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Comparative performance analysis of public-private partnership hospitals in Türkiye

Aziz Küçük^{1*} and Volkan Soner Özsoy²

Abstract

Background Public-private partnership (PPP) initiatives in healthcare are being extended globally, often to reduce the government's financial burden in public infrastructure provision. One of the important reforms in the Turkish health system is the structural and functional transformation of public hospitals through the PPP model. This study is the first longitudinal bootstrap data envelopment analysis assessment comparing the performance of public hospitals in Türkiye before and after implementing the PPP model.

Methods The efficiency of 14 PPP hospitals from 2015 to 2023 were obtained via bootstrap data envelopment analysis to correct bias in efficiency estimates. Two different models, called EQ (only equipment) and PH (only physicians) were designed to examine the performance of hospitals more comprehensively and to determine whether the reasons that negatively affect their performance are due to a lack of equipment or health professionals.

Results The findings indicated that hospitals managed on the basis of the PPP model in Türkiye generally achieved higher efficiency scores than when they were traditionally managed. Between 2015 and 2020, referred to as the pre-PPP period, the average EQ score decreased from 0.82 to 0.80, while between 2017 and 2023, referred to as the post-PPP period, this score increased from 0.76 to 0.91. Similarly, the average score of the PH model decreased from 0.93 to 0.90 in before PPP period and increased from 0.82 to 0.90 in after PPP period. Furthermore, the COVID-19 pandemic has also negatively affected the performance of the PPP model by causing a general reduction in the use of health services.

Conclusions Public hospitals built under the PPP model have made a significant contribution to strengthening Türkiye's healthcare infrastructure. This study shows that more comprehensive assessments such as comparisons with non-PPP hospitals, however long-term cost-benefit studies are needed to reach definitive conclusions about the PPP model.

Keywords Public-private partnership, Bootstrap data envelopment analysis, Healthcare reforms, City hospitals, Performance assessment

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Background

In many countries, increasing healthcare expenditures and shrinking public budgets have placed significant financial pressure on public hospitals. Therefore, governments have sought alternative policy tools to ensure the sustainable and efficient delivery of healthcare services. Among these instruments, public–private partnership (PPP) models have emerged as a potential solution to strengthen the financial sustainability of public hospitals while also improving the quality of care [1, 2]. Rooted in market-based principles, the integration of private financing into public healthcare provision represents a core component of the New Public Management (NPM) paradigm, which emphasizes efficiency and performance in the public sector [3]. Since the early 1990s, PPPs have contributed to a restructuring of public service delivery by redefining the roles and responsibilities of public and private actors. This transformation aligns with the core tenets of NPM, which legitimized the adoption of PPPs through an emphasis on efficiency, accountability, and the incorporation of market-oriented mechanisms in public governance.

The principal distinction between a traditional public investment and PPP lies in the efficient allocation of risk, whereby an optimal level of risk is systematically transferred to the private sector. Thanks to the management expertise and additional benefits provided by the private sector, value for money (VfM) is achieved through the effective transfer of risk to the party best equipped to manage it. Affordability and VfM are the benchmarks for PPP viability [4, 5]. VfM refers to the delivery of public goods in adequate quantity and quality, enhancing efficiency, maximizing economic value, and achieving predefined social objectives [6]. Achieving VfM depends on key factors such as risk transfer, output-oriented specifications, long-term contracts, performance monitoring and incentives, competition, and private sector management capabilities. Despite the theoretical benefits, empirical evidence regarding the achievement of VfM in PPPs remains inconclusive. While some studies affirm the model's capacity to deliver efficiency and quality improvements, others question whether the expected benefits materialize in practice [6–10].

Through PPP model, the government makes a long-term contract with a private partner to provide public goods or services; the private partner is responsible for the construction, operation, and maintenance of the assets necessary for the delivery of goods or services. In healthcare, PPPs have different forms ranging from contracts for support services to the complex process of design, construction, and management of hospital facilities. For example, Design Build Finance Operate (DBFO) is the most common model of concession used in the health sector. In the DBFO model, the public partner

makes annual payments to the private consortium for an extended period, often 25 or 30 years [11, 12]. In each of the PPP models, the ownership and management of hospitals; business risk; responsibility for design, construction, and investment; and duration of the contract differ [13]. In the health sector, the PPP model is implemented in many countries, such as the UK, Spain, Portugal, Germany, Brazil, South Africa, Lesotho, Singapore, and Iran.

Studies of the impact of PPPs on healthcare utilization, the quality of services, patient satisfaction, and health-related outcomes are scarce and inconclusive. Owing to limited experience and the lack of rigorous evaluations, analyses are difficult, especially in the dimensions of cost, quality, flexibility, and complexity [14]. Some studies have shown that PPPs in hospitals provide better results in improving service quality, increasing efficiency, and increasing patient satisfaction [15–18]. However, other studies have shown that traditional management does not always yield better results than hospitals do [19, 20].

The Turkish healthcare system has long faced growing pressures to enhance quality, improve access, reduce costs, and increase efficiency. While hospitals in OECD countries received, on average, 39% of total health expenditures in 2021, hospitals in Türkiye accounted for more than half (53%) of the national healthcare budget—representing the highest proportion among OECD member states [21]. The rationale behind the adoption of the PPP model in Türkiye's health sector was to involve private service providers in the delivery of ancillary services and to mobilize private capital, expertise, and managerial efficiency within the public healthcare system. Like many other countries, Türkiye adopted the build–operate–transfer model to build new city hospitals. The construction of 18 city hospitals with the PPP model was planned by the Turkish government. The first hospital in Türkiye with the PPP model started operating in 2017, and their number reached 18 by the end of 2024. In this respect, measuring the performance and efficiency of PPP hospitals in Türkiye at an early stage will provide important clues for evaluating the success of the PPP model. To the best of our knowledge, no existing study in the literature has assessed the performance of PPP hospitals in Türkiye using a before-and-after comparative approach.

To fill this gap in the literature, this study aimed to compare the performance of public hospitals via data envelopment analysis (DEA) before and after the implementation of the PPP model in Türkiye. Furthermore, this study is the first longitudinal bootstrap DEA assessment of Türkiye's PPP hospitals. In this study, a dynamic model was designed to measure the performance of hospitals. Because 20 hospitals in Türkiye were moved to newly built PPP hospitals at different times, the performance scores of hospitals were obtained by evaluating each year separately. The transformation process of PPP hospitals

started in 2017, and analyses were applied two years ago to better understand the effects of the transformation process. As the method of this study, bootstrap DEA, which is considered to yield more consistent results, was preferred over conventional DEA, which yields biased results. Because the DEA model based on the bootstrap method repeats sampling so that the efficiency scores become robust, unbiased, and more consistent. To examine the performance of hospitals more comprehensively, two different models were designed. The initial model, known as the EQ model, uses only equipment and does not include physicians or other health personnel. The second model, known as the PH model, comprises physicians without equipment. The designed models aim to determine whether the reasons that negatively affect performance are due to a lack of equipment or physicians.

