Collaborating Centre for Oxford University and CUHK
for Disaster and Medical Humanitarian Response
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Health-Emergency and Disaster Risk Management (Health-EDRM)

Technical Brief Series (#202002)

"Housing" as Health-EDRM strategy for climate adaptation: The case of rural China

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Integrated Research on Disaster Risk (IRDR) International Centre of Excellence-CCOUC

Technical Brief
June 2020 version (subject to review and further update)

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"Housing" as Health-EDRM strategy for climate adaptation: The case of rural China

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Executive Summary

Human health and well-being depends heavily on a healthy and functional living environment. Climate change, resources depletion, environmental degradation, inequality and poverty are some of the determinants not just affecting the planet home, but the health and wellness of humanity at large. Siting, structural integrity and resilience of housing are all vital as they could be powerful tools to control different environmental hazards and health risks related to climate change. The indoor and outdoor environments, materials, design and social aspects of housing, as well as local neighbourhoods all influence the health of people who living there.

Despite the profound and long-lasting impact of housing on the earth and humanity, it remains uncertain how to maximise the health and environmental benefits of housing. There is a lack of strong evidence to guide relevant policymaking. In 2018, the World Health Organisation (WHO) published a housing and health guideline to provide global, evidence-based recommendations for policymakers and practitioners to improve housing conditions. It considered the entire housing lifecycle from construction to maintenance, focusing on how to reduce risk factors for housing mainly in the urban contexts. It also called for multidisciplinary stakeholders and policymakers at country and local levels to collaborate, adapt and implement the guidelines subject to local contexts.

In 2019, the WHO launched the Health Emergency and Disaster Risk Management (Health-EDRM) Framework, which positions health at the centre of disaster risk management. The Framework suggests multidisciplinary approach of risk mitigation and primary prevention at country and community levels to reduce exposure and vulnerability subject to complex global environmental challenges. Overall, healthy post-disaster housing not only reduces hazards, exposures and vulnerabilities, but also functions as a continued process to enhance community resilience, support recovery and contribute to sustainable development. Using the case study in rural China, this technical brief examines how "housing" might be a Health-EDRM strategy for climate adaptation.

Summary for policy and research considerations

- Coupled with ever-growing population and urbanisation, the world is vulnerable to increased disasters due to extreme weather events exacerbated by climate change. Climate change has been posting threats to human's health directly and indirectly through altering our living environments. Older adults and children living in rural area with generally poorer health infrastructure are usually disproportionately affected. Climate adaptation is necessary to get everyone prepared and relieve potential health burden in the future.

- The Health-EDRM framework launched by WHO offers a risk-based and multidisciplinary approach to guide research and intervention on all health hazards in the entire disaster management cycle. It aims to mitigate health risks, build capacity and enhance resilience across different sectors on both community and country levels.

- Housing, an important Health-EDRM strategy for climate adaptation, also provides co-benefits of climate mitigation throughout the entire housing lifecycle. Appropriate siting,

design, material use, construction and maintenance could all help control the impacts of environmental health hazards. Proper housing supports physical, mental and social wellbeing and the effect is long-lasting.

- Extreme temperature could exacerbate underlying conditions of lung and heart diseases, and hence morbidity and mortality, particularly among the older population. Excess dampness worsens the situation as moisture disrupts thermoregulatory performance of human body and clothing. Increased micro-viral activities also post health threat to residents of housing. Research evidence on the combined health impacts of indoor temperature and relative humidity on extreme age groups, particularly in rural and/or post-disaster context, is urgently needed.

- Housing is an insertion point for intersectoral public health programmes, a tool for combating health inequality and supporting the achievement of sustainable development goals. Nevertheless, no strong scientific evidence is currently available to showcase how the health and environmental benefits of housing can be maximised and to guide policymaking.

- WHO has published a guideline on housing and health in 2018 with a focus on how to reduce risk factors of housing mainly in city contexts. Multidisciplinary stakeholders and policymakers need to work together to implement policies and actions subject to local contexts.

- China is the country most frequently struck by natural disasters. Affected population generally need to stay in temporary settlements or shelters during the transitional period. Indoor environment is generally poor in terms of indoor temperature, ventilation and dampness. Proper housing can play a role in different phases of disaster management, and support human's wellbeing through different levels of health prevention.

- Deprived individuals living in rural area with less resources to keep a stable indoor temperature are particularly vulnerable as they may not be well protected by proper health infrastructure. More research about the impact of housing on the health of rural communities in China is necessary.

