Impact of the China Healthy Cities Initiative on Urban Environment

Dahai Yue · Shiman Ruan · Jin Xu · Weiming Zhu ·
Luyu Zhang · Gang Cheng · Qingyue Meng

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Abstract The China Healthy Cities initiative, a nationwide public health campaign, has been implemented for 25 years. As “Healthy China 2030” becomes the key national strategy for improving population health, this initiative is an important component. However, the effects of the initiative have not been well studied. This paper aims to explore its impact on urban environment using a multiple time series design. We adopted a stratified and systematic sampling method to choose 15 China healthy cities across the country. For the selected healthy cities, 1:1 matched non-healthy cities were selected as the comparison group. We collected longitudinal data from 5 years before cities achieved the healthy

city title up to 2012. We used hierarchical models to calculate difference-in-differences estimates for examining the impact of the initiative. We found that the China Healthy Cities initiative was associated with increases in the proportion of urban domestic sewage treated (32 percentage points), the proportion of urban domestic garbage treated (30 percentage points), and the proportion of qualified farmers’ markets (40 percentage points), all of which are statistically significant ($P < 0.05$). No significant change was found for increases in green coverage of urban built-up area (5 percentage points), green space per capita (2 square meter), and days with Air Quality Index/Air Pollution

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D. Yue · J. Xu · W. Zhu · L. Zhang · G. Cheng ·
Q. Meng (✉)
China Center for Health Development Studies, Peking University,
Beijing, China
e-mail: qmeng@bjmu.edu.cn

D. Yue
e-mail: dhyue@ucla.edu

J. Xu
e-mail: xujin@bjmu.edu.cn

W. Zhu
e-mail: wmzhu@bjmu.edu.cn

L. Zhang
e-mail: lulilu@sina.com

G. Cheng
e-mail: maxdea@qq.com

D. Yue
Fielding School of Public Health, University of California Los
Angeles, Los Angeles, CA, USA

S. Ruan
Jinan Center for Diseases Control and Prevention, Jinan, China
e-mail: shimanruan@qq.com

S. Ruan
Center for Health Policy and Management, Shandong University,
Jinan, China

J. Xu
London School of Hygiene & Tropical Medicine, London, UK

Index ≤ 100 (25 days). In conclusion, the China Healthy Cities initiative was associated with significant improved urban environment in terms of infrastructure construction, yet had little impact on green space and air quality.

Keywords China Healthy Cities · Urban environment · Inter-sector collaboration

Introduction

As the world becomes more and more urbanized, there is an increasing discussion on urban health and environment as a key area of the post-2015 development agenda [1]. Environmental health factors (unsafe water, sanitation, and hygiene) account for approximately 3.1% of deaths and 3.7% of disability-adjusted life years (DALYs) worldwide [2]. While it is widely accepted that access to clean water and sanitation are human rights as well as basic needs for healthy living [3], the urban living environment continues to receive less attention at both national and international levels [4]. In response to the environmental and health problems caused by urbanization, the WHO Healthy Cities Project (HCP) was initiated in 1986 [5]. HCP promotes collaboration between local governments and community organizations to deal with priority problems related to urban health and environment [5, 6]. There was evidence demonstrating the positive environmental influence of HCP [6, 7], including in developing countries [7–9]. Most literature about HCP evaluation is related to process indicators using qualitative methods, and discussion on methodologies [10–12].

To cope with deteriorating urban environmental conditions in China, a very similar project named the China Healthy Cities (CHC) initiative was launched in 1989. However, existing literature on this topic is relatively sparse. These previous studies mainly focus on introducing how this initiative motivates service improvement [13] and inter-sectoral collaboration [14] through an awards and competition mechanism. Within the small corpus of previous Chinese publications, evaluation studies of the CHC initiative were constrained by lack of rigorous study design. For example, one study in Henan Province showed that CHCs have better urban environment conditions than non-CHCs by using a cross-sectional survey while no sufficient statistical controls were included [15]. To our knowledge, the effects

of the CHC initiative have not been well studied. This study aims to explore whether the CHC initiative contributed to improved urban environment and to what extent. As the initiative has been promoted by the Chinese government as one of the key strategies for public health as part of “Healthy China 2030,” systematic evaluation is crucial for informing policy making. Moreover, this study also helps to bring the CHC initiative on the international stage and provides valuable experience for other developing countries.

