Dynamic Monitoring of Health Shocks and Analysis of Influencing Factors among Rural Middle-aged and Elderly Population in Ningxia: An Empirical Study Based on Four Waves of 14-Year Follow-up Data before and after Comprehensive Poverty Alleviation (Postprint)

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Abstract

Background: As China's aging process continues to advance, health shock issues among the middle-aged and elderly population have increasingly become a significant social problem.

Objective: To comprehensively understand the health shock situation among middle-aged and elderly populations in rural Ningxia before and after comprehensive poverty alleviation, identify relevant influencing factors, and provide data support for effective identification and intervention of health shocks.

Methods: This study utilized four waves of health follow-up data from the early stage of the new medical reform (2009), the health poverty alleviation promotion period (2015), the poverty eradication period (2019), and the transition period between rural revitalization and health poverty alleviation (2022). A multi-stage stratified cluster random sampling method was employed to obtain study subjects. First, all townships in the sample counties (Yanchi, Haiyuan, Pengyang, Xiji) were enumerated. Administrative villages in each township were divided into three strata based on high, medium, and low economic levels. From each stratum, 40% of natural villages were randomly selected. In each

village, 33 rural households were selected using systematic sampling. Middle-aged and elderly individuals aged 45 years and above from these households served as study subjects for questionnaire surveys. The questionnaire covered general demographic characteristics, indicators related to household economic status, health-related indicators, health service utilization indicators, and health poverty alleviation policy indicators. After excluding cases with missing important variables, the four waves of surveys included 6,351, 8,035, 8,566, and 9,337 subjects, respectively. The 2 test was used to analyze trends in the prevalence of health shocks, while 2 tests or t-tests were employed to explore univariate factors affecting health shock occurrence. Based on Grossman's health demand theory, a fixed-effects binary Logit regression model was used to identify the effect sizes of relevant influencing factors.

Results: The prevalence of health shocks among middle-aged and elderly individuals in rural Ningxia was 29.74% (1,889/6,351) in 2009, 27.18% (2,184/8,035) in 2015, 31.27% (2,679/8,566) in 2019, and 25.00% (2,334/9,337) in 2022. The prevalence showed a decreasing trend across the four surveys, with statistically significant differences (2 trend = 22.520, $P < 0.001$). Regression results showed that before poverty alleviation, higher per capita annual income level and larger household size were the main positive influencing factors of health shocks ($P < 0.001$), while poor self-rated health status, borrowing due to illness, and older age were the main negative influencing factors ($P < 0.001$). After poverty alleviation, higher per capita annual income level, larger household size, and two-week outpatient visits were the main positive influencing factors ($P < 0.001$), while poor self-rated health status, borrowing due to illness, and hospitalization need in the past year were the main negative influencing factors ($P < 0.001$). Smoking had no significant effect on health shock occurrence ($P > 0.05$).

Conclusion: Over the 14-year period before and after comprehensive poverty alleviation, the prevalence of health shocks among middle-aged and elderly individuals in rural Ningxia decreased significantly. Higher per capita annual income level, larger household size, two-week outpatient visits, and borrowing due to illness were the main factors affecting health shock occurrence. Increased government funding and policy support should be provided to raise residents' income levels, while simultaneously improving the medical security system to reduce the prevalence of health shocks among middle-aged and elderly populations in rural Ningxia.

Full Text

Dynamic Monitoring and Analysis of Influencing Factors of Health Shocks in Rural Middle-Aged and Elderly People in Ningxia: Empirical Research Based on 14 Years and Four Periods of Follow-Up Data before and after Poverty Alleviation

