How Vulnerable Populations Can Avoid Falling into the Energy Poverty Trap—A Study Based on Freedom of Access to Summer Cooling Equipment

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Abstract. Global warming has led to frequent extreme weather events. As a typical example of an energy-vulnerable group, the rural elderly population is facing a new "energy poverty trap"—that is, actively or passively reducing the frequency of air-conditioning use during hot weather for various reasons, which in turn leads to increased health risks such as heatstroke and cardiovascular and cerebrovascular diseases. In light of this, this study adopts a capability approach and employs a multi-case study methodology to explore the underlying factors influencing the willingness to consume cooling services and the usage behaviors of this demographic. The findings reveal that economic status is the core factor affecting energy consumption among the elderly, while health status, social networks, and access to information are also significant factors shaping their energy consumption preferences and affordability. Based on these findings, the study proposes optimization pathways and implementation mechanisms aimed at enhancing multidimensional capability. The goal is to improve the risk-response capacity of energy-vulnerable groups in the face of heatwaves, safeguard their basic well-being under climate change scenarios, and prevent them from falling into new forms of energy poverty.

Keywords: global warming, vulnerable groups, energy poverty trap, capability, well-being

1 Introduction

The threats posed by global warming represent one of the most pressing global issues currently facing human society [1] . Future global warming may occur more rapidly and intensely, posing serious risks to human health that could worsen dramatically within decades[2]. China is a region highly sensitive to and significantly impacted by global climate change, and the threats it faces are particularly acute[3]. In response to the threat of extreme heat, the use of cooling devices such as air conditioners has become one of the primary adaptive behaviors[1]. However, while such climate adaptation behaviors improve indoor thermal comfort, they also lead to a significant increase in energy expenditure, causing some households to face energy consumption

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constraints and consequently fall into the "energy poverty trap"[4]. This represents a form of vulnerability to risk exposure, meaning that although individuals may not currently be in poverty, their well-being may rapidly decline once they encounter a shock (such as extreme heat)[5]. The subject of this study—the "vulnerable population"—refers precisely to those groups that, in the face of heatwaves, lack the capacity to maintain basic energy access, particularly rural elderly populations who have long been disadvantaged in terms of energy consumption.

Currently, a growing body of literature indicates that global warming has a significant impact on the energy consumption of vulnerable populations[6, 7]; however, there has been insufficient attention paid to groups that are disadvantaged in terms of energy consumption from a microeconomic perspective. Furthermore, Scholars point out that mainstream economics has long overlooked the psychological factors affecting energy-vulnerable populations[8]. Therefore, enhancing the energy security and autonomy of energy-vulnerable groups enables them to rely on existing energy supplies to independently and efficiently use cooling facilities, such as air conditioners, to alleviate discomfort caused by extreme summer heat. This not only strengthens the climate resilience of vulnerable groups and improves society's overall level of climate adaptation but also holds significant importance for promoting equitable climate governance. It should be noted that the cooling dilemma faced by rural older adults is not an isolated phenomenon. Low-income older adults in urban areas similarly face cooling restraint due to electricity costs accounting for an excessive proportion of their expenses[9] , Constrained by mobility limitations, people with disabilities rely more on in-home external assistance and barrier-free residential environment renovations to alleviate daily-life hardships[10]. Whether these groups share underlying mechanisms of capability deprivation constitutes an external validity issue that this paper must address.

The structure of this paper is as follows: Part Two covers the theoretical foundation and analytical framework; Part Three analyzes differences in the degree of freedom regarding the use of refrigeration equipment among vulnerable groups; Part Four examines the implementation mechanisms and underlying logic of the degree of freedom regarding the use of refrigeration equipment among vulnerable groups from the perspective of capability; and Part Five presents the research conclusions and optimization recommendations.

2 Theoretical Foundation and Analytical Framework

2.1 Theoretical Foundation

The capability approach proposed by Amartya Sen (hereinafter referred to as "Sen") offers a novel perspective and analytical framework for understanding individual well-being. By treating "capabilities" as the key to assessing personal well-being, Sen argues that promoting human development and poverty alleviation should center on enhancing individuals' opportunities for choice and their ability to access resources[11]. This approach is well-suited for analyzing how to improve vulnerable

groups' capabilities regarding energy access, energy affordability, and the enjoyment of safe and efficient energy services.