The China Healthy Cities Initiative

The China Healthy Cities Initiative has historical roots in the Patriotic Health Campaign, a public health initiative launched nationwide in the early 1950s. Until now, the Patriotic Health Campaign has been headed by political leaders at every level of government, and participated in by various sectors and local communities as a whole. It has been proven to be effective in mobilizing the public to change poor sanitation conditions, and control infectious diseases in urban areas [16]. However, the Patriotic Health Campaign left its priority to economic development after marketization reform in 1978. As a result, several environmental issues have been emerging and posing great challenges for health, including inadequate basic services and poor urban sanitation [17]. In this context, the CHC initiative was launched in an effort to strengthen the Patriotic Health Campaign and to improve urban living conditions.

The CHC initiative aims to provide urban residents with a clean, beautiful, tidy, and comfortable living and working environment, and cities participated voluntarily [18]. A multi-sector committee at the national level leads this initiative, and the Office of the National Patriotic Health Campaign Committee affiliated with the National Health and Family Planning Commission is mainly responsible for its daily operation and management. In order to win the CHC title, cities have to meet a list of environmental and health indicators. Typically, it would take cities 3 to 4 years to make improvements and get the title. Detailed procedures and criteria to name and define a city as a “China healthy city” and detailed actions undertaken by cities have been introduced elsewhere [13, 14]. There are many similarities between the CHC initiative and HCP, not only in terms of environmental indicators but also with respect to health and health services. These programs resemble each other

especially compared with HCP in other developing areas, such as Chittagong in Bangladesh [9], Fayoum in Egypt [8], and Dar es Salaam in Tanzania [8]. In the initial stage, both the CHC initiative and HCP in developing countries emphasize environment improvement and infrastructure constructions. Therefore, in this paper, those cities that succeed in this public health initiative in China are referred to as “China Healthy Cities” instead of “National Hygienic Cities” [13] or “National Sanitary Cities” [19].

Methods

Study Design and Sampling

By the end of 2011, there were 149 cities that had been titled as CHCs. Among those, 77 general prefecture-level cities were considered as the study population. We excluded provincial capital cities and cities with independent planning status due to their unique features within their provinces. We also excluded county-level cities since several of them have been amalgamated with other regions during the study period, which makes it hard to undertake a time-dependent evaluation.

This study used a multiple time series design [20]. We chose 15 CHCs as the intervention group and 15 matched non-CHCs as the comparison group. Data were collected annually for each city ranging from 5 years before CHCs gaining the title up to the 2012 calendar year. For the comparison cities, the time ranges of data collection were the same with their corresponding CHCs. We used a stratified and systematic sampling method to choose the 15 China healthy cities. We classified 77 CHCs into three groups: 42 from the eastern region, 18 from the central region, and 17 from the western region. Within each region, five cities were randomly selected based on a systematic sampling method. First, cities were ranked based on 2011 gross domestic products (GDP) per capita. Then, we selected a city from the list at random. Finally, every 4th city in the frame was selected. In order to increase the representativeness of sampled cities, sampling results with cities from different provinces were chosen. Each selected CHC was individually matched to a non-CHC within its province on the basis of four city characteristics available: GDP per capita in 2011, urban residential population, urban built-up area, and geographic proximity. Particularly, we also restricted non-CHCs to those

that did not launch the CHC initiative during the study period. These studied cities were listed in Table S1 in the appendix.

Data Sources

We designed a standardized questionnaire to collect data in December 2013 to ensure comparability across cities based on the CHC initiative criteria [21] and the WHO Healthy Cities Project indicators [7]. The questionnaire covers five dimensions: the organizational structure of the CHC initiative management, city characteristics, environmental indicators, social indicators, and health indicators. Health and social indicators were not added in the criterion of the CHC initiative until 2005. We also consider these outcomes as the indirect effect of the CHC initiative. Thus, the questions analyzed in this paper mainly focus on urban environmental indicators.

