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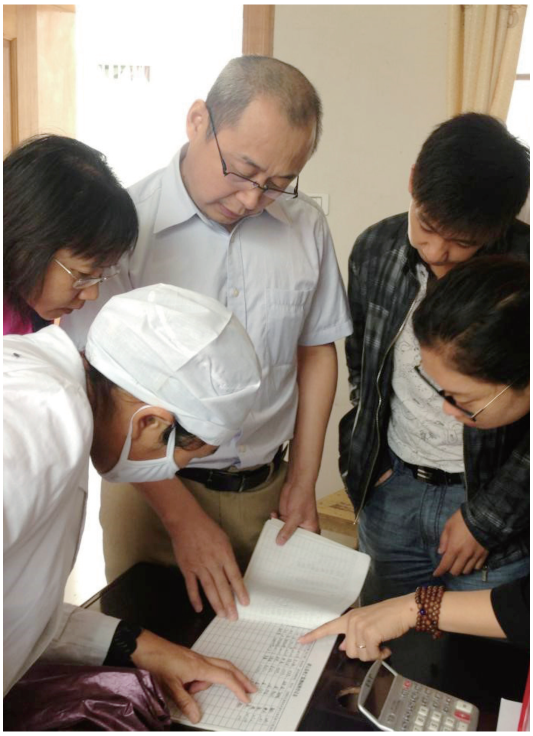

HEALTH MEASUREMENT AND EVALUATION ISSUE

Preplanned Studies

Vital Surveillances

Healthy China

Commentary

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China CDC Weekly

Cover Photo: China CDC staff onsite supervising of mortality surveillance and statistics, Yunnan Province, July 2015.
This week's issue was organized by Guest Editor Maigeng Zhou.

Preplanned Studies

Geographic Variation in Cardiovascular Health as Analyzed from the China Cardiovascular Health Index Study — 31 PLADs, China, 2017–2021

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Summary

What is already known about this topic?

The prevalence of cardiovascular disease (CVD) in China is high, while effective prevention and proper management is lacking. No available indicators were found before 2016 that could comprehensively evaluate different aspects of CVD prevention and treatment.

What is added by this report?

Constructed by combining data from multiple dimensions, China cardiovascular health index (CHI) has provided a practical indicator for each provincial-level administrative division (PLAD) to comprehensively understand its overall level and rankings of the specific dimensions of cardiovascular health.

What are the implications for public health practice?

The CHI will be beneficial for each PLAD to identify weak aspects in CVD control and prevention and redistribute resources to the most needed areas.

Cardiovascular disease (CVD) is the single largest contributor to global mortality and accounts for more than 40% of deaths in China (*1*). However, no available indicators were found before 2016 that could comprehensively evaluate different aspects of CVD prevention and treatment. Most of the metrics previously created for CVD mainly focused on certain field (prevalence of CVD, prevention, etc). In May 2017, the China Cardiovascular Health Alliance, together with the National Center for Chronic and Noncommunicable Disease Control and Prevention, China CDC, as well as other institutions jointly released the China cardiovascular health index (CHI) after a one-year expert consultation, data collection, and statistical analysis, which consists of 52 indicators from 5 dimensions (*2*). From 2017 to 2021, 3-rounds of data from official sources or the most widely recognized national database were adopted to update the CHI. Among the 31 provincial-level administrative divisions (PLADs), Shanghai, Beijing, Zhejiang, Fujian, and Jiangsu always ranked in the top 5, while Guizhou and Xizang (Tibet) always ranked in the last 5. These findings will help provincial governments customize future CVD prevention and treatment work plans. This paper uses the 3-round CHI to clarify cardiovascular health status in the 31 PLADs.

The primary purpose of the CHI was to comprehensively evaluate different aspects of CVD prevention and treatment. At the beginning of CHI development, the inclusion criteria for the indicators were discussed and those scientific, interventive, and measurable indicators were agreed to be incorporated. Second, CVD-related indicators were collected from experts in multiple fields and a pool of indicators was first proposed. Third, a two-round Delphi expert consultation was carried out and the final CHI consists of 52 indicators from 5 dimensions: the prevalence of CVD, risk factor exposure, prevention and control of risk factors, treatment of CVD, and public health policy and service capacity. Fourth, the analytic hierarchy process was adopted to determine the weight of each indicator, and the weights of the 5 dimensions mentioned above were 20.70%, 10.04%, 36.56%, 18.12%, and 14.58%, respectively. Fifth, data of the 52 indicators were collected from the most official sources or the most widely recognized database, including national surveillance such as Chinese Chronic Disease and Risk Factors Surveillance (*3*), registration systems such as National Death Registration System (*4*), scientific research covering all PLADs such as Improving Care for Cardiovascular Disease in China (CCC project) (*5*), as well as the China Health Statistics Yearbook. Sixth, all original data were cleaned through data orientation, and standard normal transformation and percent score for each indicator was computed. Finally, the weighted percent score of each indicator was summed as the CHI. Therefore, the CHI ranged from 0 to 100. The higher the CHI score was, the better cardiovascular health status was. YAAHP (version 10.4, Metadecsn Corp, Shanxi, China) was used to calculate weights and SAS software (version 9.3, SAS Institute, Cary, NC, USA) was used for data processing and statistical analysis. Figure 1 was the flow chart of the construction of the CHI, and more details could be found elsewhere (*2*).

From 2017 to 2021, the CHI was updated 3 times and CVD prevention and treatment status in 31 PLADs were compared. All data were first collected from common sources rather than self-reported data to ensure comparability. Second, data of the 52 indicators were updated to the corresponding latest data at each round to ensure timeliness. Third, the mean and standard deviation of certain indicators in 2017 were always adopted afterwards to make normal transformations until the definition or measurement methods were updated to reflect the improvement of certain indicators. In 2019 and 2021, though the dimensions and indicators did not change, definition or measurement of 19 indicators were updated in 2019 and 3 indicators were updated again in 2021. Thus, the CHI score was more comparable between 2021 and 2019 than that between 2019 and 2017.

From 2017 to 2021, multiple indicators have been improved at the national level, which leads to score increase of those indicators in most PLADs. For example, the probability of premature deaths from the total cardiovascular disease declined from 8.74% to 7.19%. The number of certified chest pain centers increased from 181 to 1,672. However, there were also

