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Equity of National Essential Public Health Services (NEPHS) in Mainland China, 2019: a cross-sectional study based on the NEPHS database

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Abstract

Background China's National Essential Public Health Service (NEPHS) Program was launched in 2009 to deliver population-based public health and individual health management services to all residents at 800,000 primary health-care centers nationwide. This study assessed NEPHS utilization data and evaluated usage inequities using comprehensive nationwide data.

Methods A cross-sectional study was conducted, selecting 16 indicators (out of 18) from 12 service packages to evaluate inequity. These included 4 indicators for services provided to all residents and 12 for pregnant women, new mothers, children aged 0–6 years, and patients with hypertension, diabetes, severe mental disorders, or tuberculosis. Data on service utilization and target populations for these indicators across the 31 provinces and 453 cities in mainland China were obtained from the NEPHS database and management platform for the period January 1 to December 31, 2019. Service utilization rates and bias-corrected bootstrap confidence intervals (CIs) were calculated to determine utilization. Inequities were assessed using the Gini coefficient and Sitthiyot-Holasut composite inequality index at the national and provincial levels, and the Theil index was employed to decompose overall inequity into within-region and between-region subgroups.

Results The NEPHS collected health records for 88.25% of China's permanent residents (95% CI: 79.23%–98.82%). The nationwide vaccination coverage rate was 97.44% (95% CI: 91.33%–99.91%). Newborn visit and child health management rates for children aged 0–6 years were 92.08% (95% CI: 74.85%–98.34%) and 90.87% (95% CI: 82.49%–98.47%), respectively. At the national level, NEPHS service utilization in 2019 was generally equitable, with Gini coefficients below 0.4 for the 15 indicators. Potential large equity gaps were observed in the provision of health education services in Shanghai [Gini coefficient = 0.358 (95% CI: 0.219, 0.444)], Inner Mongolia [Gini coefficient = 0.370 (95% CI: 0.073, 0.440)] and Xinjiang [Gini coefficient = 0.457 (95% CI: 0.217, 0.502)]. Additionally, the utilization of family planning education and sanitation inspection services also indicated potential large and severe equity gap in 13 provinces. The Theil indices revealed that inequities primarily existed within rather than between regions. Province-level results indicated perfect equity in health record management and vaccination coverage, while several provinces showed potential equity gaps in health education and family planning services. Potential equity gaps were also observed in health management services for patients with hypertension and diabetes, particularly in Beijing, Hunan and Xinjiang.

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Conclusions This study provides evidence for health planning in China's primary health sector and guidance for analyzing equity in national health programs similar to the NEPHS Program.

Keywords Equity, Public health service, Gini coefficient, Theil index

Introduction

In China, public health services have reduced the spread of infectious diseases [1, 2]. Public health services have also improved maternal and pediatric conditions, reduced mortality, increased life expectancy, and contributed to global primary care development [3]. In 2009, China launched extensive health reforms, one of which was its National Essential Public Health Service Program (NEPHSP). Aligned with the Basic Health Service Package and similar essential frameworks promoted by the World Health Organization (WHO) [4], NEPHSPs have been adopted in numerous countries [5, 6]. China's NEPHSP delivers free services as set packages to all citizens through more than 800,000 primary health-care centers (PHCCs), providing accessible care for 1.4 billion people. With a focus on pregnant women, new mothers, children, older adults, and patients with hypertension, diabetes, severe mental disorders (as defined by the WHO and the National Health Commission of China) [7, 8], or tuberculosis, the program is financed by the Chinese government to address fundamental public health needs. As of 2019, the NEPHSP provides 12 service packages through PHCCs, categorized into population-based public health services for all residents and individual health management services targeting priority populations [9].

Five population-based public health services are provided, namely (1) resident health records management, (2) health education, (3) vaccination, (4) reporting of infectious diseases and public health emergencies, and (5) family planning education and sanitation inspections. Seven individual health management services are provided, namely (6) maternal health management, (7) pediatric health management, (8) health management for older individuals, (9) health management for patients with chronic diseases such as hypertension and type 2 diabetes, (10) health management for individuals with severe mental disorders, (11) health management for individuals with tuberculosis, and (12) health management using traditional Chinese medicine (TCM). These services are affordable, equitable, high-quality, and available to all residents regardless of location or socioeconomic status [10].

The NEPHSP is a structured, comprehensive initiative designed to address major health challenges experienced by residents [11]. Government investment increased from US$2.07 per capita in 2009 to US$12.28 per capita in 2023, totaling US$1.19 trillion in 2023 [12]. This extensive project prioritizes equitable access to essential public health services [13]. The *Opinions on Deepening the Reform of the Medical and Health Care System,* issued in 2009 [14], enjoined local governments to "Promote the gradual equalization of basic public health services" [15]. The "Healthy China 2030" [16] framework advocates allocating primary medical and health-care resources on the basis of population and service coverage to ensure equitable access to essential health-care services. By 2019, the project had been operational for a decade, a suitable interval to evaluate service utilization equity within the NEPHSP and identify health-care utilization and access inequities.

Inequities in primary health-care systems are evaluated using a variety of inequality indices [17–20]. Most research has concentrated on analyzing the allocation and distribution of health-care resources [21–23]. Chen et al. [24] employed Lorenz curves and the Gini coefficient to quantify inequality in the distribution of health personnel across Chinese community health centers. Zhang et al. [25] used Gini coefficients to assess the equity of health resource distribution between Chinese hospitals and primary care institutions, identifying a potential risk of a two-tiered health-care delivery system. Whitehead et al. [26] and Wang et al. [27] analyzed spatial accessibility to primary health care in New Zealand and Sichuan Province, China, respectively. Despite these efforts, no studies have examined inequity in primary health-care service utilization in China by using routinely collected national data. Furthermore, few studies have evaluated inequity in China across regions or analyzed this inequity in detail.

