table 1).

Across districts, mortality rates for all major NCD categories varied by socioeconomic group, increasing from the richest to the poorest groups. The largest difference was observed for CVD mortality between the first and second socioeconomic groups, suggesting the highest socioeconomic inequality for this cause of death (Figure 2).

The concentration curves varied by cause of death. Neoplasms and diabetes mellitus mortality was higher in the highest socioeconomic groups, whereas CVD mortality was concentrated in the lowest group; chronic respiratory disease mortality showed a less consistent pattern (Figure 3).

Discussion

Using aggregated mortality data from the MOHME death registration system and socioeconomic data from the Statistical Center of Iran, this study assessed geographical and socioeconomic inequalities in NCD mortality in Islamic Republic of Iran during 2016–2018. The results showed variations in mortality due to major NCDs across cities, districts and provinces.

Overall NCD mortality was more concentrated among lower socioeconomic groups. This pattern is consistent with evidence from other low- and middle-income countries showing higher NCD mortality among disadvantaged populations (*18,30,31*). However, this was not uniform across causes of death. CVD mortality was

Figure 2 Average mortality rates due to major noncommunicable diseases by district socioeconomic quartile and cause of death, 2016–2018

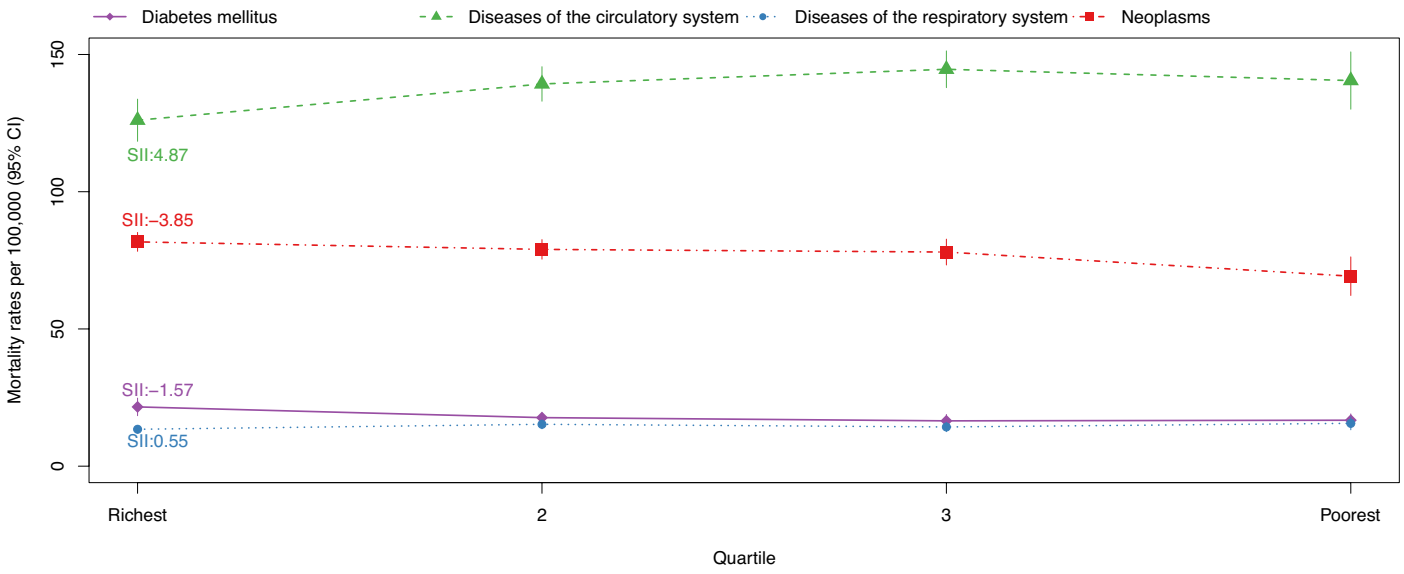
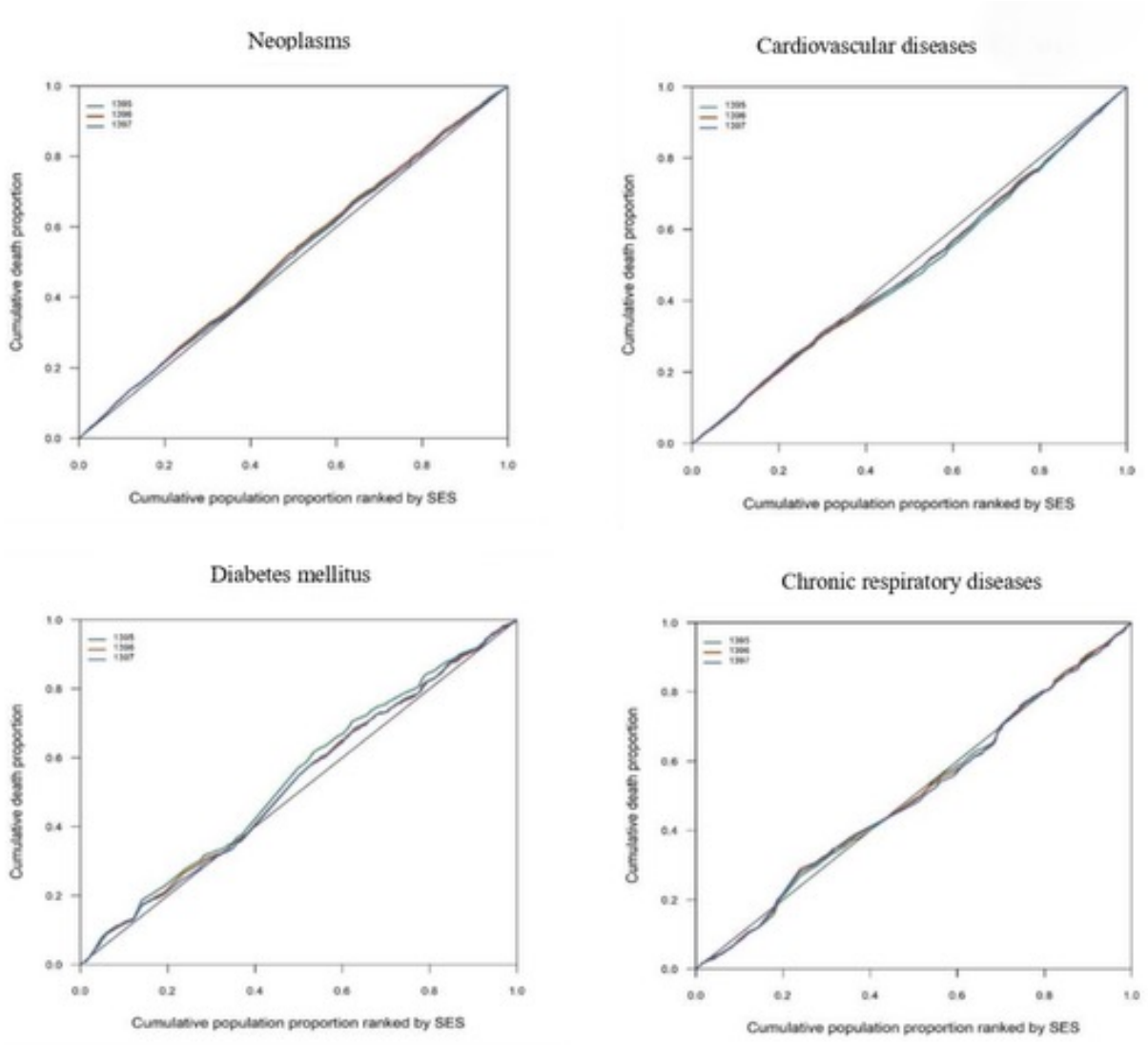


Figure 3 Concentration curves of mortality due to major noncommunicable diseases by socioeconomic status, 2016–2018



concentrated among the lower socioeconomic groups, whereas neoplasm and diabetes mellitus mortality were more common in higher socioeconomic groups. Provincial-level studies have similarly shown higher NCD mortality among populations with lower education, income and social status, which is consistent with our findings (*4*).

The index of disparity showed that inequality in chronic respiratory disease mortality varied more across provinces than inequality in mortality from other NCD causes. Differences in air pollution between provinces may partly explain this pattern, as previous studies have reported a high burden of mortality attributable to air pollution in Islamic Republic of Iran (*18,32,33*).

The concentration curves provided further evidence that socioeconomic patterns differed by cause of death. Neoplasm mortality was concentrated in the higher socioeconomic groups, similar to findings from Tehran showing higher cancer incidence in areas with higher economic status (*34*). CVD mortality was concentrated among the lower socioeconomic groups, in line with previous studies (*35*). Diabetes mellitus mortality was concentrated in the higher socioeconomic groups whereas a systematic review from Islamic Republic of Iran reported higher diabetes prevalence among lower socioeconomic groups (*25*).

Some provinces, particularly Sistan and Baluchestan and Chaharmahal and Bakhtiari, had notably high levels of inequality in NCD mortality. These disparities may reflect contextual factors such as economic deprivation, rurality, lower literacy, inadequate health infrastructure and limited access to specialised care (*36–38*). In Chaharmahal and Bakhtiari, mountainous geography and dispersed rural settlements may further limit access to health services (*37*). Environmental exposures may also contribute in some provinces, including those with high levels of air pollution (*39*). These findings highlight the need for more detailed provincial and city-level analyses of causes of death, disease burden and risk factors.

Future analyses should examine communicable and noncommunicable diseases separately and distinguish between urban and rural areas. Risk factors should be analysed by category, including metabolic (e.g. high blood pressure), behavioural (e.g. smoking) and environmental factors (e.g. air pollution). Identifying social determinants of health at the provincial level is essential for understanding regional disparities and designing more equitable NCD prevention and management policies.

Study limitations and strengths

This national study provides evidence on NCD mortality and related inequalities across Islamic Republic of Iran. However, several limitations should be considered. The absence of household-level socioeconomic data and district-level age-standardised mortality rates limited the depth of analysis and may have introduced demographic confounding, despite the use of multilevel models with demographic covariates. Socioeconomic status was estimated using district-level income and expenditure data and did not include other important dimensions such as education, occupation or housing quality. Future research should use multidimensional socioeconomic indicators to better assess social stratification. The study relied on licensed secondary data, and uncertainty was not quantified. Important sociocultural factors, including gender norms, cultural practices and differential barriers to health care access, were not fully captured. Future work should integrate standardised mortality rates, robust socioeconomic measures and sociocultural variables disaggregated by sex and age to inform effective and equitable policy interventions.

Conclusion

Improving access to NCD care and reducing inequalities in NCD mortality have long been priorities for health system policymakers in Islamic Republic of Iran. Establishing a sustainable health inequality monitoring system using existing structures and substructures, including social determinants of health research centres, could support these efforts, but will require strong commitment from policymakers and senior health system managers.

Our findings indicate that NCD mortality was concentrated among lower socioeconomic groups in Islamic Republic of Iran. More detailed studies are needed to assess inequalities in specific causes of death and disease risk factors, and to identify social determinants of health at the provincial level. Such evidence is essential for reducing health inequalities within and between provinces.

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Six-year trend of Crimean-Congo haemorrhagic fever cases in Islamic Republic of Iran

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Abstract

Background: Crimean-Congo haemorrhagic fever is a life-threatening vector-borne disease prevalent in many parts of the world.

Aim: To analyse and document the trend of Crimean-Congo haemorrhagic fever cases and fatality in Sistan and Baluchestan Province of Islamic Republic of Iran from 2018 to 2024.

Methods: Data on suspected cases of Crimean-Congo haemorrhagic fever for 2018–2024 were collected from the Communicable Disease Center of Zahedan University of Medical Sciences, Islamic Republic of Iran, and analysed using SPSS 27 and Stata 17.

Results: Of the 433 registered cases, 91 were confirmed and 16 were probable. Fatality rate was 11%. The highest number of cases was reported in 2019 (n = 167) and the lowest was in 2024 (n = 15), indicating a decreasing trend. The number of cases was higher during the winter months ($P < 0.001$).

Conclusion: Although there is a decreasing trend in the incidence of Crimean-Congo haemorrhagic fever in Sistan and Baluchestan Province, Islamic Republic of Iran, targeted interventions are needed to strengthen prevention, diagnosis and treatment, especially during the winter months.

Keywords: Crimean-Congo haemorrhagic fever, communicable disease, zoonosis, vector-borne disease, tick, Sistan, Baluchestan, Iran

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Background

Crimean-Congo haemorrhagic fever (CCHF) is the most widespread tick-borne human disease because of the extensive geographical distribution of the *Hyalomma* spp. tick vector (*1*). It is one of the most severe zoonotic viral diseases that occur in humans (*2,3*). Distribution of the CCHF virus matches that of ixodid hard ticks, with the main vectors being species of the genus *Hyalomma* (*1,4–6*). Wild and domestic animals represent an important link in the disease transmission cycle and play a key role in the spread of the virus. Animals may serve as asymptomatic reservoirs of CCHF virus, and transmission to humans occurs through tick bites, tick crushing on an open wound and contact with infected blood, body fluids, or animal or human tissues, and possibly through sexual contact (*3,5,7*).

CCHF is life-threatening and it has a vast geographic spread. A recent review reported that travel-associated CCHF appears uncommon and that transmission mainly occurs intra-continentally. However, exposure and diagnosis in different continents have been documented. Given the recently reported increased geographical distribution of ticks and CCHF in Europe, an increase in human cases may be anticipated in the near future (*1,8*).

