

Trends of mortality and years of life lost due to cardiovascular diseases in West Azerbaijan province, Iran, 2013-2024

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Research Article

Keywords: YLL, cardiovascular diseases, Trend

Posted Date: July 27th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10007337/v1>

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Additional Declarations: No competing interests reported.

Abstract

Introduction: Cardiovascular diseases (CVDs) are recognized as one of the leading causes of premature mortality worldwide and, in recent years, have imposed an increasing burden on health systems. This study aimed to calculate the Years of Life Lost (YLL) attributable to CVD over 12 years in West Azerbaijan Province, Iran.

Materials and Methods: This population-based historical cohort study examined trends in mortality and YLL due to CVD in West Azerbaijan Province. The required data were extracted from the Iranian Ministry of Health and Medical Education's system for the registration and classification of causes of death and were used to compute the YLL indicator for CVD. Temporal trends were evaluated using Joinpoint regression analysis, and statistically significant change-points and the annual percent change (APC) were estimated.

Results: Over the 12 years, 74,771 deaths due to CVD were recorded in the province. Of these, 62.0% (46,367 deaths) occurred among men, and 33.7% (27,954 deaths) occurred in the 15–29-year age group. The total YLL during the 12 years was 165,737 years among men (equivalent to 8 years per 1,000 population) and 117,999 years among women (equivalent to 6 years per 1,000 population). Based on the trend analysis, the YLL indicator for CVD showed no statistically significant change over the 12-year study period. The average annual percent change (AAPC) was –0.33%, indicating relative stability of this indicator during the interval under investigation.

Conclusion: CVDs caused a high and persistent burden of premature mortality in West Azerbaijan over 12 years, with no significant change in YLL trends. These findings highlight the urgent need for targeted and sustained public health interventions.

Introduction

Cardiovascular diseases (CVDs) remain the leading cause of death globally, with the projected rate of death to rise in the coming decades, particularly in low- and middle-income countries undergoing epidemiological and demographic transitions (1, 2). In Iran, CVDs continue to represent the leading cause of mortality and a principal contributor to the national burden of disease. According to recent epidemiologic analyses, CVDs accounted for approximately 30% of all deaths and nearly 15% of disability-adjusted life years (DALYs) in the country as of 2021. Estimates indicate that these conditions are responsible for about 40% of annual deaths nationwide, surpassing other major health issues such as diabetes and cancer. (3). This persistent burden reflects a complex interplay of genetic predispositions, lifestyle shifts, urbanization, and systemic challenges in healthcare access and prevention (4). While national-level data provide a macroscopic view of CVD trends, such aggregated statistics often obscure critical regional disparities that are essential for tailoring effective public health interventions (5).

The province of West Azerbaijan in northwestern Iran faces unique cardiovascular health challenges shaped by its diverse ethnic makeup, geography, and socioeconomic factors (6). Limited access to specialized cardiovascular care in rural areas, along with high tobacco use and traditional dietary habits, contribute to distinct patterns of CVD in the region (7). Despite these contextual factors, comprehensive, longitudinal assessments of CVD mortality and its impact on population health in West Azerbaijan remain conspicuously absent from the scientific literature. Most prior Iranian studies have either focused or that mask subnational heterogeneity, thereby limiting their utility for local policy formulation (8).

Years of life lost (YLL) is a key measure to understand the societal impact of premature death. It calculates the difference between the age at which a person dies and their expected lifespan under ideal conditions, focusing particularly on lives lost at younger ages (9). Unlike crude or age-standardized mortality rates, YLL emphasizes the loss of productive life years, offering a more nuanced lens through which to prioritize health interventions (10). While YLL has been increasingly adopted in global burden of disease studies, its application at the provincial level in Iran, particularly over an extended temporal window, is scarce (11). This gap is especially problematic in regions like West Azerbaijan, where early-onset CVDs may disproportionately affect younger populations due to undiagnosed risk factors or delayed care-seeking behavior (12).

The absence of granular, trend data on CVD-related YLL hampers evidence-based planning and resource allocation (13). Without understanding how mortality patterns and life expectancy losses have evolved over the past decade, spanning periods of economic volatility, healthcare reform, and public health campaigns, policymakers lack the empirical foundation needed to design targeted, equitable strategies (14). Moreover, the interplay between sex, age, and temporal trends in YLL remains unexplored in this setting, despite known gender disparities in CVD presentation and outcomes across the Middle East (15).

