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Epidemiological Characteristics and All-Cause Mortality of Chronic Coronary Disease in Kazakhstan: A Nationwide Administrative Data Analysis, 2014–2021

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ABSTRACT

Coronary artery disease (CAD) remains a major cause of death and disability worldwide. Chronic Coronary disease, one of its most common clinical forms, reflects the combined effects of age, obesity, hypertension, diabetes mellitus, and other chronic conditions. This study analyzed national administrative data from Kazakhstan between 2014 and 2021 to explore trends in Chronic Coronary disease incidence, comorbidities, and mortality among patients coded under International Classification of Diseases, 10th Revision (ICD-10) codes I20–I20.9 within the Unified National Electronic Healthcare System (UNEHS). A total of 624,852 patients with Chronic Coronary disease were identified through the national electronic health system. Demographic, clinical, and outcome indicators were examined to assess trends and disparities across sex, ethnicity, and place of residence. Temporal trends were formally tested using the Mann–Kendall non-parametric trend test with Sen's slope estimation. During the study period, the recorded incidence of Chronic Coronary disease decreased from 584 to 211 cases per 100,000 population (Mann–Kendall $\tau = -0.57$, $p = 0.064$; Sen's slope −44 per 100,000 per year), whereas the all-cause mortality rate rose from 19 to 100 per 100,000 ($\tau = 1.00$, $p < 0.001$; Sen's slope +12 per 100,000 per year) and period prevalence increased monotonically ($\tau = 1.00$, $p < 0.001$; Sen's slope +370 per 100,000 per year). The 2014 incidence figure should be interpreted with caution as it likely reflects a prevalent pool effect at the inception of systematic UNEHS data capture. Mortality was highest among men, older adults, ethnic Russians, and rural residents. Patients undergoing coronary artery bypass grafting (CABG) showed better survival than those treated with percutaneous coronary intervention (PCI), though this comparison should be interpreted cautiously given potential confounding by indication. Hypertension, diabetes mellitus, and multiple comorbidities substantially increased the risk of death and major adverse cardiovascular events (MACE). These results underline widening health inequalities and the urgent need for improved prevention, equitable access to care, and integrated management of chronic cardiovascular disease in Kazakhstan.

Keywords: Chronic Coronary Disease; Epidemiology; Mortality Trends; All-Cause Mortality; Kazakhstan; Major Adverse Cardiovascular Events (MACE)

Introduction

Chronic coronary disease, characterised by chest pain or discomfort resulting from myocardial ischaemia, remains a leading manifestation of coronary artery disease (CAD) and a significant public health issue globally [1,2]. In recent years, the prevalence and mortality associated with Chronic Coronary disease have been increasing across multiple regions, driven by changing demographics, comorbidities, and healthcare challenges. Understanding the epidemiological trends and associated risk factors is critical to developing effective public health interventions and improving patient outcomes [3,4].

Kazakhstan, with its diverse socio-demographic composition and evolving healthcare system, provides a unique setting to study the burden and determinants of chronic coronary disease (CCD). Studies from other countries have demonstrated that socio-demographic factors, including age, gender, and ethnicity, significantly influence the incidence and outcomes of angina [5–8]. A study in the United States highlighted substantial gender disparities, with men experiencing higher rates of adverse cardiovascular events, a finding echoed in numerous European cohorts [9–11]. Similarly, rural–urban disparities have been noted, with rural residents facing higher cardiovascular morbidity and mortality due to reduced healthcare access and delayed interventions [12–15]. In addition to socio-demographic factors, comorbidities such as hypertension, diabetes mellitus, chronic kidney disease, and obesity substantially elevate the risk of mortality and major adverse cardiovascular events (MACE) among patients with Chronic Coronary disease [16,17].

Within Kazakhstan, prior epidemiological work has documented a substantial cardiovascular disease burden, including high prevalence of hypertension and ischaemic heart disease in regional cohorts, expanding utilisation of percutaneous and surgical revascularisation, and rising mortality from circulatory causes [35–37]. However, those studies have typically been restricted to single regions, single tertiary centres, or relatively short observation windows, and none has examined the full nationwide UNEHS-defined chronic coronary disease cohort over the 2014–2021 period using formal time-series methodology [38,39]. The present study addresses this gap.

Despite the wealth of data on Chronic Coronary disease in other regions, there remains a paucity of comprehensive studies focusing on Central Asia, particularly Kazakhstan. This study aims to fill this gap by analysing nationwide data on Chronic Coronary disease between 2014 and 2021, with a focus on socio-demographic characteristics, survival outcomes, and the influence of comorbidities and treatment interventions. By identifying key risk factors and disparities, this research seeks to inform public health strategies and contribute to reducing the burden of cardiovascular disease in the region.

Materials and Methods

Study design and population

Diagnostic framework. In Kazakhstan, diagnosis of chronic coronary disease follows national protocols aligned with European Society of Cardiology (ESC) guidelines. Cases were identified using ICD-10 codes I20–I20.9 recorded as the principal (primary) diagnosis at encounter closure (i.e., at discharge for inpatient admissions and at visit closure for outpatient encounters). The principal diagnosis drives the Diagnosis-Related Group (DRG) reimbursement category in the UNEHS. Secondary diagnoses on the same encounter were used to ascertain comorbid conditions (see §2.2 and Supplementary Table 2), not to define cohort membership. Coronary angiography is performed when clinically indicated and is not mandatory for diagnosis.

This study used a retrospective cohort design analyzing the nationwide electronic inpatient and outpatient records from the UNEHS for Kazakhstan covering the period from 2014 to 2021. Details about the UNEHS and its databases are provided elsewhere [18]. The initial dataset consisted of 2,362,015 patient records; duplicates were removed based on unique combinations of population registry numbers (RPN IDs) and birth date, and following data cleaning and management procedures the final cohort comprised 624,852 patients diagnosed with Chronic Coronary disease (ICD-10 codes I20–I20.9). A list of the relevant ICD-10 codes for Chronic Coronary disease is provided in Supplementary Table 1. Per the ICD-10 Excludes1 coding rule, I20.x codes are mutually exclusive with I25.1x (atherosclerotic heart disease with angina) and I25.7x (atherosclerosis of bypass grafts with angina) codes, meaning these categories are assigned independently at each encounter. In the UNEHS reimbursement system, the principal diagnosis code drives the DRG payment category; I20.x codes were applied to encounters where Chronic Coronary disease was the principal presenting complaint, while I25.x codes were applied to chronic ischaemic disease and post-revascularisation follow-up encounters. The current cohort therefore represents a well-defined administrative population of patients whose healthcare encounters were principally classified as chronic coronary disease (CCD), consistent with the study's stated objectives. The flowchart illustrating the data preparation process is depicted in Figure 1. Population figures (mid-year denominators) were obtained from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan [19].

