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City Health Examination in China: A Methodology and Empirical Study

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Abstract: National urban planning, construction, and management levels have undergone qualitative changes in China since 2000. Nonetheless, problems caused by rapid urbanization are becoming increasingly prominent. The concept of the city health examination appears to tackle these problems and is being gradually implemented, starting from the implementation of a national strategy and leading to the concrete practice of high-quality urban development. This paper elaborates on the basic philosophy and theory of the city health examination, briefly explains indicator selection and aims, and comprehensively illustrates examination methods. It then describes the empirical research that operationalized the dataset collected from a satisfaction survey administered during the 2020 city health examination. It aims to provide a reference for the standardization, specialization, analysis, and application of the results of the city health examination in China; this may help promote a smooth elimination of 'urban diseases' and allow for the development of high-quality livable cities. This research shows that city residents are generally more satisfied with the landscape features, ecological livability, and security resilience; it also shows that residents are generally more dissatisfied with traffic issues. Residents with different characteristics showed different satisfaction levels toward different indicators. Residents were also shown to be more sensitive to innovation vitality, ecological livability, and health and comfort in considering whether to stay in their current city.

Keywords: city health examination; urban disease; methodology; living environment; satisfaction survey

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1 Introduction

During this century, the number of people living in cities has rapidly increased in most parts of the world. Such rapid urbanization is bringing about many problems. City services and infrastructure have encountered new challenges, and city governments need to constantly find more effective ways to address issues such as traffic congestion, garbage disposal, and energy supply (Smyth et al., 2018). Such problems, and others that arise from them, are known as 'urban diseases', and generally exist in cities at all levels of development. However, rapidly urbanizing cities are more prone to multiple outbreaks of urban diseases. Rapid urbanization is often accompanied by a large population concentration and high consumption of resources, which lead to air pollution (Ravishankara et al., 2020), traffic congestion (Duan et al., 2020), urban sprawl, and high energy consumption (Adetokunbo and Emeka, 2015) as well as an increase in traffic accidents, illegal bicycle

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parking, noise pollution, urban landscape destruction, and other problems (Egami et al., 2019). Racial conflicts (Rusk, 1998) and abandoned buildings (De Franco, 2021) also arise in cities of some countries and regions.

China's urbanization rate exceeded 30% in 1996, and 60% in 2019 (National Bureau of Statistics, 2021), going through the process of urbanization in about half of the time of the UK and one-third of the time of France and the US (Chen and Liu, 2012). Studies have confirmed that urban sprawl and high energy consumption can significantly lower people's living standards (Adetokunbo and Emeka, 2015). To curb this trend, the concept of 'smart growth' has quickly gained worldwide attention since 1996 (Liu et al., 2020). With the advancement of urbanization and climate change as well as the deepening of the global energy crisis, people are no longer satisfied with focusing on the space or ecology perspective when studying the sustainable development of cities. Therefore, the more comprehensive concept of a 'sustainable city' has been proposed, on which in-depth studies have been conducted (Hara et al., 2016; Haarstad, 2017; Cohen, 2018; Hatuka et al., 2018; Martin et al., 2018). Based on the concept of sustainable cities, new urban development concepts such as 'compact cities' and 'new urbanism' have been repeatedly discussed and implemented along with 'smart growth'.

At the same time, the question of what can be regarded as a 'good city' has also been widely discussed. The core of this discussion is how to meet a city's development needs after solving urban diseases. The general view is that a good city can support development and coordinate with the city's functions as well as achieve efficient operations offering economic prosperity, a good natural environment, high living standards, social equity, and cultural harmony, as well as providing residents with sustainable welfare without passing the burden onto future generations (Leung, 2005; Wang and Wang, 2007; Zhao and He, 2016). The notions of a healthy city, ecological city, low-carbon city, livable city, compact city, innovative city, and smart city all define a good city from different perspectives (Qin, 2012). The central goal of Friedmann's (1987; 2000) idea of a good city is human prosperity, underpinned by four pillars: adequate housing, affordable health care, adequate paid work, and the adequate social provision of all these services to the most vulnerable citizens. On this basis, Douglass (2016) proposes that only a dynamic and progressive city can be a good city, which should be characterized by inclusivity in public life, distributive justice, a flourishing natural environment, and a convivial social and cultural life. In addition, Ilum (2020) shows the value and importance of urban ethics in rebuilding a good city. A good city needs citizens to participate in community and public life, and the community needs to be distinctive to enhance the residents' sense of place and identity. The community should also have a good living environment, pedestrian facilities, public and private space, and an appropriate density (Safee et al., 2015). From the sociological perspective, Amin (2006) points out that a good city should have stability, development, diversity, and fairness.

Eliminating urban diseases and building a good city have become two aspects for improving residents' quality of life. The core of these problems relates to the need to proceed based on humanism in the process of urban construction, fully considering its impact on urban livability and quality (Zhang et al., 2019).

Some countries/regions have developed corresponding evaluation and guidance systems to deal with various urban diseases. For example, Australia has developed indicators to measure cities' livability to guide the decisions on investing in new enterprises or seeking employment opportunities. The 'State of Australian Cities' annual report was published for a better understanding of urban progress in terms of productivity, sustainability, and livability (Major Cities Unit, 2010). The Ministry of Housing, Communities and Local Government in the UK noted the need for efforts to find an effective way to assess and monitor cities, proposed a conceptual framework covering convenience, health, well-being, safety, and other requirements, and defined urban development goals stating that 'people want to be able to live and work now and in the future' (Crookston et al., 2006). The US state of Oregon, uses the concepts of livability and quality of life to monitor cities in both subjective and objective terms. For example, with regard to equity, fairness of the distribution of convenience facilities is used as the evaluation index of livability, while the perception of social equity and the opportunity to be exposed to different ideas are used to measure quality of life (VanZerr and Seskin, 2011). The EU participates in the European City Statistics project, a joint initiative of the European Commission and Euro-

stat, which systematically collects detailed statistics and indicators of urban life. It aims to provide comprehensive and comparable data to describe European cities and to guide the formulation of public policy (Feldmann, 2008).