The rest of this paper is structured as follows: a short description of both PPPs in the health sector and the experience in Türkiye is presented in the following section. The background of DEA models based on bootstrapping, the applied methodology, and the data validation is described in the third section. The results provided by the empirical analysis and the descriptive statistics are presented in the fourth section. The discussion and findings of the study follow in the fifth section. Concluding remarks and future research recommendations are presented in the last section.

PPPs in the health sector: the Turkish experience

For many governments after 1990, rapid changes in healthcare delivery due to an aging population, medical-technological developments and policy changes, booming healthcare costs, and decreasing government budgets have become major problems [2]. In addition to these problems, Türkiye was dealing with inefficiency in health services, inadequate care quality, lack of motivation of health personnel, and organization and management problems. In line with the need for reform that emerged in this context, the Health Transformation Program (HTP) was launched in 2003 to provide healthcare in a more effective, efficient, and equitable manner and to solve organizational and financing problems [22]. The HTP aims to use the PPP model both to increase the administrative and financial autonomy of public hospitals and to strengthen and modernize the physical and technological infrastructures of public hospitals. The government had to turn to the private sector increasingly to close the financing gap due to limited public resources. It aimed to create a new, modern and efficient health infrastructure, increase the number of beds, transform existing beds into qualified beds, reduce operating costs, and increase service quality by bringing together small hospitals under a single campus via this model. In this direction, the first legal regulation regarding the PPP model in

the health sector in Türkiye was made in 2005 with Law No. 5396. This law paved the way for the state to have public hospitals built by the private sector for a certain period and a cost. The PPP department was subsequently established within the Ministry of Health in 2007 to encourage private investors to invest in the health sector and to organize the PPP model [23]. The model designed with the build-operate-transfer method, which is among the PPP models, brings radical changes to the delivery, organization, and financing of healthcare [24]. Considering the similarities with Private Finance Initiative projects in the UK in the context of policy transfer, it can be argued that the model in Türkiye was inspired by the model in the UK [25].

In 2013, to eliminate the service delivery and financing problems that arise in practice, the Law on “Building and Renewal of Facilities and Procurement of Services through PPP Mode” No. 6428 was enacted and came into force. The principles and procedures of the PPP model changed after it entered into force. According to the legislation, contracts are formed for a period not exceeding 25 years, excluding the fixed investment term, and the lands of the campuses to be built are given to the companies free of charge by the Ministry of Treasury and Finance. The financing of the model is covered by the general budget. In the projects, financing, construction, equipment, maintenance-repair, delivery of nonclinical services, and operation of hospitals were conceded to private investors. Furthermore, medical services, which are defined as core services, are carried out under the responsibility of the public.

There are 933 hospitals in Türkiye operated by various types of Ministry of Health's, such as general, special branch, training and research [26]. PPP hospitals distinguish themselves as large-scale projects among these hospitals. Eighteen PPP hospitals, with bed capacities ranging from 475 to 3.732, have a combined bed capacity of 28.247. The total investment amount of health PPP projects is 13.43 billion dollars by 2024 costs [27]. The three main contributions of the PPP hospitals to the Turkish healthcare system can be summarized as follows [26, 28]:

1. Fulfilling Türkiye's demand for qualified hospital beds: Qualified hospital beds are those located in single or double occupancy rooms equipped with a private bathroom and shower, providing enhanced comfort and privacy for inpatients. Thanks to the establishment of new PPP hospitals, the proportion of qualified beds in public hospitals increased from 52.2% in 2016 to 82% in 2024.
2. Modernizing the physical infrastructure of public hospitals: While the average age of public hospital

- facilities was 49 years in 2013, it dropped to 13 years with PPP hospitals and accompanying investments.
- Reducing operating costs and enhancing service quality: By merging small hospitals into a single campus, efficiency in service delivery and resource utilization was achieved.

The transformation process that took place between 2017 and 2024 during the opening of PPP hospitals is summarized in Fig. 1.

Study design and methods

Bootstrap DEA

DEA based on linear programming is used to measure the relative efficiency of units such as hospitals. The proverbial model known as the CCR model of DEA proposed by Charnes et al. is both an input-oriented approach and an output-oriented approach [29]. In the earlier approach, efforts are made to minimize the inputs while maintaining the outputs at their current level. The latter approach attempts to enhance the outputs while maintaining the inputs at their current level [30–32]. Many units may appear efficient in small samples because they are on the efficiency frontier. This makes it difficult to properly rank or compare units. Furthermore, since DEA is sensitive to outliers in small samples, extreme values can distort the frontier and affect overall efficiency scores. Therefore, the DEA model based on the bootstrap method is proposed by Simar and Wilson [33–35], as the results of the standard CCR model are biased. Their proposed model repeats sampling so that the efficiency scores become robust, unbiased, and more consistent. The following is a brief explanation of how the estimated progress is calculated:

- The score $\hat{\theta}_k$ of hospital k ($i = 1, \dots, n$) for the related year is obtained via the following model (1). Here, the input-oriented model is presented.

$$\min_{\theta, \lambda, S_r^+, S_i^-} \theta = \phi - \epsilon \sum_{r=1}^s S_r^+ - \epsilon \sum_{i=1}^m S_i^-$$

$$\sum_{j=1}^n Y_{rj} \lambda_j - S_r^+ = Y_{r0}$$

$$\sum_{j=1}^n X_{ij} \lambda_j + S_i^- = \phi X_{i0}$$

$$\lambda_j, S_r^+, S_i^- \geq 0 \quad i = 1, \dots, m, r = 1, \dots, s \quad (1)$$

where θ is the efficiency score, S_i^- is the slack of inputs, S_r^+ is the slack of outputs, ϵ is a small positive number, n is the number of evaluated hospitals, m is the number of inputs, and s is the number of outputs. In addition, the input amounts of the j^{th} hospital are X_{ij} ($i = 1, \dots, m$), whereas the output amounts of the j^{th} hospital are Y_{rj} ($r = 1, \dots, s$). In this study, the number of hospitals (n) ranged between 13 and 20 according to year.

