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DOI:
10.1016/j.ecolind.2022.108602

Document Version
Final published version

Citation for published version (APA):
Chen, W., Wang, Y., Ren, Y., Yan, H., & Shen, C. (2022). A novel methodology (WM-TCM) for urban health examination: A case study of Wuhan in China. *Ecological Indicators*, *136*, [108602]. https://doi.org/10.1016/j.ecolind.2022.108602

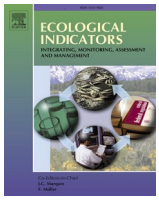
Published in:
Ecological Indicators

Ecological Indicators 136 (2022) 108602

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



Original Articles

A novel methodology (WM-TCM) for urban health examination: A case study of Wuhan in China

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ARTICLE INFO

Keywords:
Urban health examination
Urban diseases
Quantitative indicator
Indicator benchmark
Resident satisfaction
Wuhan

ABSTRACT

Rapid urbanization has brought the rampant sprawl of cities and various urban diseases have been emerging. How to effectively understand the health status of a city and diagnose the underlying problems of urban development have therefore become a critical issue. Previous studies have not yet provided scientific methodology for urban health examination. This study proposes a novel method (WM-TCM) incorporating objective (quantitative indicator-based examination) and subjective perspective (urban resident satisfaction survey) for urban health examination. A case city of Wuhan in Central China was employed. The results show that: (1) WM-TCM methodology is effective in diagnosing the underlying urban diseases; (2) In Wuhan, the urban issues such as housing price, traffic operation efficiency, property management, solid waste management, and car parking are the critical aspects jeopardizing sustainable urban development. The results also suggest that the opinions and perceptions of urban communities should be well integrated during the decision-making process of urban planning, construction, and management. It would be helpful to diagnose and to prevent urban diseases, and in end to contribute towards healthy and sustainable urban development.

1. Introduction

Urbanization is a process of population shifting from rural areas to the urban areas, and it has become an inevitable trend around the world (Ren et al., 2018). According to World Bank (2020), the proportion of global urban population has increased from 30% to 56% during the period of 1950–2019, and it is predicted that by 2050, 66% of world population will inhabit in urban areas (Madanian et al., 2018). Being as the largest-volume developing country worldwide, China has witnessed an unprecedented urbanization process since the reform and open-up in 1980s, evidenced by the booming urbanization rate from 17.9% to over 60% at national level (Fang et al., 2021; Zhang et al., 2019). The large scale and rapid urbanization development has in turn boosted China's economic prosperity and brought various social benefits (Shen et al., 2018).

However, the rapid urbanization in the country is indeed a double-edged sword which has also caused a series of problems, such as air pollution (Fang et al., 2016; Wang et al., 2017), lack of energy (Sheng and Guo, 2018), inefficient public services (Dyson, 2011), low living standards (Li et al., 2018), and land resources wasting (Xu et al., 2019). These problems, also labeled as "urban diseases", seriously hinder the quality of urbanization development. Therefore, it is imperative to diagnose these "city diseases" and design tailored "prescriptions" to address each type of urban disease and further harnessing towards the healthy urban development.

Chinese central government has indeed realized the importance of diagnosing city diseases and has proposed an initiative named "urban health examination" which aims to shape cities towards healthier, safer, and more livable. At local level, the municipality government of Beijing has played the leading role in implementing "urban health examination" programme since 2018. Furthermore, the scale of urban health examination in China has further expanded to cover 11 pilot cities in 2019, and later in the year of 2020, 36 cities have been selected as the target cities to examine their urban health performance during the rapid urbanization process (Zhang et al., 2021a).

The main philosophical hypothesis underlying the "urban health examination" is that a city is regarded as a human body (Zhang et al., 2021a). Thus, a health examination conducting upon a city is similar to

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https://doi.org/10.1016/j.ecolind.2022.108602
Received 1 October 2021; Received in revised form 9 January 2022; Accepted 24 January 2022
Available online 4 February 2022

checking physical situation of human body, and the main objective of urban health examination is to evaluate the status of urban planning, urban construction, and urban management systematically, by which the "urban diseases" can be diagnosed and shortcomings can be investigated. Following the capture and identification of "city diseases", in-depth analysis can be conducted to examine the root causes of these diseases. A series of correct medications (measures) can thus be designed to tackle and treat the identified city diseases. From this perspective, conducting urban health examination is able to contribute towards the modernization of urban management and governance capabilities, and also the harnessing towards high-quality urban development. To achieve above objective, the premier task for the urban health examination is to assess the health status of cities and diagnose the "urban diseases".

Assessing urban performance and evaluating urban development processes has become, given its policy implications, a key focus of literature. Usually, indicators for assessing urban performance can be classified into two categories, namely, "hard" indicators and "soft" indicators, and "hard" indicators are based upon objective performance data and "soft" indicators are overwhelmingly based upon subjective survey or satisfaction survey (Brown and Coulter, 1983; Kelly and Swindell, 2002). Specifically, objective perspective represents the external condition and reports the factual status as well overt behaviour of cities, which is considered external to individual urban resident perception, and objective perspective based urban performance assessment typically includes the "tangible" aspects such as urban physical environment, urban economic, and technical development. In this regard, numerous objective-perspective based indicator systems have been proposed by extant studies to measure the city performance across different dimensions, such as sustainability (Zhou et al., 2021; Leach et al., 2017), low-carbon performance (Wang et al., 2021), city smartness (Sharifi, 2020), cities' energy performance (Muñoz et al., 2020), resources and environment carrying capacity of cities (Ren et al., 2021; Wei et al., 2019; Shen et al., 2021; Wang et al., 2020a), urban resilience (Shi et al., 2021; Kabir et al., 2018), and economy eco-city (Li et al., 2021). However, objective indicator based assessment of urban performance can be biased and may suffer from both under-reporting or over-reporting (Das, 2008). Also, objective perspective based indicators may not accurately reflect urban residents' well-being experience, which is a complicated sense and is determined by multiple aspects rather than simply gauged by descriptive indicators based on external "tangible" circumstances in an urban society (Das, 2008). Besides, the objective perspective-based indicators for assessing urban performance may also involve subjective decision making in terms of indicator selection and weighting setting (Ren et al., 2021). Therefore, it is important to take into account subjective well-being of urban residents in conducting urban performance assessment (Nakamura and Managi, 2020).

Subjective perspective based urban performance assessment is overwhelmingly conducted via appraising individual's objective perception of urban life (Das, 2008). Specifically, some subjective perspective based indicators have been proposed by extant literature to gauge citizens' satisfaction (Zenker et al., 2013; Florida et al., 2013). For example, Van ryzin and Immerwahr (2007) introduced the importance-performance analysis by using urban citizen surveys to facilitate public administrators' understanding of citizens' subjective perception of urban governance performance. In fact, residential satisfaction is an important metric in gauging urban development performance, as according the principle of people-oriented, the efforts paid upon improving city performance ultimately affect and comfort city inhabitant.

Therefore, it is strongly recommended and necessary that both objective and subjective perspective based indicators should be incorporated in Quality of Life studies. If a piece of research utilizes jointly objective and subjective indicators, it probably could develop more reliable and valid inferences upon the level of quality of living in a certain urban environment and it could also identify more effectively the areas for future possible action towards enhancing urban development quality. (Milbrath 1979).

This study *aims to establish a novel methodology for conducting urban health examination and diagnose "city diseases", from both subjective and objective perspectives*. To establish the urban health examination methodology, Western Medicine (WM) method and traditional Chinese medicine (TCM) method will be jointly adopted, which represents the quantitative and qualitative based approach respectively. Following the establishment of urban health examination methodology, the Wuhan city of China will be selected as the case to demonstrate the effectiveness and applicability of established method.

The rest of this research article is therefore established as follows: Section 2 develops the theoretical foundation and conceptual framework of urban health examination from West Medicine (objective) and Traditional Chinese Medicine (subjective) dual perspectives; Section 3 presents the specific methodology and techniques for West Medicine based and Traditional Chinese Medicine based urban health examination; Section 4 demonstrates the applicability of the established urban health examination methodology via a case study in Wuhan City of Central China; Section 5 discusses the findings synthesised from case study, policy implications as well as the effectiveness of urban health examination methodology; followed by the conclusion in Section 6.