The Report on China's Urban Development 2001–2002 (China Association of Mayors, 2003) first put forward the macro theory of overcoming urban diseases through development, eliminating them through planning, and curing them through management. The National New Urbanization Plan (2014–2020) specifically calls for 'accelerating the transformation of urban development mode' and 'effectively preventing and controlling urban diseases' (Central Committee and State Council of China (CPC), 2014). At the Central City Work Conference in 2015, President Xi Jinping proposed that 'urban work should take the creation of a good human settlement environment as the central goal, and strive to build the city into a beautiful home where people and nature live in harmony'. This conference put forward new topics, directions, and content for the construction of livable cities (Zhang, 2016a; b), and provided inspiration for the design of a city health examination index system. In 2017, when President Xi Jinping inspected the management of urban planning and construction in Beijing, he proposed to 'improve the real-time monitoring, regular evaluation, and dynamic maintenance mechanism of planning, to establish an evaluation mechanism for the city health examination, and to build a city free from urban disease' (Xinhuanet, 2017). Thereafter, pilot projects for the city health examination were initiated in some Chinese cities, with its theories and methods having been continuously optimized and gradually extended to more cities. The city health examination concept serves to highlight the characteristics of ecological, high-quality, human-oriented, resilient, and sustainable city development, and innovatively explores the development path of urban transformation at present. The examination conducts a systematic, refined, and intelligent assessment of urban planning and construction management by establishing an evaluation index, allowing the discovery of urban disease and the shortcomings of urban construction. Based on these discoveries, city governments can further analyze the reasons behind the shortcomings and put forward targeted remediation measures to improve urban governance capabilities and modernization of governance systems, and promote high-quality urban development (Fang, 2019; Zhang et al., 2019).

This article introduces, explains, and discusses the philosophies, index and methods of the city health examination based on the practice and data extracted from city health examination that were conducted in Beijing in 2018, in 11 pilot cities in 2019, and in 36 volunteer cities across the country in 2020. Then, it shows an empirical case study that applied the data from the satisfaction survey in the 2020 city health examination. Through this study, we hope to provide a reference for the standardization and specialization of the city health examination to enable future analysis and application of the examination results, allow the promotion of smooth elimination of urban disease, and ensure that livable cities are built across China.

2 Basic Philosophies and Aims of City Health Examination

Traditional Chinese medicine (TCM) philosophy holds that human beings are an integral part of nature, made up of the most basic substances and their 'movements' (behaviors). The substances and movements are in a dynamic balance when a person is in a normal physiological state. Once this dynamic balance is destroyed, the person will be in a pathological state. The main reasons that people become unwell include exogenous infection (climate, infectious disease, *etc*.), internal injury (mood, diet, overwork, *etc*.), and exposure to pathological products (phlegm, blood stasis, stones, *etc*.). As all the tissues and organs of the human body are in unity, they are interrelated both physiologically and pathologically; therefore, no matter the cause of a disease, a holistic view should be emphasized in the treatment. TCM theories pay special attention to 'health maintenance' and 'preventive treatment of disease'. In the actual diagnosis of diseases, TCM uses the process of 'looking-listening-asking and feeling the pulse' to gain a comprehensive understanding of the cause and development of a patient's illness, and to explore the whole condition, so as to develop a treatment plan.

The philosophy and logic of TCM can be referred to and applied in the process of diagnosis and treatment of a city's health. People and infrastructure constitute the 'substances' of the city, and its operation process can be regarded as the 'movements'. When the two reach a dy-

namic balance, the city is healthy and stable. Once there is an imbalance between the two, causes of urban diseases will gradually accumulate. The city health examination should take a holistic view and comprehensively inspect all the city systems from different dimensions, rather than focusing only on existing problems. In addition to eliminating urban diseases, the city health examination should reduce the risk of urban diseases and prevent recurrence after eliminating them. The examination should be conducted from the outside in, that is, see the phenomenon, monitor the process, ask the levels of satisfaction, and investigate the reasons, to draw a systematic conclusion (Fig. 1).

Generally, the city health examination is systematic work that aims to continuously find the city's advantages and problems in all aspects, and scientifically formulate corresponding coping strategies combined with the city's development goals. Issues related to the city health examination, such as the construction of the methods and index system, are still in the stage of exploration. The city health examination aims to regularly analyze, evaluate, monitor, and provide feedback on the status of urban human settlements to accurately grasp the state of urban development. Based on this, more targeted urban governance could be carried out to promote the high-quality development of the urban living environment, which could help a city meet the demands of a good city and get closer to that standard (Fig. 2).

3 Index Construction of City Health Examination

Based on existing studies and the basic philosophy and theories, the content of a city health examination can be summarized into selected keywords that refer to different evaluation dimensions: livability, characteristics, inclusiveness, innovation, health, safety, convenience, and order. Under these eight dimensions, there are detailed indicators that should be selected while considering different spatial scales. The selection of these specific indicators should cover the above key indicators at all spatial scales. Moreover, selection should adhere to principles that allow for not only the scientific evaluation and monitoring of the status quo in urban construction and the quality of living environment but also reflect the direction of high-quality urban development. In addition to using objective data, a satisfaction survey was designed with corresponding questions for each dimension, so each dimension contains both objective data and subjective satisfaction data. In the city health examination of 36 cities in China in 2020, an index system comprising 8 dimensions and 50 specific indicators were adopted (Table 1).