- β^* is generated via $\hat{\theta}_1, \hat{\theta}_2, \dots, \hat{\theta}_n$ obtained in the previous step. $\beta_i^* + h\epsilon_i^*$ is obtained by using h (the bandwidth of a standard normal kernel density) in accordance with [26] and $\epsilon_i^* \sim N(0, 1)$ (a draw from an *iid* standard normal). If the value of $\beta_i^* + h\epsilon_i^*$ is less than 0, Eq. (2) is applied; otherwise, Eq. (3) is applied to produce the smoothed bootstrap sample $\theta_1^*, \theta_2^*, \dots, \theta_n^*$, for $i = 1, \dots, n$:

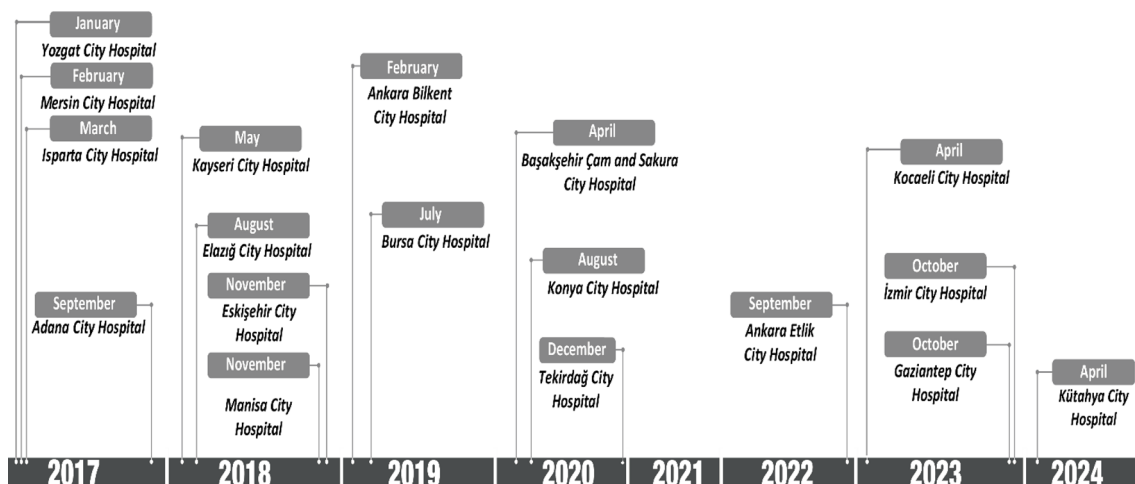


Fig. 1 Timeline view of PPP hospitals

$$\tilde{\theta}_i^* = \beta_i^* + h\varepsilon_i^* \quad (2)$$

$$\tilde{\theta}_i^* = 2 - \beta_i^* - h\varepsilon_i^* \quad (3)$$

3. The corrected smoothed bootstrap sample is obtained to ensure convergence to the original efficiency estimate via Eq. (4):

$$\theta_i^* = \bar{\beta}^* + \tilde{\beta}^* - \frac{\sum_{i=1}^n \beta_i^*}{n} / \sqrt{1 + h^2 / \hat{\sigma}_{\tilde{\theta}}^2}, \quad (4)$$

$\hat{\sigma}_{\tilde{\theta}}$ is the standard deviation of $\theta_1^*, \theta_2^*, \dots, \theta_n^*$

4. Compute the bootstrapped efficiency $\hat{\theta}_i^*$ for every hospital via Eq. (1) using $\left\{ \left(\frac{\hat{\theta}_i^*}{\hat{\theta}_{ib}^*} x_i, y_i \right), i = 1, \dots, n \right\}$ to calculate the pseudo variable inputs.
5. To obtain robust efficiency scores, steps 2–4 are repeated B times $\left\{ \hat{\theta}_{ib}^*; b = 1, \dots, B \right\}$. To achieve acceptable accuracy in this study, the technique was performed 2000 times, in accordance with the study of Simar and Wilson [33].

Data validation

Hospitals need two of the most important elements to care for patients. The most important of these is the physicians and everyone that helps them. The other is the medical equipment of hospitals, such as supplies, devices, beds, drugs, and laboratory tests. It will not be possible to take care of patients without physicians in hospitals that consist only of equipment; in contrast, it will not be possible to take care of patients in a hospital where there are physicians and health personnel and where there is no equipment. Therefore, two different models were designed to examine the performance of hospitals more comprehensively and to determine whether the reasons that negatively affect their performance are a lack of equipment or a lack of physicians. The first model is the EQ model, which consists of equipment without physicians and other health professionals. The second model is the PH model, which consists of physicians and other health professionals without equipment. The inputs and outputs used in these models were chosen on the basis

of the results of the literature review [36–39]. In the EQ model, the number of beds, the number of active operating rooms, and the number of MR and CT devices are included as inputs, whereas the number of inpatients, bed occupancy rate, total number of surgeries, and MR and CT exams are considered outputs. In the PH model, the total number of physicians, the number of nurses, and the number of other health personnel are included as inputs. The total number of visits (outpatient and emergency), case mixed index (CMI), and revenues were taken as outputs.

There are some suggestions in the literature for the discrimination power problem frequently encountered in DEA. Golany and Roll establish a rule of thumb that the number of units should be at least twice the number of inputs and outputs considered [40]. Dyson et al. [41] recommend a total of two times the product of the number of input and output variables. The two different models created in this study allow for detailed analysis and contribute to the fulfilment of the conditions of this golden rule.

The data used in this study were obtained with the approval of the MoH Directorate General for Public Hospitals. Therefore, ethical approval was not needed. The changes in 14 PPP hospitals operating between 2017 and 2023 are shown in Table 1. Because there is no data to evaluate the performance of the PPP hospitals (Kocaeli, İzmir, Gaziantep, Kütahya) that opened in 2023 and 2024, these four PPP hospitals were excluded from the study. The descriptive statistics for the input and output variables were analyzed by year (Table 2).

Results

Physicians and everything that helps them care for patients is a necessity in hospitals. All the equipment of hospitals, such as instruments, devices, or beds, is also necessary. Thus, two different models were designed to examine the performance of hospitals more comprehensively and to determine whether the reasons that negatively affect their performance are a lack of equipment or a lack of physicians. Furthermore, this study examines the use of these models to examine the effects of several hospitals being combined into some PPP hospitals in Türkiye. The EQ model consists of equipment without physicians and other health professionals, whereas the PH model consists of physicians and other health professionals without equipment. DEA models based on bootstrapping were employed to analyze the performance of hospitals in Türkiye according to the EQ and the PH model. The transformation process of PPP hospitals started in 2017, and analyses were applied two years ago to better understand the effects of the transformation process. Since the hospitals that were transformed after 2017 were taken as decision-making units (DMUs), 20

Table 1 Transformation process dependent on the time of Turkish City hospitals (2017–2023)