In 2017, the National Health Commission of China established the NEPHS database and management platform, a nationwide information system. This database and analysis platform provides a foundation for evaluating equity in NEPHS utilization in China.

This study conducted the first comprehensive analysis of NEPHS utilization and inequity in service utilization across Mainland China. The findings contribute valuable insights for identifying critical interventions and prioritizing health-care policies in China. Additionally, our approach offers lessons for developing countries addressing similar challenges in achieving equitable public health service utilization.

Methods.

Study design and setting

We conducted a cross-sectional analysis to evaluate equity in NEPHS service utilization in Mainland China using annual data from 2019. Mainland China has 365 cities in 27 provinces and 88 districts in 4 municipalities (collectively termed "453 cities and 31 provinces"). Inequities in the utilization of 12 service packages were assessed at national and provincial levels, revealing disparities in service use across China and among cities within each province. To more accurately identify sources of inequity nationwide, we divided the 31 provinces into three regions: eastern, central, and western. These regions were defined on the basis of geography and economic development, a classification extensively used in national health statistics [28]. Substantial disparities exist in economic conditions and health resource distribution among these regions. In 2019, the eastern and western regions accounted for 51.81% and 16.88%, respectively, of the national gross domestic product [29]. Compared with the prosperous eastern region and the industrial–agricultural central region, the inland western region is environmentally and economically underdeveloped. These economic differences are reflected in disparities in health care, with the western and central regions having lower densities of health institutions and health-care workers than the eastern region [30]. Our analysis decomposed overall inequity into within-region and between-region components to determine whether disparities between regions were the primary drivers of inequitable NEPHS service utilization.

Classification of indicators and data source

In 2017, China's National Health Commission produced the *Code of the National Essential Public Health Services Program, Third Edition* [9] (hereinafter "the *Code*") and issued service standards and guidelines for each package of service and has introduced key performance indicators to measure the quality of services [31]. Service details for the 12 packages are summarized in Supplementary Table 1. According to the design of the NBPHSP, evaluation of services center on process indicators, such as the proportion of patients with chronic illnesses receiving standard management and treatment for chronic conditions [31]. These key performance indicators reflect the coverage and utilization of services among residents and are also the national monitoring indicators used by the National Health Commission (NHC) for the NEPHSP. Hence, these indicators were selected for evaluating NEPHSP service utilization in this study. Additionally, we chose 11 out of the 12 service packages, excluding the package related to the reporting and management of infectious diseases and public health emergencies. For the package involving the reporting of infectious diseases and public health emergencies (4), the indicators exclusively comprised cases reported during outpatient visits at PHCCs. Reporting of infectious diseases and public health emergencies is performed by hospitals and Chinese Center for Disease Control and Prevention. Consequently, these indicators did not capture the complete scope of service utilization by residents for these indicators. Therefore, these indicators were not representative of overall service utilization and could be applied to evaluate equity.

In 2019, population-based public health service packages covered all permanent residents in the 453 cities across the 31 provinces, defined as individuals residing in a jurisdiction for more than 6 months. Individual health management service packages targeted at-risk groups, such as infants aged 0–36 months, children aged 0–6 years, pregnant women (based on the number of live births), individuals with hypertension, individuals with type 2 diabetes aged older than 35 years, and permanent residents aged 65 years or older. The 2019 population size by region and province is provided in Supplementary Table 2.

The frequency of service utilization, defined as the total number of persons who accessed services from January 1 to December 31, 2019, was denoted as N_n, while the target population, based on the population at the end of 2019 [32, 33], was denoted as P_n. The specific definitions of service utilization (U_n) and the targeted population size (P_n) for 16 indicators were presented in Table 1. Lu Liu extracted annual data on the frequency of service utilization and target population size of the 31 provinces and 453 cities from the NEPHS database and management platform using Microsoft Excel 2022 [34]. Each PHCC reports quarterly data on NEPHSP implementation, including service utilization records and population information, through the NEPHS database and management platform. The NEPHS database and analysis platform employs unique identifiers to connect multiple report forms to a single PHCC. Quarterly data are summarized, submitted, and monitored at each administrative level by the primary health departments of the health commission in counties, cities, provinces, and the national government. The primary health department of the National Health Commission compiles annual data from quarterly reports using the management platform, supplying the data used in this study (Supplementary Method 1).

Measures of inequity

This study used the Gini coefficient, Sitthiyot-Holasut composite inequality index and Theil index to evaluate

