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Original Article

Mortality Patterns and Trends in Fars Province, Iran (2015–2024): A Retrospective Analysis of Death Records

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What's Known

- Cardiovascular diseases have been identified as the leading cause of death in Iran, particularly among older adults.
- Prior mortality studies have primarily focused on national-level statistics, without detailed analysis of seasonal, spatial, or demographic variations within provinces.

What's New

- This study presented the first 10-year mortality analysis of Fars Province that incorporates seasonal and demographic trends using Gregorian calendar alignment.
- The study revealed pandemic-related mortality surges and rural–urban disparities in cause-specific death, offering actionable insight for local health interventions and chronic disease management.

Abstract

Background: Provincial mortality profiles are essential for local prevention and health-service planning. However, they are reported less frequently than national summaries in Iran. We described cause-of-death patterns and temporal changes in Fars Province from 2015 to 2024, including the disruption during the coronavirus disease 2019 pandemic.

Methods: We analyzed death registration records from the Fars provincial civil registration system, including age, sex, residence status, place of death, and an underlying cause coded using the International Classification of Diseases (ICD), 10th revision, and mapped to major cause groups. We summarized distributions by key strata and assessed temporal patterns using annual counts and within-registry proportions. Trend tests and multivariable logistic regression evaluated associations of calendar year and pandemic period with major cause groups, while unsupervised clustering summarized mortality profiles among non-neonatal records.

Results: After cleaning, 199,107 records were included. Diseases of the circulatory system accounted for 45.4% of deaths, followed by respiratory diseases, neoplasms, and external causes. All-cause deaths rose sharply in 2020-2021, with concurrent increases in respiratory and infectious causes. Cause composition varied by residence status and place of death, and clustering distinguished younger external-cause deaths from older disease-dominant profiles.

Conclusion: Mortality in Fars Province during 2015-2024 was dominated by circulatory diseases, with heterogeneity by demographic and contextual factors and a major pandemic-era increase in deaths. The findings supported prioritizing cardiovascular risk reduction and timely acute care, targeted injury prevention for younger groups, strengthened rural access to prevention and emergency services, and preparedness for future infectious surges.

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Keywords ● Mortality ● Cause of death ● Iran ● Logistic models ● Cardiovascular diseases

Introduction

Understanding mortality patterns is fundamental for effective public health policy and resource allocation. Patterns of

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cause-specific mortality and life expectancy provide essential insight into a population's health status, socioeconomic conditions, and healthcare performance. Globally, non-communicable diseases (NCDs), particularly cardiovascular diseases (CVDs), remain the leading causes of death, accounting for a substantial share of all mortality.[1, 2] According to the global burden of disease (GBD), ischemic heart disease, stroke, cancers, and injuries collectively dominate global mortality.[1] Despite rising life expectancy, disparities persist: men generally live fewer years than women, and disadvantaged populations often face higher mortality risks due to unequal healthcare access and environmental exposures.[3-5]

In Iran, mortality patterns mirror this global transition, with CVDs, cancers, and road traffic injuries among the leading contributors to death.[6,7] However, interprovincial differences remain, shaped by demographic structure, healthcare infrastructure, and socioeconomic factors. Fars Province, located in southern Iran, is among the country's most populous and diverse regions. Shiraz, the provincial capital, serves as a regional medical hub with concentrated tertiary care facilities, while rural districts may experience different exposure profiles and barriers to timely care. Studies from Fars have reported substantial mortality and years of life lost (YLL) attributable to road traffic injuries and other external causes, reinforcing the importance of provincial-level evidence to guide prevention and trauma-system planning.[8-10]

Multiple studies have examined specific mortality trends in Fars Province, particularly regarding road traffic injuries and other external causes, and these investigations consistently highlighted the major contribution of NCDs and unintentional injuries to mortality in the Province.[9,10] However, few comprehensive provincial-level analyses have simultaneously evaluated demographic and contextual differences (e.g., residence status and place of death), temporal shifts across multiple cause-of-death categories, and the broader redistribution of causes during major shocks, such as the coronavirus disease 2019 (COVID-19) pandemic.

The COVID-19 pandemic profoundly altered national and global mortality dynamics. In Iran, analytical studies of excess all-cause mortality demonstrated substantial under-ascertainment of COVID-19 fatalities and heterogeneous impacts across provinces, with pronounced mortality surges during 2020-2021.[11-13] Recent regional studies from southern Iran and other parts of the country likewise report marked excess deaths during the pandemic period, reflecting both direct viral effects and indirect disruptions to healthcare access and chronic disease management.[14, 15] Comparable international studies indicated that excess mortality and geographic disparities varied widely by setting and methodology, particularly in low- and middle-income countries.[16-18]

Beyond conventional descriptive epidemiology, large routinely collected datasets enable exploratory pattern discovery using dimensionality reduction and clustering methods. Techniques such as principal component analysis (PCA),[19, 20] t-distributed stochastic neighbor embedding (t-SNE),[21, 22] and K-means clustering,[23, 24] have been widely used to explore latent structure and identify subgroups within complex high-dimensional health data. These approaches complement standard stratified analyses by highlighting dominant multivariable patterns.[25]

From a practical perspective, province-level mortality profiling can assist local health authorities in prioritizing prevention and service planning—for example, by informing CVD risk reduction strategies, targeting injury prevention in higher-risk settings, and strengthening preparedness for future infectious surges. Accordingly, this study aimed to analyze 10 years of routinely collected death records from Fars Province (2015–2024) to characterize cause-specific mortality patterns and temporal trends, assess differences by age, sex, residence status, and place of death, quantify changes during the pandemic period, and explore latent structure using unsupervised pattern analysis. The study was reported in accordance with the REporting of Studies Conducted using Observational Routinely-collected health Data (RECORD) guideline.[26]