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Abstract

Background: With the continuous advancement of the aging process in China, health problems among middle-aged and elderly populations have increasingly become a significant social issue that cannot be overlooked. **Objective:** To comprehensively understand the prevalence trends of health shocks in rural middle-aged and elderly populations in Ningxia during the 14-year period before and after poverty alleviation, identify dynamic changes in related influencing factors, and provide data support for effective identification and intervention of health shocks. **Methods:** This study utilized four waves of health follow-up data from the early stage of the new medical reform (2009), the health poverty alleviation promotion period (2015), the poverty alleviation 攻坚 period (2019), and the rural revitalization and health poverty alleviation transition period (2022). Research subjects were obtained through multi-stage stratified cluster random sampling. All townships in the sample counties (Yanchi, Haiyuan, Pengyang, Xiji) were enumerated, and administrative villages in each township were stratified into three levels based on high, medium, and low economic status. From each level, 40% of natural villages were randomly selected, and 33 rural households were systematically sampled from each village. All middle-aged and elderly individuals aged 45 years and above in selected households were surveyed using a questionnaire covering general demographic characteristics, family economic status indicators, health-related indicators, health service utilization indicators, and health poverty alleviation policy indicators. After excluding cases with missing values for important variables, 6,351, 8,035, 8,566, and 9,337 subjects were included in the four survey waves, respectively. Chi-square tests were used to analyze trends in health shock incidence, while chi-square or t-tests explored univariate factors influencing health shocks. Fixed-effects binary Logit regression

models based on Grossman's health demand theory were employed to identify effect sizes of influencing factors. **Results:** The incidence of health shocks among rural middle-aged and elderly people in Ningxia was 29.74% (1,889/6,351) in 2009, 27.18% (2,184/8,035) in 2015, 31.27% (2,679/8,566) in 2019, and 25.00% (2,334/9,337) in 2022, showing a statistically significant declining trend (^{2} = 22.520, P < 0.001). Regression results revealed that before poverty alleviation, higher per capita annual income and larger family size were the main positive influencing factors of health shocks (P < 0.001), while poor self-rated health status, debt due to illness, and older age were the main negative influencing factors (P < 0.001). After poverty alleviation, higher per capita annual income, larger family size, and medical consultations within two weeks were the main positive influencing factors (P < 0.001), while poor self-rated health status, debt due to illness, and annual hospitalization were the main negative influencing factors (P < 0.001). Smoking did not significantly affect health shock occurrence (P > 0.05). **Conclusion:** Over the 14-year period before and after poverty alleviation, the incidence of health shocks among rural middle-aged and elderly populations in Ningxia decreased significantly. Higher per capita annual income, larger family size, medical consultations within two weeks, and debt due to illness were the main factors affecting health shock occurrence. Increased government funding and policy support are needed to improve residents' income levels and perfect the medical security system, thereby reducing the incidence of health shocks among rural middle-aged and elderly populations in Ningxia.

Keywords: Health status; Health shocks; Grossman's theory of health needs; Dynamic monitoring; Influencing factors; Middle-aged and elderly people

Introduction

Since the beginning of the 21st century, the overall health level of Chinese residents has achieved leapfrog improvement, with health indicators ranking among the top in developing countries [1]. In 2020, China successfully completed its poverty alleviation objectives, eliminating "absolute poverty." However, with the continuous advancement of population aging, health shocks have increasingly become a significant social problem that cannot be ignored. Health issues among middle-aged and elderly populations represent the core challenge of aging, and the primary problem to solve for healthy aging is how to address the negative impacts of sudden health shocks.

Health shock refers to the long-term fluctuation effect on future family health welfare levels caused by uncertainty in family members' health status in the short term [2-3]. Health shocks not only crowd out family income and consumption welfare in the short term to cope with increased medical treatment costs, but also exert long-term negative impacts on household production investment and living standards [4-6]. As a special social group, middle-aged and elderly people are more vulnerable to health shocks due to the loss of health capital

and reduced social participation. A review of relevant literature reveals that Grossman's health demand theory has been widely applied in health assessment and analysis of health influencing factors [7-9]. Therefore, this study, based on Grossman's health demand theory, explores in detail the relationship between health-related factors and health shocks among rural middle-aged and elderly populations in Ningxia, as well as the dynamic trend of health shock frequency, to comprehensively evaluate the distribution of health shocks among rural residents in southern Ningxia mountainous areas before and after poverty alleviation from a longitudinal perspective, providing data support for effective identification and intervention of health shocks.

Methods

Data Sources

This study utilized four waves of health follow-up data from the early stage of the new medical reform (2009), the health poverty alleviation promotion period (2015), the poverty alleviation 攻坚 period (2019), and the rural revitalization and health poverty alleviation transition period (2022). Research subjects were obtained through multi-stage stratified cluster random sampling, and health-related questionnaires were administered after obtaining informed consent from all participants. This study was approved by the Ethics Committee of Ningxia Medical University (Approval No.: 2022-G165).