Table 1 Indicators Used for Equity Evaluation of NEPHS Utilization

Domains	Code[a]	Indicators		U_n	P_n
Population-Based Public Health Services	A1. Resident Health Records Management	X1	Health Records Management	Number of persons whose records were established at PHCCs	Number of permanent residents[b]
	A2. Health Education	X2	Health Education	Number of persons who participated in health education activities	Number of permanent residents
	A3. Family Planning Education and Sanitation Inspections	X3	Family Planning Education and Sanitation Inspection	Number of sanitation inspections assisted by PHCCs	Number of permanent residents
	A4. Vaccination	X4	Vaccination Coverage	Number of persons vaccinated according to relevant guidelines	Number of persons who should be vaccinated stipulated in the *Code*[c]
Individual Health Management Services	A6. Maternal Health Management	X5	Early Pregnancy Management	Number of pregnant women who received their *Handbook* and received their first checkup in the first trimester (13 weeks)	Number of live births[d]
		X6	Postnatal Visits for New Mothers	Number of mothers who received one postnatal visit within a week after discharge	Number of live births
	A7. Pediatric Health Management A11. Traditional Chinese Medicine Health Management	X7	Newborn Visits	Number of newborns who received visits	Number of live births
		X8	Health Management for Children Aged 0–6 Years	Number of children aged 0–6 years who received visits	Number of children aged 0–6 years
		X9	TCM Management for Children Aged 0–36 Months	Number of children aged 0–36 months who received the TCM management services stipulated in the *Code*	Number of children aged 0–36 months
	A8. Health Management of Patients with chronic diseases	X10	Health Management for Patients With Hypertension	Number of patients with hypertension who received standard health management services[e] stipulated in the *Code*	Number of permanent residents
		X11	Blood Pressure Control for Patients With Hypertension	Number of patients whose blood pressure was controlled at the latest follow-up visit (BP < 140/90 mmHg and BP < 150/90 mmHg for older adults)	Number of patients with hypertension who received health management services
		X12	Health Management for Patients With Diabetes	Number of patients with type 2 diabetes mellitus receiving the standard health management services[e] stipulated in the *Code*	Number of permanent residents
		X13	Blood Glucose Control for Patients With Diabetes	Number of patients whose blood glucose was controlled at the latest follow-up visit (fasting blood glucose < 7 mmol/L)	Number of patients with diabetes who received health management services

Table 1 (continued)

Domains	Code[a]	Indicators		U_n	P_n
	A9. Health Management of Patients With Tuberculosis	X14	Health Management for Patients With Tuberculosis	Number of patients receiving the standard health management services[e] stipulated in the *Code*	Number of patients with tuberculosis
	A10. Management of Patients With Severe Mental Illness	X15	Health Management for Patients with Severe Mental Disorders	Number of patients with severe mental disorders receiving the standard health management services[e] stipulated in the *Code*	Number of patients with severe mental disorders
	A11. Traditional Chinese Medicine Health Management A12. Older Adult Health Management	X16	TCM Management for Older Adults Aged 65 Years and Above	Number of older adults aged 65 years and above receiving TCM management services	Number of permanent residents aged 65 years and above

Abbreviations: U_n Service utilization, P_n Population size, *BP* blood pressure, TCM traditional Chinese medicine

[a] See supplementary materials, Table 1, for detailed descriptions of the "Code" and corresponding service packages

[b] Permanent residents refer to residents who have lived in a district for more than 6 months

[c] See supplementary materials, Table 1, Code A4 for individuals who should be vaccinated

[d] Each infant born alive is considered a live birth, whether they are part of a multiple pregnancy or not [35]

[e] The criteria for standard health management services were detailed in the main content of Codes A8, A9, and A10, which outline the required services and standard procedures according to the Code

inequity in service utilization within the NEPHS. The Gini coefficient [36] was adopted to depict overall inequality in NEPHS utilization across China and within its 31 provinces. Due to the Gini coefficient's less sensitive to inequality at the tails of service utilization distribution and the inter-decile ratios' neglect the inequality in the middle part, so we also adopted Sitthiyot-Holasut composite inequality index to distinguish inequality among provinces that share the same Gini index but have different service utilization gaps between the top 10% and the bottom 10% [37]. Additionally, the Theil index and two subindices were used to assess the contributions of between-region and within-region inequities [38, 39]. The formulas appear in Supplementary Method 2, 3 and 4. Furthermore, a sensitivity analysis was conducted to evaluate the robustness of the Gini coefficient by applying the agglomeration degree, an alternative measure of inequity, to verify consistency in service utilization inequity [23]. The formulas for calculating service agglomeration degree are provided in Supplementary Method 5.

Statistical analysis

Health service utilization rate measures the frequency of visits made to health facilities within one year [40, 41]. In this study, service utilization was described by calculating the service utilization rates, which represent the proportion of residents utilizing each specific service within packages during the year 2019. The rate was calculated as $R_n = (U_n / P_n) \times 100$ [31]. Service utilization rates were reported for China and each of the 31 provinces.

The Gini coefficients of the 16 indicators were reported for all of China and its 31 provinces, with values varying between 0 (completely equitable) and 1 (completely inequitable) [42]. Specifically, the Gini coefficients less than or equal to 0.2 indicate perfect equity, greater than 0.2 through 0.3 relative equity, greater than 0.3 through 0.4 adequate equity, from 0.4 through 0.5 large equity gap, and greater than 0.5 indicate severe equity gap [43]. We also constructed bias-corrected bootstrap confidence intervals (CIs) for the Gini coefficients and service utilization rates using sampling with replacement [44, 45]. We calculated the 2.5th and 97.5th percentiles from 1,000 bootstrapped Gini coefficients and service utilization rates. We subsequently calculated the total Theil index (T), Theil within-region (T_{WR}), and Theil between-region (T_{BR}) values for the 16 indicators for China. The condition $T = 0$ indicates complete equitability in service utilization, with lower values indicating greater equitability and larger values indicating greater inequity [46]. Additionally, a service agglomeration degree value of 1 indicates that the service utilization is nearly completely equitable on the basis of population [47]. Service agglomeration degrees and median service agglomeration degrees for the 16 indicators were calculated for each of the 31 provinces to reflect the median level of inequity in service utilization across China. All analyses were conducted using R version 4.2.3. This study was conducted per the Guidelines for Strengthening the Reporting of Observational Studies in Epidemiology [48] (Supplementary Method 6).