4 Implementation Methods of City Health Examination

4.1 A combination of subjective and objective examination

Both subjective and objective data collected for the purpose of the city health examination provide feedback on urban conditions and problems. However, both types of data have their own advantages and disadvantages in reflecting the real situation. Objective data, obtained through statistics or monitoring, can reflect the real situation as an indicator at a certain point in time. It can not

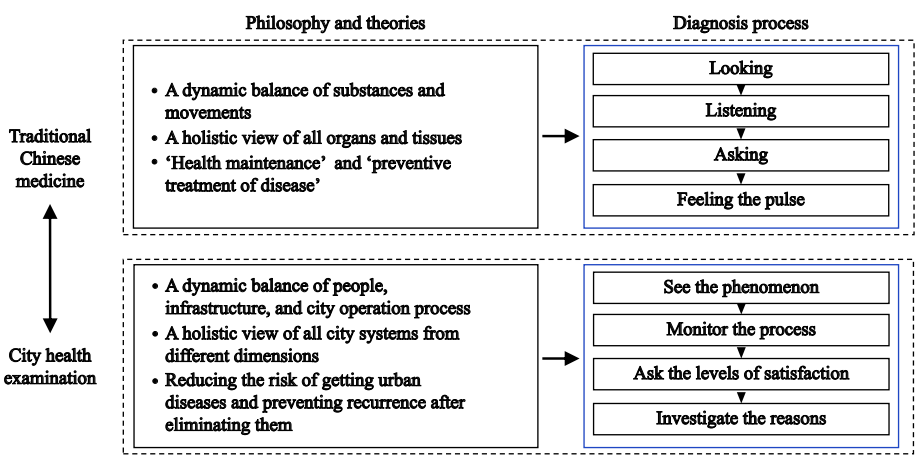

Fig. 1 A comparison of the basic theories and process between traditional Chinese medicine and the city health examination

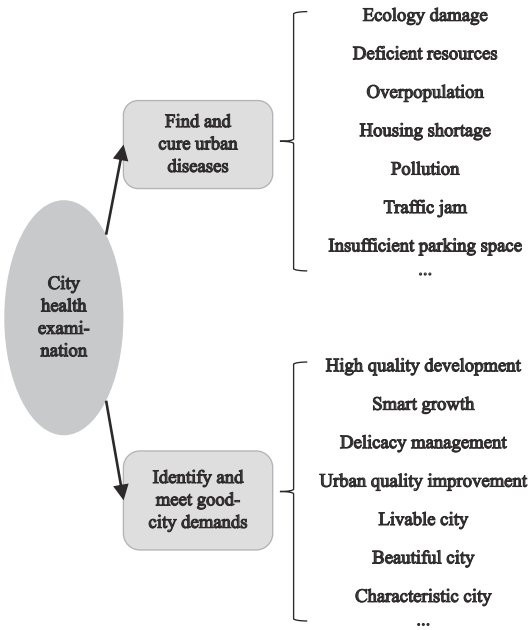

Fig. 2 Scope and aims of the city health examination

be easily manipulated and, therefore, reflects the quality of the indicator and facilitates comparison between different cities. But in the final analysis, the purpose of the city health examination is to improve urban life and citizens' satisfaction. Differences in natural conditions, development levels, and local culture in different cities may affect residents' tolerance and attention to different indicators, so the merits and demerits of objective indicators may not necessarily represent residents' satisfaction or dissatisfaction. At this point, subjective data with satisfaction as the main content becomes an important supplement to city health examination. Subjective satisfaction data directly reflects residents' satisfaction with different indicators, which is helpful in identifying areas in a city in urgent need of improvement. However, subjective satisfaction data are not convincing enough in terms of inter-city comparison. Therefore, subjective and objective data complement each other to obtain city health examination results in a more comprehensive way. In addition, the underlying causes of urban problems can be further explored through the comparison of subjective and objective data.

4.2 A combination of self-examination and third-party examination

'Who should carry it out?' is an important question in terms of the city health examination. From the perspective of understanding the city, the local government should be the ideal executor of the city health examination; local government staff usually live and work in the city and have a personal understanding of existing problems as well as the formulation and implementation of various policies, which is conducive to extracting the most useful information from various health examination data. However, for country-led city health examination carried out simultaneously in many cities, local governments may deliberately conceal or exaggerate problems when considering comparisons or competition between cities, resulting in less objective examination results. The inclusion of third-party health examination can avoid such problems. Third-party institutions can look for problems from a relatively objective and fair standpoint. Based on the same basic data, the combination of local government self-examination and third-party examination can help remedy any blind spots of the two executing parties.

4.3 The application of an iterative upgrade mode

The method system for the city health examination is not immutable, and needs to be constantly enriched and improved in the process of practice. Since the official launch of the city health examination in Chinese cities in 2018, the work has been continuously optimized and improved regarding method framework, indicator selection, and work implementation. Upon completion of each examination round, the organizers, interviewees, and the developers of the health examination report are interviewed, and their feedback, opinions, and suggestions are incorporated in formulation of the next round of the examination plan. For the examination indicator system, after each round of examination, indicators with poor differentiation, little impact on residents' lives, and of low concern are removed. Combined with feedback, public opinion, and national policies, only indicators closely related to residents' lives and of high concern are added to the index, so the constant iteration and upgrading of the examination program can bring the content of a city health examination closer to reality and better reflect the prominent problems existing in the current city.

