

Evaluating a Provincial Chronic Disease Plan in Cold Rural China: A Decade-Long Interrupted Time Series Analysis (2015-2025)

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Abstract

Background

China faces a growing burden of chronic non-communicable diseases (NCDs), particularly in resource-limited rural areas with extreme climatic conditions. To address this challenge, the National Chronic Disease Prevention and Control Initiative, implemented at the provincial level in Heilongjiang Province (2017–2025). However, evidence on the effectiveness of subnational prevention strategies in such settings remains scarce. This study aimed to evaluate the impact of this policy on chronic disease prevalence trends in a cold rural region.

Methods

We conducted a longitudinal interrupted time series analysis using data from a natural population cohort in Mingshui County ($n = 10694$ participants, mean age of 57.98 ± 8.80 years, 61.75% female) from 2015 to 2025. Annual prevalence, proportional distribution, and year-over-year growth rates for eight major categories of chronic diseases were calculated. Segmented regression models assessed policy effects on prevalence trends, while network analysis visualized multimorbidity patterns.

Results

The overall prevalence of chronic diseases increased from 2015 to 2025, but policy implementation in 2019 significant slowed the growth trajectory (slope change = -0.542% per year, $p < 0.05$). Disease-specific trends were heterogeneous: cardiovascular disease maintained the highest prevalence (2015: 23.1%; 2025: 67.0%), its annual growth rate demonstrated the most significant deceleration post-policy (difference = -5.536%), while respiratory diseases showed accelerated growth (difference = $+0.499\%$). Multimorbidity prevalence increased persistently, with a core cluster of cardiovascular, endocrine/metabolic, digestive, and respiratory diseases forming the central pattern of disease co-occurrence.

Conclusions

The provincial chronic disease prevention initiative effectively curbed the growth of certain diseases like cardiovascular conditions, but its impact on respiratory diseases and multimorbidity remains limited. These findings underscore the necessity for more targeted interventions addressing region-specific risk factors and multimorbidity patterns in cold rural settings. This study provides critical evidence for optimizing chronic disease control strategies in similar high-risk environments globally.

1. Background

Chronic non-communicable diseases (NCDs), including cardiovascular diseases, chronic respiratory diseases, endocrine and metabolic diseases, and cancers, represent a predominant global health burden, posing severe challenges to public health systems and socioeconomic development worldwide[1]. With accelerating population aging, the co-occurrence of multiple chronic conditions—multimorbidity—has become increasingly prevalent. This phenomenon significantly exacerbates clinical complexity and healthcare costs, emerging as a critical challenge in NCDs prevention and control[2].

As one of the world's most populous nation, China is undergoing rapid demographic and epidemiological transitions, leading to a progressively heavy burden of NCDs[3]. It is estimated that NCDs account for nearly 90% of all deaths and over 80% of the total disease burden in China[4]. Of particular concern is that healthcare expenditures for individuals with multimorbidity far exceed those for patients with a single chronic condition[5], underscoring the urgency of this public health issue.

The prevalence of chronic diseases is closely linked to socioeconomic, environmental, and behavioral factors[6–8]. Heilongjiang Province, a typical cold region in northern China, experiences long, severe winters that influence local lifestyles, resulting in reduced outdoor activity and diets high in meat, alcohol, salt, and fat. Consequently, the region exhibits a distinct disease profile, characterized by a significantly higher prevalence of chronic diseases such as cardiovascular diseases and non-alcoholic fatty liver disease compared to the national average[9–12]. More critically, given the region's unique cold climate, lifestyle, and the known high prevalence of NCDs, it is highly plausible that multimorbidity manifests a distinct clustering pattern[13, 14]. This knowledge gap is compounded by the limited capacity of primary healthcare institutions to manage complex multimorbidity, rendering the situation particularly urgent[15].

In response to these challenges, the Chinese government has implemented a series of national strategies for NCD prevention and control[16, 17]. Accordingly, the Chinese government launched the National Chronic Disease Prevention and Control Initiative in 2017, with provincial implementation plans including Heilongjiang's Medium- to Long-Term Plan (2017–2025)[18]. However, robust evidence regarding the effectiveness of such subnational plans, particularly in resource-limited, cold rural settings where unique environmental and lifestyle factors may modulate both disease risk and policy impact, remains scarce. This study therefore employs an interrupted time series design to quantify the impact of the Heilongjiang Provincial Medium- to Long-Term Plan (2017–2025) on chronic disease prevalence trends and multimorbidity patterns from 2015 to 2025, aiming to fill this critical evidence gap and inform targeted strategies for similar regions.

2. Materials and methods

2.1 Study design and data sources

This study employed an interrupted time series design based on longitudinal data from a natural population cohort in Mingshui County, Suihua City, Heilongjiang Province, to evaluate chronic disease

prevalence trends from 2015 to 2025 and assess the effectiveness of the Chronic Disease Prevention and Control Policy in Heilongjiang Province. Data were integrated from two primary sources:

Baseline Cohort Data: Demographic characteristics, lifestyle factors, and health from the established natural population cohort for chronic diseases in Mingshui County[19]. This study utilized baseline data on demographic characteristicstatus from this cohort.

Inpatient Medical Record Data: Comprehensive medical records from two major hospitals in Mingshui County (Mingshui County People's Hospital and Mingshui County Kangying Hospital) for all cohort members from January 1, 2015, to June 30, 2025.

The study protocol was approved by the relevant Institutional Ethics Review Board of the Center for Endemic Disease Control, Chinese Center for Disease Control and Prevention. The plan has been approved by the Ethics Committee of Harbin Medical University (Ethics Number: hrbmuecdc20240601). The flowchart of the study design is presented in Fig. 1.

2.2 Study setting and population

Mingshui County, under the administration of Suihua City, Heilongjiang Province, represents a typical rural cold and economically underdeveloped area in China (Fig. 2). This region is a typical representative of rural cold areas in China, whose distinct climatic conditions, economic profile, and demographic structure make it highly representative for investigating chronic diseases in such settings.

The study population comprised 10694 adult permanent residents from the natural population cohort, recruited through community mobilization and health examinations between November 2018 and September 2019.

2.3 Variable definitions and chronic disease metrics

Chronic Diseases: Eight major categories of chronic disease were identified using International Classification of Diseases, Tenth Revision (ICD-10) codes: 1) Cardiovascular diseases, 2) Endocrine and metabolic disorders, 3) Digestive diseases, 4) Musculoskeletal system disorders, 5) Neurological disorders, 6) Renal diseases, 7) Respiratory diseases, 8) Cancers.

Multimorbidity was defined as the coexistence of two or more of the above-defined chronic disease categories within the same individual in a given year.

Three core metrics were calculated to comprehensively assess the disease burden and its evolution:

Period Prevalence: Cumulative number of individuals diagnosed with a specific disease by year-end (December 31st) divided by the total participant.

Disease-specific Proportion: Annual proportion of individuals with a specific chronic disease relative to all individuals with chronic diseases. This metric reveals the relative composition of the overall chronic disease spectrum.

Year-over-Year Growth Rate: Percentage change in period prevalence from one year to the next, reflecting the relative speed of change.

All data underwent uniform cleaning, coding, and anonymization before statistical analysis.

2.4 Interrupted time series analysis

To quantitatively assess the net effect of the policy intervention (the end of 2018 as the intervention point), we conducted an interrupted time series analysis (ITSA) using segmented regression models at both the overall and disease-specific levels. The basic model was specified as follows:

$$Y_t = \beta_0 + \beta_1 \times T_t + \beta_2 \times X_t + \beta_3 \times (T_t - T_0) \times X_t + \varepsilon_t$$

Where:

Y_t = the prevalence rate at time t .

T_t = a continuous variable representing time (sequentially from the start of the study).

X_t = a binary variable indicating the intervention phase (0 = pre-intervention, 1 = post-intervention).

T_0 = the time point at which the intervention occurred.

ε_t = the random error term at time t .

Model Application:

Overall Analysis: A model was fitted to the overall chronic disease prevalence to assess the policy's aggregate impact.

Disease-specific Analysis: Separate models with identical structure were fitted for the prevalence of each specific disease category. The core outcome of interest was the estimate of β_3 for each disease, representing the difference-in-slopes (change in annual growth rate) before and after the intervention.