- China is a vast country with diverse customs and socio-cultural characteristics and rural China existed a diversity of local housing options which are bioclimatic and sensitive to local culture and geographical environments. The experience of China could potentially shed lights on how to rebuild better in a post-disaster rural setting. Further cross-disciplinary research on locally appropriate and healthy housing advancements and contextual research on the linkage of local housing and health are recommended.

Background

Since the industrial revolution 250 years ago, profound economic, technical and medical advancements have been taking place. Humanity can now live much longer, and world population has experienced record high growth in terms of population and energy use since the 1950. There have been unprecedented and dramatic changes in our earth system that characterised the great acceleration (1). Among all indicators of environmental degradation, additional carbon dioxide and other greenhouse gases have trapped extra heat, leading to an ever-growing increase in surface temperature. Earth's systems and processes have been irreversibly influenced by human activities.

Our current and upcoming generations can only thrive on a liveable planet home. Humanity is now using an equivalent of 1.7 planets to provide resources and maintain human daily lives. If current production and consumption continue, human race will need an equivalent of 2 earths to support our living (2) as human is now using natural resources much faster than they can be replenished. The concept of sustainability, i.e. *"meeting the needs of the present without comprising the ability of future generations to meet their own needs"* as defined by United Nations in 1987,(3) remains conceptual rather than applicable.

Climate change, resources depletion, environmental degradation, inequality and poverty are some of the determinants not just affecting our planet home, but the health and wellness of humanity at large. The World Health Organisation (WHO) also declared that "climate change is the greatest threat to global health in the 21st Century."(4) It is inevitable that mankind, other animals and the ecosystem would be threatened. It is imperative that more ambitious and bold adaptation measures should be adopted and executed for the world to address current climate emergency.

Nevertheless, current global and system-wide challenges are interconnected in nature and nexus thinking amongst interdisciplinary stakeholders is necessary. Sound risk management, mitigation and preparedness are vital to protect human health from disastrous events. In 2018, the WHO launched the Health-EDRM framework to mitigate health risks, build stronger capacities and enhance resilience across different sectors at both country and community levels.(5,6) It is risk-based and multidisciplinary approach that encompasses research and intervention on all health hazards throughout the entire emergency management cycle. Employing the Health-EDRM framework, this paper aims to use housing in rural China context as a case to examine how "housing" can be considered as a primary Health-EDRM strategy for climate adaptation.

Climate and its impact on health

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is defined as a significant change in climate persisting over an extended period, say decades or more.(7,8) United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."(9) Such prolonged and human-induced alternations are making changes to our living environment globally. Climate change posts significant health threat to human beings as it exacerbates weather-related natural disasters, increases the frequency and intensity of extreme precipitation, and brings along extreme weather events including heat waves, cold spells and floods. The number of weather-related disasters has more than tripled globally since 1960, and China has been the country most frequently struck by natural disasters. Evidence also showed that extreme temperature contributes directly to deaths from cardiovascular and respiratory diseases, particularly among older people. Climate change has been causing serious health and social problems around the world, especially for those living in areas with poorer health infrastructure. Climate adaption is necessary for all countries to prepare for this global change.

Climate adaptation, as defined by the Intergovernmental Panel on Climate Change (IPCC), is the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.(9) In reality, housing has the potential to improve health directly or indirectly through influencing other determinants of health. Amongst various sectors, housing sector contributes to 19% of greenhouse gas emission and about 1/3 black carbon emission.(10) As assessed by IPCC, housing was regarded as a sector with the greatest potential for cost-effective mitigation of climate change.(11) From a housing life course perspective, the building materials, the design, the way of constructing, maintaining, renovating and demolishing the house could influence both the social and environmental determinants of health. Housing not only has a profound impact on planet earth, but also human health and well-being as human race depends heavily on a healthy and functional living environment. From a micro perspective, siting, structural integrity and resilience of housing are all vital as they could be powerful tools to control different environmental hazards and health risks related to climate change. Housing also has long-lasting impact as it normally exists for decades. How to maximise the health and environmental benefits of housing remains inconclusive in published literature and there is a lack of evidence to guide relevant policymaking. There remains a lot of room to exploit and maximise the health and environmental benefits of housing and get protected from expected climate and its effects.

