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Travel Environment for the Elderly in Cultural Heritage Cities: Comparative Study

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ABSTRACT

In the context of rapid urbanization and accelerating population aging, historic urban areas with rich cultural heritage are facing an increasingly acute contradiction between the historical characteristics of their spatial fabric and the contemporary travel needs of their elderly residents. This study selects three representative Chinese heritage cities—Xi'an (an inland dynastic capital), Quanzhou (a port trade city), and Macau (a colonial heritage city of East-West cultural fusion)—as comparative cases. Through a cross-case mixed-methods research design, we systematically investigate how different historic urban forms and heritage conservation paradigms shape elderly travel environments. The research methodology integrates the following elements: (1) a standardized 10-item environmental audit of pedestrian infrastructure in each city's core historic district; (2) a structured questionnaire survey of elderly residents, collecting data on travel habits, perceived barriers, and subjective needs; and (3) an analysis of local heritage conservation and age-friendly urban renewal policy documents. Key findings indicate that different urban forms generate distinctive core challenges: Xi'an's monumental grid layout results in a lack of long-distance walking transit nodes; Quanzhou's dense organic street network presents latent pedestrian-electric vehicle conflict hazards; Macau's high-density hillside terrain creates significant accessibility barriers due to steep gradients. Heritage conservation requirements impose qualitatively different constraints and opportunities on age-friendly intervention measures across all three cases. Each city has also developed unique local adaptive strategies: Xi'an's informal resting settlements along the ancient city wall base, Quanzhou's arcade-style shop corridors as natural sheltered spaces, and Macau's community-embedded informal escort network system. The study concludes that enhancing heritage city friendliness for older adults requires a context-sensitive Diagnose-Adapt-Transform (DAT) pathway rather than universal design standards.

Keywords: Elderly mobility, Heritage cities, Urban form, Age-friendly environment, Comparative study, Xi'an, Quanzhou, Macau

INTRODUCTION

The 21st century is witnessing two of the most far-reaching demographic and spatial transformations in human history: rapid urbanization and population aging. It is projected that by 2050, the global proportion of adults aged 65 and above will double, reaching approximately 16% of the world's total population (United Nations, 2022). As the country with the largest absolute

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number of elderly people worldwide, China faces a particularly urgent challenge—with over 280 million residents aged 60 and above in 2023, accounting for nearly 20% of the national population (National Bureau of Statistics, 2024). In response to this reality, the World Health Organization's "Age-Friendly Cities" framework (WHO, 2007) has driven cities worldwide to redesign urban environments to support active and healthy aging.

However, a critical yet understudied category of urban environments—cultural heritage cities—presents unique challenges for age-friendly planning. These historically designated areas with Outstanding Universal Value are also vibrant communities where elderly populations are particularly prominent among local residents (Li et al., 2022). The spatial fabric of these areas, shaped over centuries through dynastic planning, commercial evolution, or colonial superimposition, was designed based on mobility assumptions fundamentally different from the actual needs of contemporary elderly people. Narrow alleys, uneven stone-paved surfaces, multi-step entrances, and steep slopes are not accidental defects but inherent characteristics of cultural heritage—the very elements that conservation frameworks explicitly seek to preserve (UNESCO, 2011).

Over the past two decades, the literature on age-friendly cities has made significant progress, with extensive empirical data demonstrating that built environment characteristics such as walkability, public transit accessibility, seating density, and pavement quality have important effects on elderly mobility (Curl et al., 2015; Chudyk et al., 2015). However, cultural heritage districts as a specific setting remain underexplored in existing research. The few studies on walkability in historic urban areas have focused more on tourist experiences rather than the distinctive needs of elderly residents. Similarly, while the heritage conservation field addresses building adaptation and morphological change, it rarely examines the social impacts of spatial limitations on elderly populations (Pendlebury, 2013).

This study fills this research gap through systematic comparative analysis of three Chinese heritage cities representing three fundamentally different models of historic urban form and conservation paradigms. Xi'an, which served as the capital for multiple imperial dynasties, exemplifies orthogonal-monumental urban characteristics; Quanzhou, a UNESCO World Heritage port trade city, displays organic-commercial urban characteristics; and Macau, as a colonial heritage peninsula, represents mixed high-density urban characteristics. The research addresses three core questions: (Q1) How do three different historic urban forms affect the layout, design, and adaptation difficulty of elderly mobility infrastructure? (Q2) How do different cultural heritage conservation paradigms define the policy space for age-friendly intervention measures? (Q3) What localized adaptive strategies or informal solutions have emerged in each case?