Against this backdrop, the present study aims to address these critical knowledge gaps by analyzing trends in both mortality rates and years of life lost attributable to CVDs in West Azerbaijan province from 2013 to 2024.

Methods

Study Design

This retrospective population-based mortality trend study was conducted using death registry data from 2013 to 2023. The study focused on all registered deaths attributed to CVDs across urban and rural areas of West Azerbaijan province, Iran, during the study period.

Data Sources

A total of 74,771 death records due to CVDs were initially obtained from the electronic population-based death registration system

Mortality data were collected through the electronic death registration system, which integrates information from multiple sources. The Legal Medicine Organization (Forensic Medicine) serves as the primary source of data, while additional sources such as hospitals, cemeteries, and urban and rural health centers in West Azerbaijan province enhance the system's sensitivity and completeness.

To ensure accurate record linkage, the national identification number was used as a unique identifier. This enabled precise matching and aggregation of data across sources. The registration system employs a multi-step quality assurance protocol. Death reports submitted by each source are first reviewed at the local health center level, where they are verified and cleaned. Duplicate records are identified and removed based on key identifiers such as father's name, date and time of death, and national ID number. The cleaned and aggregated data are then entered into the national death registration database.

Inclusion and exclusion criteria:

All deaths attributed to CVDs, as classified in the electronic population-based death registration system, among residents of West Azerbaijan province during the period from 2013 to 2023, regardless of age or sex, were included in the study. Records were excluded if they were identified as duplicates (determined through matching on key identifiers such as the father's name, time of death, and national identification number) or if the underlying cause of death due to CVDs could not be confirmed because of missing or insufficient documentation.

Coding of causes of death:

Causes of death in this study were coded using the International Classification of Diseases, 10th Revision (ICD-10), in accordance with national protocols and World Health Organization (WHO) guidelines, ensuring consistency in the classification of CVDs. To address potential misclassification, a multi-layer verification process was implemented at the health center level in West Azerbaijan province, including cross-referencing the reported causes of death with clinical and forensic documentation. Death records that lacked sufficient information to confirm CVDs as the underlying cause were excluded from the final dataset. In addition, continuous professional training for registry personnel and ongoing inter-sectoral collaboration played a key role in improving the accuracy and reliability of cause-of-death coding throughout the study period.

Variables and definitions:

The primary outcome variables in this study included age at death, sex, year of death, mortality due to CVDs, and years of life lost YLL. Age at death was defined as the age in completed years at the time of death, providing key insight into the distribution of mortality across different age groups. Sex categorizes individuals as male or female, recognizing the potential disparities in cardiovascular mortality between genders. The year of death referred to the calendar year in which the death occurred, allowing assessment of temporal trends over the study period (2013 to 2023). Mortality due to CVDs was defined as deaths attributed to heart and vascular disorders, including but not limited to coronary artery disease and stroke, based on ICD-10 codes. YLL was calculated as a measure of premature mortality, reflecting the years lost when death occurred before the expected standard lifespan. The standard life expectancy used as a benchmark was based on national reference values or WHO standards. Deaths lacking sufficient information for accurate classification or YLL estimation were excluded. In this context, educational level was not a primary variable; however, in other sections of the study, the term "undergraduate" refers to individuals with a bachelor's degree, typically awarded upon completion of a four-year academic program at a university in Iran.

Statistical Analysis:

First, using graphs and descriptive statistics, the trend in the mortality ratio was illustrated in relation to demographic variables. The subsequent formula was employed to determine the years of life lost as a result of deaths caused by CVDs (16):

$$YLL = NC^{(ra)} / (\beta + r)^2 [e^{-(\beta + r)(L+a)} [- (\beta + r)(L + a)_1] - e^{-(\beta + r)a} [- (\beta + r)a - 1]]$$

Where N is the number of deaths at a certain age and gender. L is the standard of living of the deceased at the same age and gender. r is the Discounting Rate, which is equal to 0.03. β is the contract rate in calculating the age value, equal to 0.04. C is a modified constant value equal to 0.1658. a is the age at which death occurred, and e denotes Euler's number (≈ 2.718). The main idea behind the YLL calculation is to estimate the total number of years that are prematurely lost due to early death by considering the age at death, the expected remaining years based on life expectancy, and adjustments for factors like quality of life and standardization.

The formula begins with the number of deaths at each age, multiplies that by the expected remaining years of life for those individuals, incorporates adjustments for economic and demographic variables using standard constants, and then applies a discount rate to reflect the present value of future years lost. To ensure standardization, the standard population data from 2013 for low- and middle-income countries was used (17).