4.4 Crosscheck with data from other sources

Data from other sources can be used as references for preparing city health examination reports, or can be combined with the examination results to carry out in-

Table 1 Common index system used in the city health examination of 36 cities in China in 2020

Function	Dimension	Specific indicators	
		Objective indicators	Subjective satisfaction indicators
Basis	Security resilience	The density of waterlogging points in urban built-up areas; the death rate per 10000 vehicles in the city; the number of large construction accidents per 10000 people in the city; the area of emergency shelters per capita; the coverage rate of urban secondary and above hospitals; urban medical waste treatment capacity; the size of public facility areas that meet the conditions for emergency transformation per capita; the concentration of urban traditional commercial wholesale markets	Public security; traffic safety; emergency shelters; traditional trade wholesale market management order; fire safety
	Health and comfort	The coverage rate of community convenience stores; the coverage rate of community care facilities for older adults; the coverage rate of inclusive kindergartens; the outpatient rate of community health service centers; the area of sports venues per capita; the area of community sports venues per capita; proportion of land area in old communities; proportion of high-rise and high-density residential land; proportion of high-density hospitals	Number of general hospitals; sports venues; large-scale shopping facilities; community inclusive kindergartens; community care facilities for older adults; community health service centers; community supermarkets and convenience stores; maintenance of community roads, fitness equipment and other facilities; old community renovation; neighborhood relations
Methods	Convenient traffic	Average vehicle speed during peak hours in built-up areas; urban road network density; average one-way commuting time of permanent urban residents; ratio of parking spaces to car ownership in residential areas; public transportation travel share rate	Walking environment; cycling environment; public transportation; road patency and congestion; time spent commuting after work or school; car parking
	Neatness and order	The recycling rate of urban domestic waste; the rate of the centralized collection of urban domestic sewage; the density of public toilets in built-up areas; the rate of establishment of various types of urban pipe networks; the proportion of residential communities that implement professional real estate management	Residential waste classification; real estate management in the residential community; city appearance; sanitary conditions of public toilets
Motivation	Diversity and inclusiveness	The coverage rate of basic public services for the permanent population; the coverage rate of barrier-free facilities in public spaces; the ratio of urban residents' minimum living security standards to the per capita consumption expenditure of urban residents in the previous year; the ratio of annual rent per unit area to the per capita disposable income of residents; the ratio of average housing price to the per capita disposable income of residents	Acceptability of housing prices; acceptability of house-renting prices; the friendliness to floating populations; the friendliness to international people; the friendliness to vulnerable groups; subsistence allowance standard; social security standard; urban barrier-free facilities
	Innovation vitality	Percentage of urban permanent registered population; proportion of newly-increased urban employment population with university education level; proportion of total social research and development expenditure in the gross domestic product; non-public economic growth rate; number of high-tech enterprises per 10000 people	Job opportunities; suitability to start a company or do business; policy environment to start a company or do business; talent introduction policy
Goals	Ecological livability	Regional development intensity; urban population density; urban development intensity; proportion of urban blue and green spaces; number of days with good air quality (AQI≤ 100); ratio of urban water environment quality better than Level Ⅴ (based on Environmental quality standards for surface water, China National Standards GB3838—2002); coverage of green space service radius; urban greenway density; proportion of green buildings in new construction	Parks and green spaces; waterfront accessible spaces; public open spaces; building density; air pollution; water pollution; noise pollution
	Landscape features	The preservation rate of the integrity of urban historical and cultural blocks; the utilization rate of industrial heritage; the average density of urban historical buildings; the attraction of domestic and foreign tourists	Landscape protection; historical block protection; restoration and utilization of historical buildings and traditional houses; landmark buildings; landscape aesthetics; cultural features

depth analytical studies. For example, most urban residents in China can complain to the city government via telephone or the Internet when they encounter various problems related to facilities and public services. After receiving a complaint, the government will record the complaint time, place, subject, specific content, and other information, and incorporate them into the database. Every year, the data from the complaint database can be compared against the city health examination results to explore whether there is synchronicity between inadequate facilities, resident dissatisfaction and complaints, and so on. Further studies can be conducted on any inconsistencies. In addition, various kinds of city evaluation and ranking data released by some research or commercial institutions can also be crosschecked with city health examination results to promote continuous improvement of the city health examination method system. The relationship among the main implementation methods of the city health examination is shown in Fig. 3.

5 A Sample Study on Satisfaction Using City Health Examination Data

5.1 Data and methods

Every aspect of the city health examination was designed to serve city residents, with the main goal being the provision of a better living environment. Thus, constructing a 'people-centered' urban human settlement environment cannot occur separately from attention to residents' actual needs and feelings. Satisfaction evaluation, an important variable in the field of human settlement environment research (Zhang et al., 2019), advocates for obtaining residents' subjective perceptions of various elements of the human settlement environment from a people-oriented perspective, to reveal the interactive law between the settlement environment and individual residents' needs. Evaluating satisfaction is conducted by using the evaluation system described in sections 3 and 4 (i.e., self-examination, third-party examination, and a subjective evaluation index system). Specifically, satisfaction data were obtained through a survey examining the current status of the residential environment in the pilot cities.

