Journal of Health, Population and Nutrition

RESEARCH Open Access

Economic and healthcare influences on circulatory diseases in Kazakhstan: a retrospective ecological study

Olzhas Zhamantayev[1*], Nurlan Smagulov[2], Gulmira Tykezhanova[2], Maira Kenzhekeyeva[1] and Gulden Karshalova[1]

Abstract

Background Health is a key driver of the United Nations Sustainable Development Goals. This study examined the relationships between economic indicators, demographic metrics, and health system factors and morbidity due to non-communicable diseases, such as diseases of the circulatory system, in Kazakhstan.

Methods This retrospective ecological study utilized regionally aggregated data from 2010 to 2020 for all 14 regions in Kazakhstan. Data on incidence rates of diseases of the circulatory system (DCS) and socioeconomic, demographic, and healthcare variables were sourced from the Bureau of National Statistics and the Ministry of Health. Variables included gross regional product per capita, population density, living wage, unemployment rates, average monthly salary, Gini coefficient, income below subsistence level, housing space per capita, average monthly wage in healthcare, doctor and nurse densities per 10,000 population, and number of hospital beds. A correlation analysis was performed followed by stepwise regression to identify significant predictors.

Results The analysis identified that higher living wages (β = 0.7), population density (β = 0.275), nurse density (β = 0.212), and average monthly salary (β = 0.502) were positively associated with higher DCS incidence rates. Conversely, gross regional product per capita (β = -0.68), housing space per capita (β = -0.441), and income below the subsistence level (β = -0.161) were negatively associated with DCS incidence. The model explained approximately 63.7% of variance in DCS incidence.

Conclusions Socioeconomic and healthcare factors significantly influence the incidence of circulatory diseases in Kazakhstan. Policies aimed at improving economic conditions such as increasing living wages and reducing unemployment may help lower DCS morbidity. Additionally, equitable distribution of healthcare resources like nurses could enhance early detection and management of circulatory diseases, contributing to better public health outcomes in a middle-income country setting.

Keywords Circulatory system, Cardiovascular diseases, Non-communicable diseases, Socioeconomic factors, Healthcare, Public health, Kazakhstan

*Correspondence:
Olzhas Zhamantayev
zhamantaev@qmu.kz
[1]School of Public Health, Karaganda Medical University, 40 Gogol Str, Karaganda 100000, Kazakhstan
[2]Faculty of Biology and Geography, Karaganda Buketov University, 28 Universitet Str, Karaganda 100028, Kazakhstan

Introduction

Non-communicable diseases (NCDs) are the leading cause of death globally, contributing to 41 million deaths annually [1]. Moreover, the NCD burden is large in lower- and middle-income countries (LMICs), accounting for 60–80% of all deaths. A major part of the burden is on cardiovascular diseases (CVDs), respiratory disease, cancer, and diabetes. This burden is associated with socioeconomic, demographic, and healthcare-related factors, most of which can be avoided by preventive measures [2, 3]. Understanding these associationsof disease incidence is important for developing effective public health strategies. Socioeconomic and healthcare-related factors have been shown to influence the occurrence rates of various health conditions within populations [4, 5]. Thus, health is influenced not only by individual risk factors and behavioral patterns but also by a whole range of economic and social conditions. Moreover, when assessing the regional NCD burden, NCD prevention should also consider the importance of demographic indicators such as population growth, aging, density, and others [6, 7].

The economic vitality of a region, as indicated by gross regional product (GRP) per capita, is hypothesized to be inversely related to disease incidence due to its association with better access to resources and healthier living conditions [8]. Studies have shown that countries with higher levels of income inequality (as measured by the Gini coefficient) tend to have higher rates of some NCD morbidity and mortality rates [9, 10]. Some countries with higher Gini coefficients had greater burdens of CVDs, chronic respiratory diseases, digestive diseases and even infectious diseases [11, 12]. Poverty indicators such as minimum subsistence levels and unemployment rates are expected to show a strong positive correlation with disease incidence due to associated psychosocial stresses and limited access to healthcare [13–15]. According to Rahman et al., financial disparities contribute to higher NCD incidence rates among households [16]. The financial capacity represented by average monthly nominal salaries might reflect an individual's ability to afford preventative care or prompt treatment when necessary [17]. A national health survey (2012) in the USA revealed that individuals living in low-income households were more likely to have heart disease, stroke, and respiratory diseases. Additionally, CVDs, respiratory diseases and cancers were more common among the unemployed population [18]. Some studies highlight that individuals who lost their jobs are more likely to experience increased cause-specific morbidity and mortality [19, 20].

Population density can also play a dual role, while denser regions may struggle with infectious disease transmission and environmental factors impacting respiratory health indicators [21, 22], they may also benefit from more concentrated healthcare services. People in LMICs living in urban areas tend to have higher rates of hypertension, obesity, and diabetes than those living in rural areas [23]. Htet et al. reported that the rural Myanmar population has a high prevalence of risky health behaviors (alcohol consumption and low vegetable consumption) [24].

Healthcare provisioning is another key element included and explored in this study. The availability of medical professionals is anticipated to correlate inversely with disease incidence due to improved accessibility and quality of care [25]. A study from Kazakhstan concluded that hospital bed availability signals a healthcare system's capacity for treating acute cases effectively and managing chronic illnesses over time [26]. Typically, carriers of NCDs utilize health services more frequently. The most reported factors influencing the pursuit of private NCD care are patients' higher socioeconomic status and greater availability of services [27, 28].