CCHF is highly prevalent in Asia and the Middle East (*1*), and Southeast Asian countries are more vulnerable due to the increasing population and the developing nature of healthcare infrastructure and communities. Iran, Iraq, Turkey, and Uzbekistan have reported more than 50 CCHF cases per year, while Afghanistan, China, Egypt, India, Kazakhstan, Oman, Pakistan and the United Arab Emirates have reported 5–49 cases (*1*). Saudi Arabia and Turkmenistan have reported virologic and tick vector evidence while Jordan, Syria and Yemen have recorded tick vector presence. CCHF prevalence has been increasing annually in many countries, including China, Egypt, India, Islamic Republic of Iran, Iraq, Kazakhstan, Pakistan, Saudi Arabia, United Arab Emirates, and Turkey (*1*).

Islamic Republic of Iran and its eastern and western neighbours, Pakistan and Turkey, are endemic to CCHF (*1*). This disease has been reported in 27 out of 31 provinces of Islamic Republic of Iran, and Sistan and Baluchestan Province, located in the southeast, has been identified as an endemic area because of the unique ecologic conditions such as the hot and dry climate and a significant tick population.

The impact of CCHF on public health in Sistan and Baluchestan Province cannot be overemphasized. Outbreaks of the disease have occurred sporadically over the years, resulting in many hospitalizations and deaths (*9*). Challenges facing local health authorities include limited resources for prevention, diagnosis and treatment, as well as insufficient public awareness about the disease. The province has the highest number of CCHF patients in the country and it shares borders with countries where CCHF is endemic (*9*).

Certain tick species are considered the main reservoirs and vectors of the virus in Sistan and Baluchestan and different animals are suspected as vectors (*10,11*). Numerous wild and domestic animals, such as cattle, goat, sheep, ostrich, and hare can become infected and act as hosts without showing clinical symptoms. Although the viraemic phase is short (2–7 days) in a majority of vertebrate hosts, these hosts support the spread of the virus from one tick to another.

Rodents and shrews are widely distributed in peridomestic habitats and contact with human populations often occurs, posing a potential risk of disease transmission. A study reported the first known detection of CCHF virus RNA in rodents in Kenya (*10*). The virus sequences were found in house rats (*Rattus rattus*) and house mice (*Mus musculus*), both species known to inhabit human dwellings. *Rattus rattus* hosts a wide variety of harmful internal and external parasites, such as fleas and tick larvae, which harbour disease-causing microorganisms that can infect humans and animals resulting in serious diseases. *Mus musculus* lives as a human commensal in close association with humans in houses and granaries.

CCHF is clinically characterized by progressive haemorrhages, fever and muscle pain (*1*). The virus can remain in the blood of animals at 40°C for up to 10 days and in the liver for up to 40 days, throughout the lifespan of the tick (800 days).

Afghanistan and Pakistan are considered as source countries of CCHF for Islamic Republic of Iran (*14*). Heavy livestock such as camel, cattle and sheep are smuggled illegally from Afghanistan and Pakistan through the Sistan and Baluchestan borders and slaughtered and offered to the public without observing health standards. The indigenous people of these areas also crush infected ticks with their hands, keep livestock at home, illegally slaughter livestock in homes or public places, and have contact with blood and tissues of infected livestock.

Although studies have been conducted on variables that increase the probability of the disease (*11–13*) in Sistan and Baluchestan Province, no study has examined CCHF trend and associated mortality in recent years. Therefore, this study aimed to analyse and document the trend of CCHF cases and fatality in the province from 2018 to 2024.

Methods

Sistan and Baluchestan Province is the second largest of the 31 provinces in Islamic Republic of Iran, with an area of 181 785 km^2. It is located in the southeast of the country and shares borders with Afghanistan and Pakistan. The climatic conditions are relatively similar to those of the border provinces of Afghanistan and Pakistan.

Data on suspected CCHF cases were collected from the Communicable Disease Center of Zahedan University of Medical Sciences and Health Services and analysed. Descriptive statistics, including frequency, percentage, mean, standard deviation (SD), and median and interquartile range (IQR) were used. For the trend study, descriptive statistics and bootstrapped quantile regression were used because the outcome (years) was a discrete variable without a normal distribution. In the quantile regression, "year" was considered as the outcome variable, and its median was predicted with regression. Data analyses were performed using SPSS 27 and Stata 17.

Ethics considerations

The study protocol was reviewed and approved by the Ethical Review Committee of Zahedan University of Medical Sciences (IR.ZAUMS.REC.1403.028). To protect the privacy and personal information of the patients and maintain their trust and confidence, their names and other identities were excluded.

Results

Of the 433 suspected CCHF cases, 91 were confirmed and 16 were probable (Table 1). Most of the cases (343) were reported in Zahedan, the centre of the province. The mean age of all suspected cases was 35.5 ± 17.7 years and most of them (308, 71.1%) were male. Fatality rate was 11.0% among confirmed cases (10 of 91), 18.8% among probable cases (3 of 16), 10.4% among suspected cases (34 of 326), and 10.9% among all cases (47 of 433). Fatality trend was not statistically significant (Table 4, Figures 1a and 1b).

In terms of nationality, 377 cases (87.1%) were Iranians, 49 (11.3%) were Afghans, 6 (1.4%) were Pakistani, and 1 (0.2%) did not have a birth certificate. Thirteen cases (3.0%) were pregnant and there were 2 cases (0.5%) of abortion. Six cases (1.4%) had addiction problems, while 150 (34.7%) were rural and 282 (65.1%) urban residents (Table 2). Clinical diagnosis after disease symptom onset was made in 5.3 ± 4.9 days (median 4 days, IQR 2–7 days, range 0–43 days).

Hamun, Khash, Nimrooz, Saravan, Sib and Suran, Zahak districts (1 year lower in median, $P = 0.012$), and Kuhbanan District (2 years lower in median, $P < 0.001$) exhibited negative CCHF infections trends compared to Zahedan (Figure 1c) (Table 3). The highest number of cases were recorded in 2019 (167) and the lowest in 2024 (15), indicating a decreasing trend. However, the number of cases was high in 2022 (midpoint) (Table 4). The median incidence was higher during winter than spring ($P < 0.001$) for 3 years (Table 3, Figure 1d and 1e).

Table 1 **Disease case definition by district, all patients**

District	Patient cases	Disease outcome			
		Died		Improved	
		Number	Percentage	Number	Percentage
All	Confirmed	10	11.0	81	89.0
	Probable	3	18.8	13	81.3
	Suspected	34	10.4	292	89.6
	Total	47	10.9	386	89.1
Hamun	Confirmed	0	0	0	0
	Probable	0	0	1	100
	Suspected	0	0	0	0
Khash	Confirmed	0	0	3	100
	Probable	0	0	1	100
	Suspected	3	16.7	15	83.3
Mirjaveh	Confirmed	0	0	3	100
	Probable	0	0	0	0
	Suspected	0	0	5	100
Nimrooz	Confirmed	0	0	0	0
	Probable	0	0	1	100
	Suspected	0	0	0	0
Saravan	Confirmed	2	15.4	11	84.6
	Probable	0	0	0	0
	Suspected	5	13.5	32	86.5
Sib and Suran	Confirmed	0	0	0	0
	Probable	0	0	1	100
	Suspected	0	0	1	100
Zabol	Confirmed	0	0	1	100
	Probable	0	0	0	0
	Suspected	0	0	2	100
Zahak	Confirmed	0	0	0	0
	Probable	0	0	0	0
	Suspected	0	0	1	100
Zahedan	Confirmed	8	11.3	63	88.7
	Probable	3	25.0	9	75.0
	Suspected	26	10.0	234	90.0
Kuhbanan	Confirmed	0	0	0	0
	Probable	0	0	0	0
	Suspected	0	0	1	100

Discussion

CCHF is one of the most important vector-borne diseases that can be acquired following the bite by the *Hyalomma* species of ticks (*1*). CCHF virus has a trisegmented genome and different genotypes have been identified. The genetic diversity correlates with regional geographic distribution: genotype I (Africa 1), genotype II (Africa 2), genotype III (Africa 3), genotype IVa (Asia 1), genotype IVb (Asia 2), genotype V (Europe 1) and genotype VI (Europe 2) (*8*). The genomic clades are: Clade I West Africa; Clade II Central Africa; Clade III South and West Africa; Clade IV Middle East and Asia; and Clade V and VI Europe and Greece. The Asian clade is further divided into 2 distinct clades, Asia 1 and Asia 2. This phylogenetic classification of the virus is based on the S segments of the CCHF virus (*1*).

In this study, we found 433 suspected CCHF cases, of which 91 were confirmed and 16 were probable. Most cases were young males, which may be attributed to the patients' occupations. The most frequent occupation was housewives (23.3%), followed by freelance (16.6%). Most cities showed a negative trend compared with Zahedan, the centre of the province (Table 3 and Figure 1c), indicating that most cases were in the centre of the

Table 2 Occupation and residence of patients

Distribution	Number	Percentage	Distribution	Number	Percentage
Occupation					
Butcher	31	7.2	Military	7	1.6
Child	9	2.1	Other occupations	50	11.5
Driver	21	4.8	Rancher	33	7.6
Employee	18	4.2	Rancher-farmer	14	3.2
Freelance	72	16.6	Rancher-livestock business	15	3.5
Health care provider	4	0.9	Student	33	7.6
Housewife	101	23.3	Worker	25	5.8
Residence					
Afghanistan	4	0.9	Khash	12	2.8
Ahmadabad	1	0.2	Kheyrabad	2	0.5
Allahabad Dumak	3	0.7	Kohan	1	0.2
Ascan	1	0.2	Kohkhajeh	1	0.2
Aspich	1	0.2	Kolangur	1	0.2
Chabahar	1	0.2	Koulou	1	0.2
Chad	1	0.2	Kurin	3	0.7
Chah Nasrollah Rigi	1	0.2	Kuteh	1	0.2
Chah Zilan	1	0.2	Machan	1	0.2
Chahahmad	4	0.9	Mehrshahr	5	1.2
Chahdavood	1	0.2	Meshkan Chan	1	0.2
Chahjamal	1	0.2	Mirjaveh	8	1.9
Cheshmeh Ziyarat	2	0.5	Mohammadi	1	0.2
Dashtuk	3	0.7	Murtishirinzad	1	0.2
Dehlotfollah	1	0.2	Nazil Bahrabad	1	0.2
Dehnopiran	1	0.2	Nikshahr	1	0.2
Dehnoposht Adimi	1	0.2	Nosratabad	3	0.7
Dehvaran	2	0.5	Padagi	2	0.5
Dezzak	2	0.5	Pakistan	3	0.7
Durbon	1	0.2	Panjgur	1	0.2
Eftekharabad	1	0.2	Poshtkuh Islamabad	1	0.2
Esmailabad	1	0.2	Qaderabad	3	0.7
Fanuj	1	0.2	Rigmalek	3	0.7
Galugah	1	0.2	Rostamabad	1	0.2
Ghafurabad	1	0.2	Rual	1	0.2
Goharshahr	1	0.2	Sabzgaz	2	0.5
Golchah	1	0.2	Safararbabi	1	0.2
Gragheh	1	0.2	Safarshah	1	0.2
Hajiabad	2	0.5	Saidabad	1	0.2
Hasanabad	1	0.2	Saravan	37	8.6
Hematabad	3	0.7	Sefidak	1	0.2
Hesaruye	1	0.2	Shahrak Damdaran	9	2.1
Hiduj	1	0.2	Shirabad	1	0.2
Hirmand	1	0.2	Shoru Mohammadabad	1	0.2
Hossain Abad Cheshmeh Ziarat	1	0.2	Sirkan	2	0.5
Houtabad Chahnorbkhsh	1	0.2	Siyadak	1	0.2
Irafshan Mitagbaluch	1	0.2	Sohrab Gholami	1	0.2

Table 2 **Occupation and residence of patients**

Distribution	Number	Percentage	Distribution	Number	Percentage
Residence					
Irandegan	1	0.2	Suran	2	0.5
Iranshahr	3	0.7	Surian	1	0.2
Jaalq Soro	1	0.2	Talab	1	0.2
Jakigur	1	0.2	Tamin	1	0.2
Jaleq	1	0.2	Tavakkolabad	1	0.2
Junabad	1	0.2	Valiabad	1	0.2
Kafeh Balochi	1	0.2	Yousefabad	1	0.2
Kalegazan	1	0.2	Zabol	4	0.9
Kamalabad	2	0.5	Zaboli	2	0.5
Karvandar	1	0.2	Zahedan	225	52.2
Kavaar	1	0.2	Zangian	1	0.2
Kent	1	0.2	Zehak	2	0.5
Kershan Adernagh	1	0.2	Mirshah	1	0.2
Keshtegan	1	0.2	Kuhbanan	1	0.2

province. A positive time trend was found for winter, suggesting the need for more attention to the winter season (Table 3, Figure 1d and 1e).

The fatality rate was 11.0%, compared to 8.4% in a 2010–2017 study in Zahedan (*13*). A study in Afghanistan reported 21.6% fatality at a referral centre (*15*). It was not clear whether this higher fatality rate was due to poor treatment services or lower case detection. Sharifi-Mood et al reported 123 confirmed cases in Zahedan (91 in 1999–2003 and 32 in 2005–2007) (*12*).

Most cases in our study were young males. A national surveillance data from Afghanistan reported 69% male cases and 45% aged 16–30 years (*16*), which aligns with our study. In Uganda, among livestock farmers, males were approximately twice as likely to be seropositive (*17*).

The most common occupation was housewife (23.3%), followed by freelance (16.6%). A 1999–2011 study in Zahedan found 34% of cases to be slaughterhouse workers, 28.5% livestock handlers and farmers, and 9% housewives (*18*), contradicting our findings and showing a shift from high-risk occupations to housewives and freelance. However, it should be noted that their study was on confirmed cases only.