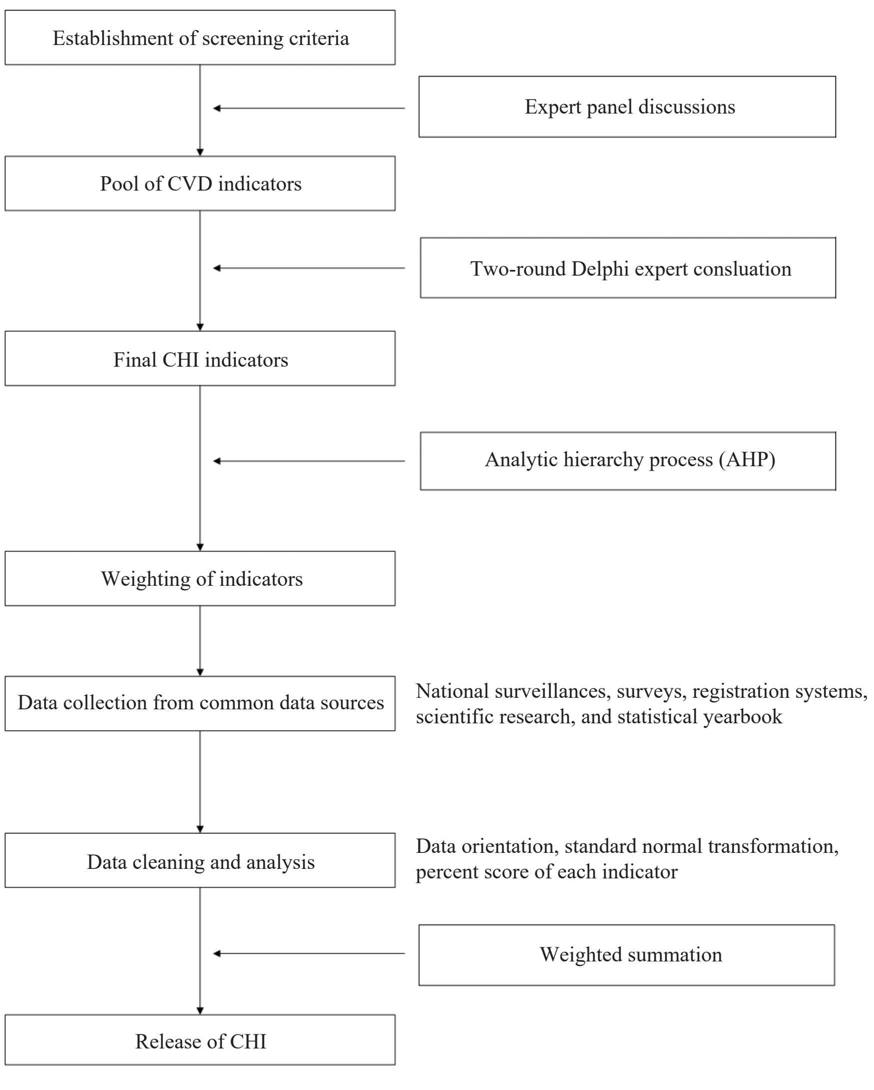

FIGURE 1. Flow chart of the construction of the CHI.
Abbreviations: CVD=cardiovascular disease; CHI=cardiovascular health index.

some indicators getting worse at the national level, such as the overweight rate and number of CDC professionals, which may lead to declining scores. Table 1 showed the changes of some indicators.

In 2017, Beijing had the highest score of CHI and Xizang (Tibet) had the lowest score. In 2021, Shanghai ranked first and Xizang (Tibet) still ranked last. Although provincial rankings changed across years, some trends were still observable. Among the 31 PLADs, Shanghai, Beijing, Zhejiang, Fujian, and Jiangsu always ranked in the top 5 while Guizhou and Xizang (Tibet) always ranked in the last 5. From 2019 to 2021, the national CHI score increased from 50.37 to 57.42 points, with an increase of 7.05 points. Overall, 28 of the 31 PLADs had more CHI scores except for Zhejiang, Jilin, and Ningxia; 15 of the 31 PLADs exceeded the national level and Sichuan had the highest score at 15.73 points, which can be found in Table 2.

Table 3 showed the latest provincial performance on each dimension of CHI. Shanghai (19.53), Ningxia (7.26), Beijing (33.06), Beijing (14.13), and Shanghai (12.35) had the highest scores on the five dimensions, respectively. While Heilongjiang (4.07), Tianjin (2.73), Guangxi (10.37), Anhui (5.72), and Xizang (Tibet) (4.58) had the corresponding lowest scores in these dimensions.

DISCUSSION

The present prevalence of CVD in China is high while effective prevention and proper management is lacking. Prior to the CHI, the provincial-specific priority was unlikely to have been recognized by government or health administrations. CHI was developed to be a practical indicator for each PLAD to comprehensively understand its cardiovascular health status and rankings of each specific field (*6*). Generally, the prevention and treatment of CVD was constantly improving at the national level from 2017 to 2021. The change of the three-round CHI scores has fully reflected this phenomenon not only at the national level but also at the provincial level, which has confirmed its role as an evaluation indicator of cardiovascular health. Inspired by this evaluation method, the health administration departments of Shandong and Guangdong provinces developed their provincial cardiovascular health index at the city level in 2018 and 2019; their research results have also been released (*7*).

According to these 3-round results, the eastern and developed PLADs experienced higher CHI scores than those in underdeveloped and western regions. Specifically, PLADs ranked in the top five always had better performance on prevention and control of risk factors, treatment of CVD, and public health policy and service capacity. In the long term, the efforts in these dimensions will reduce the morbidity of CVD and premature death. However, those latter-ranking PLADs, such as Xizang (Tibet) Autonomous Region and Guizhou Province, had poor performance in these areas, which may be related to inadequate medical and health resources (*8*) and poor healthcare accessibility due to inconvenient transportation. In the future, more resources need to be invested in these PLADs to improve CVD control and prevention.

TABLE 1. The change trend of some CVD-related indicators from CHI — China, 2017–2021.

Indicator	CHI 2017	CHI 2019	CHI 2021
Probability of premature deaths from the total cardiovascular disease (%)	8.74	8.24	7.19
Overweight rate (%)	31.30	32.74	33.56
Concentration of PM2.5 (μg/m^3)	50.00	43.00	36.00
Number of chest pain centers	181	3,707*	4,743†
Proportion of STEMI patients receiving reperfusion therapy (%)	56.84	62.10	67.40
In-hospital mortality of AMI patients (%)	5.71	5.31	4.60
Residents' health literacy level (%)	10.25	14.18	19.17
Number of practicing (assistant) physicians (per million of people)	2210.89	2441.79	2761.98
Number of CDC professionals (per ten thousand people)	1.39	1.37	1.34
Number of general practitioners (per ten thousand people)	1.37	1.82	2.61

Abbreviations: CVD=cardiovascular disease; CHI=cardiovascular health index; PM2.5=particulate matter 2.5; STEMI=ST-segment elevation myocardial infarction; AMI=acute myocardial infarction.

* 2,924 chest pain centers under construction but not yet certified were contained.

† 3,071 chest pain centers under construction but not yet certified were contained.

TABLE 2. The CHI scores and ranks of 31 PLADs — China, 2017, 2019, and 2021.

PLADs	CHI 2017		CHI 2019		CHI 2021		CHI 2021 minus CHI 2017	CHI 2021 minus CHI 2019
	Score	Rank	Score	Rank	Score	Rank		
Shanghai	75.33	2	78.12	2	83.27	1	7.95	5.15
Beijing	75.37	1	76.29	3	79.62	2	4.25	3.33
Zhejiang	74.40	3	78.40	1	77.88	3	3.49	−0.51
Fujian	61.63	5	64.75	5	75.22	4	13.60	10.47
Jiangsu	71.80	4	67.73	4	72.35	5	0.55	4.62
Tianjin	60.49	6	58.49	7	66.85	6	6.36	8.36
Guangdong	59.19	7	56.53	8	66.71	7	7.52	10.18
Shandong	52.90	8	52.23	10	64.01	8	11.12	11.79
Sichuan	50.12	10	47.98	16	63.70	9	13.59	15.73
Ningxia	47.36	12	63.50	6	62.19	10	14.83	−1.31
Hubei	45.99	14	49.41	12	62.09	11	16.10	12.68
Xinjiang	46.96	13	52.05	11	61.85	12	14.89	9.80
Chongqing	52.12	9	54.89	9	60.30	13	8.18	5.41
Jiangxi	48.01	11	48.77	14	58.26	14	10.25	9.49
Hunan	44.41	15	42.05	22	56.31	15	11.90	14.26
Henan	42.62	20	40.77	27	55.70	16	13.08	14.92
Anhui	43.62	17	45.73	18	55.22	17	11.60	9.48
Hainan	42.28	21	48.59	15	55.19	18	12.92	6.61
Inner Mongolia	38.76	24	41.20	23	53.25	19	14.49	12.05
Shanxi	38.05	26	46.05	17	52.66	20	14.61	6.61
Yunnan	37.99	27	44.12	19	50.98	21	12.99	6.86
Qinghai	42.90	19	48.88	13	50.39	22	7.49	1.51
Gansu	44.18	16	41.00	24	49.82	23	5.64	8.82
Hebei	43.44	18	43.60	21	49.56	24	6.12	5.96
Shaanxi	36.24	28	40.83	25	48.32	25	12.08	7.50
Heilongjiang	33.63	29	33.50	31	44.01	26	10.38	10.51
Guangxi	38.30	25	40.80	26	43.00	27	4.71	2.21
Guizhou	32.48	30	35.41	30	42.20	28	9.72	6.79
Jilin	39.21	23	43.93	20	40.24	29	1.03	−3.69
Liaoning	39.89	22	38.07	28	39.64	30	−0.25	1.57
Xizang (Tibet)	30.17	31	37.80	29	39.12	31	8.95	1.32
Total	48.06		50.37		57.42		9.36	7.05

Abbreviations: CHI=cardiovascular health index; PLADs=provincial-level administrative divisions.