Results

Overall NEPHS utilization

Supplementary Tables 3 and 4 present the estimated service utilization rates of the 16 indicators across China and its 31 provinces in 2019. For population-based public health service packages, residents' health record registration rate was 88.25% (95% CI: 79.23%–98.82%). This rate was highest in Henan (98.82%) and lowest in Heilongjiang (79.23%). Participation in health education activities was 13.83% (95% CI: 5.22%–85.85%) nationwide. Participation was highest in Xinjiang (85.85%) and lowest in Guangxi (0.24%). Nationwide, vaccination coverage was high, with a rate of 97.44% (95% CI: 91.33%–99.91%), ranging from 91.33% in Tibet to 129.21% in Tianjin. Additionally, the nationwide rate of participation in family planning education and sanitation inspections was 0.48% (95% CI: 0.10%–1.16%), ranging from 0.10% in Hebei to 1.16% in Shanxi.

For individual health management service packages, the nationwide early pregnancy management rate was 86.55% (95% CI: 61.74%–106.71%), ranging from 98.27% (95% CI: 83.40%–257.7%) in Tianjin to 61.74% (95% CI: 26.70%–93.85%) in Tibet. The postpartum visit rate was 91.26% (95% CI: 71.71%−106.58%). This rate was highest in Tianjin (98.15%; 95% CI: 83.40%–256.90%) and lowest in Tibet (71.71%; 95% CI: 48.51%–99.74%). Regarding pediatric health management service packages, the nationwide visit rate was highest for the newborn age group (92.08%; 95% CI: 74.85%–98.34%), and the health management rate was highest for the children aged 0–6 years age group (90.87%; 95% CI: 82.49%–98.47%). Jiangxi reported the lowest rates for these indicators at 74.85% and 75.97%, respectively. The rate of pediatric TCM health management reached 69.86% (95% CI: 46.76%–82.85%), and the rate of health management for older adults was 62.17% (95% CI: 52.66%–80.02%).

The service utilization rate for hypertensive management exceeded that for diabetes, and the rate of patients whose condition was well-managed surpassed the standardized health management rate. The nationwide standardized health management rate was 1.67% (95% CI: 0.12%–3.52%) for individuals with diabetes and 5.41% (95% CI: 3.40%–10.62%) for those with hypertension. Additionally, the nationwide rate of patients with managed noncommunicable diseases was 63.73% (95% CI:

48.97%–94.80%) for those with diabetes and 67.79% (95% CI: 48.97%–94.80%) for those with hypertension. Moreover, the nationwide standardized management rate for patients with tuberculosis was 98.53% (95% CI: 95.53%–99.73%) and 89.17% (95% CI: 78.67%–98.27%) for individuals with severe mental disorders.

Equity of NEPHS utilization across China in 2019

The Gini coefficients of NEPHS utilization across China in 2019 are presented in Table 2. The coefficients for health record management and vaccination coverage were 0.031 (0.018, 0.039) and 0.010 (0.007, 0.011), respectively, indicating perfect equity in service utilization for these packages. The Gini coefficient for health education was 0.295 (0.169, 0.428), indicating relative equity based on the point estimate. However, the confidence interval suggests uncertainty, as it spans from perfect equity to a large equity gap. The Gini coefficient for the utilization of family planning education and sanitation inspections across China was 0.317 (0.230, 0.369), indicating no large equity gap. Finally, individual health management packages achieved near-perfect equity, with Gini coefficients for 12 indicators (X5–X16) all being less than 0.3. Additionally, indicators with the same estimated Gini coefficient further revealed inequality between different indicators through composite inequality indices. Newborn visits and health management for patients with sever mental disorders have the same estimated Gini coefficient of 0.028. However, the composite inequality index in newborn visits was 0.350, whereas that in health management for patients with sever mental disorders was 0.399. This suggested that, after considering the service utilization shares of the top and bottom 10%, utilization inequality in health management for patients with severe mental disorders is higher than that in newborn visits.

Sensitivity analysis results for the agglomeration degree are presented in Supplementary Table 5. Median service agglomeration degrees for health education (0.8936), family planning education and sanitation inspections (0.8289), and health management for individuals with diabetes (0.9306) deviated by more than 1 from the median service agglomeration degrees for other indicators (0.9580–1.0289). These findings align with the nationwide Gini coefficients and those of the 31 provinces, demonstrating robust and stable equity outcomes.

Table 3 presents the total Theil index and subindices for within-region and between-region disparities. In 2019, the total Theil index for the 16 indicators ranged from 0.0000 (X14) to 0.2151 (X7). The Theil index for between-region disparities ranged from 0.0000 (X14) to 0.1043 (X11), and the Theil index for within-region disparities ranged from 0.0000 (X14) to 0.1733 (X7). These results indicate that inequity in NEPHS utilization primarily resulted from disparities within regions, as demonstrated by the within-region Theil indices, which were consistently higher than the between-region index values across the 16 indicators.