Housing, Health-EDRM and sustainability

In 1946, the World Health Organization (WHO) defined health as "*a state of complete physical, mental and social well-being and not merely the absence of disease of infirmity*."(12) Following this perspective on health, our home is not merely a physical structure, but a strategic tool for health improvement as everyone needs a home and people spend much of their lifetime in it. The indoor and outdoor environments, material and social aspects of housing, as well as local neighbourhoods are all influencing the health of people who living there. The physical structure of our home can be the potential source of different hazards such as cold, heat, accidents, damp/mould, carbon monoxide, hygiene and other housing-related health risks (13). In light of this, the WHO has regarded healthy housing as shelters that support a state of complete physiological, mental and social wellbeing. It should be able to protect the health and well-being of residents from a variety of disease-related health hazards. Healthy housing refers to four dimensions of housing, namely: the house structure, the home social environment, the neighbourhood and community, and the entire life-cycle of housing (14). A healthy home should be sited, designed, constructed, renovated and maintained in a way that supports the health of residents in terms of physical, mental state and social wellbeing (15).

Housing can also take a proactive role in promoting health in terms of emergency and disaster risk management. The following table showcased the role of housing in health prevention in the disaster context:

Table 1: The role of housing in health prevention in disaster context

	Primary Prevention	Secondary Prevention	Tertiary Prevention
Disasters	Flooding, typhoon, earthquake, landslide, heat wave, cold spell, snowstorm.		
Stages	Prevention/Preparedness	Emergency Response	Recovery
Objectives	Prevent disaster-related death, injuries and illness	Mitigate health consequence of a disaster	Minimise the effects of diseases and disability
Targets	At-risk people	Early/asymptomatic	Established diseases
Implementation strategies (physical structure)	Housing with climate adaptation 1. Materials: (16) • Light-weight structure: e.g. roof, light steel framework • Natural materials: bamboo, wood, advanced rammed earth • Thermal mass 2. Design & construction (17):	Transitional settlements/shelters 1. Installation: • Mosquito screens/nets • Solar panel, screen, blind, wall or roof fabric with reflectance 2. Design & construction: • Protection from weather hazards (rain, wind, sun, cold)	Housing/transitional shelters/reconstruction 1. Installation/Design & construction: • Unblocked access for wheelchair (>0.65m) • Handrail and ramp • Non slippery materials • Avoiding door steps/steep staircases

	Primary Prevention	Secondary Prevention	Tertiary Prevention
	• Quake-resistant structure, withstanding collapse through redistributing the forces that travel through from them during an earthquake event. • Reinforcement: shear wall, cross braces, diaphragms, moment-resisting frames • Foundation: sound and strong, floating foundation • Prefabricated materials for easy construction 3. Siting(17): • Away from slope, riverbank, riverbed, lower course of the dam floodgate, dangerous goods storage, high voltage power transmission tower, destroyed building, earthquake split, underground wiring • Flat and preferably location with higher elevation • Elevated flooring • Community infrastructure with higher level of disaster resistance 4. Disaster preparedness (planning for evacuation, knowing the location of safety access, preparing emergency kits with key prescription, first-aids materials, copy of important documents), drill	• Proper ventilation (fresh air>10m3/ph, victims >50, 0.0077 m2/person, victims <50, 0.0052 • Preventing excess dampness • Avoiding dirt floor • Space for bed and resting • Appropriate and safe area for cooking • Safety access • Zoning needed for more than 50 people. 3. Housekeeping (18) • Provision of clean water source, electricity, sanitary and waste management. • No indoor smoking • Fire safety	• Design and facility for quarantine, isolation and social distancing • Arranging area for storage 2. Housekeeping: • Proper outdoor space to dry laundry (avoiding excess indoor dampness) • Washing
Implementation strategies (mental wellbeing)	1. Renovation subsidies 2. Affordable housing 4. Identifying safest area at home in case of emergency	1. Choice of housing colour tone 2. Sense of safety and security 3. Dignity 4. Cultural sensitivity 5. Community empowerment: Participation in the recovery process	1. Flexibility for incremental improvement of housing 2. Being empowered to rebuild community

	Primary Prevention	Secondary Prevention	Tertiary Prevention
Implementation strategies (social wellbeing)	1. Community engagement to enhance resilience 2. Community disaster preparedness mutual-help group	1. Setting of community camps to enhance community interaction and gathering 2. Siting: Preferring location with easy access to medical, health and public services 3. Supporting the preservation of local heritage, religion and custom.	1. Access to rehabilitation facilities/services 2. Caring and support to elderly/disabled who are living alone