Statistical Diagnostics: The Durbin-Watson statistic was used to test for autocorrelation in the residuals. If significant autocorrelation ($p < 0.05$) was detected, the model was corrected using the Prais-Winsten estimation method within a generalized least squares framework.

2.5 Multimorbidity and co-occurrence network analysis

Multimorbidity prevalence trends were analyzed by calculating annual prevalence of individuals with exactly two chronic diseases and with three or more chronic diseases was calculated separately as a

percentage of the total cohort. Disease co-occurrence network analysis was performed using cumulative prevalence data up to 2025, with nodes representing diseases and edges representing pairwise co-occurrence. Node size was proportional to degree centrality, and edge thickness represented the frequency of co-occurrence. The Fruchterman-Reingold algorithm was used for network layout.

2.6 Statistical analysis

All statistical analyses were performed using R software (version 4.5.1). Continuous variables conforming to a normal distribution are described using mean $\pm$ standard deviation. Categorical variables are described using frequencies (percentages). All statistical tests were two-sided, and a p-value < 0.05 was considered statistically significant.

3. Results

3.1 Baseline characteristics

The study cohort comprised 10694 participants (4093 males (38.27%) and 6601 females (61.73%)), with mean age of 57.98 ± 8.80 years (Table 1). Educational attainment was relatively low (46.07% completed primary school; 30.57% never attended school). This proportion was significantly higher among females (39.60%) than males (16.00%). The majority (91.46%) were married, with significant gender differences in lifestyle factors (e.g., smoking: 44.66% males vs. 34.18% females; alcohol consumption: 54.87% males vs. 9.71% females).

3.2 Temporal trends in prevalence rates of chronic diseases

As illustrated in Fig. 3, all eight major chronic disease categories in rural Heilongjiang Province demonstrated increasing prevalence rates from 2015 to 2025. Cardiovascular diseases maintained the highest prevalence (23.31% to 67.55%), followed by endocrine and metabolic disorders (3.69% to 17.35%), digestive diseases (7.78% to 18.72%), and respiratory diseases (3.20% to 15.86%). The prevalence of cancers (0.40% to 3.17%), musculoskeletal disorders (from 3.50% to 7.85%), neurological disorders (0.01% to 1.01%), and renal diseases (0.02% to 0.64%) also increased from relatively low baselines, indicating a comprehensive rise in chronic disease burden across all categories.

The disease-specific proportions trends (Fig. 4) revealed the significant structure shift in chronic disease burden. Despite increasing absolute prevalence, cardiovascular diseases' proportional contribution peaked around 2019 and subsequently declined, while endocrine and metabolic disorders and respiratory diseases showed sustained upward trends in their relative importance. Concurrently, the proportion of cancers increased, whereas digestive and musculoskeletal diseases demonstrated declining shares.

3.3 Temporal trends in growth rates of chronic diseases

Analysis of year-over-year growth rates (Fig. 5) demonstrated a clear deceleration in the rate of increase across all chronic diseases. The growth trajectory can be divided into two distinct phases: (1) a steep decline in growth rates prior to 2020, particularly for neurological disorders and renal diseases (initially high growth rates of 72.74% and 53.76%, respectively), and (2) a stabilization phase after 2020, with growth rates approaching zero for most diseases. Notably, respiratory diseases exhibited a significant acceleration in growth rate (difference = + 0.499%, $p < 0.05$) following policy implementation in 2019, contrasting with the overall deceleration trend.

Table 1
Baseline characteristics of the study participants.

Characteristics	Male (n, %)	Female (n, %)	Total (n, %)
Age (years)	59.22 ± 8.85	57.21 ± 8.67	57.98 ± 8.80
Education			
Have never been to school	655 (16.00)	2614 (39.60)	3269 (30.57)
Primary school	1977 (48.30)	2950 (44.69)	4927 (46.07)
Middle school or above	1461 (35.70)	1037 (15.71)	2498 (23.36)
Marital status			
Never married	87 (2.13)	30 (0.45)	117 (1.09)
Married	3764 (91.96)	6017 (91.15)	9781 (91.46)
Separated or divorced	47 (1.15)	47 (0.71)	94 (0.88)
Widowed	195 (4.76)	507 (7.68)	702 (6.56)
Smoking history			
Never smoker	1767 (43.17)	3874 (58.69)	5641 (52.75)
Smoker	1828 (44.66)	2256 (34.18)	4084 (38.19)
Ex regular smoker	298 (7.28)	208 (3.15)	506 (4.73)
Missing	200 (4.89)	263 (3.98)	463 (4.33)
Alcohol status			
Never or almost never	1640 (40.07)	5680 (86.05)	7320 (68.45)
Irregular drinking	919 (22.45)	539 (8.17)	1458 (13.63)
Regular drinking	1327 (32.42)	102 (1.54)	1429 (13.36)
Missing	207 (5.06)	280 (4.24)	487 (4.56)

The volatility ananlysis (Table 2, Fig. 6) further highlighted the differential stability of disease trends. Neurological and renal diseases (mean: 72.74 and 53.76, sd: 86.44 and 48.64), while cardiovascular and digestive diseases exhibited more stable growth patterns (lower mean growth rates and compact distribution). This pattern of deceleration followed by stabilization, coupled with the accelerated growth of respiratory diseases, underscores the heterogeneous impact of the provincial chronic disease prevention initiative on different disease categories in cold rural settings.

Table 2
Statistical summary of the annual growth rates for eight major chronic disease categories (2016–2025).

Disease Category	Years	Mean (SD)	Median	Min to Max	P Value
Neurological disorders	10	72.74 (86.44)	34.64	17.65 to 300.00	0.026*
Renal diseases	9	53.76 (48.64)	35.00	7.94 to 150.00	0.011*
Cancers	10	24.00 (17.71)	16.39	4.31 to 53.85	0.002*
Respiratory diseases	10	17.55 (6.84)	16.87	6.20 to 27.38	< 0.001
Endocrine and Metabolic disorders	10	17.23 (11.78)	14.41	3.75 to 40.00	0.001*
Cardiovascular diseases	10	11.7 (11.14)	5.25	2.11 to 33.25	0.009*
Digestive diseases	10	9.33 (6.07)	8.08	2.14 to 18.92	< 0.001
Musculoskeletal disorders	10	8.55 (5.76)	6.64	1.70 to 21.38	0.001*
Note: Data are presented as percentage growth rates (%). * indicates statistical significance (p < 0.05) based on two-sided t-test. SD = standard deviation					

3.4 Impact of policy intervention: interrupted time series analysis

Interrupted time series analysis revealed a significant impact of the Heilongjiang Provincial Chronic Disease Prevention and Control Initiative (implemented in late 2018) on the long-term trends of chronic disease prevalence in rural areas. The model demonstrated excellent fit to the data ($R^2 = 0.996$), with residuals evenly distributed around zero and no significant trends or autocorrelation (Fig. 8), confirming the reliability of the analytical approach.

Prior to policy implementation, chronic disease prevalence exhibited a stable upward trend (Fig. 7). While no significant level change was observed at the time of policy implementation (level change = 0.318, $p > 0.05$), the annual growth rate showed a statistically significant deceleration following intervention (slope change = -0.542% per year, $p < 0.05$), indicating the policy effectively curbed growth momentum of chronic disease prevalence without immediate reduction in absolute levels.

Stratified analysis by disease category revealed heterogeneous intervention effects (Table 3).

Three distinct patterns emerged:

Significant growth deceleration: Cardiovascular diseases (slope difference = -5.536%, adjusted $p < 0.001$) and digestive diseases (slope difference = -0.706%, adjusted $p < 0.001$) demonstrated the most pronounced reductions in annual growth rates.

Marginal growth deceleration: Musculoskeletal disorders showed a marginally significant decline in growth rate (slope difference = -0.261%, adjusted $p = 0.051$).

Accelerated growth: Respiratory diseases were the only category exhibiting a statistically significant increase in annual growth rate following policy implementation (slope difference = + 0.499%, adjusted $p < 0.05$).