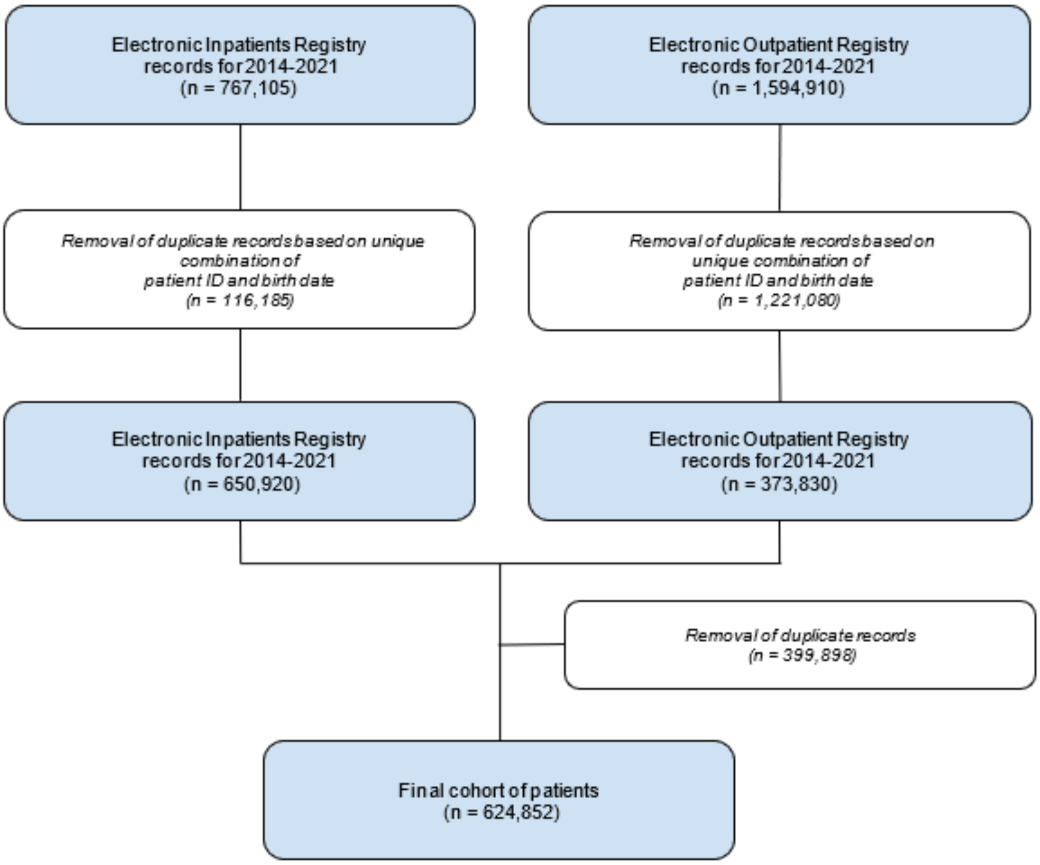

Figure 1. Flow chart of cohort set-up.

Exposures and covariates

The study assessed socio-demographic characteristics (age, gender, ethnicity, place of residence), admission type (urgent vs. elective), and coronary revascularisations, including coronary angioplasty with stenting (percutaneous coronary intervention, PCI) and coronary artery bypass graft (CABG) surgery. Age was categorised as 18–34, 35–44, 45–54, 55–64, 65–74, and ≥75 years. These 10-year strata follow the categorisation used by the Global Burden of Disease cardiovascular reports and by ESC EUROASPIRE registries, enabling direct comparability with previously published national administrative cohort studies of ischaemic heart disease.

Kazakhstan is home to more than 120 nationalities; the Bureau of National Statistics reports that ethnic Kazakhs (~71%) and Russians (~15%) together account for approximately 87% of the resident population [19]. All remaining nationalities (including Uzbeks, Ukrainians, Tatars, Uyghurs, Germans, and Koreans) each contributed cell counts too small to support stable estimation of stratum-specific hazard ratios when crossed by age, sex, and outcome. Ethnicity was therefore grouped into three mutually exclusive categories — Kazakh, Russian, and Other — to preserve statistical power, avoid privileging any single minority group, and remain comparable to prior Kazakhstani cardiovascular studies based on UNEHS data [35–37].

Data on comorbid conditions were extracted using ICD-10 codes. Key comorbidities included hypertension, atherosclerotic heart disease (ASHD), diabetes mellitus (DM), heart failure (HF), chronic kidney disease (CKD), acute myocardial infarction (AMI), obesity, chronic obstructive pulmonary disease (COPD), peripheral vascular disease (PVD), and arrhythmia. The identification of these diseases based on ICD-10 codes is provided in Supplementary Table 2; data linkage was performed using unique population registry numbers (RPN IDs).

Outcome assessment

The primary outcome was all-cause mortality during the study period. Secondary outcomes were cause-specific (cardiovascular) mortality and the incidence of MACE. MACE events were coded as stroke, AMI, HF, arrhythmia, and ASHD. Given the dataset's inclusion of various comorbidities, integrating these factors into the MACE analysis allows for a more comprehensive assessment of cardiovascular risks. This approach aligns with findings by Miao et al., who identified predictors of MACE in patients with atherosclerotic disease or multiple risk factors, and with insights from discussions on MACE in relation to atherosclerotic cardiovascular disease and heart failure (Supplementary Table 3) [20,21]. Mortality data were verified through linkage to the national mortality registry. The cohort was assessed for the incidence of chronic coronary disease, as well as all-cause and cause-specific mortality rates. Any death that occurred during the observation period was recorded as all-cause mortality. For survival analysis, the start date was set as the first day of the initial admission, and follow-up extended until 31 December 2021, or until the date of death, whichever came first.

Statistical analysis

All variables were analyzed as categorical, with the incidence, period prevalence, and all-cause mortality presented as both absolute figures and rates per 100,000 population annually throughout the study period. Period prevalence was calculated as the total number of individuals diagnosed with Chronic Coronary disease (both new and existing cases) within each calendar year (1 January–31 December), divided by the mid-year population, multiplied by 100,000. The following formulas were used to calculate key epidemiological measures:

Incidence rate (per 100,000) = (Number of new cases diagnosed during year t / Mid-year population at risk during year t) × 100,000.