However, the capability approach focuses on opportunities and choices at the individual level and pays insufficient attention to structural injustices within energy systems. Research on energy justice thus offers a complementary perspective. McCauley propose three dimensions of energy justice—distributive justice, procedural justice, and recognition justice—to identify the unfair distribution of energy burdens, the lack of decision-making participation by vulnerable groups, and the institutional roots of the neglect of their needs by mainstream policies[12]. Sovacool and Dworkin further note that energy justice requires the benefits and costs of energy services to be distributed equitably, and that decision-making processes be representative and fair[13]. Combining Sen's capability approach with the energy justice framework can explain both "why individuals lack the freedom to access cooling" and "how the energy system exacerbates this deprivation through pricing structures, policy procedures, and social perceptions"[14]. Therefore, this paper introduces the macro-structural perspective of energy justice beyond the micro-level dimension of capabilities to comprehensively understand the mechanisms underlying energy poverty in cooling among rural elderly populations. Existing literature often applies either capability theory or energy justice theory in isolation, with few studies integrating both to analyze energy poverty in cooling; this paper's interdisciplinary perspective fills this gap in the existing research.

2.2 Analytical Framework

Amartya Sen's theory of capable agency provides an important interpretive framework for research on the well-being of vulnerable groups. According to this theory, functional activities constitute achievements, while capable agency refers to the ability to realize such achievements. One of the main strengths of this framework is its flexibility and versatility, which allows researchers to develop and apply it in many different ways[15]. Adopting the theory of capable agency can enhance the capacity levels of vulnerable populations from a capabilities perspective. Therefore, this paper combines the concept of capable agency with four dimensions—economic opportunities, health conditions, social opportunities, and information access—to construct the framework (as shown in Figure 1).

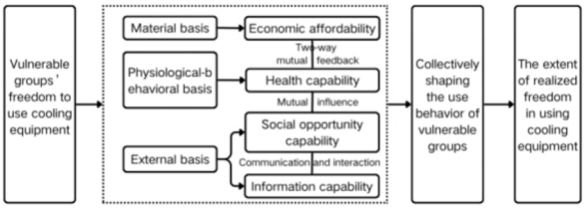


Fig. 1. Factor Influence Diagram

3 Analysis of Differences in Freedom of Use of Refrigeration Equipment Among Vulnerable Groups in Real-World Settings

Conducting a comparative analysis of the interviewees' freedom of use helps to systematically identify the structural constraints and individual barriers that vulnerable groups face when using refrigeration equipment, thereby enabling the development of more effective countermeasures from a theoretical perspective. The basic characteristics of the interviewees are shown in Table 1.

Table 1. Basic Information on Survey Participants

Name	Age	Gender	Occupation	Identity	Place of residence
ZWX	70	male	farmer	the public	County B, Nanning
QYM	66	female	farmer	the public	L Village, Q District, Guigang
WQH	62	male	farmer	the public	County Z, Guilin
WMB	82	male	The corner store owner	the public	Liuzhou L Village
QT	70	male	Rice shop owner	the public	L Village, Q District, Guigang
QXZ	75	female	Retired employees	the public	County F, Chongzuo

To determine whether the study's findings apply exclusively to rural older adults, this section introduces urban low-income older adults and people with disabilities for a comparative analysis[16]. While these two groups share energy vulnerability with rural older adults, they differ in terms of livelihood structures, physiological characteristics, and institutional exclusion, which helps identify which mechanisms are universal across these groups.

3.1 Economic Constraints

Sen (2001) argues that income serves as the material foundation of well-being[17]. A key manifestation of vulnerable groups falling into the energy poverty trap is that they refuse to use or reduce their use of cooling facilities, such as air conditioners, due to economic instability or high electricity bills, thereby exposing themselves to the risks associated with heatwaves.

First, unstable income affects their energy consumption behavior, primarily manifested in vulnerable groups voluntarily or involuntarily reducing their use of cooling equipment due to their unstable economic circumstances. During a survey conducted in Village L, County B, Nanning, a local elderly farmer remarked, "*Droughts are too frequent; we can't make much money, so we can't afford to use air conditioning" (Interview Record: 20250718ZWX)*. The lack of a stable income source and unstable financial circumstances cause vulnerable groups to subconsciously reduce or stop using cooling equipment, thereby trapping them in a predicament of energy deprivation.

Second, the structure of electricity rates fails to provide adequate support for vulnerable groups, as energy pricing does not sufficiently take their economic circumstances into account. During a survey in Village L, we learned of a household consisting solely of an elderly couple who rely primarily on farming for their livelihood. When asked about the burden of electricity bills, the elderly farmer remarked, "*Our monthly electricity bill comes to over 200 yuan for the two of us, which is a bit more than we expected." (Interview Record: 20250718ZWX)*. This indicates that current energy pricing does not fully account for the actual financial capacity of the elderly, which in turn increases their concerns regarding energy consumption.