No significant changes in annual growth rates were observed for endocrine and metabolic disorders, neurological disorders, renal diseases, or cancers (all adjusted $p > 0.05$).

These findings indicate that while the provincial chronic disease prevention initiative has been effective in curbing the growth of certain chronic diseases, particularly cardiovascular and digestive diseases, its impact on respiratory diseases has been counterproductive, and it has had limited effect on neurological disorders, renal diseases, and multimorbidity. This heterogeneity underscores the need for more targeted interventions addressing region-specific risk factors and disease patterns.

Table 3

Segmented regression analysis by chronic disease category: Comparison of annual increase before and after policy implementation.

Disease category	Annual increase, 2015–2018, %	Annual increase, 2019–2025, %	Difference in annual increase, %	P value	Adjusted P value
Cardiovascular diseases	7.997	2.461	-5.536	< 0.001	< 0.001***
Digestive diseases	1.615	0.909	-0.706	< 0.001	< 0.001***
Respiratory diseases	1.061	1.561	0.499	0.001	0.010*
Musculoskeletal disorders	0.631	0.370	-0.261	0.006	0.051 [†]
Endocrine and metabolic disorders	1.623	1.372	-0.251	0.016	0.126
Neurological disorders	0.049	0.141	0.092	0.036	0.285
Renal diseases	0.042	0.087	0.04	0.050	0.400
Cancers	0.308	0.289	-0.019	0.538	1.000
Note: Data are presented as annual percentage change from segmented regression analysis. Significance levels are based on the interaction term testing the difference in slopes between periods. *P < 0.05, **P < 0.01, ***P < 0.001, †P = 0.051 (borderline significance)					

3.5 Multimorbidity patterns

Despite an overall slowdown in the annual growth rate of chronic disease prevalence following the implementation of the Provincial Chronic Disease Prevention and Control Initiative, the composition of the chronic disease burden underwent a significant transformation toward multimorbidity (Fig. 9). The proportion of individuals with a single chronic disease increased rapidly from 2015 to 2019 but plateaued and declined thereafter. In contrast, the prevalence of individuals with two chronic diseases and three or more chronic diseases both exhibited a continuous and parallel upward trend throughout the study period (2015–2025), indicating a rapidly shift from single-disease to multimorbidity-dominant chronic disease burden.

Disease co-occurrence network analysis (Fig. 10) revealed a distinct core-periphery structure within the multimorbidity landscape. Cardiovascular diseases and endocrine and metabolic diseases demonstrated the highest degree centrality, forming the core hubs of the network. These diseases exhibited strong associations with digestive diseases and respiratory diseases, collectively constituting a tightly interconnected "cardiovascular-metabolic-digestive-respiratory" core disease cluster. In contrast, neurological disorders and renal diseases occupied positions within the network.

The findings underscore a critical need for future chronic disease prevention and control strategies to transition from single-disease management toward integrated multimorbidity cluster care, particularly targeting the identified core disease cluster that dominates the multimorbidity landscape in this cold rural region.

4. Discussion

This 11-year longitudinal study provides the first comprehensive evaluation of a provincial chronic disease prevention initiative in a cold rural region of China. Our findings across three key dimensions—overall disease burden, disease-specific growth patterns, and the emergence of complex multimorbidity—offer critical insights for NCD control in resource-limited, high-risk settings.

Interrupted time series analysis, a standard quasi-experimental method for evaluating public health interventions[20], revealed a significant deceleration in the growth trajectory of overall chronic disease prevalence following policy implementation of the Heilongjiang Medium- and Long-Term Plan (2017–2025). This effect manifested as a change in the slope of growth rather than an immediate reduction in absolute prevalence rates—a pattern consistent with the gradual impact of population-level public health strategies. The policy's effectiveness varied substantially across disease categories: the significant deceleration in cardiovascular and digestive diseases growth likely reflects the direct success of targeted interventions central to the plan, such as community-based hypertension screening and salt-reduction campaigns[21]. In contrast, respiratory diseases showed accelerated growth, highlighting a critical gap in addressing region-specific environmental risk factors, notably prolonged exposure to indoor air pollution from solid fuel combustion used for heating during the long winter months[22, 23].

The marginal slowing of musculoskeletal disease growth ($p = 0.051$) suggests that certain conditions may require longer or more intensive approaches to achieve statistically significant effects[24]. Notably, neurological and renal disease trends exhibited substantial volatility, likely reflecting their complex etiologies and disparities in diagnostic and treatment access in low-resource settings[25, 26], whereas cardiovascular disease trends remained more stable due to their established prioritization in primary care.

Our analysis revealed a profound transformation in the disease spectrum: while cardiovascular diseases (CVD) retained the highest prevalence, their proportional contribution to the total disease burden began to decline after peaking. This pattern aligns with the "prevalence ceiling" effect in aging populations—an epidemiological phenomenon where the prevalence of a specific disease stops increasing significantly and plateaus after reaching a threshold, as the number of elderly patients approaches saturation and new cases gradually decrease, while endocrine and metabolic diseases—still in their ascendant phase—continue to increase in relative proportion. More significantly, multimorbidity has emerged as the predominant form of chronic disease burden, with growth primarily driven by cases involving three or more conditions. Disease co-occurrence network analysis demonstrated a highly structured, clustered architecture centered around a "cardiometabolic-digestive-respiratory" core cluster, suggesting shared

underlying pathophysiological mechanisms rather than independent disease processes. This cluster appears to represent the clinical manifestation of "accelerated aging" across multiple organ systems, with core mechanisms including cellular senescence and chronic inflammatory microenvironment[27].

The period of relatively low and stagnant growth rates observed post-2019 coincides with the COVID-19 pandemic, which likely influenced disease trends through dual pathways: disrupting healthcare access and exacerbating risks among individuals with pre-existing conditions[28]. This complicates the interpretation of policy effects, though our interrupted time series analysis helps isolate the policy's impact from pandemic-related disruptions.

Several limitations warrant consideration. First, the observational nature of the study cannot fully exclude the influence of unmeasured historical confounders. Second, reliance on inpatient data from two regional hospitals may underestimate milder cases and limit generalizability. Third, improvements in diagnostic capabilities over time may partially explain observed trends. Finally, the findings are specific to a cold, rural Chinese context and require validation in other settings.

Notwithstanding these limitations, this study offers a unique perspective on NCD control in challenging environments. The Heilongjiang Provincial Plan has demonstrated measurable success in curbing the growth rates for certain conditions, yet it has not reversed the overarching trend of rising multimorbidity burden. This underscores the need for a fundamental paradigm shift in chronic disease management: from single-disease approaches to integrated multimorbidity cluster care; from generalized interventions to precise, context-specific strategies; and from uniform national templates to regionally adapted approaches that prioritize cold-region environmental risk factors.

These findings provide critical evidence for optimizing chronic disease control strategies in resource-limited, cold rural settings globally, particularly as the world faces an escalating burden of complex multimorbidity requiring innovative, integrated solutions.

5. Conclusions

The Heilongjiang Provincial Plan for Chronic Disease Prevention and Control demonstrated measurable success in curbing the growth of chronic diseases through comprehensive strategies, particularly early screening. Interrupted time series analysis confirmed significant deceleration in overall chronic disease prevalence and the specific trends of cardiovascular and digestive diseases. However, the policy's impact was heterogeneous: limited effectiveness against respiratory diseases and failure to reverse the rising trend of multimorbidity. Multimorbidity has become the dominant disease pattern, with network analysis revealing a highly structured "cardiometabolic" corecluster reflecting shared pathophysiological mechanisms (e.g., accelerated aging), not random comorbidity. These findings necessitate a three-pronged paradigm shift: from a single-disease management to integrated multimorbidity clusters care; from generalized interventions to precision approaches targeting cold-region environmental risk factors; from uniform national strategies to regionally adapted frameworks. This evidence-based transformation is critical for optimizing chronic disease control in resource-limited cold rural settings globally.