After receiving training, officials at the Office of the Patriotic Health Campaign Committee (similar with coordinators of HCP) in each city were responsible for coordinating various related sectors to provide the required data. We sent questionnaires to them by email before our field study to collect information. In order to ensure the objectiveness of self-reported data in the questionnaires, we request cities to provide data sources and materials supporting their data. These data are mainly based on the Statistics Yearbook of Cities. Research assistants checked the quality of data by randomly selecting 3 years of data for each city and comparing with local statistical yearbooks and city official documents before and during our fieldwork. Once differences were found, we contacted cities to explain the reasons for the discrepancies and asked them to provide all data according to more objective data sources, such as statistics yearbook of cities. Returned questionnaires were also carefully checked for completeness in order to minimize missing values.

Measures

Outcomes, measured at city levels, include the proportion of urban domestic sewage treated, the proportion of urban domestic garbage treated, the proportion of qualified farmers' markets, green coverage of urban built-up areas, green space per capita, and number of days with $AQI/API \leq 100$ (Table 1). Independent variables include whether one city has already been a China Healthy City (1 indicates yes and 0 indicates no), urban GDP per

Table 1 Measurements of environmental indicators

Outcomes	Definitions	Data sources
The proportion of urban domestic sewage treated	Treated domestic sewage divided by total amount of domestic urban sewage in a given year, ranging from 0 to 100.	Statistical Yearbook of Cities
The proportion of urban domestic garbage treated	Harmless treated domestic garbage divided by the total amount of urban domestic garbage in a given year, ranging from 0 to 100.	Statistical Yearbook of Cities
The proportion of qualified farmers' markets	Number of qualified farmers' markets ^a divided by total farmers' markets in one city in a given year, ranging from 0 to 100.	Official monitoring data from the Industrial and Commercial Bureau
Green coverage of urban built-up area	Green coverage refers to the coverage of green space in the built-up area ^b of a city, including mainly public green space.	Statistical Yearbook of Cities
Green space per capita	Calculated by dividing the total green space by the total population of a city in a given year, measured in square meters.	Statistical Yearbook of Cities
Number of days AQI/API ≤ 100	Number of days air quality index (AQI) or prior air pollution index (API) less than or equal to 100, in a given year.	Official monitoring data from the Environmental Protection Bureau

^aStandards for qualified farmers' markets were based on "Regulations of Standardized Farmers' Markets Establishment and Service (*Biaozhunhua Caishichang Shezhi Yu Guanli Guifan*)" provided by the Ministry of Commerce of the People's Republic of China. These standards include regulations concerning infrastructure, sanitation, hygiene of sellers, and display of products, etc.

^bBuilt-up area refers to urbanized areas and often includes parts of urban, rural, and sub-urban areas

capita (Chinese Yuan), urban residential population (millions), and urban built-up area (squared kilometers). Additionally, we also included region as a categorical variable to indicate regional differences, with 1 = Eastern China, 2 = Central China, and 3 = Western China.

"Nominal time" scale was created for describing temporal trends of outcomes. In this scale, we set the year CHCs won the CHC title as 0 (the named year), such that "−5" refers to 5 years before CHCs got the title (baseline), and "17" represents 17 years after CHCs winning the title. Nominal time ranges from −5 to 17. Number of observations deceased after nominal time 0 for cities getting the title in later years, since we only collected data up to 2012. For example, if "the named year" for one city was 2011, we would only have 1-year measurement for the city after it became a CHC. We decided to restrict our sample to those with nominal time less than 15 in order to ensure at least three observations for each time.

Statistical Analysis

Descriptive statistics of city characteristics in the two groups were displayed using mean, median, 25% percentiles, and 75% percentiles. Both Wilcoxon rank-sum test and two-sample *T* test were applied to test differences between the two groups. Empirical summary plots of outcome variables across nominal time by the CHC

group and non-CHC group were plotted to visualize the temporal trends.

We used hierarchical models to accommodate correlations between observations within cities and provinces. To start, we explored different fixed effects to appropriately model the time trend for each outcome based on log likelihood ratio test, Akaike information criterion (AIC), and Bayesian information criterion (BIC) (Table S2). Then, we examined various covariance structures for observations within cities based on preferred fixed effects, and those with the smallest AIC and BIC were chosen (Table S3). Final models for each outcome were specified respectively (Section 1, Supplement). For ease of interpretation, we calculated adjusted difference-in-differences estimates to display the effects of the CHC initiative, which essentially were linear combinations of coefficients (γ) of interaction terms in final models (Table S4). Data were analyzed using SAS 9.3.