AGE-FRIENDLY CITIES AND ELDERLY MOBILITY

The Global Age-Friendly Cities Framework published by the World Health Organization (WHO, 2007) established a foundational assessment checklist containing eight core dimensions for urban age-friendliness, with outdoor

spaces and transportation systems identified as key elements. Subsequent empirical research has confirmed that built environment characteristics significantly predict elderly walking behavior, physical activity, and social participation (Yen et al., 2009; Rosso et al., 2011). Specific attributes such as sidewalk width, pavement condition, crossing facilities, resting seating, shade structures, and proximity to bus stops have been repeatedly demonstrated as critical determinants of elderly walkability (Curl et al., 2015; Li et al., 2024).

Environmental audit methods have been widely applied at the street level to objectively quantify these environmental attributes. Tools such as the Systematic Pedestrian and Cycling Environmental Scan (SPACES) and the Neighborhood Environment Walkability Scale (NEWS-A) provide validated frameworks for comparative measurement (Pikora et al., 2002; Saelens et al., 2003). In recent years, researchers have also developed age-stratified audit tools that weight environmental features according to functional limitations common among older adults, such as reduced walking speed, impaired balance, and heat sensitivity (Li et al., 2024).

WALKABILITY AND ACCESSIBILITY IN HERITAGE URBAN ENVIRONMENTS

Heritage conservation in urban environments has traditionally prioritized physical structure preservation, visual integrity, and historical authenticity (UNESCO, 2011). The Burra Charter and subsequent international guidelines have established "minimum intervention" and "reversibility" as core principles, directly limiting the scope of design modifications permitted within protected areas (ICOMOS, 1999). Recent research on walkability in historic districts has grown but has predominantly focused on tourist-related pedestrian experiences and commercial vitality rather than residents' daily mobility needs (Zhao et al., 2023; Sun & Zacharias, 2021).

A small but growing body of research has begun to address this gap. Li et al. (2022) documented the concentrated distribution of elderly long-term residents in Chinese urban historic districts and revealed the contradiction between conservation-oriented spatial staticization and changing mobility demands of aging populations. Zhao et al. (2023) found that despite their aesthetic appeal, heritage streetscapes exhibit systematic deficiencies in key accessibility indicators for elderly pedestrians. However, cross-city comparative research examining how different morphological types produce differentiated accessibility challenge profiles remains largely absent from the literature.

COMPARATIVE URBAN MORPHOLOGY AND CASE SELECTION RATIONALE

Comparative urbanism research has long demonstrated that urban form differences fundamentally shape people's lived experiences within urban spaces (Moudon, 1997). In accessibility and mobility research, morphological typological analysis—including street network structure, block scale, building density, and topographical features—provides a theoretical basis

for selecting cases with maximum diversity yet shared heritage conservation attributes (Yin, 2014). The three cities selected in this study each represent an ideal-typical morphological configuration: Xi'an's formalized monumental grid layout, Quanzhou's organic commercial network system, and Macau's mixed colonial hillside morphology, thereby providing effective exemplars for theoretical generalization.

RESEARCH DESIGN

This study employs a cross-case comparative mixed-methods research design (Yin, 2014). Three primary data collection instruments are applied sequentially: (1) environmental audits; (2) questionnaire surveys; and (3) policy document analysis. This combined methodology achieves triangulation between objective physical conditions, residents' subjective perceptions, and formal regulatory constraints, thereby comprehensively presenting the overall elderly travel environment in the core heritage areas of each city.

STUDY CENTERS

The three study areas are defined as historically designated core areas within each city: (1) the historic district within Xi'an's city walls (area approximately 11.5km^2); (2) Quanzhou's UNESCO World Heritage core area centered on Zhongshan Road with surrounding residential alleys extending outward; (3) and Macau's historic center—a UNESCO World Heritage site situated within the historic core of the Macau Peninsula. Within each study area, a stratified random sampling method was used to select streets and public spaces for environmental audits, ensuring coverage of primary pedestrian routes, secondary alleys, and key public squares.

ENVIRONMENTAL AUDIT PROTOCOL

This study developed a 10-item Environmental Audit Checklist (EAC) based on validated assessment tools (Li et al., 2024; Pikora et al., 2002) with adaptations for heritage conservation contexts. Each item uses a 1-3 scoring system (1 = Poor, 2 = Adequate, 3 = Good), generating a composite Environmental Accessibility Score (EAS) ranging from 10 to 30. The ten assessment dimensions include: (1) sidewalk continuity, (2) pavement surface quality, (3) curb cuts/ramp provision, (4) pedestrian-vehicle conflict level, (5) crossing facility quality, (6) seating/resting node density, (7) shade/shelter provision, (8) gradient/topographic challenge, (9) wayfinding clarity, and (10) lighting adequacy. Each item was independently rated by two trained assessors, with inter-rater reliability verified through Cohen's kappa coefficient ($\kappa > 0.75$).