Study Subjects and Methods

Using four waves of follow-up data, this study employed multi-stage stratified cluster random sampling to obtain research subjects. All administrative villages in the sample counties (Yanchi, Haiyuan, Pengyang, Xiji) were stratified into three levels based on economic status. From each level, 40% of natural villages were randomly selected, and 33 rural households were systematically sampled from each village. All middle-aged and elderly individuals aged 45 years and above in selected households underwent face-to-face questionnaire surveys. The survey content included general demographic characteristics, family economic status indicators, health-related indicators, health service utilization indicators, and health poverty alleviation policy indicators. Individuals aged 45 years and above as defined by "A5 age $\geq$ 45 years" in the questionnaire were considered middle-aged and elderly. After excluding those who failed to complete the questionnaire due to poor hearing and cases with missing important variables, the final sample comprised 6,351 subjects in 2009, 8,035 in 2015, 8,566 in 2019, and 9,337 in 2022.

Definition of Health Shock Indicators

Following the definition by Ai Xiaoqian et al. [10], health shock occurrence was defined as follows: (1) Within two weeks before the survey, taking $ $1 day off work, school, or bed rest due to discomfort, with out-of-pocket medical expenses

(including transportation, accommodation, meals, caregiving, and other costs) accounting for $ $10% of annual household income; or (2) Annual healthcare expenditures accounting for $ $40% of annual household income. Meeting either condition indicated a health shock (coded as 1); otherwise, no health shock occurred (coded as 0). Health shock incidence frequency was calculated as the number of health shock cases divided by the total survey population.

Variable Selection and Assignment

Based on Grossman's health demand model [7,9] and the current situation of middle-aged and elderly populations in rural Ningxia, influencing factors were categorized into demographic characteristics, health capital loss, health economic burden, and other health-related factors (see Table 1).

Quality Control

Quality control personnel were assigned before, during, and after the survey to strictly control quality at every stage. Before the survey, training manuals were developed, and interviewers received centralized training. During the survey, questionnaire content was checked at three levels by interviewers, team leaders, and quality control staff to ensure completeness and validity. After the survey, double data entry was implemented to improve data entry accuracy.

Statistical Methods

EpiData 3.1 software was used for data entry and logical verification, while SPSS 27.0 and Stata 17.0 were employed for data processing and analysis. Measurement data were described as ($\bar{x} \pm s$), with t-tests for inter-group comparisons. Enumeration data were expressed as relative frequencies, with chi-square tests for inter-group comparisons. Fixed-effects binary Logit regression models were constructed to analyze influencing factors of health shocks. The significance level was set at $\alpha = 0.05$.

Results

Basic Characteristics of Rural Middle-Aged and Elderly Populations in Southern Ningxia

The four surveys included 6,351, 8,035, 8,566, and 9,337 rural middle-aged and elderly individuals in 2009, 2015, 2019, and 2022, respectively. The male-to-female ratios were 1.06:1, 1.03:1, 1.04:1, and 1.04:1 across the four surveys. The proportion of individuals aged $ $60 years was 38.21%, 41.69%, 42.58%, and 46.72%, respectively. The proportion of married individuals was 86.73%, 88.71%, 88.65%, and 89.13%, respectively. The proportion with no formal education was 55.08%, 44.87%, 45.59%, and 42.06%, respectively. Detailed information is provided in Table 2 .

Comparison of Health Shock Groups among Rural Middle-Aged and Elderly Populations in Ningxia across Different Periods

The incidence of health shocks among rural middle-aged and elderly populations in Ningxia was 29.74% (1,889/6,351) in 2009, 27.18% (2,184/8,035) in 2015, 31.27% (2,679/8,566) in 2019, and 25.00% (2,334/9,337) in 2022, showing a statistically significant declining trend (^{2} = 22.520, P < 0.001). Age, education level, family size, household income, chronic disease status, two-week illness status, annual hospitalization need, two-week medical consultation, medical borrowing due to illness, smoking status, and self-rated health status all showed statistically significant differences between groups with and without health shocks (P < 0.001). Gender and marital status showed no significant differences between groups (P > 0.05). Details are provided in Table 3 .

