Rational: Living environment is a key factor in shaping the health behavior and status of the older adults. Under the background of deepening aging in rural areas, how to realize healthy aging and promote healthy equity in rural areas are important issues that need to be paid attention to in the national strategy of responding to population aging actively in China. However, the existing researches on environmental health effects mainly focus on urban communities and older aldues in cities, while there is still a lack of research on the impact of rural environment on rural elderly people's health. Meanwhile, gender difference is a fundamental perspective in gerontological research and public policy, yet most frameworks for studying the effects of living environment on older adult's health have only analyzed the average effects, with fewer studies examining these effects from the perspective of gender difference.

Research Design: Based on the five rounds of China Family Panel Studies from 2010 to 2018, this paper empirically analyzes the impact of rural settlement environment on aging health in rural china from the perspective of gender differences by three-level linear development model.

There are three hypotheses to be tested: hypothesis 1: The rural living environment has a significant effect on elderly health, meaning that areas with a higher level of rural living environment tend to have better health outcomes for rural older adults. Hypothesis 2: There are significant gender differences in the impact of rural living environment on the health of the older adults in rural areas. Hypothesis 3: The interaction between rural living environment and gender may affect the health status of the older adults, that is, the rural living environment may narrow the gender differences in rural aging health.

This paper primarily investigates the long-term impact of rural residential environments on the health status of the older adults, which also varies over time. The data encompasses influencing factors at three levels: the tracking period, individual level, and village-residential level. Therefore, the three-level linear development model, which has unique advantages in handling cross-level non-independent nested structural tracking data, is selected to address the ecological fallacy in research on aging health issues.

The specific modeling steps are as follows:

Layer-1 Model：

$$Health_{ijk} = \pi_{0jk} + \pi_{1jk} Time_{ijk} + \varepsilon_{ijk} \quad (1)$$

Layer-2 Model：

$$\pi_{0jk} = \beta_{00k} + \beta_{0ik} X_{jk} + r_{0jk} \quad (2)$$

$$\pi_{1jk} = \beta_{10k} + \beta_{11k} X_{jk} + r_{1jk} \quad (3)$$

Layer-3 Model：

$$\beta_{00k} = \gamma_{000} + \gamma_{001} Environment_k + \mu_{00k} \quad (4)$$

$$\beta_{0ik} = \gamma_{0i0} + \gamma_{0i1} Environment_k + \mu_{0ik} \quad (5)$$

$$\beta_{10k} = \gamma_{100} + \gamma_{101} Environment_k + \mu_{10k} \quad (6)$$

$$\beta_{1ik} = \gamma_{1i0} + \gamma_{1i1} Environment_k + \mu_{1ik} \quad (7)$$

Major Findings:

The unconditional null model results indicate that approximately 22.58% of the total variation in the health status of rural older adults is explained by individual-level explanatory variables, and approximately 4.84% is explained by village-level explanatory variables. This suggests the necessity to incorporate new explanatory variables that can help account for observations at both individual and village levels. By further incorporating time variables to estimate the trajectory of elderly health changes from 2010 to 2018, the results show a significant negative impact of time variables on elderly health status, indicating that the health status of the older adults inevitably declines with time, that is, as they age. The use of a three-level linear development model for estimating elderly health status demonstrates good applicability.

Model 2 analyzes the gender differences in the health status of rural older individuals and their changing trajectories. Compared to female elderly individuals, male older individuals exhibit significantly better health conditions, possessing a certain health advantage. This finding aligns with the research conclusions of Xue and Wang. Simultaneously, the coefficient of the linear trend for gender is significantly positive, indicating that the gender differences in health status among rural older individuals widen over time. The health disadvantage faced by women accumulates continuously during old age, which is consistent with the research findings of Lu and Sun based on the China Health and Retirement Longitudinal Study data from 2010 to 2018.

The Model 3 preliminarily fits the impact of rural residential environment on rural elderly health and its time-varying characteristics. The model estimation results show that the rural residential environment has a significant positive impact on the health status of rural older adults. From the perspective of time trend, the linear change trend of the rural residential environment is significantly negative, indicating that although the elderly health-promoting effect of the rural residential environment has shown a certain degree of weakening trend over time, which may be due to the inevitable decline in health with age and the cumulative impact of other socioeconomic factors, this effect still exists significantly. After adding individual-level control variables, the results of the full Model 4 still hold, with no significant changes in the magnitude, direction, and significance of the impact effect. That is, the higher the level of rural residential environment, the better the health status of rural older adults. This indicates that the current rural residential environment in China has a significant elderly health effect, and research hypothesis 1 is verified. Improved village infrastructure can provide material conditions for promoting the improvement of elderly health status and enhancing quality of life. A livable and healthy rural ecological environment has a good protective effect on the physical and mental health of the older adutls. Improving the rural residential environment can effectively enhance the level of rural elderly health and lay the environmental and material foundation for achieving healthy aging.