2. Urban health examination: Theoretical philosophy and conceptualization

2.1. Physical examination

A physical examination is an evaluation of human body health and its functions using the approaches of inspection, palpation, percussion, and auscultation. A complete human body health assessment also includes gathering information about a person's medical history and lifestyle, conducting laboratory tests, and screening for disease. A comprehensive physical examination provides an opportunity for the healthcare professional to obtain baseline health information about the patient for future use, and to investigate the risks of potential diseases, by which proper medicine or action can be taken to prevent the further emergence or deterioration of diseases (The free dictionary by Farlex, 2021).

There are generally two approaches for human body physical examination and medical diagnosis, namely Western Medicine method and Traditional Chinese Medicine method:

- Western Medicine (WM) Method. Laboratory tests are adopted to examine the performance of patient's body systems, such as head, breasts, heart, musculoskeletal, and pulmonary systems. Particularly, some vital physical examination indicators or signs including pulse, breathing rate, body temperature, and blood pressure are observed and recorded. Medical professionals can detect any irregularities in terms of body health by comparing the patient's body performances of these indicator with the benchmark or normal value.
- Traditional Chinese medicine (TCM) method. TMC originates from ancient China and has a long history. The important role of TCM and its profound influence upon the health care system is well appreciated. In referring to the principle of TMC, four methods of TCM are usually adopted to diagnose disease, namely, look, listen, question, and feel the pulse[1] (Chan, 1995; Zhang et al., 2021a). In other word, the TCM diagnosis is based on the subjective description and feelings of signs and symptoms from patients.

Above two approaches of human body medical diagnostics provide valuable theoretical foundation for conceptualizing the methodology

[1] 望、闻、问、切

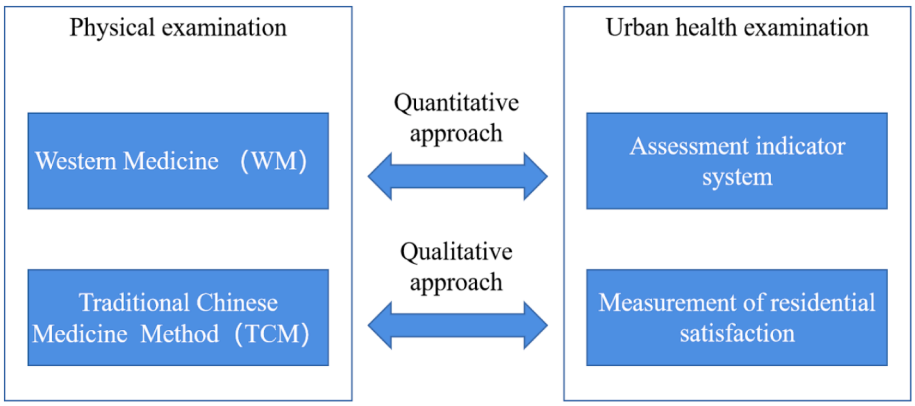

Fig. 1. Conceptual framework for urban health examination.

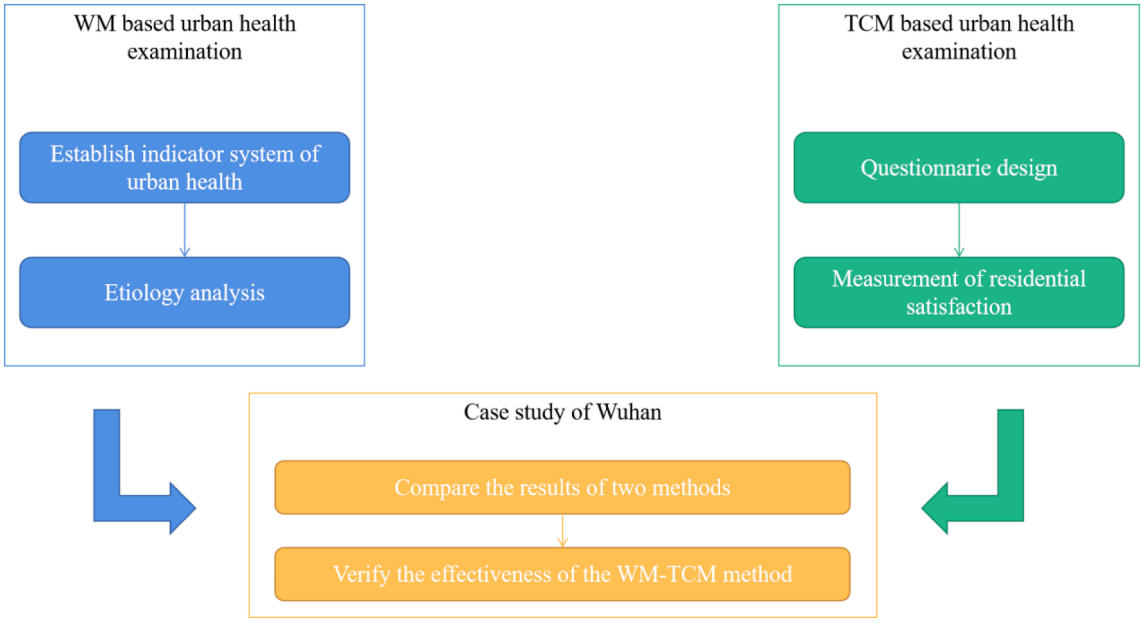

Fig. 2. Research roadmap.

framework of urban health examination to diagnose and understand the potential health risks and disease of cities.

2.2. Conceptual framework of urban health examination

Centred with the discussion of what can be regarded as a 'good city', researchers have continuously explored to interpret this conception from various viewpoints. While the most-widely accepted viewpoint is that a good city should be capable to support development and coordinate with the city's functions as well as achieve efficient operations offering economic prosperity, comfort natural environment, high living standards, social equity, and cultural vitality (Feldmann, 2008; Ren et al., 2021). And the core principle for defining "urban health" or "healthy city" is that the city can meet its development needs and goals while addressing properly urban diseases, and provide an ecological, comfortable, safe, ordered, convenient living environment to properly support and satisfy the work, living, mobility and other key demands of urban residents.

In fact, similar to human body, a city can be appreciated as an organic life system which is composed by complex interdependent subsystems across both "hard" and "soft" aspects, such as housing, transportation, sanitation, facilities, land use, commodities, and communication (Leach et al., 2019; Wang et al., 2020b). These subsystems function jointly to maintain the dynamic healthy status of an urban society, just like a human body system (for example, transportation facility system enables the elements mobility and flow in cities as blood system that pumps blood across human body). The interwoven connection of above urban sub-system facilities the interaction between urban inhabitant, government bureaus and private-sectors, and benefits each stakeholders by improving product circulation efficiency and public service delivery during the urban development process (Leach, et al., 2019). However, the improper concentration of urban "hard" and "soft" components can also induce significant negative consequences, such as generating urban heat islands, air pollution, and inefficient public services. Therefore, it is essential to conduct urban health examination to help city governors to understand the health status of the concerned urban context and identify timely the underlying urban diseases.

Usually, two different approaches are adopted to evaluate urban performance (Luque-Martínez and Muñoz-Leiva, 2005):

- *Assessment indicator systems based approach.* This type of urban health examination approach usually establishes an evaluation indicator system from a specific point of view. Then, numerical empirical data

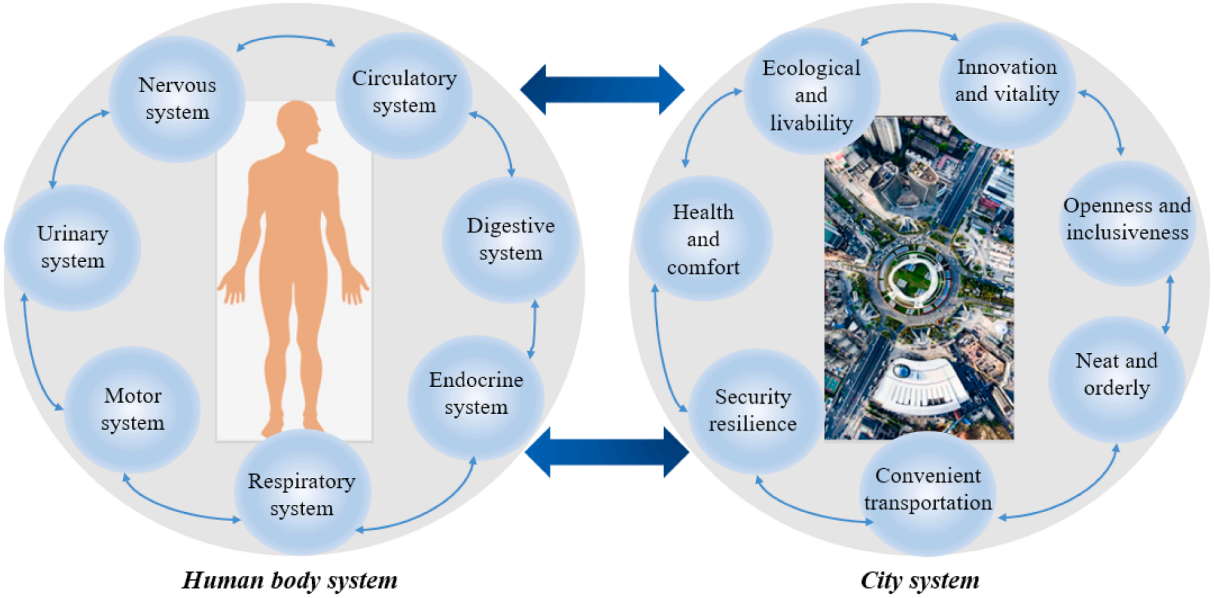

Fig. 3. Illustrative city system for conducting urban health examination.