Equity of NEPHS utilization in the 31 provinces in 2019

In 2019, population-based public health service packages indicated perfect equity in residents' health record management and vaccination coverage across all provinces, which had Gini coefficients less than 0.1. Twenty-eight provinces exhibited relative or adequate equity in health

Table 2 Estimated Gini Coefficients of NEPHS Utilization in Mainland China in 2019

Code	Indicators	Gini Coefficients	Composite Inequality Indice
X1	Health Records Management	0.031 (0.018,0.039)	0.369 (0.266,0.410)
X2	Health Education	0.295 (0.169,0.428)	0.466 (0.348,0.560)
X3	Family Planning Education and Sanitation Inspection	0.317 (0.230,0.369)	0.359 (0.294,0.376)
X4	Vaccination Coverage	0.010 (0.007,0.011)	0.359 (0.279,0.372)
X5	Early Pregnancy Management	0.038 (0.026,0.047)	0.354 (0.282,0.398)
X6	Postnatal Visits for New Mothers	0.030 (0.016,0.043)	0.352 (0.285,0.390)
X7	Newborn Visits	0.028 (0.015,0.040)	0.350 (0.285,0.382)
X8	Health Management for Children Aged 0–6 Years	0.024 (0.014,0.035)	0.362 (0.296,0.389)
X9	TCM Management for Children Aged 0–36 Months	0.056 (0.034,0.079)	0.317 (0.238,0.370)
X10	Health Management for Patients With Hypertension	0.164 (0.106,0.224)	0.415 (0.285,0.455)
X11	Blood Pressure Control for Patients With Hypertension	0.061 (0.037,0.077)	0.412 (0.262,0.465)
X12	Health Management for Patients With Diabetes	0.184 (0.133,0.226)	0.442 (0.295,0.576)
X13	Blood Glucose Control for Patients With Diabetes	0.066 (0.035,0.086)	0.421 (0.271,0.575)
X14	Health Management for Patients With Tuberculosis	0.005 (0.003,0.006)	0.344 (0.292,0.374)
X15	Health Management for Patients with Severe Mental Disorders	0.028 (0.018,0.037)	0.399 (0.275,0.475)
X16	TCM Management for Older Adults Aged 65 Years and Above	0.050 (0.035,0.062)	0.400 (0.287,0.458)

Table 3 Theil Indices of NEPHS Utilization in 2019

Code	Indicators	T	T_{BR}	T_{WR}
X1	Health Records Management	0.0007	0.0002	0.0004
X2	Health Education	0.0752	0.0186	0.0567
X3	Family Planning Education and Sanitation Inspection	0.0728	0.0059	0.0669
X4	Vaccination Coverage	0.0580	0.0131	0.0450
X5	Early Pregnancy Management	0.0658	0.0102	0.0556
X6	Postnatal Visits for New Mothers	0.1626	0.0301	0.1326
X7	Newborn Visits	0.2151	0.0418	0.1733
X8	Health Management for Children Aged 0–6 Years	0.1388	0.0287	0.1101
X9	TCM Management for Children Aged 0–36 Months	0.1932	0.0400	0.1533
X10	Health Management for Patients With Hypertension	0.0190	0.0008	0.0182
X11	Blood Pressure Control for Patients With Hypertension	0.1488	0.1043	0.0445
X12	Health Management for Patients With Diabetes	0.0225	0.0038	0.0187
X13	Blood Glucose Control for Patients With Diabetes	0.1986	0.0590	0.1395
X14	Health Management for Patients With Tuberculosis	0.0000	0.0000	0.0000
X15	Health Management for Patients with Severe Mental Disorders	0.0006	0.0001	0.0005
X16	TCM Management for Older Adults Aged 65 Years and Above	0.2053	0.0608	0.1445

education. However, in some regions, including Inner Mongolia, Shanghai, and Xinjiang, the upper bounds of the confidence intervals exceeded 0.4, suggesting potential equity gaps in participation in health education activities. Additionally, among Shandong, Hainan in the eastern region had the same estimated Gini coeffieient (0.102). But the composite inequality index in Shandong was 0.228(0.153, 0.235), whereas that in Hainan was 0.344 (0.115,0.348), suggesting that inequality in Hainan is higher that in the Shandong. Eighteen provinces exhibited relative or adequate equity in the utilization of family planning education and sanitation inspections. The upper bounds of the confidence intervals for Beijing, Hunan and Xinjiang exceeded 0.5, indicating potential severe equity gaps, with Gini coefficients of 0.636 (0.375, 0.758), 0.399 (0.157, 0.500) and 0.359 (0.190, 0.520), respectively (Fig. 1, Supplementary Table 6).