Our study sought to examine how socioeconomic and healthcare factors may be associated with the morbidity rates of diseases of the circulatory system (DCS) in Kazakhstan, a middle-income country in the Central Asian region.

Methods

This study employed a longitudinal ecological design. Data for incidence rates and socioeconomic, demographic, and healthcare variables were sourced from the Bureau of National Statistics of Kazakhstan [29] and annual reports of the Ministry of Health [30]. We utilized regionally aggregated data spanning an 11-year period (2010–2020) for all 14 Kazakhstan regions (Akmola, Aktobe, Almaty, Atyrau, East Kazakhstan, West Kazakhstan, Zhambyl, Karaganda, Kostanay, Kyzylorda, Mangistau, Pavlodar, North Kazakhstan, and South Kazakhstan). This database compiles regional datasets from the Bureau of National Statistics of Kazakhstan and the Ministry of Healthcare, both adhering to stringent data management protocols. Local offices in each region regularly update demographic, economic, and healthcare statistics. The selection of variables was guided by prior literature and data availability [29, 30]:

- Gross Regional Product (GRP) per capita: GRP per capita is the total economic output of a region divided by its population. It is measured in tenge (KZT).
- Population density: The number of people living per square kilometer in a given region. Measured as people/km^2.
- Living wage: The minimum income necessary for a worker to meet their basic needs, including food,

housing, and other essentials. Defined annually by the government in tenge KZT.
- Unemployed population: The total number of individuals who are without a job and actively seeking employment within a specific region.
- Average monthly salary: The mean salary earned by workers in a region within a month, reported in KZT.
- Gini coefficient: A measure that represents income inequality within a region on a scale from 0 (perfect equality) to 1 (maximum inequality).
- Income below the subsistence level: Percentage or number of people whose income is below the minimum level required for basic sustenance, as defined by the government. Measured as a percentage.
- Housing space per capita: The average amount of living space available per person, measured in square meters per capita (m^2/capita).
- Average monthly wage in healthcare: The mean monthly earnings for individuals working in the healthcare sector, reported in KZT.
- Doctor density, per 10,000 population: The number of doctors available per 10,000 residents in a region.
- Nurse density, per 10,000 population: The number of nurses available per 10,000 residents in a region.
- Number of hospital beds: Total number of hospital beds available in medical facilities within a region, presented as an absolute count.
- Number of hospital beds: The rate at which diseases related to the circulatory system occur within the population, measured per 100,000 population annually.

To identify the relationships between DCS incidence and selected variables, a correlation analysis was performed. We focused on diseases of the circulatory system a priori due to their significant public health burden in Kazakhstan. Our initial analysis of variance across different disease categories confirmed that DCS showed the highest magnitude of variance, calculated as the sum of the squares of correlation coefficients between all independent variables and one dependent variable. The ICD-10 code of the DCS is I00-I99. This group contains the following diseases: ischemic heart disease, hypertensive disease, cerebrovascular disease, acute rheumatic fever, chronic rheumatic heart disease, and pulmonary circulation disease.

This study utilized stepwise regression to identify a subset of potential variables that best explained the variance in the dependent variable, "Diseases of the circulatory system". We used a backward stepwise selection process, starting with all variables and iteratively removing the least significant predictor until all remaining variables were significant at $p<0.05$. The variables considered in the model included living wages, gross regional product per capita, housing space per capita, population density, nurse density per 10,000 population, average monthly salary, and income below the subsistence level. The reported coefficients and significance levels for each variable reflect their contributions to the model after the stepwise selection process.

In the analysis presented, several variables were subjected to a natural logarithm (ln) transformation. Many socioeconomic and health-related variables often exhibit right-skewed distributions, where the majority of observations are concentrated at lower values with a long tail extending to higher values. Applying the natural logarithm can mitigate the effects of skewness, resulting in a more symmetric distribution.

We checked for multicollinearity using Variance Inflation Factors (VIFs). A VIF greater than 10 typically indicates significant multicollinearity among independent variables in a regression model. Variables with VIF > 10 were excluded from the final model.

Results

Selected statistics are presented in Table 1 and include measures of central tendency, variability, skewness, and kurtosis for economic and health-related variables. Analysis of the key statistical descriptors revealed the following:

The ln-transformed gross regional product had a mean of 7.61 with a standard deviation of 0.60551, indicating moderate variation. Kurtosis was slightly positively skewed (0.131), indicating a distribution that was less peaked than normal (-0.72). The population density had a mean of 5.19, with high variability (SD: 1.84). It is somewhat skewed to the right (0.69), indicating that higher population densities are less common. The average living wage was quite variable across the observations (SD: 6026.19) and slightly positively skewed (0.48), suggesting that higher wages were less frequent. The unemployment data were log-transformed, likely due to high skewness in its original form, which now shows a slight positive skew (0.593). The Gini coefficient had a low mean value of 0.2486 with very little dispersion around it and displayed negative skewness (-0.291), implying that inequality was usually not extremely high. The average monthly nominal wage in healthcare had notable right skewness (0.832), and its less-peaked-than-normal distribution suggests that there are regions with relatively high healthcare wages. Doctor density was almost normally distributed but slightly platykurtic (-0.71 kurtosis), so it was consistent but varied enough across different areas.