The adjusted mortality ratio by gender was also presented using a graph. Joinpoint regression analysis will be used to identify and quantify trends in leading causes of mortality, including the calculation of Annual Percent Change (APC) and statistical significance. YLL will be estimated for each major cause using Microsoft Excel, based on standard YLL formulas. Crude mortality rates per 10,000 population were calculated by dividing annual deaths by the mid-year population and multiplying by 10,000. Age-specific mortality rates were derived for defined age groups and applied to the 2013 standard population of low- and middle-income countries. Age-standardized mortality rates (ASMRs) per 100,000 population were then computed using the direct standardization method.

Results

In the 12-year study period (2013–2024), there were 74,771 deaths from CVDs in the West Azerbaijan province. Of those, 62.0% (46,367 cases) took place in cities, 37.4% (27,954 cases) in village's and for 0.6% (450 cases) the place was not noted.

The city population had more deaths than the country's population. In general, death rates have been going up over the years. Both city and country people experienced their highest mortality in 2020, after which the number went down a bit and then went back up again, showing a lasting load of cardiovascular problems (Fig. 1).

The proportional mortality rate due to CVDs in West Azerbaijan province shows a relatively stable trend. It fluctuates between 33% and 44%, begins at 44% in 2013, then reduces gradually until around 2021 (lowest point at 33%), and then rises slightly again, reaching 40% by 2024. This pattern indicates that CVDs consistently represent a significant proportion of total mortality in the province (Fig. 2).

The total number of YLL due to CVDs was different based on sex and age group. So that males generally experience higher YLL in most age groups compared to females. The highest YLL number appears in males aged 55–59 and 60–64 (18,000). Females' YLL peak was between 65–69 and 70–74 years (11,700). YLL is relatively low in younger age groups for both genders but begins to rise significantly after age 40, indicating that the burden of CVDs on premature mortality increases substantially in middle-aged and older adults, with a notably greater impact on the male population (Fig. 3).

The results of this study reveal that the total number of deaths among males (51.9%) was higher than among females (48.1%). The crude mortality rate was around 18 to 22 per 10,000 for both sexes, and the age-standardized rates (ASR) ranged from approximately 25 to 30 per 100,000. The number of YLL was higher in males compared to females in all periods of the study, and the total of YLL was 284,369 in both sexes. The YLL rate was approximately 7 to 9 per 1,000 population. Although there was a slight increase in rates between 2020 and 2021, the results show a stable trend in mortality and YLL (Table 1).

Table 1

Crude and standardized mortality rate (per 100,000 population) and YLL due to cardiovascular diseases by sex and year in West Azerbaijan province, 201

Year	No. death			Crude mortality rate Per (10'000)			ASR (95%CI) Per (100'000 population)			No. YLL			YLL Per (1000)	
	Male	Female	Both sex	Male	Female	Both sex	Male	Female	Both sex	Male	Female	Both sex	Male	Fem
2013	3105	2739	5844	19	18	19	26.3(25.3–27.3)	23.9(23.0–24.8)	25.1(24.5–25.7)	15638	11553	27191	10	7
2014	2775	2671	5446	17	17	17	23.3(22.5–24.2)	23.2(22.3–24.1)	23.3(22.7–23.9)	12281	9824	22105	8	6
2015	2994	2641	5635	18	17	17	25.0(24.1–25.9)	29.2(22.0–23.7)	24.0(23.3–24.6)	14573	10841	25414	9	7
2016	2949	2684	5633	18	17	17	24.5(23.6–25.4)	23.2(23.3–24.0)	23.8(23.2–24.4)	12834	9325	22159	8	6
2017	2991	2849	5840	18	17	18	24.6(23.7–25.4)	24.3(23.4–25.2)	24.5(23.8–25.1)	12638	9111	21749	8	6
2018	3034	2944	5978	18	18	18	24.7(23.8–25.6)	24.9(24.0–25.8)	24.8(24.2–25.4)	12016	8817	20833	7	5
2019	3270	3010	6280	19	18	19	26.5(25.6–27.4)	25.3(24.4–26.2)	25.9(25.3–26.6)	13276	9557	22833	8	6
2020	3793	3613	7406	22	21	22	30.6(29.6–31.5)	30.3(29.3–31.3)	30.4(29.7–31.1)	15162	10601	25763	9	6
2021	3679	3503	7182	21	21	21	29.5(28.6–30.5)	29.2(28.2–30.1)	29.4(28.7–30.0)	14201	10754	24955	8	6
2022	3347	3062	6409	19	18	18	26.8(25.9–27.7)	25.4(24.5–26.3)	26.1(25.4–26.7)	14010	8993	23003	8	5
2023	3447	3072	6519	20	18	19	27.5(26.6–28.4)	25.4(24.5–26.3)	26.5(25.8–27.1)	14975	9043	24018	8	5
2024	3420	3179	6599	19	18	19	27.2(26.3–28.1)	26.2(25.3–27.2)	26.7(26.1–27.4)	14133	10213	24346	8	6
Total	38804	35967	74771	19	18	19	26.4(26.1–26.7)	25.4(25.1–25.6)	25.9(25.7–26.1)	165737	118632	284369	8	6