Improving housing conditions also contributes to the achievement of different Sustainable Development Goals (SDGs). To safeguard a viable future for generations to come, 17 Sustainable Development Goals (SDGs) have been identified and adopted by member states of the United Nations, who have pledged to mobilise efforts to eliminate poverty, protect environment, fight against inequalities and tackle climate change, and thereby build a better world by 2030. Proper housing can enhance resilience of the poor and vulnerable and reduce their exposure to climate-related extreme events and disasters (SDG1, Target 1.5). Currently, some low-carbon bioclimatic features of housing such as passive design, natural ventilation, and thermal mass insulation do not rely heavily on energy to maintain a comfortable environment. Some "high science low technology" construction techniques also allow the engagement of village communities in building a green and healthy home. Supported with appropriate housing policies and sustainable housing solutions, countries and vulnerable communities can strengthen their capacity of risk reduction and the management of global health risks (SDG3, Target 3d) and making cities and human settlements inclusive, safe, resilient and sustainable (SDG11, Targets: 11.1, 11.5, 11a, b and c). Housing is not only a key insertion point for inter sectoral public health programmes and primary prevention, but also a way to mitigate climate change and build a sustainable home for our future generations at large. It can be a powerful tool for health prevention, risk mitigation, climate change adaptation, and supporting sustainable development in a long run.

Healthy housing: Global evidence

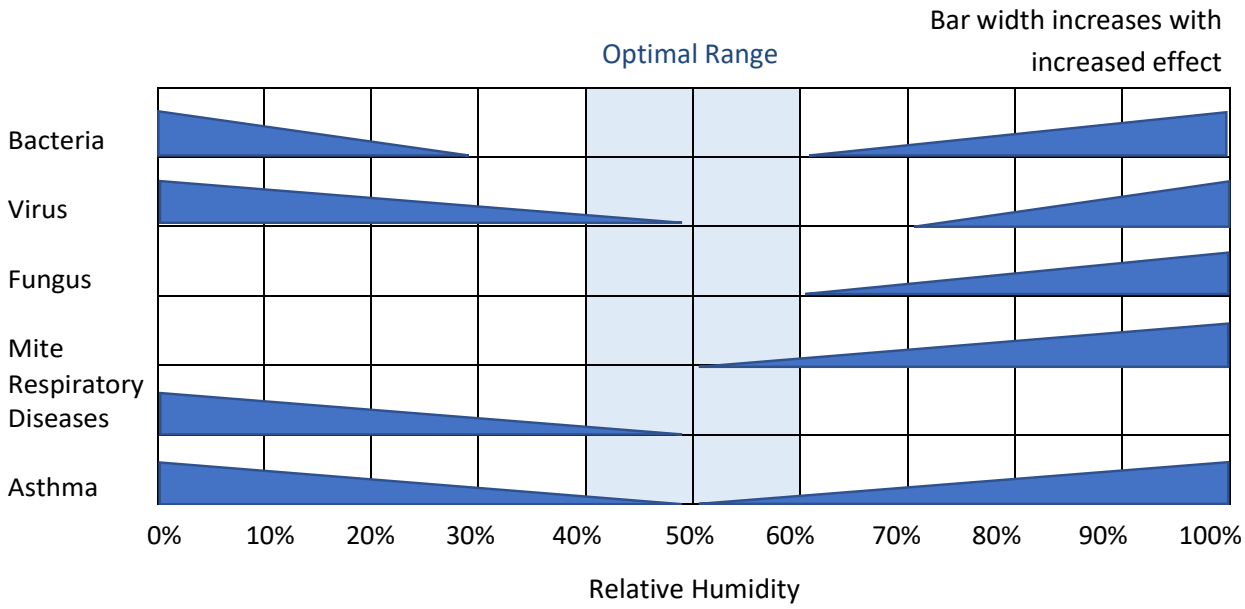
Over the past decades, many scientific studies were conducted to understand the linkage between housing and health. There were also epidemiological studies linking substandard housing with an increased risk of chronic illness.(13) The physical structure of housing could be a potential source of a wide range of hazards such as cold, heat, accidents, damp/mould, carbon monoxide, radon, hygiene and other housing-related health risks. Below are some of the key areas that showing the linkages between housing and health:

- **Crowding:** increasing risk of exposure to infectious diseases.
- **Cold home:** poor cardiovascular and respiratory outcomes.
- **High indoor temperature:** heat-related illnesses or increase cardiovascular mortality.

- **Mould and Dampness:** allergy, respiratory infection.
- **Deficient housing:** slip or fall, increased risk of injuries.
- **Indoor air pollution:** non-commutable disease outcomes, harming respiratory and cardiovascular health, allergic and irritant reactions.
- **Poor clean water supply and sanitation facilities:** food safety, personal hygiene, development of communicable diseases.
- **Insecurity:** low affordability, stress of high mortgage liability.
- **Poor accessibility:** risk of injuries for the disabled and older people, stress and isolation.