Several sensitivity analyses were done. We repeated our analysis by restricting the sample to those with nominal time less than 7, to ensure at least 11 observations at any given nominal time. Analyses based on full sample were also explored. Additionally, instead of treating province as a random effect, we fitted models using province as fixed effects and also calculated difference-in-differences estimates.

Results

Table 2 presents characteristics of China healthy cities and their comparison cities in 2011. There is no statistically significant difference in all of the three city characteristics. Urban residential population (0.93 vs. 1.30 millions) and urban built-up areas (68.74 vs. 69.17 km²) were slightly smaller in CHC group measured by the median statistics. However, urban GDP per capita has a big gap between the two groups, although it remains not statistically significant. The median level of urban GDP per capita is 10,000 (Chinese Yuan) higher in the CHC group than that in the non-CHC group.

Figure 1 plots the unadjusted urban environmental outcomes in the CHC group and the comparison group from nominal time -5 to 6. The proportion of urban domestic sewage and garbage treated had similar time trends; the CHC group started lower but increased rapidly. Specifically, CHC cities had the proportion of urban domestic sewage treated 10.5 percentage points lower (37.1 vs. 47.6%) at baseline, but 16.5 percentage points higher 3 years after getting the title (85.7 vs. 69.2%). Similarly, the proportion of urban domestic garbage of CHC group was 10.2 percentage points lower (73.8 vs. 84.0%) at baseline, but 9.0 percentage points higher at the year winning the title. The most obvious effect of CHC goes to the proportion of qualified farmers' markets; the CHC group had almost the same level with the comparison group at the baseline, but increased dramatically during the following time, resulting in 25.3 percentage points higher in the 3rd year after achieving the CHC title. Although green coverage of urban built-up area seems to follow a similar trend

with sewage and garbage treatment, the CHC group increased moderately faster than the comparison group. In terms of green space per capita, the CHC group had a nonlinear trend and rose up slightly faster. However, the effect of the CHC initiative is not obvious in terms of number of days with AQI/API ≤ 100 ; cities in the comparison group caught up at the 3rd year post.

Table 3 displays adjusted difference-in-differences estimates based on hierarchical models for each outcome, after controlling for covariates. On average, the CHC initiative was significantly ($P < 0.05$) associated with around 32 percentage points increase in the proportion of urban domestic sewage treated, 30 percentage points increase in the proportion of urban domestic garbage treated, and 40 percentage points increase in the proportion of qualified farmers' markets, after controlling for other factors. Additionally, the CHC initiative was only associated with 5 percentage points increase in green coverage of urban built-up area, which was marginally significant ($P < 0.1$). However, although there were 2-m² increase for green space per capita and 25 more days with AQI/API ≤ 100 associated with the CHC initiative, these changes were not statistically significant. Alternative models and other sample definitions resulted in findings consistent with those presented above (Tables S5, S6, and S7).

Discussion

This is the first study that the effects of the CHC initiative were systematically evaluated. We found that the CHC initiative was associated with improvements in

Table 2 Characteristics of studied CHCs and non-CHCs in 2011

	Number	Mean	Median	25% percentiles	75% percentiles	<i>P</i>
Urban GDP per capita (RMB)						
CHCs	15	67,729	49,898	40,301	101,306	0.130
Non-CHCs	15	46,485	38,418	35,157	62,309	
Urban population (million)						
CHCs	15	1.53	0.93	0.71	1.43	0.468
Non-CHCs	15	1.20	1.30	0.63	1.55	
Urban area (km ²)						
CHCs	15	86.96	68.74	55.00	93.40	0.852
Non-CHCs	15	72.16	69.17	45.42	91.50	

P values in the table were from Wilcoxon rank-sum test. Two-sample *T* test also showed no significant difference between the CHC and non-CHC groups at alpha = 0.05 level

CHC China Healthy Cities, Non-CHC non-China Healthy Cities

Fig. 1 Unadjusted trends in selected urban environmental indicators, by China Healthy Cities groups. Notes: The figure presents unadjusted means in the China Healthy Cities group and the comparison group by nominal time. The error bars represent

95% confidence intervals. Data from the China Healthy Cities group are shifted slightly to the right to avoid overlap. SAS 9.3 programming software was used to draw above plots

urban environment, especially in the area of infrastructure construction. But we did not find evidence of significant changes in public green space and air quality associated with the CHC initiative.