Based on the Joinpoint analysis, the annual percent change (APC) of YLL by considering sex was – 4.09% (95% CI: -9.1 to 1.2, p = 0.117) between 2013 and 2017. This trend indicated a non-significant decreasing trend in this period. Furthermore, we witnessed a non-significant increasing trend between 2017 and 2024, and the APC was 1.88% (95% CI: -0.47 to 4.3, p = 0.110). There was no noticeable increase in total YLL over the full period (2013–2024), and APC was – 0.09% (95% CI: -2.3 to 2.2, p = 0.897). Overall, there was no statistically significant change in YLL due to CVDs between 2013 and 2024, and the average annual percent change (AAPC) for total YLL by sex was – 0.33% (95% CI: -2.57 to 1.96, p = 0.774) (Fig. 4 and Table 2).

Table 2
Join point analyses of the number of YLL due to cardiovascular diseases in West Azerbaijan province by year and sex, 2013–2024

Annual Percent Change (APC)					
		Years	APC	95% CI*	P-value
Total YLL by sex	Segment 1	2013–2017	-4.087	-9.1-1.2	0.117
	Segment 2	2017–2024	1.879	- .47 – 4.3	0.110
Total YLL	Segment 1	2013–2024	-0.094	-2.3-2.2	0.897
Average Annual Percent Change (AAPC)					
		Years	AAPC	95% CI	P- Value
Total YLL by sex	Full range	2013–2024	-0.332	-2.57-1.96	0.774
Total YLL	Full range	2013–2024	-0.094	-2.3-2.2	0.897
*CI, confidence interval					

Discussion

The results of the present study showed that CVDs remain the most important causes of mortality and YLL in West Azerbaijan province. This finding is consistent with the results of similar studies in other regions of Iran. Mirahmadizadeh et al. reported in southern Iran that CVDs have the highest contribution to mortality and YLL and the burden of these diseases is increasing (18). Also, Sepanlou et al. showed in northeastern Iran that hypertension and other metabolic risk factors play a major role in CVD death (19). This alignment indicates that the epidemiological trend in Iran has changed from communicable diseases to noncommunicable diseases and the burden of CVDs has been established as the main cause of premature death in the country. In other words, the pattern observed in West Azerbaijan Province is a reflection of this epidemiological transition and the increasing role of lifestyle and chronic risk factors. Similarly, the global report by Mensah et al. in the GBD study shows that CVDs remain the leading cause of death worldwide, accounting for more than 30% of global deaths (20). This similarity in trends reflects the global nature of the high burden of CVD.

In this study, CVD mortality and YLL were significantly higher in men than in women. Similar results were reported by Sharifi et al. in Fars Province (21) and by Naderimagham et al. in a longitudinal study (5). Nowbar et al. (22) reported in a global study that the mortality rate from ischemic heart disease was significantly higher in men than in women, which is likely due to behavioral, hormonal, and lifestyle differences (23).. This difference is likely due to the higher prevalence of risk behaviors, including tobacco use, hypertension, hyperlipidemia, and poor dietary patterns in men (24). Therefore, implementing gender-sensitive prevention programs, including health education for men, early screening, and targeted behavioral interventions, can have a significant impact on reducing the burden of disease. Indeed, gender analysis of disease burden is of particular importance in the design of public health interventions.

The temporal pattern of mortality in the present study showed that, despite a relative decrease in the ASR, the crude number of deaths increased in some years. This phenomenon, also reported in the studies of Azarbakhsh and Mansouri, is known as the “paradox of aging” and indicates that the increase in the elderly population leads to a natural increase in crude mortality even if age-specific indicators improve (25, 26). The Global GBD report by Roth et al. also reported this phenomenon in countries with a growing elderly population, including Japan, Italy, and China (27). In other words, reducing the risk of death in each age group cannot prevent the impact of the increase in the number of elderly people on overall mortality. This trend highlights the need to pay attention to health policies focused on aging and to develop specialized cardiac services for this age group.