City	Closed Public Hospitals	Opened City Hospitals
Yozgat	Yozgat State Hospital	Yozgat City Hospital
Mersin	Mersin State Hospital Mersin Maternity Hospital	Mersin City Hospital
Isparta	Isparta State Hospital Isparta Maternity Hospital	Isparta City Hospital
Adana	Adana Numune Training and Research Hospital	Adana City Hospital
Kayseri	Kayseri Training and Research Hospital	Kayseri City Hospital
Elazığ	Elazığ Training and Research Hospital	Elazığ Fethi Sekin City Hospital
Eskişehir	Eskişehir State Hospital	Eskişehir City Hospital
Manisa	Manisa State Hospital	Manisa City Hospital
Ankara	Ankara Atatürk Training and Research Hospital Türkiye Yüksek İhtisas Training and Research Hospital Ankara Numune Training and Research Hospital Ankara Child Health and Diseases Haematology Oncology TRH Ankara Dr. Zekai Tahir Burak Maternity TRH Ankara Physical Medicine and Rehabilitation TRH	Ankara Bilkent City Hospital
Ankara	<i>New founded</i>	Ankara Etlik City Hospital
Bursa	Bursa State Hospital Bursa Prof. Dr. Türkan Akyol Chest Diseases Hospital	Bursa City Hospital
İstanbul	<i>New founded</i>	Başakşehir Çam ve Sakura City Hospital
Konya	Konya Training and Research Hospital	Konya City Hospital
Tekirdağ	Tekirdağ State Hospital	Tekirdağ Dr. İsmail Fehmi Cumalıoğlu City Hospital

hospitals were taken as DMUs in 2015, and the results of the DEA analysis on the basis of bootstrapping are presented in Table A in Supplementary File 1. As it gives more consistent results, the bootstrap DEA results are included in Table 3 for two different models for each year. However, the analysis results for all years from 2017 to 2023 are presented in detail in the Supplementary File 1 year by year. Furthermore, the abbreviations shown in Table 3 and Tables A–H of the Supplementary File 1 are as follows. CH: city hospital built on PPP model, PH: public hospital, TRH: training and research hospital, MH: maternity hospital, PMRH: physical medicine and rehabilitation hospital. In addition, the original names of some hospitals are not included in these tables. For example, the original name of Ankara MTRH is Dr. Zekai Tahir Burak Women's Health Training and Research Hospital, and the original name of Bursa CDH is Bursa Prof. Dr. Türkan Akyol Chest Diseases Hospital. The original name of Başakşehir CH is Başakşehir Çam & Sakura City Hospital, the original name of Tekirdağ CH is Tekirdağ Dr. İsmail Fehmi Cumalıoğlu City Hospital, and the original name of Elazığ CH is Elazığ Fethi Sekin City Hospital.

The results of the conventional CCR model are given in the second and fourth columns of Table A of the Supplementary File 1 for the EQ and PH models, respectively. The results of DEA on the basis of bootstrapping with the confidence intervals given in parentheses are shown in the third and fifth columns for the EQ and PH models, respectively. According to conventional CCR rankings, 9

of the 20 hospitals are efficient hospitals in terms of EQ, and 11 are efficient hospitals in terms of PH. However, when the bias-corrected results are examined in Table 3, Kayseri TRH is in first place, with a score of 0.94, whereas Türkiye Yüksek İhtisas TRH is in last place, with a score of 0.54 for the EQ model. Similarly, when the bias-corrected results are examined, Mersin SH is in first place, with a score of 0.94, whereas Konya TRH is in last place, with a score of 0.73 for the PH model. Table 3 presents the bias-corrected results for two different models for each year.

The results of the analysis are presented in Table B of the Supplementary File 1 for 2016. Like in the previous year, hospitals that do not have PPP hospitals but will be transformed into PPP hospitals are taken as DMUs. Mersin SH is in first place, with a score of 0.92, whereas Elazığ TRH is in last place, with a score of 0.65 for the EQ model. Similarly, when the bias-corrected results are examined, Tekirdağ SH is in first place, with a score of 0.97, whereas Isparta SH is in last place, with a score of 0.80 for the PH model.

In 2017, 3 new PPP hospitals were opened instead of 5 different hospitals. Therefore, 18 hospitals were taken as DMUs in 2017. The results of the analysis are presented in Table C of the Supplementary File 1 for 2017. According to the conventional CCR results of the EQ model, 8 hospitals are in an efficient position, whereas according to the conventional CCR results of the PH model, 6 hospitals are in an efficient position. According to the EQ