We observed 2 peaks, in 2019 and 2022, for infections trend and only one (2019) for mortality trend (Table 4, Figure 1a and 1b), possibly due to better case finding in 2022 or progress in treatment and improved disease management in that year. It may also be due to demographic shifts. We found a significant seasonal pattern, with winter associated with a 3-year higher median infection rate, indicating a positive trend. This increasing trend may be due to a lower number of confirmed cases. However, we did not find an increasing trend in fatality during 2018–2024 (Table 4).

There was a positive trend during winter. Vector-borne disease trends fluctuate from year to year and the seasons influence the distribution and dynamics of diseases throughout the year (*19*). Seasonal variations in disease occurrence are common in infectious diseases transmitted by arthropods, especially in temperate climate countries (*20*). Typically, seasonality is linked to increased reproductive capacity of vectors during periods of high temperature and humidity. Climatic factors can also affect host behaviour, leading to changes in disease occurrence (*20*). Disease transmission is usually higher during the warmer months (*21*).

Study strengths and limitations

One strength of our study was the investigation of probable and suspected cases, in addition to confirmed cases, which may have helped reduce selection bias. The limitations include the small size and short duration of the study. Ecological and confounding factors were not examined. Therefore, we recommend a study with a larger sample size and longer duration, which will also consider ecological and confounding factors.

Conclusion

We found a significant seasonal pattern in the incidence of CCHF, with winter associated with a 3-year higher median infection rate. Although there is a decreasing trend in the incidence of Crimean-Congo haemorrhagic fever in Sistan and Baluchestan Province, Islamic Republic of Iran, targeted interventions are needed to strengthen prevention, diagnosis and treatment, especially during the winter months.

Funding: This study was supported by Zahedan University of Medical Sciences.

Competing interests: None declared.

Table 3 CCHF infections trend of by district, season and month using bootstrapped quantile regression

CCHF infection	Coefficient	*P* value
District		
Zahedan	Reference	
Hamun	-1	**0.012**
Khash	-1	**0.012**
Mirjaveh	-1	**0.137**
Nimrooz	-1	**0.012**
Saravan	-1	**0.012**
Sib and Suran	-1	**0.012**
Zabol	1	**0.516**
Zahak	-1	**0.012**
Kuhbanan	-2	**< 0.001**
Season		
Spring	Reference	
Summer	1	**0.151**
Autumn	0	**1.0**
Winter	3	**< 0.001**
Month		
January	Reference	
February	-2	**0.312**
March	0	**1.0**
April	-4	**0.03**
May	-3	**0.095**
June	-3	**0.016**
July	-3	**0.061**
August	-4	**0.001**
September	-4	**0.001**
October	-4	**0.001**
November	-4	**0.013**
December	-1	**0.417**

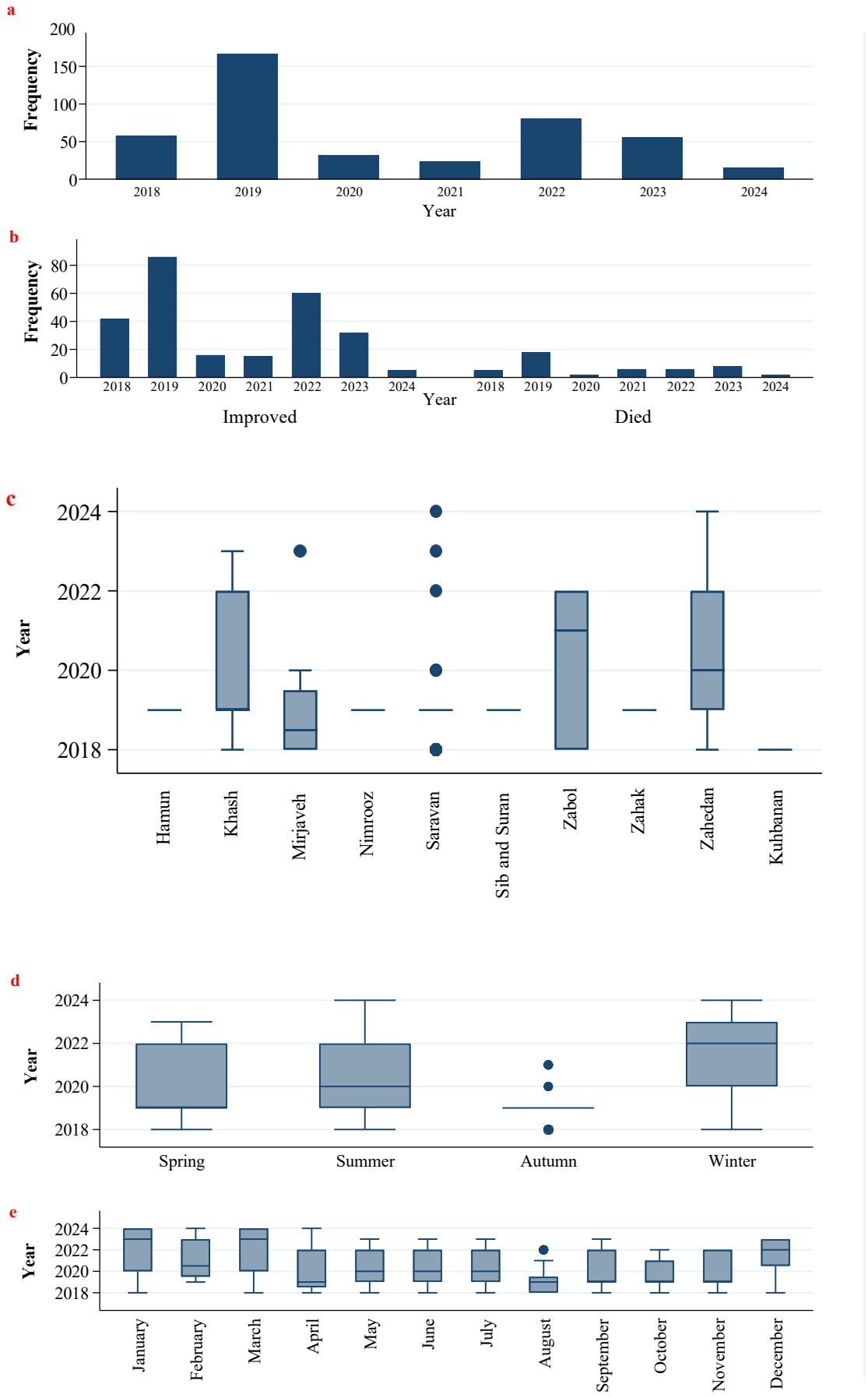
Significant P values (P < 0.05) are shown in bold font. In the bootstrapped quantile regression, the outcome was the median (Quantile 50) of the years. For example, the median of the years was three units higher in winter compared to spring.

Table 4 CCHF cases and fatality trend using logistic regression

Cases			
Years	**Number**	**Percentage**	**Cumulative**
2018	58	13.4	13.4
2019	167	38.6	52.0
2020	32	7.4	59.4
2021	24	5.5	64.9
2022	81	18.7	83.6
2023	56	12.9	96.5
2024	15	3.5	100
Total	433	100	
Fatality trend			
Years	OR	*P* value	95% CI
2018	Reference		
2019	1.8	0.296	0.611–5.1
2020	1.1	0.956	0.185–6.0
2021	3.4	0.073	0.893–12.6
2022	0.84	0.785	0.241–2.9
2023	2.1	0.229	0.627–7.0
2024	3.4	0.207	0.511–22.1

OR = odds ratio; CI = confidence interval. OR indicates the likelihood of death being influenced by each year. For instance, in 2021, the chance of death increased by 3.4 times compared to 2018 (although this difference was not statistically significant).

Figure 1 CCHF infections trend for all cases (a), divided by those who died and those who improved (b); box plots for CCHF infections trend in districts (c), seasons (d) and months (e). Comparing figures (c), (d) and (e) with the first, second and third parts of Table 3 – the quantile regression, respectively. For example, in figure (d), winter had a higher median than spring for three years(i.e. regression coefficient = +3).



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Ten-year estimates of cardiovascular disease mortality risk in Islamic Republic of Iran

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Abstract

Background: Cardiovascular disease is a leading cause of death globally and a major public health challenge in Islamic Republic of Iran. Risk estimation can help identify high-risk groups and guide prevention.

Aim: To estimate the cardiovascular disease mortality risk over a 10-year period among adults aged 30–70 years in Yazd Province, Islamic Republic of Iran.

Methods: In 2023, we obtained health data for 2090 adults (809 men and 1281 women) aged 30–70 years in Yazd Province, Islamic Republic of Iran, from the Ministry of Health and Medical Education. We estimated the 10-year risk of cardiovascular disease mortality, using the Framingham risk model, and used independent t test and chi-square test to assess the differences between groups. $P < 0.05$ was considered statistically significant.

Results: Men had higher systolic blood pressure and smoking prevalence than women, while women had higher total cholesterol ($P < 0.001$). Men had higher estimated 10-year cardiovascular disease mortality risk than women. Low risk was more common among women than men (95.9% versus 58.6%). Moderate risk was more common among men than among women (29.6% versus 3.3%), as was high risk (11.8% versus 0.8%).

Conclusion: The observed differences in cardiovascular disease mortality risk factors among the study population indicate the need for preventive measures tailored to the men and women groups. Prevention should focus on smoking, blood pressure control and cholesterol management.

Keywords: cardiovascular disease, mortality risk, smoking, blood pressure control, cholesterol management, Iran

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of death worldwide and a major public health challenge in Islamic Republic of Iran. Recent Global Burden of Disease estimates indicate that they account for approximately 30% of total deaths (*1*). Sex differences in the risk patterns and underlying factors of these diseases, including hypertension, diabetes, dyslipidemia and tobacco use, highlight the need for targeted interventions *(2,3)*. The use of standardised risk assessment tools, such as the Framingham model, makes it possible to predict 10-year cardiovascular disease risk at individual and population levels *(4,5)*.

The Framingham model was selected because it is widely used, accessible and has been validated in several populations. It allows meaningful CVD mortality risk patterns to be compared between men and women. This study estimated the 10-year risk of death from cardiovascular diseases among adults aged 30–70 years in Yazd Province, with a particular focus on sex differences.

This study focused on CVD mortality risk rather than general CVD risk, an outcome that has been less commonly assessed in Iranian studies. The use of original Framingham equations and coefficients, together with a large population sample from Yazd Province, provides local evidence to inform CVD prevention policies and planning.

Methods

We conducted a cross-sectional study in 2023 among adults aged 30–70 years in Yazd Province, Islamic Republic of Iran. This age range was selected because the Iranian Integrated Health System (SIB) provides preventive and health services for this population, ensuring comprehensive and reliable data coverage. Outside this age range, systematic health services and data collection are not routinely conducted.

Data were obtained from SIB through stratified cluster sampling. SIB is a national electronic health record platform developed and maintained by the Ministry of Health and Medical Education in Islamic Republic

of Iran. It continuously collects and updates individual health data through primary health care centres, where trained staff record demographic, clinical and laboratory information. Medical history and smoking status were self-reported during interviews and recorded in SIB, and clinical and laboratory variables were obtained from SIB records. Each participant has a unique health record and is periodically followed up for risk factor monitoring, for example at baseline, 3 months and annually.

The 10-year risk of cardiovascular mortality was estimated using the Framingham risk model. Data analysis was performed using Microsoft Excel and SPSS. Independent t-tests and chi-square tests were used to assess differences between groups, and $P < 0.05$ was considered statistically significant.

The Framingham risk model, originally developed from the Framingham Heart Study, is one of the most widely used tools for predicting CVD risk and mortality. The model incorporates key clinical and demographic variables, including age, sex, blood pressure, cholesterol levels and smoking status, to estimate the absolute probability of CVD events or death within a 10-year period *(5,6)*. Although initially designed to predict overall cardiovascular events, subsequent adaptations have been used to estimate cardiovascular mortality in different populations, demonstrating acceptable external validity and calibration *(7)*.

To calculate the estimated 10-year risk of cardiovascular mortality, we applied the standard Framingham equations using baseline measurements, including age, sex, total cholesterol, high-density lipoprotein (HDL) cholesterol, systolic blood pressure, smoking status and antihypertensive treatment status. As this was a cross-sectional study, participants were not followed longitudinally. Instead, their risk was estimated from baseline characteristics. Separate formulas were applied for men and women, and the risk scores were computed manually using the published equations. Calculations were cross-checked using Omni Calculator *(8)*. This approach is consistent with similar applications of the Framingham risk score in other populations *(7)*. The risk calculation formulas for men and women were as follows:

For men:

Risk score= (52.01× ln(age)) + (20.01 × ln[total cholesterol]) + (−0.91 × ln[HDL cholesterol]) + (1.31 × ln[systolic blood pressure]) + (0.24 × antihypertensive treatment) + (12.1 × smoking status) + (−4.61 × ln[age]:ln(total cholesterol))+((−2.84) x ln[age]:Smoker) + (−2.93) × ln[age]:ln[age]) − 172.30

Mortality probability = 1−0.9402^exp (risk score)

For women:

Risk score = (31.76 × ln[age]) + (22.47 × ln[total cholesterol]) + (−1.19 × ln[HDL cholesterol]) + (2.55 × ln[systolic blood pressure]) + (0.42 × antihypertensive treatment) + (13.08 × smoking status) + (−5.06 × ln[age] × ln[total cholesterol]) + (−3 × ln[age] × smoking status) − 146.59

Mortality probability = 1 − 0.98767^exp (risk score)

In the equations, ln indicates the natural logarithm and × indicates multiplication; interaction terms are expressed as products of the relevant variables.

Ethics considerations

The study was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Islamic Republic of Iran (IR.SSU.REC.1404.048). Informed consent was obtained from all participants.