In terms of age, the highest rate of YLL in the present study was observed in the middle-aged and elderly groups. The findings of Ghaem et al. in Shiraz showed that hypertension, diabetes, and dyslipidemia are more common in these age groups and are directly related to increased risk of heart disease (28). Also, Zibaenezhad et al. emphasized that early control of these risk factors is effective in preventing premature death (29). Global findings also confirm this; as Roth et al. reported in their global analysis that more than half of cardiac deaths occur in the fifth and sixth decades of life (27). Therefore, focusing interventions on middle-aged groups and designing educational and screening programs in the fourth and fifth decades of life can make a significant contribution to reducing YLL.

Environmental factors, along with behavioral factors, play a role in increasing cardiac mortality, depending on the location and location of urban and rural living. Motairek et al. showed that exposure to particulate matter (PM_{2.5}) in the Eastern Mediterranean region is associated with a significant increase in mortality from heart disease. Jalali et al. (30) also reported a significant association between air pollution and increased risk of CVD in Isfahan province (31). These findings are consistent with international evidence, as Khan et al. stated in their global review that air pollution is one of the ten main risk factors for cardiac mortality worldwide (32). This evidence shows that urban and rural climate conditions are effective in the burden of CVDs. Therefore, controlling air pollution and improving environmental conditions are key measures to reduce the burden of heart disease. Therefore, health policies should be cross-sectoral, and cooperation between environmental, transport, and health organizations should be strengthened to provide a healthier environment for the prevention of heart disease.

The results of the systematic review by Hasani et al. showed that in low- and middle-income countries, YLL due to CVD is very high, and preventive measures, especially blood pressure control and lifestyle modification, can play a key role in reducing it (33). Also, the global report by Mensah et al. from the GBD study emphasizes that strengthening primary care and focusing on prevention can significantly reduce the global burden of CVD (20). This evidence, along with the findings of the present study, emphasizes that Iran is in a similar epidemiological transition stage to other developing countries and that improving the

primary care system, public awareness, and behavior change can stop the increasing trend of the disease burden. Although no significant change was observed in the AAPC index in the present study, there is a possibility of an increase in the disease burden in the future, given the aging of the population and the increase in metabolic risk factors. Roth et al. also showed in their global GBD analysis that the burden of heart disease is increasing in countries with aging populations and inadequate control of risk factors (33). Mensah also showed that without continued preventive interventions and continuous monitoring of risk factors, the global burden of CVD will increase in the coming decades (20). Therefore, the relative stability of the indicators in this study should not be interpreted as a definite success; rather, it should be considered a warning to maintain and expand preventive programs to prevent a return to the upward trend in the coming years.

This study had two main limitations. First, the YLL estimates did not account for changes in incidence or mortality rates. Second, population dynamics such as aging, growth, and demographic shifts, which affect death patterns, were not considered. Future research incorporating comprehensive clinical, registry, and socioeconomic data could enhance the accuracy and depth of cardiovascular mortality assessment.

Conclusion

The results of the present study showed that CVDs remain one of the main causes of mortality and YLL in West Azerbaijan province and account for a high share of premature deaths. Despite the relative decrease in the ASR in recent years, the absolute number of deaths from CVD has had a relatively stable trend and increased in some years, which may reflect the increasing aging and changing population structure. Men had the highest share of mortality and YLL in all years of the study, which indicates the need to design gender-sensitive prevention and health education programs. Also, the high concentration of YLL in middle-aged and elderly age groups indicates the importance of early screening, lifestyle modification, and careful control of chronic risk factors such as high blood pressure, diabetes, and blood lipids. In addition to individual factors, the impact of environmental conditions, including air pollution, on the incidence and exacerbation of CVDs should be taken seriously. Therefore, health programs should be implemented in a multisectoral and inter-agency manner and, in addition to education and health care, should also address the improvement of the quality of the environment and lifestyle of the community. To reduce the future burden of CVD, it is necessary to strengthen primary care, develop an electronic disease registration system, and use local data in decision-making. Overall, the present study shows that although some indicators indicate relative control of the burden of heart disease, the aging process and persistence of risk factors are a potential threat to the health of the community. Adopting comprehensive preventive approaches, public health education, and developing health-oriented policies at the national level can lead to a sustainable reduction in mortality and YLL from CVDs in the coming years.