Though Shanghai ranked first according to the CHI 2021, the indicators of the exposure level of CVD risk factors, which includes the prevalence of obesity, hypertension, etc , had lower rankings among the 31 PLADs, on which more efforts need to be made in future work. In addition, for those PLADs that have declined or improved little over recent years, more attention on CVD prevention and treatment from provincial governments and health administration departments are urgently needed. For each PLAD, CHI will be beneficial for identifying weaknesses in CVD control and prevention and setting priorities for improvement.

Based on 7 cardiovascular disease risk factors or health behaviors, the American Heart Association developed a new definition of ideal cardiovascular health for adults and children in 2010. Then the percentage with ideal cardiovascular health (*9*) and age-

TABLE 3. The scores of each dimension of CHI — China, 2021.

PLADs	Prevalence of CVD		Exposure of risk factors		Prevention and control of risk factors		Treatment of CVD		Public health policy and service capacity	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Beijing	17.30	6	3.57	26	33.06	1	14.13	1	11.56	2
Tianjin	12.19	15	2.73	31	28.48	6	13.08	3	10.38	3
Hebei	4.79	30	3.23	30	22.08	17	10.08	13	9.38	7
Shanxi	9.16	21	3.48	28	25.65	12	9.53	19	4.83	29
Inner Mongolia	6.57	27	3.90	24	26.68	8	8.17	27	7.94	13
Liaoning	7.31	25	4.07	23	13.93	27	8.32	26	6.01	26
Jilin	6.68	26	3.62	25	13.93	28	9.70	17	6.31	24
Heilongjiang	4.07	31	4.53	21	18.01	22	9.60	18	7.79	14
Shanghai	19.53	1	5.48	13	32.34	3	13.57	2	12.35	1
Jiangsu	17.95	5	4.64	19	30.27	5	11.43	9	8.05	12
Zhejiang	19.46	2	5.69	12	30.83	4	13.05	4	8.85	8
Anhui	14.63	11	3.52	27	23.92	15	5.72	31	7.43	16
Fujian	19.34	3	7.16	2	26.29	10	12.24	7	10.19	4
Jiangxi	16.80	7	6.72	4	20.00	19	10.05	14	4.68	30
Shandong	13.32	13	6.21	9	25.98	11	9.00	25	9.50	5
Henan	8.56	24	3.28	29	26.65	9	7.77	28	9.44	6
Hubei	15.30	10	5.31	17	24.66	13	9.84	15	6.98	18
Hunan	12.44	14	4.58	20	20.85	18	12.48	6	5.96	28
Guangdong	18.22	4	6.62	6	22.47	16	11.26	10	8.14	11
Guangxi	12.15	16	6.38	8	10.37	31	7.19	30	6.90	19
Hainan	14.24	12	6.95	3	13.70	29	11.94	8	8.36	9
Chongqing	16.02	8	5.37	15	19.75	20	10.99	12	8.18	10
Sichuan	15.46	9	5.88	11	24.43	14	11.16	11	6.78	21
Guizhou	8.65	23	5.39	14	12.47	30	9.08	24	6.61	22
Yunnan	10.48	19	6.57	7	18.00	23	9.10	23	6.82	20
Xizang (Tibet)	5.18	28	6.63	5	15.03	26	7.70	29	4.58	31
Shaanxi	10.71	18	4.10	22	17.61	24	9.31	22	6.60	23
Gansu	11.41	17	6.00	10	16.95	25	9.48	21	5.97	27
Qinghai	8.87	22	5.33	16	18.93	21	9.49	20	7.77	15
Ningxia	9.66	20	7.26	1	28.47	7	9.76	16	7.04	17
Xinjiang	5.06	29	5.31	18	32.94	2	12.49	5	6.05	25
Total	11.98		5.15		22.41		10.22		7.66	

Abbreviations: CHI=cardiovascular health index; CVD=cardiovascular disease; PLADs=provincial-level administrative divisions.

adjusted prevalence of cardiovascular health index (*10*) were adopted to evaluate status of cardiovascular health in the 51 States. Unlike this metric, China CHI was more comprehensive, including exposure and prevention of risk factors, health behaviors, clinical diagnosis and treatment, public health policy, and medical and health resources. In addition, a percent score was more sensitive to capture minor progress than simple grades, which may encourage each evaluation object to continue their effort to improving scores.

This study was subject to some limitations. First, the accessibility of data had been regarded as a critical condition during the selection of indicators. Therefore, some currently unmeasured but important indicators such as incidence of CVD were not yet incorporated.

Second, this study was mainly descriptive and more in-depth analysis on the impact that socioeconomic factors have on the overall CHI should be explored.

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Vital Surveillances

National Cancer Data Linkage Platform of China: Design, Methods, and Application

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ABSTRACT

Background: The National Cancer Center (NCC) and China CDC cooperatively designed a National Cancer Data Linkage (NCDL) Platform to fulfill the task of sharing cancer outcome data through an automatic web-based system.

Methods: NCC and China CDC established a web-based NCDL Platform to link death information from China CDC with the cancer database from NCC. Overall, 76,708 cancer patients' data were analyzed to assess the feasibility and match rate of the NCDL Platform for 7 major cancers.

Results: The function of the platform includes a data application and approval system, data linkage module, and results visualization system. Through the platform, 38.9% cases were identified as deaths cases from the NCDL Platform in the first 3 years after cancer diagnosis. The linkage rate was highest in liver cancer and lowest in breast cancer.

Conclusions: The NCDL Platform provides a powerful and efficient way to link national vital statistics with national cancer programs' data. Expanding cancer outcome data linkage may not only improve data collection efficiency, but also improve data use.

INTRODUCTION

Cancer outcome data are important indicators to assess the magnitude of the cancer burden as well as monitor the effects of programs on cancer control. The National Cancer Center (NCC) is the Chinese government's principal agency for national cancer control programs, which regularly collects cancer-related data. Under the responsibility of the China CDC, the China Cause of Death Reporting System (CDRS) regularly collects death registration data from each county of the country based on an internet-based reporting system, which forms the National Mortality Database (*1*). Strengthening data exchange and maximizing data use through informatics between NCC and China CDC have become important tasks in the Healthy China Program 2019–2030 (*2*). To fulfill this task, NCC and China CDC cooperatively established a web-based National Cancer Data Linkage (NCDL) Platform to retrieve the vital status for cancer patients. To develop the NCDL Platform and determine its efficacy among cancer patients, we used a multicenter hospital-based cancer database from NCC to link with National Mortality Database from China CDC.

METHODS

NCDL Platform Development and Architecture

Under a cooperative framework from NCC and China CDC, we first signed an agreement between two national bureaus, which described stepwise implementation regarding data linkage and sharing. We developed two methods for data linkage: deterministic linkage using individual participant identification cards and probabilistic linkage using identifiable information if the patient lacks identification card (Figure 1A). We developed a unique access portal to the webserver controlled by firewalls. The system requires timely servicing and monitoring to ensure there are no cyber security vulnerabilities. Real-time logs auditing aims to ensure the security of data transmission between two bureaus (Figure 1B).

Data Sources

The National Mortality Database was from CDRS (*3*). The CDRS includes data from the Vital Registration System, representative Disease Surveillance Points System, the expanded provincial and county registration system, and the in-hospital death reports. All deaths were reported online through