Results

In this study, men had higher mean systolic blood pressure than women (121.6 [SD 15.8] mmHg versus 116.8 [SD 15.3] mmHg; $P < 0.001$), while mean total cholesterol

Table 1 Cardiovascular disease risk factors by sex

Risk factor	Men (n = 809)			Women (n = 1281)			*P* value
	Mean (SD) or n/N (%)	SE	95% CI	Mean (SD) or n/N (%)	SE	95% CI	
Systolic blood pressure (mmHg)	121.6 (15.8)	0.56	120.5–122.7	116.8 (15.3)	0.43	116.0–117.6	< 0.001
Total cholesterol (mg/dL)	174.1 (41.2)	1.45	171.3–176.9	182.2 (42.4)	1.19	179.9–184.5	< 0.001
HDL cholesterol (mg/dL)	50.8 (32.5)	1.14	48.6–53.0	50.2 (25.4)	0.71	48.8–51.6	0.653
Age (years)	57.5 (13.5)	0.48	56.6–58.4	53.4 (13.1)	0.37	52.7–54.1	< 0.001
Receiving antihypertensive treatment	42.2% (341/809)	1.8%	38.8–45.6%	40.2% (515/1281)	1.7%	37.6–42.9%	0.367
Smoking	9.5% (77/809)	1.0%	7.5–11.7%	0.4% (5/1281)	0.2%	0.05–0.9%	< 0.001

Notes: continuous variables are presented as mean (SD); categorical variables are presented as n/N (%). HDL = high-density lipoprotein; SE = standard error; CI = confidence interval. For continuous variables, SE was calculated as SD/√n and 95% CI as mean ± 1.96 × SE. For proportions, SE was calculated as √[p(1−p)/n], and 95% CI was estimated using the Wilson method. P values were derived from independent t-tests for continuous variables and χ^2 tests for categorical variables.

was higher among women (182.2 [SD 42.4] mg/dL versus 174.1 [SD 41.2] mg/dL; $P < 0.001$). There was no significant difference in HDL levels between the 2 groups ($P = 0.65$). Men were older than women (mean age 57.5 [SD 13.5] years versus 53.4 [SD 13.1] years; $P < 0.001$) and were more likely to smoke (9.5% versus 0.4%; $P < 0.001$). Antihypertensive treatment did not differ significantly between men and women (42.2% versus 40.2%, respectively; $P = 0.367$) (Table 1).

Based on the Framingham risk categories, individuals with a predicted 10-year CVD mortality risk < 10% were classified as low risk, those with 10–20% as moderate risk, and those with > 20% were classified as high risk.

The estimated 10-year cardiovascular mortality risk was higher among men than among women. Low risk was more common among women than among men (95.9% versus 58.6%). Moderate risk was more common among men than among women (29.6% versus 3.3%), as was high risk (11.8% versus 0.8%) (Figure 1).

Discussion

This study showed significant sex differences in cardiovascular risk factors and estimated 10-year cardiovascular mortality risk in Yazd Province. Men had higher systolic blood pressure, older mean age and substantially greater smoking prevalence. These differences were reflected in a higher proportion of men in the moderate- and high-risk categories than women. In contrast, although women had higher mean cholesterol levels, the majority were classified as low risk.

Several biological and behavioural mechanisms may explain these differences. Female sex hormones, particularly oestrogen before menopause, and sex differences in lipid distribution and inflammatory responses may partly explain the lower estimated risk among women despite their higher mean total cholesterol. Among men, higher smoking prevalence, older mean age and higher systolic blood pressure may have contributed to the higher estimated mortality risk observed in this study. Less frequent use of preventive health care services, poorer blood pressure control and lower uptake of antihypertensive treatment may also contribute to cardiovascular mortality risk among men. This combination of biological and behavioural factors has been highlighted in previous studies (*9*).

The findings of this study are consistent with research from Islamic Republic of Iran reporting sex differences in blood pressure and cigarette smoking. Studies from other provinces have shown that, overall, CVD risk is higher among men than among women (*10–12*). Similar studies in other countries have confirmed these sex-related differences (*13,14*). Differences in total cholesterol levels and blood pressure between men and women have been observed in other populations.

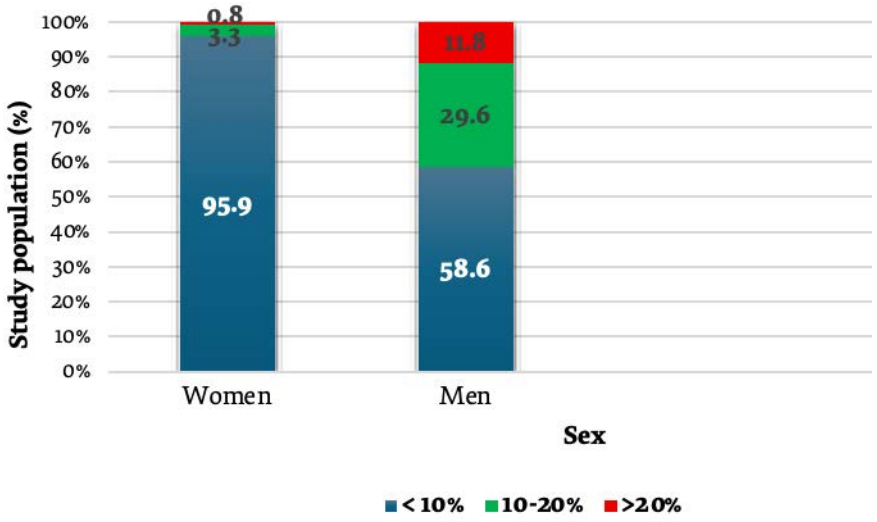
Findings specific to Yazd Province, including unhealthy dietary patterns, low physical activity and high prevalence of hypertension, indicate that the local risk profile is similar to that of other provinces but has distinct characteristics. Previous local studies, such as the Yazd Healthy Heart Project and urban surveys, have shown that obesity, hypertension and sedentary lifestyle contribute to the cardiovascular risk burden in Yazd Province (*15*).

Overall, the findings suggest that sex differences in estimated cardiovascular mortality risk in Yazd Province were largely related to differences in age, systolic blood pressure and smoking prevalence. Using routinely collected health system data for risk assessment may help identify adults who need closer follow-up, particularly among men in the moderate- and high-risk categories.

Policy implications

The findings of this study underscore the need for health policies that take sex-specific differences into account.

Figure 1 Estimated 10-year cardiovascular disease mortality risk by sex



Prevention programmes should prioritise blood pressure control and smoking cessation, with particular attention to men and other higher-risk groups. Culturally tailored health education materials in primary health care centres and workplace settings can directly target these groups. Mass media campaigns, including television, radio and social media platforms, may help raise public awareness and normalise preventive behaviours such as regular blood pressure checks and smoking cessation.

Although women had lower estimated mortality risk, their cholesterol levels require regular monitoring. Incorporating cardiovascular mortality risk assessment into national screening programmes can guide policymaking and resource allocation and help target prevention and follow-up for higher-risk groups.

Strengths and limitations of the study

One strength of this study is its large sample size, which is representative of the population of Yazd Province. The use of stratified cluster sampling as a probability-based method further strengthens the representativeness of the study population and enhances the generalisability of the findings.

However, the study also has limitations. Lifestyle factors, such as diet and physical activity, were not assessed in detail. These data would have allowed a more comprehensive analysis of cardiovascular risk factors. Information on participants' medical history and smoking status was obtained through self-report during interviews, because no other reliable sources, such as medical records, were available. Self-reported data may be subject to recall bias or social desirability bias. The Framingham model does not account for all lifestyle, socioeconomic and contextual factors that may influence cardiovascular mortality risk.

Conclusion

This study highlights the importance of cardiovascular mortality risk assessment for CVD prevention in Yazd Province, Islamic Republic of Iran. The observed sex differences in risk factors and estimated 10-year mortality risk highlight the importance of tailoring prevention measures to the risk profiles of men and women. For men, reducing smoking and managing systolic blood pressure are essential, while for women, regular monitoring of cholesterol levels should be strengthened. Integrating these findings into local health policies can improve resource allocation, strengthen preventive strategies, and help reduce the morbidity and mortality associated with cardiovascular diseases in the region.

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Preventing invasive meningococcal disease during Hajj in Saudi Arabia

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Abstract

Background: Hajj is associated with an increased risk of invasive meningococcal disease, because of close contact among large numbers of pilgrims from diverse geographic regions.

Aim: To recommend evidence-based vaccination strategies for strengthening the prevention of invasive meningococcal disease during Hajj.

Methods: We convened a panel of experts from 4 medical societies to review epidemiologic data, immunisation policies and other evidence on PubMed on meningococcal vaccines, including the quadrivalent conjugate vaccine against serogroups A, C, W and Y and meningococcal serogroup B vaccine (MenB), available in Saudi Arabia. Based on their findings they drafted a consensus statement of recommendations for the prevention of meningococcal disease during Hajj.

Results: We found from our review that invasive meningococcal disease remains a significant health risk during Hajj. Based on the findings, we recommend MenB vaccination for adults intending to perform Hajj. Vaccination should specifically target vulnerable populations, particularly people with chronic disease, immunocompromised individuals, those with occupational risk, children aged 2 months to 18 years and adults aged ≥ 60 years. Integration of vaccination into Hajj and Umrah registration systems, clear communication, adverse event monitoring and evaluation of programme impact may support uptake.

Conclusion: Adding MenB vaccination to existing quadrivalent meningococcal conjugate vaccine recommendations can strengthen protection and reduce the risk of invasive meningococcal disease outbreaks during Hajj.

Keywords: meningococcal disease, meningococcal vaccine, Hajj, immunisation, mass gathering, Saudi Arabia

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Background

Hajj is one of the largest annual religious mass gatherings in the world, bringing millions of Muslims from different countries to Mecca, Saudi Arabia. In 2023, nearly 1.7 million international pilgrims from 184 countries attended Hajj over 5 days (*1*). Invasive meningococcal disease (IMD), caused by *Neisseria meningitidis (N. meningitidis)*, poses a significant health risk during Hajj because of close contact among pilgrims from diverse geographic regions (*2,3*). The case-fatality rate (CFR) is high and varies by bacterial serogroup, patient age and timeliness of treatment. Meningitis-associated CFRs of 5–10% have been reported, even with appropriate antibiotic treatment, increasing to 9.1–26.4% in developing countries (*4*). Survivors may experience long-term sequelae, such as hearing loss, cognitive deficits, motor impairment, psychological disorders and organ damage (*5*).

Lowering the risk of transmission during Hajj requires strengthened surveillance, rapid diagnosis, appropriate treatment and preventive measures, placing considerable pressure on health services. The burden of IMD during Hajj extends beyond individual health effects to broader public health implications. The convergence of millions of pilgrims from different countries increases the risk of exposure to unfamiliar strains and acquisition of meningococcal carriage (*6*). Upon returning home, pilgrims may introduce these serogroups into their local populations, potentially leading to outbreaks (*2*). Hajj has historically been associated with invasive meningococcal disease outbreaks. An outbreak caused by *N. meningitidis* serogroup W135 in 2000 led to high mortality and changes in the vaccination policy (*7*).

Currently, the quadrivalent meningococcal vaccine against serogroups A, C, W and Y (MenACWY) is required for all international pilgrims and residents of Saudi Arabia performing Hajj (*3*). Although this requirement has helped reduce outbreak risk, it does not cover other serogroups, such as meningococcal serogroup B (MenB), for which effective protein-based vaccines became available only recently (3,8). This article presents expert

consensus recommendations from 4 Saudi medical societies on preventing IMD during Hajj in Saudi Arabia.

Methods

This paper was developed through a collaborative process involving 4 major medical societies in Saudi Arabia: the Saudi Society of Epidemiology, the Saudi Society of Family and Community Medicine, the Saudi Society of Public Health, and the Saudi Society of Clinical Medical Microbiology and Infectious Diseases. The panel included 8 experts in epidemiology, infectious diseases, public health and family medicine, including clinicians, academic researchers and public health policymakers.

The consensus was based on the nominal group technique and included statement development and iterative review. The statement development was informed by a literature search of MEDLINE through PubMed from inception to December 2024. Various combinations of the following keywords were used to identify potentially eligible literature: invasive meningococcal disease, Hajj, mass gatherings, meningococcal vaccination, meningococcal epidemiology, *Neisseria meningitidis*, pilgrimage, mass events, vaccine strategy, and meningitis outbreaks. The consensus statement was primarily informed by studies classified as level 1 evidence (*9*).

The draft consensus statement was reviewed through 3 iterative rounds. In the first round, panellists reviewed the evidence and provided initial feedback on the draft statements. In the second round, statements were refined and recirculated for further rating and discussion. In the third round, consensus was defined as ≥ 80% agreement among panellists. The final manuscript was reviewed and approved by all participating experts.

Results

Neisseria meningitidis carriage among pilgrims

Table 1 summarises published data on *N. meningitidis* carriage among pilgrims from countries sending the largest numbers of pilgrims to Saudi Arabia, including baseline carriage, pre-Hajj and post-Hajj carriage, and predominant serogroups (*11,41–47*).

Previous studies have reported variation in *N. meningitidis* carriage by country of origin. A survey of 2017 Hajj pilgrims found an overall carriage prevalence of 4.6%. Among 34 serogroup-positive samples, 10 were MenB (*10*). Indonesian pilgrims had a pre-Hajj carriage rate of 1.3% in 2001, increasing to 7.7% upon return (*2*). In 2014, carriage on arrival was 2.0%, with no significant acquisition during Hajj (*11*). Among Indian pilgrims, carriage on arrival was 21.3% in 2001, but no carriage was detected in 2014 (*2,11*). Pakistani pilgrims had a carriage rate of 1.0% on arrival in 2014, primarily MenB (*11*). Carriage among Bangladeshi pilgrims was 20.5% on arrival in 2001 and 2.5% in 2014 (*2,11*). Egyptian pilgrims had a carriage rate of 1.0% on arrival in 2014, all due to MenB (*11*).