Materials and Methods

Study Design, Setting, and Data Source

We conducted a retrospective observational study using routinely collected death-registration data from Fars Province, Iran. The dataset was obtained from the official registry maintained by Shiraz University of Medical Sciences (Shiraz, Iran) and included individual death records for 2015–2024. Each record contained demographic information (including sex and age), contextual variables (residence status and place of death), and physician-certified cause-of-death codes based on the International Classification of Diseases (ICD), 10th revision (ICD-10) codes. The dataset was anonymized before analysis. The study was approved by the Institutional Review Board of Shiraz University of Medical Sciences (approval code: IR.SUMS.

REC.1404.359). Informed consent was waived due to the retrospective, anonymized nature of the study.

Eligibility Criteria and Data Preparation

Inclusion criteria were all registered death records in Fars Province during 2015–2024 with available year and cause-of-death information. Exclusion criteria were records outside the study period (2015–2024), records flagged as unreliable cause coding by the registry quality-control field "Null Code" (only "Not Null Code" were retained), and records with implausible age values (negative age or extreme outliers >120 years) or inconsistent dates leading to negative age.

Neonatal deaths (≤7 days; "Live birth") were identified as a distinct subgroup due to their markedly different age distribution and cause structure. They were retained for descriptive summaries but excluded from the unsupervised pattern analysis, which focused on the adult/non-neonatal dataset. Duplicate values were observed in the registry identifier ("Serial Number"). Since the data extract was row-based and duplicates might reflect registry processes rather than true duplicate records, all analyses were conducted at the record (row) level, and this identifier limitation is acknowledged.

Causes of death were analyzed using two complementary representations: (1) ICD-10 chapter-level groupings, as provided in the dataset's cause-category fields, and (2) major aggregated cause groups used for trend and regression analyses (circulatory, cancer, respiratory, infectious, external, and other).

For clarity, the full disease names corresponding to the ICD-10 chapter codes are explained below:

•A–B: Certain infectious and parasitic diseases
•C–D: Neoplasms
•E: Endocrine, nutritional, and metabolic diseases
•F: Mental and behavioral disorders
•G: Diseases of the nervous system
•H: Diseases of the eye and adnexa; diseases of the ear and mastoid process
•I: Diseases of the circulatory system
•J: Diseases of the respiratory system
•K: Diseases of the digestive system
•L: Diseases of the skin and subcutaneous tissue
•M: Diseases of the musculoskeletal system and connective tissue
•N: Diseases of the genitourinary system
•O: Pregnancy, childbirth, and the puerperium
•P: Certain conditions originating in the perinatal period
•Q: Congenital malformations, deformations, and chromosomal abnormalities
•R: Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified
•S–T: Injury, poisoning, and certain other consequences of external causes
•V–Y: External causes of morbidity and mortality
•Z: Factors influencing health status and contact with health services
•U07: Coronavirus disease 2019 (COVID-19).

Statistical Analysis and Pattern Discovery

Descriptive analyses summarized categorical variables as counts and percentages, and continuous variables (age at death) as median with distributional plots. Temporal patterns were examined using annual counts and within-registry proportions; mortality rates were not calculated since population denominators were unavailable.

To assess monotonic temporal changes, the Jonckheere–Terpstra (JT) test was applied to evaluate ordered differences in age at death across years, and the Cochran–Armitage test for trend to evaluate linear trends in annual proportions of major cause groups. Multivariable associations were assessed using separate logistic regression models for each major cause group, with the binary outcome defined as membership in the group versus all other deaths. Each model included a centered calendar year, COVID-19 period indicator (2020–2021 vs. other years), season, sex, residence status, and place of death. All tests were two-sided, with a significance level of $\alpha=0.05$. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs).

To explore latent structure beyond stratified summaries, unsupervised analyses were performed on the non-neonatal subset using a feature matrix consisting of one-hot encoded categorical variables (sex, residence status, place of death, and cause category) and standardized age (z-score). Principal component analysis (PCA) was computed with two components. K-means clustering was fitted with five clusters (n_clusters=5; n_init=10; random_state=42). For nonlinear visualization, t-distributed stochastic neighbor embedding (t-SNE) was computed in two dimensions (perplexity=30; init="pca"; learning_rate="auto"; random_state=42). For computational efficiency, PCA and K-means were applied to a random subsample of up to 15,000 records, and t-SNE to up to 8,000 records (random_state=42).

All analyses were performed in Python using pandas (Pandas development team; USA), NumPy (NumPy developers; USA), Matplotlib (Matplotlib development team; USA), Scikit-learn (Inria; France), and SciPy (Enthought Inc. and SciPy developers; USA).