Abbreviations

NCDs

Chronic non-communicable diseases

ICD-10

International Classification of Diseases-10

ITSA

Interrupted time series analysis

CVD

Cardiovascular diseases

Declarations

Ethics approval and consent to participate

Ethical approval for this study was conducted by the relevant Institutional Ethics Review Board of the Center for Endemic Disease Control, Chinese Center for Disease Control and Prevention (hrbmuecdc20240601). The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants were informed about the purpose of the study, assured of confidentiality, and provided written consent prior to participation. Participation was voluntary, and respondents could withdraw at any time without consequence.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

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Authors' contributions

Z.L.X., C.L., X.N.L., and Y.H.G contributed to the conceptualisation of research question and study design. Z.L.X. and C.L. contributed literature search, data analysis and production of the manuscript. Z.L.X., C.L., P.D., Y.Y.L., L.S., Y.T.Y., X.M.D., J.H., Y.Y.L., Y.C.W., X.D.Z., and Z.F.X. were responsible for the acquisition of data. Z.L.X., C.L., and X.N.L. had access to the raw data and contributed to the validation and verification of the data. X.N.L. and Y.H.G had the final responsibility for the decision to submit for publication. All authors contributed to the interpretation of results and writing of the manuscript.

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Figures

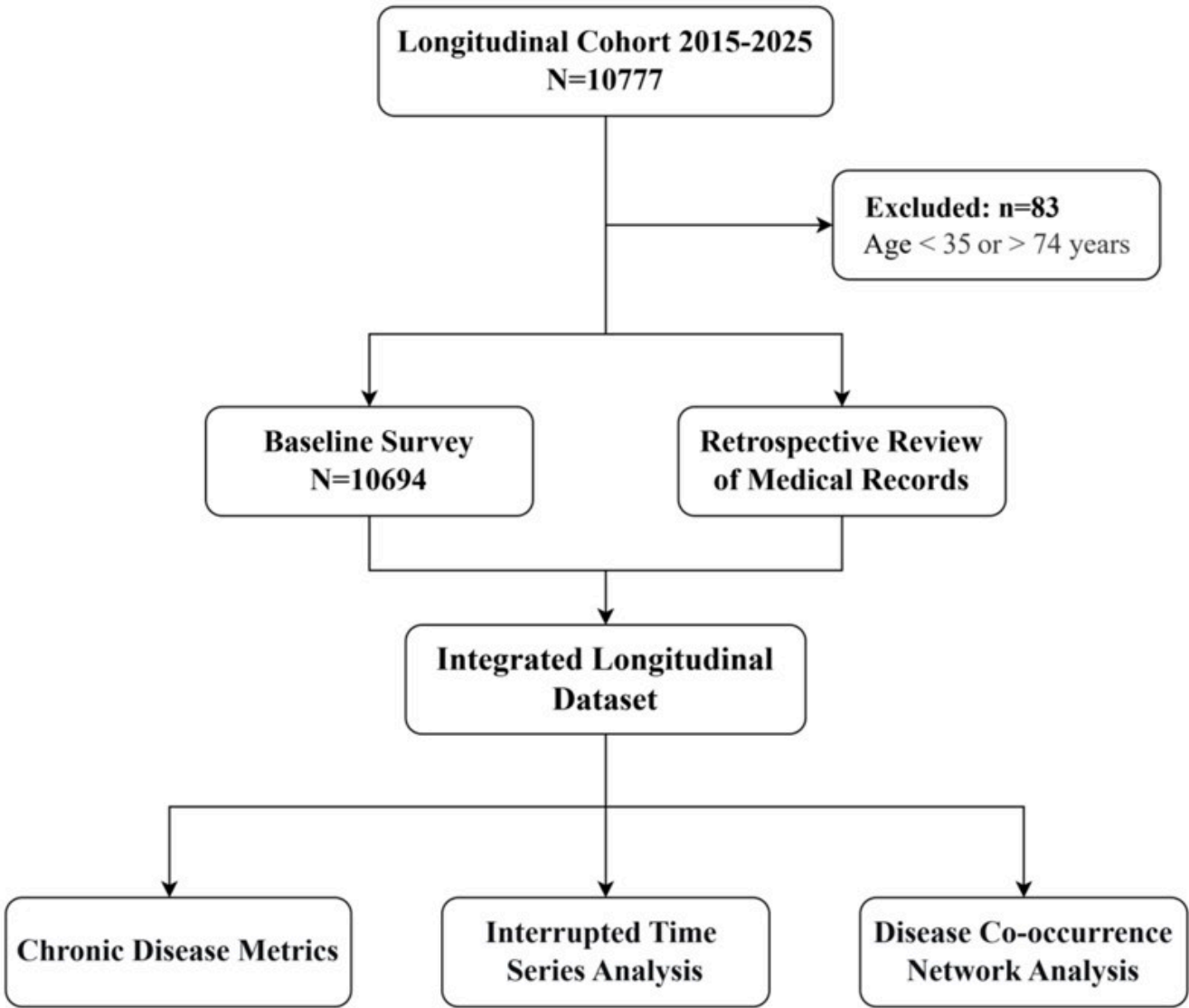


Figure 1

Flowchart of the study design.

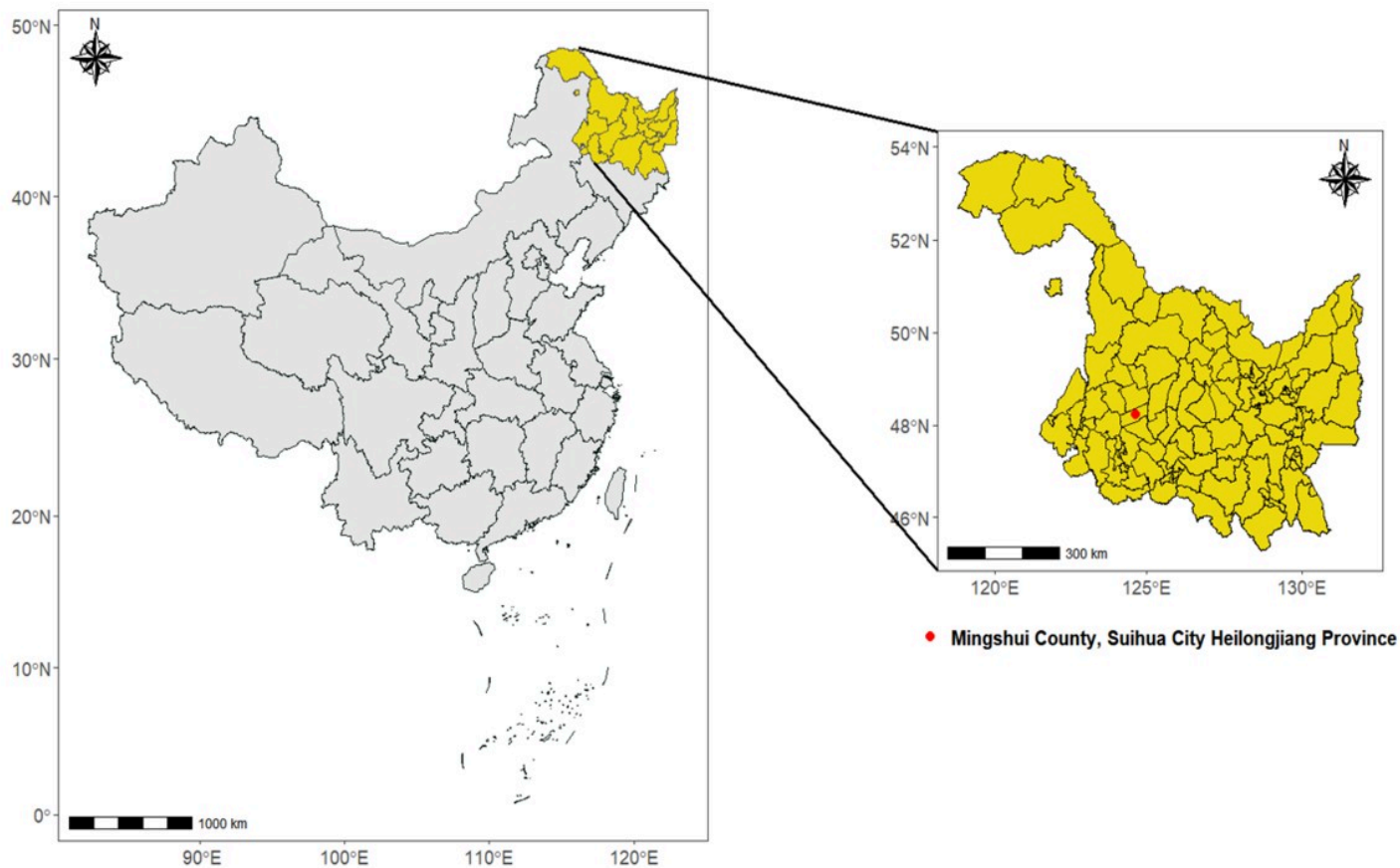


Figure 2

Geographical location of the study area: Mingshui County, Suihua City, Heilongjiang Province, China.