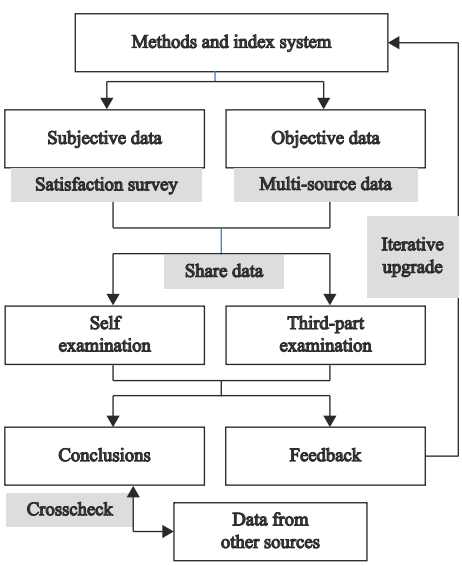

Fig. 3 The relationship among the main implementation methods of the city health examination

An online satisfaction survey was conducted as part of the city health examination in 2020. The electronic questionnaire was sent to residents (through ways like social media, communication software community, and posters with a QR code entry) in 36 cities: Chengdu, Dalian, Fuzhou, Ganzhou, Guangzhou, Guiyang, Harbin, Haikou, Hangzhou, Hefei, Hohhot, Huangshi, Jinan, Jingdezhen, Kunming, Lanzhou, Luoyang, Quzhou, Xiamen, Shanghai, Nanjing, Nanning, Suining, Taiyuan, Tianjin, Shenyang, Shijiazhuang, Wuhan, Xi'an, Xining, Yinchuan, Zhengzhou, Changchun, Changsha, Chongqing, and Urumqi (Fig. 4). Before completing the questionnaire, all respondents were informed that the individual information provided would be used for scientific research and would be kept confidential. This study was conducted with the consent of the Ministry of Housing and Urban-Rural Development of China, who sponsored the city health examination in 2020.

All completed questionnaires were directly uploaded to the server. Obvious illogical-feedback questionnaires (e.g., where all indicators under a certain dimension were rated 'unsatisfied' but the average satisfaction with the dimension was 'very satisfied') would be automatically deleted by the server system. According to the research needs, the questionnaires could be further filtered. More than 320 000 people responded to the electronic questionnaires from the 36 cities. Some questionnaires were randomly dropped for an apparent imbalance of respondent composition in certain cities (e.g., when there was a disproportionate ratio of public servants within the respondents in a city, some of questionnaires filled out by public servants were randomly ex-

Fig. 4 The 36 cities conducted the city health examination in 2020

cluded). A total of 265 000 valid questionnaires were retained and counted in this sample study, with an effective response rate of 82.8%.

The questionnaire asked respondents about their average satisfaction with the eight dimensions of the city health examination and 50 specific indicators ('Subjective satisfaction indicators' column in Table 1). A 100-point scale was used to measure all questions, ranging from 20 (very dissatisfied), 40 (dissatisfied), 60 (acceptable), 80 (satisfied) to 100 (very satisfied). A 'don't know' option was included for the respondents who had no clear opinion on the questions.

A large amount of information was mined from the data we collected. Specifically, based on this data, this section aims to present empirical research on the main problems and optimization directions of the studied cities. In this section, descriptive statistics are used to describe the satisfaction dimensions and indicators that received the lowest scores, the groups of residents who were the most unsatisfied, and the indicators that received the lowest satisfaction scores by residents' characteristics (age, sex, income, education, *etc*.), all of which reflect the cities' most serious problems. Using 'city stickiness' (i.e., residents' willingness to continue living in the city for a long time) as the entry point, correlation analysis was employed to assess the indicators to which the residents were the most sensitive. The conclusions provided herein can and should be used as the main directions for city governments for making optimization policies. Finally, measures and suggestions on how to deal with highlighted problems and optimize cities have been described.

5.2 Finding problems: what are residents most unsatisfied with?

5.2.1 Satisfaction with different dimensions and indicators

As shown in Fig. 5, among the eight dimensions, residents' average satisfaction with landscape features, ecological livability, and security resilience was higher than with the other dimensions, and average satisfaction with convenient traffic was notably lower. Innovation vitality and neatness and order also showed lower scores. Among the eight dimensions, the variance of the scores of convenient traffic, ecological livability, and innovation vitality was relatively higher; namely, between-cit-

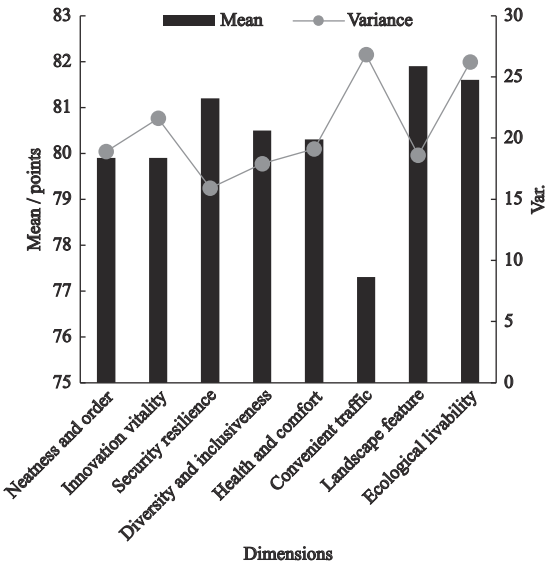

Fig. 5 Mean satisfaction scores and satisfaction score variances for the eight dimensions in the city health examination

ies satisfaction differences were larger for these dimensions. The variance of the scores of security resilience, diversity, and inclusiveness was relatively lower.

By comparing the scores for the 50 specific indicators across the 36 cities, it can be observed that residents' dissatisfaction was highly consistent across cities and occurred toward some specific indicators. Particularly, difficulty parking was the most common problem across cities; the average score for the 50 indicators was 49.6, and the average satisfaction score for parking was 68.8. Hohhot, Xi'an, and Shenyang showed the lowest satisfaction scores, all of which were below 60 points. In addition, the satisfaction scores for other traffic indicators, such as road patency and time spent commuting after work or school, were not optimistic.