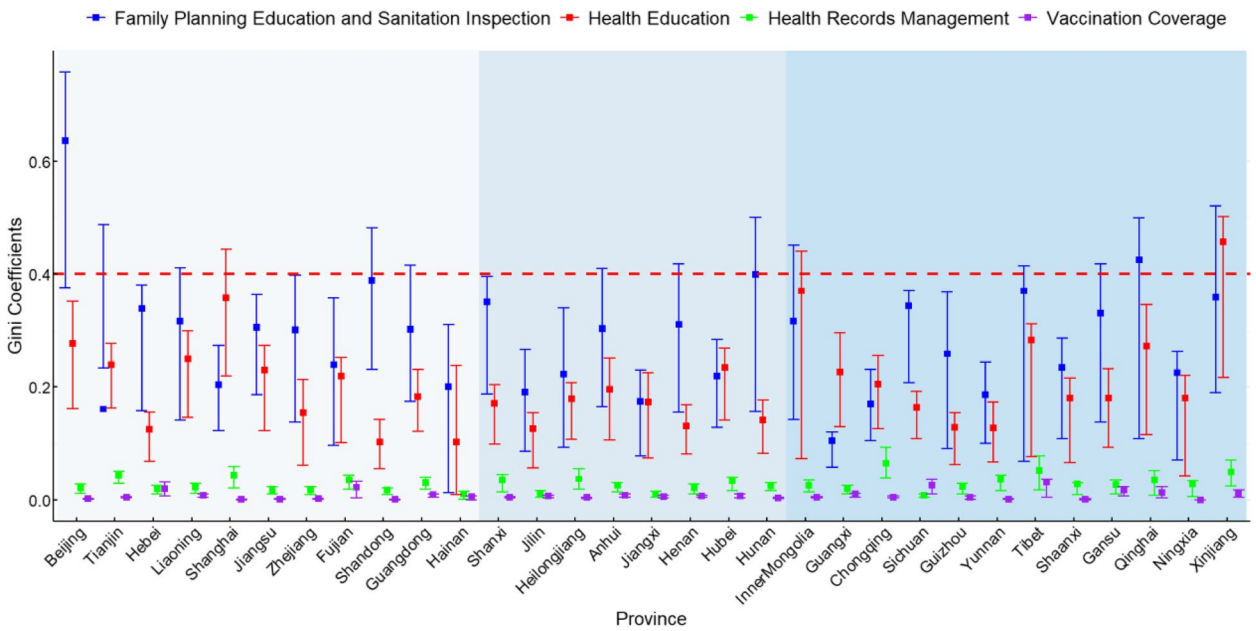

Fig. 1 Gini coefficients of population-based public health service utilization in 31 provinces in 2019

For individual health management service packages, small disparities existed in service utilization among cities within provinces, particularly in maternal, pediatric, older adult, tuberculosis and severe mental disorders health management services. Most Gini coefficients for these services were less than 0.3. However, severe gaps in health management services for patients with noncommunicable diseases were observed in Beijing, where the Gini coefficients for hypertension and diabetes management both exceeded 0.5. Additionally, the utilization of health management services for patients with diabetes showed potential equity gaps, with a Gini coefficient of 0.331 (0.103, 0.436). Regarding the postnatal visits for maternal, both Ningxia and Chongqing in the western region had the same estimated Gini coeffient (0.012). But the inequality index in Ningxia was 0.488, whereas that in Chongqing was 0.234, suggesting that inequality in Ningxia was higher that in Chongqing. For the health management for diabetic patients, both Jiangsu and Fujian in the eastern region had the same Gini coeffient (0.075). The composite inequality index in Jiangsu was 0.183, whereas that in Fujian was 0.374, suggesting that inequality in Fujian was higher that in Jiangsu (Fig. 2, Supplementary Table 7).

Discussion

This study is the first to use routinely collected national data from the NEPHS database and management platform to evaluate the equity of NEPHS utilization in China across 31 provinces. The NEPHSP collected health records for 1.2 billion individuals (88.25% of permanent residents) in 2019. In addition to extensive health record coverage, vaccination coverage reached 97.44% nationwide, surpassing the 95% target set by the WHO for 2020 [49]. The NEPHSP's universal utilization was also reflected in maternal and newborn health management rates, with postnatal visits, newborn visits, and 0–6-year-old child health management rates all exceeding 90%. Additionally, early pregnancy management rates surpassed 85%. Several countries, including Sweden [50] and Brazil [51], have adopted national programs to deliver postnatal care and child health services. Similar programs exist in low-income and lower-middle-income countries [52]. Anecdotal reports suggest that most governments implementing these programs on a large scale encounter considerable challenges and fail to achieve the coverage levels necessary to substantially reduce mortality [53]. Given these findings, the high utilization rates achieved by the NEPHSP are particularly notable, especially their scale within the primary health-care sector. The NEPHSP offers valuable lessons for other countries. Global data from 2019 indicate that high-income countries, including South Korea and Canada, reported the highest control rates for patients treated for hypertension, with rates exceeding 60% [54]. The present study demonstrates that control rates in China are comparable to those in these countries and substantially higher than the rate reported by the Chinese National Center for Cardiovascular Disease [55]. The management rate for patients with diabetes was approximately 65%, exceeding the national rate of 49.2% reported in a large-scale epidemiological analysis [56]. These achievements are attributable to the NEPHSP's coverage of approximately 109 million patients with hypertension and 31.357 million patients with diabetes. However, more than half of all patients with these conditions in China remain outside NEPHSP management [57]. Expanding health management services for patients with noncommunicable diseases in PHCCs through the NEPHSP could substantially improve national blood pressure and blood glucose control rates. These findings demonstrate that NEPHS serves hundreds of millions of individuals.

At the national level, NEPHS service utilization in 2019 was generally equitable, with Gini coefficients below 0.4 for the 15 indicators. This observation aligns with findings from a study on the equalization of primary health services in China using alternative indicators [58]. Despite the overall equity, potential large equity gaps were observed in the provision of health education services in Shanghai, Inner Mongolia and Xinjiang. Additionally, the utilization of family planning education and sanitation inspection services also indicated potential large and severe equity gap in 13 provinces. These inequities may result from PHCCs conducting a fixed number of health education activities and sanitation inspections without adjusting targets on the basis of population size [9]. Ideally, larger populations should have proportionally higher targets for these activities [59]. The lack of population-adjusted targets creates inequities among cities across the 31 provinces when measuring service utilization by population size. We suggest that the National Health Commission mitigate these disparities by adjusting the absolute targets of these indicators to align with population statistics. Additionally, indicators should better reflect the quality of health education services for residents, such as health literacy levels, to provide a more accurate representation of health education activity utilization.