Declarations

Ethics approval and consent to participate

Ethical approval for this retrospective, population-based study was secured before beginning research activities from the Research Ethics Committees of Urmia University of Medical Sciences (Approval ID: IR.UMSU.REC.1404.292). All procedures were performed following relevant ethical standards and institutional guidelines.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from [Najaf Ahmadi Aghzariat, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of [Najaf Ahmadi Aghzariat].

Competing interests

The authors declare that there is no conflict of interest.

Funding

Not applicable.

Authors' contributions

Research idea and study design: NA, MZ; data acquisition: ER, FB; data analysis/ interpretation: MN, FB; statistical analysis: MN; supervision or mentorship: NZ, MZ; manuscript draft writing: KM, SM. All authors revised and approved the draft of the manuscript.

Acknowledgments

The authors would like to gratefully acknowledge the research deputy of Urmia University of Medical Sciences. The authors used AI-assisted language support (ChatGPT, GPT -5 mini) to improve the manuscript's clarity and style.

Clinical trial number: Not applicable.

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Figures

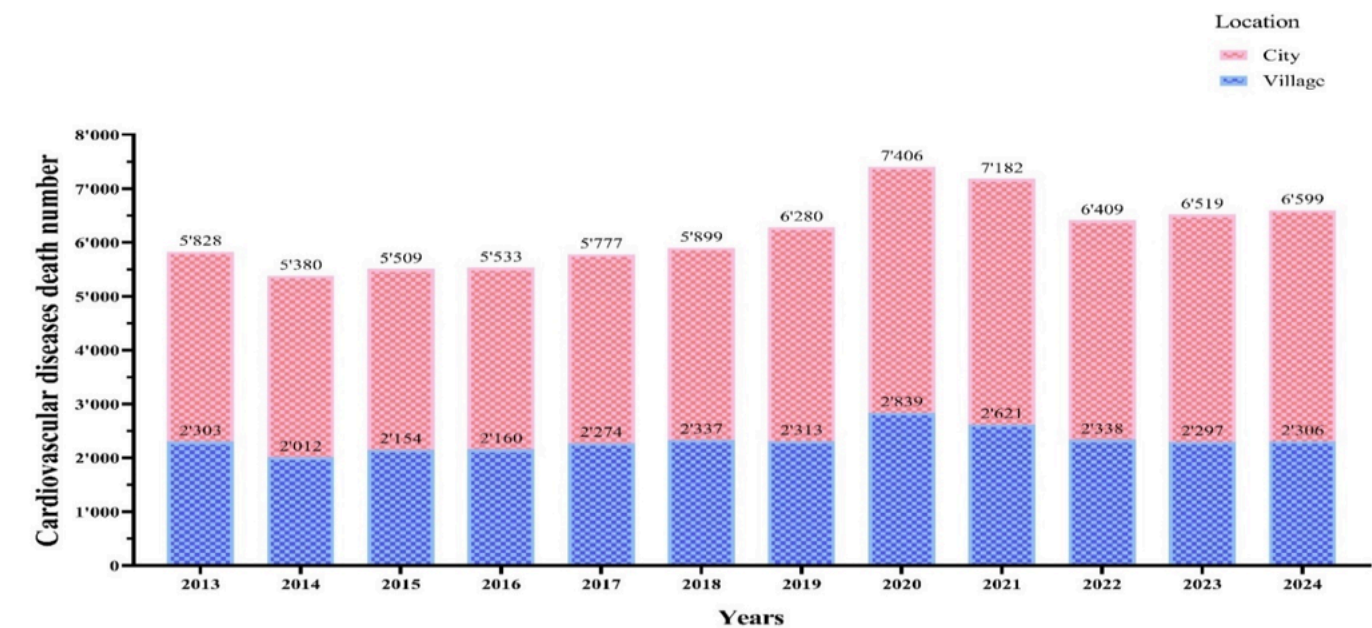


Figure 1

Mortality trends due to cardiovascular diseases by place of residence in West Azerbaijan province, 2013-2024