The impact of other control variables on the health status of rural older adults (as shown in Model 4) is as follows. In terms of individual characteristics, the coefficient of age is significantly negative, indicating that health status tends to deteriorate significantly with age. The health status of elderly people in rural areas is worse, which is consistent with the research findings of prior studies. Compared to elderly people without spouses, those with spouses in rural areas have better health status, which is basically consistent with the analysis results of Wang and Jiao. Both education level and income have a significantly positive impact on health status, indicating that elderly people in rural areas with higher education levels and better income conditions can access more health resources and enjoy better health status, which is consistent with the socioeconomic fundamental

factors theory. In terms of health behavior habits, the coefficient of smoking is -0.016, which is significant at the 1% level, indicating that smoking is harmful to the health of the older adults. However, the impact of alcohol consumption on health is significantly positive, suggesting that elderly people in rural areas who consume alcohol have better health status. This may be related to survivorship bias, selection bias where healthy elderly people are more likely to consume alcohol, and the fact that moderate alcohol consumption rather than abuse is beneficial. This is also consistent with the research findings of Chen and Sun. In terms of social security and family status, basic social medical insurance can reduce the medical burden on the older alduts and improve the accessibility of medical services, having a significant positive impact on improving the health status of rural older adults. This is consistent with the research findings of early literature. There may be self-selection between health status and child care, that is, only elderly people with poorer health status have their children responsible for their care, but the impact is not significant.

Models 5 and 6 conducted gender-specific sample regressions, focusing on analyzing the gender heterogeneity of the aging health effects of rural living environments. The model results showed that, after controlling for other variables, there were certain gender differences in the aging health-promoting effects of rural living environments. Specifically, the positive impact of rural living environments on the health status of rural male old adults was more significant than that on rural female old adults, validating Research Hypothesis 2. The possible main reasons are as follows: First, physiological gender differences exist, with males being more susceptible to changes in environmental factors such as temperature, air quality, and humidity, thus leading to more pronounced health benefits for male older adults in the process of environmental improvement, which is similar to the research conclusions of Yu et al. Second, there is a gender division of labor in social roles, with male elderly possibly undertaking more labor activities and social responsibilities. In rural areas, physical activities such as farm labor and outdoor walking have certain health protection mechanisms, while male older adults often have higher socioeconomic status and more resources, broader social networks, and higher social participation. Meanwhile, female older adults are more likely to be restricted by family care and household chores, with relatively limited time and space for physical activities and social network. Therefore, the aging health-promoting effects of rural living environments are more pronounced among male elderly. Third, gender differences in aging-friendly facilities are weakened. Currently, the design and renovation of aging-friendly infrastructure in rural areas in China still adopt a universal "gender-neutral" standard, lacking consideration for female elderly's physiological functions, health status, production and lifestyle, etc. These measures are also more beneficial to male elderly, resulting in many female elderly unable to fully enjoy the health benefits brought by infrastructure and ecological environment.

Model 6 incorporates the interaction term between village-level variables and individual-level variables to explore the moderating effect of rural living environment on the impact of gender on the health status of the older adults. The model results show that, after controlling for other variables, the impact of gender on health status remains significantly positive. However, the interaction term between gender and rural living environment has a significant negative effect on health status with a sign opposite to that of the gender variable. This indicates that rural living environment weakens the positive impact of gender on the health status of the older adults to some extent, suggesting that the rural living environment can significantly narrow the gender differences in aging health. This suggests that the health level of rural older adults is also influenced by the interactive effects of

individual intrinsic factors and macro external conditions, validating Hypothesis 3. As a basic public service and social welfare, rural living environment, with its public characteristics, may narrow the gap between male and female elderly in accessing and utilizing resources, services, and the environment caused by marketization factors. It is an important way to promote health equity among rural older adults. Therefore, improving macro health policies is conducive to eliminating health inequalities, similar to the findings of prior studies. The specific shape of the health curve also indicates that as the level of rural living environment improves, the slope of the gender curve for rural aging health slows down, and the gender difference narrows. Therefore, continuously improving rural infrastructure and ecological environment from a macro perspective is conducive to narrowing gender inequalities in the health of rural older adults.

Conclusion and Discussion: The above findings of this paper provide empirical evidences and policy implications for improving the supply of health public services and products such as rural living environment and gender-friendly and aging-friendly environmental facilities, so as to realize healthy aging in rural areas and narrow health inequality among the older adults. In the future, it is necessary to increase the supply of public health services and products continuously, improve the modern public health governance systems, improve rural pension infrastructure, strengthen the comprehensive improvement and protection of rural ecological environment, improve the environmental awareness and environmental autonomy ability of rural older population, and shape their behavior and habits of healthy life. On the other hand, it is necessary to correctly understand the demographic characteristics in the process of rural aging. Specially, paying more attention to the gender difference in the health status of the older adults from the aspects of physiology, production and life, narrowing the gender injustice in the policy process itself, thereby, refining the policies to respond to the differentiated needs of female elderly people, and enhancing the inclusiveness of public policies on aging health.

Key words: Rural Human Settlement Environment; Aging Health; Gender Differences; Linear Development Model