The CHC initiative actually made a strong case for government to increase financial commitment in lagging infrastructure that requires much-needed resources: specifically for sewage disposal, garbage collection and treatment, and construction of farmers' markets. Cities participating in this initiative were encouraged to invest

in these fields, largely due to the concrete measurements, awards and competition [13], and predefined benchmarks [14]. To deal with wastewater and garbage, CHC cities had either established or upgraded their wastewater and household solid waste treatment plants during the CHC initiative. Particularly, specific government departments were set up during the initiative period to be directly responsible for these two domains. Many constructions were done for farmers' markets to meet predefined standards in terms of infrastructure,

Table 3 Difference-in-differences estimates of effects of the CHC initiative on urban environmental indicators

	The proportion of urban domestic sewage treated		The proportion of urban domestic garbage treated		The proportion of qualified farmers' markets		Green coverage of urban built-up area		Green space per capita (m ²)		Number of days with AQI/API ≤ 100	
	Est	P	Est	P	Est	P	Est	P	Est	P	Est	P
The named year to baseline	33.60 (12.47)	0.008	30.82 (11.67)	0.009	32.97 (10.07)	0.001	4.52 (2.58)	0.081	2.94 (1.76)	0.096	25.42 (27.63)	0.359
1st year post to baseline	33.17 (12.42)	0.008	30.11 (11.41)	0.009	39.57 (12.08)	0.001	5.05 (2.89)	0.083	2.21 (1.90)	0.246	25.66 (29.51)	0.386
2nd year post to baseline	32.74 (12.46)	0.009	29.40 (11.37)	0.011	39.55 (12.04)	0.001	5.45 (3.16)	0.086	1.48 (2.14)	0.491	24.71 (30.78)	0.423
3rd year post to baseline	32.31 (12.61)	0.011	28.69 (11.54)	0.014	39.54 (12.30)	0.002	5.72 (3.38)	0.0106	1.58 (2.12)	0.459	22.72 (31.66)	0.474

Est refers to difference-in-differences estimate from hierarchical models for each outcome after controlling for urban gross domestic products per capita, urban residential population, urban built-up area, and region. Standard errors of estimates were included in parentheses. The named year denotes the year when CHCs got the title, which varies across cities. Baseline was the 5th year before the named year, 1st year post was the first year after the named year, 2nd year post was the second year after the named year, and 3rd year post was the third year after the named year

sanitation, hygiene of sellers, etc. In contrast, while many efforts were conducted to improve public green space and air quality [14], these effects were found to not be statistically significant in our study. This might be because the CHC criteria include relative low minimum thresholds for these indicators—for example, 36% for green coverage of built-up areas and 8.5 m² for public space per capita. Most cities have already met these requirements at the baseline and would allocate resources to other lagged areas.

The platform for multi-sector collaboration provided by the CHC initiative is the key for its achievements in improving urban environment. The CHC initiative, as a sort of competitive campaign, has successfully stimulated inter-sectoral collaboration and improved public and environment health [14]. During the initiative period, the municipal government assigned the measurements of CHC criteria to a group of departments or sectors. For the collection and treatment of wastewater and garbage, publicity departments made fliers and advertisements to raise residents' awareness of sanitation. Construction sectors were responsible for constructing the refuse processing plants. Companies, factories, and even commercial tenants are accountable for improving living and working environments within and near their locations. Similar inter-sector collaborations were also used for construction and regulation of farmers' markets. In these cases, performance assessment was based on a certain package of outcomes or measurements. This resulted in an incentive to be aligned with outputs shared across agencies or departments, rather than outputs for individual sectors. It was the temporal institution "Office of Creating China Healthy Cities" that is directly responsible for coordinating these agencies, usually led by the mayor or deputy mayor during the period of the CHC initiative. What is more, the transparency and accountability of indicators and target values is helpful in making multi-sectoral collaboration more measurable. To make each sector and staff accountable, municipal governments also established various rewards and punishment systems that are directly related to one's political career or economic interests [13].