Amongst different health hazards, focus in this report will be on temperature and relative humidity, not only for their combined effect on health, but also for their close relationship with climate adaptation, energy consumption and sustainability. Extreme temperature could exacerbate underlying medical conditions of lung and heart diseases, hence morbidity and mortality especially for older population.(10)(19)(20)(21) Indoor dampness even worsens the situation as moisture disrupts both heat dissipation of body and the insulation performance of clothes. Extremes in relative humidity (Figure 1) also contribute to increased microbial and chemical activities that are harmful to health.(22) There are proven combined effects of temperature and relative humidity on human physiological responses.(23)(24)(25)(26) Poor insulation, airtightness and poor heating all contributes to an unstable indoor temperature, poor thermal comfort as well as damp and mouldy conditions. This is particularly common for population with low socio-economic status and/or those living in post-disaster transitional housing as they have limited resources to cool and warm their home, as well as keeping it well ventilated.

Fig. 1: Relationship of relative humidity and adverse health effects.



Adapted from: Arundel, A.V., et al. "Indirect Health Effects of Relative Humidity in Indoor Environments." Environmental Health Perspectives. Vol. 65, p. 358 (1986).

In 2008, WHO published a housing and health guideline to provide global, evidence-based recommendations for policymakers and practitioners to improve housing conditions. It considered the entire housing lifecycle from construction to maintenance, and focusing on how to reduce risk factors for housing mainly in the city contexts.

Below are some key recommendations made in the WHO guidelines to promote healthy housing and indeed many of the issues raised are very typical in tent, settlement camp or transitional prefabricated housing after a disaster:

Table 2: Key recommendations of the WHO Housing and Health Guidelines

Issue	Recommendation	Strength of recommendation
Overcrowding	• Overcrowding prevention and reduction strategy	Strong
Home Safety and Injuries	• Measures to reduce housing hazards that can result in unintentional injuries. • Installation of safety devices such as stair gates, window guards and smoke alarms	Strong
Accessibility	• Taking into account the ageing population trend, as well as current and projected population with functional impairments, when providing adequate barrier-free facilities.	Strong
Insulation against indoor coldness	• Protecting dwellers from harmful health effects of coldness. • In cold and temperate areas, 18^{o}C is recommended for the general population during cold seasons	Strong Conditional
Indoor heat	• Developing and implementing strategy to protect population from high ambient temperature	Conditional

Source: World Health Organization (2018) WHO Housing and health guidelines. Available at: http://www.who.int/phe%0Ahttp://apps.who.int/bookorders. (Assessed 8 May 2019)

Housing and Health-EDRM in China

Under the leadership of the State Council, the Chinese government is also shifting to a proactive, risk-based, all-hazard and interdisciplinary approach in emergency and disaster risk management. China is frequently hit by natural disasters with significant life and economic

losses. To integrate scattered disaster management resources, step up emergency preparedness, and promote the effectiveness and capacity in emergency response, the State Council established the Ministry of Emergency Management in 2018. In the coming three years (2020-2022), a nation-wide comprehensive risk assessment on natural hazards will be conducted by a highly interdisciplinary team of experts. The objectives of the assessment are: (1) assessing the vulnerability of disaster-vulnerable entities such as the population, housing, infrastructure, public services, environment, etc., (2) evaluating the capacity of different regions in resisting and managing disasters, and (3) assessing the vulnerability of different regions in China. These are important steps and approaches that adhere to WHO’s Health-EDRM Framework.

As part of the nation-wide Precision Poverty Alleviation Campaign, the Central government has also made a significant move to reduce disaster risks through renovating dilapidated rural homes of impoverished households. The poor and/or underprivileged households with disabled or impaired family members receiving subsistence allowance from the government (i.e. Pinkunhu 貧困戶, Dibaohu 低保戶, Nongcun Fensan Gongyang Tekun Renyuan 農村分散供養特困人員, Pinkun Canjiren Jiating 貧困殘疾人家庭) and living in rural dilapidated homes are covered by the policy. As of the third quarter of 2019, the Central Government has supported over 28.27 million poor rural households to conduct renovation and make their home safe (27). The policy is supporting the most vulnerable rural communities to enhance safety of the housing environment and protect them from potential housing hazards resulted from disasters.