From the perspective of energy justice, the current electricity pricing structure fails to distinguish between essential cooling and comfort-oriented consumption, and lacks progressive subsidies for vulnerable groups, reflecting a lack of distributive justice[12]. This institutional arrangement disproportionately shifts energy costs onto low-income rural households, structurally weakening their economic capacity rather than merely reflecting a lack of individual payment ability[12].

First, a comparison with low-income elderly in urban areas. Wang et al. found that although low-income elderly in Chinese cities are connected to the power grid, they continue to use solid fuels rather than electric cooling due to energy cultural norms and a sense of relative deprivation[18]. Unlike the absolute income instability faced by rural elderly, the urban group experiences relative energy poverty—their pensions are stable but insufficient relative to the cost of urban living[18]. However, both groups share the same structural dilemma: current electricity rates do not distinguish between cooling for survival and cooling for comfort, leading both groups to voluntarily reduce their use of cooling[12]. This suggests that although the mechanisms underlying economic deprivation differ (absolute scarcity vs. relative deprivation), they converge on similar behavioral outcomes due to a lack of distributive justice.

3.2 Health Status

Grossman (1972) noted that health status has a significant impact on individuals[19]. L Village in District Q, Guigang, is a multi-ethnic village with a predominantly Zhuang population. The use of air conditioning among vulnerable groups in this village is constrained by various factors.

First, health status influences their energy consumption behavior. Older adults in poorer health are more cautious and restrained in their use of air conditioning. Some explicitly stated, "*The summer heat is truly unbearable, and I want to use the air conditioner, but as soon as I turn it on, I get a headache, so I have no choice but to endure the heat without it" (Interview Record: 20250712QYM).* Although these older adults have a need for cooling, they are constrained by their own health conditions. To avoid physical discomfort caused by air conditioning, they are forced to voluntarily reduce or forgo its use, creating a dilemma where they "dare not use it even though it’s hot."

Second, there is a lack of professional guidance. Due to their educational background and the medical conditions in their regions, most vulnerable groups lack knowledge and understanding of health matters, leading them to rely on their own

experience when coping with high temperatures. A 62-year-old man surnamed Wang from Village B in Z County, Guangxi, said, "*I didn't go to school much, so I don't know how to protect my health" (Interview Record: 202501003WQH)*. This reflects how older adults, due to a lack of medical knowledge, tend to underestimate their own health risks, thereby increasing their vulnerability to heatstroke, cardiovascular disease, and other health hazards.

According to Friedman, 50.8% of people with disabilities in the United States reduced their consumption of essential goods to cover energy bills during the pandemic, and 36.1% maintained unsafe indoor temperatures at home, figures significantly higher than those for non-disabled populations. Health-capacity constraints among this group are more physiologically rigid: thermoregulatory impairments and reliance on electrically powered medical equipment render their cooling needs objective and non-negotiable[20]. Whereas rural older adults are "hesitant to use" air conditioning due to cognitive biases, people with disabilities face cooling demands they "cannot avoid" owing to physical functional dependencies. This reveals that health capacity operates through two pathways—the cognitive-perceptual pathway (for older adults) and the physiological-functional pathway (for people with disabilities)—which necessitates differentiated policy responses.

3.3 Social Interaction

Stewart (2013) argues that individuals are so closely connected to others that it is difficult to separate them and treat them as independent entities, highlighting the importance of interpersonal relationships and social interaction[21]. However, vulnerable populations have limited resources and capacity to act on their own, which prevents them from accessing broader social support networks and welfare services.

First, family dynamics influence the use of cooling equipment. Interpersonal relationships within the household directly affect older adults' willingness to use such equipment. An 82-year-old resident of L Village in Liuzhou stated, "*Because my wife is in poor health, I worry that direct exposure to cold air from the air conditioner or excessively low temperatures might worsen her condition. Therefore, I avoid using cooling equipment whenever possible" (Interview Record: 20250729WMB)*. It is evident that some elderly individuals proactively reduce or even refrain from using air conditioners to maintain family harmony and protect the health of their loved ones, preferring to endure the heat themselves rather than compromise their family members' well-being. Such choices, rooted in familial affection and caregiving responsibilities, significantly limit and influence the actual use of cooling devices among the elderly. Consequently, the use of cooling devices is to some extent influenced by the level of family harmony; to avoid family conflicts, vulnerable groups choose to silently endure high temperatures rather than freely enjoy the comfort and convenience provided by energy services.