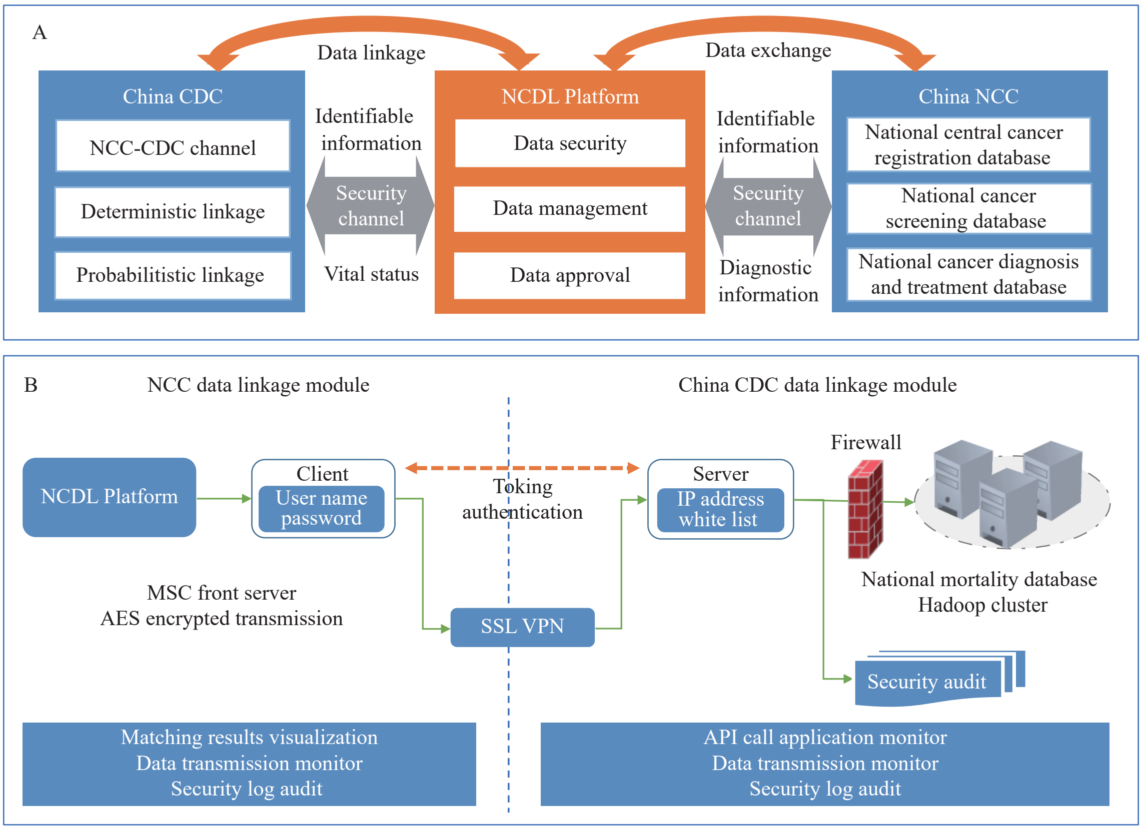

FIGURE 1. NCDL Platform architecture developed by NCC China and China CDC in 2021; (A) The framework of NCDL Platform; (B) Data security infrastructure of NCDL.
Abbreviations: NCDL=National Cancer Data Linkage; NCC=National Cancer Center.

China CDC's Death Information System with detailed information on the date of death and causes of death. To ensure data quality, CDC workers undertook routine data checks.

The multicenter hospital-based cancer database from NCC was used to test the feasibility of NCDL Platform, which included detailed, high-quality cancer data (*4*). We abstracted the information covering both urban and rural areas across six geographical regions of China. We identified all eligible cases diagnosed with first primary invasive cancer during 2016–2017 and whose home address was in the selected regions. We further linked the patients' information with the local population-based cancer registries, where registries' staff followed up the cancer patients by linking the local mortality surveillance system and/or actively contacting the patients or the next of kin to retrieve vital status (*5–6*).

Statistical Analysis

December 31, 2019 was used as the last date of contact in the study. The data match rate was calculated with the number of deaths identified by the NCDL Platform divided by the corresponding number of cancer patients. We examined the match rate overall, by age at diagnosis, area of residence, and stage at diagnosis. We examined if the match rates were different in patients with different characteristics using chi-squared test. We analyzed all cancers combined and separately for each cancer type.

RESULTS

The function of the platform included three parts: a data application and approval system, data linkage module, and data visualization system. Through the platform, a multicenter hospital-based cancer database from NCC was successfully linked with National Mortality Database from China CDC securely and automatically.

Table 1 listed the selected characteristics for the linked dataset. A total of 76,708 cancer patients were included. With use of the NCDL Platform, 29,814 deaths were identifided with an overall match rate of 38.9%. Patients with liver cancer had the highest match rate (56.1%), followed by lung cancer (50.0%),

TABLE 1. Baseline characteristics and results of the linked cancer dataset for patients diagnosed using National Cancer Data Linkage Platform, China, 2016–2017.

Items	All cancers	Lung	Stomach	Colorectum	Liver	Female breast	Esophagus	Ovary
No. of cases	76,708	22,820	12,807	11,338	6,519	11,975	9,471	1,778
Mean age at diagnosis (SD) (years)	61.4 (11.5)	63.0 (10.1)	63.6 (10.9)	63.2 (11.9)	58.2 (11.9)	53.5 (11.3)	66.1 (9.16)	55.6 (12.4)
Sex (%)								
Male	43,449/76,708 (56.6)	15,134/22,820 (66.3)	9,330/12,807 (72.9)	6,695/11,338 (59.0)	5,274/6,519 (80.9)	0/11,975 (0)	7,016/9,471 (74.1)	0/1,778 (0)
Female	33,259/76,708 (43.4)	7,686/22,820 (33.7)	3,477/12,807 (27.1)	4,643/11,338 (41.0)	1,245/6519 (19.1)	11,975/11,975 (100)	2,455/9,471 (25.9)	1,778/1,778 (100)
Area (%)								
Urban	56,065/76,708 (73.1)	16,738/22,820 (73.3)	8,925/12,807 (69.7)	8,773/11,338 (77.4)	4,530/6,519 (69.5)	9,562/11,975 (79.8)	6,195/9,471 (65.4)	1,342/1,778 (75.5)
Rural	20,643/76,708 (26.9)	6,082/22,820 (26.7)	3,882/12,807 (30.3)	2,565/11,338 (22.6)	1,989/6,519 (30.5)	2,413/11,975 (20.2)	3,276/9,471 (34.6)	436/1,778 (24.5)
Total deaths (%)	29,814/76,708 (38.9)	11,411/22,820 (50.0)	5,458/12,807 (42.6)	3,041/11,338 (26.8)	3,656/6,519 (56.1)	1,016/11,975 (8.5)	4,632/9,471 (48.9)	600/1,778 (33.7)
Death from China CDC (%)	27,747/29,814 (93.1)	10,766/11,411 (94.3)	5,109/5,458 (93.6)	2,791/3,041 (91.8)	3,456/3656 (94.5)	761/1,016 (74.9)	4,311/4,632 (93.1)	553/600 (92.2)
Death from cancer	24,691/27,747 (89.0)	9,473/10,766 (88.0)	4,571/5,109 (89.5)	2,489/2,791 (89.2)	3,086/3,456 (89.3)	692/761 (90.9)	3,881/4,311 (90.0)	499/553 (90.2)
Death from non-cancer	3,056/27,747 (11.0)	1,293/10,766 (12.0)	538/5,109 (10.5)	302/2,791 (10.8)	370/3,456 (10.7)	69/761 (9.1)	430/4,311 (10.0)	54/553 (9.8)
Death supplemented from NCC (%)	2,067/29,814 (6.9)	645/11,411 (5.7)	349/5,458 (6.4)	250/3,041 (8.2)	200/3,656 (5.5)	255/1,016 (25.1)	321/4,632 (6.9)	47/600 (7.8)

Abbreviation: NCC=National Cancer Center; SD=standard deviation.

esophageal cancer (48.9%), stomach cancer (42.6%), ovarian cancer (33.7%), colorectal cancer (26.8%), and breast cancer (8.5%). Because some registries actively tracked the patients' vital status, we tracked the vital status information from the hospital-based cancer database and added another 2,067 (6.9% of all death cases) deaths from the NCC database only.

Figure 2 showed the data match rates for cancer patients by sex, area, year of diagnosis and stage. We found the data match rates in patients who were 60 years and above were significantly higher than those who were less than 60 years (44.2% *vs*. 30.9%). Male patients generally had a higher match rate than females (47.8% *vs*. 27.2%). The match rate was higher in patients with stage III/IV than those with stage I/II (53.7% *vs*. 14.3%).

DISCUSSION

In the present study, we described the development and implementation of the NCDL Platform. This is the first nationwide cancer outcome data linkage system that enables a highly efficient data linkage and bilateral data sharing to the best of our knowledge. Our study results demonstrated the feasibility of NCDL Platform as well as the advantages of data linkage and sharing. There is important public health significance of the NCDL Platform. First, through the complementation of the two systems, the data integrity of the cancer registration system and CDRS can be improved. Second, through the integration and linking of the two systems, indicators related to cancer outcomes such as mortality, survival time, and disease burden of cancer can be calculated more accurately.