of diagnosis indicators can be collected from statistical yearbooks, publications, and government websites (Zhou et al., 2015). Consequently, city development status can be measured via these indicator performances.

- Residential satisfaction based method. Citizens or residents are enjoying the function of different urban services, whose opinion can directly reflect the quality of urban development. This approach based city performance assessment first collect the opinion from a group of citizens or political, economic, social and cultural leaders via questionnaire, in-depth interviews, focus group, etc. It is appreciated that the approaches of in-depth interview or focus group allow the prior identification of the underlying factors promoting or hindering urban health condition (Luque et al., 2002; Wong, 2002).

As shown in Fig. 1, the approaches of human physical examination and the approaches of urban performance assessment share similar philosophical idea. Inspired by the human physical examination, this study proposes an innovative methodology for urban health examination, which combines the principle and idea of "WMM" and "TCM" to diagnose "city diseases". Specifically, urban health condition will be examined in a quantitative way by using evaluation indicator system and etiology analysis (WM). Simultaneously, a qualitative approach of public satisfaction measurement will be adopted to assess urban inhabitant's satisfaction (TCM). The adoption of "subjective"-"objective" dual approaches can help conduct effectively and holistically the city health examination and diseases diagnosis, thus reduce the risk, prevent the recurrence and deterioration of urban diseases.

3. Research roadmap

Based on the above theoretical foundation and conceptual framework, this study proposes a WM-TCM methodology for urban health examination, and the research roadmap of this study is shown in Fig. 2.

The methodology for urban health examination is composed by two components, namely, West Medicine (WM) based urban health examination and Traditional Chinese Medicine (TCM) based urban health examination. Specifically, WM method for urban health examination includes two procedures: Firstly, a comprehensive evaluation indicator system of urban health will be established by referring to extant literature and discussion with government officials; and then, an etiology analysis will be conducted to diagnose city diseases. TCM method for urban health examination also includes two stages: firstly, a questionnaire will be designed in responding to the indicator system of urban health examination; then, a measurement scale will be established to examine urban residents' satisfaction upon the city's health status. Followed by the WM-TCM methodology establishment, the city of Wuhan in Central China will be adopted as the case city to conduct urban health examination. Consequently, the urban diseases identified by above two methods will be compared to verify the effectiveness of the proposed WM-TCM methodology and analyze the city health and development status of Wuhan, based upon which policy implications will be synthesised to inform urban development in Wuhan and in a wider context of urban China towards enhancing city healthy status and urban well-being.

3.1. WM method for urban health examination

3.1.1. Establishing indicator system of urban health

In western medicine or modern medicine, some important indicators are chosen as the symptoms for measuring physical health. By applying this principle of western medicine, the first step for urban health examination is to determine the explicit indicator system of urban health. Urban health examination is a comprehensive inspection of urban development status, covering various subsystems across urban economy, urban society, urban population, urban resource, environment, and other subsystems of cities (Zhang et al., 2021a,b). These subsystems function jointly to maintain the dynamic healthy status of an urban society, just like how the organ subsystems works and operates within a human body (see the illustrative Fig. 3). Each individual subsystem is inter-related, interacted and restricted with each other. Under the guidance of Ministry of Housing and Urban-Rural Development of PRC, this study establishes the evaluation indicator system by referring to the existing literature and authoritative indicator systems, including China's Habitat Environment Award Evaluation Indicator System (Ministry of Housing and Urban-Rural Development of PRC, 2016), Sustainable Development Goals (United Nations, 2021), Global City Indicators (World Bank, 2009), Urban Indicator (UN-Habitat, 2014). Consequently, seven dimensional aspects are considered for urban health examination, namely, ecological and livability, health and comfort, security resilience, convenient transportation, neat and orderly, openness and inclusiveness, innovation and vitality.

Following the establishment of urban health examination

Table 1
Urban health examination indicator system.

Target Layer	Criterion Layer	Indicator Layer
Urban health examination	Ecological and livability	Regional development intensity (%)
		Green coverage rate in built-up area (%)
		Days with good air quality (day)
		Proportion that the quality of urban water environment better than the five categories (%)
		Service radius coverage rate of parks and green spaces (%)
		Proportion of green buildings in new buildings (%)
	Health and comfort	Coverage rate of community convenience service facilities (%)
		Coverage rate of community service facilities for the elderly (%)
		Coverage rate of inclusive kindergartens (%)
		Community health service center outpatient share rate (%)
		Sport facility area per capita (m^2/person)
		Proportion of land area used in old communities (%)
		Number of beds in medical institutions per 1,000 people (units/1,000)
	Security resilience	Urban death rate per 10,000 vehicles (unit person/10,000 vehicles)
		Refuge area per capita (m^2/ person)
		Safety mortality rate from production accidents per 100,000,000 yuan GDP (%)
		Capacity of urban medical waste treatment (%)
	Convenient transportation	Average vehicle speed during peak hours (km/h)
		Density of urban road network (km/km^2)
		Average one-way commuting time of urban permanent population (minutes)
		The ratio of parking spaces to car ownership in residential areas (%)
		Travel share rate of public transportation (%)
	Neat and orderly	Recycling rate of urban solid waste (%)
		Centralized collection rate of urban domestic sewage (%)
		Density of public toilets in built-up areas (block/square kilometer)
		Percentage of residential communities with professional property management (%)
	Openness and inclusiveness	Coverage rate of basic public services for permanent population (%) (social security, medical care, education, housing)
		Coverage rate of barrier-free facilities in public space (%)
		Rent-to-income ratio
		House price to income ratio
	Innovation and vitality	Percentage of population with university education level among newly employed urban population (%)
		Proportion of R&D expenditure in GDP of the whole society (%)
		Number of patents per 10,000 people (units/ 10,000 people)
		Number of high-tech enterprises per 10,000 people (units/10,000 people)

dimensions, specific indicator system has been introduced to examine the urban health status, which contains three layer: Target Layer, Criterion Layer, and Indicator Layer (See Table 1). Target Layer represents the overarching objective of the evaluation indicator system, namely, urban health examination. Criterion Layer represents the development objectives of healthy city, including the above mentioned seven aspects. For each development objective of healthy city, a set of indicators are employed to measure its development status, and there are in total 34

Table 2
Urban health indicator systems for obtaining urban resident's satisfaction.

Target Layer	Criterion Layer	Qualitative indicator
Resident satisfaction upon urban health	Ecological and livability	Urban park green space
		Urban public open space
		Urban building density
		Air pollution
		Water pollution
		Sound pollution
	Health and comfort	Urban sports venues
		General hospital
		Daily convenience shopping facilities such as community supermarkets and convenience stores
		Community facilities for the elderly
		Community kindergarten
		Community health center
		Renovation level of old community
	Security resilience	Social security
		Road traffic safety
		Emergency shelter
		Fire safety
	Neat and orderly	Level of residential waste sorting
		Community property management
		cleanliness level of road and city appearance
		Public toilet installation and sanitation status
	Convenient transportation	Public transportation
		Road accessibility
		Car parking
		Commuting time
	Openness and inclusiveness	Acceptability of housing prices
		Acceptability of housing rent prices
		Care for disadvantaged groups
		Level of urban social insurance protection
		Urban barrier-free facilities
	Innovation and vitality	Job opportunities
		Whether the city is suitable for starting a company and doing business
		The city's policy environment for starting companies and doing business
		Policy for talent introduction

Table 3
Urban residents' satisfaction degree.