All-cause mortality rate (per 100,000) = (Number of deaths during year t / Mid-year population during year t) × 100,000.

Age-specific incidence rate (per 100,000) = (Number of new cases in age group a during year t / Mid-year population of age group a during year t) × 100,000.

These standard epidemiological measures are widely used in public health research, as recommended by the World Health Organization [22] and supported by Rothman et al. in Modern Epidemiology, 3rd ed. [23]. Mid-year denominators were obtained from the Bureau of National Statistics [19].

To formally evaluate monotonic temporal trends in incidence, period prevalence, and all-cause mortality, we applied the non-parametric Mann–Kendall trend test, with the magnitude of change quantified by the Sen's slope estimator and reported with 95% confidence intervals derived from the variance of Kendall's S. The Mann–Kendall test does not assume normality and is robust to outliers, which is desirable for short administrative time series. Trends were considered statistically significant at a two-sided $p < 0.05$.

Stratified propensity matching was not employed, as the research aimed to describe epidemiological trends and associations rather than to establish causality between matched groups. Instead, Cox regression models were used to adjust for potential confounders, including age, gender, ethnicity, and comorbidities, enabling the analysis to account for confounding effects while harnessing the statistical power of the full dataset. Assumption validation for Cox models was performed using log–log plots and the likelihood ratio (LR) test; hazard ratios (HRs) from models where Kaplan–Meier curves showed visible convergence or crossing (e.g., ethnicity and revascularisation type subgroups) should be interpreted as time-averaged estimates. These models were applied to compute both crude and adjusted HRs for all-cause mortality, cause-specific mortality, and MACE. The statistical significance of these HRs was evaluated using 95% confidence intervals (CIs) and corresponding p-values.

Admission type was missing for 46.75% of encounters, concentrated in the early years of UNEHS adoption and in particular hospital systems, suggesting a missing-at-random (MAR) rather than missing-completely-at-random (MCAR) mechanism. We used the missing-indicator approach, retaining these encounters with "missing" as an explicit category, which avoids the bias of complete-case analysis when missingness is non-random and preserves statistical power [40,41]. Multiple imputation by chained equations (MICE), as described by White & Royston (2009) [42], would be a complementary approach and is recommended for future analyses where the underlying admission-type information can be retrieved through additional data linkage; this was not feasible in the present study because the source administrative records did not preserve the missing field. The robustness of this design choice is supported by the consistency of effect estimates across our four nested models (Table 2).

Four multivariable models were developed to examine the adjusted effects of variables on mortality for both all-cause and cause-specific analyses and on MACE. Model 1 included socio-demographic factors (age, gender, ethnicity, place of residence, admission type, and revascularisation type). Model 2 added comorbid conditions to Model 1. Models 3 and 4 were used to analyse cause-specific mortality and MACE, respectively. Model fit for Cox regression was assessed through the likelihood ratio test and a global goodness-of-fit test. A significance threshold of 0.05 was applied throughout the analyses, which were conducted using STATA 16.1.

This study used secondary data derived from the UNEHS, with no direct involvement of patients. Consequently, the requirement for informed consent from study participants was waived by the Nazarbayev University Institutional Review Ethics Committee (NU-IREC 490/18112021).

Results

Socio-demographic characteristics

The dataset analysed 624,852 patients diagnosed with Chronic Coronary disease in Kazakhstan between 2014 and 2021. The cohort included 309,725 (49.57%) female and 315,127 (50.43%) male patients, with a mean age of 63.75 years (SD 10.78). Most patients were of Kazakh ethnicity (31.09%), followed by Russian (12.65%). Rural residence was more common among men (28.87%) than women (24.04%). Mortality rates varied significantly by age, peaking among the elderly (≥75 years) at 8,677.81 per 100,000 person-years. Urban residents constituted 59.62% of patients, while 26.48% lived in rural areas. Elective admissions were lower than urgent ones (25.55% vs. 27.70%), highlighting the acute nature of disease onset for many patients. Among comorbidities, hypertension was most prevalent (49.96%), followed by atherosclerotic heart disease (27.23%) and diabetes mellitus (10.38%). Table 1 outlines the baseline characteristics of the cohort.

Table 1. Socio-demographic and medical characteristics of Chronic Coronary disease patients by gender, 2014–2021

Variable	Overall (n=624,852)	p-value	Female (n=309,725)	Male (n=315,127)	Mortality rate per 100,000 person-years [95% CI]
Age, Mean±SD	63.75±10.78	<0.001	66.09±10.38	61.46±10.68	
Age groups, n (%)		<0.001			
18–34	3,019 (0.48)		826 (0.27)	2,193 (0.70)	687.82 [560.38–844.71]
35–44	20,783 (3.33)		5,649 (1.82)	15,134 (4.80)	961.51 [899.28–1028.05]
45–54	95,835 (15.34)		34,490 (11.14)	61,345 (19.47)	1358.14 [1353.74–1429.71]
55–64	212,275 (33.97)		94,394 (30.48)	117,881 (37.41)	2292.11 [2260.61–2324.05]
65–74	183,518 (29.37)		103,603 (33.45)	79,915 (25.36)	3940.59 [3894.32–3987.42]
≥75	109,422 (17.51)		70,763 (22.85)	38,659 (12.27)	8677.38 [8586.82–8768.91]
Ethnicity, n (%)		<0.001			
Kazakh	194,240 (31.09)		82,217 (26.55)	112,023 (35.55)	3577.73 [3537.03–3618.89]
Russian	79,063 (12.65)		41,381 (13.36)	37,682 (11.96)	5662.54 [5579.87–5746.44]
Other	351,549 (56.26)		186,127 (60.09)	165,422 (52.49)	3093.42 [3064.03–3123.10]
Residence, n (%)		<0.001			
Rural	165,435 (26.48)		74,446 (24.04)	90,989 (28.87)	3958.32 [3888.71–4027.93]
Urban	372,568 (59.62)		192,195 (62.05)	180,373 (57.24)	3920.54 [3874.44–3967.21]
Missing	86,849 (13.90)		43,084 (13.91)	43,765 (13.89)	