Regression Analysis Results of Health Shock Occurrence among Rural Middle-Aged and Elderly Populations in Ningxia

Using health shock occurrence as the dependent variable, variables showing significant univariate results were included as independent variables. The variance inflation factor (VIF) method was used for multicollinearity diagnosis, with the maximum VIF of 1.755 (far less than 10), indicating no serious multicollinearity. Considering potential endogeneity in panel data, fixed-effects binary Logit regression analysis was conducted. Data from 2009, 2015, and 2019 were used for pre-poverty alleviation analysis, while 2022 data were used for post-poverty alleviation analysis. Results showed that before poverty alleviation, higher per capita annual income and larger family size were main positive influencing factors of health shocks (P < 0.001), while poor self-rated health status, medical borrowing due to illness, and older age were main negative influencing factors (P < 0.001). After poverty alleviation, higher per capita annual income, larger family size, and two-week medical consultations were main positive influencing factors (P < 0.001), while poor self-rated health status, medical borrowing due to illness, and annual hospitalization were main negative influencing factors (P < 0.001). Smoking did not significantly affect health shock occurrence (P > 0.05). Details are provided in Table 4 .

Discussion

Declining Trend in Health Shock Incidence among Rural Middle-Aged and Elderly Populations in Ningxia during the 14-Year Poverty Alleviation Period

This study examined dynamic changes in health shock incidence among rural middle-aged and elderly populations in Ningxia across four periods: early new medical reform (2009), health poverty alleviation promotion (2015), poverty alleviation 攻坚 (2019), and rural revitalization transition (2022). Results showed that with the achievement of comprehensive poverty alleviation, the overall incidence of health shocks declined. A slight increase in 2019 may be related to

the COVID-19 pandemic, which caused strong short-term health shocks among middle-aged and elderly populations. Literature review reveals that before the new medical reform (2009), rural residents in Ningxia generally held the belief of "delaying minor illnesses and enduring serious ones," with common phenomena of minor illnesses developing into serious conditions [11-12]. Coupled with limited health education coverage and generally low education levels among middle-aged and elderly populations, healthcare awareness was lacking, and most residents adopted a "endure minor illnesses" attitude when health events occurred [13], missing optimal treatment timing and leading to increased medical expenditures and higher health shock incidence. Since the new medical reform implementation, increased medical insurance coverage, expanded access to quality healthcare resources, and improved health service accessibility [13-14] have contributed to declining health shock incidence.

Higher Income Levels Significantly Reduce Health Shock Risk among Middle-Aged and Elderly Populations

Income level is closely related to health shock occurrence. Regression results from both pre- and post-poverty alleviation periods indicate that compared with lower-income middle-aged and elderly populations, income improvement significantly reduces health shock incidence, representing the most prominent protective factor. This may be because higher-income populations have greater payment capacity to cope with sudden health shock risks, enabling timely medical visits when negative health events occur, thereby reducing a series of negative consequences including poverty due to illness. These findings are consistent with studies by Ai Xiaoqian et al. [10] and Qiu Xiaolong et al. [15] on income impacts on health shocks, demonstrating that economic factors are the most fundamental influences on health shock occurrence. Therefore, effectively increasing income for rural residents in southern Ningxia mountainous areas and reducing medical expenditures can significantly lower health shock risk, improve residents' medical-seeking enthusiasm, avoid phenomena of "enduring minor illnesses and delaying serious ones," and comprehensively improve residents' health levels to better consolidate poverty alleviation achievements.

Larger Family Size Significantly Reduces Health Shock Risk among Middle-Aged and Elderly Populations

Regression analysis showed that compared with family sizes of 1-3 members, OR values were smaller for family sizes of 4-6 members and $ $7 members, indicating that larger family size is a protective factor against health shocks. This finding aligns with relevant literature [16]. The underlying reasons may be that more family members mean more diversified income sources and relatively higher family economic stability. When facing sudden health problems, families can mobilize resources more quickly to reduce treatment delays caused by economic pressure. Additionally, increased family size may dilute individual-level health shock risk, effectively reducing the affordability burden of health

services for rural middle-aged and elderly populations. Furthermore, economic support, mental health support, companionship, and human support from family members may all reduce health shock risk and enhance middle-aged and elderly populations' ability to withstand health shock risks to varying degrees, consistent with findings from YUAN et al. [17].