The outcome variable, DCS, showed significant incidence trends across the 14 regions of Kazakhstan from 2010 to 2020 (Table S1). Akmola region exhibited a substantial increase in DCS cases, rising from 1982.2

Table 1 Summary statistics: socioeconomic, demographic, and healthcare variables

Variable	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
GRP per capita	13	59.3	26.66	12.22	1.13	0.24
GRP per capita_ln	6.5	8.87	7.61	0.61	0.131	-0.72
Population density	2.5	9.6	5.19	1.84	0.69	-0.39
Living wage	11,759	33,816	21189.06	6026.19	0.476	-0.89
Unemployed population	665	7093.4	2422.07	1539.23	1.298	1.23
Unemployed population_ln	2.56	4.08	3.19	0.41	0.593	-0.80
Average monthly salary	55933.31	228,413	123064.06	46476.43	0.68	-0.61
Gini coefficient	0.17	0.32	0.25	0.04	-0.291	-0.75
Income below the subsistence level	1.3	7	3.74	1.48	0.606	-0.53
Housing -space per capita	18.46	23.6	20.95	1.33	0.046	-0.98
Average monthly wage in healthcare	62,340	162849.85	97790.54	27110.04	0.832	-0.32
Doctor density, per 10,000 population	18.7	36.7	26.42	4.47	0.355	-0.71
Nurse density, per 10,000 population	57.7	92.6	72.38	8.59	0.397	-0.42
Number of hospital beds	2367	13,800	6202.97	2870.35	0.966	0.05
Diseases of the circulatory system	1879.2	5210.4	3267.28	801.75	0.39	-0.51

Notes sourced from Bureau of National Statistics of Kazakhstan and the Ministry of Healthcare

Table 2 Regression model predictors of DCS incidence

Items	Unstandardized coefficients, 95,0% CI	Standardized coefficients	SE	*p*-value	VIF
(Constant)	10913.35, (7323.232, 14503.469)		1812.942	0.000	
Living wage	0.093, (0.057, 0.13)	0.7	0.018	0.000	6.2
GRP per capita_ln	-900.53 (-1296.694, -504.362)	-0.68	200.056	0.000	7.4
Housing space per capita	-265.23, (-373.249, -157.207)	-0.441	54.549	0.000	2.7
Population density	119.44, (52.212, 186.658)	0.275	33.946	0.001	2
Nurses density	19.78, (7.804, 31.753)	0.212	6.047	0.001	1.4
Average monthly salary	0.009, (0.003, 0.015)	0.502	0.003	0.005	9.9
Income below subsistence level	-87.32, (-163.754, -10.879)	-0.161	38.60	0.026	1.6

per 100,000 population in 2010 to 4974.9 in 2020. Similarly, Zhambyl and South Kazakhstan displayed notable increases, with Zhambyl's incidence growing from 3131.4 to 5210.4 and South Kazakhstan's from 2767.9 to 5174.5 over the same period. Conversely, some regions like East Kazakhstan experienced more moderate but consistent increases, moving from 2760.6 to 4270.3.

In 2010, the minimum DCS incidence was recorded in Kostanay at 1879.2 per 100,000 population, while the maximum was in Almaty at 3801.2. By 2020, these values had increased significantly, with Pavlodar recording a minimum incidence of 3290.8 and South Kazakhstan reaching a maximum of 5174.5.

Based on the Pearson correlation matrix (Table S2), we identified some relationships between disease-related variables and other factors. Diseases of the circulatory system were positively correlated with population density (r=0.46), suggesting that as population density increases, so does the incidence of circulatory diseases. They were also positively correlated with living wages (r=0.46) and other economic factors, such as average salary in healthcare (r=0.39). Respiratory diseases were also positively correlated with population density, albeit to a lesser extent than were circulatory diseases (r=0.33). This could indicate a pattern where certain health issues are more prevalent in denser populations. They also had a moderate linkage (r=0.33) to the unemployment level.

According to Table 2, the regression model demonstrated significant results for the selected variables. A one-unit increase in the living wage was associated with a 0.093-unit increase in predicted circulatory diseases (β=0.7, p<0.001), while a logarithmic increase in gross regional product of one unit was correlated with a decrease of 900.528 units (β = -0.68, p<0.001). Improvements in housing space per capita by one unit were associated with a decrease of 265.228 units (β = -0.441, p<0.001), whereas a one-unit rise in population density indicated an increase of 119.435 units (β=0.275, p=0.001) in predicted circulatory diseases. The presence of one additional nurse per 10,000 people correlated with a 19.779 unit increase (β=0.212, p=0.001), and a one-unit increase in average monthly salary resulted in a 0.009 unit increase (β=0.502, p=0.005). Conversely, an increase of one unit in income below the subsistence level was associated with a decrease of 87.317 units (β = -0.161, p=0.026) in predicted circulatory diseases.

By comparing the relative importance of different predictors, the standardized coefficients shed light on

the relative importance of each predictor. Living wages demonstrated a positive and statistically significant association (β=0.7, $p<0.001$), indicating that regions with higher living wages tended to experience an increased incidence of circulatory diseases. Conversely, GRP capita exhibited a negative association (β = -0.68, $p<0.001$), suggesting that higher economic productivity was linked to a decreased incidence of circulatory diseases. Housing space per capitaalso had a negative association (β = -0.441, $p<0.001$), implying that regions with better housing provisions had lower rates of circulatory diseases. Population density, nurse density per 10,000 people, and average monthly salary displayed positive associations, with population density having the strongest association (β=0.275, $p=0.001$). However, income below the subsistence level demonstrated a negative association (β = -0.161, $p=0.026$), suggesting that higher levels of income below the subsistence level were associated with a lower incidence of circulatory diseases.