A potential large or severe equity gap was observed in Beijing for health management services targeting those with noncommunicable diseases. This gap may stem from the NEPHSP implementation mechanism. Due to the large number of patients with noncommunicable diseases in China, the annual target for managing patients with hypertension and diabetes within each jurisdiction is determined by upper-level health authorities and does not include all patients in each jurisdiction. For example,

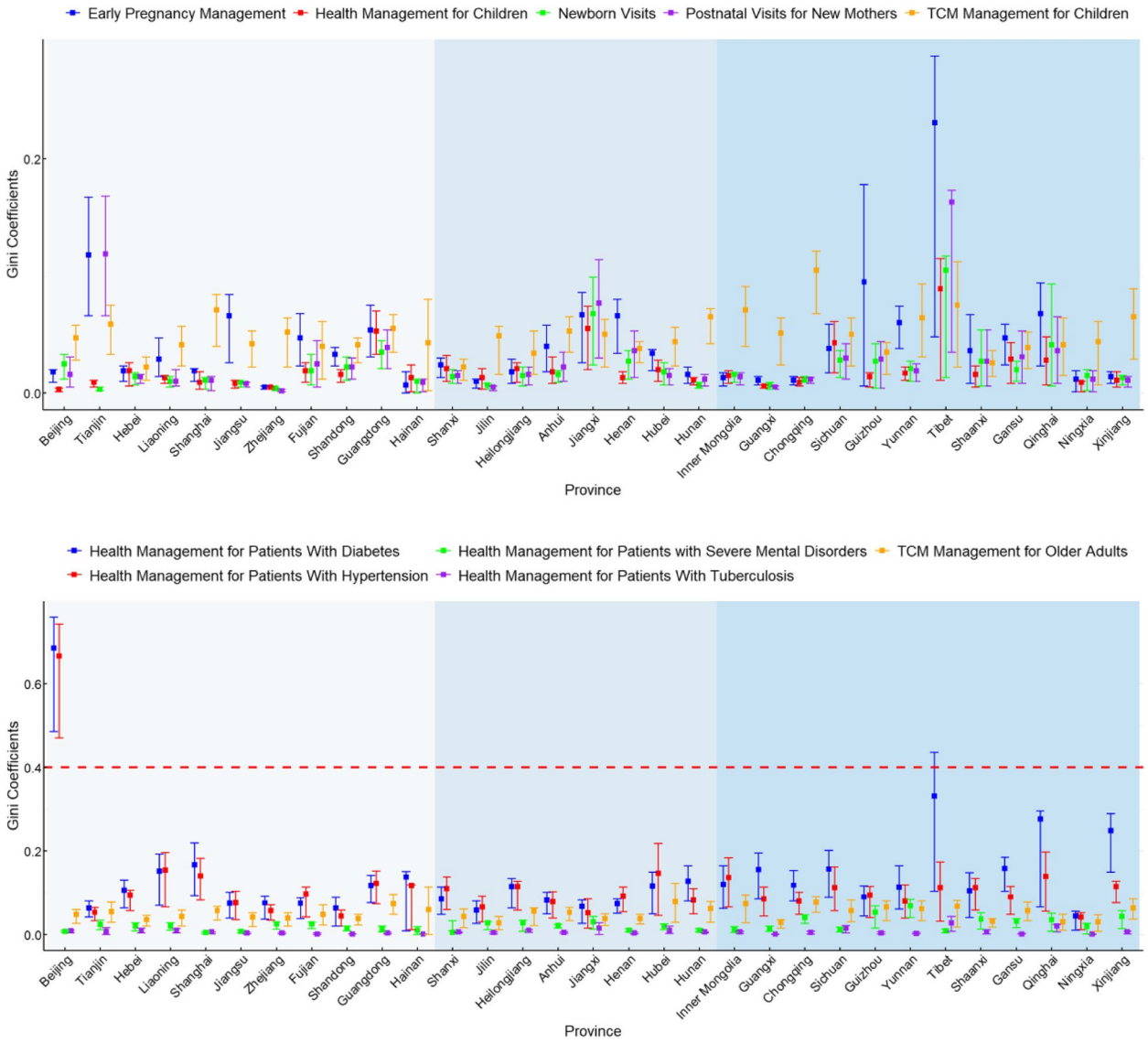

Fig. 2 Gini coefficients of individual health management service utilization in 31 provinces in 2019

the Beijing Health Commission set the target number of patients to be managed in each district in 2019 on the basis of district population sizes. District health commissions then allocated these targets according to the populations served by each PHCC. The target number of patients to be managed was allocated hierarchically. Nevertheless, when we examined the population size and service utilization records for patients with noncommunicable diseases in each district of Beijing, the target numbers were inconsistent with population sizes. For example, Chaoyang District, which had the largest population, received the second-lowest target number for managing patients with hypertension and diabetes. Consequently, the number of patients managed did not align with the district's population size, resulting in an equity gap.

The Health Commission of Beijing should reevaluate the allocation of target numbers for managing these patients to better reflect population needs and service utilization. This process should involve determining target numbers on the basis of both the actual population size and the health needs of each district rather than relying solely on base population counts. Refining the target-setting approach would enable a more equitable distribution of resources and address disparities in health-care access. Furthermore, regular reviews and adjustments based on demographic and service utilization data should

be implemented to enhance equity in managing patients with noncommunicable diseases.