Medical Borrowing Due to Illness as a Major Negative Factor Affecting Health Shock Occurrence

Pre-poverty alleviation regression results showed that medical borrowing due to illness significantly affected health shock incidence. Literature review [18-19] suggests this may be because residents in southern Ningxia mountainous areas have single income sources and low economic levels. Preoccupied with basic livelihoods, many residents neglect their health, lack regular physical examination habits, and often discover diseases at advanced stages when treatment difficulty and costs increase accordingly. Facing high medical expenses, many families with limited economic conditions cannot afford treatment independently and must borrow from relatives or apply for loans, exacerbating family economic burdens and potentially causing debt accumulation and reduced quality of life. This phenomenon is consistent with domestic and international research findings [20-21]. Although China achieved the goal of lifting all rural poor out of poverty under current standards in 2020, due to the special geographical environment of southern Ningxia mountainous areas where residents rely mainly on traditional crop cultivation with extremely limited and unstable income sources, the phenomenon of "poverty due to illness" remains serious [22-23]. Particularly for newly lifted families, a major illness can easily push them back into poverty, making it difficult to effectively consolidate poverty alleviation achievements. Therefore, medical borrowing due to illness persists as a major influencing factor.

Changing Impact of Two-Week Medical Consultations on Health Shock Occurrence before and after Poverty Alleviation

Regression results showed that before poverty alleviation, two-week medical consultations were a risk factor for health shocks, but became a protective factor after poverty alleviation. Before poverty alleviation, rural middle-aged and elderly populations had few income sources, low economic levels, incomplete medical facilities, and inadequate health education, resulting in insufficient medical payment capacity, lack of health awareness, and low attention to their health status, with low two-week consultation rates [24-26]. This delayed optimal treatment timing and ultimately led to higher medical expenditures. After poverty alleviation, increased two-week consultation rates [14] improved health shock conditions, possibly related to both poverty alleviation policies and new medical reform policies. In recent years, President Xi has been committed to poverty alleviation work, and China won the poverty alleviation battle in 2020, improving living conditions for rural residents. When health events occur, middle-aged and

elderly people can now seek timely medical treatment, achieving "early diagnosis and early treatment" to prevent disease progression and reduce health shock incidence. Additionally, since the 2009 new medical reform, policy changes, increased medical insurance coverage, and improved affordability of medical services for rural middle-aged and elderly populations have enabled timely access to quality healthcare, further reducing health shock incidence.

Policy Recommendations

This study found that health shock occurrence is influenced by multiple factors including per capita annual income, family size, two-week medical consultations, and medical borrowing due to illness. Based on these findings, we propose the following recommendations. First, the government should increase financial and healthcare resource investment in southern Ningxia mountainous areas, improve rural residents' income levels, expand medical facilities, ensure healthcare coverage and quality, and enhance middle-aged and elderly populations' ability to withstand health risks. Second, strengthen rural healthcare system construction, improve primary healthcare service capacity, provide affordable medical insurance and catastrophic illness assistance mechanisms, reduce economic shocks from disease, and thereby lower health shock incidence. Third, intensify health education efforts for rural middle-aged and elderly populations, improve health awareness and disease prevention capabilities, promote "early prevention, early diagnosis, and early treatment," reduce phenomena of "delaying minor illnesses and enduring serious ones," and consequently reduce health shock risk among rural middle-aged and elderly populations in Ningxia.

Author Contributions: Yang Juan was responsible for conceptualization, design, data analysis, and manuscript writing; Liu Shan conducted data cleaning and organization; Li Fei performed literature review and synthesis; Meng Haodong contributed to manuscript polishing and revision; Qiao Hui participated in manuscript revision; Xie Yongxin was responsible for quality control, review, and overall supervision. All authors participated in household survey data collection. This article has no conflicts of interest.

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