Table 2 Descriptive statistics of inputs and outputs by years

Year (The number of hospitals)	Stats.	The number of beds	The total number of physicians	The num- ber of nurses	The number of other health personnel	The number of active operating rooms	The number MR and CT devices	Total number of visits (Outpatient and Emergency) (x1000)	The number of inpatients	Bed occu- pancy rate	Total number of surgeries	Case Mixed Index (CMI)	The number of MR and CT shots	Revenues (x1000)
2015 (20)	Min	129	24	50	48	2	1	58.07	2687	67.43	1	0.61	559	12413.86
	Max	1414	842	1005	1020	36	7	4078.08	93,988	98.08	95,034	2.59	178,520	255459.60
	Mean	588.9	293.9	407.5	419.7	14.56	3.63	1376.58	36220.9	81.4	37769.84	1.17	87825.35	102353.59
	Std. Dev.	341.86	235.63	253.8	227.63	7.7	1.69	950.17	21758.7	8.33	23488.88	0.43	54816.94	67624.19
2016 (20)	Min	139	22	59	134	2	1	70.96	2548	57.77	4670	0.6	565	11879.55
	Max	1489	869	1020	1040	36	7	4619.87	94,969	97.25	75,336	2.76	206,728	285146.78
	Mean	609.6	292.5	418.6	420.26	14.83	3.47	1486.07	36433.9	79.19	38841.06	1.18	98717.71	114049.14
	Std. Dev.	354.39	237.15	261.39	228.83	8.12	1.68	1062.32	22329.95	9.25	22287.92	0.45	62020.63	77741.32
2017 (18)	Min	138	21	72	123	4	1	76.78	2742	50.34	8543	0.84	13819	14084.79
	Max	1489	852	1031	1028	44	7	4892.05	94,410	96.17	74,294	2.88	210,815	327501.47
	Mean	708.44	330.33	482.33	464.59	19.06	3.81	1723.82	41423.28	74.82	45400.44	1.22	111327.8	141195.77
	Std. Dev.	373.64	230.48	262.32	257.25	10.08	1.59	1176.21	25409.85	10.02	23590.29	0.45	62053.99	88958.24
2018 (18)	Min	130	26	73	43	4	1	81.27	2855	39.07	8117	0.84	13508	15539.88
	Max	1607	856	1071	1174	47	6	3992.49	97,768	95.21	98,289	2.71	212,274	346958.87
	Mean	760.72	353.83	536.44	474.33	21.25	3.88	1739.85	42,663	75.04	48201.44	1.2	115594.6	157979.74
	Std. Dev.	453.72	247.54	299	286.11	12.54	1.62	1084.69	27284.88	12.78	25537.03	0.41	64354.23	100742.87
2019 (13)	Min	130	24	64	43	9	2	168.69	2747	33.41	26,613	0.91	70,015	9632.64
	Max	3332	1506	2735	2000	43	13	4472.04	146,467	94.68	127,865	1.67	435,831	680048.21
	Mean	1109.69	440.54	852.08	692.54	24.92	5.17	2379.23	58955.54	68.19	61812.83	1.12	176217.7	236396.20
	Std. Dev.	774.66	381	649.37	496.2	11.89	2.61	1136.53	36982.28	18.36	31549.83	0.18	103793.4	175127.13
2020 (13)	Min	475	131	271	250	9	2	621.25	13,791	19.1	15,633	1.03	37,943	72135.10
	Max	4881	2795	2735	2011	113	15	3345.72	137,756	73.56	89,390	1.67	531,423	910848.84
	Mean	1504.23	655.54	1100.54	798.15	32.54	6	1735.97	49,188	57.22	39039.62	1.26	183071.2	272458.34
	Std. Dev.	1128.15	674.71	662.07	458.57	25.36	3.78	709.30	30497.15	13.74	21275.07	0.16	122196.8	215490.88
2021 (13)	Min	475	138	344	287	12	3	768.45	23,855	54.95	16,010	0.95	81,946	100441.47
	Max	4066	3219	2735	2011	115	15	5062.76	177,755	84.66	141,276	1.72	602,747	1578663.47
	Mean	1440.62	753.38	1136.77	832.08	37.46	6.08	2469.10	65801.69	69.07	63861.08	1.26	241,330	476342.43
	Std. Dev.	936.97	810.81	646.89	462.14	26.16	3.73	1059.10	39086.84	9.36	33009.7	0.21	141317.5	378732.65
2022 (13)	Min	475	154	394	342	12	3	778.93	27,800	64.86	27,886	0.92	88,420	150527.67
	Max	4153	3460	3026	2049	115	15	5768.37	187,474	86.64	218,972	1.76	638,576	2407901.14
	Mean	1446.31	818.38	1248.77	880.92	38.31	5.92	2674.39	72652.69	77.5	81091.77	1.31	264309.9	751770.62
	Std. Dev.	955.5	860.96	717.73	467.01	26.15	3.81	1209.91	41010.74	7.43	49307.14	0.23	155795.2	566914.62
2023 (14)	Min	475	147	428	348	12	3	863.651	27,176	62.58	26,879	0.81	102,222	300823.32
	Max	4111	3964	3961	2307	131	15	6490.22	169,420	92.56	221,935	1.72	1,058,063	4228436.53
	Mean	1634.00	1077.00	1557.64	993.36	47.79	6.36	3121.35	79343.71	80.61	88110.79	1.30	333837.86	1503386.94
	Std. Dev.	1137.66	1060.61	1095.12	507.28	35.31	4.01	1563.73	41155.26	9.53	53279.28	0.25	246010.86	1012293.00

model, the highest bias-corrected score was for Bursa SH, whereas the lowest score was for Türkiye Yüksek İhtisas TRH. In the PH model, the highest bias-corrected score is for Mersin SH, whereas the lowest score is for Yozgat SH.

The analysis results for 2018, the year in which the number of PPP hospitals reached 5, are presented in Table D of the Supplementary File 1. According to Table 3, in the EQ model, the highest bias-corrected score was for Manisa SH, whereas the lowest score was for Türkiye Yüksek İhtisas TRH. In the PH model, the highest bias-corrected score is for Elazığ TRH, whereas the lowest score is for Ankara Oncology TRH.

The year 2019 was an important milestone for PPP hospitals. Six hospitals in Ankara were closed, and Ankara Bilkent City Hospital was opened. In addition, Manisa, Eskişehir, and Elazığ City Hospitals were opened in 2019. A total of 13 hospitals were evaluated in 2019, with 9 city hospitals and 4 noncity hospitals. The analysis results for this year are presented in Table E of the Supplementary File 1. The EQ model, in which 8 out of 13 hospitals are efficient, and the PH model, in which 7 out of 13 hospitals are efficient, show that the discrimination power between these hospitals weakens. Therefore, the bias-corrected scores obtained by bootstrapping are more accurate. According to Table 3, as of 2019, Manisa CH has the highest bias-corrected score in the EQ model, whereas Elazığ CH has the lowest bias-corrected score. According to Table 3, in the PH model, while the Isparta CH has the highest bias-corrected score, the Ankara Bilkent CH has the lowest bias-corrected score.

In 2020, Bursa SH and Bursa CDH closed, and Bursa CH opened. In addition, the completely newly established Başakşehir CH was put into service this year. A total of 13 units were evaluated in 2020, with 11 city hospitals and 2 noncity hospitals. The analysis results for this year are presented in Table F of the Supplementary File 1. Since Başakşehir CH has just entered service, both models have the lowest bias-corrected scores. According to Table 3, while the highest bias-corrected score for the EQ model is Isparta CH, the highest bias-corrected score for the PH model is Ankara Bilkent CH.

In 2021, Konya TRH and Tekirdağ SH closed, and Konya and Tekirdağ CH opened. A total of 13 city hospitals were evaluated in 2021, and their detailed results are presented in Table G of the Supplementary File 1. According to Table 3, Tekirdağ CH has the highest bias-corrected score in the EQ model, whereas Elazığ CH has the lowest bias-corrected score. Furthermore, in the PH model, while Ankara Bilkent CH has the highest bias-corrected score, Konya CH has the lowest bias-corrected score.

A total of 13 city hospitals were evaluated in 2022, and their detailed results are presented in Table H of the

Supplementary File 1. According to Table 3, Eskişehir CH has the highest bias-corrected score in the EQ model, whereas Ankara Bilkent CH has the lowest bias-corrected score. Furthermore, in the PH model, while Adana CH has the highest bias-corrected score, Kayseri CH has the lowest bias-corrected score.

As Ankara Etlik City Hospital was opened toward the end of 2022, 14 city hospitals were evaluated in 2023, and their detailed results are presented in Table I of the Supplementary File 1. According to Table 3, Eskişehir CH has the highest bias-corrected score in the EQ model, whereas Ankara Etlik CH has the lowest bias-corrected score. Furthermore, in the PH model, while Adana CH has the highest bias-corrected score, Kayseri CH has the lowest bias-corrected score.