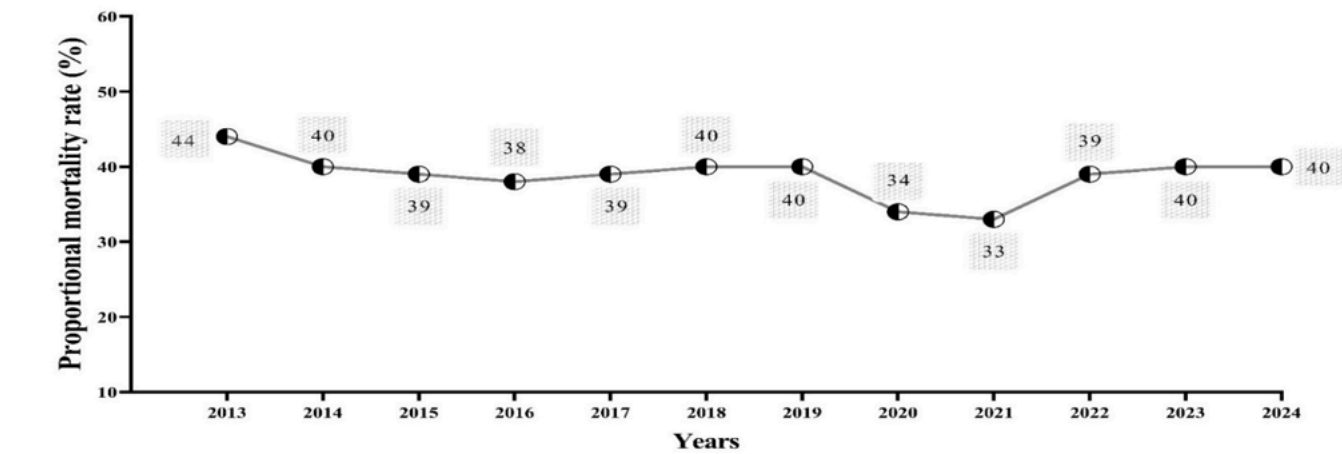


Figure 2

Trend in proportional mortality rate due to cardiovascular diseases in West Azerbaijan province, 2013-2024

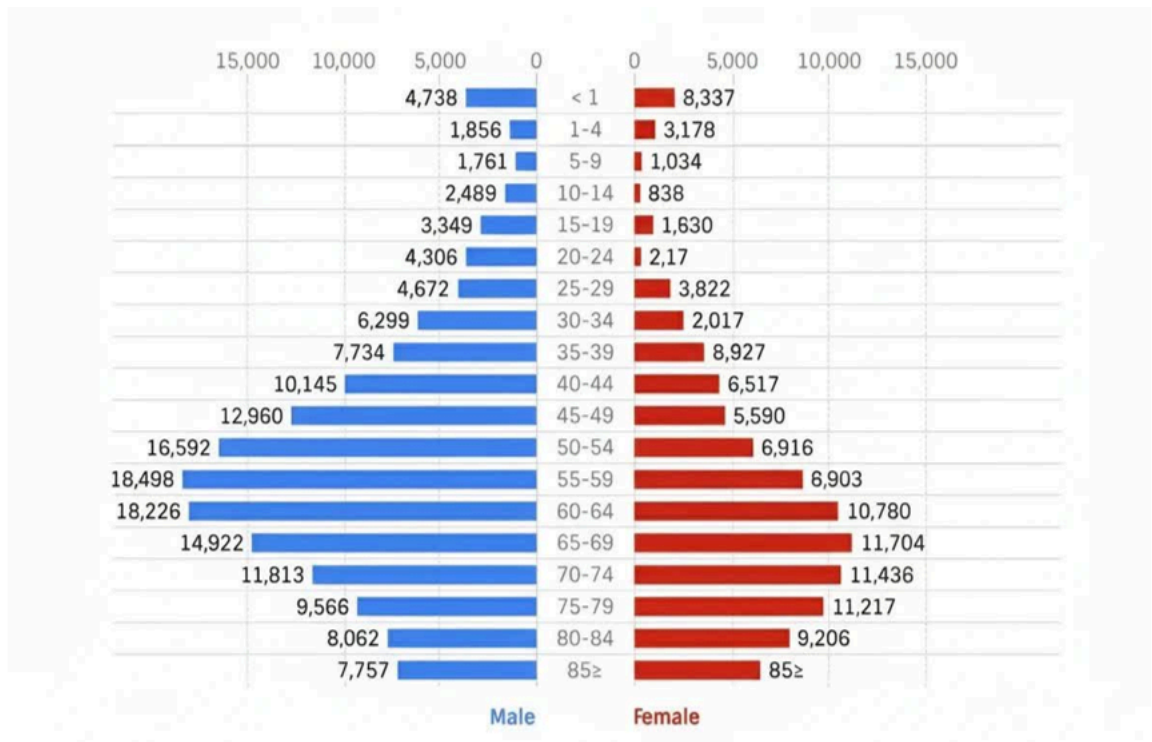


Figure 3

The total number of YLL due to cardiovascular diseases in West Azerbaijan province by gender in age groups