The overall inequity in 2019 primarily resulted from disparities within rather than between regions, as indicated by the Theil index results. This finding contradicts the conclusion of an earlier study that reported that health inequity is primarily driven by regional economic disparities [60]. A review of the literature from 2009 to 2018 revealed persistent disparities in the utilization of NEPHS across eastern, central, and western China [61]. To address these disparities, the NEPHSP was entirely financed by national, provincial, and prefecture governments. Nevertheless, regional economic disparities have led to substantial variation in fiscal capacity among provinces. To ensure equitable NEPHS utilization, the central government provided greater financial support to underdeveloped provinces in western China through transfer payments. For example, in 2016, the per capita subsidy standard was US$7.43 in the eastern region, US$7.15 in the central region, and US$6.57 in the western region. National-level subsidies accounted for 25.50%, 60.57%, and 79.52% of these amounts, respectively [62]. This financing mechanism acknowledged regional disparities and promoted equity. Two studies analyzing the influence of the NEPHSP on noncommunicable disease management from 2007 to 2010 in China revealed that regional disparities persisted but were narrowing [63, 64]. The present study provides evidence that by 2019, inequity between regions was no longer the primary contributor to overall inequity, contradicting earlier findings. In 2016, the government's "Healthy China 2030 Action Plan" proposed allocating essential health resources on the basis of the number of permanent residents and the service radius in cities to ensure equal access to essential health services for all [65]. This study provides empirical evidence on utilization rates across the 31 provinces and inequities within each province, enabling health administrators to implement targeted measures. Inequities between provinces and within regions urgently require addressing. For example, regarding blood pressure control measures for patients with hypertension in the eastern region, Shandong had a considerably lower rate than did Shanghai. Heilongjiang and Jilin lagged behind other central provinces, and Qinghai, Yunnan, and Tibet had considerable potential for improvement compared with other western provinces. To reduce inequities between provinces within broader regions, China's National Health Commission should prioritize planning and resource allocation to address disparities. High-quality resources should be directed toward provinces with fewer resources and less utilization, especially support for skilled personnel, essential equipment, and funding.

This study has several limitations. First, the estimated service utilization rates may be overestimated because the data were obtained from the NEPHS database, which relies on self-reports from PHCCs rather than objective, nonadjustable records of residents receiving services [66]. The reported cases may be inflated because these statistics are tied to PHCC performance evaluations [31], incentivizing administrators to report higher numbers. Although health commissions conduct random checks on PHCC reports, they do not verify all data through field audits, potentially limiting the accuracy of our findings. Second, a limitation of our study was the exclusive use of univariate inequality measures, specifically the Gini coefficient, to assess service utilization inequities. Due to data accessibility constraints, we were unable to include key socio-demographic variables such as income, education, and other factors across the 453 cities (districts) in China. As a result, we could not apply bivariate inequality measures that could account for the combined effects of multiple variables on health service inequities [67]. This limitation may affect the interpretation and generalizability of our findings, as factors like income and education could potentially influence inequities in service utilization. Further research that incorporates these additional variables would offer a more comprehensive understanding of health service inequities. Third, while the central government established the service standards and key performance indicators for the delivery of NEPHS, these standards and indicators have not been refined since the Programme was established in 2009. Measures of utilization centre on the coverage of key practices, which were selected for this study and monitored by the National Health Commission (NHC) of China. However, these measures are not linked to health outcomes and do not account for changes in the population's needs over time. For instance, indicators such as the number of individuals attending health education lectures primarily reflect service coverage, rather than actual service utilization by residents. This highlighted the need for more comprehensive data sources, such as nationwide population-based health surveys or case-specific routine facility information systems, to better assess service utilization and effectiveness. Specifically, the establishment of a nationwide NEPHSP information system that can access individual case data would allow for dynamic monitoring of service utilization across national, provincial, and city levels. Fourth, the results of the Gini coefficients in this study were derived by comparing point estimates with threshold values. However, the uncertainty of point estimates may lead to varying interpretations of equity. This uncertainty underscored the need for caution in interpreting the results for health education at both national

and provincial levels, as well as for family planning education and sanitation inspection at the provincial level.

This study highlighted the inequity in NEPHS utilization across China and within its provinces, providing insights for evidence-based primary health planning and management. This study also provides a framework for evaluating the achievement of equity goals in national primary health programs similar to the NEPHSP. The findings contribute novel perspectives for promoting equity in primary health care and essential health services globally, offering actionable recommendations for improving service delivery and policy implementation at both national and provincial levels.

Conclusion

This study examined equity in NEPHS utilization in China in 2019 by using data from the national NEPHS database and management platform. The rates of health record registration, vaccination coverage, and maternal and child health services were especially notable. Equity gaps were identified in health education across Inner Mongolia, Shanghai, and Xinjiang, and family planning education, and sanitation inspection services across provinces, particularly in Beijing, Hunan and Xinjiang. Inequities in NEPHS utilization were primarily observed within regions rather than between regions despite considerable disparities in regional economic development. This analysis provides empirical evidence for targeted policies and large-scale national programs to reduce inequities in NEPHS utilization within primary healthcare sectors. China's NEPHS must implement more scientific allocation mechanisms to determine target numbers, refine the *Code* with specific implementation standards on the basis of population needs, and adjust resource allocation and financial support for provinces with low utilization rates.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
Lu LIU, Jinhong ZHAO, Lili YOU designed the study. Lu LIU, Jinhong ZHAO and Yuxing WANG reviewed the literature, performed the analyses, and wrote the draft of the manuscript. Xinyue CHEN, Siqi ZHANG and Mengyu LI contributed to cleaning the data and Plotting graphs and charts. The manuscript was reviewed and revised by Lili YOU and Yuanli LIU. All authors contributed to the interpretation of data and the final approved version.

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Data availability
The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at the National Health Commission of China.

Declarations

Ethics approval and consent to participate
This study was performed in line with the principles of the Declaration of Helsinki, and approval was granted by the Ethics Committee of the Chinese Academy of Medical Sciences and Peking Union Medical College (nºCAMS-PUMC-IEC-2022–025). Informed consent was not applicable to this study.

Consent for publication
Not applicable.

Competing interests
Authors have no relevant financial or non-financial interests to disclose. And this study has no other competing interesting.

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