Table 1: Death records in Fars Province (2015–2024): distribution by sex, residence, and place of death

Characteristic		Frequency n (%)
Total deaths		199,107
Sex	Male	117,486 (59.0%)
	Female	81,606 (41.0%)
Residence	Urban	143,250 (71.9%)
	Rural	51,176 (25.7%)
	Unknown	4,681 (2.4%)
Place of death	Hospital	95,175 (47.8%)
	Home	73,557 (36.9%)
	Public place (street/highway)	3,378 (1.7%)
	Outpatient clinic	1,179 (0.6%)
	Nursing home	597 (0.3%)
	Other	8,360 (4.2%)
	Unknown	16,900 (8.5%)

Table 2: Leading broad causes of death in Fars Province (2015–2024) according to the ICD-10

Cause-of-death category (ICD-10)	Frequency of Deaths n (%)
Circulatory system diseases (I00–I99)	90,500 (45.4%)
Respiratory diseases (J00–J99)	19,300 (9.7%)
Neoplasms (C00–D48)	17,300 (8.7%)
External causes (accidents, injuries, V01–Y89)	17,000 (8.5%)
Infectious and parasitic diseases (A00–B99)	13,500 (6.8%)
Ill-defined or unknown causes (R00–R99)	13,400 (6.8%)
All other causes (remaining categories)	28,100 (14%)

ICD-10: International classification of diseases-10th revisions

Results

Study Records and Decedent Characteristics

After data cleaning, 199,107 death records from 2015 to 2024 were included. Neonatal deaths (≤7 days) accounted for 215 records and were analyzed as a separate subgroup. The distribution of deaths by sex, residence status, and place of death is presented in table 1.

Leading Causes of Death

The overall distribution of major cause-of-death groups is summarized in table 2. Diseases of the circulatory system were the leading cause

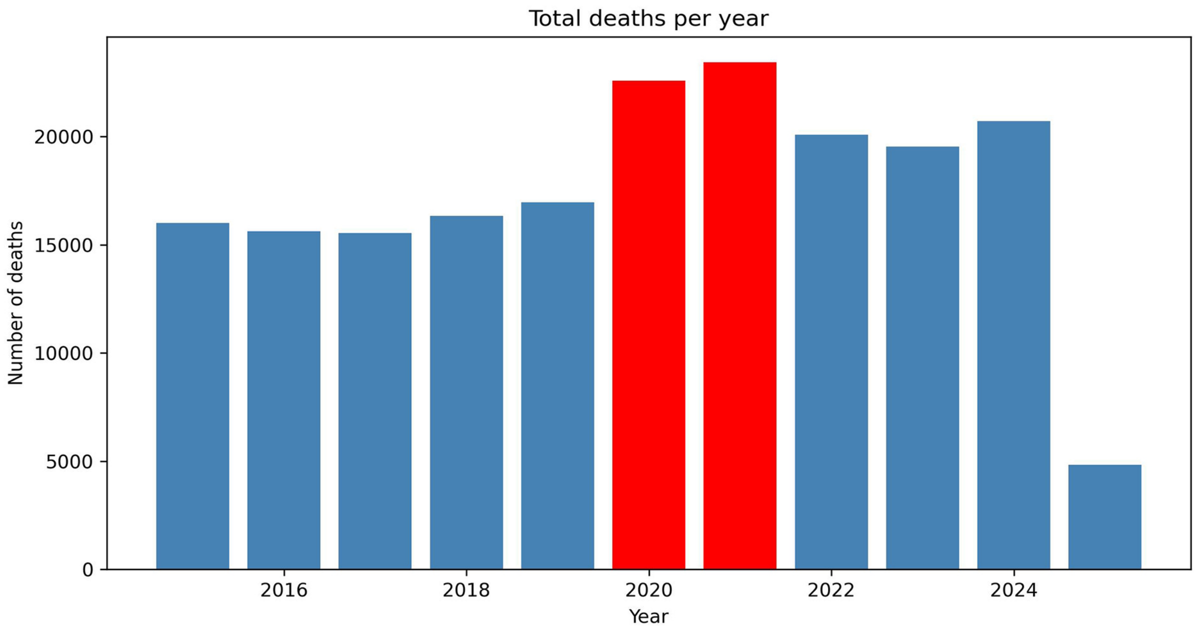

Figure 1: This figure shows the annual number of registered deaths in Fars Province from 2015 to 2024, with the pandemic years highlighted.

group over the study period, followed by diseases of the respiratory system, neoplasms, external causes of morbidity and mortality, infectious and parasitic diseases, and ill-defined causes.

Temporal Patterns and Trend Testing

Annual all-cause death counts are shown in figure 1, which demonstrates a pronounced increase during the COVID-19 years (2020–2021) compared with surrounding years. Annual deaths attributed to diseases of the respiratory system are shown in figure 2, with a marked increase during 2020–2021 followed by a subsequent decline.

A monotonic increase in age at death was observed over the study period. The median age at death increased from 26,067 days in 2015 to 26,272.5 days in 2024, and the Jonckheere–Terpstra test confirmed a statistically significant upward trend (Z=7.36, P<0.001).

Formal trend testing results for cause-group proportions are provided in table 3. The Cochran–Armitage test indicated significant temporal changes in within-registry proportions for several major cause groups. Adjusted logistic regression results for major cause groups are reported in table 4, including the association of the COVID-19 period indicator with cause-group classification. The year was modeled as a continuous variable (per 1-year increase).

The variable "Year" was modeled as a continuous predictor (per 1-year increase), not as a median or categorical variable. Odds ratios (OR) were estimated using multivariable logistic regression, and the significance level (P<0.05) was added to the legend.