Residents were also commonly unsatisfied with housing and housing rental prices; particularly, their acceptability of housing prices showed an average score of 69.4, while acceptability of house-renting prices showed an average score of 73.7. The latter score was only higher than those for car parking and housing prices. Other residence- and transportation-related indicators (e.g., real estate management, road patency, old community renovation, time spent commuting after work or school, residential waste classification, and care facilities for older adults) also showed low satisfaction scores. Thus, residents were more dissatisfied with indicators closely related to their daily life, which are also more difficult to largely improve in a short period of time.

5.2.2 Satisfaction with different characteristics

Comparing the differences between residents with different characteristics (Fig. 6), the following conclusions can be drawn:

Women's average satisfaction was lower than that of men; particularly, the average satisfaction of female respondents was nearly one point lower than that of male respondents. Among the eight dimensions, women's satisfaction with security resilience showed the largest gap in comparison to men. Regarding specific indicators, except for satisfaction with sports venues, women's satisfaction with all other indicators was lower than that of men; the indicators with the largest gap were public security, air pollution, water pollution, acceptability of housing prices, and sanitary conditions of public toilets.

Middle-aged people were less satisfied than the other age groups; particularly, the average satisfaction of people aged 30–59 was lower than that of the younger

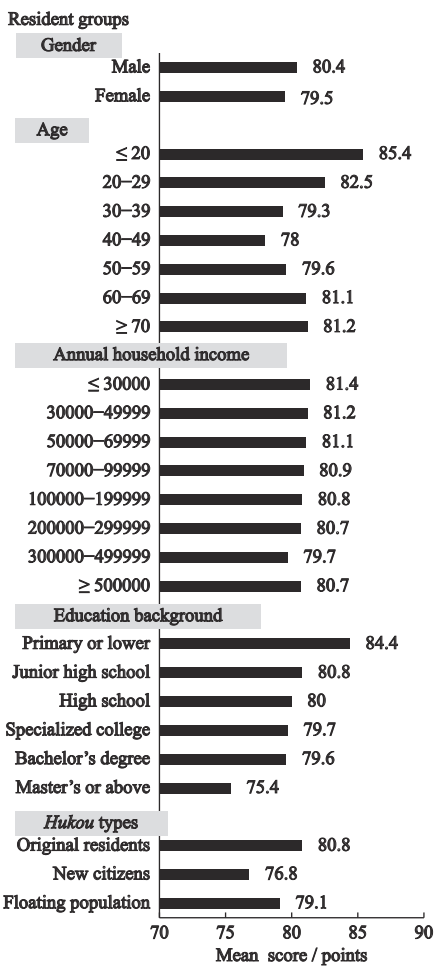

Fig. 6 Mean satisfaction scores of residents with different characteristics

and older groups, with people aged 40–49 being the ones least satisfied. Comparing different age groups and the mean of all populations, it was shown that people aged 30–39 had lower satisfaction scores for pollution-related and traffic-related indicators. People aged 40–49 were the most dissatisfied with parking, community care facilities for older adults, acceptability of housing prices, and house-renting prices. People aged 50–59 were the most dissatisfied with care facilities for older adults, shopping facilities, and old community renovation.

Satisfaction score differences among different annual household income groups were not significant, but there were obvious differences in the indicators with which different income groups were most dissatisfied. Low-income people were more dissatisfied with public security, subsistence allowance standard, social security standard, and sanitary conditions of public toilets. Middle-income people were more dissatisfied with acceptability of housing and house-renting prices, real estate management in the residential community, parking, waste classification, and community facilities. High-income groups were less satisfied with traffic-related indicators, such as parking, road patency, time spent commuting after work or school, and cycling environments. People in the highest income group were also dissatisfied with innovation vitality indicators, such as talent introduction policies and the policy environment for starting a company or doing business.

Overall, satisfaction showed a decreasing trend with an increase in education. People with no more than primary school education showed the highest satisfaction, while those with a postgraduate degree or above showed the lowest satisfaction. The junior high school graduates showed lower satisfaction scores for the friendliness to floating populations and public security. High school graduates showed lower satisfaction scores for subsistence allowance standard and convenience stores. Specialized college graduates were more dissatisfied with acceptability of housing prices and subsistence allowance standard. Those with a bachelor's degree showed the lowest satisfaction with parking and road patency. Participants who had a master's degree or above were more dissatisfied with parking and talent introduction policies.

Hukou is a system of household registration used in mainland China, which is the registration of an individual in the system. A household registration record officially identifies a person as a permanent resident of an area and includes identifying information such as name, parents, spouse, birthplace, and date of birth. Compared with original residents (i.e., people with local *hukou* and who were born locally) and the floating population (i.e., people without local *hukou*), the average satisfaction of new citizens (i.e., the migrant population with local *hukou*) was obviously lower. New citizens had a relatively low satisfaction with parking, real estate management in the residential community, care facilities for older adults, waste classification, and community-inclusive kindergarten. The floating population was less satisfied with the friendliness to floating populations, disadvantaged groups, and international people, and acceptability of house-renting prices.

5.2.3 Major problems found in cities

More dissatisfaction means more severe problems; based on the survey results, many cities had problems in common. Traffic-related problems, for instance, were common difficulties faced by most cities; huge populations and the rapid growth of the number of motor vehicles have caused traffic congestion and parking difficulties to become daily routines in many cities, directly affecting residents' daily lives. Therefore, the dimension which residents were less satisfied with was convenient traffic in almost all participating cities, and traffic is a key area that needs to be enhanced through targeted governance.