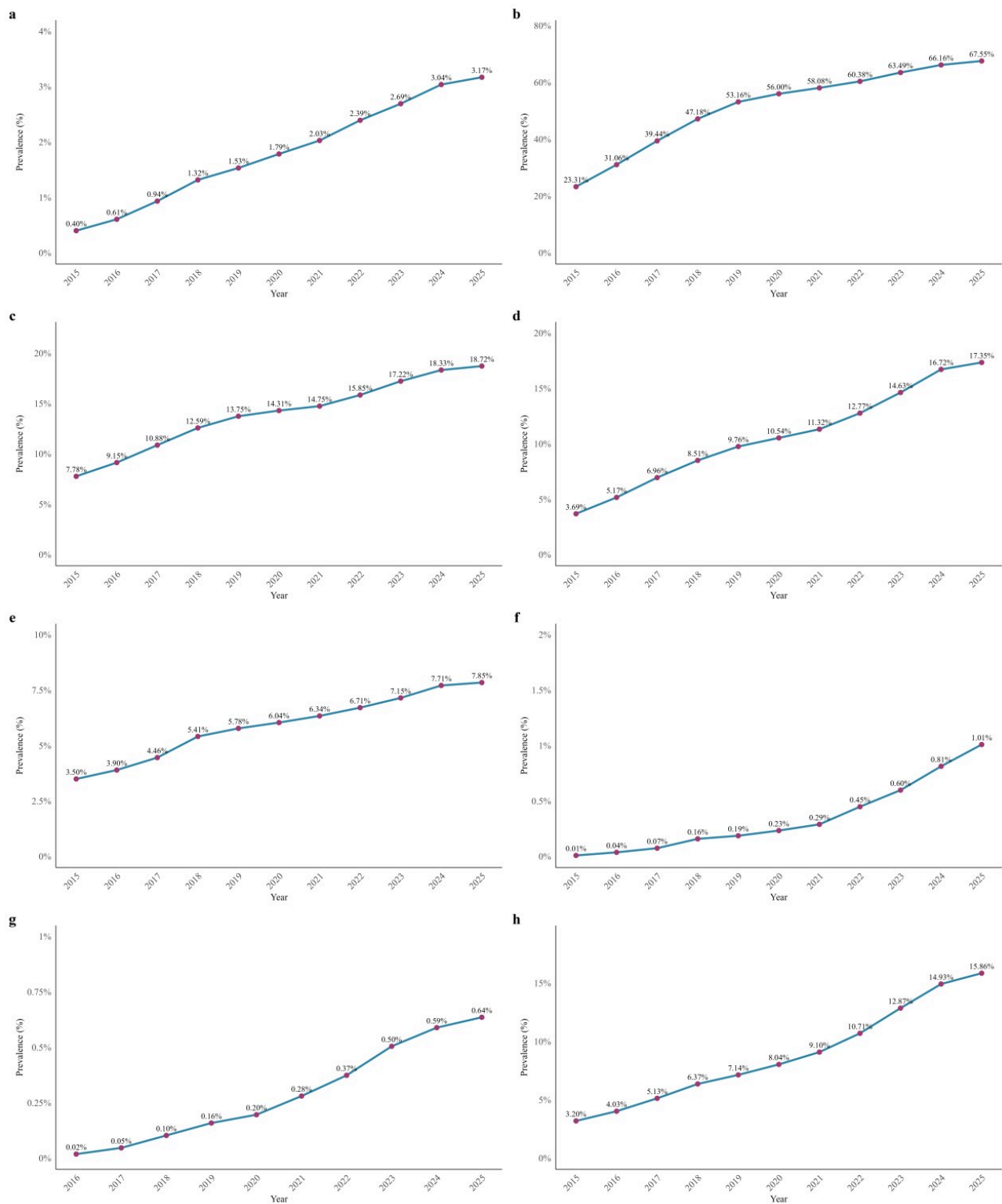


Figure 3

Trends in the prevalence of major chronic diseases in rural Heilongjiang province, China, 2015-2025. a: Cancers; b: Cardiovascular diseases; c: Digestive diseases; d: Endocrine and metabolic disorders; e: Musculoskeletal disorders; f: Neurological disorders; g: Renal diseases; h: Respiratory diseases.

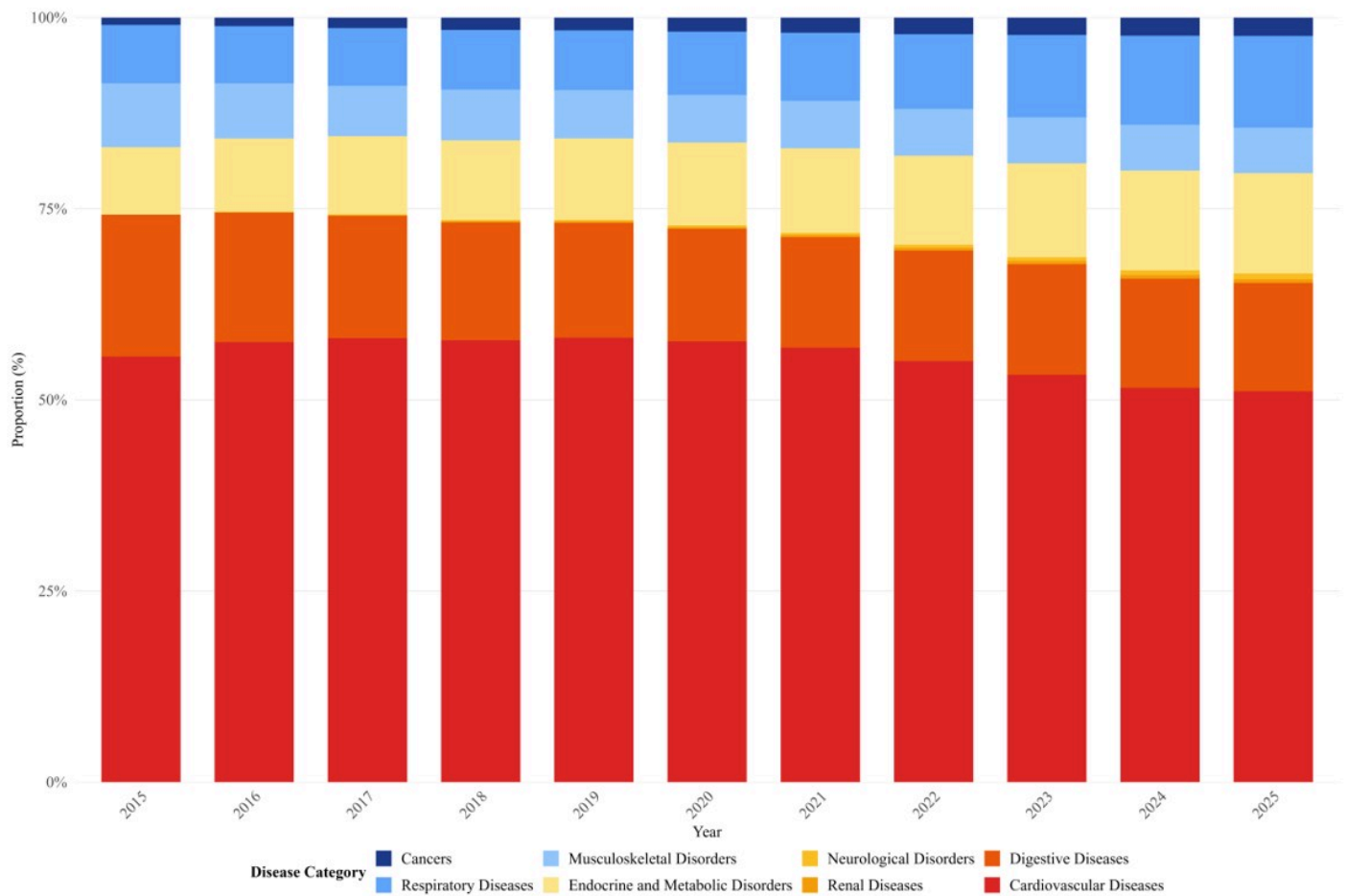


Figure 4

Temporal changes in the composition of the chronic disease spectrum in rural Heilongjiang Province, China, 2015-2025.