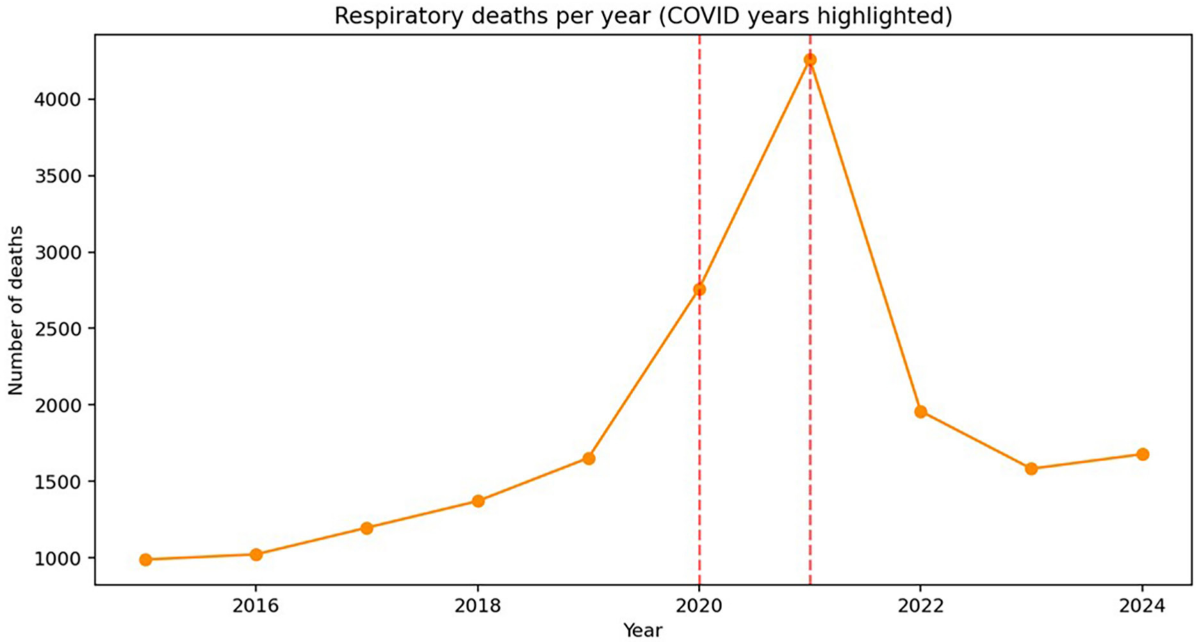

Figure 2: Annual deaths attributed to diseases of the respiratory system from 2015 to 2024 are illustrated in this figure, with vertical markers indicating the pandemic period.

Table 3: Cochran–Armitage trend test for annual cause-group proportions (within-registry composition) 2015–2024

Major cause group	Proportion 2015	Proportion 2024	Z	P value	Interpretation
Circulatory	0.545	0.483	-18.45	<0.001	Decreasing composition
Cancer	0.122	0.104	-15.60	<0.001	Decreasing composition
Respiratory	0.068	0.090	0.46	0.647	No monotonic trend
External	0.150	0.129	-12.65	<0.001	Decreasing composition
Infectious	0.017	0.121	70.81	<0.001	Increasing composition

Table 4: Adjusted logistic regression models for major cause groups, 2015–2024 (n=174,552)

Major cause group	Year (per 1-year) OR (95% CI)	P value (Year)	COVID-period OR (95% CI)	P value (COVID-19)
Circulatory	0.959 (0.956–0.963)	<0.001	0.817 (0.798–0.836)	<0.001
Cancer	0.954 (0.949–0.959)	<0.001	0.682 (0.655–0.709)	<0.001
Respiratory	0.999 (0.992–1.005)	0.718	0.672 (0.643–0.703)	<0.001
External	1.029 (1.022–1.035)	<0.001	0.817 (0.784–0.852)	<0.001
Infectious	1.288 (1.277–1.298)	<0.001	3.997 (3.867–4.131)	<0.001

Odds ratios (ORs) with 95% confidence intervals (CIs) were estimated from separate multivariable logistic regression models for each cause group. Two-sided P values are reported. $P<0.05$ was considered statistically significant ($\alpha=0.05$).

Stratified Distributions by Sex, Residence, and Place of Death

The age distribution of deaths by sex is shown in figure 3. Figure 4 displays age-at-death distributions for the six most common cause groups. External causes show the youngest

Figure 3: Age-at-death distribution among non-neonatal decedents stratified by sex is illustrated, where the Y-axis represents the number of deaths.