Second, social support networks also influence the use of cooling equipment. Field research in District Q of Guigang revealed that many elderly residents regularly gather under highway overpasses to stay cool and chat, forming relatively stable informal social circles. This not only meets their need for cooling but also serves as a venue for

daily socializing and leisure activities, thereby partially replacing or reducing the independent use of home cooling equipment. These differences in usage behavior, resulting from the provision of recreational and cooling spaces within the local social environment, play a positive and constructive role in helping the elderly overcome the constraints of limited and inadequate access to energy.

However, this informal adaptation also reflects a lack of procedural justice and recognition justice: the elderly seek relief under bridges precisely because public cooling governance has failed to include their participation, and their vulnerability to high temperatures has not been formally acknowledged by energy policies[14]. Such social networks serve as compensatory mechanisms in the absence of institutional support, rather than representing true empowerment.

Furthermore, social support is particularly critical for people with disabilities, people with disabilities still face numerous challenges in terms of community support, including practical barriers such as insufficient participation in social activities, a lack of resources, and inadequate infrastructure[22]. For people with disabilities who lack sufficient social support, building a support network is an effective approach that not only improves the quality of life for people with disabilities and their families but also strengthens the resilience of local communities[23].

3.4 Access to Information

The Asia-Pacific Economic Review (2025) argues that limited access to information among the elderly prevents them from obtaining equal access to welfare benefits and basic resources, thereby leading to inequitable distribution of social resources. Therefore, this paper examines whether vulnerable groups lose their freedom to use energy due to cognitive biases or insufficient information literacy[24]. Therefore, this paper examines whether vulnerable groups lose their freedom to use energy due to cognitive biases or insufficient informational capability.

First, information channels are limited. A survey conducted in District Q of Guigang revealed that because traditional communication channels—such as community bulletin boards, radio broadcasts, and paper notices—tend to provide only general information, this demographic lacks awareness of various appliance subsidy policies. A 70-year-old resident of District Q stated, "*I am unaware of any policies regarding appliance subsidies" (Interview Record: 202507012QT)*. This lack of awareness prevents most elderly residents from fully benefiting from these programs. Consequently, the elderly face limitations in their access to and use of cooling equipment such as air conditioners, which may even imply inequities in the distribution of social resources.

Second, there is a clear problem of delayed information updates, with entrenched perceptions playing a significant role in hindering progress. Vulnerable groups primarily rely on television, neighborhood conversations, or past experiences to obtain information, resulting in a severe lag in their awareness of dynamic changes in electricity pricing policies (such as peak-off-peak rates and summer subsidies for low-income households). During a field survey in County F, Chongzuo City, a 75-year-old man remarked, "*In the past, we got by with just a fan; now, running the air conditioner uses too much electricity, and the bills are always so high*." *(Interview*

Record: 20251008QXZ). This elderly man's household pays an average monthly electricity bill of 100–150 yuan, accounting for 10%–15% of his monthly income. Traditional notions of frugality lead him to refuse to use air conditioning even on extremely hot days, demonstrating a behavioral tendency to cling to traditional beliefs and reject the use of cooling equipment.

4 Mechanisms and Underlying Logic for Realizing the Freedom to Use Community Refrigeration Equipment from the Perspective of Capability

4.1 Mechanisms

Economic Capability.

Drawing on research on Sen's concept of capable agency, Naz (2022) observes that economic and material conditions serve a foundational role as essential means to realize individual capabilities and well-being, even though they are not ends in themselves[25], and the lack of such conditions is a key factor contributing to weak capabilities. From an individual perspective, Robeyns (2005) argues that economic resources serve as the key foundation (input) for transforming personal traits into functional realization and capabilities[15]. Therefore, possessing a certain level of economic agency is a crucial prerequisite for vulnerable groups to achieve freedom in the use of cooling equipment. Its role lies primarily in breaking the material constraints of "affordability and accessibility" associated with air conditioners and other cooling equipment. Specifically, this can be achieved by enhancing their economic capacity, thereby transforming their existing economic resources into actual freedom to use cooling equipment. In light of research on economic vulnerability, enhancing the economic capability of vulnerable groups can be achieved, on the one hand, by the government implementing more robust, targeted energy subsidy policies at the national level. This would restrict enterprises from engaging in disorderly price hikes, ensuring that subsidies for air conditioners and other cooling equipment are effectively delivered. Consequently, this would reduce the purchase costs of cooling equipment for vulnerable groups, thereby preventing situations where they are forced to forgo the use of such equipment due to financial hardship. On the other hand, targeted assistance and a combination of measures—such as distributing special "Cooling Funds"—can be employed to improve the energy consumption capacity of vulnerable groups. This would reduce their economic vulnerability and help ensure they have sufficient financial means and conditions to freely acquire and use air conditioners and other cooling equipment during the hot season.