Among Turkish pilgrims, carriage increased from 13.3% before Hajj to 27.4% after Hajj in 2010, mainly due to meningococcal serogroups W and B (*12*). In 2018, pre-departure carriage was 3.9%, all due to MenB (*13*). Nigerian pilgrims had a carriage rate of 6.8% in 2001 and 16.5% in 2014 (*2,11*). Post-Hajj data from Morocco showed a carriage rate of 2.7%, with 12.6% due to MenB (*14*).

Evidence on meningococcal vaccines

Plain polysaccharide vaccines, available since the late 1960s, were initially the primary defence used against

Table 1 *N. meningitidis* carriage and causative serogroups among pilgrims from countries sending the largest numbers of pilgrims

Country	Approximate number of pilgrims	Baseline carriage (%)	Predominant baseline serogroups	Pre-Hajj carriage (%)	Post-Hajj carriage (%)	Pre- Hajj carriage
Indonesia	212 730	–	–	2.0 (MenB, 100%)	0–7.7	MenB
India	200 000	1.5–14.4	MenA (100%) in one report; MenB (100%) in one report	0	0–4.5 (MenW, 100%)	MenA, MenB, MenW
Pakistan	189 210	–	–	1.0 (MenB, 100%)	0	MenB
Bangladesh	126 193	–	MenA (87.1–97.7), MenB (2.3–4.3)	2.5 (MenB, 100%)	3.7–6.7	MenA, MenB
Islamic Republic of Iran	88 000	8.0	MenC (50%), MenA (22.2%), MenY (16.6%)	5.2 (MenB 25.7%, MenC 14.2%, MenW 2.9%)	1.4–4.6 (MenB 6.4%, MenC 3.2%, MenW 3.2%)	MenB, MenC, MenW, MenA
Egypt	85 663	–	MenA (34–35%), MenB (51%), MenW (4%)	1.0 (MenB, 100%)	1.1	MenA, MenB, MenW
Türkiye	82 784	0.6–6.3	MenB (9.4–86.1%), MenC (35.2%), MenA (5.2–8.7%), MenY (4.2%)	13.3 (MenW 82.5%, MenB 14.3%)	25.6–27.4 (MenW 91.4%, MenB 6.2%)	MenW, MenB, MenC, MenA, MenY

Note: Carriage rates refer to nasopharyngeal colonisation detected among pilgrims during study years. Serogroup distribution is based on available data from the cited studies.

MenA, MenB, MenC, MenW and MenY: *meningococcal serogroups A, B, C, W and Y.*

Table 2 WHO key considerations for preventing and controlling infection during mass gatherings

Stage	Key activities and considerations
Before the event	• Identify infection risks; • Evaluate existing IPC measures; • Assess training of HCPs on IPC measures and address any gaps; • Review the legal framework for implementing IPC measures; • Conduct a cost-effectiveness analysis of IPC measures; • Assess the status of public health and other services involved in IPC; • Engage in international collaboration for risk assessment, information sharing, and rapid communication; • Evaluate potential mitigation measures, including pre-event immunisation and health status assessment before entry; • Assess the impact of restrictive IPC measures on public opinion, political, economic, psychological, and human rights aspects; • Develop IPC guidelines based on international recommendations and tailor them to local contexts; • Train event staff in IPC measures; • Regularly check supplies of IPC equipment and utilities.
During the event	• Provide free access to health care to encourage prompt identification of, and response to, infection; • Provide easily accessible written information in languages relevant to attendees; • Support populations with low health literacy through visual aids and empowerment strategies; • Immunise contacts of infected individuals and monitor the health of close contacts; • Follow established protocols for transporting cases; • Isolate contagious individuals and quarantine exposed persons; • Implement appropriate responses to infection risks, such as hand hygiene, face masks, cough etiquette, physical distancing and contact avoidance; • Communicate infection risks to the general public using pre-developed materials.
After the event	• Maintain ongoing situational awareness for rapid reporting and response to the spread of communicable diseases; • Engage in international collaboration, including exchange of knowledge and experience.

IPC: infection prevention and control; HCPs: health care professionals.

Source: WHO (48).

IMD (*15*). However, these vaccines had important limitations, including the inability to induce a strong and long-lasting immune response, especially in infants (*16*). These limitations led to the development of conjugate vaccines, which induce boostable immune responses in infants, provide longer-term immunity, have herd effects and do not cause hyporesponsiveness after repeated use (*17*). Several licensed meningococcal vaccines are available worldwide, including monovalent vaccines targeting serogroups C and A, quadrivalent vaccines against serogroups A, C, W and Y, and protein-based vaccines offering broad protection against MenB strains (Table 3) (*18*).

Evidence on MenB vaccines

Polysaccharide-based vaccines against MenB are not feasible because the structural similarity between MenB alpha-2-linked polysialic acid and polysialic acid in human neuronal cells may result in poor immunogenicity and a risk of autoimmune responses (*19*). Outer membrane vesicle vaccines were used in several countries, including Brazil, Chile, Cuba, France and Norway, to manage clonal MenB outbreaks during the 1980s, and later in New Zealand during 2004–2008 (*20*).

Sequencing of the first meningococcal genome enabled reverse vaccinology approaches that led to the development of the 4-component MenB vaccine (Bexsero®), which contains factor H-binding protein (fHbp), neisserial adhesin A (NadA), neisseria heparin-binding antigen (NHBA), and outer membrane vesicles expressing PorA P1.4, derived from the New Zealand MenB strain (*21*).

The 4-component MenB (4CMenB) vaccine has been evaluated in various settings. In the United Kingdom, the introduction of the vaccine into the national infant immunisation programme was associated with a 75% decrease in MenB incidence among age groups fully eligible for vaccination over 3 years after implementation (*22*). In Northern Ireland, the introduction of the vaccine was associated with a 77.8% decrease in MenB cases among children aged < 1 year, exceeding the predicted 62.5% strain coverage based on the Meningococcal Antigen Typing System for 2014–2015 strains (*23*).

A school-based trial in South Australia assessed the impact of the 4CMenB vaccine on carriage and infection among adolescents. The trial demonstrated direct protection against MenB, with fewer cases among people aged 17–19 years in 2017 and 2018 than expected. Vaccination coverage was high, with 99.5% of students receiving one dose and 97% receiving 2 doses. No MenB cases occurred in the trial population after the start of the study, compared with 12 cases among adolescents aged 15–18 years in 2015–2016 (*24*).

In Quebec, Canada, a 2014 vaccination campaign using the 4CMenB vaccine was associated with a 96% decrease in MenB incidence in the targeted age group 2 months–20 years, from 11.4 to 0.4 cases per 100 000 people. After adjusting for age and geographic variations, the risk reduction was 86% (95% confidence interval: -2% to 98%) (*25*).

The 4CMenB vaccine may provide cross-protection against other meningococcal serogroups, as shown by serum bactericidal antibody activity against the hypervirulent meningococcal serogroup W ST-11 strain in vaccinated infants (*21*). Evidence is available for MenB-FHbp, a bivalent recombinant lipoprotein vaccine targeting factor H-binding protein subfamilies A and B. In a large trial involving more than 3 600 adolescents

Table 3 Currently available meningococcal vaccines

Vaccine	Meningococcal serogroup	Type
MenACWY-D	A, C, W, Y	Polysaccharides conjugated to diphtheria toxoid
MenACWY-CRM	A, C, W, Y	Polysaccharides conjugated to CRM197, a (nontoxic) mutant diphtheria toxin
MenACWY-TT	A, C, W, Y	Polysaccharides conjugated to tetanus toxoid
MenB-4C	B	Recombinant-derived outer membrane proteins NadA, NHBA, fHbp (subfamily B), plus PorA-containing outer membrane vesicles
MenB-FHbp	B	Recombinant-derived lipidated fHbp (subfamilies A and B)

fHbp: factor H binding protein; NadA: neisserial adhesin A; NHBA: neisserial heparin-binding antigen

Source: adapted from Marshall et al. (18).

and young adults, MenB-FHbp elicited a robust immune response against diverse MenB strains among approximately 80% of participants.

MenB vaccination during Hajj

Before the 2001 vaccination policy, large Hajj-associated IMD outbreaks occurred, including a 1987 serogroup A outbreak with approximately 2000 cases and a 2000–2001 serogroup W135 outbreak with more than 400 cases worldwide and 35 deaths in Saudi Arabia (7). The immunisation regulations for Hajj and Umrah pilgrims, established in 2001, have helped reduce the incidence of IMD among pilgrims. However, challenges remain in the implementation of current prevention policies, including inconsistent use of conjugate vaccines and continued use of polysaccharide vaccines among many pilgrims (2). Sporadic cases have continued to occur, including 14 cases reported among pilgrims between 2002 and 2011 (7). Transmission has also been reported, including meningococcal infections in 2019 among Umrah pilgrims returning to the United Kingdom, caused by a ciprofloxacin-resistant strain (*26*).

Current Hajj and Umrah vaccination requirements focus on quadrivalent meningococcal vaccines against serogroups A, C, W and Y. Conjugate quadrivalent vaccines are more effective than polysaccharide vaccines and are recommended, particularly for frequent pilgrims (*27*). However, implementation remains inconsistent and many pilgrims still receive polysaccharide vaccines (*11*). Current mandatory vaccination does not cover serogroups such as MenB and meningococcal serogroup X.

Although no large-scale MenB outbreak has occurred during Hajj in Saudi Arabia, MenB has been identified in national and pilgrimage-related evidence. Between 1995 and 2011, MenB accounted for 10.1% of *N. meningitidis* isolates identified in Saudi Arabia, and during 2002–2011, it accounted for 17% of typed isolates (7). More recently, 44 IMD cases were reported in Saudi Arabia, with sporadic disease attributed to both MenB and meningococcal serogroup W (*28*). Carriage studies have shown that MenB is commonly carried by pilgrims, with a carriage rate reported among 1–28% of isolates (*2,10*).

MenB has been reported in countries that send the largest numbers of pilgrims, including Bangladesh, India, Indonesia, Islamic Republic of Iran, Pakistan and Türkiye (*29–34*).

Expert consensus recommendations

Given the current evidence, the panel endorsed incorporating MenB vaccination into the existing immunisation requirements for Hajj pilgrims. Vaccination should specifically target vulnerable populations, particularly people with chronic diseases, immunocompromised individuals, those with occupational risk, children aged 2 months–18 years and adults aged ≥ 60 years.

Discussion

The evidence reviewed by the panel indicates that MenB vaccination should be considered as part of a broader strategy to reduce the risk of invasive meningococcal disease during Hajj. Current Hajj and Umrah prevention policies have substantially reduced the risk of large outbreaks caused by meningococcal serogroups A, C, W and Y, but they do not cover MenB. This leaves a prevention gap, particularly given the documented presence of MenB in Saudi Arabia, among pilgrims and in countries that send large numbers of pilgrims to Hajj.

It is important to distinguish between carriage, sporadic disease and outbreaks. Although no large-scale MenB outbreak has occurred during Hajj, the persistent carriage reservoir among international pilgrims creates a risk of transmission during the pilgrimage and onward dissemination to home countries, where outbreaks could occur. Pilgrims from countries with MenB circulation may carry the serogroup to Hajj, where crowding, close contact and rapid population movement may facilitate transmission. Incorporating MenB vaccination would therefore represent a proactive public health measure to close a gap in current prevention strategies before a major outbreak emerges.

WHO has outlined key measures for preventing and controlling infections during mass gatherings such as Hajj and Umrah, including vaccination, surveillance, risk communication, infection prevention and control, and preparedness planning (Table 2). These measures support a comprehensive approach in which MenB vaccination complements existing public health measures.

Incorporating MenB vaccination into the immunisation requirements for Hajj and Umrah pilgrims would require careful planning. Cost-effectiveness modelling studies from countries that have implemented MenB vaccination have shown mixed results, indicating the need for a locally adapted model to assess the cost-effectiveness of introducing MenB vaccination for Hajj (*37*). Although an additional vaccine would increase upfront costs, these costs may be offset by the prevention of invasive meningococcal disease cases and avoidance of outbreak-related health care and societal costs (*38*).

Acceptability among pilgrims is another important consideration. Early engagement with travel agencies and health care providers in countries of origin is essential to support adoption and high vaccination coverage. Integration of MenB vaccination into Hajj and Umrah registration systems may also support uptake, provided that requirements are communicated clearly and early.

Although vaccination is central to preventing invasive meningococcal disease during Hajj, non-vaccination measures remain important. Enhanced surveillance systems are needed to detect cases early and enable rapid response, particularly given the international diversity of pilgrims (*39*). Robust infection prevention and control measures, including case isolation, contact tracing and outbreak preparedness, should complement vaccination efforts (*40*). Public health education targeting pilgrims and health care providers can improve awareness of IMD symptoms, encourage early care-seeking and support adherence to prevention policies.

Taken together, these complementary approaches indicate that vaccination alone is insufficient. A multifaceted strategy that integrates immunisation with strong non-vaccination measures is needed to safeguard pilgrims and prevent the international spread of invasive meningococcal disease.

Conclusion

The immunisation regulations for Hajj and Umrah pilgrims have substantially reduced the incidence of invasive meningococcal disease among pilgrims. However, current epidemiologic patterns and the availability of MenB vaccines indicate the need to update prevention strategies. Incorporating MenB vaccination into existing immunisation requirements for Hajj pilgrims, particularly for vulnerable groups, may strengthen protection and reduce the risk of invasive meningococcal disease outbreaks during Hajj.