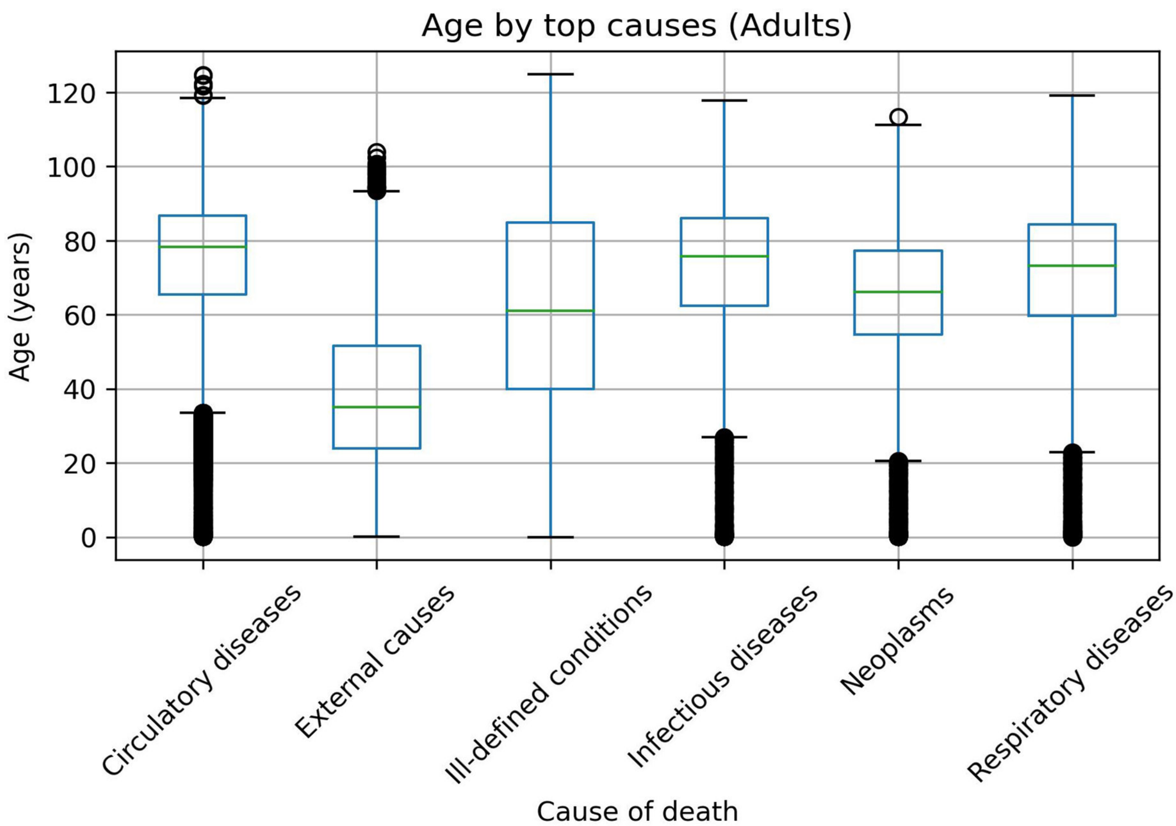

Figure 4: Age at death across the most common cause-of-death groups among non-neonatal decedents is summarized using boxplots.

median age at death (50 years), whereas neoplasms, circulatory diseases, and respiratory diseases peaked in older adulthood (median 75 years), reflecting expected epidemiological patterns. The composition of major cause-of-death groups stratified by residence status and place of death is presented in figures 5 and 6. These figures reveal distinct cause-of-death profiles across strata.

Unsupervised Pattern Analysis

K-means clustering with five clusters was applied to non-neonatal death records to identify distinct mortality profiles. Neonatal deaths were not included in this model. Therefore, they were not assigned a cluster number. Instead, they were treated as a separate descriptive subgroup because of their distinct age distribution and cause structure. The five non-neonatal clusters were differentiated primarily by age range, sex distribution, place of death, and major cause-of-death grouping, as summarized below.

• Cluster 0: Young male external-cause profile: This cluster consisted predominantly of male decedents in younger age ranges and was characterized by a high concentration of deaths from external causes. Deaths in this cluster were more frequently recorded outside hospital settings than disease-dominant clusters. In the full dataset, this cluster showed a strong male predominance and a younger age profile (median age in the mid-30s).

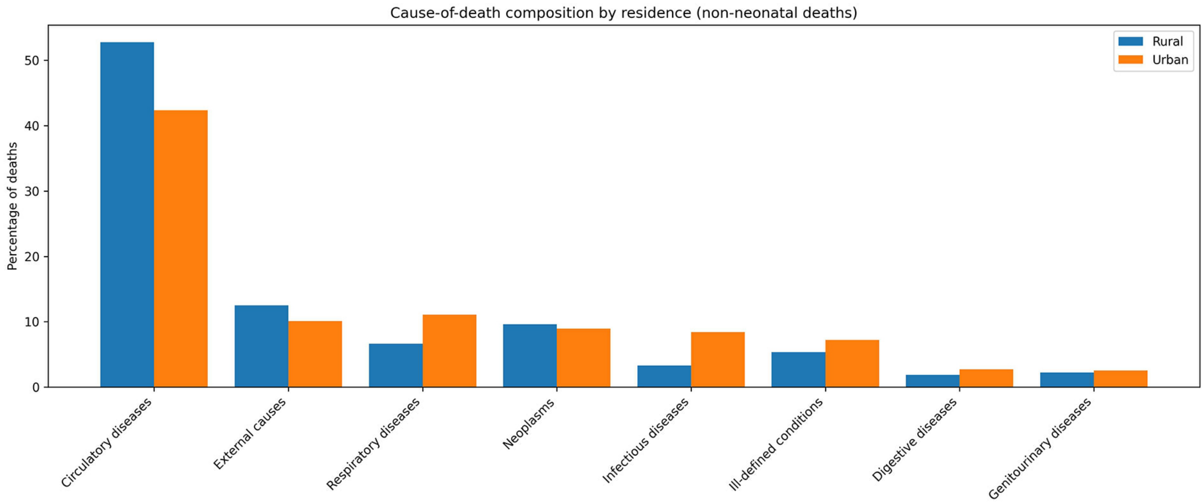

Figure 5: Cause-of-death composition by residence (urban vs. rural) in Fars Province is shown. Urban areas show higher proportions of respiratory deaths, while rural areas exhibit more cardiovascular and injury-related deaths.