In the regression model summary, the R^2 was 0.637, indicating that the model explained approximately 63.7% of the variability in the dependent DCS variable. The adjusted R^2 was 0.615, which reflects the number of predictors included in the model. The standard error of the estimate is 497.4, representing the standard deviation of the residuals. The F-statistic (29.529) tests our hypothesis that at least one predictor variable in the model is significantly related to the dependent variable.

The residual analysis showed that the model had a good fit (Figs. 1 and 2), with residuals centered at approximately 0 and a reasonable spread.

Discussion

Health is a key driver of the United Nations Sustainable Development Goals (SDGs), and reducing health inequalities and NCDs should become key in promoting the overall SDG agenda. The interaction between inequalities and health is complex: better economic outcomes for households enhance health, low socioeconomic status leads to chronic ill health, and NCDs reduce the income status of households [31]. The results from a systematic review highlighted that being in low socioeconomic status groups was associated with high CVD and cancer risks [32].

In our study, diseases of the circulatory system exhibited the highest magnitude of variance among all disease groups examined, suggesting a strong collective influence of the chosen independent variables on this category. This may indicate that socioeconomic and healthcare-related factors may play a considerable role in explaining

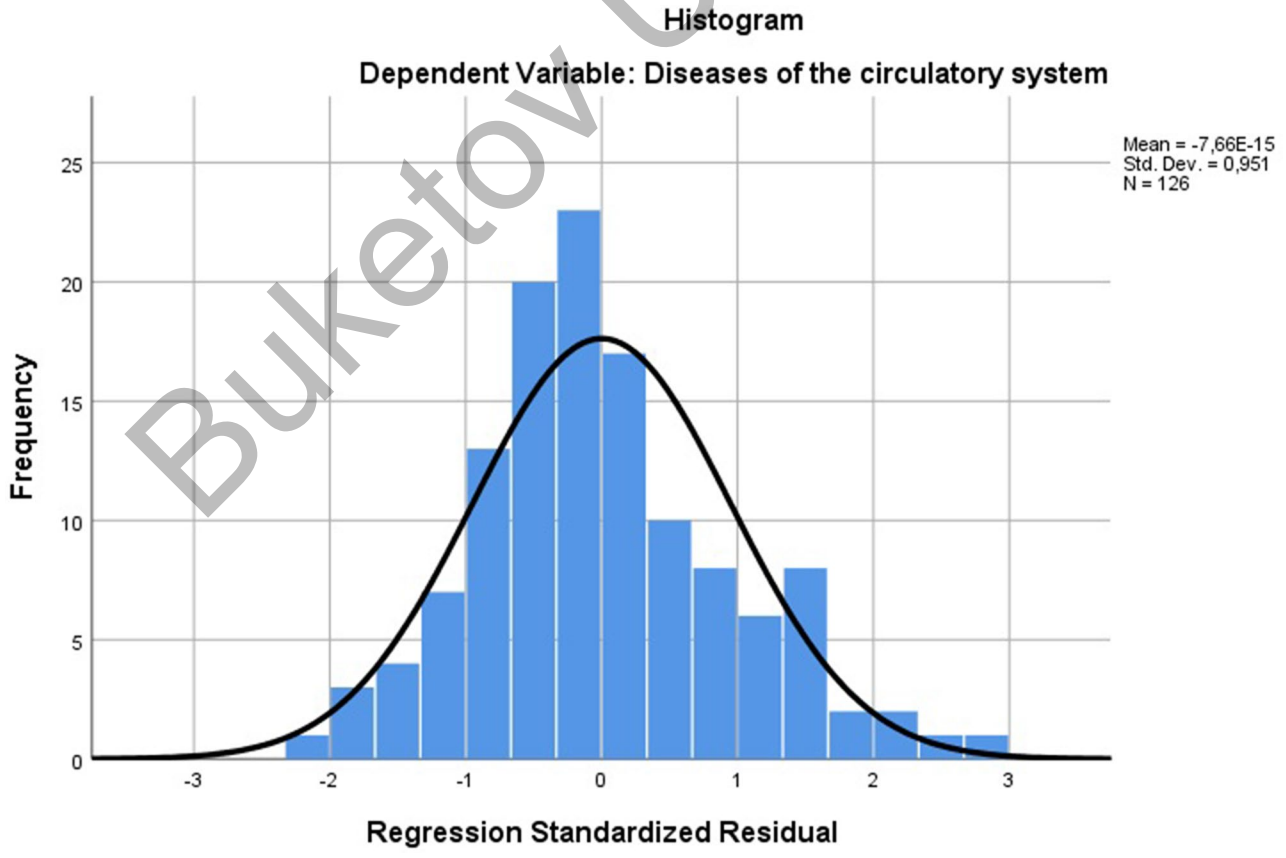

Fig. 1 Regression standardized residuals' distribution

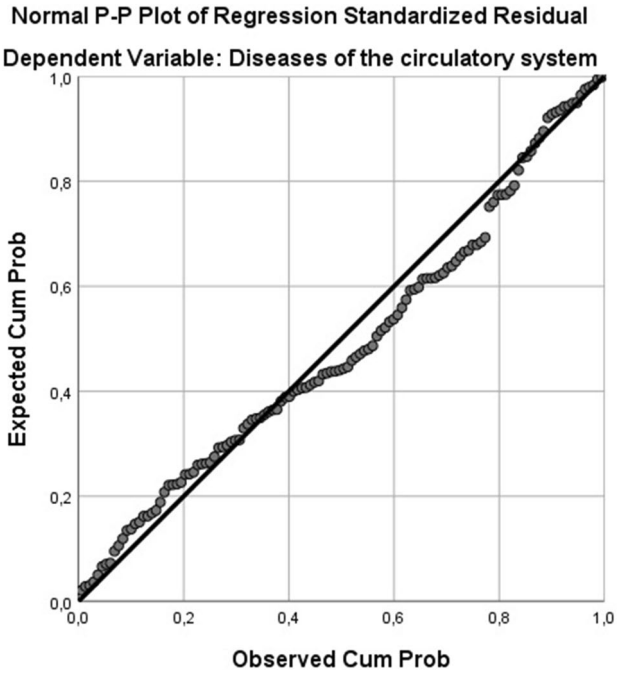

Fig. 2 Standardized residuals' normal P-P plot

the variability in the incidence of circulatory diseases. The correlation analysis suggested potential relationships between various socioeconomic factors and health indicators. Our regression model demonstrated significant explanatory power for the incidence of DCS in Kazakhstan.

The regression model indicated that the living wage, GRP per capita, housing space per capita, population density, nurse density per 10,000 people, average monthly salary, and income below the subsistence level collectively influenced the DCS incidence. Overall, our findings suggest that reducing income inequality, decreasing unemployment leves, and ensuring living wages could contribute to lowering a particular NCD morbidity. These results align with previous studies that have emphasized the role of social determinants in health outcomes. Both social and economic determinants have a direct connection to human disease and health since they can contribute to the emergence and spread of many human diseases [33].

GRP per capita may serve as an indicator of regional economic strength and is often associated with better healthcare infrastructure and services due to more substantial financial investments in the public health sector. However, economic prosperity does not uniformly translate into improved health outcomes [34]. The negative correlation between GRP per capita and DCS contrasts with findings from high-income countries [35], where economic growth typically improves healthcare access and reduces disease prevalence. In Kazakhstan, this might reflect regional disparities in income distribution or differences in public health infrastructure. According to the World Bank (2012), lower-income countries have higher rates of NCDs due to lower health expenditures and a lack of access to quality healthcare [36]. Poverty also contributes significantly, as it limits access to healthy food options and preventive healthcare. An American study reported the association of poverty aspects with coronary artery disease, hypertension and stoke prevalence [37]. The Gini coefficient is a measure of income inequality, with higher values indicating greater inequality. Several studies have reported positive associations between the GINI coefficient and NCD morbidity, particularly for cardiovascular diseases and diabetes [9, 11]. The mechanism behind this association is thought to be the adverse effects of income inequality on social determinants of health, such as education, employment, and housing conditions, which in turn contribute to the development of NCDs.