Since the transformation of each PPP hospital occurred at different times, this transformation trend and transformation time are shown in Fig. 1. The transformation process, in which 6 different hospitals were closed and a single Ankara Bilkent City Hospital was opened, is shown in Fig. 2. Since the relocation of state hospitals to Ankara Bilkent City Hospital did not occur all together but rather gradually, its efficiency decreased in 2019. While the performance of some branch hospitals was lower than that of both models before 2019, a significant acceleration in performance was observed after PPP. Similarly, the transformation process of all other PPP hospitals is summarized in Figure A in the Supplementary File 2.

From 2015 to 2023, PPP hospitals were put into service in parts. The average PH and EQ scores of the bias-corrected scores are shown in Table 4; Fig. 3 to illustrate trends at a glance. According to Table 4, the average EQ scores increased until 2020 before PPP. The decrease in 2020 was seen both before and after PPP and is thought to be due to the pandemic effect. It is seen that there was no continuous increase in average EQ scores after PPP. This is thought to be due to the low efficiency of newly opened PPP hospitals. If you pay attention, you can see that there was a continuous increase after 2020. In average PH scores, there was a continuous increase before PPP until the pandemic period. If the pandemic period is excluded after PPP, it can be said that they increased their efficiency continuously.

Discussion

This study evaluates the performance of public hospitals in Türkiye before and after the implementation of the PPP model, covering the period from 2015 to 2023. The results of the analysis revealed that public hospitals operating with the PPP model in Türkiye generally achieved higher efficiency scores than when they were traditionally managed. However, a temporary decline in efficiency was observed in the initial years of operation, as newly

Closed Public Hospitals			Opened City Hospitals			2015		2016		2017		2018		2019		2020		2021		2022		2023	
			EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	EQ	PH	
Yozgat SH (until 2017)			0.79	0.95	0.87	0.96	0.81	0.64	0.93	0.94	0.93	0.94	0.87	0.88	0.94	0.93	0.95	0.94	0.92	0.94	0.92	0.94	
Mersin SH (until 2017)			0.92	0.97	0.91	0.95	0.79	0.98	0.96	0.96	0.93	0.96	0.86	0.93	0.92	0.87	0.90	0.86	0.91	0.84	0.91	0.84	
Mersin MH (until 2017)			0.89	0.95	0.90	0.95																	
İsparta SH (until 2017)			0.72	0.88	0.67	0.80	0.69	0.86	0.97	0.86	0.93	0.96	0.90	0.90	0.91	0.94	0.85	0.94	0.95	0.92	0.95	0.92	
İsparta MH (until 2017)			0.89	0.95	0.90	0.94																	
Adana Numune TRH (until 2018)			0.90	0.95	0.91	0.95	0.90	0.95	0.93	0.97	0.94	0.94	0.86	0.90	0.95	0.92	0.94	0.95	0.94	0.95	0.94	0.95	
Kayseri TRH (until 2018)			0.94	0.91	0.86	0.91	0.86	0.96	0.96	0.97	0.81	0.83	0.85	0.85	0.94	0.84	0.93	0.72	0.95	0.72	0.95	0.72	
Elazığ TRH (until 2019)			0.67	0.96	0.65	0.84	0.76	0.94	0.86	0.98	0.65	0.75	0.58	0.72	0.71	0.85	0.84	0.75	0.95	0.87	0.95	0.87	
Eskişehir SH (until 2019)			0.84	0.97	0.85	0.89	0.91	0.92	0.96	0.95	0.82	0.92	0.86	0.91	0.95	0.92	0.97	0.94	0.97	0.94	0.97	0.94	
Manisa SH (until 2019)			0.92	0.95	0.91	0.95	0.91	0.94	0.98	0.97	0.95	0.92	0.85	0.91	0.93	0.90	0.93	0.92	0.93	0.94	0.93	0.94	
Ankara Atatürk TRH (until 2019)			0.89	0.97	0.91	0.94	0.90	0.93	0.95	0.96	0.92	0.74	0.74	0.94	0.86	0.94	0.75	0.94	0.95	0.88	0.95	0.88	
Ankara Bilkent CH (since 2019)			0.54	0.96	0.69	0.92	0.65	0.95	0.67	0.96													
Türkiye Yüksek İhtisas TRH (until 2019)			0.71	0.85	0.73	0.90	0.74	0.88	0.96	0.93													
Ankara Numune TRH (until 2019)			0.65	0.89	0.83	0.81	0.90	0.73	0.97	0.83													
Ankara Oncology TRH (until 2019)			0.88	0.96	0.91	0.95	0.90	0.92	0.95	0.89													
Ankara MTRH (until 2019)			0.89	0.95	0.90	0.94	0.90	0.93	0.95	0.96													
Ankara PMRH (until 2019)			0.80	0.88	0.82	0.91	0.94	0.95	0.97	0.96	0.94	0.94	0.83	0.91	0.93	0.92	0.93	0.92	0.96	0.94	0.94	0.94	
Bursa SH (until 2020)			0.88	0.95	0.90	0.94	0.90	0.94	0.95	0.96	0.92	0.93											
Bursa CDH (until 2020)																							
Başakşehir CH (since 2020)													0.31	0.21	0.76	0.66	0.78	0.83	0.84	0.94	0.94	0.94	
Konya CH (since 2021)			0.86	0.73	0.79	0.82	0.84	0.91	0.90	0.97	0.88	0.95	0.74	0.92	0.94	0.59	0.93	0.83	0.95	0.87	0.95	0.87	
Tekirdağ SH (until 2021)			0.88	0.96	0.90	0.96	0.81	0.97	0.97	0.96	0.94												

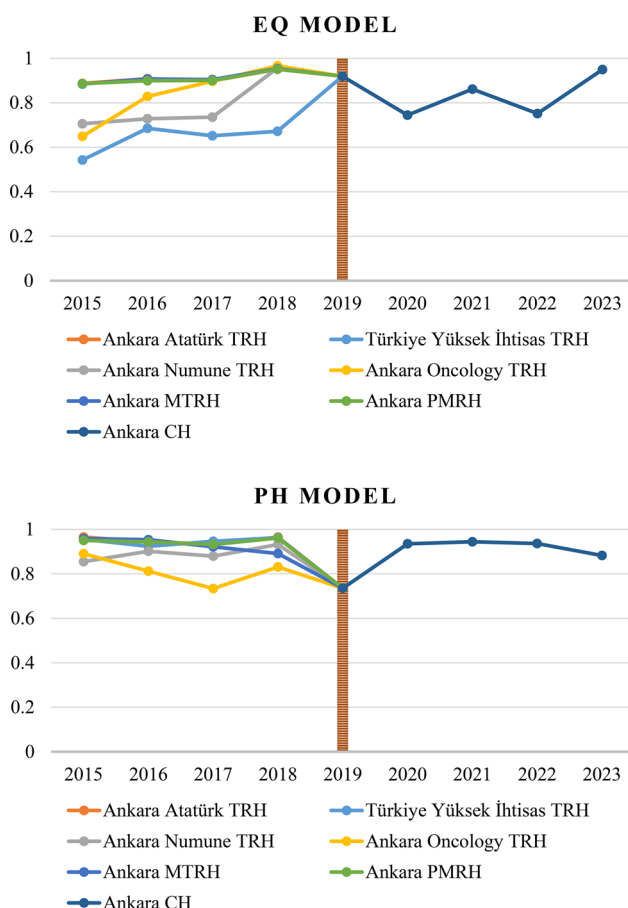


Fig. 2 The trend of scores of ankara bilkent city hospital before and after PPP

established PPP hospitals typically require a transitional period to reach full operational capacity.