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Strengthening the integration of rehabilitation into health systems for Universal Health Coverage in the Eastern Mediterranean Region

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Justification and purpose

There are demographic and epidemiologic increases in the demand for rehabilitation services globally. By 2050, the population of those aged ≥60 is expected to double to 2.1 billion, straining health systems (*1,2*). The incidence of non-communicable diseases (NCDs) like stroke, diabetes and neurologic disorders is increasing and musculoskeletal injuries currently affect 1.3 billion people (*3,4*). An estimated 2.41 billion individuals require rehabilitation to optimise function, reduce disability and improve their quality-of-life, yet access gaps persist, especially in low- and middle-income countries (LMICs) in the Eastern Mediterranean Region (EMR) (*5–9*).

These gaps slow the achievement of Universal Health Coverage (UHC) and increase economic productivity (*7*). The WHO Rehabilitation 2030 initiative calls for the integration of rehabilitation as a people-centred approach at the primary, secondary and tertiary levels of health care (*10–13*). The barriers to the integration of rehabilitation into health systems in LMICs include resource shortages, workforce deficits, fragmented systems, high costs, inadequate infrastructure, and stigma (*13–15*). The COVID-19 pandemic highlighted the need for community-based healthcare models (*14,15*).

This policy brief proposes evidence-based policy options for the integration of rehabilitation into health systems in the LMICs in EMR, particularly primary health centres and at the community level, in alignment with UHC and Sustainable Development Goals (SDGs).

Key policy options and messages

The following options, drawn from global evidence, will help improve access, quality, cost-efficiency, and resilience of rehabilitation services:

- Develop national strategic plans and policies to integrate rehabilitation services into public health and UHC strategies, aligned with the WHO guidelines.
- Embed rehabilitation into primary care with clear referral pathways across health care levels.
- Expand professional training for rehabilitation professionals, primary care workers and community health workers (CHWs).
- Invest in digital technologies such as telerehabilitation and electronic health records for service delivery.
- Scale-up culturally adapted community-based rehabilitation (CBR) in underserved areas.
- Establish dedicated rehabilitation units in ministries of health for stewardship and oversight.
- Implement sustainable financing for rehabilitation (e.g. insurance, public-private partnerships) to reduce out-of-pocket costs.
- Launch awareness campaigns to reduce stigma and promote the role of rehabilitation in independence.

Description of the policy options, including their advantages and disadvantages

The following are the short-, medium- and long-term options, including the advantages, disadvantages, feasibility, equity, and stakeholder roles:

How this policy brief was developed (methodology)

This brief was based on a systematic scoping review (PRISMA-ScR guidelines) of literature from 2000 to 2024. Databases (PubMed, Scopus, Web of Science) were searched using terms like "rehabilitation integration," "universal health coverage," and "health systems." Of the 6926 records, 54 studies were included after CASP quality appraisal (>80% compliance) (*16*). Thematic synthesis extracted models (e.g. horizontal/vertical integration), barriers/facilitators and outcomes, focusing on LMICs/EMR. Geographic trends: 59% high-income coutries (HICs), 35% middle-income, 6% low-income. No primary data; ethics code IIR.USWR.REC.1403.141 (synthesis only).

Further important considerations

To operationalize these recommendations, the following phased plan is proposed:

Phase 1: Planning and policy development

- Form a national taskforce with representatives from the health system, rehabilitation authorities, NGOs, and universities to draft a strategic rehabilitation plan.
- Assess current rehabilitation services using the WHO Systematic Assessment of Rehabilitation Situation (STARS) tool (*10*).
- Develop a national policy draft emphasising primary care integration and sustainable financing.

Phase 2: Capacity building and training

- Design training programmes for rehabilitation specialists and CHWs.
- Implement interprofessional training to foster team collaboration.
- Conduct public education for families and individuals with disabilities.

Phase 3: Implementation and scaling

- Pilot integration in selected primary care centres with defined referral pathways.
- Launch telerehabilitation platforms and integrate with electronic health records (EHRs).
- Expand CBR in underserved communities with NGO support.

Phase 4: Monitoring and evaluation

- Establish a monitoring system with key performance indicators (access, quality, satisfaction).
- Conduct periodic evaluations and revise policies for continuous improvement.

Resources needed

Budget: Allocate national health funds, international partnerships, and insurance schemes.

Workforce: Recruit and train rehabilitation specialists and CHWs.

Technology: Invest in telerehabilitation and health information systems.

Equipment: Distribute assistive devices in underserved and remote areas.

Implementation challenges

Despite the clear benefits of integrating rehabilitation into health systems, several challenges may hinder implementation. These include:

1. *Workforce shortages:* Many countries—especially LMICs—face a limited supply of trained rehabilitation professionals, limiting scale-up potential.
2. *Fragmented service delivery:* Poor coordination between sectors and levels of care often leads to gaps in continuity and follow-up.
3. *Insufficient funding:* Rehabilitation is often underfunded or omitted from national health financing schemes.
4. *Weak governance and leadership:* Absence of dedicated rehabilitation units within ministries hinders national planning and regulation.
5. *Low political prioritisation:* Rehabilitation lacks visibility in many national UHC and health system strengthening agendas.
6. *Digital divide:* Implementation of telerehabilitation is constrained by internet access, device availability and digital literacy in some regions.
7. *Cultural stigma:* Misunderstandings about disability and rehabilitation services can reduce demand and investment.

Mitigation strategies

- Leverage international support and technical guidance (e.g. WHO Rehabilitation 2030 framework).
- Promote multisectoral coordination among the health, education, labour, and social protection sectors.
- Pilot scalable interventions in selected districts before national rollout.
- Build advocacy coalitions including professional associations, patient groups, and NGOs.

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Description of the policy options, including their advantages and disadvantages

The following are the short-, medium- and long-term options, including the advantages, disadvantages, feasibility, equity, and stakeholder roles:

Policy option	Description	Advantages**	Disadvantages**	Cost and feasibility of implementation (including acceptability, organizational factors, etc.)	Equity considerations (gender, socioeconomic, ethnicity, geographical)	Stakeholder responsibilities	Description
Short-term: Policy and primary care integration	Develop national plans/ policies aligned with WHO guidelines Embed rehabilitation in primary care with referrals (Recommendations 1–2)	Improves access and coordination reduces hospital admissions Aligns with Rehabilitation 2030 Evidence from HICs/ LMICs shows better outcomes (*10,11*)	Requires governance changes Potential resistance from fragmented systems	Low-medium cost (use existing funds) High feasibility in EMR with strong stewardship Quick rollout via taskforces	Addresses urban-rural gaps Benefits low-income groups via primary access Gender-neutral but supports women caregivers	Ministries of health Policy drafting NGOs/ universities Taskforce input	Develop national plans/ policies aligned with WHO Embed rehabilitation in primary care with referrals (Recommendations 1–2).
Medium-term: Capacity building, digital and CBR	Expand training Invest in telerehabilitation/EHRs Scale CBR models (Recommendations 3–6)	Enhances workforce Improves continuity via technology Community engagement reduces stigma Effective for NCDs/ neurological conditions (*17–18*).	Workforce shortages Digital divide in rural areas Training costs	Medium cost (international partnerships) Feasible with pilots EMR pilots show scalability post-COVID-19	Reduces socioeconomic barriers via CBR Promotes geographic equity in remote areas Inclusive for ethnic minorities/ people with disabilities	Universities: training Health systems/CHWs: delivery NGOs: CBR support	Expand training Invest in telerehabilitation/EHRs Scale CBR models (Recommendations 3–6)
Long-term: Financing and awareness	Sustainable models (insurance/ partnerships) Public campaigns (Recommendations 7–8)	Reduces financial barriers Boosts demand Promotes equity and resilience	High initial investment Political prioritisation required	Medium-high cost (insurance schemes) Feasible long-term with donors EMR examples show cost saving.	Promotes socioeconomic equity Reduces stigma for marginalised groups (e.g. elderly, disabled)	Governments/ donors: funding Health systems/NGOs: campaigns Patients/ families: advocacy	Sustainable models (insurance/partnerships) Public campaigns (Recommendations 7–8)

***Evidence from 54 studies (e.g. horizontal integration effective for chronic management; high certainty in LMICs)*

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Road traffic injuries and road safety efforts in Saudi Arabia

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Abstract

Background: Road traffic injuries and deaths remain a major public health concern in Saudi Arabia.

Aim: To review the burden and risk factors for road traffic injuries in Saudi Arabia and describe recent government road safety efforts.

Methods: We reviewed official government documents and published literature on national trends, risk factors, emergency response and injury patterns of road traffic injuries and road safety efforts by the Government of Saudi Arabia.

Results: Between 2013 and 2023, serious road traffic accidents decreased by 46% in Saudi Arabia, fatalities by 44% and injuries by 40% as a result of stricter traffic monitoring and public awareness campaigns. In spite of this progress, the burden remains concentrated among specific population groups and regions. The key challenges include non-compliance to safety measures and non-completion of infrastructure upgrades.

Conclusion: Saudi Arabia has achieved measurable reductions in road traffic accidents, injuries and fatalities. However, achieving the Vision 2030 road safety target will require sustained enforcement, safer infrastructure, stronger road safety education, and wider use of data-driven technologies.

Keywords: road traffic injury, road traffic accident, road traffic fatality, road safety, traffic law, Saudi Arabia

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Introduction

Road traffic injuries are a major global public health challenge, causing about 1.2 million deaths and 20–50 million non-fatal injuries annually, many resulting in long-term disability (1). More than half of road traffic deaths occur among pedestrians, cyclists and motorcyclists. Most road traffic injuries occur among people aged 18–59 years, and men are 3 times as likely as women to be affected. Beyond the human toll, road traffic injuries impose a substantial economic burden, costing countries an estimated 3% of gross domestic product annually (1). Key risk factors include speeding and other risky driving behaviours, driving under the influence of drugs or alcohol, distraction, unsafe infrastructure and vehicles, and weak enforcement of traffic laws (Table 1). The United Nations General Assembly has set a target of halving global road traffic deaths and injuries by 2030 (1).

In Saudi Arabia, road traffic accidents and their resulting injuries remain a leading cause of death, especially among young adults. In 2016, the road traffic fatality rate was 28.8 per 100 000, higher than in low-income countries (24.1 per 100 000) and more than 3 times the rate in high-income countries (2,3). Road safety has therefore been prioritised under Saudi Arabia's Vision 2030 Health Sector Transformation Programme, which aims to reduce road traffic fatalities to fewer than 10 per 100 000 population by 2030 (4). The government has implemented a multifaceted approach involving stricter traffic laws, road and infrastructure improvements, public education campaigns and improved emergency medical services (2–4).

Although road safety indicators have improved in Saudi Arabia, evidence on the burden, risk factors, injury patterns and government road safety efforts remains limited. This review summarises evidence on road traffic accidents in Saudi Arabia, including national trends, major risk factors, injury patterns and current government road safety efforts.

Methods

We conducted a review of official government documents and published literature on road traffic accidents in Saudi Arabia. We included sources describing national trends, risk factors, emergency response, injury patterns and government road safety initiatives. We summarised

Table 1 Major risk factors for road traffic accidents in Saudi Arabia

Category	Subcategory	Risk factors	Relevance to road safety
Human factors	Driving behaviour	Speeding; driving under the influence of alcohol, drugs, or medicines that impair driving; non-use of seatbelts or child restraints; distracted driving, including mobile phone use; fatigue or drowsy driving; aggressive or reckless driving; violation of traffic rules and signals	These behaviours reduce attention, reaction time and vehicle control.
	Driver characteristics	Young or older age; male sex; limited driving experience or poor driving skills; health issues, including impaired vision and cognitive function; stress, anger or risk-taking behaviour	Individual demographic, health and psychological factors can influence driving behaviour, hazard perception and crash risk.
Vehicle factors	Mechanical and technical condition	Poor vehicle maintenance (brake failure, worn tyres); vehicle age and condition; poor lighting (headlights, indicators); malfunctioning safety devices (airbags, seatbelts); vehicle overloading	Vehicle defects and poor maintenance can increase accident risk and worsen injury severity when accidents occur.
	Vehicle design and type	Motorcycles, heavy vehicles and other higher-risk vehicle types; poor stability or manoeuvrability; absence of safety features such as anti-lock braking systems and electronic stability control	Vehicle design and safety features influence stability, crash avoidance and occupant protection.
Road and environmental factors	Road design and infrastructure	Sharp curves and inadequate lanes; insufficient road signage and markings; lack of pedestrian crossings or barriers; inadequate street lighting; potholes and uneven road surfaces	Poor road design and infrastructure can reduce visibility and place pedestrians and other road users at greater risk.
	Weather and visibility	Rain, fog or dust reducing visibility; extreme heat contributing to fatigue or tyre failure; low humidity affecting vehicle performance; strong winds affecting control; night driving or glare at dawn or dusk	Environmental conditions can impair visibility, traction and driver alertness.
Other contributing factors	Systemic and policy factors	Inadequate enforcement of traffic laws; insufficient driver education and licensing standards; delayed emergency response; lack of road safety campaigns	Broader systemic issues can influence prevention and post-crash outcomes.

the evidence descriptively because the included sources varied in design, data sources and outcome definitions.

Results and discussion

Burden, characteristics and risk factors of road traffic accidents in Saudi Arabia

Burden and demographic characteristics

Data from the Ministerial Traffic Safety Committee indicate reductions in serious road traffic accidents, injuries and fatalities in Saudi Arabia during the past decade. Between 2013 and 2023, serious accidents decreased from approximately 30 000 to 16 000, fatalities from 8000 to 4500, and injuries from 40 000 to 24 000. The road traffic fatality rate decreased from 25.0 to 13.2 per 100 000 population during the same period, while the estimated financial cost decreased from 38 billion to 30 billion Saudi riyals between 2017 and 2023 (7).