Our study revealed an unexpected negative association between income below the subsistence level and the incidence of circulatory diseases. The negative correlation between income below subsistence level and DCS incidence could be due to underreporting of cases in poorer regions or limited healthcare access skewing the data. It is possible that individuals in these areas are less likely to seek medical help until conditions become critical, resulting in lower recorded incidences but potentially higher mortality rates. This could be a result of confounding variables not accounted for in our model, or an artifact of the ecological study design. Researchers from the Dominican Republic found that when workers received compensation meeting living wage standards, some of their lifestyle patterns shifted, without apparent influence on cardiovascular risks [38]. A study in Iran by Davari et al. (2019) found that the socioeconomic status can be a strong predictor for the heart disease incidence [39]. For instance, the positive association between cost of living and morbidity could be explained by several mechanisms. Higher living costs may increase chronic stress levels, a known risk factor for cardiovascular diseases [40, 41]. Additionally, areas with higher costs of living often coincide with urban centers that have better healthcare facilities, potentially leading to higher detection rates of circulatory diseases [42]. However, these urban areas may also have lifestyle factors conducive to circulatory diseases, such as sedentary work environments and high consumption of processed foods [43, 44].

There is limited research about associations between housing space per capita and heart diseases in LMICs. Our findings indicate a positive association between population density and DCS incidence. This aligns with studies conducted in urban areas of other countries. For instance, a study from Hong Kong found that higher liveable floor area and neighborhood scale residential density

were associated with lower odds of hypertension [45]. A review focusing on Western countries reported that high population density is associated with increased mortality rates for multiple types of cancer, cardiovascular disease, and respiratory diseases, as well as a higher incidence of several cancers and respiratory conditions [46]. These population density issues can also create strain healthcare systems, complicating the provision of adequate medical services [47, 48].

There is also limited data on associations of nurse density and DCS morbidity levels. The influence of nurse density on health outcomes can be complex and sometimes underestimated. The positive correlation between nurse density and DCS incidence in our study might seem counter-intuitive at first. However, it can be explained by better disease detection and reporting in well-staffed areas. Higher nurse density ensures more frequent health check-ups and early diagnosis, leading to higher reported incidences. Factors such as nurses' education levels, work environment, and the overall organization of healthcare services can moderate this relationship [49]. Moreover, in resource-limited settings, increasing nurse density might have even more pronounced effects on health outcomes, as suggested by research in low- and middle-income countries [50].

Kazakhstan has demonstrated a commitment to improving public health through the implementation of comprehensive National Health programs. The most recent of these, the "Densaulyk" State Program for 2016–2019, and its successor for 2020–2025, have placed significant emphasis on addressing the growing burden NCDs in the country [51, 52]. These programs reflect Kazakhstan's recognition of the need to tackle major health challenges, including diseases of the circulatory system, which our study has identified as a primary concern. In line with these national initiatives, there has been an increased focus on research to identify factors contributing to major NCDs. Our analysis highlights major socioeconomic determinants of DCS in Kazakhstan. For instance, the influence of living wage suggests that improving economic conditions at the household level could reduce disease prevalence. This finding supports policies aimed at increasing minimum wages and providing economic support to low-income families. Moreover, our results underscore the importance of healthcare workforce distribution. Ensuring equitable distribution of nurses and other healthcare professionals across regions could improve early detection and management of circulatory diseases.