The opening of some PPP hospitals outside the city center negatively affects their efficiency. Owing to the inaccessibility of these hospitals, the demand and thus the production of services decreased as patients preferred other hospitals (public or private). For example, while Elazığ TRH was located in the city center, it was moved to a location near the eastern border of the city in mid-2018 under the name Elazığ City Hospital. The distance of the hospital from the residential area made it difficult for patients and their relatives to reach the hospital, and for this reason, the number of outpatients and inpatients and the number of surgeries decreased. Therefore, hospital efficiency decreased in 2019; this

negative situation continued in 2020 with the impact of the pandemic, and a partial improvement was observed in 2021 and 2022. By 2023, it had completely gotten rid of the negative impact and reached an efficiency score of approximately 0.90. As noted earlier, as one of the contributions of city hospitals built under the PPP model, strengthening the physical infrastructure of hospitals has improved the performance of the EQ model. Similarly, the Konya TRH old hospital building, which was closed after the opening of Konya City Hospital, has continued its activities as Konya Meram State Hospital since September 2020. For this reason, Konya City Hospital's PH efficiency score decreased in 2020 and 2021 due to the difficulties associated with the establishment phase and the decrease in service production. Later, this performance increased in 2022 and 2023, which is referred to as the recovery process.

It has been observed that city hospitals generally experience a decline in EQ scores in the years immediately following their opening. For example, Ankara Bilkent City Hospital has been evaluated to have fallen to a score of 0.75, then entered a recovery period and increased to 0.95 in Fig. 2. Similarly, it is anticipated that Etlik City Hospital, which operated in 2023, has a score of 0.56 and will also enter a recovery period in the following years.

The COVID-19 disease, which has become a pandemic since March 2020, has also negatively affected the performance of PPP hospitals. To prioritize COVID-19 care and curb the spread of the disease, elective surgeries were postponed, and simultaneous epidemic control strategies (weekend curfews, nationwide curfews for people under 20 and over 65, campaigns promoting 'stay at home') were implemented. This reduced the number of hospital admissions while also reducing the number of hospital visits by patients who were concerned about possible exposure to infection [42–44]. In this context, a decrease in patient volume negatively affects the income-expenditure balance of hospitals. However, PPP hospitals, by functioning as “pandemic hospitals”, emerged as strategic assets in the national crisis response. They absorbed much of the healthcare burden during the pandemic and, as a result, were relatively less affected than other public hospitals in the short term. Nonetheless, while PPP hospitals benefitted from their prioritized role and infrastructure during the crisis, the widespread deferral of elective procedures and routine care caused to

Table 4 Bias-corrected results and mean EQ and PH scores of hospitals by year

	2015	2016	2017	2018	2019	2020	2021	2022	2023
EQ Before PPP	0,8224 (0,11)	0,8396 (0,09)	0,8546 (0,08)	0,9256 (0,08)	0,9197 (0,02)	0,797 (0,06)			
After PPP			0,7643 (0,05)	0,9488 (0,02)	0,8753 (0,09)	0,7745 (0,17)	0,891 (0,08)	0,8969 (0,07)	0,9116 (0,10)
PH Before PPP	0,9277 (0,06)	0,9136 (0,05)	0,9204 (0,05)	0,9454 (0,04)	0,945 (0,01)	0,9003 (0,02)			
After PPP			0,8226 (0,14)	0,9407 (0,04)	0,8825 (0,08)	0,8229 (0,20)	0,8611 (0,11)	0,8813 (0,07)	0,8971 (0,06)

* Standard deviation is shown in parentheses

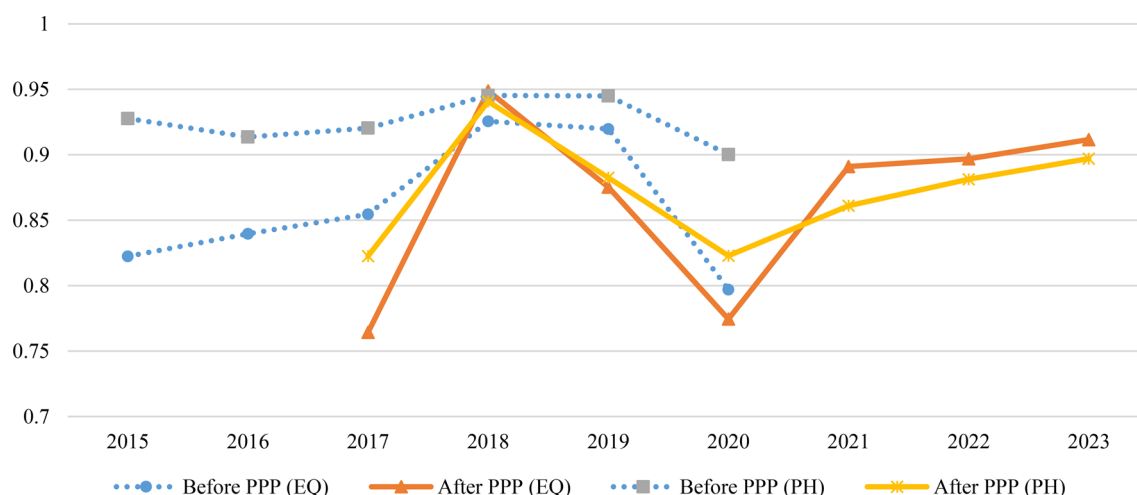


Fig. 3 The trend of average bias-corrected scores of EQ and PH before and after PPP

service backlogs and unmet health needs. These backlogs may pose long-term challenges to operational efficiency and resource optimization in the post-pandemic period, potentially undermining some of the short-term gains realized during the emergency response phase.