The match rates revealed the proportion of death across cancers in different patients (*5*). The validated results were consistent with the intrinsic characteristics of the death surveillance data, such as cancer sites with poor prognosis, or poor prognosis with late cancer stage being more likely to get death outcome in a shorter period. The linked dataset from the NCDL Platform is a potentially valuable resource that allows for further cross-sectional and longitudinal studies. Given that NCC actively followed-up cancer patients through Cancer Registration and Follow-up Program, it may also provide a channel to improve data completeness of death registration through the NCDL Platform (*3*,*7*).

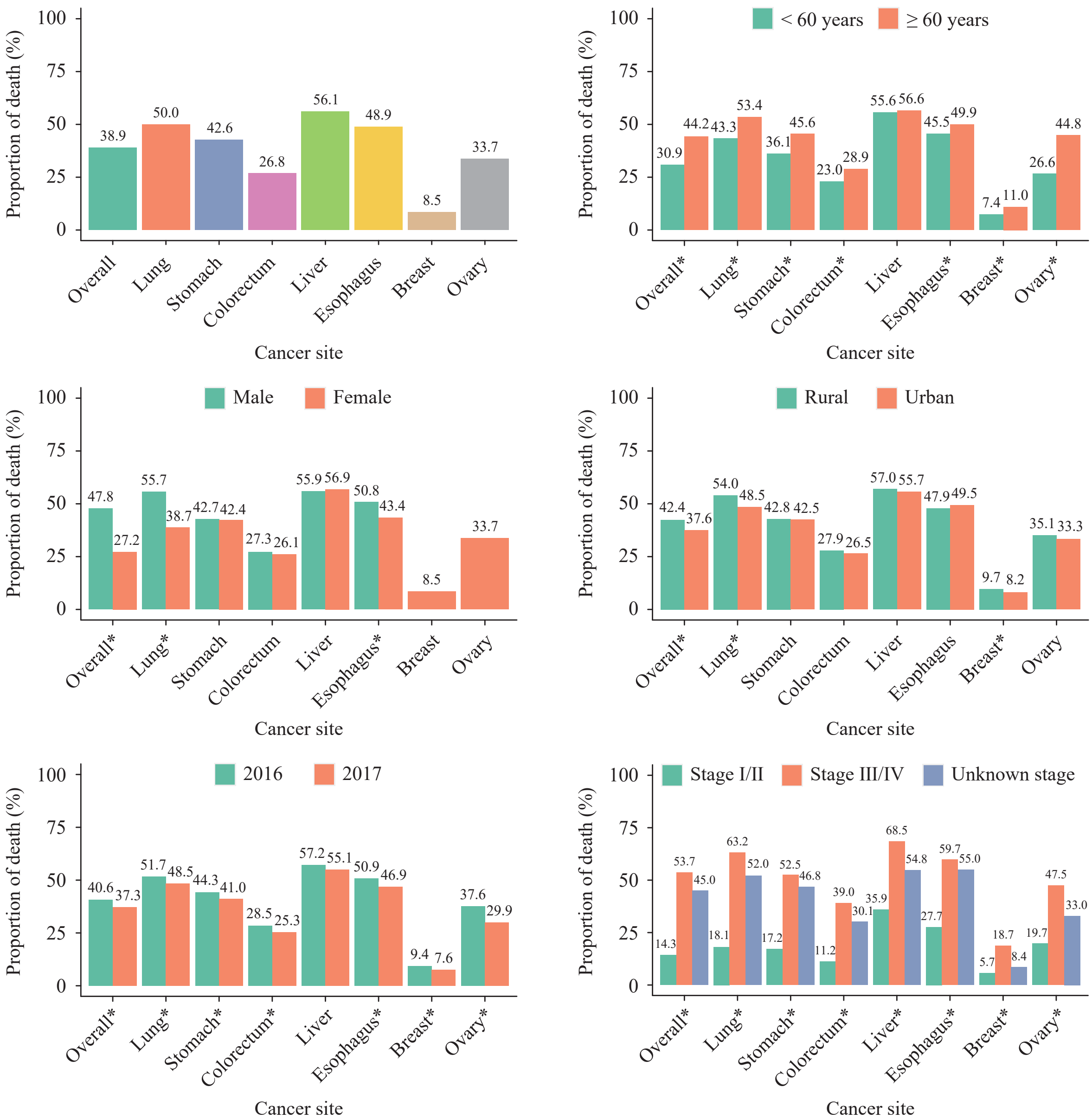

FIGURE 2. Data match rates (proportion of death) for cancer patients diagnosed during 2016–2017 and followed up to 2019 using NCDL Platform in China.
Abbreviations: NCDL=National Cancer Data Linkage.
* statistical significance between groups.

Automatic data linkage, data security and data confidentiality were among the highest priorities of the NCDL Platform design. The application of innovative informatics ensures the security of bilateral data transmission. Through the NCDL Platform, National Mortality Database and cancer control programs' database could be easily connected, which is more time-efficient for data exchange and sharing. Through this feasibility study, NCC and China CDC have established a standardized procedure for future data exchange.

Records linkage improves data completeness and quality. However, when unique identifiers are unavailable, successful record linkage cannot be assessed using deterministic linkage methods. The algorithm of probabilistic linkage is still under validation and optimization. Further research in this area will help to improve the successful data match rate. Considering the security issue, the NCDL Platform is not currently assessable to the public. We only issued institutional account with strict rules to ensure data transmission safety. The development and fulfillment of the NCDL Platfom had fulfilled the goal of efficient collection of cancer outcome data and maximized cancer data use between institutions.

In conclusion, the study demonstrated the feasibility of using NCDL Platform to bring together information on cancer diagnosis and treatment with information on vital status. Continued use of the NCDL platform will increase cancer outcome data collection efficiency and boost cancer data use.

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Healthy China

The Future Challenges of Population Health in China: A Projection of the Major Health Problems and Life Expectancy — China, 2015–2050

Jiangmei Liu[1]; Bo Jiang[1]; Yanhong Fu[2]; Zhuo Wang[3]; Min Liu[1]; Peng Yin[1]; Maigeng Zhou[1,#]

According to the Seventh National Population Census in 2020, the life expectancy of the Chinese population has been gradually rising in the past 10 years (*1*). With China's industrialization, urbanization, and rapidly aging population, behavioral changes, and environmental factors have a growing impact on health. The strategy based on "curing disease" cannot meet the public's health needs.

Thus, in 2016, the "Program for a Healthy China 2030" announced by the Central Committee of the Chinese Communist Party. This is the first long-term health strategic plan at the national level since the founding of the People's Republic of China. In 2019, in order to further implement the "Healthy China 2030" strategy, the State Council issued the "Healthy China Action Plan 2019–2030" and emphasizes "intervening in health influencing factors, protecting full-life-cycle health, and preventing and controlling major diseases", highlights the concept of great health and focus on disease prevention and health promotion, and specifies the objectives and tasks of 15 unique campaigns (*2*).

Based on results of Burden of Disease Study in China up to 2019, we forecast the main health problems and disease burden of China in 2030, 2035, and 2050, aiming for the following: 1) update the prediction results of 2030 and assess the attainability of the "Healthy China 2030" goals; and 2) explore changes in the leading health problems of Chinese residents to put forward appropriate prevention and control suggestions by 2050.

We predicted the mortality rates, the premature mortality rate from 4 main non-communicable chronic diseases (NCDs), and life expectancy in the years 2030, 2035, and 2050 in the mainland of China. Using data from the Global Burden of Disease 2019 (GBD 2019), the variables included all-cause and cause-specific mortality, summary exposure value (SEV) of risk factors, the relative risk (RR) of exposure to risk factor and disease, and the sociodemographic index (SDI), a composite index per capita income, educational attainment, and total fertility rate (*3*). Population data were obtained from the Global Burden of Disease Study, which predicted the number of people in different sex and age groups of China between 2020 and 2050 (*4*). To facilitate the evaluation of Healthy China 2030 goals, baseline results in 2015 and interim results for 2025 will also be presented.