As limitations, it is important to note that while our model explains a substantial portion of the variance, approximately 36.3% remains unexplained. This suggests the presence of other important factors not captured in our analysis, including educational attainment, dietary habits, genetic predispositions, and environmental variables not measured in this study. Future research should aim to identify and incorporate these additional variables to enhance our understanding of DCS determinants in Kazakhstan. Our reliance on secondary data also means that we are dependent on the accuracy of the original data collection methods. However, it is important to note that Kazakhstan, like many countries, adheres to up-to-date standards and rules for collecting, classifying, recording, and reporting medical statistical data [53, 54]. The Bureau of National Statistics of Kazakhstan and the Ministry of Healthcare follow stringent protocols in their data management practices, which includes regular audits and quality checks. While this does not completely eliminate the potential for errors or biases in the original data collection, it does provide a degree of confidence in the overall quality and consistency of the data used in our study. Furthermore, our results are specific to the region studied and may not be generalizable beyond these settings. It is also worth noting that some variables had limited influence on certain disease categories, indicating possible areas where further longitudinal study could enhance understanding.

Conclusions

In our study, living wages, population density, and nurse density had positive associations with DCS morbidity. The average monthly salary also had a positive influence. On the other hand, the GRP per capita, housing space per capita, and income below the subsistence level had negative associations on DCS morbidity rates. Our results suggest that socioeconomic and healthcare factors have a significant association with the incidence of diseases of the circulatory system in Kazakhstan. Improvements in the living wage, population density, nurse density, average monthly salary, gross regional income per capita, and housing living space may contribute to managing the public health issues of circulatory diseases in a middle-income country. Overall, NCDs have emerged as the leading cause of morbidity and mortality worldwide, posing a significant public health challenge that transcends national borders and socioeconomic statuses. It is therefore important that policies aimed at improving health and reducing inequalities concerning health should consider not only healthcare practices and healthy behaviors but also the socioeconomic conditions that influence root causes of health.

Abbreviations

NCD	Non-communicable disease
LMIC	Low- and middle-income countries
CVD	Cardiovascular disease
GRP	Gross regional product
KZT	Kazakhstani tenge
DCS	Diseases of the circulatory system
ICD	International Classification of Diseases

SD	Standard deviation
CI	Confidence interval
SE	Standard error
VIF	Variance inflation factor
SDGs	Sustainable Development Goals

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-024-00697-y.

Supplementary Material 1

Acknowledgements
Not applicable.

Author contributions
O.Z. and N.S designed the study. O.Z., G.T., M.K. and G.K. prepared the manuscript draft. G.T., M.K. and G.K. collected the data. N.S. conducted statistical analysis. All authors contributed to revising the manuscript. O.Z. prepared and edited the final manuscript. N.S. reviewed the final version.

Funding
This study was supported by the grant from the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (IRN AP14871897 "Organizational and methodological aspects of improving social and hygienic monitoring").

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The present study has received ethical approval from the IRB Ethics Committee of Karaganda Medical University, protocol number 09–45, November 27, 2023. The committee has granted a waiver for the informed consent, acknowledging the retrospective nature of the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 2 March 2024 / Accepted: 19 November 2024
Published online: 26 November 2024