Variable	Overall (n=624,852)	p-value	Female (n=309,725)	Male (n=315,127)	Mortality rate per 100,000 person-years [95% CI]
Admission type, n (%)		<0.001			
Urgent	173,109 (27.70)		79,434 (25.65)	93,675 (29.73)	4828.42 [4776.95–4880.44]
Elective	159,637 (25.55)		72,170 (23.30)	87,467 (27.76)	3623.63 [3578.89–3667.89]
Missing	292,106 (46.75)		158,121 (51.05)	133,985 (42.52)	
All-cause death, n (%)		<0.001			
Dead	89,908 (14.39)		41,241 (13.32)	48,667 (15.44)	
Revascularisation type, n (%)		<0.001			
PCI	24,273 (3.88)		7,914 (2.56)	16,359 (5.19)	2794.97 [2681.79–2912.93]
CABG	10,727 (1.72)		2,470 (0.80)	8,257 (2.62)	2123.73 [1987.50–2269.30]
No intervention	589,852 (94.40)		299,341 (96.65)	290,511 (92.19)	
Comorbid conditions, n (%)					
Hypertension	312,167 (49.96)	<0.001	174,657 (56.39)	137,510 (43.64)	4727.58 [4689.61–4765.86]
ASHD	170,162 (27.23)	<0.001	81,585 (26.34)	88,577 (28.11)	4094.92 [4046.59–4143.78]
Diabetes mellitus	64,851 (10.38)	<0.001	40,566 (13.10)	24,285 (7.71)	6594.49 [6492.69–6697.15]
Heart failure	63,507 (10.16)	<0.001	30,174 (9.74)	33,333 (10.58)	5006.84 [4919.21–5095.75]
CKD	31,852 (5.10)	<0.001	16,737 (5.40)	15,115 (4.80)	7523.59 [7373.81–7677.50]
AMI	25,006 (4.00)	<0.001	7,872 (2.54)	17,134 (5.44)	7119.36 [6948.39–7293.53]
Stroke	20,843 (3.34)	<0.001	9,705 (3.13)	11,138 (3.53)	12059.94 [11808.87–12317.39]
Obesity	17,617 (2.82)	<0.001	9,472 (3.06)	8,148 (2.58)	4507.41 [4360.03–4659.75]
COPD	11,224 (1.80)	<0.001	5,289 (1.71)	5,935 (1.88)	8494.43 [8216.21–8782.09]
Arrhythmia	8,037 (1.29)	<0.001	3,763 (1.21)	4,274 (1.36)	7738.50 [7423.75–8066.61]
PVD	4,110 (0.66)	<0.001	2,126 (0.69)	1,984 (0.63)	6956.58 [6545.47–7393.53]

AMI – acute myocardial infarction; HF – heart failure; COPD – chronic obstructive pulmonary disease; DM – diabetes mellitus; ASHD – atherosclerotic heart disease; CKD – chronic kidney disease; PVD – peripheral vascular disease; PCI – percutaneous coronary intervention; CABG – coronary artery bypass grafting.

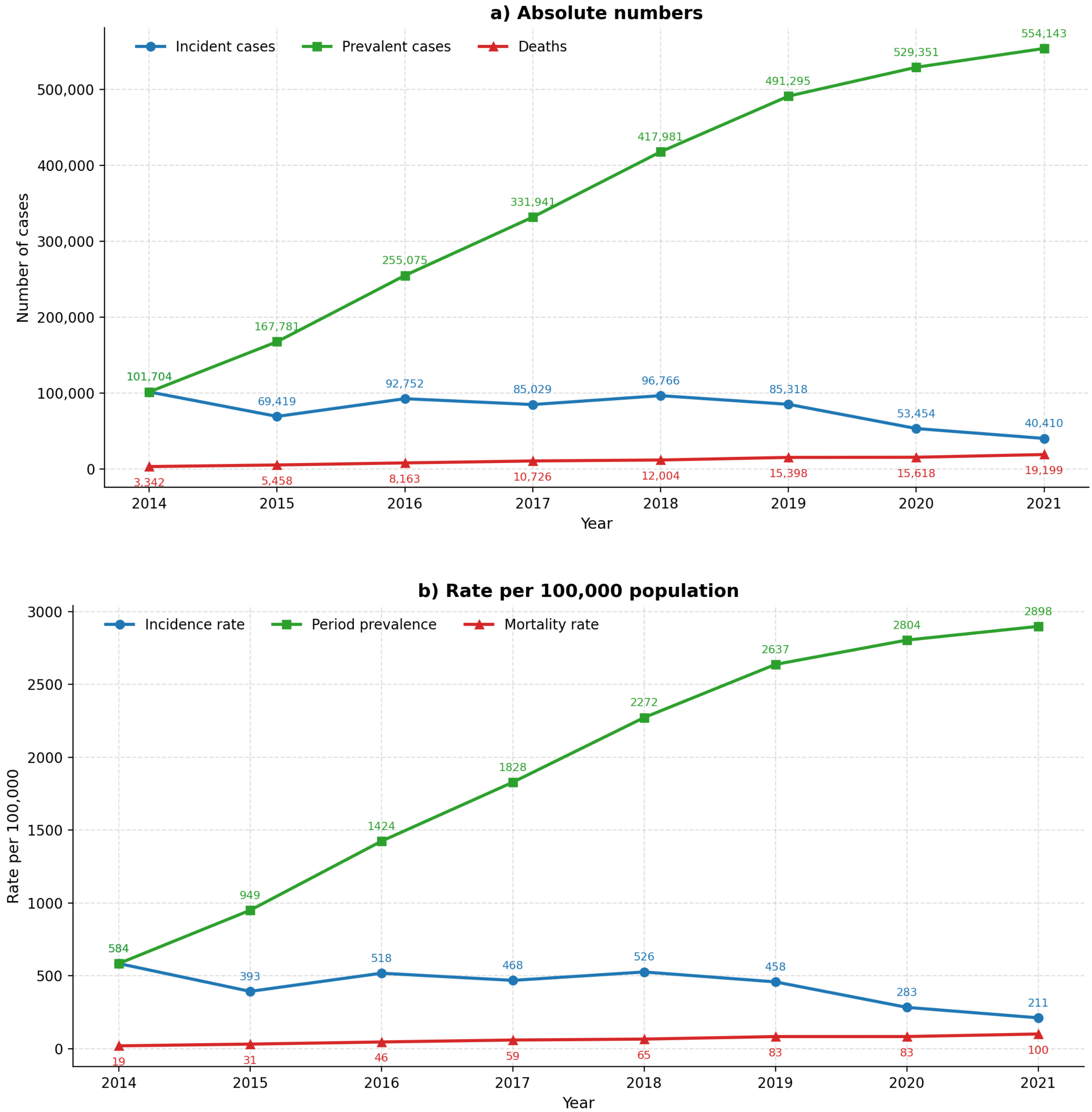

Figure 2. Incidence, period prevalence, and all-cause mortality of Chronic Coronary disease patients in Kazakhstan by year: (a) absolute numbers; (b) rate per 100,000 population. Period prevalence refers to the total number of individuals diagnosed with Chronic Coronary disease (both new and existing cases) within each calendar year.