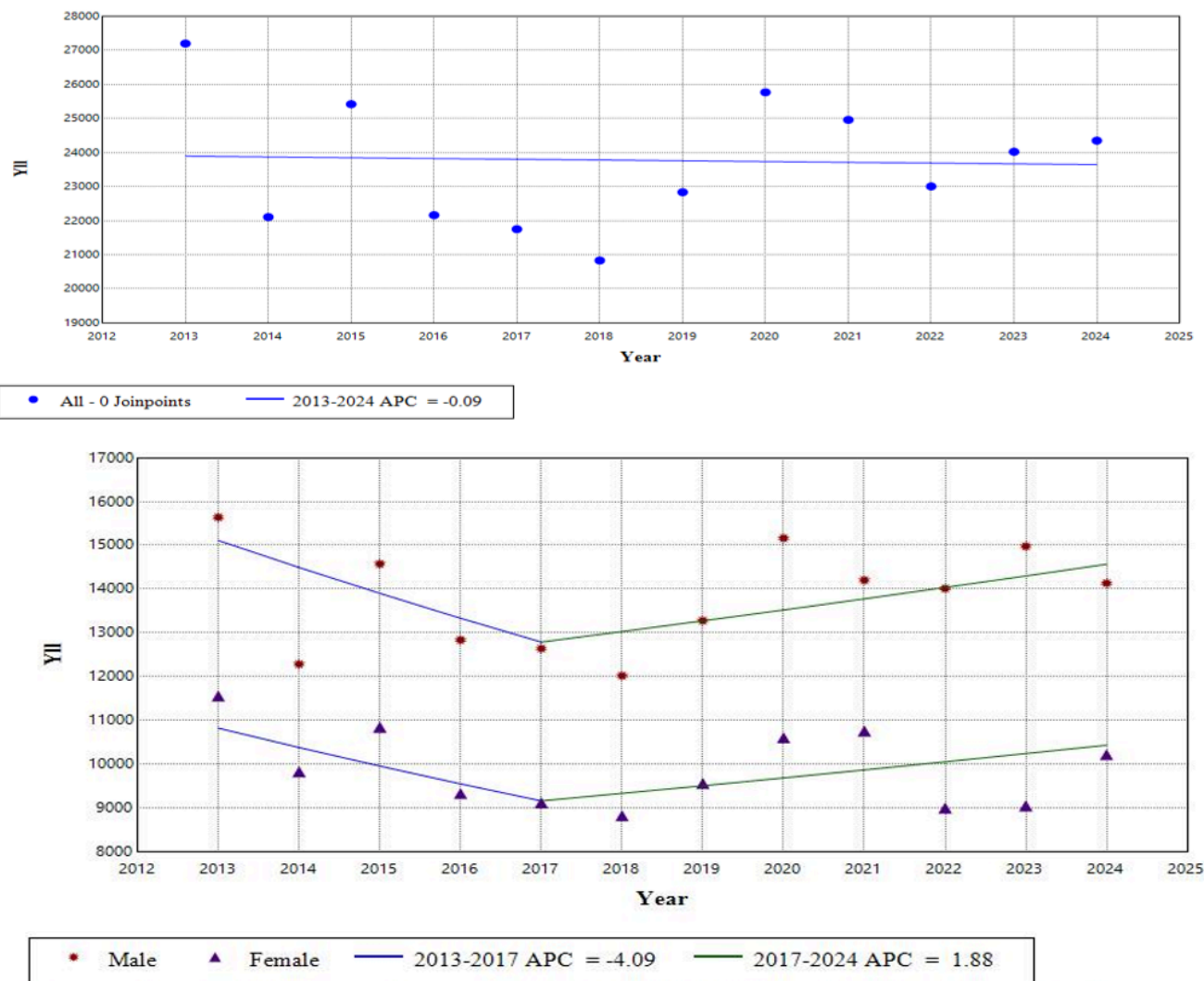


Figure 4

The overall trend in YLL due to cardiovascular diseases in West Azerbaijan province by year and sex, 2013-2024