Response Options	Score
Very satisfied/very suitable/very friendly/very not serious/ Very acceptable	100
Satisfied/suitable/friendly/not too serious/acceptable	80
General	60
Not satisfied/not suitable/unfriendly/serious/unacceptable	40
Very dissatisfied /unsuitable/very unfriendly/very serious/ unacceptable	20
Not familiar with	Unscored

measurement indicators for conducting urban health examination (see Table 1). These specific indicators are selected via two sources, namely from academic research or authoritative reports as supporting references and via discussing with government officials who are under the Bureaus and Departments taking responsibilities upon urban planning, construction and management (United Nations, 2021; Ministry of Housing and Urban-Rural Development of PRC, 2016; Ren et al., 2021; Liu et al., 2020; Liao et al., 2020). Both approaches for indicator selecting and setting have been well-received and adopted by extant literature in establishing urban performance assessment index systems.

3.1.2. *Etiology analysis*

In line with the establishment of urban health examination indicator

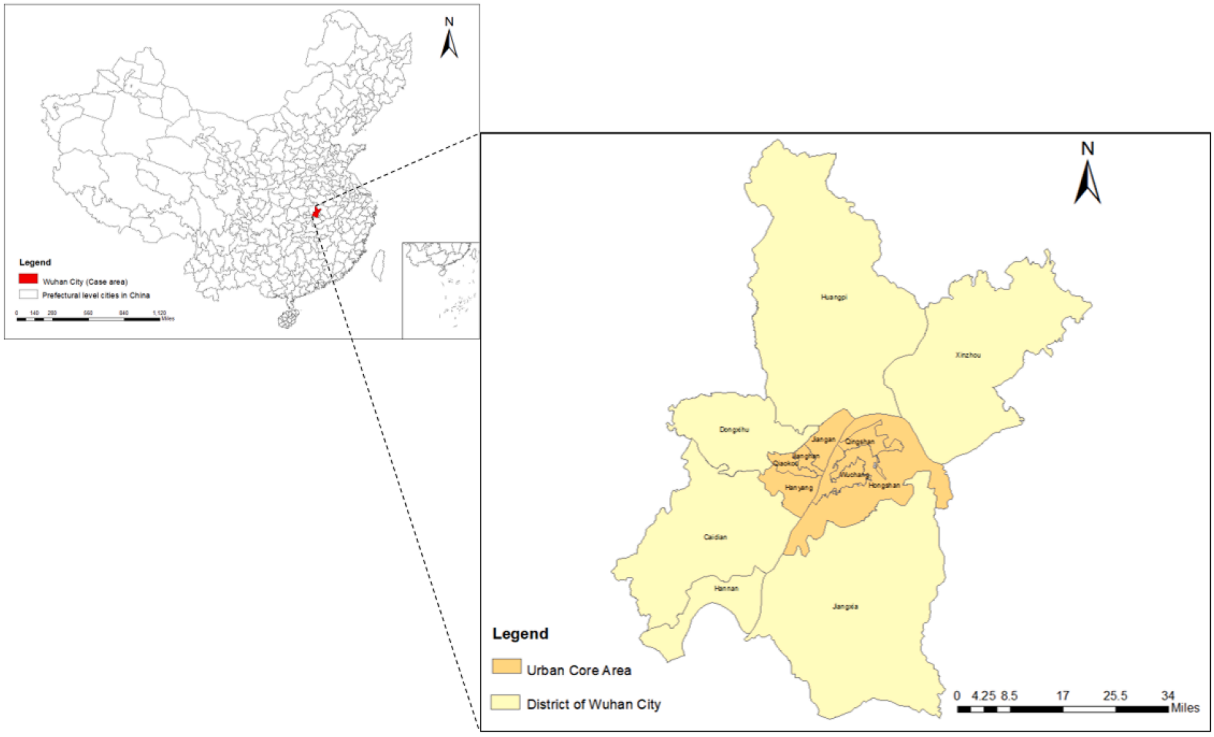

Fig. 4. Spatial location of Wuhan City.

system, the "city diseases" that restrict urban healthy development will be diagnosed. In the process of human physical examination, each indicator should be compared with a normal value or a normal range to examine whether this person have the risks of any diseases, and further in-depth investigation and treatment can be conducted to improve the body health status. This principle also applies in the process of urban health examination, therefore the important task is to determine the normal value or the normal range for each urban health examination indicator. Given the nature of these indicators listed in Table 1, there are usually three types of indicator benchmark, namely, maximum target values, minimum target values, and interval numbers. If the practical value of an urban health examination indicator for a specific city is not within the scope of the indicator benchmark, the concerned city may encounter some problems that are represented by the particular indicator.

There are several different ways to determine the benchmark for indicators reported by previous researches (Luque-Martínez and Muñoz-Leiva, 2005). In this study, the benchmarks of urban health examination indicator are determined by referring to the national standards or specifications, national planning, the academic researches, investigation reports, and the suggestions from experts (see the details of indicator benchmark setting in Section 4.2).

With the determination of indicator benchmark, the next step is to compare the practical value of each urban health examination indicator with the indicator benchmark to investigate whether the concerned city performs well in terms of the seven aspects shown in Table 1. Therefore, it is necessary to define a way to measure the distance between the practical value and the benchmark value of each indicators. It should also be noted that the proposal of methods is aiming to examine the urban health status and identify any urban diseases existing in the concerned city, rather to find out the good performers or evaluate how good the city performances in these dimensions. Following the above principle and targeting at three types of indicator benchmark (maximum target value, minimum target value, and interval target value), this study proposes corresponding methods to measure the gap between the practical value and the benchmark value of each indicator:

(1) For the indicators whose benchmarks are maximum target values such as *proportion of land use area in old communities*, the distance between the practical value and the benchmark value can be measured by adopting the formula below:

$$D_i = \begin{cases} 0 & x_i \le a_i \\ \dfrac{x_i - a_i}{a_i} & x_i > a_i \end{cases} \tag{1}$$

where D_i denotes the distance between the practical value x_i and the benchmark value in regard to the indicator i, a_i denotes the maximum value of benchmark in regard to the indicator i.

(2) For indicators whose benchmarks are minimum target value such as *days with good air quality*, the distance between the practical value and the benchmark value can be measured by adopting the formula below:

$$D_i = \begin{cases} 0 & x_i \ge b_i \\ \dfrac{b_i - x_i}{b_i} & x_i < b_i \end{cases} \tag{2}$$

where D_i denotes the distance between the practical value x_i and the benchmark value in regard to the indicator i, b_i denotes the minimum target value of benchmark in regard to the indicator i.

(3) For indicators whose benchmarks are the interval numbers such as *regional development intensity* and *house price to income ratio*, the distance between the practical value and the benchmark can be measured by adopting the formula below:

$$\mathrm{D_i} = \begin{cases} 0 & \mathrm{k_i} \le \mathrm{x_i} \le \mathrm{m_i} \\ \dfrac{(\mathrm{k_i} - \mathrm{x_i})}{\mathrm{k_i}} & \mathrm{x_i} < \mathrm{k_i} \\ \dfrac{(\mathrm{x_i} - \mathrm{m_i})}{\mathrm{m_i}} & \mathrm{x_i} > \mathrm{m_i} \end{cases} \tag{3}$$

where D_i denotes the distance between the practical value $\mathrm{x_i}$ and the benchmark value in regard to the indicator i, $\mathrm{k_i}$ and $\mathrm{m_i}$ is the upper and lower limits of the interval number in regard to the indicator i.

Table 4
Indicator benchmark value and benchmark-setting method for urban health examination in Wuhan City.