We attributed the change in mortality from 1990 to 2015 to 3 parts (*5*):

1) Mortality that can be explained by sociodemographic variables (SDI): Studies have shown that SDI has high explanatory of mortality level (*6*), and this variable can be used to better estimate the basic level of mortality. Thus, we assumed that basic mortality could be estimated as a function of SDI, age, and time.

2) Mortality due to related risk factors: The SEV is the relative risk-weighted prevalence of exposure, where 0 is no risk in the population and 1 is the entire population at maximum risk. Based on the distribution characteristics of all risk factors SEVs estimated by GBD 2019 (*3*), we first calculate the rate of change observed in each risk factor by sex and age in the past years across China. Two scenarios were used for the prediction, a "better control" scenario and a "worse control" scenario. The better scenario was constructed from the 85th percentile rate of change for all the risk factors. We then constructed a "worse control" scenario using the 15th percentile of rate of change for all the risk factors. We calculated the "natural trends" of the risk factors based on the average change rates of the risk factors from 1990 to 2015 in China.

3) Mortality that cannot be explained by SDI and risk factors: Considering that sociodemographic variables and included risk factors could not fully explain all changes of mortality, we used ARIMA model to predict the residual of the mortality that was not explained by sociodemographic variables and risk factors. The predicted results of the above three parts

were added together to obtain death rates by sex, age, and major diseases under different scenarios.

Premature mortality rate from 4 major NCDs was defined as the unconditional probability of death between ages 30–69 years from cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases (*7*). The life table method was used to calculate the life expectancy. The predicted premature mortality rate and life expectancy were calculated based on predicted mortality by sex and age-group. Age-standardized mortality rate was calculated using the world population from GBD 2019 (*8*).

Under the natural trend scenario, the total number of deaths in 2050 in China is estimated at 19.37 million (Table 1), among which 0.51 million are infectious diseases (2.6%), 18.01 million are NCDs (93.0%), and 0.85 million are injuries (4.4%). In 2050, the total death is estimated to be 15.82 million (18.3% lower than the natural trend) and 23.25 million (20.1% higher than the natural trend) for the better control and worse control scenarios, respectively. In 2050, the age-standardized mortality rate of all-cause in China will be 435.8/100,000, decreased by 32.8% from 648.7/100,000 in 2015. Compared to the natural trend, there will be a 29.3% reduction of NCDs age-standardized mortality rate, under the “better control” scenario.

As shown in Figure 1, in 2015, the premature mortality of the 4 major NCDs was 18.4%. Under the “natural trend” scenario, the premature mortality will be 14.6% by 2030 and 12.4% by 2050 (a 32.9% decrease from 2015). For “worse control” scenarios, premature mortality decreased from 16.4% in 2030 to 16.1% in 2050, only decreasing 12.7%. For “better control” scenarios, the premature mortality was reduced to 12.5% by 2030, achieving the goal of reducing the premature mortality to less than 13.0% by 2030 set out in the Healthy China Action (2019–2030) (*2*). By 2050, premature mortality was reduced to 8.5%, with a decrease of 53.9% from 2015.

In 2015, the life expectancy of Chinese residents was 76.84 years (Figure 2). If the current trend of economic development and health improvement continues (natural trend), the life expectancy is expected to be 79.95 years by 2030 and 82.13 years by 2050. Under the “better control” scenario, the life expectancy in 2030 was projected to exceed the Healthy China target of 2.8 years (reached 81.84 years) (*2*), and under the “worse control” scenario, life expectancy reached only 78.35 years in 2030 which could not meet the target. Under the “better control” scenario, the life expectancy was expected to reach 86.76 years in 2050, while under the “worse control” scenario, it was expected to be 78.12 years, 1.22 years

TABLE 1. Projected all-cause and three major diseases mortality under different scenarios, China, 2015–2050.

Scenarios	Cause	2015			2025			2030			2035			2050		
		No. of death*	Rate†	ASMR†	No. of death*	Rate†	ASMR†	No. of death*	Rate†	ASMR†	No. of death*	Rate†	ASMR†	No. of death*	Rate†	ASMR†
Natural trend	All causes	9.99	723.0	648.7	11.99	841.2	552.6	13.49	947.9	519.7	15.15	1083.3	493.2	19.37	1519.8	435.8
	Infectious disease	0.37	26.5	33.2	0.34	23.5	21.3	0.36	25.1	19.3	0.39	28.2	18.0	0.51	40.1	14.8
	NCD	8.88	642.6	566.1	10.91	765.4	490.4	12.36	868.5	462.2	13.95	997.4	439.2	18.01	1413.3	390.6
	Injury	0.75	53.9	49.5	0.75	52.3	40.9	0.77	54.3	38.2	0.81	57.7	36.1	0.85	66.3	30.4
Better control	All causes	–	–	–	11.08	776.7	505.3	11.99	842.2	450.3	13.06	934.0	406.0	15.82	1241.5	311.7
	Infectious disease	–	–	–	0.31	21.9	19.8	0.32	22.6	17.1	0.35	24.6	15.0	0.43	34.0	10.6
	NCD	–	–	–	10.04	704.4	446.3	10.93	768.1	397.7	11.96	855.1	358.4	14.59	1144.8	276.2
	Injury	–	–	–	0.72	50.5	39.2	0.73	51.5	35.5	0.76	54.2	32.5	0.80	62.7	24.9
Worse control	All causes	–	–	–	12.83	899.9	597.3	14.99	105.3	593.4	17.32	1238.6	594.0	23.25	1824.8	612.5
	Infectious disease	–	–	–	0.36	25.2	23.1	0.40	2.8	22.5	0.46	33.1	22.7	0.64	50.5	25.0
	NCD	–	–	–	11.72	821.7	532.3	13.80	96.9	531.1	16.04	1146.9	533.1	21.79	1709.8	553.4
	Injury	–	–	–	0.76	53.1	41.9	0.79	5.5	39.8	0.82	58.6	38.2	0.82	64.5	34.1

Note: – data not applicable.

Abbreviations: NCD=non-communicable chronic disease; ASMR=age-standardized mortality rate. No.=number.

* million.

† per 100,000 population.

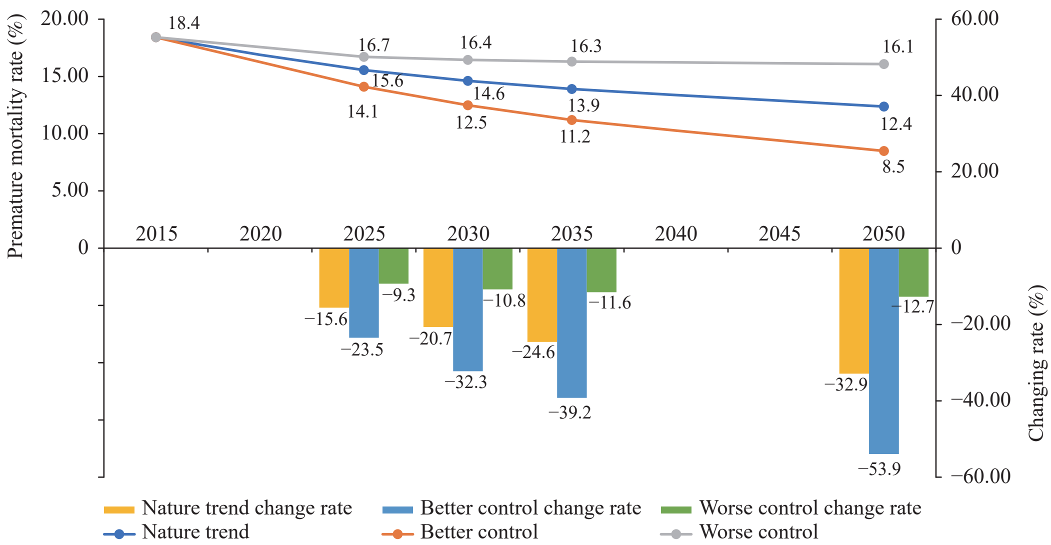

FIGURE 1. Projected trends and change rates of premature mortality rate from 4 major non-communicable and chronic diseases (NCDs) in different scenarios in China, 2015–2050.