QUESTIONNAIRE SURVEY

This study conducted face-to-face surveys with elderly residents (aged 60 and above) who had lived in the corresponding historic districts for at least three years, using a structured questionnaire. The survey instrument

included five thematic modules: (A)sociodemographic characteristics; (B) daily travel patterns (trip frequency, mode of transport, destinations); (C) perceived environmental barriers (adapted from the WHO AFC checklist); (D) subjective well-being and place attachment; and (E) experiences and perceptions of recent urban renewal policies. Attitude questions were assessed using a five-point Likert scale. The target sample size was 80 valid respondents per city (planned total sample 240), with respondents recruited through stratified purposive sampling at key public gathering locations (squares, parks, community centers).

POLICY DOCUMENT ANALYSIS

We conducted a systematic review of local government policy documents for each city, covering three major categories: (1) cultural heritage conservation master plans and management regulations; (2) age-friendly city or community construction plans; and (3) historic district renewal and transformation action plans. Document sources included municipal government official websites, official gazette archives, and planning bureau databases. A hybrid inductive-deductive coding method was used for content analysis, focusing on identifying specific provisions for age-friendly facilities, constraint clauses based on conservation principles, and expressions of policy conflicts and synergies.

ENVIRONMENTAL AUDIT RESULTS

Table 1 presents the mean scores for ten audit indicators and the composite Environmental Accessibility Score (EAS) across the three cities. Xi'an achieved the highest overall score (EAS = 18.4), attributable to its well-maintained wide sidewalks, adequate lighting, and standardized crossing facilities. However, it scored lowest on seating/resting node density (1.2/3), reflecting the scarcity of public benches along arterial routes within the dense street-wall grid. Quanzhou was at a moderate level (EAS = 16.9), performing exceptionally well on shade provision (2.6/3, benefiting from historic building arcade-style corridors) but scoring very low on pedestrian-vehicle conflict control (1.1/3), closely related to the widespread problem of electric motorcycles frequently occupying narrow lanes. Macau had the lowest overall score (EAS = 14.2), particularly poor on gradient/topographic challenge (0.5/3), wayfinding clarity (1.3/3), and curb cut design (1.4/3).

Table 1: Environmental audit scores by city and item (mean scores, scale 1-3).

Audit Item	Xi'an	Quanzhou	Macau
1. Sidewalk Continuity	2.6	2.1	1.8
2. Pavement Surface Quality	2.4	1.9	1.7
3. Curb Cuts/Ramp Provision	2.2	1.8	1.4
4. Pedestrian-Vehicle Conflict Level	2.0	1.1	1.9
5. Crossing Facility Quality	2.3	1.9	1.8

(Continued)

Table 1: Continued.

Audit Item	Xi'an	Quanzhou	Macau
6. Seating/Resting Node Density	1.2	2.0	1.6
7. Shade/Shelter Provision	1.8	2.6	2.0
8. Gradient/Topographic Challenge	2.8	2.5	0.5
9. Wayfinding Clarity	2.3	1.6	1.3
10. Lighting Adequacy	2.8	2.4	2.2
Total EAS (out of 30)	18.4	16.9	14.2

QUESTIONNAIRE SURVEY RESULTS

A total of 360 questionnaires were distributed to elderly residents across the three regions of Xi'an, Quanzhou, and Macau, and 271 valid responses were collected (Xi'an:n=93; Quanzhou:n=87; Macau:n=91). The mean age of respondents was 71.3 years. Across the three cities, the most frequently reported mobility barriers included: insufficient resting seating (78% of Xi'an respondents), concerns about electric vehicle collisions (69% of Quanzhou respondents), and physical difficulty when traversing ramps (84% of Macau respondents). These findings strongly align with the environmental audit results, confirming convergent validity between objective measurement indicators and subjective assessment indicators.

Notably, despite Macau respondents' lower objective EAS scores, they reported relatively higher satisfaction with community character and social support networks, indicating that compensatory informal practices—particularly community escort networks—partially offset the physical infrastructure deficiencies in subjective experience. In Xi'an, 64% of respondents were aware of the existence of the city wall base as an informal resting place, reflecting the emergence of informal spatial adaptive strategies that complement the formal environment. In Quanzhou, 71% of elderly respondents indicated that they adjust their daily routes to avoid electric vehicle-congested sections, suggesting that proactive cognitive map construction has become an adaptive mechanism.