Moreover, residents' dissatisfaction with acceptability of housing and house-renting prices showed that real estate prices are too high, and non-concordant with the current household income of most residents. When housing becomes a financial product instead of a public product, it can become a huge burden for non-original residents; this can further affect their life satisfaction and turn into a serious urban problem. In the past decade, this phenomenon has gradually spread from first-tier cities to small- and medium-sized cities across China; accordingly, controlling the excessive growth of housing prices is an important national issue and should be addressed.

The survey also found significant satisfaction differences between different cities. For example, compared with coastal cities, some cities in central and wstern China showed a large gap in job opportunities and policy environment for starting a company or doing

business, being less attractive to high-tech talents. Accordingly, city residents were less satisfied with their innovation vitality. There were also marked differences in dissatisfaction levels among residents of different cities for common problems such as traffic.

Residents with different characteristics provided different satisfaction scores for different indicators. For example, women were less satisfied with security resilience, environmental pollution, and public health. New citizens were less satisfied with the health and comfort indicators within communities, while the floating population was less satisfied with the friendliness to floating populations, disadvantaged groups, and international people, as well as acceptability of house-renting prices. These results showed that floating populations might be more concerned about the city's friendliness and tolerance and about the costs of living in the current city.

5.3 Meeting demands: increasing city stickiness

5.3.1 The relationship between satisfaction and city stickiness

The need to become stickier and more attractive is an important development consideration for most cities. This turns them into places where residents want to live and work, and where talent from outside wants to settle. To meet these demands, it is necessary to understand the city's present level of stickiness and the factors that are effective in improving it. The 2020 city health examination questionnaire included the question, 'Would you consider living in this city for a long time (at least five years)?' to which residents had to respond by choosing from among the following options: 'Yes' (stickiness score of 100), 'not sure' (stickiness score of 50), and 'No' (stickiness score of 0). Selecting the response 'not sure' denoted that those residents were hesitant; to them, the stickiness of their city was neither more nor less compelling than the attractiveness of other cities — explaining the median value of 50 points. The average value of this stickiness score was used to estimate city stickiness for a variety of residents with different characteristics.

Generally, compared with cities in eastern China, most cities in the northeast and northwest (except for Yinchuan) and some cities in the south lacked stickiness; cities with lower stickiness scores were Urumqi, Harbin, Changchun, and Dalian.

Understanding the indicators that often cause residents to move is critical to assessing the factors that influence a city's stickiness. Thus, this study examined the relationship between the satisfaction levels of the residents of a city (measured using various indicators) and their willingness to remain in the city.

As shown in Fig. 7, innovation vitality, ecological livability, and health and comfort were found to be highly correlated with city stickiness. Residents' average satisfaction with convenient transportation and security resilience showed low correlations with stickiness. Among specific indicators, friendliness towards foreigners and suitability to start a company or do business, and policy environment for starting a company or doing business were highly correlated with stickiness; however, parking, acceptability of housing prices, and community care facilities for older adults had low correlation coefficients.

The higher correlation between innovation vitality and stickiness confirms the widely accepted position that job satisfaction (or lack thereof) plays a crucial role in making residents 'vote with their feet' (i.e., leave a place they are not satisfied with and settle somewhere else) (e.g., Gu et al., 1999; Storper, 2013; Bjarnason, 2014; Lin et al., 2019). The close relationship between ecological livability, health and comfort, and city stickiness has been discussed in a series of studies; researchers believe that changes in cities' environmental quality will induce migration (Lundholm et al., 2004; Vilhelmson and Thulin, 2013). Moreover, people may choose to move to other cities when exposed to air pollution in one city (Banzhaf and Walsh, 2008). Li et al. (2014) pointed out that indicators such as land quality, water quality, and people's assessment and expectations their city in terms of its handling of environmental issues are closely related to residents' intention to migrate.

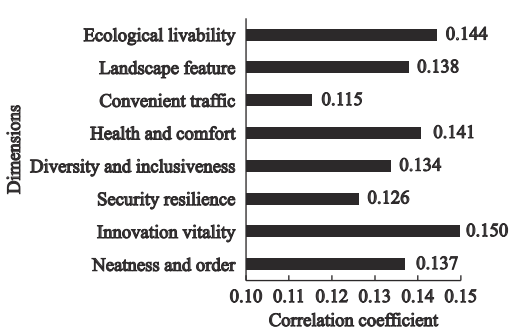

Fig. 7 The correlation between the average satisfaction of the eight dimensions and a city's stickiness

Residents' average satisfaction with convenient traffic showed the lowest correlation with stickiness. This connection can be understood by referring to Ivlevs's (2014; 2015) studies, which show that people who do not travel frequently and are less affected by transportation conditions tend to be unemployed, freelancing, or not well established in their jobs; these people incur lower costs while changing their workplaces or have other motivations to move. However, people who need to travel frequently and are affected by traffic conditions tend to be settled in their jobs and are likely to incur greater costs if they choose to migrate; thus, they lack the motivation to relocate.

5.3.2 City stickiness for residents with different hukou types

A person's *hukou* type relates to their identity, personal connections, and social security rights in the city. These variables may have an impact on whether residents choose to move to another city. Therefore, this section separately analyzes how city stickiness is experienced by people with different *hukou* types. Among original residents, new citizens, and floating populations, the first two groups showed a higher willingness to stay in the city, while the third had low willingness to remain (Fig. 8). Thus, the *hukou* may have a significant impact on residents' choice to stay in a city.