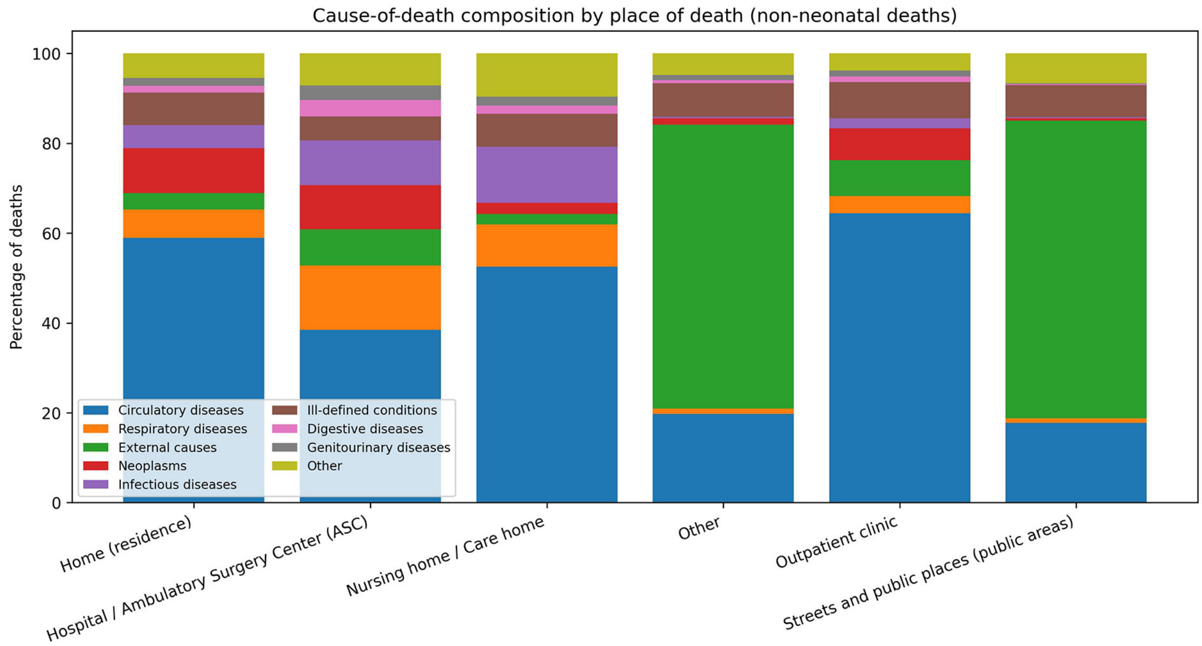

Figure 6: The bars illustrate the cause-of-death distribution by place of death. Hospitals and homes are the dominant locations, with public-place fatalities showing a high proportion of external causes.

• Cluster 1: Middle-aged to older hospital acute-disease profile: This cluster comprised mainly middle-aged to older adults and showed a predominance of hospital deaths. The cause-of-death composition was concentrated in diseases of the circulatory system and diseases of the respiratory system, with other internal medical causes present at lower proportions.

• Cluster 2: Very elderly, predominantly out-of-hospital profile: This cluster was characterized by very advanced ages and a higher representation of female decedents. A larger share of deaths occurred outside hospital settings. The cause composition included a substantial proportion of circulatory diseases, along with a higher presence of ill-defined causes than other clusters.

• Cluster 3: Predominantly female chronic non-communicable profile: This smaller cluster included mostly female decedents in mid- to late adulthood and showed a higher representation of chronic non-communicable causes, including neoplasms and endocrine or metabolic conditions.

• Cluster 4: Mixed profile: This remaining cluster captured records not dominated by a single age band or cause group and showed a broader distribution across causes and places of death than the other clusters.

Figure 7 presents the two-dimensional principal component analysis projection, colored by cluster assignment. It reveals separation between the younger external-cause cluster and the older disease-dominant clusters. Figure 8 presents the two-dimensional t-distributed stochastic neighbor embedding visualization, where cluster structure is more apparent. In this embedding, cluster alignment follows gradients in age and differences in major cause-of-death groups. Across both projections, separation was largely driven by age structure and cause grouping, with younger external-cause deaths distinct from older disease-dominant deaths.

Discussion

Mortality patterns in Fars Province were consistent with Iran's long-standing epidemiologic transition, in which NCDs —particularly CVDs— have become the dominant contributors to death. This pattern aligned with national evidence indicating the major contribution of cardiovascular disease to mortality in Iran, as well as reports from southern Iran indicating that premature mortality remains concentrated in CVDs, external causes, and cancers.[6, 27, 28] However, the high proportional contribution of circulatory diseases in the present registry should be interpreted critically. It may reflect not only true disease burden but also demographic structure, referral patterns, and cause-of-death certification practices.

The dominance of circulatory mortality supports continued prioritization of cardiovascular prevention and acute care in provincial health planning. Iran has experienced persistent challenges related to hypertension,