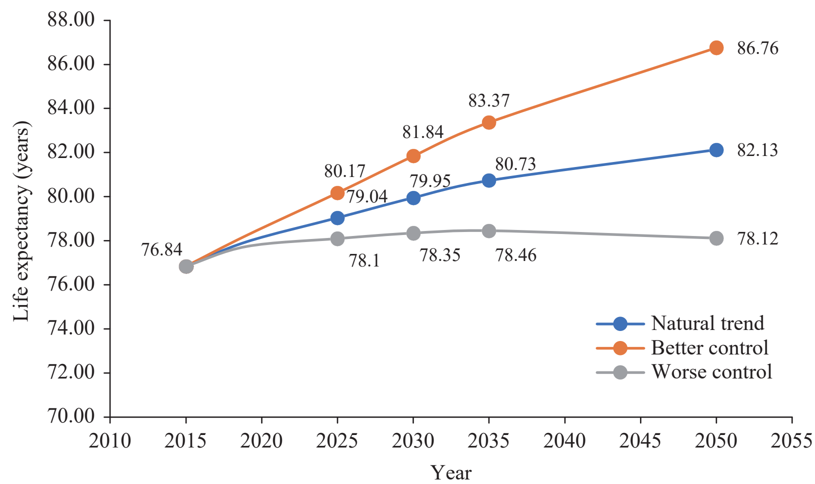

FIGURE 2. Predicted trends of life expectancy in different scenarios in China, 2015–2050.

higher than in 2015 and slightly lower than in 2030.

According to China's current economic development speed and the improvement of residents' health status, the expected life expectancy of Chinese residents in 2030 is expected to be 79.95 years old. If the risk factors are not well controlled, the goal will not be achieved by 2030. These results were consistent with our research team's previous findings (*8*).

The health status of Chinese residents has further improved, and life expectancy has continued to increase, but the growth rate has slowed down. From 2015 to 2025, it was projected to increase by about 1 year every 5 years, but after that, it would increase an average of about 0.75 years every 5 years until 2050. Since 2011, the United States, the United Kingdom, France, Germany, Sweden, and the Netherlands had seen significant slowdowns in life expectancy gains. Slower improvements in the mortality of old people may be the main reason. In these countries, improvements in cardiovascular disease (CVD) mortality rates have slowed, while deaths from dementia and Alzheimer's disease are rising. While some risk factors such as smoking, alcohol abuse, high blood pressure, and cholesterol levels continue to decline, the prevalence of obesity and diabetes continues to rise (*9*). This study also suggests that, under the better control of risk factors, the life expectancy in China can maintain a rapid and stable growth rate by 2050.

The study was subject to at least 2 limitations. The basic data of this study were all from the Global Burden of Disease (GBD) study, so biases in the estimation of deaths and exposure levels of risk factors in GBD would affect the final projection results. Meanwhile, we did not estimate the uncertainty intervals of each indicator which would reflect the deviation of the estimations. However, the prediction of different scenarios also provides a range of indicators.

Although the life expectancy of Chinese residents continues to improve and the overall health level continues to improve, it is still necessary to pay attention to the burden of NCDs, especially among people aged 30–69 years. Meanwhile, effectively controlling risk factors will help achieve the health goals of the Healthy China Action in the future.

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Commentary

Disease Burden: Progresses Made, Current State, Future Challenges, and Opportunities

Haidong Wang#

DEMOGRAPHIC AND EPIDEMIOLOGICAL TRANSITIONS AND CURRENT STATE OF DISEASE BURDEN IN CHINA

Over the past three decades, the world has witnessed perhaps the most dramatic demographic and epidemiological transitions in China. During this period, the population of China has grown by a quarter of its size in 1990 to 1.41 billion in 2020 (*1*). Even though the fertility rate in China has experienced a sustained decline, mortality among the Chinese population has improved tremendously. Life expectancy at birth, a succinct summary index of overall mortality levels, has improved by 9.5 years to 77.6 years in 2019 (*2*). This is equivalent to an increase of a third of a year in life expectancy at birth for every calendar year in the past three decades, a feat rarely achieved by other countries at similar starting points.

Such impressive improvements in all-cause mortality coincided with a shift in both levels and compositions of causes of death during the same period. This rapid epidemiological transition manifested in a fast shift of disease burden from communicable diseases to non-communicable diseases (NCD), a continuation of health trends which started well before the 1990s. In 1990, about 12% of deaths in China came from infectious diseases. This proportion declined significantly to less than 3% in 2019. Meanwhile, the proportion of deaths due to NCDs increased by 17 percentage points to 90.1% in 2019 (*3*). With the continued improvement in economic conditions and general living conditions, it is safe to say almost all disease burden in China in the future lies in various diseases in the NCD category, a feature shared by all developed nations currently.

With this shift in disease burden to NCDs and improvements in health care and medical treatment, an average Chinese citizen spends more years with less-than-optimal health now compared to 1990. In 1990, the difference between life expectancy and healthy life expectancy (HALE) was 6.6 years. This gap has increased by about 40% over the past three decades to 9.1 years in 2019 (*2*). Such interconnections between improvements in population health and the challenges they present to both the public health and medical community requires rigorous research on the disease burden for precise and targeted health policy setting in China.

UNIQUE OPPORTUNITY IN BURDEN OF DISEASE RESEARCH

To know precisely where the disease burdens are coming from, health analyses must consider the combination of fatal and non-fatal outcomes of each disease and the risk factors responsible for each disease. Data on causes of death, prevalence and incidence of different diseases, and risk factor prevalence and exposures among the population should be used in combination with sophisticated statistical models, which can make sense of often sparse and biased data that may be inconsistent among different aspects of a single disease. All these factors are sorely needed to capture the full picture of health trends.

China is uniquely positioned to provide a wealth of data on population health to track precise distribution of disease burdens and its changes over time. In addition to diligently collected demographic data from the decennial censuses, intercensal surveys, and various sample surveys on fertility, the Chinese government has made tremendous achievements in setting up various disease surveillance systems, and civil and vital registration systems. Established in 1978 with only two pilot surveillance points in Beijing, the Disease Surveillance Points system (DSP), the bellwether of cause of death tracking system in China, has gradually increased to 145 points by 1990 with a covered population of 10 million. Further improvement in the last decade increased the number of DSP sites to 605, covering about one-quarter of the Chinese population (*4*). Being representative at the provincial level, cause of death data from DSP is indeed the gold standard for mortality and burden of disease analysis in China. Another example of such richness in data is the National Maternal and Child Health Surveillance system, a perfect complement to the DSP system, which provides much more nuanced and accurate information on disease burden among children under age five.

Yet, to make sense of various data systems focusing on different aspects of the health of a population, a unified analytical framework is sorely needed to generate internally consistent estimates on incidence, prevalence, mortality, morbidity, and the associated risk factors of not just a few major diseases, but all diseases classified in the International Classifications of Diseases. This is particularly true for China, a country with over 1.4 billion population.

The Global Burden of Disease (GBD) analytical framework, developed for the World Health Organizations more than two decades ago, is the most comprehensive and continuously improved tool for the assessment of the burden of disease at the population level. Over the past decade, researchers from GBD's global collaborative network of over 7,000 members and the researchers from various research institutions in China and the China CDC have produced not only a systematic assessment of disease burdens and its associated risk factors at the country level, but also at the provincial level (*5*). The provincial level study is one of the first two in the world, the other being a state-level disease burden assessment for the United States.

FUTURE DIRECTIONS FOR BURDEN OF DISEASE WORK IN CHINA

County Level Estimation For More Targeted Interventions

While provincial level assessments of burden of disease provide much needed information that national level metrics fail to present, for most provincial-level administrative divisions (PLADs) in China, a more granular assessment is necessary because of the population sizes of PLADs. The heterogeneity in geography, economics, and other socio-epidemiological situations among counties even within the same PLAD further demonstrate that provincial level assessment is not enough. Evaluation of disease burden at the county level is critical in providing the much-needed population health information for both the national and provincial governments to make targeted and efficient public health policies to make sure no one is left behind. Figure 1 below shows the age standardized death rate due to stroke at the county level in US in 2014. Our experience with burden of disease analysis at the county level in the United States shows the policy relevancy given the high level of heterogeneity among counties within the state and across the country (*6*).