References

1. World Health Organization. Noncommunicable diseases. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases#:~:text=Key%20facts,%2D%20and%20middle%2Dincome%20countries. Accessed 15 Jan 2024.
2. Boutayeb A. The Burden of Communicable and Non-Communicable Diseases in Developing Countries. Handbook of Disease Burdens and Quality of Life Measures. 2010:531–46, https://doi.org/10.1007/978-0-387-78665-0_32
3. Miranda JJ, Kinra S, Casas JP, Davey Smith G, Ebrahim S. Noncommunicable diseases in low- and middle-income countries: context, determinants and health policy. Trop Med Int Health. 2008;13(10):1225–34. https://doi.org/10.1111/j.1365-3156.2008.02116.x.
4. Ndubuisi NE. Noncommunicable diseases Prevention in low- and Middle-Income countries: an overview of Health in all policies (HiAP). Inquiry. 2021 Jan-Dec;58:46958020927885, https://doi.org/10.1177/0046958020927885
5. Jailobaeva K, Falconer J, Loffreda G, Arakelyan S, Witter S, Ager A. An analysis of policy and funding priorities of global actors regarding noncommunicable disease in low- and middle-income countries. Global Health. 2021;17(1):68. https://doi.org/10.1186/s12992-021-00713-4.
6. Hambleton IR, Caixeta R, Jeyaseelan SM, Luciani S, Hennis AJM. The rising burden of non-communicable diseases in the Americas and the impact of population aging: a secondary analysis of available data. Lancet Reg Health - Americas. 2023;21:100483.
7. Husain MJ, Datta BK, Kostova D. Disease and demography: a systems-dynamic cohort-component population model to assess the implications of disease-specific mortality targets. BMJ Open. 2021;11(5):e043313. https://doi.org/10.1136/bmjopen-2020-043313.
8. Khanzada A, Mousa A, Thompson R, Rawaf D, Ikpeme M, Watt H, Mechili EA. The Association between GDP and noncommunicable disease mortality in the WHO European Region. Eur J Pub Health. 2021;31(Supplement3):ckab164. https://doi.org/10.1093/eurpub/ckab164.264.
9. Gaspar RS, Rossi L, Hone T, Dornelles AZ. Income inequality and noncommunicable disease mortality and morbidity in Brazil States: a longitudinal analysis 2002–2017. Lancet Reg Health Am. 2021;2:100042. https://doi.org/10.1016/j.lana.2021.100042.
10. Gavurová B, Kováč V, Šoltés M, Kot S, Majerník J. Income inequality in non-communicable diseases mortality among the regions of the Slovak Republic. Cent Eur J Public Health. 2017;25(Supplement 2):S31–6.
11. Andrade CAS, Mahrouseh N, Gabrani J, Charalampous P, Cuschieri S, Grad DA, et al. Inequalities in the burden of noncommunicable diseases across European countries: a systematic analysis of the global burden of Disease 2019 study. Int J Equity Health. 2023;22(1):140. https://doi.org/10.1186/s12939-023-01958-8.
12. Abeles J, Conway DJ. The Gini coefficient as a useful measure of malaria inequality among populations. Malar J. 2020;19:444. https://doi.org/10.1186/s12936-020-03489-x.
13. Jaeggi AV, Blackwell AD, von Rueden C, Trumble BC, Stieglitz J, Garcia AR, et al. Do wealth and inequality associate with health in a small-scale subsistence society? Elife. 2021;10:e59437. https://doi.org/10.7554/eLife.59437.
14. Alsan MM, Westerhaus M, Herce M, Nakashima K, Farmer PE. Poverty, global health, and infectious disease: lessons from Haiti and Rwanda. Infect Dis Clin North Am. 2011;25(3):611–22. https://doi.org/10.1016/j.idc.2011.05.004. ix.
15. Goldstein J, Jacoby E, del Aguila R, Lopez A. Poverty is a predictor of non-communicable disease among adults in Peruvian cities. Prev Med. 2005;41(3–4):800–6.
16. Rahman T, Gasbarro D, Alam K. Financial risk protection against noncommunicable diseases: trends and patterns in Bangladesh. BMC Public Health. 2022;22:1835. https://doi.org/10.1186/s12889-022-14243-0.
17. Kankeu HT, Saksena P, Xu K, Evans DB. The financial burden from noncommunicable diseases in low- and middle-income countries: a literature review. Health Res Policy Syst. 2013;11:31. https://doi.org/10.1186/1478-4505-11-31.
18. Vital and Health Statistics Report Series 10. https://www.cdc.gov/nchs/data/series/sr_10/sr10_260.pdf. Accessed 17 Jan 2024.
19. Beale N, Nethercott S. Job-loss and family morbidity: a study of a factory closure. J R Coll Gen Pract. 1985;35(280):510–4.
20. Eliason M, Storrie D. Does Job loss Shorten Life? J Hum Resour. 2009;44(2):277–302. https://www.jstor.org/stable/20648898. Accessed 20 Jan 2024.
21. Hazarie S, Hazarie S, Soriano-Paños D, Arenas A, et al. Interplay between population density and mobility in determining the spread of epidemics in cities. Commun Phys. 2021;4:191. https://doi.org/10.1038/s42005-021-00679-0.
22. Carnegie ER, Inglis G, Taylor A, Bak-Klimek A, Okoye O. Is Population Density Associated with Non-communicable Disease in Western developed countries? A systematic review. Int J Environ Res Public Health. 2022;19(5):2638. https://doi.org/10.3390/ijerph19052638.
23. The Lancet Diabetes &, Endocrinology. Urbanisation, inequality, and non-communicable disease risk. 2017;5(5):313. https://www.thelancet.com/journals/landia/article/PIIS2213-8587(17)30116-X/fulltext. Accessed 20 Jan 2024.
24. Htet AS, Bjertness MB, Sherpa LY, et al. Urban–rural differences in the prevalence of noncommunicable diseases risk factors among 25–74 years old citizens in Yangon Region, Myanmar: a cross-sectional study. BMC Public Health. 2016;16:1225. https://doi.org/10.1186/s12889-016-3882-3.
25. Ananthakrishnan AN, Hoffmann RG, Saeian K. Higher physician density is associated with lower incidence of late-stage colorectal cancer. J Gen Intern Med. 2010;25(11):1164–71. https://doi.org/10.1007/s11606-010-1457-z.
26. Kumar AB, Izekenova A, Abikulova A. Inpatient care in Kazakhstan: a comparative analysis. J Res Med Sci. 2013;18(7):549–53.
27. Malta DC, Bernal RTI, Lima MG, Araújo SSC, Silva MMAD, Freitas MIF, Barros MBA. Noncommunicable diseases and the use of health services: analysis of the National Health Survey in Brazil. Rev Saude Publica. 2017;51(suppl 1):4 s. https://doi.org/10.1590/S1518-8787.2017051000090