In terms of post-disaster temporary and transitional housing, indoor health hazards are generally prominent. Study revealed that the indoor temperature of post-disaster tents could be 9 degree Celsius higher than outdoor temperature even if it was not closed. Excess dampness is also very common in settlements. Immunocompromised patients, older people and children, who are common in post-disaster contexts, are all vulnerable to medical conditions such as asthma, respiratory and/or skin infections. An increased clinic visit was also observed for victims living in those temporary housing (28). The issue is particularly challenging for rural communities as they are generally not allowed to build their transitional shelters on farmland. For some mountainous area, the availability of land for settlement maybe limited. Rural communities are mostly encouraged to live with their relatives and friends or stay in their temporary tents. Prolonged stay in those tents with deteriorating indoor conditions will result in deteriorating health conditions of victims, and in turn further burden the healthcare system. Nevertheless, epidemiological evidence to guide policy is very limited.

Healthy housing: Local China context

In China, healthy building is in the domain of green building sector and it has experienced robust development in recent years. With the policy background of “Healthy China 2030”, the central

government has a significant shift in focus from disease treatment to health promotion and health management. While everyone has the responsibility to take care of their own health, it highlighted the importance to construct a "healthy environment". It also stressed collaboration and that all policies should incorporate health elements rather than only those from the health-related departments (29). Key indices reported in "Healthy China 2030" showed China was expected to extend life expectance to 79. The scale of healthy industry is expected to double to RMB 16 trillion by 2030 (30). In the 13th Five-Year Plan for the Development of Building Energy Efficiency and Green Buildings, it was also stressed that building should be people-oriented and meet the people's growing demand for "health" and "comfort" in built environment (31). In this regard, the Central Government had a political will to enhance primary prevention of disease and health promotion and management in recent years. Contextual research and demonstrative projects are needed to support local implementation.

From 2012 to 2015, the government has commissioned a national-wide study about the impact of indoor living environment to health. It provided a snapshot view on the health outcomes of inhabitants living in different climate zones of China. In the study, a total of 2,471 questionnaires were collected from provinces, states and cities from 5 climatic zones. Like the WHO housing and health guidelines, the study mainly focused on urban areas. Young adults and adults with age under 45 were their main respondents. The indoor environment of respondents is relatively stable for their access to air conditioning in summer and winter. It provided an overview showing the association of different indoor parameters and self-reported health outcomes of inhabitants. It also supported the development of the "China Healthy Building Standard", which offered guidance to the industry to construct a healthy living environment.

When examining studies that assessed thermal comfort of residents in rural China, findings indicated rural residents exhibited stronger ability to resist cold and reported a wider range of temperature for thermal comfort in winter.(32)(33) The comfortable temperature even ranged from 4.4 to 18.4 degree Celsius. Thermal comfort level was found around 15 degree Celsius for older people in rural area.(32) When referring to key performance parameter of indoor living environment in China (Table 2), the indoor living environment has already fall into Grade III and Grade IV. Vulnerable groups such as older people and children are likely to encounter health risks. As older people have a progressive decrease in thermal perception, acceptable temperature may not satisfy their long-term physical health requirement.

Table 3: Key Performance Parameter of Indoor Living Environment in China in Assessment Standard for Healthy Building (T/ASC 02-2016)

Item	Parameters	National Standard	Risk Level			
			Grade I	Grade II	Grade III	Grade IV

Comfort Level	Temperature ^{O}C	Summer	22-28	24≤ t ≤26	26< t ≤28	28< t ≤32	t > 32
		Winter	16-24	22≤ t ≤24	16≤ t <22	12≤ t <16	t<12 or t>24
		Transitional Season	18-32	18≤ t ≤32	-	t<18 or t>32	-
	Relative Humidity Φ (%)	Summer	40-80	40≤ Φ ≤80	60 < Φ ≤ 70	70 < Φ ≤ 80	Φ > 80
		Winter	30-60	30≤ Φ ≤60	30≤ Φ <40 60< Φ ≤70	20≤ Φ <30 70< Φ ≤80	Φ < 20 or Φ>80
		Transitional Season	30-80	30≤ Φ ≤80	-	Φ < 30 or Φ>80	-
Air Quality	CO^2 (%)		0.1	≤0.08	0.08~0.1	0.1~0.15	>0.15
	PM2.5 (μg/m^3)		75	≤35	36~75	76~150	>150

Grade 1: Within national standard, most satisfactory
Grade 2: Prolonged exposure may have health risk.
Grade 3: For vulnerable groups e.g. children and older people, they are likely to encounter health risk.
Grade 4: Health risk is prominent. Mitigation measures are crucial. Prolonged exposure will affect body function.

Source: 陳濱;"室內健康環境表徵參數及評價方法"研究課題組. 中國典型地區居住建築室內健康環境狀況調查研究報告 (2012-2015 年). 中國建築工業出版社; 2017.