Figure 2 illustrates the trends in incidence, period prevalence, and all-cause mortality. The incidence rate decreased from 584 to 211 per 100,000 population from 2014 to 2021, while the all-cause mortality rate rose from 19 to 100 per 100,000 over the same period. The 2014 incidence figure (584 per 100,000) should be interpreted with caution: as the UNEHS began systematic nationwide data capture from this year, the initial figure likely reflects a "prevalent pool" effect, capturing both existing and new cases rather than purely incident cases. The subsequent decline from 2015 onward may therefore partly reflect the transition from capturing prevalent to capturing truly incident cases, a recognised limitation of administrative database studies initiated without a prior washout period [43,44], in addition to changes in healthcare-seeking behaviour and, from 2020, disruptions during the COVID-19 pandemic. The notable decline in incidence in 2020 and 2021 likely reflects disruptions in healthcare access and reporting during the pandemic.

Figure 3 presents the age- and sex-specific incidence rate over the observation period, showing a marked increase in older populations, with men exhibiting higher rates. Figure 4 illustrates the population pyramid of the Chronic Coronary disease cohort, with numerical counts and percentages displayed for each age stratum. The distribution highlights the strong concentration of cases in the 55–69 year strata and the need for targeted interventions for older patients, particularly men, to reduce mortality and improve outcomes.

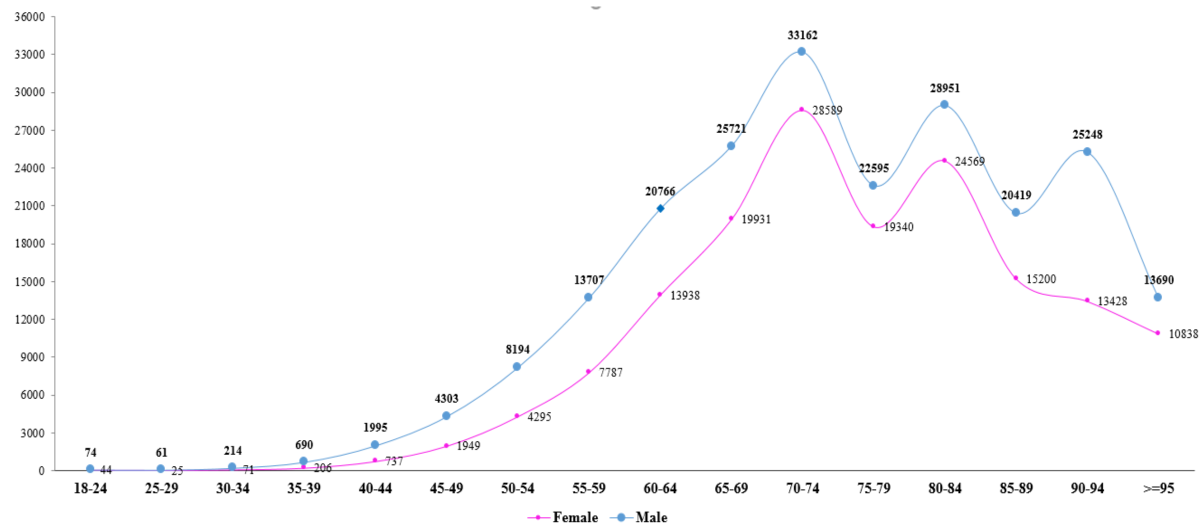

Figure 3. Age- and sex-specific incidence rate of Chronic Coronary disease per 100,000 population (age at diagnosis).

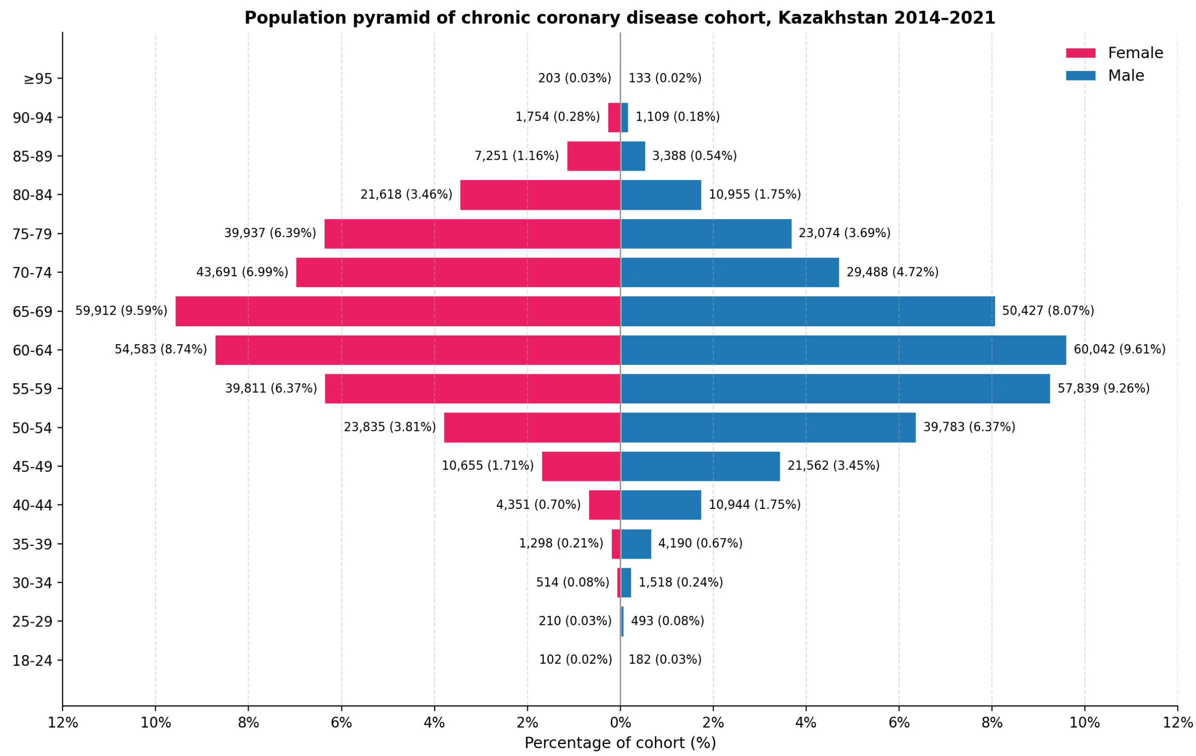

Figure 4. Population pyramid of the Chronic Coronary disease cohort, 2014–2021, with absolute counts and percentages of the total cohort displayed for each age stratum, by sex.