Such subsidies should explicitly recognize the legitimate cooling needs of rural elderly as a distinct vulnerable group, rather than being treated as generalized poverty relief[12]; simultaneously, a village-level energy deliberation mechanism should be established to ensure procedural justice in their participation in decision-making[14].

Health Capacity.

Improvements in health capacity can enhance vulnerable groups' awareness of health risks associated with high temperatures. Zheng et al. (2024) show that health spending can meaningfully raise both absolute and relative income by affecting illness duration, educational attainment, job opportunities, and productive labor hours[26], and income generation. Improvements in health status directly enhance the economic capacity and livelihood resilience of impoverished rural populations. The pathways to improving health are primarily manifested as follows: First, fully considering the health status of the elderly, promoting the alignment of health standards with energy consumption needs at the policy level, prioritizing the energy demands of vulnerable groups arising from health needs, and optimizing energy assistance policies; Second, strengthening professional health guidance. Most vulnerable groups have limited educational attainment and face inadequate local medical resources, resulting in a lack of specialized knowledge regarding physical health—particularly heat-related protection. Consequently, they struggle to fully recognize the potential health risks posed by high temperatures and are unable to use cooling equipment scientifically to maintain their health. Therefore, it is necessary to disseminate knowledge on heat protection, summer care for chronic diseases, and the proper use of cooling equipment to enhance vulnerable groups' health awareness and self-protection capabilities.

Social Support Capacity.

Yang et al. (2024) found that social capital plays a significant role in the impact of multiple shocks on farmers' coping strategies[27]. Social support capacity serves as a crucial safeguard for vulnerable groups to freely use refrigeration equipment, accounting for 9.8% of the underlying mechanisms. To overcome the constraints of individual capacity limitations and achieve resource sharing and mutual benefit, this protective role plays a crucial part, primarily manifesting at two core levels: family and society. First, by leveraging family relationships to build a solid internal foundation for the use of cooling equipment. Creating a harmonious and caring family atmosphere encourages children to proactively address the health needs of the elderly during heatwaves, actively purchasing and setting up cooling equipment to help the elderly stay cool throughout the summer; second, at the societal level, improving social support networks is equally crucial. Social networks formed through geographical and occupational ties can effectively compensate for deficiencies in family support, providing diverse forms of support for vulnerable groups in their use of cooling equipment.

Information Accessibility.

Ding and Zhang (2025) note that if older adults are able to use relatively complex service platforms—such as government websites, village WeChat groups, and short-video platforms—to effectively identify, integrate, and utilize information resources, this will greatly enhance their ability to use available information to better care for themselves in their daily lives[28]. Enhancing information accessibility can help vulnerable groups promptly learn about relevant policies—such as subsidies for

air conditioner purchases and electricity bill reductions—and successfully obtain and use cooling equipment. Specific pathways to ensure the flow and enhancement of information capability include: First, ensuring unobstructed access to information and breaking down barriers to policy information. By leveraging grassroots resources such as community residents' committees, village committees, and grid workers, and through offline methods such as posting posters, conducting door-to-door outreach, and distributing simple handbooks, information regarding cooling-related subsidy policies and application procedures can be accurately conveyed to vulnerable groups; Second, promoting the updating and upgrading of information to address misconceptions and misunderstandings. By regularly disseminating the latest updates on the replacement of cooling equipment and adjustments to electricity rates, vulnerable groups can promptly access policy information, thereby shifting their mindset from psychological resistance and reluctance to use such equipment to a willingness to accept and actively utilize it.

4.2 Underlying Logic

In light of the objective reality of frequent global heatwaves and the increasingly prominent health risks associated with high temperatures, it is essential to fully recognize that vulnerable groups' ability to freely use cooling equipment is, at its core, the result of the interplay and synergistic empowerment of their multidimensional capabilities. The safeguarding of individuals' daily well-being relies on systematic support from economic status, health status, the ability to access social resources, and information literacy. These capabilities are intertwined and mutually dependent, collectively determining whether vulnerable groups can freely access, operate, and control air conditioning and other cooling devices during summer heatwaves.