Comparing the respective correlation coefficients of the relationships between the satisfaction levels of these three groups and their willingness to stay in their city of residence, we drew the following conclusions: new citizens' willingness to live in the city is more sensitive to satisfaction than that of the other two groups, while the willingness of floating populations is the least sensitive; at the same satisfaction level, new citizens are most likely to plan to move to another city, while the floating population is the least likely to.

Original residents displayed a higher-than-average sensitivity to indicators such as real estate management in the residential community and old community renovation. New citizens were sensitive to indicators such as ease of business and job opportunities. The floating population was sensitive to indicators such as friendliness towards foreigners and restoration and utilization of historical buildings and traditional houses.

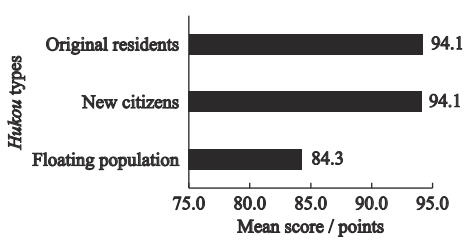

Fig. 8 Willingness to continue living in the current city among residents with different hukou types

5.3.3 Improving city stickiness: major pathways

While aspects of a city should be improved, an effective approach to improve city stickiness is to meet and satisfy the needs that residents perceive to be the most important. For example, although traffic problems had the lowest satisfaction scores, city stickiness would be more efficiently enhanced by upgrading the innovation vitality and ecological livability of the city. Local governments should specifically prioritize friendliness to foreign populations and ease of doing business. This conclusion was derived from the full sample, but there could be variations by city; therefore, individual cities should examine their specific characteristics before making concrete plans.

Furthermore, an improvement in a single indicator was shown to have potentially different effects on different resident groups. For floating populations, stickiness may be advanced through focusing on eliminating *hukou* barriers, equalizing welfare, and creating a friendly environment for migrant residents. For original residents, stickiness may be advanced by enhancing the comfort of the living environment. For new citizens, improving the environment for entrepreneurship and employment may be conducive to greater stickiness. Furthermore, the results showed that specific strategies are needed for different groups, based on sex, age, income, and educational background.

5.4 Discussion

During the city health examination, conducting surveys to assess residents' satisfaction may enable more citizens to participate in city management, contributing to the formation of a social atmosphere through which people are conduced to care about and participate in the city health examination. With the help of new media and network technology, residents can have diminished burdens regarding survey completion while being able to provide direct and clear feedback to policy makers and city managers about their feelings on different aspects of the city. According to the satisfaction survey that was analyzed in this study, the following typical

problems should be focused upon, solved, and/or improved by city governments as soon as possible.

Regarding the most common reasons for dissatisfaction among residents, such as housing- and traffic-related problems, improvements should address the following: a compact and intensive spatial structure should be advocated; a mixed layout of functions and composite land use should be emphasized; a more appropriate balance regarding the transportation from house to employment should be promoted; parking should be optimized; public transportation and non-motorized traveling methods should be encouraged and prioritized on the road; an urban housing security system in which the Chinese government is the mainstay should be actively explored, established, and improved; new regulations should be devised to strengthen the owners and residents committees' abilities to supervise real estate management companies; and renovation projects of old communities should be promoted by city governments in an orderly manner. Additionally, specific groups' dissatisfaction should be addressed; given that each group has differentiated needs, these should be actively targeted and responded to.

Though a series of results with practical value can be drawn from this study, some limitations remain. The most important one is that all survey participants evaluated their satisfaction with the city they were currently living in, so, as a result, each city was evaluated by a different group of people. Since residents of different cities may have different characters and different understandings of satisfaction, satisfaction scores between cities cannot be directly compared. Consequently, a city with a high satisfaction score for a certain indicator is not necessarily better for this indicator. This problem could be remedied by describing each level or score of satisfaction in a more detailed way. Moreover, at present, only a small number of cities have participated in the city health examination, and these cities are scattered all over the country, which makes it difficult to conduct a rigorous and detailed spatial analysis. Since more cities will join in the examination, better approaches may be found in future research and practice.

6 Conclusions

This paper began by providing information on the background and purpose of the city health examination in China, thereafter combining existing research and practical work to explore and introduce the core logic, key indicators, and specific implementation methods of the examination. An index of 8 dimensions and 50 specific indicators was designed and employed in the 2020 city health examination in 36 Chinese cities.

Furthermore, this paper conducted an empirical study based on data from the satisfaction survey that was conducted during the city health examination in 2020. It briefly analyzed the main problems currently being faced by the participating cities and by the populations, with different characteristics in each city, thereafter concisely examining the relationship between residents' satisfaction and city stickiness. Results mainly showed that residents' average satisfaction with convenient traffic was much lower than that with all other dimensions. Differences were found for the indicators with the lowest satisfaction scores for residents with different characteristics. Moreover, residents' satisfaction with innovation vitality, ecological livability, and health and comfort were highly correlated with city stickiness. Additionally, there were clear differences in the main influencing factors of city stickiness in residents with different hukou types.

The systematic methodology for the city health examination introduced in this paper has been proved to be practical, efficient, and convincing, and the relevant government departments are willing to apply it nationally. It can also be referenced by other countries that might be planning to diagnose their cities. It is worth noting that China's city health examination are still in the experimentation and improvement stage, and the methodology needs to be refined to overcome its limitations. There is still ample room for improvements in the framework design, index selection, implementation mechanisms, and technical means of the examination. Moreover, a city health examination can generate a large amount of data for researchers to analyze and study, which can then be mined from different entry points and used in different forms to obtain more information for use in supporting the construction of enhanced livable cities. Future research could focus on either the refinement of the methodology or mining the collected data with expansion and depth.

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