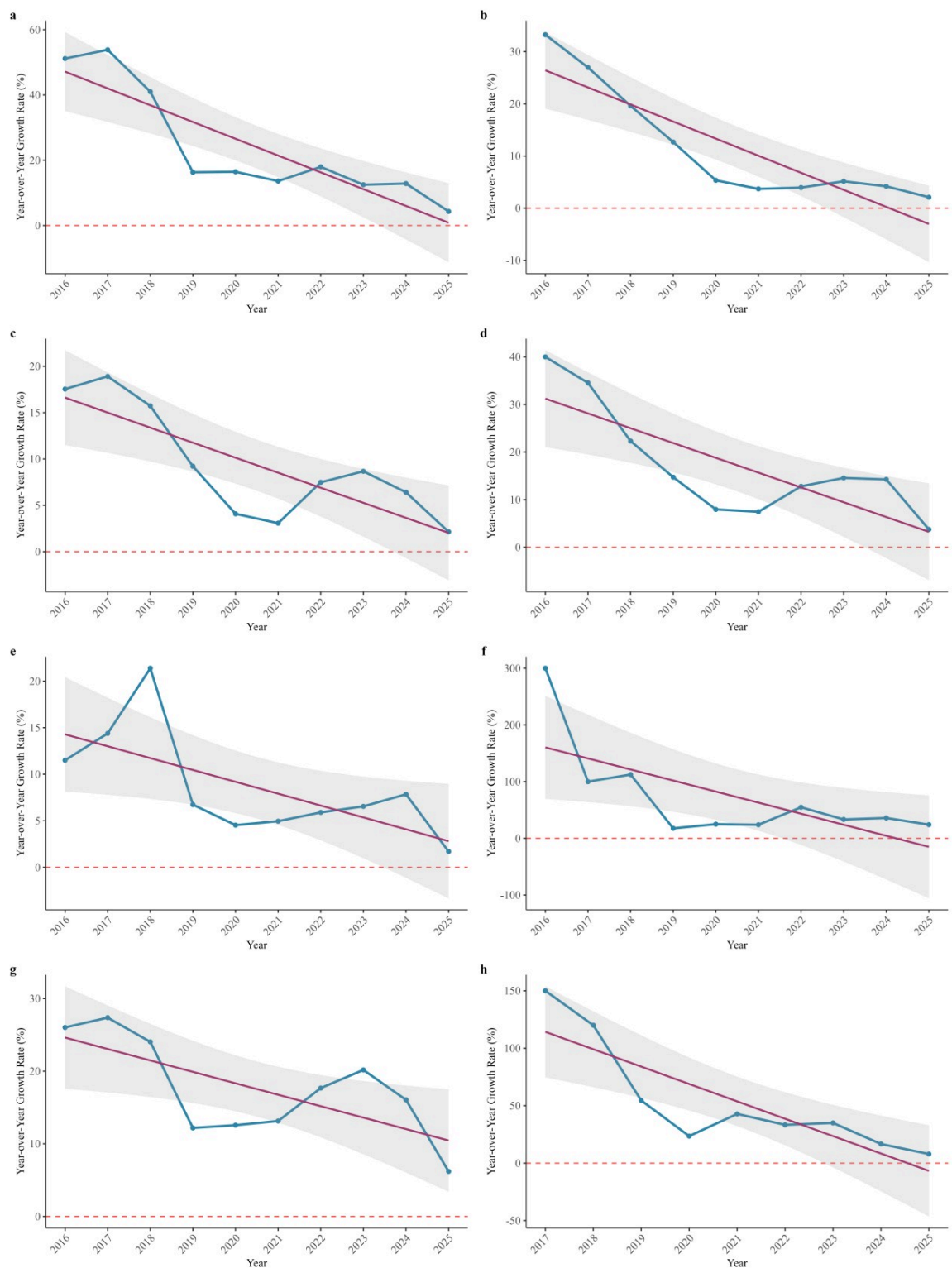


Figure 5

Year-over-year growth rates of major chronic diseases prevalence in rural Heilongjiang province, China, 2015-2025. a: Cancers; b: Cardiovascular diseases; c: Digestive diseases; d: Endocrine and metabolic disorders; e: Musculoskeletal disorders; f: Neurological disorders; g: Respiratory diseases; h: Renal diseases

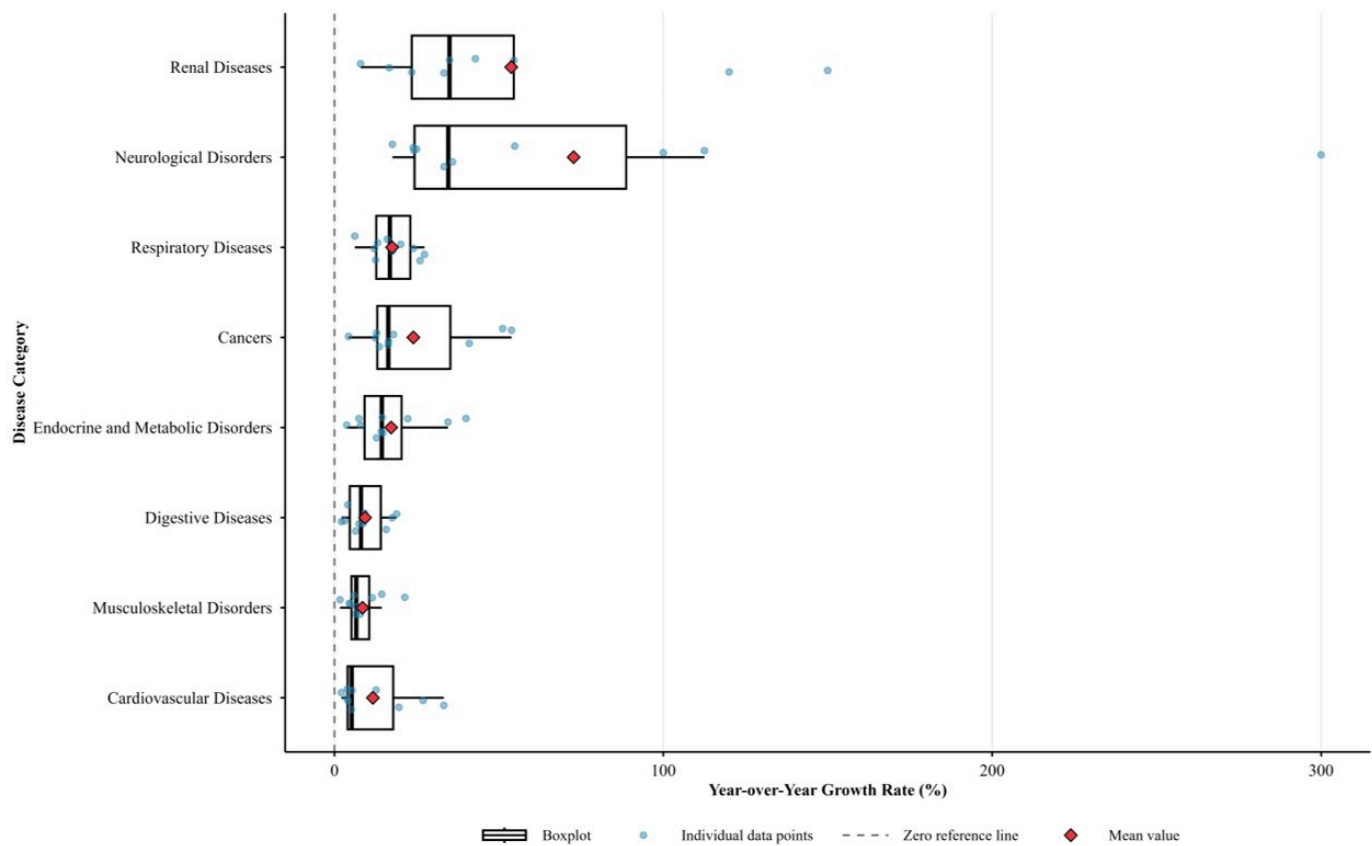


Figure 6

Distribution of annual growth rates across different chronic disease categories.