Urban health examination indicator	Indicator benchmark value	Indicator benchmark-setting method	Indicator benchmark value of Wuhan
Regional development intensity (%)	20–30%	Academic research (Research on the Total Control and Differential Management Policy of China's Construction Land)	37.84%
Green coverage rate in built-up area (%)	≥36%	National specification (The Standard of National Sanitary City)	40.02%
Days with good air quality (day)	≥292	National specification (The requirement of Ministry of Ecology and Environment of the People's Republic of China)	244
Proportion that the quality of urban water environment is better than the five categories (%)	100%	National specification (Excellent rate of water quality in Prefecture-level cities nationwide)	71.20%
Service radius coverage rate of parks and green spaces (%)	≥90%	National specification (China Habitat Environment Award)	88.70%
Proportion of green buildings in new buildings (%)	≥70%	National specification (Action Plan for Green Building implementation)	79.40%
Coverage rate of community convenience service facilities (%)	100%	National planning (Urban and Rural Community Service System Construction Plan (2016 ~ 2020))	70.70%
Coverage rate of community service facilities for the elderly (%)	>75%	National planning (Urban and Rural Community Service System Construction Plan (2016 ~ 2020)))	61.70%
Coverage rate of inclusive kindergartens (%)	≥80%	National specification (Opinions of the CPC Central Committee and the State Council on Deepening Reform and Standardizing Development of Preschool Education)	62%
Community health service center outpatient share rate (%)	≥23%	National average level of major cities across the country in 2020	30%
Sports facility area per capital (m2/person)	≥1.8	National specification (Requirements of General Administration of Sport)	1.99
Proportion of land area used in old communities (%)	≤40%	Expert opinion	46.40%
Number of beds in medical institutions per 1,000 (units/1,000)	≥6	National planning (National Medical and Health Service System Planning Outline (2015–2020))	8.59
Urban death rate per 10,000 vehicles (unit person/10,000 vehicles)	<2	National standard (National Unblocked Project Evaluation Standard)	1.48
Refuge area per capital (m2/person)	> 1.5	National standard (Earthquake emergency shelter site and supporting facilities)	4.34
Safety mortality rate from production accidents per 100,000,000 yuan GDP (%)	≤0.0686	National Planning (Notice of the 13th Five-Year Plan for Work Safety)	0.023
Capacity of urban medical waste treatment (%)	100%	Expert opinion	106.80%
Average vehicle speed during peak hours in built-up areas (km/h)	≥40	Investigation report (China Urban Traffic Report of Baidu Company)	22.5
Density of urban road network (km/km2)	≥ 8	National standard (Planning Standards for Urban Comprehensive Transportation System)	6.52
Average one-way commuting time of urban permanent population (minutes)	≤36	The average level of major cities across the country in 2020	41.55
The ratio of parking spaces to car ownership in residential areas (%)	≥130%	Target number of the developed country	93.40%
Travel share rate of public transportation (%)	≥50%	National specification (Action Plan for Green Travel)	55.50%
Recycling rate of urban solid waste (%)	≥35%	National specification (Several Opinions on Further Promoting the Classification of Domestic Waste)	24%
Centralized collection rate of urban domestic sewage (%)	≥85%	National standard (Standard for National Sanitary City)	57.50%
Density of public toilets in built-up areas (block/square kilometer)	≥3	National standard (Planning Standards for Urban Environmental Sanitation Facilities)	5.39
Percentage of residential communities with professional property management (%)	100%	Experts opinion	64.20%
Coverage rate of basic public services for permanent population (%) (social security, medical care, education, housing)	≥90	National specification (Notice of the State Council on Issuing the Plan for Promoting the Equalization of Basic Public Services during the 13th Five-Year Plan)	57.60%
Coverage rate of barrier-free facilities in public space (%)	≥85%	National specification (Implementation Opinions on Further Strengthening and Improving Travel Services for the Elderly and Disabled)	64.90%
Rent-to-income ratio	<25%	Experts' opinion	22.50%
House price to income ratio	6 ~ 8	Experts' opinion	13.54
Percentage of population with university education level among newly	≥65%	Expert's opinion	56.90%

(continued on next page)

Table 4 (*continued*)

Urban health examination indicator	Indicator benchmark value	Indicator benchmark-setting method	Indicator benchmark value of Wuhan
employed urban population (%)			
Proportion of R&D expenditure in GDP of the whole society (%)	≥2.50%	National specification (Notice of the "13th Five-Year" National Science and Technology Innovation Plan)	2.54%
Number of high-tech enterprises per 10,000 people (units/10,000 people)	≥1.6	The average number of China	3.93
Number of patents per 10,000 people (units/10,1000 people)	≥12	National specification (Notice of the "13th Five-Year" National Science and Technology Innovation Plan)	20.5

Furthermore, in order to make the measurement results comparable, a standardization process is conducted:

$$O_i = \frac{D_i}{\sum_{i=1}^{n} D_i} \tag{4}$$

where O_i denotes the severity of disease represented by the indicator i, n denotes the total number of indicators (n = 34 in this study). If O_i is equal to zero, the concerned city is healthy on the perspective represented by indicator i. If O_i is greater than zero, the concerned city is considered unhealthy upon the perspective represented by indicator i. Specifically, the higher the value, the more unhealthy the city performs in regard to indicator i.

3.2. TCM method for urban health examination

3.2.1. Questionnaire design

Traditional Chinese Medicine (TCM) regards patient's subjective feelings as the core reference for diagnosis. This principle also applies for urban health examination: Cities are essentially built and existed for their citizens, who play an active role in the city and are not just passive beneficiaries of what city offers; this makes citizen's satisfaction with the locality and related local policies one of the most important societal indicators. For this, residential satisfaction can be described as subjective feelings about urban development status and living environment. Satisfaction is a vivid assessment of perceived discrepancy between one's aspirations and achievement, and resident satisfaction as a cognitive judgmental process is dependent upon a comparison of one's circumstances with what is thought to be an appropriate standard (Brown et al., 2004). Therefore, urban resident satisfaction can be adopted as an evaluation technique for measuring individuals' perception of livelihood quality and the residential environment (Biswas et al., 2021). This study therefore adopts residential satisfaction survey to collect urban citizens' perception of feelings and consciousness upon the livelihood quality of city. In referring to the indicator system established in Table 1, another indicator system for obtaining residential satisfaction of urban health status is also established (see Table 2). This indicator system also has three layers, with the first layer representing the target of this indicator system (resident satisfaction upon urban health status), the second layer sharing the same dimensions as the criterion layer in Table 1, and the third layer representing the qualitative indicators in corresponding to the quantitative indicators in Table 1 (for example, the indicator "*days with good air quality*" in Table 1 corresponds to "*air pollution*" in Table 2).

Based upon the indicator system in Table 2, the questionnaire for obtaining residents satisfaction upon urban health status is designed as shown in the Appendix I. Two sections of questions are included in the urban residents satisfaction questionnaire. The first section of question covers basic information of participant urban residents (e.g., age, gender, occupation); and the second type of questions are questions

Fig. 5. Interface of online urban residents satisfaction survey conducted in Wuhan (*in Chinese*).

Table 5
Basic information of participant urban residents.

Feature	Value	Number	Percentage (%)
Age	Below 20 years old	126	1.9
	20–29	1093	16.2
	30–39	2482	36.8
	40–49	1760	26.1
	50–59	795	11.8
	60–69	405	6
	Over 70 years old	81	1.2
Gender	Male	3690	54.7
	Female	3052	45.3
Education level	Primary school level or below	59	0.8
	Middle school level	362	5.4
	High school level	1258	18.7
	Junior college level	2575	38.2
	University level (Undergraduate)	2176	32.3
	Postgraduate level and above	312	4.6
Occupation	Non-occupied	256	3.8
	Government official	1071	15.9
	Individual entrepreneur (self-employed)	278	4.1
	Worker	645	9.6
	Educational researchers	185	2.7
	Retirees	588	8.7
	Corporate employees	1153	17.1
	Business and service employees	736	10.9
	student	149	2.2
	Freelancer	1681	24.9
Household annual income level	Below 30,000 RMB	1195	17.7
	30,000–49,000 RMB	1303	19.3
	50,000–69, 000 RMB	1143	16.9
	70,000–99,000 RMB	1076	15.9
	100,000–199,000 RMB	1397	20.7
	200,000–299,000 RMB	396	5.8
	300,000–499,000 RMB	161	2.4
	Over 500,000 RMB	71	1
Hukou status	Local birth with local *Hukou*	5376	79.7
	Nonlocal birth and obtained local *Hukou* after 18 years old	898	13.3
	Nonlocal *Hukou*	470	6.9
	Foreign Nationality	7	0

converted from the indicators shown in Table 2, to examine to what extent are urban residents satisfied with each perspective of urban living environment. For each residential satisfaction question, the principle of Likert Scaling approach is adopted to measure the satisfaction degree (Shen et al., 2018; Zhang et al., 2021a,b), and hundred-mark system is used to make sure that the results of TCM urban heath examination (resident satisfaction survey) can be compared with the result of WM (objective indicator based urban health examination). Thus six ranges of option are provided for participants to denote different degrees of satisfaction (see Table 3).