Implications in the rural China context

Ageing population

According to the WHO (34), over 30% of the population in China will be over 60 by 2050. However, China only has slightly more than 20 years to adapt to such a change in population structure, when comparing with France where they have been using 150 years for similar adaptation. It's crucial and urgent to create an elderly friendly environment that promotes healthy ageing living environment subject to changing climate and environment. In China, the prevalence of hypertension among people aged 60 years and above was 66.9%. (35) Stroke, causing 20% of death per year, is also a leading causes of death in China. (36) In winter, there is higher incidence of diagnosed cardiovascular diseases for older people, which triggers unfavourable medical conditions. Disability and poor medical conditions resulted will have a negative impact on the wellness of the older people and their family, and further burden the healthcare system.

Vulnerable group in rural China

As of 2019, there were still 563 million of people living in rural area, despite rapid urbanisation in China. (37) Among all rural population, there were 288 million rural migrant workers spending most of the time in the city to make a living and returning their hometown only during holiday, mostly during Chinese New Year.(38) As they are not covered by medical insurance like other urban residents, they may need to return to their hometown to get alternative medical services in case they suffer from serious illness. For those poor rural migrant workers who cannot afford a living in urban area and obtain their resident identity in city, they will need to return to their home village after retirement. It implies older population in rural area will continue to increase in coming years if the resident registration system remains unchanged.

Population living in rural area is generally more vulnerable in terms of certain environmental and social determinants of health. Rural area is characterised by relatively poor toilet conditions, sanitation and access to quality healthcare services. In 2013, it was also reported that people living in rural area have high harmful drinking rate (10.3%) than those living in urban area (7.3%), with an average of over 61 grams/day alcohol consumption among men and 41 grams/day among women. (39) This is probably due to local custom and drinking culture, particularly in minority communities. As for housing, the housing standard and control for healthy indoor conditions are generally suboptimal. They are more vulnerable to extreme climate events and disaster risks.

In reality, a significant number of people spending most of their time living in the villages are older people, children, women and poor people who are left behind in the villages. They are particularly vulnerable during a disaster, and take a relative high share of disease burden associated with emergencies.(40) Studies also showed that children and older people are more susceptible to cold-associated infections due to their immature or weakening immunity. Evidence in Europe also suggested that women had greater risk than men in terms of heat-related illness.(40) In this regard, proper housing that can protect residents from cold, heat and extreme weather events provides crucial primary prevention and climate adaptation that helps promote resilience of vulnerable communities in rural China.

The knowledge gap in the China context

Lack of appropriate assessment tool

Despite all the available tools, guidelines and studies, localised tools and recommendations focusing on rural context remains very limited. Currently, all assessment tools available globally, as well as the China Healthy Housing Label all focus on building and housing environments in the urban context, or more specifically mostly used by high-end building and residential areas. The recommendations made by WHO housing and health guidelines mainly target inhabitants in the urban context. National, regional and local adaptations are required to prioritise and customise, subject to local context. As China is very large with diverse geographical, climatic

and cultural characteristics, vigorous localisation and adaptation of assessment tools are needed so that more relevant targeted recommendations could be made.

Lack of study linking housing conditions and health outcomes of rural inhabitants

At present, studies linking housing conditions and health outcomes for rural inhabitants in China are very limited. As reviewed in the WHO guidelines, further studies are needed to understand the impact of extreme temperature to old people, children and people with chronic illness.(10) Localised recommendations with technical conditions, level of development and human capacity and resources are necessary to address health hazards related to indoor dampness and mould.(41) Specifically on indoor temperature and health, a global systematic review also recommended that further studies to understand temperature threshold, with holistic view of all indoor environmental factors such as humidity and air velocity, are necessary to fill current knowledge gap.(21)

As for the nationwide indoor housing conditions survey conducted during 2012-15, limited information had been found for rural context, especially situation of how older population might have adapted. Furthermore, the study respondents were mostly living in housing with air conditioning and thus relatively stable indoor environment was expected. Many marginalised vulnerable groups might not be able to afford related electric appliance and energy bill to maintain a stable thermal indoor environment and their health outcomes remain unknown.

Currently available scientific evidence targeting rural China mainly focuses on understanding how the design and construction of building envelop can provide thermal comfort to residents, and they were conducted by experts from architectural/engineering field(32)(42)(43). Further studies to understand the linkage of indoor temperature and its health impact are needed so that more appropriate adaptation measures could be recommended.