28. Brindley C, Wijemunige N, Dieteren C, et al. Health seeking behaviors and private sector delivery of care for noncommunicable diseases in low- and middle-income countries: a systematic review. BMC Health Serv Res. 2024;24:127. https://doi.org/10.1186/s12913-023-10464-0.
29. Bureau of National statistics. https://www.gov.kz/memleket/entities/stat?lang=en. Accessed 17 Jan 2024.
30. Health statistics of Kazakhstan https:https://nrchd.kz/index.php/ru/?option=com_content&view=article&id=973. Accessed 17 Jan 2024.
31. Bekker LG, Alleyne G, Baral S, Cepeda J, Daskalakis D, Dowdy D et al. Advancing global health and strengthening the HIV response in the era of the Sustainable Development Goals: the International AIDS Society—Lancet Commission. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31070-5/fulltext
32. Williams J, Allen L, Wickramasinghe K, Mikkelsen B, Roberts N, Townsend N. A systematic review of associations between noncommunicable diseases and socioeconomic status within low- and lower-middle-income countries. J Glob Health. 2018;8(2):020409. https://doi.org/10.7189/jogh.08.020409.
33. Samsonova AN. Factors determining the health status of the population: socio-economic and natural-climatic indicators. Mosc Economic J. https://doi.org/10.24411/2413-046X-2020-10827
34. Volume 122, The Quarterly Journal of Economics, Issue. August 3, 2007, Pages 1265–306, https://doi.org/10.1162/qjec.122.3.1265
35. World Heart Federation. World heart report 2023. Confronting the world's number one killer. https://world-heart-federation.org/wp-content/uploads/World-Heart-Report-2023.pdf. Accessed 29 June 2024.
36. Health, and Noncommunicable Diseases. https://documents1.worldbank.org/curated/en/991041503690161370/pdf/119110-WP-P154324-PUBLIC-47p-pphealthNCDsbackgroundfinal.pdf. Accessed 20 Jan 2024.
37. Minhas AMK, Jain V, Li M, Ariss RW, Fudim M, Michos ED et al. Family income and cardiovascular disease risk in American adults. Sci Rep. 2023;13(1).
38. Rehkopf DH, Burmaster K, Landefeld JC, Adler-Milstein S, Flynn EP, Acevedo MC et al. The impact of a private sector living wage intervention on consumption and cardiovascular disease risk factors in a middle income country. BMC Public Health. 2018;18(1).
39. Davari M, Maracy MR, Khorasani E. Socioeconomic status, cardiac risk factors, and cardiovascular disease: a novel approach to determination of this association. ARYA Atherosclerosis. 2019;15(6):260–6.
40. Satyjeet F, Naz S, Kumar V, Aung NH, Bansari K, Irfan S et al. Psychological stress as a risk factor for cardiovascular disease: a case-control study. Cureus. 2020;12(10).
41. Sims M, Kershaw KN, Breathett K, Jackson EA, Lewis LM, Mujahid MS et al. Importance of Housing and Cardiovascular Health and Well-Being: A Scientific Statement From the American Heart Association. Circulation: Cardiovascular Quality and Outcomes. 2020;13(8).
42. Urbanization. and cardiovascular disease Raising heart-healthy children in today's cities. https://world-heart-federation.org/wp-content/uploads/2017/05/FinalWHFUrbanizationLoResWeb.pdf. Accessed 02 July 2024.
43. Boakye K, Bovbjerg M, Schuna J, Branscum A, Varma RP, Ismail R, et al. Urbanization and physical activity in the global prospective urban and rural epidemiology study. Sci Rep. 2023;13(1):290.
44. Colozza D. A qualitative exploration of ultra-processed foods consumption and eating out behaviours in an Indonesian urban food environment. Nutr Health. 2022;026010602211338.
45. Sarkar C, Lai KY, Ni MY, Kumari S, Leung GM, Webster C. S Basu editor 2021 Liveable residential space, residential density, and hypertension in Hong Kong: a population-based cohort study. PLoS Med 18 11 e1003824.
46. Carnegie ER, Inglis G, Taylor A, Bak-Klimek A, Okoye O. Is Population Density Associated with Non-communicable Disease in Western developed countries? A systematic review. Int J Environ Res Public Health. 2022;19(5):2638.
47. Hanlon M, Burstein R, Masters SH, et al. Exploring the relationship between population density and maternal health coverage. BMC Health Serv Res. 2012;12:416. https://doi.org/10.1186/1472-6963-12-416.
48. Suzuki T, Koike S, Matsumoto M. Effect and significance of incorporating access in estimating the number of required physicians: focus on differences in population density in the target area. Int J Health Geogr. 2021;20(1):21. https://doi.org/10.1186/s12942-021-00274-0.
49. Aiken LH, Sloane DM, Bruyneel L, Van den Heede K, Griffiths P, Busse R, et al. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. Lancet. 2014;383(9931):1824–30.
50. Squires A, Uyei SJ, Beltrán-Sánchez H, Jones SA. Examining the influence of country-level and health system factors on nursing and physician personnel production. Hum Resour Health. 2016;14(1).
51. Mukasheva G, Abenova M, Shaltynov A, Tsigengage O, Mussabekova Z, Bulegenov T, et al. Incidence and mortality of Cardiovascular Disease in the Republic of Kazakhstan: 2004–2017. Iran J Public Health. 2022;51(4):821–30.
52. Glushkova N, Turdaliyeva B, Kulzhanov M, Karibayeva IK, Kamaliev M, Smailova D, et al. Examining disparities in cardiovascular disease prevention strategies and incidence rates between urban and rural populations: insights from Kazakhstan. Sci Rep. 2023;13(1):20917.
53. On approval of. forms of accounting documentation in the field of healthcare, as well as instructions for filling them out. https://adilet.zan.kz/kaz/docs/V2000021579. Accessed 02 July 2024.
54. On approval of the rules. for the implementation of statistical observation in the field of healthcare, the form of statistical accounting and reporting in the field of healthcare, the procedure for their maintenance, completion and deadlines for submission. https://adilet.zan.kz/kaz/docs/V2000021735. Accessed 02 July 2024.

Publisher's note