3.2.2. Measurement of residential satisfaction

For 34 types of questions converted from indicators in Table 2, the satisfaction value of each question (each indicator perspective) can be obtained by using the following formula:

$$Qt_i = (C_i{*}100 + D_i{*}80 + E_i{*}60 + F_i{*}40 + G_i{*}20)/(I_i - H_i) \quad (5)$$

where Qt_i represents the satisfaction value of i^{th} second-type question (corresponding to the i^{th} indicator), $i = 1, 2, \ldots, 34$; C_i, D_i, E_i, F_i, G_i denotes respectively the number of questionnaires that have the answer of very satisfied, relatively satisfied, general, relatively dissatisfied, and very dissatisfied among all valid questionnaires for the i^{th} indicator; I_i denotes the total number of samples and H_i denotes the number of questionnaires with the answer of "Not familiar with" among all questionnaires for the i^{th} indicator.

And the residents satisfaction value of 7 criterion layer of urban living environment can be obtained by using the following formula:

$$QT_j = (Qt_m + \ldots + Qt_n)/(n - m + 1) \quad (6)$$

where QT_j denotes the satisfaction value of j^{th} criterion layer in Table 2, Qt_m, $\ldots Qt_n$ denotes all questions under the j^{th} criterion layer, $(n-m+1)$ denotes the number of the questions in the j^{th} criterion layer.

Consequently, the overall value of residential satisfaction upon urban health status can be obtained by calculating the average satisfaction value of 7 criterion layers:

$$Q_z = (QT_1 + QT_2 + QT_3 + QT_4 + QT_5 + QT_6 + QT_7)/7 \quad (7)$$

where Q_z denotes the overall value of residential satisfaction upon urban living environment, and the maximum value of Q_z is 100; QT_i represents the satisfaction value of the i^{th} criterion layer of urban living environment, $i = 1,2,..,7$.

4. Case study

4.1. Study area

Wuhan City (29°58′–31°22′ N, 113°41′–115°05′ E) is the well-known capital city of the Hubei province in Central China with a total area of 8569.15 km^2 (Zhang et al., 2020), see the location of Wuhan City in Fig. 4. It is an important industrial and scientific education center and major transportation hub. City of Wuhan has been experiencing a rapid urbanization process and booting its economic development since the millennium. In 2020, the gross domestic product (GDP) of Wuhan reached 1561.61 billion yuan, ranking the ninth across all the 293 prefectural cities in mainland China, and the population reached 11.21 million at the same year. However, with the dramatic socioeconomic development, city of Wuhan has also encountered similar problems as other mega-cities met in China, such as air pollution, traffic jam, and rocketing housing price (Al-Qaness et al., 2021; Lin et al., 2017). Especially, in the beginning of 2020, the outbreak of novel coronavirus (COVID-19) took place in Wuhan, and the Covid-19 epidemic has exposed a series of problems upon Wuhan's urban development, such as the shortage of medical resource, high population density induced high speed of virus-spreading (Zhang et al., 2021c). Given the socioeconomic and the specific pandemic context of Wuhan, it is essential to examine the urban heath status of the city, for which any risks of urban disease can be timely diagnosed and tailored measures can therefore be taken to effectively prevent the emergence or severity of these urban diseases.

4.2. Empirical data collection

4.2.1. Data of urban health examination evaluation indicator

In order to ensure the authority and validity of indicator data, our research team collected empirical data of 34 urban health examination indicators (in Table 1) by adopting field survey. Firstly, each indicator is distributed to the corresponding government bureaus in Wuhan city, for which a total of 27 government bureaus are involved, including Wuhan Bureau of Statistics, Wuhan Public Security Bureau, Wuhan Municipal Development and Reform Commission, etc. After the distribution of indicator data to corresponding government bureaus, the empirical data of each indicator was collected from these bureaus through face-to-face interview or telephone interview. The indicator data has been further checked by the head of each government bureau to guarantee the data creditability.

Another important task for urban health examination is to determine the benchmark of each evaluation indicator. In this study, the indicator benchmark is determined by referring to the government specifications or standards, national plannings, academic researches, national average level, investigation reports, and experts' opinions. Moreover, the experts from both government (such as Wuhan Urban and Rural Construction

Table 6
Performance of urban health examination indicators of Wuhan.

Indicator	O_i
House price to income ratio	0.1353
Average vehicle speed during peak hours in built-up areas (km/h)	0.0854
Coverage rate of basic public services for permanent population (%)	0.0703
Percentage of residential communities with professional property management (%)	0.0699
Centralized collection rate of urban domestic sewage (%)	0.0632
Recycling rate of Urban solid waste (%)	0.0614
Coverage rate of community convenience service facilities (%)	0.0572
Proportion that the quality of urban water environment is better than the five categories (%)	0.0563
The ratio of parking spaces to car ownership in residential areas (%)	0.0550
Regional development intensity (%)	0.0511
Coverage rate of barrier-free facilities in public space (%)	0.0462
Coverage rate of inclusive kindergartens (%)	0.0440
Density of urban road network (km/km2)	0.0361
Coverage rate of community service facilities for the elderly (%)	0.0346
Days with good air quality (day)	0.0321
Proportion of land area used in old communities (%)	0.0312
Average one-way commuting time of urban permanent population (minutes)	0.0301
Percentage of population with university education level among newly employed urban population (%)	0.0243
Capacity of urban medical waste treatment(%)	0.0133
Service radius coverage rate of parks and green spaces (%)	0.0028
Green coverage rate in built-up area (%)	0.0000
Proportion of green buildings in new buildings (%)	0.0000
Community health service center outpatient share rate (%)	0.0000
Sports facility area per capital (m2/person)	0.0000
Number of beds in medical institutions per thousand	0.0000
Urban death rate per 10,000 vehicles(unit person/10,000 vehicles)	0.0000
Refuge area per capital (m2/ person)	0.0000
Safety mortality rate from production accidents per 100,000,000 yuan GDP (%)	0.0000
Travel share rate of Public transportation (%)	0.0000
Density of public toilets in built-up areas (block/square kilometer)	0.0000
Rent-to-income ratio	0.0000
The proportion of R&D expenditure in GDP of the whole society (%)	0.0000
Number of high-tech enterprises per 10,000 people (units/10,000 people)	0.0000
Number of patents per 10,000 people (units/10,000 people)	0.0000

Bureau) and academia (such as Wuhan University, Wuhan University of Technology, Huazhong University of Science and Technology) were invited to attend a workshop to debate the rationale of indicator benchmarks and further finalize the benchmark of each indicator. Consequently, the benchmark values and benchmark-setting methods of each urban health examination indicators are finalized and presented in Table 4.

4.2.2. Data of residential satisfaction upon urban living environment

The main target participants of resident satisfaction survey are the urban resident in city of Wuhan who are over the age of 16, who have a relatively stable local residence and have been living in Wuhan for more than six months. Those who just stay in Wuhan for short-term or for travelling are therefore excluded. The participants of residential satisfaction survey cover across government officials, private-sector staffs, self-employed entrepreneurs from all walks of life; besides, from the perspective of income-level, the residents satisfaction survey of this study involves the participants of low, medium, and high income groups. Furthermore, this study adopts random sampling method to distribute the survey questionnaire to the residents in different communities across the city of Wuhan. Specifically, the urban residents from the urban core areas of Wuhan city (Jianggan District, Jianghan District, Qiaokou District, Wuchang District, Hongshan District, Qingshan District, and Hanyang District, see Fig. 4) are invited to participate the urban resident satisfaction survey, and for each urban core district, 30 neighbourhood communities are covered. In conducting the online resident satisfaction survey, urban inhabitants from these 210 randomly selected neighbourhood communities were invited to scan the code, enter the

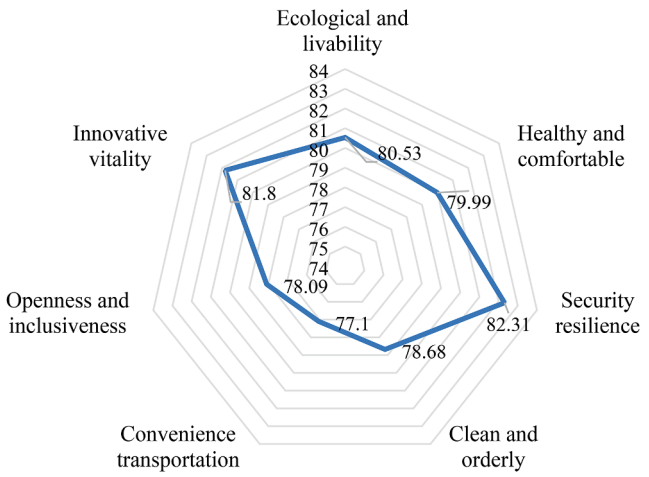

Fig. 6. The performance of 7 criterion layers.

satisfaction questionnaire and fill in the questionnaire (see Fig. 5).