Trend analysis

The Mann–Kendall test detected a strong, statistically significant increase in both period prevalence (Kendall's τ = 1.00, p = 0.0008) and all-cause mortality (τ = 1.00, p = 0.0008) over 2014–2021. Sen's slopes were +370.4 per 100,000 per year (95% CI 294.9–422.1) for prevalence and +11.6 per 100,000 per year (95% CI 9.8–13.3) for all-cause mortality. For the incidence rate, the Mann–Kendall test indicated a downward tendency that did not reach statistical significance over this 8-year series (τ = −0.57, p = 0.064; Sen's slope −43.9 per 100,000 per year, 95% CI −68.1 to +4.2). Case fatality remained essentially stable at approximately 3% (τ = −0.29, p = 0.39). The increasing trend in absolute deaths was also significant (Sen's slope +2,236 deaths per year, 95% CI 1,920–2,485). Full results, including absolute counts and rates, are reported in Supplementary Table 4. These findings provide formal statistical support for the divergent trajectories of incidence, prevalence, and mortality discussed in §4.

Mortality outcomes and comorbidities

The overall mortality rate during the study period was 14.39%, with a higher rate observed in males (15.45%) compared with females (13.32%). Mortality significantly increased with age, reaching its highest in individuals aged 75 years and older. An unadjusted Kaplan–Meier survival analysis (Supplementary Figure 1) revealed notable survival differences across gender, ethnicity, place of residence, and revascularisation type.

Cox regression analyses revealed that CKD, AMI, and stroke were strong predictors of mortality, with HRs exceeding 2.0. The change from lower to higher risk of death in different analysis types is shown in Table 2

Table 2. Association between socio-demographic factors, comorbidities, revascularisation types and mortality among patients with Chronic Coronary disease, 2014–2021.

Variables	Unadjusted (All-cause) HR (95% CI)	Model 1 (All-cause) HR (95% CI)	Model 2 (All-cause) HR (95% CI)	Model 3 (Cause-specific) HR (95% CI)	Model 4 (MACE) HR (95% CI)
Gender					
Women	Ref.	Ref.	Ref.	Ref.	Ref.
Men	1.16 [1.14–1.17]	1.29 [1.19–1.41]	1.41 [1.30–1.53]	1.41 [1.21–1.65]	0.98 [0.94–1.02]
Age groups					
18–34	Ref.	Ref.	Ref.	Ref.	Ref.
35–44	1.40 [1.13–1.74]	1.63 [0.22–11.92]	1.33 [0.18–9.78]	0.28 [0.03–2.24]	1.04 [0.69–1.56]
45–54	2.03 [1.65–2.49]	2.50 [0.35–17.82]	1.97 [0.28–14.03]	0.57 [0.08–4.10]	0.95 [0.64–1.43]
55–64	3.33 [2.71–4.09]	3.60 [0.51–25.61]	2.76 [0.39–19.62]	0.63 [0.08–4.50]	1.07 [0.71–1.59]
65–74	5.73 [4.66–7.04]	5.92 [0.83–42.08]	4.38 [0.62–31.15]	0.94 [0.13–6.73]	1.15 [0.77–1.72]
≥75	12.62 [10.27–15.50]	10.73 [1.51–76.30]	7.92 [1.11–56.34]	1.41 [0.19–10.11]	1.16 [0.77–1.73]
Ethnicity					
Other	Ref.	Ref.	Ref.	Ref.	Ref.
Kazakh	1.16 [1.14–1.18]	0.87 [0.83–0.91]	0.89 [0.85–0.93]	0.87 [0.80–0.95]	1.03 [1.01–1.05]
Russian	1.84 [1.81–1.87]	1.07 [1.02–1.13]	1.09 [1.03–1.14]	1.13 [1.03–1.24]	0.98 [0.95–1.01]
Residence					
Urban	Ref.	Ref.	Ref.	Ref.	Ref.
Rural	1.09 [1.08–1.11]	1.10 [1.03–1.13]	1.18 [1.09–1.29]	1.06 [0.91–1.23]	0.97 [0.93–1.01]
Admission type					
Elective	Ref.	Ref.	Ref.	Ref.	Ref.
Urgent	1.32 [1.29–1.34]	1.23 [1.19–1.27]	1.15 [1.07–1.24]	1.23 [1.07–1.41]	0.89 [0.86–0.93]
Revascularisation type					
CABG	Ref.	Ref.	Ref.	Ref.	Ref.
PCI	1.30 [1.20–1.41]	1.19 [1.09–1.29]	1.23 [1.13–1.33]	1.02 [0.88–1.18]	0.89 [0.87–0.93]
Comorbid conditions					
Hypertension	1.95 [1.93–1.98]	—	1.60 [1.46–1.75]	4.65 [3.77–5.74]	1.00 [0.96–1.05]
ASHD	1.21 [1.19–1.22]	—	0.96 [0.88–1.05]	1.26 [1.09–1.46]	6.68 [6.43–6.93]

Variables	Unadjusted (All-cause) HR (95% CI)	Model 1 (All-cause) HR (95% CI)	Model 2 (All-cause) HR (95% CI)	Model 3 (Cause-specific) HR (95% CI)	Model 4 (MACE) HR (95% CI)
Diabetes mellitus	2.02 [1.99–2.05]	—	1.72 [1.56–1.90]	1.61 [1.37–1.89]	1.27 [1.21–1.33]
Heart failure	1.46 [1.43–1.49]	—	1.14 [1.00–1.22]	1.65 [1.42–1.94]	3.23 [3.12–3.35]
CKD	2.23 [2.18–2.28]	—	1.59 [1.42–1.78]	1.38 [1.15–1.66]	1.00 [0.94–1.06]
AMI	2.07 [2.02–2.12]	—	1.33 [1.20–1.46]	1.59 [1.36–1.86]	1.62 [1.55–1.69]
Stroke	3.62 [3.54–3.69]	—	3.01 [2.64–3.43]	3.83 [3.14–4.67]	2.15 [1.99–2.32]
Obesity	1.32 [1.27–1.36]	—	1.13 [0.99–1.29]	0.98 [0.78–1.23]	1.08 [1.01–1.16]
COPD	2.42 [2.34–2.51]	—	1.77 [1.36–2.29]	1.93 [1.21–3.05]	1.89 [1.53–2.33]
Arrhythmia	2.19 [2.09–2.28]	—	1.49 [1.19–1.88]	2.58 [1.85–3.59]	3.67 [3.33–4.06]
PVD	1.95 [1.83–2.07]	—	1.43 [1.09–1.87]	2.00 [1.31–3.06]	1.39 [1.10–1.76]