Despite this progress, the burden remains concentrated among specific population groups and regions. In 2023, men accounted for 87% of road traffic fatalities, and Saudi nationals accounted for 56%. The largest proportions of road traffic fatalities and injuries were among adults aged 18–30 years (35% and 31%, respectively), followed by those aged 31–40 years (22% and 19%). Children and adolescents aged 0–17 years accounted for 14% of fatalities and 24% of injuries, while people aged 41–50 years accounted for 13% and 12%, and those aged >50 years for 16% and 14%, respectively. Makkah and Riyadh reported the highest numbers of road traffic injuries and fatalities in the country (7).

Emergency medical response

Emergency medical response is a key component of post-crash care. In an analysis of 95 372 road traffic accidents recorded by the Saudi Red Crescent Authority between 2016 and 2020, mean response intervals were 46.2 ± 10.3 seconds for mission acceptance, 108.4 ± 15.2 seconds for ambulance mobilisation, 10.7 ± 3.1 minutes to reach the crash site, 95.3 ± 18.7 seconds to initiate treatment, and 17.4 ± 5.2 minutes spent at the scene (8).

Ambulance safety may affect emergency response capacity. In a national study of 160 ambulance-related road traffic accidents reported from January 2020 to July 2022, direct collisions accounted for 90% of cases and ambulance drivers were reported to be at fault in 42% (9). Such incidents may delay prehospital response, reduce emergency medical service efficiency and affect outcomes for injured patients.

Risk factors and high-risk driving behaviours

The evidence points consistently to risky driving behaviours as major contributors to road traffic accidents and severe injuries in Saudi Arabia. In a study of 342 male drivers treated for road traffic injuries at King Salman Armed Forces Hospital and King Khalid Armed Forces Hospital in Tabuk, 62% were aged < 36 years and 90% were from low- and middle-income groups. Mobile phone use while driving, over-speeding and overtaking

were associated with nearly 4-, 3-, and 2-fold higher likelihoods of severe injury, respectively (*10*).

A study of driving behaviour among 424 young drivers at Alasala Colleges in the Eastern Province, conducted between November 2021 and February 2022, found that 26% of young male drivers and 19% of young female drivers reported involvement in road traffic accidents. Aggressive and speeding-related behaviours were more common among male drivers, although risky driving behaviours were observed in both sexes. Driving experience, risky driving behaviours, vehicle type, traffic violations, mobile phone use with headphones while driving and other distractions were identified as predictors of road traffic accidents (*11*).

In an observational study of 1700 drivers on 13 major highways and inner-city intersection sites in Riyadh, 14% of drivers were seen using mobile phones while driving and only 34% were wearing seatbelts (*12*). In the Eastern Province, road traffic accident severity between 2009 and 2016 was associated with driver-related factors, including sleep deprivation, distraction, over-speeding, sudden lane deviation, collisions with vehicles, road barriers, pedestrians or motorcyclists, and adverse weather conditions, particularly rain (*13*).

Roundabouts and drifting

Roundabouts are circular intersections designed to improve traffic flow and reduce collision risk by slowing vehicles and minimising conflict points compared with conventional intersections. Their safety benefits depend, however, on drivers yielding to circulating traffic, signalling correctly and following lane rules. In a field study involving 384 drivers at 5 roundabouts in Riyadh, nearly 90% violated at least one traffic regulation, most commonly exiting without signalling or entering without yielding. Drivers' responses indicated limited knowledge of roundabout regulations and inadequate coverage of this topic during driver licensing and education (*14*).

Tafheet, or Saudi drifting, is an illegal high-speed drifting practice on public roads in which drivers deliberately cause vehicles to skid or slide sideways at high speed, often while spinning or swerving between lanes. It is usually performed using sedans or other non-sport vehicles, unlike traditional drifting, which involves high-performance cars. Spectators often gather to watch, increasing the risk of road traffic accidents involving drivers and bystanders. In a study of 799 male students in grades 7–12 from government, private and international schools in Riyadh, around 40% reported taking part in *tafheet*. This was more common among students who also reported unsafe driving behaviours, such as traffic law violations, non-use of seatbelts and mobile phone use while driving (*15*).

Patterns and complications of road traffic injuries

The available hospital-based studies describe the profile, severity and complications of road traffic injuries in several Saudi settings. Among 10 855 patients with road traffic injuries who presented to the emergency department of King Khalid Hospital in Ha'il between January 2016 and December 2017, 74% were male. The most common injuries were fractures (48%), followed by lacerations (32%), crush injuries (11%), penetrating injuries (8%), abdominal and pelvic visceral injuries (1%), thoracic visceral injuries (0.4%), and amputations (0.2%) (*16*).

In a study of 300 patients with road traffic injuries treated at the emergency departments of King Khalid Hospital and Prince Sultan Center for Health Services in Al-Kharj between December 2018 and December 2019, 91% of patients were male and car crashes were reported as the most common cause of injury (89%). Admission to an intensive care unit was required for 22% of patients, with chest, abdomen, upper limbs, and spinal injuries contributing significantly to these admissions (*17*).

Among 5797 traumatic road traffic injuries registered at Aseer Central Hospital in Abha between January 2010 and December 2019, traumatic spinal injuries accounted for 14%. The patients had a mean age of 30.7 years and most were male. Lumbar and cervical injuries were the most common, occurring in 33% and 31% of cases, respectively. Overall, 7% of patients required critical care admission, and the in-hospital mortality rate was 5% (*18*).

In a review of 572 road traffic accident patients who presented to the Radiology Department at King Fahad Military Medical Complex in Dhahran between July 2014 and July 2017 and underwent whole body-computed tomography, no trauma-related abnormalities were detected in 31%. Head, face and neck injuries occurred in 8.8% of cases, while chest, abdomen and pelvis injuries were seen in 31%, and combined injuries in 32%. Most patients (90%) were unrestrained. The leading injury mechanism was rollover (70%), followed by frontal collisions (23%), side impacts (5%) and rear impacts (2%). The absence of trauma-related abnormalities were 10% more frequent among restrained patients. Chest, abdominal and pelvic injuries were 3% higher, and combined injuries were 10% more common among unrestrained patients. Deaths occurred only among unrestrained patients (4%), all of whom had combined injuries (*19*).

Trauma registry data from King Abdulaziz Medical City in Riyadh showed differences in injury severity by age and sex. Among 1314 patients aged > 14 years who had been involved in non-fatal road traffic accidents between 2015 and 2017, 88% were male and the median age was 25 years. Two-thirds of patients were admitted to a ward. Severe injury scores were more common among males, whereas females had a higher proportion of chest injuries. Head and neck injuries were similarly distributed by sex, and adults aged ≥ 65 years were more likely to have severe head, neck and chest injuries (*20*).

Older hospital data show that road traffic accidents have long contributed to severe trauma outcomes in Saudi Arabia. A review of trauma admissions to the surgical intensive care unit at King Khalid University Hospital, Riyadh, from 30 October 1984 to 29 October

1989, identified 181 trauma cases, representing 16% of total surgical admissions. Road traffic accidents accounted for 83% of these cases, and male patients outnumbered female patients by 6 to 1. Of the 30 deaths, 16 occurred within 24 hours and 14 after multiple organ failure. Positive cultures were found in 50% of those who died (*21*).

Data on 303 road traffic accident victims who were dead on arrival at the emergency department of Assir Central Hospital, Abha, between August 1989 and May 1994 showed that 45% had head and neck injuries, 39% had thoracic injuries and 35% skull fractures (*22*).

Government efforts to reduce the burden of road traffic accidents

Recognising the heavy human and economic toll of road traffic accidents, Saudi Arabia has implemented coordinated actions across ministries and agencies to create a safer transport system (Table 2).

Governance and strategic framework

Under Vision 2030, Saudi Arabia has adopted the safe system approach to reduce road traffic deaths and injuries through safer road design, stricter laws, stronger enforcement and improved road-user behaviour. The reforms include a demerit points system and behavioural programmes for repeat violations, as well as a graduated driver licensing system that allows new drivers to gain experience under safer conditions before obtaining full driving privileges. Vehicle inspection and registration standards have been strengthened to improve compliance with safety requirements. Pedestrian facilities are being expanded and public transport promoted to reduce congestion and the risk of road traffic accidents. Public education is also central to the framework, supported by regularly evaluated social marketing campaigns and centralised communication to improve coordination and impact (*4*,*23*).

Established in 2018, the Ministerial Traffic Safety Committee coordinates national road safety action across government sectors, including health, transport and logistics, commerce, media, municipal and rural affairs and housing, communications and information technology, interior, and education. The committee brings together the Royal Court and international stakeholders, including WHO. It coordinates a multisectoral response to road traffic accidents, covering law enforcement, standardised data collection, trauma care, road infrastructure, vehicle safety, traffic management, public awareness and education, community engagement, post-crash management and safety measures for pedestrians and users of dedicated lanes (*2*–*4*).

Legislative reforms and enforcement of traffic laws

Saudi Arabia has strengthened penalties for dangerous road behaviours, including over-speeding, reckless driving, seatbelt violations and mobile phone use while driving. The demerit points system applies escalating sanctions for repeat offences, from temporary licence suspension to licence withdrawal. Non-Saudi drivers who repeatedly violate traffic laws may face deportation. Those caught driving while their licences are suspended may face fines and imprisonment, depending on the length of suspension. Drivers under permanent

Table 2 Government road safety initiatives in Saudi Arabia

Domain/initiative	Key actions and components	Intended impact
Vision 2030 framework	Adoption of the Safe System Approach; safer road design; stricter laws and enforcement; demerit points system; graduated driver licensing; enhanced vehicle inspection; expanded pedestrian and public transport infrastructure; public education campaigns	Reduce road deaths and injuries; improve road-user behaviour; promote safe and sustainable mobility
Ministerial Traffic Safety Committee	Established in 2018 to coordinate multisectoral road safety action, including enforcement, data collection, trauma care, infrastructure, vehicle safety, traffic management, public awareness and pedestrian safety	Strengthen coordination, policy integration and national road safety governance
Legislative reforms and traffic enforcement	Stronger penalties for speeding, seatbelt violations and mobile phone use while driving; escalating sanctions through the traffic points system, including possible licence suspension and deportation of repeat non-Saudi offenders; automated enforcement through Saher; real-time detection of violations; mandatory inspections, speed limiters, driver training, electronic logging and advanced driver assistance systems for heavy goods vehicles and public service vehicles	Improve compliance with traffic laws; deter violations; strengthen monitoring and reduce preventable driver- and vehicle-related risks
Infrastructure development and road safety improvements	Major investments under Vision 2030, including upgraded highways, guardrails and improved signage; speed bumps, roundabouts, pedestrian bridges and crossings in major cities	Reduce accident severity; protect pedestrians and other vulnerable users; improve traffic flow
Technology and data-driven road safety	Use of geographic information systems, artificial intelligence and smart traffic management; predictive modelling for high-risk areas; mobile applications for real-time alerts and traffic information	Identify high-risk locations; prevent secondary accidents; support evidence-based interventions
Public awareness and education	National campaigns by the Ministry of Interior, General Directorate of Traffic and Saudi Traffic Safety Society on speeding, distraction, child safety and seatbelt use; Gulf and Arab Traffic Safety Week activities; school and university partnerships	Promote safer driving culture; increase compliance with safety measures; strengthen community participation in road safety

suspension may regain licences after 2 years if they complete approved training (*24,25*).

The Saher system, launched in 2010, links traffic management, vehicle monitoring and automated enforcement across major Saudi cities. Through a network of digital cameras connected to the National Information Center, it regulates traffic lights according to vehicle volume, tracks traffic department vehicles to improve response times, identifies vehicles at city entrances and exits, displays real-time information for drivers, monitors traffic flow and detects violations using fixed and mobile radars. Command-and-control centres in 8 cities manage these functions in real time. When a violation is detected, cameras capture the vehicle licence plate, the owner's information is retrieved from the national database, and the ticket is issued electronically (*26*).

Regulations for heavy goods vehicles and public service vehicles have also been strengthened. These measures include stricter licensing requirements, advanced driver training, regular assessments, mandatory vehicle inspections and speed-limiting devices. Electronic logging devices are used to monitor driving hours and help prevent fatigue-related accidents, and advanced driver assistance systems, including collision avoidance and lane departure warning systems, are encouraged (*27*).

Infrastructure, technology and road safety improvements

As part of Vision 2030, Saudi Arabia has invested substantially in road infrastructure and safety engineering, including safer road designs, upgraded highways, guardrails and improved signage across the country. Urban planning increasingly incorporates speed bumps, roundabouts and traffic-calming measures, while pedestrian bridges and crossings in major cities such as Riyadh and Jeddah aim to reduce pedestrian-related accidents. These efforts are intended to improve safety on highways, where severe accidents are common, and in urban settings, where vulnerable road users face greater risk (*28,29*).

Technology is being used to support road safety planning and traffic management. In addition to the Saher system, authorities use geographic information systems, artificial intelligence and smart traffic management to identify accident-prone areas, predict risk and improve traffic flow. These systems can adjust traffic signals automatically, communicate with emergency services and provide real-time traffic updates and hazard alerts through mobile applications to support safer driving (*30,31*).

Public awareness and education

Public education remains central to Saudi Arabia's road safety strategy. The Ministry of Interior, General Directorate of Traffic and Saudi Traffic Safety Society (*Salamh*) run campaigns on speeding, distraction and impaired driving. During the Gulf and Arab Traffic Safety Week, lectures, workshops and media campaigns promote seatbelt use and safe driving. *Salamh* produces educational content on child seat safety, intersections and overtaking. Social media is used to reach younger populations, and partnerships with schools, universities and private sector organisations help integrate road safety messages into education and driver training (*32,33*).

Study limitations

This review has some limitations. The included sources varied in design, data sources and outcome definitions, limiting comparability and precluding quantitative synthesis. Official statistics and reports may have been affected by underreporting or changes in data collection methods over time. The evidence was not collected through a systematic search, study quality was not assessed and causal relationships could not be established.