These mechanisms of multi-sector collaboration are very helpful to ensure policy coherence for improving public services between various stakeholders, who sometimes have conflicting goals and priorities facing scarce economic resources. This is virtually consistent with WHO Healthy Cities Project, which brings voluntary sectors and communities together in a partnership to

focus on urban health and health-related issues [5]. For instance, in Jiayuguan city, there was a coordination meeting every week during the initiative period, where the mayor and directors from departments came together to negotiate on conflicting objectives and tasks. Coordinated by the mayor rather than the director of health or other individual agency, these meetings were seen to be relatively productive and efficient. In conclusion, effective multi-sector collaboration and strong incentives from awards and competition were served to be the key for the CHC initiative to improve urban environment.

How to make the CHC initiative sustainable remains a quite challenging issue. In many cities, the temporary institutions set up to coordinate inter-sector collaboration for the CHC initiative have been dismissed after winning the title, and their responsibilities transferred to a sub-agency within existing health departments. The low political power of the health sectors within government makes it very hard to effectively carry out the coordination task. To address this problem at the national level, a sample of CHCs are randomly selected for reassessment every 3 years, based on the latest standards [13]. At the local level, municipal governments have also figured out several response options. A good example is Baoji city in Shaanxi Province; a specific one million (Chinese Yuan) budget is annually assigned by the municipal government to award those junior government facilities for good performance in urban environments. However, despite such policies, inter-sector collaboration still faces many difficulties and is highly dependent on personal relationships. Furthermore, influenced by the fiscal and administration cycle in the government, the support for the CHC initiative is unstable and depends on the problem-solving priorities of individual mayors. Therefore, how to make the CHC initiative soundly institutionalized is the key to its sustainable development.

Our study contributes to the current literature in many important ways. This is the first time examining the effects of the CHC initiative on urban environment in its 25-year history at a national scale using longitudinal data. Based on a multiple time series study design, we could control for many threats to internal validity, including secular trends and other events than the CHC initiative [20]. This design also strengthened our study by demonstrating the effects of the CHC initiative twice; once against the baseline and once against the comparison group. Additionally, our difference-in-differences

estimates accounted for time invariant factors, such as cities' geographic locations. Results of this study not only provide more rigorous evidence for the CHC initiative's important role in improving public health in "Healthy China 2030" but also help to encourage China to more actively participate in the WHO Healthy Cities Project. Moreover, we add to the growing body of evaluation research of healthy cities by conducting a quantitative study, which could pave the way for evaluation studies of both China Healthy Cities and the WHO Healthy Cities Project. Finally, by providing added approaches of improving social determinants of health, we also hope that the experience of the CHC initiative could be applied in other settings to assist with health determinants.

This study has several methodological limitations. First, since the CHC initiative is a voluntary program, self-selection is a concern. This study has partly controlled for this issue through matching research design and also including these variables in final regression models for difference-in-differences estimates. However, unobservable time variant factors were not controlled in the final models. It is likely that cities with more willingness to participate in the program have stronger motivations to improve their environment during the period. In this case, we might overestimate the effects of the CHC initiative. Second, reverse causality is also a concern in this study. We might expect that those with better urban environment were more likely to join and win. In addition, some cities were rather driven by social pressure in notorious urban environments. It is impossible for this study to control for this threat, which prevents us from making causal inference. Third, since we only included prefecture-level cities, our results might not be generalizable to all CHC cities.

Despite these limitations, we still found that the CHC initiative was significantly associated with improvements in urban environment. Whether these effects contributed to population health, however, still remains uncertain. We expect improvements in urban living settings, and public health environment could contribute to health improvements, by decreasing morbidity of water-born infectious disease, asthma, and other chronic diseases. There is sparse evidence of health implications of the CHC initiative, which merits more studies in the future.

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Author's Contributions QM and GC designed the study. All authors contributed to the data collection and revisions of the manuscript. DY analyzed the data and drafted the manuscript. QM coordinated the study. All authors have read and approved the final manuscript.

Compliance with Ethical Standards

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