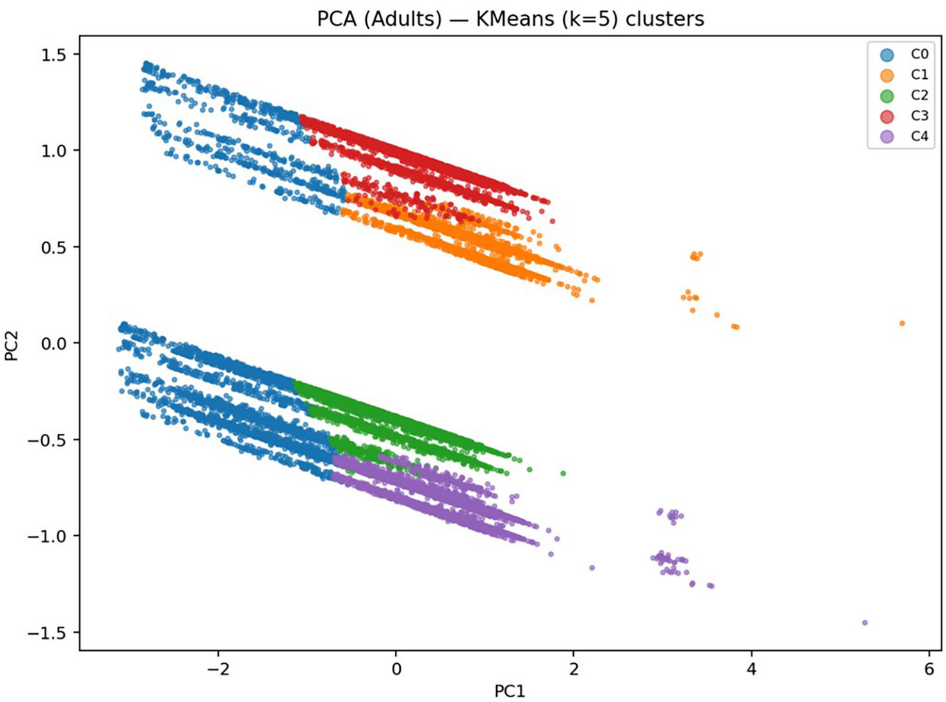

Figure 7: The figure displays the PCA projection colored by K-Means clustering (K=5) on adult death data. Distinct clusters suggest groupings by cause, age, and setting of death.

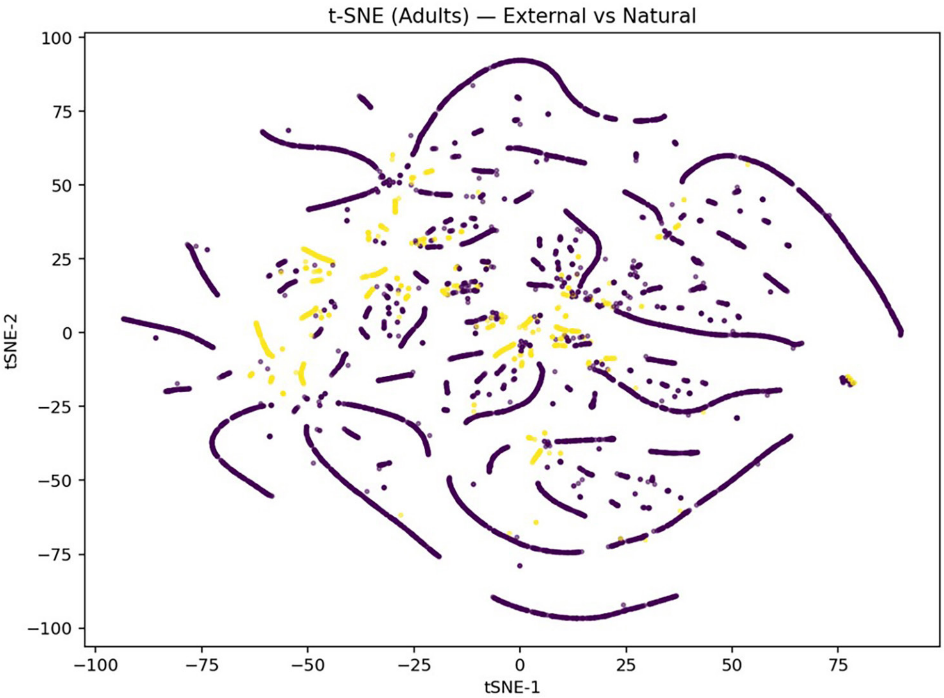

Figure 8: The figure shows the t-SNE projection of adult deaths by cause type. The high-dimensional structure reveals diffuse but meaningful separation between natural and external causes.

diabetes, obesity, physical inactivity, and other modifiable cardiovascular risk factors, despite improvements in health-system coverage and chronic disease management.[6, 29, 30] The findings therefore reinforced the need for earlier detection and sustained control of cardiovascular risk factors, particularly hypertension and diabetes, as well as timely referral pathways for acute coronary syndromes and stroke.

At the same time, the contribution of neoplasms should not be interpreted as a minor burden. Studies from Fars and Iran indicated that cancer mortality and YLL remain important, and routine registration may underestimate cancer mortality compared with specialized registry sources.[31] Thus, CVD and cancer prevention should be viewed as complementary long-term priorities rather than competing areas of policy attention.

The age and sex distribution observed in this study aligned with previous Iranian and regional literature on injury epidemiology. Excess male mortality at younger ages was consistently attributed to external causes, particularly road traffic injuries, occupational exposures, and risk-taking behaviors. Prior studies from Fars Province documented a substantial burden of mortality and YLL attributable to road traffic injuries, while national injury analyses demonstrated geographic and socioeconomic disparities in injury incidence and outcomes.[7, 8] Collectively, these findings indicated that reducing premature mortality in Fars requires targeted road-safety enforcement, community-based education, improved transport infrastructure, and enhanced prehospital and trauma-care systems, with particular emphasis on younger men and rural populations.

The mortality patterns observed during 2020–2021 were consistent with Iranian and international studies examining excess mortality during the COVID-19 pandemic. Province-level analyses in Iran demonstrated that reported COVID-19–attributed deaths substantially underestimated the total mortality burden, whereas national time-series studies identified marked elevations in all-cause mortality during pandemic waves.[11-13] Studies from southern and northeastern Iran similarly documented excess mortality during the early pandemic period, although demographic and geographic patterns exhibited regional heterogeneity.[14, 15] This heterogeneity indicated that pandemic-related mortality was influenced not only by infection burden but also by healthcare accessibility, hospital capacity, testing and death certification practices, and disruption to chronic disease management. For Fars Province, the key implication is that mortality surveillance systems should monitor all-cause deaths alongside major cause-specific categories and be integrated with preparedness frameworks designed to maintain essential non-COVID-19 health services during infectious disease surges.