All p-values < 0.001 unless otherwise stated. Model 1: socio-demographic factors. Model 2: Model 1 + comorbid conditions. Model 3: cause-specific (cardiovascular) mortality. Model 4: major adverse cardiovascular events (MACE). Abbreviations as in Table 1.

Table 2 indicates that men had a 1.16-fold higher unadjusted hazard of all-cause mortality compared with women (HR 1.16, 95% CI 1.14–1.17), with a significant log-rank test ($p < 0.001$). Ethnic Russians showed lower survival rates compared with other groups (HR 1.84, 95% CI 1.81–1.87). Urban dwellers exhibited better survival than rural counterparts. Patients undergoing CABG had higher survival than those receiving PCI. Advanced age substantially increased the risk, with those aged ≥75 years showing a 12.62-fold risk compared with the youngest group (18–34 years). Comorbidities such as hypertension, diabetes mellitus, and chronic kidney disease significantly elevated the risk of mortality and MACE. Revascularisation type influenced outcomes; CABG was associated with lower mortality and MACE rates than PCI.

For cause-specific (cardiovascular) mortality (Model 3, Table 2), the strongest independent predictors were hypertension (HR 4.65, 95% CI 3.77–5.74), stroke (HR 3.83, 95% CI 3.14–4.67), arrhythmia (HR 2.58, 95% CI 1.85–3.59), peripheral vascular disease (HR 2.00, 95% CI 1.31–3.06), COPD (HR 1.93, 95% CI 1.21–3.05), heart failure (HR 1.65, 95% CI 1.42–1.94), AMI (HR 1.59, 95% CI 1.36–1.86), and diabetes mellitus (HR 1.61, 95% CI 1.37–1.89). Male sex (HR 1.41, 95% CI 1.21–1.65) and Russian ethnicity (HR 1.13, 95% CI 1.03–1.24) also remained independently associated with cardiovascular death after adjustment, while age did not reach significance in the cause-specific mortality model. For MACE (Model 4, Table 2), the strongest independent predictors were ASHD (HR 6.68, 95% CI 6.43–6.93), arrhythmia (HR 3.67, 95% CI 3.33–4.06), heart failure (HR 3.23, 95% CI 3.12–3.35), stroke (HR 2.15, 95% CI 1.99–2.32), COPD (HR 1.89, 95% CI 1.53–2.33), AMI (HR 1.62, 95% CI 1.55–1.69), PVD (HR 1.39, 95% CI 1.10–1.76), and diabetes mellitus (HR 1.27, 95% CI 1.21–1.33).

Discussion

To the best of our knowledge, this is the first in-depth epidemiological report of chronic coronary disease in Central Asia and Kazakhstan using a large nationwide cohort. This study comprehensively analysed the epidemiology and mortality trends of Chronic Coronary disease in Kazakhstan from 2014 to 2021, revealing key socio-demographic disparities, survival outcomes, and factors associated with cause-specific mortality and MACE. The findings align with and extend knowledge on cardiovascular disease burdens, both locally and globally.

The main finding is the significant decrease in coded Chronic Coronary disease incidence during 2020 and 2021. This trend may be partially attributed to healthcare system strain during the COVID-19 pandemic, which has been similarly observed worldwide. For example, studies from Italy and the UK reported a rise in cardiovascular events during the pandemic due to delays in care and changes in healthcare access patterns [24,25]. An alternative explanation for the broader declining incidence trend (2014–2021) is the maturation of UNEHS coding practices over the study period. As clinicians and hospital coders became more proficient in clinical documentation and DRG-based reimbursement, there may have been a gradual migration from non-specific

I20.x codes (e.g., I20.9, unspecified chronic coronary disease) toward combination codes such as I25.11x (atherosclerotic heart disease with angina), which — by virtue of the ICD-10 Excludes1 rule — are assigned instead of, not alongside, I20.x codes. This shift would cause patients to "disappear" from the I20-defined cohort without a true reduction in disease burden, creating an apparent decline in coded incidence. This phenomenon has been documented in other national administrative database studies where electronic health system maturation coincides with diagnostic code migration [45,46]. Future sensitivity analyses including I25.11x and I25.7x cohorts in parallel would help test this hypothesis and provide a more complete picture of symptomatic ischaemic heart disease burden in Kazakhstan.

Several factors plausibly contribute to the simultaneous decline in coded incidence, growth of period prevalence, and increase in all-cause mortality observed and formally tested in §3.1.1. First, the prevalent pool is ageing: as patients accumulate across calendar years, an increasing share of the cohort enters age strata (≥65 years) in which our Cox models showed several-fold higher hazards of death. Second, the prevalent cohort carries a heavier burden of mortality-relevant comorbidities (hypertension, diabetes mellitus, chronic kidney disease, heart failure), all of which were strongly and independently associated with mortality in our adjusted models. Third, mortality ascertainment improved as linkage to the national mortality registry matured, so more deaths in the cohort were captured later in the period. Finally, excess cardiovascular mortality during the COVID-19 pandemic — documented internationally — likely contributed to the 2020–2021 increase. Taken together, these mechanisms explain why a falling incidence rate is compatible with a rising mortality rate over the same period.