China has been one of the most successful countries in achieving the Millennium Development Goals. To obtain similar or higher levels of success in the Sustainable Development Goal era, more nuanced and targeted interventions are needed to help counties that are lagging behind to achieve their full potential in improving population health. Burden of disease analysis at the county level is uniquely equipped to provide key information for decision makers at both the provincial and national levels. Researchers in China, particularly those at both the national and provincial CDCs, should take the challenge and further advance population health assessment in China at the county level.

Integrating Scenario Forecasting as a Policy Tool

Most burden of disease work focuses on making sensible and comprehensive population health estimates up to now using historic and empirical data. Such analysis is important as it provides the baseline of burden of disease of a population. Even equipped with such information, natural questions for policymakers are what interventions are available and what impact a certain intervention would exert on the future of population health and burden of disease. In this regard, scenario-based forecasting is critical in helping policymakers to make sense of the best intervention programs to achieve specific population health goals with the available budget and resources.

The GBD collaborative network has expanded upon the framework of Comparative Risk Analysis developed for the first Global Burden of Disease study at World Health Organization to make scenario specific forecasts of cause specific burden by assuming different level of changes in risk factors associated with various diseases (*7*). Figure 2 below shows the global distribution of country level mortality due to stroke in 2040 based on both mortality and risk factor assessments up to year 2016. This type of scenario-based forecast is a particularly useful tool for policymakers, effectively

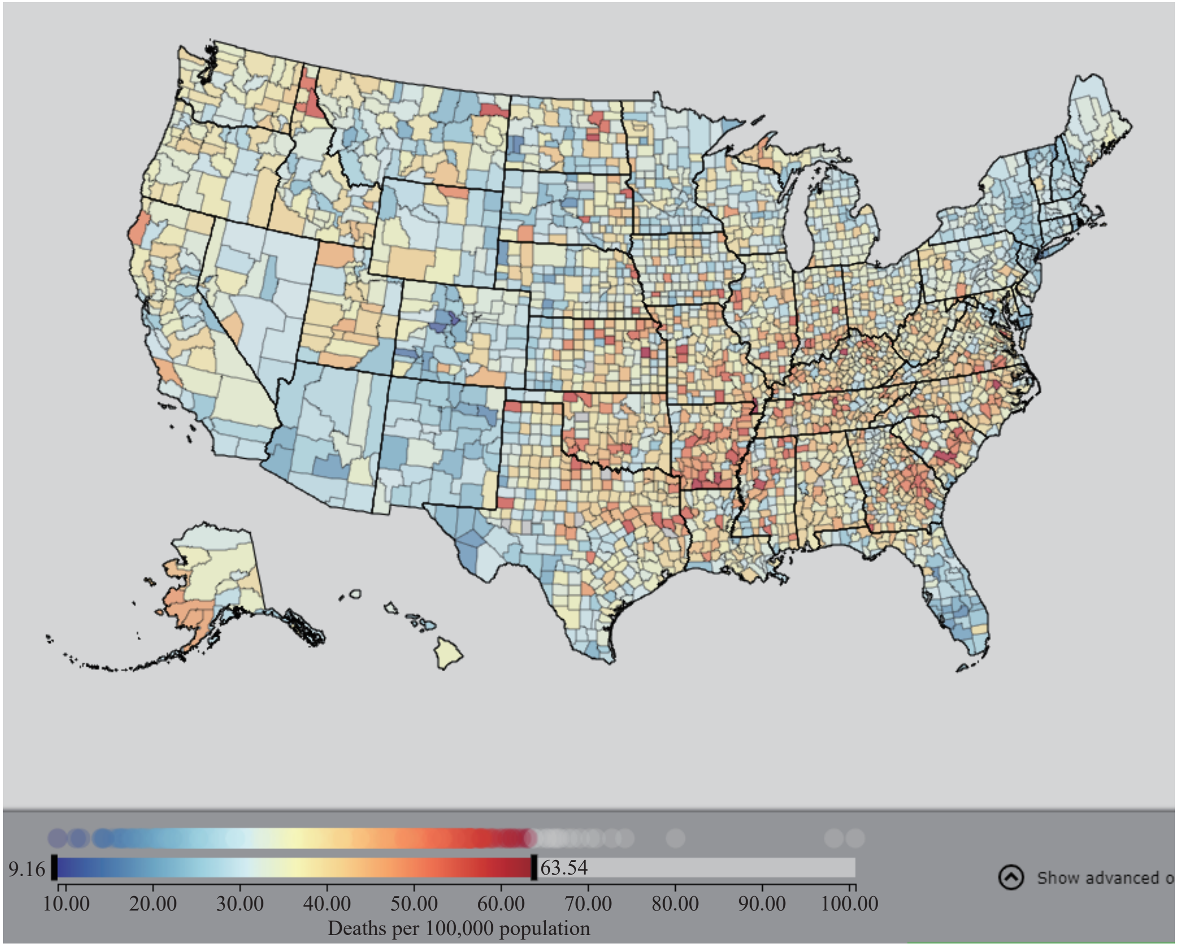

FIGURE 1. Age standardized death rate due to stroke at the county level in the United States in 2014.
Note: the figure is captured from the United States Health Map | IHME Viz Hub (healthdata.org).

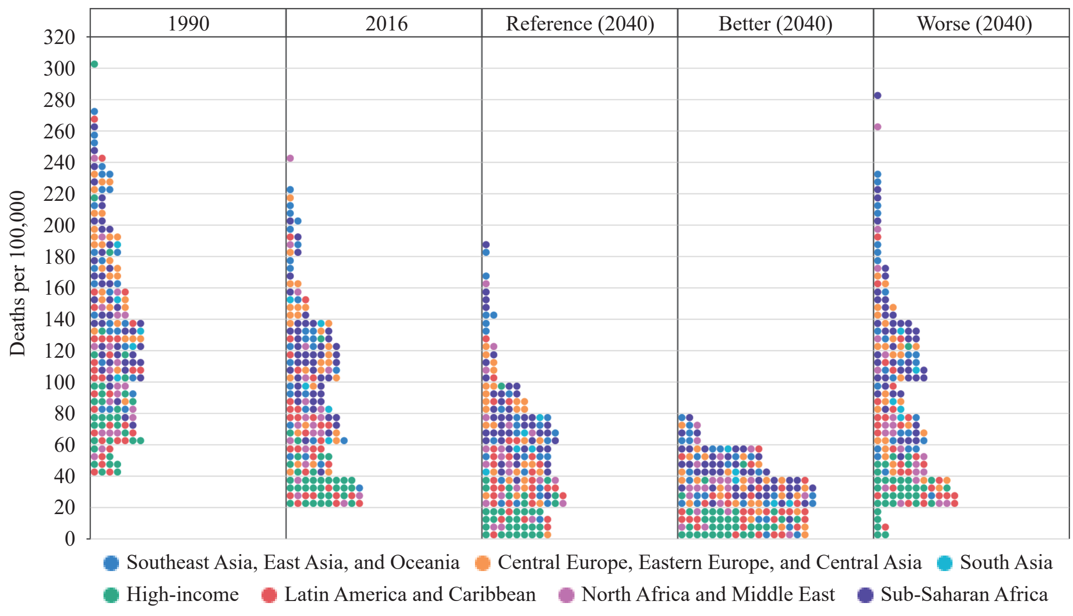

FIGURE 2. Global distribution of country level mortality due to stroke in 2040.
Note: Data is based on both mortality and risk factor assessments up to year 2016.
Resource: GBD Foresight | IHME Viz Hub (healthdata.org).

providing a menu of interventions with tangible changes in population health metrics such as number of deaths averted, improvement in life expectancy, and years of lives saved.

With rapid improvements in mortality and falling fertility rate, particularly since the Reform and Opening in 1978, China is experiencing rapid population aging which is likely to continue further into the future. The increasing burden of disease, particularly due to NCDs, while presenting a significant challenge to both national and subnational governments, also presents a historic opportunity for various industries to develop necessary technologies, tools, and medicines to improve quality of life, improving survival from diseases, and further improve life expectancy and HALE. To meet such a challenge, detailed and accurate assessments of burden of disease at county, provincial, and national levels should be considered a top priority for policymakers.

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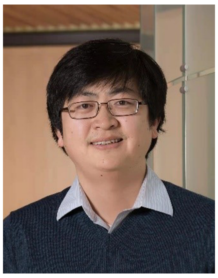

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