With the help of local government and community managers, the questionnaire distribution had been conducted from July 20 to August 20, 2020. A total number of 8356 urban residents in Wuhan had participated in this satisfaction survey, among which 6742 responses were valid and had been used for further analyze. The basic background information of these urban resident participants is shown in Table 5.

4.3. Results

4.3.1. Results of urban health examination by using WM method

By using the formula (1) to (4), the performance of each urban health examination indicators of Wuhan city can be calculated as shown in Table 6.

The urban health examination indicators in Table 6 are ranked according to the O_i value. The indicator with unhealthy performance is represented by red color, while the indicator with healthy performance is represented by green color. The darkness of the red color indicates the severity of disease represented by the specific indicator. In other word, the deeper the red color, the unhealthier that Wuhan is diagnosed in terms of the urban aspect represented by the indicator. It can be found from Table 6 that the five reddest indicators of Wuhan city are the *housing price to income ratio, average vehicle speed during peak hours, coverage rate of basic public services for permanent population, percentage of residential communities with professional property management, centralized collection rate of urban sewage*. Above five darkest indicators indicate that Wuhan city is diagnosed with urban diseases in the aspects of housing price, traffic operation efficiency, public services, property management, and sewage treatment.

4.3.2. Results of urban health examination by using TCM method

By adopting the formula (5) to (7), the overall satisfaction value of urban residents in Wuhan is 81.53, indicating that the local inhabitants are basically satisfied upon the urban health status and urban living environment in Wuhan. The performances of 7 criterion layers are 80.53 (Ecological and livability), 79.99 (Healthy and comfortable), 82.31 (Security resilience), 78.68 (Clean and orderly), 77.1 (Convenience transportation), 78.09 (Openness and inclusiveness), 81.80 (Innovative vitality), as shown in Fig. 6.

Specifically, the resident satisfaction of each urban living environment indicator (corresponding to each second-type question in the questionnaire) is also obtained as shown in Table 7.

In Table 7, the residents satisfaction indicators are ranked based on their residents satisfaction value. Indicator marked with red color represents the resident satisfaction value upon urban heath status represented by this indicator is under 80, and the deeper the red, the lower level of residents satisfaction is. The indicator marked with green color means the satisfaction value of the urban living environment represented by this indicator is above 80. The deeper the green, the higher level of residents satisfaction upon this specific aspect of urban living environment. Among all the 34 aspects of urban living environment, urban residents in Wuhan are generally unsatisfied with car parking. Additionally, high housing price, air pollution, road congestion, and community property management are other critical issues of urban living environment which currently with low-level of residential satisfaction. The results suggest that these aspects of critical urban diseases should be highly addressed by the local government in the future urban planning, construction and management of Wuhan city.

5. Discussion

In this section, the results of WM method (quantitative indicator evaluation) and TCM method (residents satisfaction survey) based urban health examination in Wuhan are compared to verify the effectiveness of WM-TCM methodology proposed in this study.

Firstly, the top ten urban diseases identified by two methods are compared as shown in Table 8.

It can found that there are five same urban diseases identified by both methods (as highlighted in Table 8), including *housing price, traffic operation efficiency, property management, solid waste management, and car parking*. This indicates that these two approaches are both effective in assisting urban governors to understand the health development status of their city and diagnose the underlying critical urban diseases that would jeopardize the sustainability of urban development. For these five important urban diseases identified by urban health examination, this study puts forward tailored governance strategies and policy recommendations to help address above urban diseases and improve the urban well-being and health status of Wuhan.

- To address the challenges of housing price, it is recommended that a housing supply system should be better delivered by integrating two approaches. Firstly, a set of basic housing infrastructures for urban disadvantaged residents, such as college students who just graduated, low income groups, and rural-to-urban migrant workers. Secondly, government can further improve the housing security system via enhancing rental security and property rights security.
- Efforts should be made to promote the construction and delivery of green transport facilities like subway and passenger bus. Government should strengthen the construction of rail network and bus station, and provide seamless connection between passenger bus and subway to improve the traffic operation efficiency of a mega city like Wuhan.
- For the aspect of property management, local governmental bodies are strongly suggested to optimize property management services and solving the problems such as loss of property rights and chaos of property rights particularly in old urban communities. Also, during the process of property management enhancement, the independent management ability of urban neighbourhood committees can be cultivated to improve the grass-root governance ability.
- For addressing the urban disease of solid waste management issue, household garbage classification and treatment system are suggested to be established. By this, the management of household garbage classification and resource utilization can be enhanced. Relevant laws, regulations, and standards should be put forward to ensure the effectively implementation of this system.
- For addressing the car parking challenges, local governmental bodies and real estate developers should jointly improve the delivery of public parking services. In particular, the construction of three dimensional parking buildings and smart parking slots are highly recommended to improve the car parking efficiency.

Another impressive finding is that the differences exist in the results

Table 7
Urban residents satisfaction upon urban living environment in Wuhan.

Urban living environment indicator	Satisfaction value
Car parking	70.92
Acceptability of housing prices in the city	71.91
Acceptability of rent in the city	75.22
Community property management	76.21
Air pollution	76.24
Road congestion	76.53
Renovation level of old community	77.17
Level of residential waste sorting	77.44
Sound pollution	77.65
Commuting time	77.88
Community inclusive kindergarten	78.91
Urban building density	79.22
Community facilities for the elderly	79.27
Urban sports venues	79.36
Urban barrier-free facilities	79.46
General hospital	79.63
Job opportunities	79.7
Level of urban social insurance protection	80.16
Water pollution	80.18
Cleanliness level of road and city appearance	80.49
Public toilet installation and sanitation status	80.56
Road traffic safety	81.27
Community health center	81.88
Emergency shelter	81.93
The city's policy environment for starting companies, setting up businesses, and doing business	82.11
Fire safety	82.38
Policy for talent introduction	82.65
Whether the city is suitable for founding a company and doing business	82.73
Public transportation	83.07
Social security	83.67
Care for disadvantaged groups	83.71
Daily convenience shopping facilities such as community supermarkets and convenience stores	83.73
Urban public open space	84.05
Urban park green space construction	85.86

between WM (quantitative indicator evaluation) and TCM (residents satisfaction survey) methods. In this regard, some extant studies have also observed similar findings and opined that the relationship between objective perspective-based city performance assessing and urban citizen satisfaction can be complicated. For example, according to James (2007), high citizen satisfaction may be due to citizens' low expectations to public services, and *vice versa*. Das (2008) and Rezvani et al. (2013) both pointed out that the correlation between objective method and subjective method was not to be high. Liao (2009) indicated that objective indicators are positively correlated with subjective satisfaction in the environment dimension, but negative correlation has been found in education dimension.

In this study, the reasons contributed to the gap between urban physical examination and residents' satisfaction can be understood as follows. Urban planners and urban governors in large Chinese cities tend to pay more attentions upon the delivery of urban infrastructure system, thus the indicators representing the level of urban construction tend to perform well or even over-performed than the city's real development status (Wang et al., 2020b). This over-performance of urban infrastructure delivery can be evidenced by the high level of indicators such as sewage treatment, community convenience service facilities. However, this rampant process of urban construction overwhelmingly takes little consideration of urban residents' public opinion, who are indeed the service objects of urban development. From the perspective of urban residents, their perception of urban construction and development tend to base on subjective feeling. Consequently, urban residents are more concerned with the aspects closely related to their everyday life, such as car parking, rent housing, air pollution, and road congestion, which would impact directly upon their well-being and life quality. Although there is no doubt that the improvement of urban infrastructures or

Table 8
Comparison upon the urban diseases identified by the two methods.