Another critical finding was the substantial risk of mortality in males, particularly among older adults. This gender disparity mirrors the results from studies in the U.S. and Europe, which have consistently shown higher mortality rates in men with coronary artery disease compared with women [9,10]. Differences in comorbidity burden, hormonal factors, and healthcare-seeking behaviour may explain these patterns [26]. In our study cohort, the ethnic distribution showed Kazakhs comprising 31.09%, Russians 12.65%, and the Other category accounting for 56.26%. Kazakhstan is home to over 120 nationalities, with Kazakhs (approximately 67%) and Russians (approximately 20%) forming most of the general population, according to the Bureau of National Statistics of Kazakhstan [19]. The Other category in our study includes numerous smaller ethnic groups (e.g., Ukrainians, Uzbeks, Tatars), each with insufficient individual sample sizes to analyse separately without compromising statistical power. Therefore, we grouped them into Other to ensure robust analyses. Notably, the higher proportion of Other in our cohort compared with the national demographic (where Other is approximately 13%) reflects the Chronic Coronary disease patient population in our dataset, which may differ from the general population due to disease-specific factors or healthcare access patterns.

Ethnic and geographic differences in survival outcomes also emerged, with ethnic Russians experiencing poorer survival compared with other groups. Similar trends have been noted in Eastern European countries, where ethnicity and socioeconomic factors influence cardiovascular outcomes [27], and consistent excess cardiovascular mortality among ethnic Russian populations has been reported in domestic Kazakhstani analyses [35,37]. Urban dwellers demonstrated better survival outcomes compared with their rural counterparts, likely reflecting disparities in healthcare access, socioeconomic factors, and resource availability. Similar findings have been reported in China, where urban–rural health insurance integration was associated with improved healthcare access and outcomes for rural populations, and in the U.S., where rural residents faced challenges such as fewer specialised healthcare providers and reduced adherence to cardiovascular care guidelines, contributing to poorer outcomes in rural settings [28,29].

Regarding treatment modalities, our results indicate that patients undergoing CABG had better survival outcomes than those receiving PCI. This finding aligns with the established superiority of CABG for certain high-risk populations, as demonstrated in the SYNTAX trial and subsequent meta-analyses [30,31]. Our data further underline the importance of timely and appropriate intervention for optimising outcomes, particularly among high-risk patients with comorbidities. However, it is important to note that the survival comparison between CABG and PCI in this cohort is subject to potential confounding by indication. Patients coded under I20.0 (unstable angina) who underwent PCI likely represent higher-acuity presentations, including acute coronary syndromes requiring urgent intervention, while patients referred for CABG are typically clinically stabilised prior to surgery and selected for anatomy suitable for surgical planning. This case-mix imbalance — not stratified by procedure urgency in the current analysis due to the high rate of missing admission-type data — may partly explain the observed survival difference. The CABG survival advantage should therefore be interpreted as an observational association rather than a causal treatment effect, and future analyses should incorporate procedure urgency stratification and, where feasible, propensity score matching for the revascularised subgroup.

Comorbid conditions such as hypertension, diabetes mellitus, and chronic kidney disease were strongly associated with increased risk of mortality and MACE. These comorbidities have been well documented as major contributors to cardiovascular mortality and reinforce the need for comprehensive disease management strategies [32]. Integrated chronic disease management significantly impacts cardiovascular risk reduction, particularly among patients with chronic coronary disease (CCD). Studies conducted in Brazil emphasise the systemic challenges and opportunities within public health frameworks to mitigate these risks effectively [33]. Similarly, evidence from Canada highlights the importance of structured guidelines in primary care to manage and lower cardiovascular disease burdens [34]. These findings suggest that adopting comprehensive and adaptable chronic disease management models may be pivotal for improving angina-related outcomes in settings like Kazakhstan.

Strengths and limitations

This study benefits from a large, nationwide dataset spanning 2014 to 2021, offering a robust basis for analyzing long-term trends in Chronic Coronary disease in Kazakhstan. By providing a comprehensive analysis of socio-demographic factors, comorbidities, and treatment modalities, it identifies critical risk factors and disparities that influence patient outcomes. The inclusion of Kaplan–Meier survival analysis, multivariable Cox regression, and formal Mann–Kendall/Sen trend testing allows for an in-depth exploration of temporal trends and associated risks. Additionally, the study's focus on a Central Asian population fills a significant gap in global cardiovascular research by contributing valuable regional data. However, the observational nature of the study limits causal inferences, with potential residual confounding despite multivariate adjustments. Regional differences in healthcare access and delivery, particularly between rural and urban settings, may have influenced outcomes. Furthermore, the study could not account for the impact of unmeasured factors such as socioeconomic status and health behaviours, potentially affecting generalizability. An additional limitation pertains to the impact of the COVID-19 pandemic on healthcare systems during the years 2020–2021. With a significant allocation of healthcare resources to combat COVID-19, the diagnosis and management of Chronic Coronary disease may have been deprioritized, potentially leading to underreporting or misclassification of cases. Consequently, the incidence and mortality trends for these two years may not fully reflect the true burden of Chronic Coronary disease in Kazakhstan.

Conclusion

This nationwide study from Kazakhstan reveals significant disparities in Chronic Coronary disease incidence and mortality across demographic groups, with elevated risks observed among men, older adults, ethnic Russians, and rural residents. Period prevalence and all-cause mortality increased significantly over 2014–2021 (Mann–Kendall $p < 0.001$), while coded incidence showed a non-significant declining tendency. The disproportionate impact of comorbidities, including hypertension, diabetes mellitus, and chronic kidney disease, highlights the urgent need for integrated chronic disease management. Improving healthcare access, particularly in rural areas, and tailoring interventions for high-risk groups are crucial for reducing cardiovascular morbidity and mortality. These findings underscore the importance of equitable healthcare policies and resource allocation to address the disparities and improve outcomes in this region.

Supplementary Materials

Supplementary file available via: https://www.journalehdi.com/suppfile/764/ehdi049_Supplementary_Materials.pdf

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writing—original draft preparation, S.Y. and A.G.; writing—review and editing, A.G., A.R., R.K., A.A., D.M. and G.N.; visualization, S.Y.; supervision, A.G. and A.R.. All authors have read and agreed to the published version of the manuscript.

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Competing interests: The authors declare that they have no competing interests.

Ethics approval and consent to participate: The study was approved by the Institutional Review Ethics Committee of Nazarbayev University (NU-IREC 490/18112021), with exemption from informed consent. The study was conducted in accordance with the ethical standards of human studies and followed the revised version of the Declaration of Helsinki.

Availability of data and materials: The data that support the findings of this study are available from the Republican Center for Electronic Health of the Ministry of Health of the Republic of Kazakhstan but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Following completion of the analysis, individual-level data access was closed in accordance with the data governance protocols of the Republican Center for Electronic Health. Data may be available from the corresponding author, upon reasonable request and with permission of the Ministry of Health of the Republic of Kazakhstan.

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