5 Conclusions and Recommendations

5.1 Key Findings

At a time when heatwaves are becoming more frequent and health risks associated with high temperatures are intensifying, the cooling needs of energy-vulnerable groups are closely linked to their physical and mental health, personal well-being, and even social equity. When access to cooling equipment is restricted or insufficient, energy-vulnerable groups are prone to falling into the "energy poverty trap of cooling." This phenomenon reflects not only issues of energy accessibility but also the deprivation of agency and the unequal distribution of social welfare. The core findings of this study are as follows:

First, a lack of economic resources is the primary factor inhibiting the use of cooling. This study found that the economic resources of energy-vulnerable populations influence their frequency of use of cooling equipment.

Second, health-related cognitive biases affect the ability of energy-vulnerable groups to adapt to climate change. In the current context of global warming and frequent extreme weather events, individuals in poor health use cooling equipment sig-

nificantly less often. This stems from physiological biases in their perception of high temperatures and psychological misperceptions regarding the threats posed by high temperatures.

Third, a lack of social support and limited access to information and capabilities imposes multiple objective constraints on vulnerable groups' use of modern cooling equipment such as air conditioners, thereby trapping these energy-vulnerable populations in a structural and substantive "cooling energy poverty" trap. This finding provides empirical evidence for Sen's capability approach at the micro-behavioral level[17].

This research framework is applicable across different groups but requires contextual calibration. Economic and informational deprivation exhibit structural persistence across various energy-vulnerable groups[16], [18], [20]; however, the relative importance of health-related and social capabilities varies by group—social networks are particularly critical for rural older adults living alone, while physical accessibility and reliance on medical devices are predominant among people with disabilities. Overall, economic deprivation and information barriers are universal across groups, whereas health constraints and social support are group-specific. Future research should quantify differences in the weighting of these dimensions through large-scale comparative studies to enhance the framework's external validity.

5.2 Key Recommendations

Based on the findings of the above study, the following recommendations are proposed with regard to heatwave response and energy equity:

(1) Implement dual economic and psychological interventions to provide targeted energy benefits. Rural energy assistance should go beyond tiered electricity pricing or one-time subsidies; instead, it should provide a cooling electricity allowance for groups eligible for senior citizen subsidies, with discounted rates within the allowance and full-price rates beyond it. Access should be restricted to high-efficiency equipment, using efficiency gains to offset demand expansion. Concurrently, grassroots medical personnel should define moderate cooling as a necessary expense for chronic disease prevention. In their outreach, they should emphasize the dual risks of "heat-related illness" and "health hazards from excessive cold," avoiding the notion that "more cooling is always better." All promotional materials must be reviewed and finalized by county-level health authorities to prevent misinterpretation during grassroots implementation;

(2) Build support networks to enhance social capital and climate resilience. Policies should encourage and fund community-level "heatwave mutual-aid" mechanisms that provide equipment maintenance checks and emergency assistance for elderly adults living alone or with poor health. These services extend the service life of cooling devices and prevent the loss of cooling capacity due to unrepaired malfunctions.

(3) Promote the research and development of age-friendly inclusive technologies and the popularization of health knowledge. Age-friendly cooling products with simplified operation and intelligent temperature control shall be included in government procurement and energy-efficiency subsidy catalogs to lower purchase costs for older

adults through volume-based pricing. Health authorities shall lead village-level clinics in conducting science outreach to correct one-sided perceptions such as "air-conditioner sickness", disseminate scientific knowledge on indoor environmental management, and distribute simple operation guides to lower usage barriers and improve vulnerable older adults' willingness to use cooling equipment.

5.3 Research Limitations and Future Directions

This study employs a cross-sectional, multi-case design, which is suitable for exploring mechanisms but cannot establish a causal relationship between improved capabilities and health outcomes. In rural areas, there are limited places where the elderly can go to escape the heat during extreme heat waves. As a result, many elderly people choose to stay indoors, but extreme heat continues to drive up mortality rates among the elderly in rural and remote areas[29]. Based on this, a future study could select 200–300 rural elderly households in Guangxi and track them over three consecutive summers from 2026 to 2028, measuring the four-dimensional capability index, cooling usage behavior, and health outcomes (incidence of heatstroke, number of emergency visits for cardiovascular and cerebrovascular events).

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