Ranking	Urban diseases identified by WM method	Ranking	Urban diseases identified by TCM method
1	**Housing price**	1	**Car parking**
2	**Traffic operation efficiency**	2	**Housing price**
3	Public services	3	Renting house
4	**Property management**	4	**Property management**
5	Sewage treatment	5	Air pollution
6	**Solid waste management**	6	Road congestion
7	Community convenience service facilities	7	Urban renewal
8	Under water environment	8	**Waste management**
9	**Car parking**	9	Sound pollution
10	Regional development intensity	10	**Traffic operation efficiency**

service facilities can benefit upon urban residents, the opinions and perceptions of communities should also be well integrated during the decision-making process of urban planning, construction and management. In this regard, the research finding from this study can effectively rectify the deviation of traditional urban performance evaluation studies which are biased upon the quantitative-indicator evaluation. Furthermore, extant literature also pointed out that the urban residents' needs would increase in line with urban economic growth, thus the satisfaction degree of urban residents may vary at different stages of urban development, for which an "inverted-U" curve may exist between the urban development level and urban residents satisfaction degree (Lenzi and Perucca, 2016; Mohit et al., 2010). For this, more challenges are therefore brought to urban governors to address and tackle properly the dynamic demands of urban residents with incorporating their own urban contexts.

In summary, the WM-TCM urban health examination methodology proposed in this study can help city governors understand the development status of their city, and diagnose effectively and holistically the underlying cities diseases, so that tailored measures can be adopted to prevent the severity of these diseases and further contribute to healthy and sustainable urban development.

6. Conclusion

Rapid urbanization has brought the rampant sprawl of cities, where various urban diseases are emerging, and this is particularly the case of cities located in the developing countries. Policy-makers and urban planners are endeavored to address these urban diseases and improve the function of cities. It is therefore important to develop a scientific methodology to understand the health status of a city and diagnose the underlying problems of urban development, so that effective policy measures can be taken to address these diseases. It appears that previous studies have not yet provided a set of scientific methodology for urban health examination, to fill this inherent limitation of extant literature, this study proposes a novel method (WM-TCM) for urban health examination which introduces the implication from medicine area. The applicability and effectiveness of the proposed methodology have been demonstrated via a case city of Wuhan, Central China.

The results of this study prove that the proposed method can help policymakers and urban planners to identify and diagnose city diseases effectively and holistically. The main contributions of this study include three aspects. Theoretically, this study proposes a new perspective to assess city performance from the perspective of urban health examination where a city is regarded as a human body. Additionally, a novel methodology incorporated the implication of West Medicine (WM) and Traditional Chinese Medicine (TCM) are proposed for urban health examination. Specifically, WM in the urban health examination refers to the qualitative indicator based examination, and TCM in the urban health examination refers to the resident satisfaction survey. Practically, the WM-TCM method can be applied in other cities globally for city diseases diagnosis, so that local urban governors can be provided with effective information to adopt tailored measures to promote the health urban development.

This study argues that diagnosing appropriately the city diseases is as important as treating these diseases. Without proper urban disease diagnosis, some underlying problems can not be identified and understood, so that the policy measures for urban development would tend out to be blindness and weakness. The WM-TCM urban health examination methodology is evidence-based, which includes both subjective and objective perspective of a city's health status. So that the policy intervention based upon this urban health examination results can effectively alleviate the critical urban development problems. Besides, the indicator benchmark setting method can help city governors to dynamically and holistically monitor their city's development status.

The limitations of this study are also appreciated. This study only adopts one-year empirical data in the case study of Wuhan city. Future studies are recommended to conduct the urban health examination by using the WM-TCM methodology across different years, so that the dynamism of urban health development status and the evolving trajectory of urban diseases can be captured and analyzed. More indicators representing the diverse aspects of urban development can be further incorporated into urban health examination, including both quantitative-indicator based examination and urban residents satisfaction survey.

CRediT authorship contribution statement

Wei Chen: Supervision, Project administration. **Yong Wang:** Data curation, Formal analysis. **Yitian Ren:** Writing – original draft, Writing – review & editing, Visualization. **Hang Yan:** Conceptualization, Methodology, Writing – original draft. **Cong Shen:** Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research work is supported by the Independent Innovation Research Fund of Wuhan University of Technology [grant number 3120621133]; and supported by the 2020 Wuhan Urban Health Examination of Wuhan Urban and Rural Construction Bureau [grant number HBCZ-20121136-202684]. The third author is supported by SEED Postgraduate Research Scholarship of The University of Manchester, UK. The authors appreciate the insightful comments provided by the anonymous reviewers.

Appendix A

Thank you for participating the residential satisfaction survey of Wuhan. This survey aims to help governments to identify the problems of urban construction and management in Wuhan, so that effective policy measures can be taken accordingly to address these problems. The data collected via this questionnaire will be used only for research aim and will not be used for any commercial purpose or disclosure. Thanks again for your participation!

1 Participant basic information s:

1. Your gender is:

(1). Male
(2). Female

2 Your age is:

Under 20

(1). 20–29
(2). 30–39
(3). 40–49
(4). 50–59
(5). 60–69
(6). Above 70

3. Your occupation is:

(1). Government officers
(2). Educator or researchers
(3). Enterprise staff
(4). Self-employed
(5). Factory worker
(6). Service worker
(7). Freelancers
(8). Students
(9). Retiree
(10). Unemployed

4 How long have you lived in Wuhan City:

(1). <6 months
(2). 6 months to 1 year
(3). 1–5 years
(4). 5–10 years
(5). >10 years

2. Residential satisfaction of urban development

5. Your satisfaction degree with urban parks and green spaces

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

6 Your satisfaction degree with the public open space in the city

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

7 Your satisfaction degree with urban building density

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

8 Is the air pollution in your city serious

(1). Not serious
(2). Not too serious
(3). General
(4). Serious
(5). Very Serious
(6). Not familiar with

9 Is the water pollution in your city serious

(1). Not serious
(2). Not too serious
(3). General
(4). Serious
(5). Very Serious
(6). Not familiar with

10 Is the noise pollution in your city serious

(1). Not serious
(2). Not too serious
(3). General
(4). Serious
(5). Very Serious
(6). Not familiar with

11 Your satisfaction degree with public transportation

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

12 Your satisfaction degree with the smoothness of the road

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

13 Your satisfaction degree with the time spent commuting (schooling)

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

14 Your satisfaction degree with car parking

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

15.Your satisfaction degree with urban general hospitals

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

16. Your satisfaction degree with urban sports venues

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

17. Your satisfaction degree with the city's large shopping facilities

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

18. Your satisfaction degree with community inclusive kindergartens

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

19. Your satisfaction degree with community elderly care facilities

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

20 Your satisfaction degree with community health service centers, community supermarkets, convenience stores and other facilities

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

21. Your satisfaction degree with the level of renovation of old communities.

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

22. Your acceptance with housing prices in your city

(1). Very acceptable
(2). Acceptable
(3). General
(4). Not acceptable
(5). Very unacceptable
(6). Not familiar with

23. Your acceptance with rent in your city

(1). Totally acceptable
(2). Acceptable
(3). General
(4). Not acceptable
(5). Totally unacceptable
(6). Not familiar with

24. What do you think of the city's friendliness to disadvantaged groups?

(1). Very friendly
(2). Friendly
(3). General
(4). Unfriendly
(5). Very Unfriendly
(6). Not familiar with

25. Your satisfaction degree with the level of urban social insurance security

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

26 Your satisfaction degree with urban barrier-free facilities

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

27. Your satisfaction degree with social security

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

28. Your satisfaction degree with road traffic safety

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

29. Your satisfaction degree with emergency shelter

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

30 Your satisfaction degree with fire safety

(1). Very satisfied
(2). Satisfied

(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

31. Your satisfaction degree with job opportunities in the city

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

32. Do you think the city is suitable for starting a company and doing business?

(1). Very suitable
(2). Suitable
(3). General
(4). Not suitable
(5). Very unsuitable
(6). Not familiar with

33. Your satisfaction degree with the policy environment for starting a company and doing business

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

34. Your satisfaction degree with the talent introduction policy

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

35. Your satisfaction degree with the level of waste classification in the community

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

36. Your satisfaction degree with community property management

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

37. Your satisfaction degree with the city appearance and environment such as roads

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

38. Your satisfaction degree with the sanitary condition of public toilets

(1). Very satisfied
(2). Satisfied
(3). General
(4). Not satisfied
(5). Very dissatisfied
(6). Not familiar with

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