Lack of study linking vernacular housing and health benefits to inhabitants

In the "Healthy China 2030" policy enacted by the Chinese State Council in 2016, promoting environmental health is one of the key elements to achieve "health for all". In terms of housing improvement in rural China, governments of different levels, experts and practitioners in the field have focused efforts on improving accessibility and safety of villagers living in remote disaster-prone locations through relocation. With the national dilapidated housing renovation scheme, structural performance of dwellings were also improved to enhance resilience of rural dwellers against natural disasters. Coupled with the ambitious targets of the targeted poverty alleviation campaign to tackle poverty with improved housing conditions by 2020, the quickest solutions are centralised and conventional united cluster of conventional brick and concrete houses, which could be realised in a relatively short time.

Nevertheless, these united concrete and brick houses are less sensitive to local climate, cultural, environmental and socio-economical limitations. Those solutions also imply potential housing debt, high carbon emission, high cost of maintaining thermal comfort, and large ecological footprints. Income gap could hardly be narrowed as most grassroots communities may not be able to participate in construction to enjoy related economic benefits or simply do not have a choice on their own dwellings. With the backdrop of fast economic growth of China in recent years, if the relatively low carbon footprint rural area follows the city’s mode of consumption and development, the nation could hardly achieve sustainability from economic, environmental and social point of view, or even simply provide a healthy and comfortable environment for the rural dwellers.

In the vast territory of China, many vernacular rural dwellings were built with different local materials, methods and styles with a wealth of local wisdom and culture. There exists traditional wisdom that could respond well to local climate, geography and socio-cultural needs through its long history of evolution. These vernacular rural dwellings could be locally appropriate in providing indigenous rural communities with better health outcomes, physiological and psychological "comfort" and better social environments for neighbourhood. Some typical examples are advanced rammed earth dwellings and stilt houses commonly found in different parts of rural China. Nevertheless, they are not the panacea for villagers as there remains health hazards are due to poor practices, drawbacks and limitations on construction technology. With appropriate technical innovation and advancement, they could become locally appropriate, affordable and sustainable dwellings that promote wellness, health and comfort. Some award-winning earth construction projects are currently available and they were being advocated in different provinces (44). However, no scientific evidence has been found to show the associations between housing environment and health.

Lack of study linking transitional housing and health benefits to inhabitants

In addition to rural inhabitants, reviews also indicated that research on temporary settlements for those displaced have been very limited and the health issues have been “utterly overlooked” (45). According to Sphere Minimum Standards for Shelter and Settlement, displaced people in a humanitarian context should have the right of living with human dignity, protection from climate and other risks, security and receiving humanitarian assistance to sustain family and community life as much as possible (46). Nevertheless, many temporary shelters have not been able to provide healthy living conditions, especially for rural areas with extreme climates. Evaluation and research on thermal performance of shelters are very limited. In many overseas cases, many displaced people may need to live for longer time than expected as their permanent homes may take time to be relocated and rebuilt.

Policy and research implication

Although healthy housing is catching more attention among policy makers and relevant industries, challenges remain prominent in the China context. China is a large country with diverse natural environment, climatic conditions, as well as socioeconomic and cultural characteristics. Various types of vernacular dwellings have been developed, which respond surprisingly well in terms of passive solar gains, thermal comfort, passive solar control and ventilation, etc.(47) In traditional Chinese philosophy, human is an integral part of nature *("Tian Ren He Yi"*) and it provides a simple and direct answer about the dependence of human health on earth as emphasised in the emerging field of planetary health. Some key research questions towards sustainable and healthy housing for all include the following:

1. What is the association between health and rural and transitional housing based on evidence?
2. How health-housing co-benefits can be measured?
3. How health-housing co-benefits can be maximised?

Limitations

This technical brief seeks to explore the potential of how housing in rural China might be adopted as a Health-EDRM strategy for climate adaptation. Given China is a vast county and the social-economic, cultural and geographical characteristics vary in different rural areas of China, more site-specific analysis and recommendation are not possible.

Moreover, the health of residents can be affected by many different factors in addition to housing. The performance of traditional houses also varies and they contain both drawbacks and merits. These all make the generalisation of the issue and recommendation difficult. Further intervention studies and health cost analysis on housing improvements would be useful to get quality evidence to guide policymaking.

Subject to the rapid development of rural area and policy, periodic reviews and updates of this technical brief will be necessary.

Conclusion

In view of the inadequate existing studies on the relationship between housing and Health-EDRM, extensive interdisciplinary researches are needed to see how the health impacts of housing can be measured and quantified, so as to fill the knowledge gap. Adequate housing is the right of all. With full respect, understanding and appreciation of the wealth of wisdom developed by ancestors, it is possible to bridge the knowledge gap and find a sustainable and locally appropriate way of realising healthy and resilient housing, as well as a sustainable, healthy and just planet home for all.

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