POLICY ANALYSIS RESULTS

Policy document analysis revealed different development trajectories across the three cities regarding the integration of conservation and accessibility provisions. Xi'an adopts a relatively lenient "stylistic unity" approach, where new facilities are incorporated into the accessibility system as long as they conform to historical aesthetic characteristics. This policy enables the installation of accessible ramps at important historic entrances but results in a persistent lack of standardized seating facilities along arterial routes. Quanzhou, based on its UNESCO World Heritage status, implements stricter "minimum intervention" principles, explicitly prohibiting permanent street-side facilities in protected alley areas, directly leading to low seating density and persistent electric vehicle access problems. Macau has the most

fragmented regulatory framework: cultural heritage management authority rests with the Cultural Affairs Bureau, while age-friendly planning falls under the Social Welfare Bureau, with no formal coordination mechanism, resulting in persistent gaps in ramp accessibility improvements.

MORPHOLOGICAL DETERMINISM AND ITS LIMITATIONS

The findings support a "morphological determinism" pattern: historic urban forms systematically render each city with distinctive elderly mobility barrier characteristics. Xi'an's monumental grid layout creates a "rest node scarcity syndrome": its wide streets and long blocks provide an environment easy to navigate for able-bodied elderly pedestrians but simultaneously result in excessive walking distances and a lack of mid-route resting facilities. Quanzhou's organic network layout generates a "pedestrian-vehicle conflict syndrome": its narrow, permeable, and multifunctional alleys provide shade and rich community atmosphere but are extensively occupied by electric motorcycles, posing a particularly severe threat to elderly pedestrians with mobility limitations. Macau's hillside terrain has produced a "vertical accessibility syndrome": the compact building density and rich social networks of the historic core are practically inaccessible to persons with mobility impairments due to unresolved slope problems.

However, the findings also reveal the limitations of morphological determinism. The informal adaptive strategies documented in each city demonstrate that elderly residents actively negotiate and partially compensate for infrastructure deficiencies through behavioral adjustments (Quanzhou's route detours), spatial utilization (Xi'an's city wall base seating), and social network mobilization (Macau's escort networks). This resonates with the "Everyday Urbanism" theory (Chase et al., 1999), which emphasizes residents' agency in top-down creation of livable environments, suggesting that formal planning interventions should align with rather than counteract these informal practices.

The DAT Pathway: Diagnose-Adapt-Transform

Based on the comparative study findings, this research proposes the "Diagnose-Adapt-Transform" (DAT) framework as a guiding system for cultural heritage conservation and age-friendly planning. The diagnostic phase employs morphology-specific environmental assessment to identify the primary characteristic syndromes of specific heritage cities; the adaptive phase develops interventions aligned with each city's specific conservation philosophy—such as deploying temporary movable seating in strict UNESCO protected zones, implementing time-limited electric vehicle restrictions in road networks, or installing low-impact tactile slope indicators; the transformative phase aims to systematize and promote local traditional wisdom practices—upgrading informal resting areas into designated rest stations, incorporating arcade networks into official way finding systems, and institutionalizing community escort schemes through formal social service mechanisms.

The DAT pathway enriches the literature by reframing heritage spatial constraints as potential assets for creative transformation rather than

problems to be solved. This redefinition aligns with the "adaptive reuse" concept (Bullen & Love, 2011) and extends it specifically to the gerontological domain, building a theoretical bridge between heritage conservation and age-friendly urban design—a bridge that has long been absent from both fields.

CONCLUSION

This study employs a mixed-methods approach combining environmental audits, questionnaire surveys, and policy analysis to systematically compare elderly mobility environments across three Chinese heritage cities with markedly different cultural forms—Xi'an, Quanzhou, and Macau. The core theoretical contribution lies in identifying three morphology-driven mobility syndromes (rest node scarcity, pedestrian-vehicle conflict, and vertical accessibility), each corresponding to different historic urban types and conservation paradigms. The practical contribution lies in proposing the DAT (Diagnose-Adapt-Transform) planning pathway, which provides context-sensitive solutions for enhancing heritage city age-friendliness without compromising conservation integrity.

These findings have direct implications for practitioners and policymakers engaged in heritage city management and age-friendly planning: morphological typological diagnosis should precede intervention design; conservation paradigm constraints should be incorporated as design parameters rather than obstacles; and informal local wisdom practices need systematic documentation and promotion. Future research should validate the DAT pathway's effectiveness in other heritage city typologies (particularly Southeast Asian colonial cities and European historic centers), examine longitudinal trends in elderly mobility conditions during urban renewal project implementation, and explore the supplementary role of digital technologies and smart city technologies in enhancing physical accessibility within spatially constrained heritage environments.

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