Conclusion

Saudi Arabia has achieved measurable reductions in road traffic accidents, injuries and fatalities during the past decade, reflecting sustained national attention to road safety. Reforms combine the safe system approach with stronger traffic enforcement, improved vehicle safety standards, infrastructure upgrades, emergency response, public education and technology-supported traffic management. Maintaining progress towards the Vision 2030 road safety target will require consistent enforcement, stronger compliance with seatbelt requirements and restrictions on distracted driving, continued infrastructure improvements and data-driven action on high-risk behaviours and locations.

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Advantages and disadvantages of mobile phones for students

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Dear Editor,

We read with interest the article by Yaakoubi et al on the relationship between smartphone addiction and motor-cognitive performance among Tunisian adolescents. The Arabic version of the short version of the smartphone addiction questionnaire was used (*1*). Motor functions were assessed using the Takei Grip D dynamometer, MySprint app and Flamingo Balance Test, while cognitive functions were assessed using the Wiener test system (*1*). Among 120 students classified as smartphone addicts, daily mobile phone usage time (DMPUT) was higher, sprint time was shorter, grip strength was lower, and cognitive accuracy was lower than in non-addicted adolescents (*1*). The study is promising but it requires further discussion.

First, it is important to note that the parameters for physical performance and cognitive functions depend not only on daily mobile phone usage time but also on numerous other factors. Sprint time, balance, and handgrip strength are strongly influenced by physical condition, motivation to run fast, the training status of the balance system, body mass index (BMI), comorbidities, the use of concomitant medications, and the consumption of illegal drugs, tobacco and alcohol. If these influencing factors are not included in the assessment, a reduction in sprint time and handgrip strength in individuals with addiction problems cannot be reliably attributed only to the DMPUT.

Second, cognitive performance does not depend solely on DMPUT, but on numerous other influencing factors. These include genetic factors, the parents' level of education and social status, upbringing, diet, comorbidities, and the use of concomitant medications. If these influencing factors are not considered, general conclusions about the effects of digital mobile phone use on cognitive performance remain unreliable.

Third, a smartphone is not only a useful tool, toy, entertainment device, status symbol, means of expression, and communication, but also an electronic device that causes significant radiation exposure for the user and their immediate surroundings. Mobile phones emit radiofrequency radiation, a type of non-ionizing electromagnetic radiation. Smartphone emissions fall into the same category as radio waves, microwaves and Wi-Fi signals and are far below the threshold of ionizing radiation such as X-rays or gamma rays (*2*). However, radiofrequency radiation causes molecules in our bodies to vibrate and generates small amounts of heat (*3*). Whether high frequency radiation truly lacks the necessary energy to break chemical bonds or directly damage DNA is a matter of debate. It is also worth considering that bacteria, viruses, fungi, protozoa, and other pathogens can be found on a mobile phone. Therefore, it is advisable to clean the device thoroughly and regularly. Intensive smartphone use can lead to a condition known as "text neck syndrome". Prolonged downward gaze at the phone puts significant strain on the neck muscles, which can result in tension, cramps, and even pain that radiates into the shoulders, arms and back.

Fourth, smartphones can be misused by providers as a manipulative tool to influence and control thoughts, feelings, behaviour, and world views. They can even be used as eavesdropping devices with appropriate methods. It should be considered that mobile phones can significantly impair productivity due to the constant stream of notifications, compulsive scrolling on social media, and their widespread use at the workplace (*4*).

In conclusion, if there is no power shortage, smartphone addiction can only be prevented by limiting digital media consumption, either through self-restraint or through legal restrictions on access, and by limiting access to emergency communications.

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Response by authors of the article

Mohamed Yaakoubi, Ahmed Ghorbel, Anis Saddoud, Liwa Masmoudi, Omar Trabelsi, Faical Farhat and Adnene Gharbi

Thank you for the comments on our article, Smartphone addiction and motor-cognitive performance among adolescents in Tunisia. We appreciate the commentator's interest in our work and welcome the opportunity for constructive scientific dialogue. The following is our response to the points raised:

Potential confounding factors in physical performance

The commentator correctly notes that physical performance outcomes such as sprint time, balance and handgrip strength may be influenced by several factors, including physical activity level, body composition, training status, comorbidities, and substance use. We agree that these variables are important considerations when interpreting physical performance measures. However, several methodological safeguards were observed in our study to minimise the influence of such factors. Specifically, we excluded adolescents with low physical activity levels (IPAQ-SF <25th percentile), those who had been engaged in organised sports for more than one year, those reporting tobacco use, and those with irregular sleep patterns. All regression analyses were adjusted for age, sex and BMI, as indicated in Table 3. We explicitly acknowledged the possibility of residual confounding in the discussion section, noting that socioeconomic status and nutritional factors were not directly assessed and, therefore, could not be fully controlled.

Although residual confounding cannot be entirely excluded, we believe that the study design, exclusion criteria and statistical adjustments have substantially helped reduce the influence of several key confounding variables identified by the commentator. Importantly, our study was designed to examine associations and not to infer causality. We agree that future longitudinal studies incorporating a broader range of biological, environmental and behavioural covariates would strengthen the evidence base.

Potential confounding factors in cognitive performance

We agree that cognitive performance is shaped by a complex interplay of factors, including genetic influences, parental education, socioeconomic circumstances, nutritional status, medical conditions, and medication use. These considerations were acknowledged in the discussion section, where we stated that socioeconomic and nutritional variables were not directly assessed and that the findings should be interpreted primarily within the context of urban Tunisian adolescents. However, the study groups did not differ significantly in age, height, weight, or BMI (all $P > 0.05$), reducing the likelihood that basic demographic or anthropometric differences accounted for the observed findings. Adolescents with sensory or motor impairments and those using medications that could affect cognitive functioning were excluded from participation. After adjustment for relevant covariates, smartphone addiction severity remained significantly associated with cognitive accuracy (error rate). Therefore, although unmeasured confounding cannot be completely ruled out, available evidence supports the robustness of the observed association.

Mobile phone radiation and microbial contamination

We respectfully note that this issue lies beyond the scope of the study. Our investigation focused on behavioural smartphone addiction and its association with motor and cognitive performance among adolescents. We did not assess exposure to radiofrequency radiation, Wi-Fi signals or microbial contamination of mobile phone surfaces. These subjects are undoubtedly important from a public health perspective; however, they address distinct research questions that require different methodological approaches. We therefore consider them to be outside the objectives and scope of the study and defer any discussion on these issues to research that is specifically designed to examine such exposures.

Conclusion

We thank the commentator for emphasising the importance of considering potential confounding factors in research examining smartphone use and adolescent health. We would like to highlight that several of the concerns raised were addressed in the original manuscript through participant selection criteria, statistical adjustment procedures and explicit discussion of the study limitations. While acknowledging the inherent limitations of cross-sectional research, we believe that our findings provide a meaningful contribution to the growing literature on smartphone addiction and motor-cognitive functioning among adolescents, particularly within the underrepresented North African context.

We appreciate the journal's commitment to fostering constructive scientific discussion and thank the commentator for the opportunity to further clarify our work.

Enhancing the capacity of rural health workers for brucellosis prevention and control in livestock-reliant communities

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Dear Editor,

Brucellosis remains a significant zoonotic disease in several rural areas of Islamic Republic of Iran and the broader Eastern Mediterranean Region (EMR), particularly in communities where livestock handling is central to daily life (*1,2*). Although national control programmes have made remarkable progress in reducing brucellosis incidence, effective prevention, early recognition, and timely reporting at the primary health care level remain challenging. Rural health workers are often the first point of contact in village health houses (primary rural health care units staffed by trained community health workers), placing them in a crucial position to influence public awareness and disease surveillance (*3*).

During my field experience with the rural health networks in northwestern Islamic Republic of Iran, I have observed gaps in practical knowledge and confidence among rural health workers regarding brucellosis (*4*). For example, in several livestock-dependent villages in the region, I observed delayed reporting of febrile illness among farmers engaged in animal husbandry—often associated with the consumption of unpasteurised dairy products—as a recurring barrier to timely diagnosis and control of brucellosis. Although training curricula cover theoretical aspects of the disease, frontline staff frequently encounter difficulties in educating livestock owners about safe animal husbandry practices, early recognition of clinical signs in humans and the importance of early reporting (*1,5*). These gaps can compromise prevention efforts and delay public health interventions.

Several strategies may be beneficial in addressing these challenges. One is scenario-based training sessions that use real-life case studies to improve practical skills in the recognition of early symptoms and implementing preventive measures (*4*). Two, joint workshops with veterinary services, that reinforce the One Health approach to brucellosis control (*2,5*). Three, community education toolkits that equip rural health workers with culturally appropriate materials for livestock owners and families (*3*). Four, is the need for feedback channels on reported cases, allowing health workers to learn from the outcomes and strengthen their confidence in surveillance (*4*).

Enhancing the capacity of rural health workers in brucellosis prevention and control is not merely a technical exercise; it is fundamental for maintaining community trust, preventing outbreaks and ensuring effective zoonotic disease management (*1,2,5*). By strengthening their role through targeted training and practical support, timely interventions can be achieved, ultimately reducing disease burden in vulnerable rural populations.

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Why does Pakistan lag in the use of fibrinolytics in patients with ischemic stroke?

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Dear Editor,

I am writing to address a significant concern within our health system; the challenges in using fibrinolytics for individuals experiencing ischemic stroke in Pakistan. Acute ischemic stroke is a neurologic emergency for which every minute of delay results in neuronal loss and worsened disability (*1,2*). Intravenous thrombolysis with alteplase (tPA) improves outcomes when administered within the 3–4.5-hour therapeutic window (*2*).

The pathophysiology of ischemic stroke indicates an urgency for reperfusion: the ischemic core is irreversibly injured, while the surrounding penumbra is hypoperfused yet salvageable with timely reperfusion (*2*). Stroke is among the leading causes of death and disability in Pakistan (*3,4*), yet the use of thrombolytics remains limited.

A stroke unit is a specialised ward providing multidisciplinary care, rapid imaging, intravenous thrombolysis, post-treatment monitoring, and secondary prevention. However, in Pakistan, access to such units is limited and uneven, with availability concentrated in major urban centres and private tertiary hospitals (*4,5*). Delays are further compounded by low public awareness of stroke symptoms, limited pre-hospital triage, concerns about haemorrhagic risk (*6*), inadequate infrastructure, and affordability barriers (*5*).

Globally, tenecteplase is increasingly favoured over alteplase because of its easier administration, lower cost and comparable or superior outcomes (*7–9*). Yet, tenecteplase remains unavailable in Pakistan (*10*). At the community level, adopting the balance, eyes, face, arm, speech, time (BE-FAST) approach can improve recognition of the anterior and posterior circulation strokes and prompt urgent evaluation (*11*). At the system level, training emergency teams, implementing pre-notification protocols, achieving door-to-needle targets, and ensuring round-the-clock imaging are essential to minimise delays (*5,6*).

Experience from other countries shows that organised stroke systems can greatly improve thrombolysis rates. In the United States of America, stroke units, pre-hospital notification and door-to-needle protocols have helped reduce delays and improved outcomes (*12*). Germany and the Czech Republic have achieved high rates through regional networks and telemedicine (*13*). These examples demonstrate that with coordinated policy and appropriate infrastructure and training, major gains are possible even in resource-limited settings.

In conclusion, by raising public awareness, expanding stroke units, ensuring equitable access to thrombolytics, and introducing tenecteplase, Pakistan can reduce preventable disability and mortality and align its stroke care with international standards.

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The quality of death certificates depends on the training, competence and independence of the issuers, and the intensity of the investigation into the cause of death

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Dear Editor,

We read with interest the article by Kazemeini et al on error analysis in a sample of 25 123 medical death certificates (*1*). The article reported that only 29.3% of the certificates were filled correctly and 67.7% were incomplete. Almost two-thirds of the deaths (63.3%) occurred in hospitals and a few outpatient settings, while almost one-third occurred at home (32.3%). The most frequent error (86.3%) was the omission of the period between the onset of illness and death, and the least frequent error (14.5%) was illegible handwriting. The study is noteworthy but requires further discussion.

Firstly, it was not reported whether nationally standardised death certificate forms were used. If no standardised forms existed, it is understandable that important information was missing or incorrectly stated. Standardised forms with predefined questions and categories are essential and could improve the work of issuing doctors and authorities.

Secondly, information is lacking regarding whether or not physicians in the country have been trained to correctly complete death certificates. Particularly, physicians who do not regularly complete death certificates, or who are doing so for the first time, may find it difficult to comply with the regulations. Because completing death certificates is not part of medical training, no one can be held responsible.

Thirdly, more information should be provided regarding the differences between the cause of death listed by the physician who issued the first and the second death certificates, which was issued in 4112 cases involving a forensic autopsy. What were the reasons for ordering a forensic autopsy in 16% of the cases? It should be specified how many forensic and non-forensic death certificates listed homicide and its subcategory (unlawful, lawful, criminological, special legal category) as the cause of death. It would also be interesting to know how often the forensic autopsy failed to uncover the correct cause of death and how frequently the forensic cause of death differed from the cause of death on site.

Fourthly, on the deficiencies beyond those already mentioned. There was no information about the number of patients who died suddenly and unexpectedly, particularly regarding cases of sudden cardiac death, sudden unexpected death in Parkinson's disease, and sudden unexpected death in epilepsy. Distinguishing between unexpected and expected death is crucial for medical, epidemiologic and forensic reasons.

Fifthly, the circumstances under which death certificates were issued were not documented. Since the accuracy of death certificates depends significantly on the circumstances of their issuance, it is important to know how frequently they were issued: at night, under duress, or under the influence of witnesses, authorities, or individuals not involved in the death.

In conclusion, determining the cause of death is of paramount importance from a familial, legal, medical, and epidemiological perspective.

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