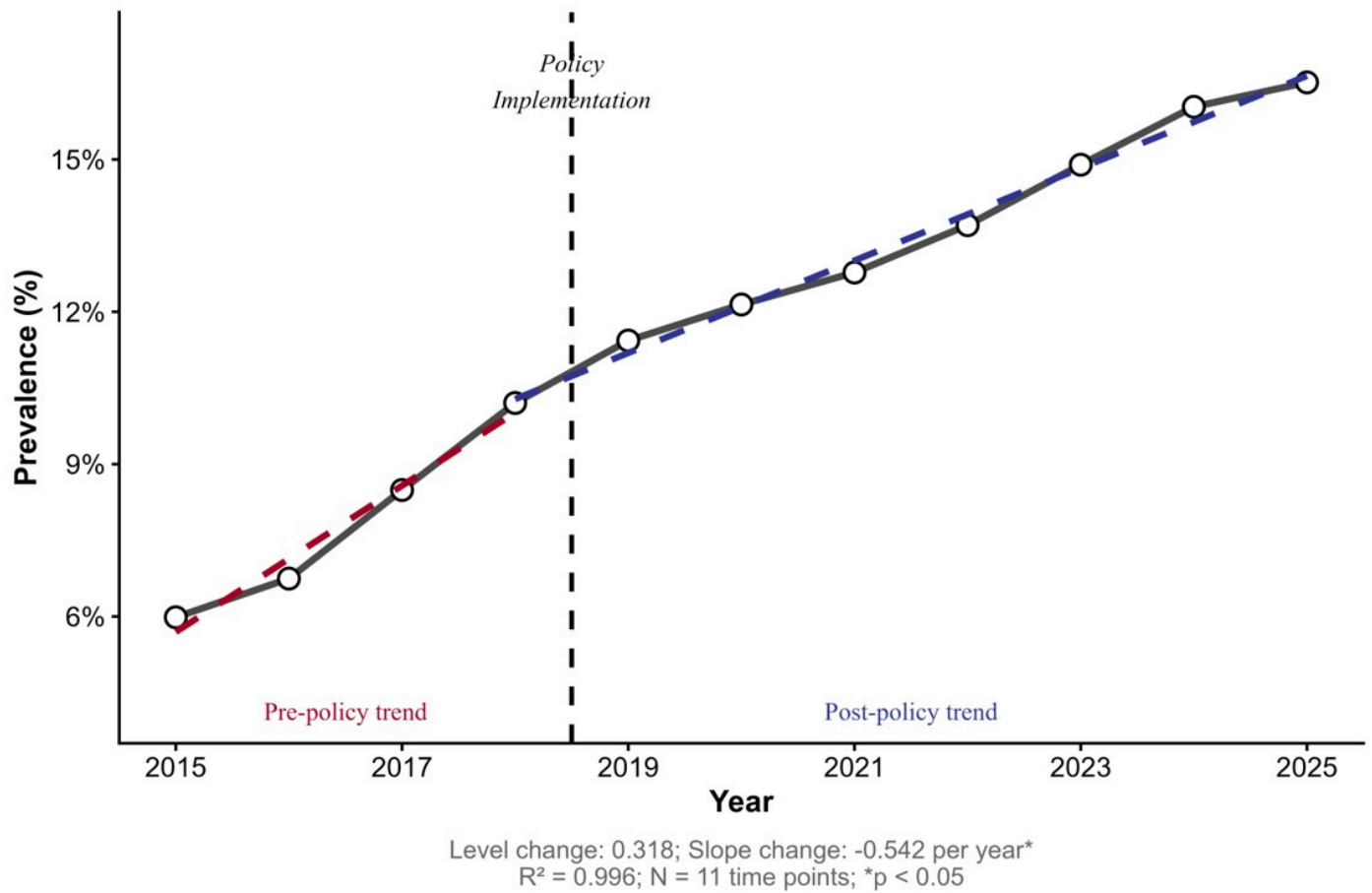


Figure 7

Interrupted time series analysis of the impact of the Provincial Chronic Disease Prevention and Control Initiative on the overall prevalence of chronic diseases in rural Heilongjiang province (2015-2025).

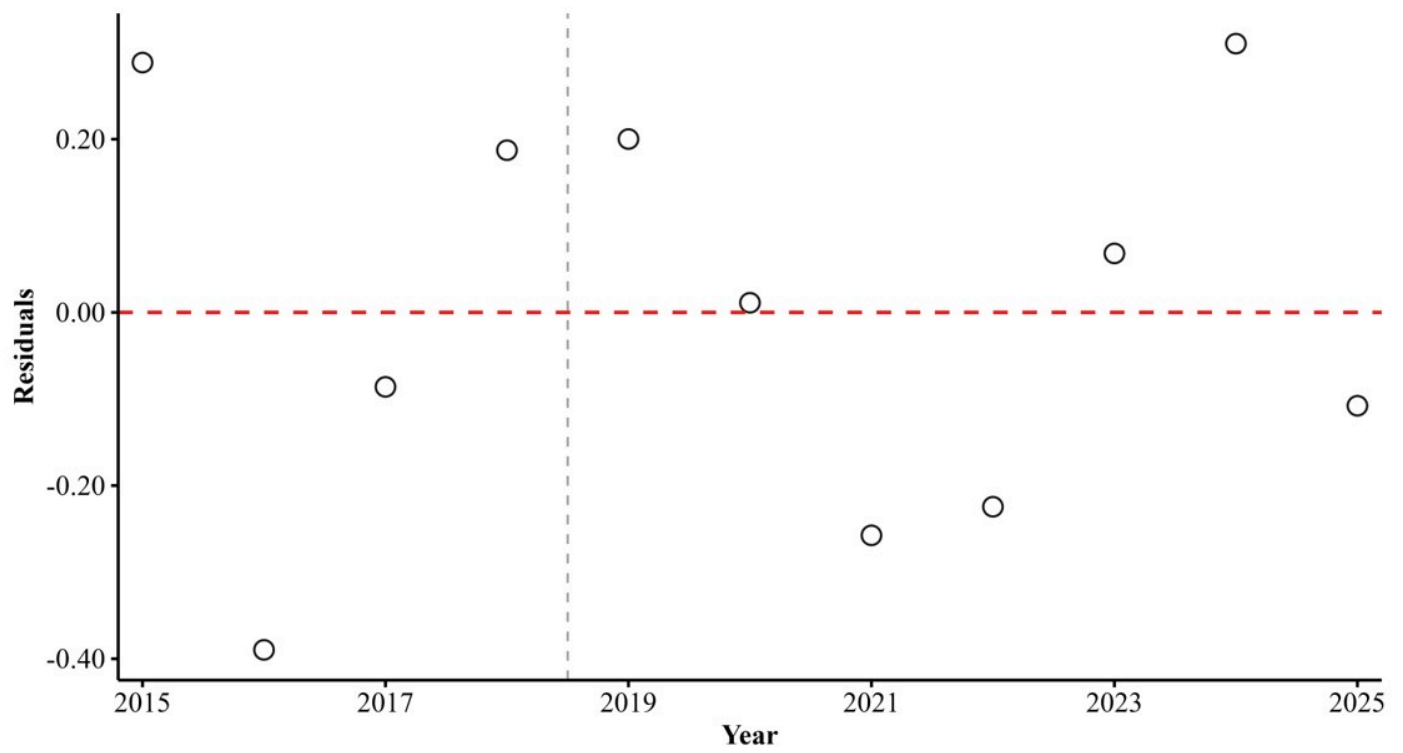


Figure 8

Residual plot from the interrupted time series analysis of overall chronic disease prevalence.