Although urban–rural differences warrant cautious interpretation, they carry important implications for equity. Iran's rural primary healthcare network has expanded access to basic health services and chronic disease screening.[32] Nevertheless, persistent disparities remain in hypertension awareness, treatment, and control, alongside challenges in referral quality, continuity of care, and access to specialized services.[29, 30] Consequently, the higher proportional burden of circulatory mortality among rural residents likely reflects a combination of older age structure, delayed diagnosis, reduced continuity of follow-up, prolonged transport times, and limited access to specialized emergency care. Variations in certification settings might also contribute to these patterns, as out-of-hospital deaths are more frequently assigned broader or less specific underlying causes. Therefore, strategies to strengthen rural chronic disease management, emergency transport, referral pathways, and death-certification quality should be implemented in an integrated manner.

Place of death offers an additional lens through which to assess health system needs. Hospital deaths might signify access to formal care for acute events, yet they might also reflect delayed presentation or the provision of intensive interventions during the terminal phase of illness. Conversely, while home deaths might in some cases align with patient or family preference, in some cases, palliative services, or timely engagement with medical services.[33, 34] This distinction carries important implications for policy interpretation. Efforts to enhance hospital responsiveness for acute cardiovascular, respiratory, and traumatic conditions should be accompanied by expansion of community-based services, including home nursing, palliative care, and structured referral mechanisms for patients with advanced chronic disease.

The unsupervised pattern analysis should be interpreted as exploratory rather than diagnostic. The primary utility of this approach is descriptive: clustering and dimensionality-reduction methods can effectively summarize multidimensional heterogeneity that is difficult to be captured through single-variable stratification, thereby facilitating the communication of broad mortality profiles to health planners.[19, 24, 25] In this study, the clustering results underscored that mortality prevention strategies should not be organized solely around cause of death, but rather around integrated profiles of age, sex, setting, and disease category. However, such clusters inherently depend on available registry variables, data preprocessing protocols, and algorithmic parameters. Consequently, they require external validation in future studies incorporating more granular clinical, geographic, and population-level datasets.

Several limitations should be considered when interpreting these findings. First, the analysis relies on the accuracy and completeness of routine vital registration data. Although official death-registration systems constitute a cornerstone of mortality surveillance, prior Iranian studies demonstrated that completeness and accuracy might vary across disease groups, provinces, and data sources. For example, cancer mortality in Fars Province has been reported as underestimated in routine registration systems, and registry validation studies in Iran have identified systematic limitations in cause-of-death assignment.[31, 35] Second, causes of death were analyzed primarily using broad ICD-10 groupings, which enhances interpretability but may obscure heterogeneity within specific subcategories. Third, population denominators were unavailable in the registry extract. Consequently, temporal comparisons relied on absolute counts and within-registry proportions rather than the age-standardized mortality rate. Fourth, the dataset lacked detailed socioeconomic, clinical, behavioral, and healthcare-access variables, thereby limiting causal interpretation regarding observed subgroup differences. Finally, the presence of duplicate identifier values and the exploratory nature of the clustering analysis introduced additional methodological uncertainty. Future research should prioritize linkage of registry data with population denominators, district-level socioeconomic indicators, individual clinical records, and validated cause-of-death coding audits to strengthen causal inference and enhance surveillance utility.

Conclusion

This provincial registry-based analysis of deaths in Fars, Iran (2015 to 2024) demonstrated the sustained predominance of NCDs, primarily circulatory diseases, alongside substantial contributions from respiratory diseases, neoplasms, external causes, and infectious diseases. Mortality patterns differed by sex, age, residence status, and place of death, reflecting considerable heterogeneity in preventable risk and health service requirements across population subgroups. Additionally, the time series analysis revealed a marked disruption during 2020–2021, consistent with pandemic-related increases in all-cause mortality and shifts in cause-of-death distribution.

These findings underscored province-level priorities that combine cardiovascular risk-factor prevention with timely and equitable access to acute cardiovascular and stroke care. They also highlighted targeted injury prevention for younger adults, particularly males and rural populations. Other priorities included strengthened rural access to chronic and emergency care, improved emergency response and trauma care pathways, expanded community-based and end-of-life services, and sustained preparedness for future infectious surges. Strengthening registry data quality and completeness, along with the incorporation of population denominators and additional contextual variables, will further improve the utility of routine mortality data for surveillance and planning.

Authors' Contribution

O.E served as the corresponding author and led the overall organization, coordination, and management of the project. A.S was primarily responsible for conducting the data analysis and drafting the manuscript. N.A, as the head of the Artificial Intelligence Clinical Laboratory and Biological Data Bank, provided overarching supervision and guidance throughout the project. M. S contributed by providing access to the primary dataset used in the analysis. A.N.M oversaw the medical aspects of the research and contributed substantially to the writing of the manuscript. A.M participated in data analysis and contributed to the manuscript preparation. Z.T contributed to data analysis and assisted in manuscript writing. A.G and E.A supported the project by assisting in data cleaning and preprocessing. A.K proposed the research idea and provided strategic supervision during the course of the study. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of AI use

The authors declared that no AI tools were used in the preparation of this manuscript.

Conflict of Interest

Owrang Eilami, serving as an Editorial Board Member of the Journal, played no role in the handling of this manuscript at any stage. To ensure impartiality, the Editorial Board convened a team of independent experts to review the manuscript without his involvement or awareness.

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