Different results have been obtained in studies comparing hospitals managed with the PPP model before and after or with other traditionally managed public hospitals in different countries around the world. In many cases, the PPP model provides better efficiency outcomes than those of traditionally managed hospitals do. The first hospital built in Spain is the Hospital de La Ribera Valencia, which is located in Alzira and is a very typical example of the use of the PPP model. A comprehensive comparative study of the performance of this model, known as the Alzira model, revealed that the PPP model generally did not outperform other public hospitals but showed remarkable improvement in some areas of care [45]. Spain's Alzira model—pioneering in its integration of public and private healthcare functions—was developed within a decentralized health system and involved significant public oversight and adaptive policy reforms over time. In contrast, Türkiye's adoption of PPPs occurred under a highly centralized framework as part of the rapid rollout of the HTP, where PPP hospitals were positioned as flagship investments to modernize healthcare infrastructure and expand service capacity. This shows that the political-economic context in which the PPP model is implemented plays an important role in shaping the results. Another study of performance and efficiency analyses of five PPP hospitals in Spain revealed that PPP hospitals obtained better-than-average results but were not always better than other public hospitals [19]. A study conducted using the Malmquist index in hospitals dependent on the Madrid Health Service between 2009 and 2014 revealed that hospitals managed with the

PPP model were more efficient than hospitals under traditional management [18]. Similarly, a study using DEA in hospitals in the Madrid region of Spain (25 hospitals) during the period 2013–2017 reported that hospitals adopting PPPs in chronic disease care had higher efficiency than did traditionally managed hospitals [46]. In Portugal, where the PPP model is common, PPP hospitals can deliver healthcare that is at least as good as that of public hospitals at the social performance level [47]. According to the results of the efficiency analysis of PPP hospitals in Portugal between 2012 and 2014, the levels of PPP hospitals seem to be considerably higher than the national average across all inputs [48].

In Brazil, a comparison of 12 PPP hospitals with similar, nonreformed, directly managed hospitals via DEA revealed that PPP hospitals were significantly more efficient [16]. The specific PPP experiences of Lesotho, Turks and Caicos Islands have also shown that the model fundamentally improves quality, access, and efficiency in healthcare delivery [49, 50]. Another country where the experience of implementing PPPs in the hospital sector has been examined is Iran. In a study conducted by Bastani et al. [17] the key performance indicators of Hasheminejad Hospital, which is the first PPP project in Iran, were compared and analyzed 3 years before and 3 years after the PPP model was implemented. Significant improvements in this hospital's performance indicators (such as the bed occupancy rate, average length of stay, bed turnover, number of deaths, and number of emergency referrals) were observed after the PPP model was implemented. Shadpour et al. [51] showed that with the implementation of the PPP model at the Hasheminejad Kidney Center in Tehran, the government indisputably gained from the PPP model in all five measured areas: finance, services, personnel, administration, and education. In terms of the cost of services provided, there

is also evidence that the financial performance of PPP hospitals is better than that of hospitals with traditional management. Compared with traditional infrastructure projects, the PPP model is completed in a shorter time and has higher budget compliance [52, 53]. Regarding the cost of service production, Iyer et al. [54] reported that the average cost of vaginal and cesarean deliveries was lower in PPP hospitals. A study evaluating the management capacity ability and profitability of eight PPP hospitals in Taiwan from 2015 to 2020 revealed that the PPP model alleviated the government's financial burdens and achieved profitability [55].

Contrary to the above findings, Karpagam et al. [20] suggested that the PPP model implemented in a hospital in the Indian state of Karnataka underperformed in many ways. The lack of a monitoring system, low bed occupancy rate, poor accountability systems and governance, and the absence of a grievance redressal system were also highlighted as common problems experienced by most PPPs. Additionally, Etemadian et al. [56] revealed that several challenges were encountered in the implementation of the model in a PPP hospital in Iran, such as a vague and unclear partnership model, political changes, inadequate legal regulations, design and building problems, and a lack of long-term funding. When evaluated in conjunction with Türkiye's experience, these findings suggest that the success of the PPP model in the health sector requires not only effective planning, political support, and a stable economic situation, but also contract transparency, accountability mechanisms, and an equitable allocation of risks between public and private partners. Although PPPs have delivered short-term efficiency gains in healthcare infrastructure, such as rapid hospital construction and operational improvements, their long-term fiscal sustainability remains questionable. Policymakers should critically assess whether these benefits outweigh the higher lifecycle costs and governance challenges associated with the model.

One of the limitations of this study was that PPP hospitals focused on indicators of service production, neglecting the effects of these hospitals on outcomes such as service access, clinical quality, innovation in care delivery, clinical outcomes, patient satisfaction, and cost-effectiveness metrics. Another potential limitation of the study was the use of the DEA model as the analysis method and the exclusion of other nonparametric methods used in the efficiency analysis. Furthermore, future studies should be conducted with hybrid methods such as mixed-methods research combining DEA with qualitative stakeholder interviews or should compare city hospitals operated with the PPP model and public hospitals of similar scale in Türkiye. Finally, the exploration of integrated input models and sensitivity analysis using

alternative nonparametric methods were also suggested for future studies.

Conclusion

Türkiye's experience with PPP hospitals provides valuable lessons on both the potential and limitations of private sector engagement in healthcare infrastructure. Initially, PPP hospitals delivered notable efficiency gains—particularly in terms of rapid expansion of bed capacity and responsiveness to urgent healthcare needs, as evidenced during the COVID-19 pandemic. However, these short-term benefits are increasingly weighed against concerns about the model's long-term financial and operational sustainability. Notably, the relatively high costs associated with PPP hospital projects, when compared to traditionally financed facilities, have prompted a reevaluation of the model's viability [57]. Reflecting this shift, the Turkish government has increasingly relied on general budget resources for hospital development. Over the past five years, six city hospitals have been constructed using general budget financing. Currently, 11 additional city hospitals are being built with public funds, and the tendering and project development phases for nine more are underway [28].

These developments indicate that PPPs should not be treated as a universal solution. Instead, they should be deployed as context-sensitive policy instruments, adjusted to align with national institutional capacities, fiscal realities, and healthcare system objectives. To enhance the effectiveness and sustainability of PPP arrangements, policymakers are encouraged to revise contractual frameworks to:

- Integrate comprehensive performance monitoring that extends beyond financial metrics to include clinical quality, service efficiency, and patient outcomes;
- Promote equitable geographic distribution of healthcare infrastructure, especially prioritizing investments in underserved and rural areas;
- Embed contractual flexibility that enables adaptation to evolving healthcare demands and systemic shocks, such as global pandemics.

While PPPs can serve as catalysts for healthcare system modernization, their success ultimately depends on transparent governance, alignment with public health priorities, and the presence of a robust regulatory environment. Moving forward, empirical studies are needed to rigorously assess the long-term fiscal impacts, contributions to health system resilience, and implications for health equity associated with PPP models.

Abbreviations

DBFO	Design Build Finance Operate
DEA	Data Envelopment Analysis
HTP	Health Transformation Program
MoH	Ministry of Health
NPM	New Public Management
PPP	Public-Private Partnership
VfM	Value for Money

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author (AK) on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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