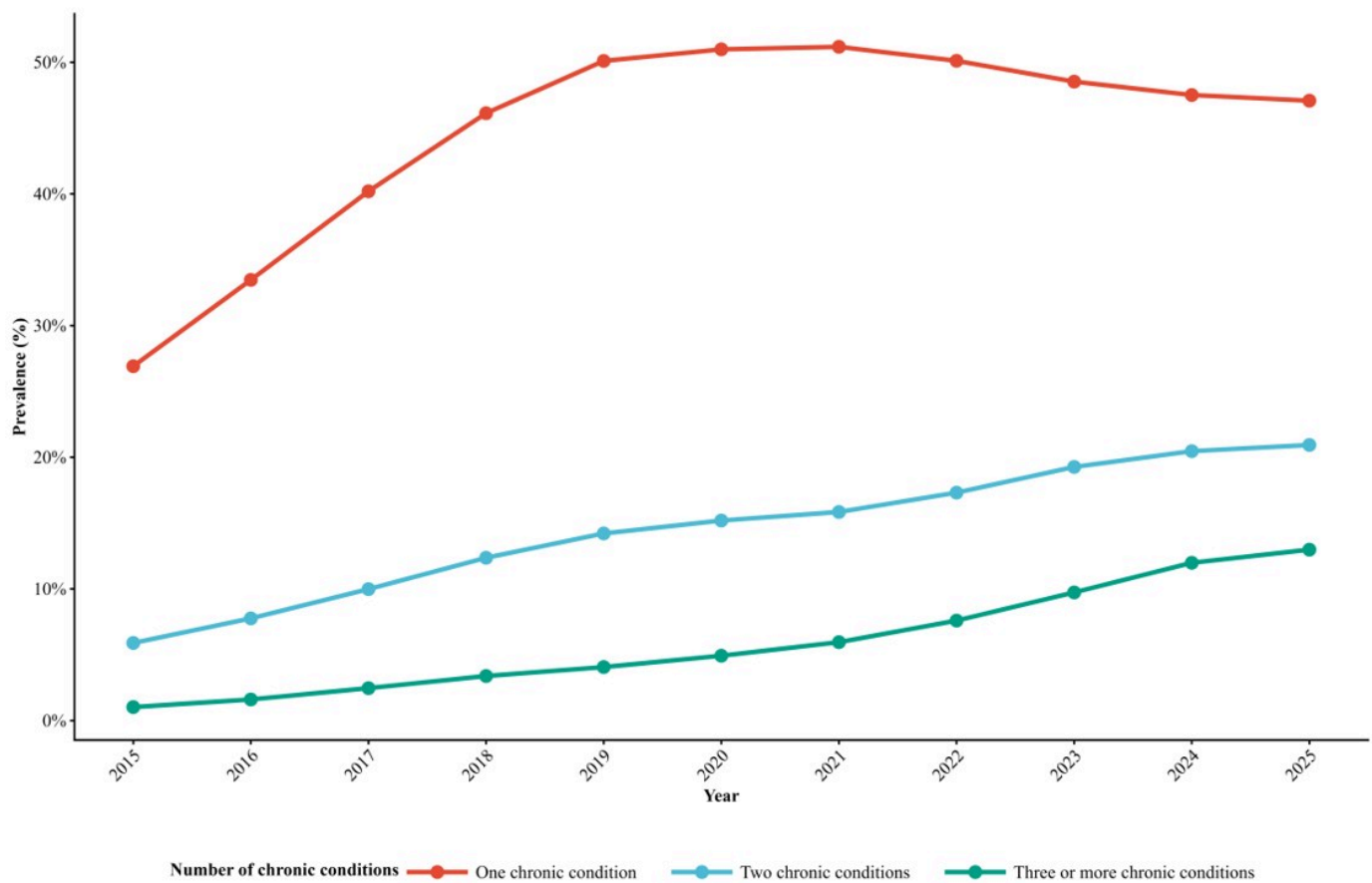


Figure 9

Trends in the prevalence of population with varying numbers of chronic conditions in rural Heilongjiang, China (2015-2025).

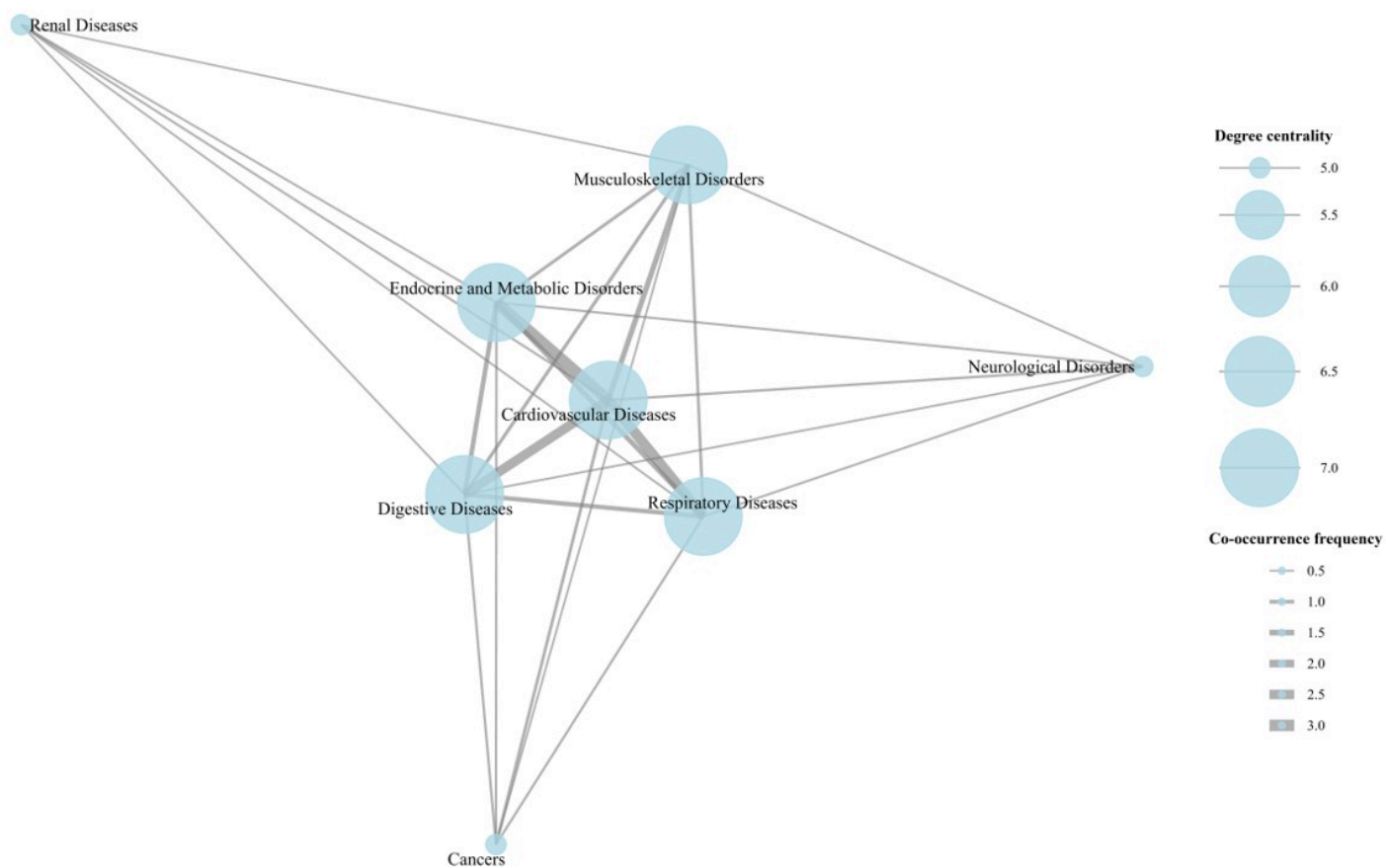


Figure 10

Network of multimorbidity among adults in rural Heilongjiang Province, China (2015-2025).