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Original Article

Evaluation of three different pricing policies in total knee arthroplasty surgery: A clinical pathway-based tariff and reimbursement simulation

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Abstract

Aim: This research examines the effects of the multi-layered tariff structure (Health Practices Communique-HPC, Public Health Services Price Tariff-PHSPT, and Health Tourism Price Tariff-Annex 2A) in the Turkish health financing system on the financial sustainability of public hospitals, using a holistic approach through Primary Total Knee Arthroplasty (TKA), a high-volume, material-intensive elective surgery.

Materials and Methods: Instead of traditional static methods, a patient-centered "Clinical Pathway-Based Cost Simulation" model was used in the study, analyzing the entire medical service production process, from the patient's outpatient visit to post-discharge follow-up, using secondary data integration techniques.

Results: The findings quantitatively demonstrate that HPC base prices, which represent Social Security Institution reimbursements, lag increases in foreign currency-indexed biomedical implant costs, creating a devastating price squeeze for hospitals. According to case-based simulation results, HPC payments cover only 59.33% of the calculated operational consumables cost for TKA surgery, indicating below-cost pricing. In contrast, the PHSPT fee applied to paying domestic patients covers 202.68% of the cost, while the Annex-2A tariff under health tourism covers 283.88%. This margin difference creates a necessary "cross-subsidization" mechanism for public hospitals to cover their HPC deficits through health tourism revenues. The revenue from a single international patient can finance approximately 4.79 domestic patients.

Conclusion: Consequently, to prevent domestic patients from facing capacity allocation dilemmas in the public system and to ensure equitable access to services, it is necessary to switch to dynamic reimbursement models that explicitly separate implant costs from the procedure package in surgeries that rely heavily on imported materials.

Keywords: Health policy, health financing, reimbursement simulation, total knee arthroplasty

INTRODUCTION

Healthcare pricing is more than just an accounting process; it is a critical macro-policy tool that directly shapes resource allocation, service access, and the strategic behavior of healthcare institutions. Today, the accelerating aging of the global population and the increasing prevalence of obesity have significantly increased the number of major surgical procedures performed in orthopedic and traumatology clinics. Primary Total Knee Arthroplasty (TKA), one of the leading procedures, has been among the fastest-growing elective surgical procedures in the Organisation for Economic Co-operation and Development (OECD) countries over the last decade (1).

TKA, while clinically effective in treating pain and functional loss due to osteoarthritis, is a "high-cost" procedure for hospitals, with implant costs being a determining factor. In recent years, standardization of perioperative care (e.g., accelerated recovery

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approaches), shorter hospital stays, and outpatient surgical trends have transformed the clinical flow of TKA; reimbursement models are also being reshaped in line with package payment and value-based approaches (2). High operation volume maximizes the budgetary impact of TKA procedures on healthcare systems and public hospitals. Indeed, TKA is predominantly material-intensive rather than solely physician-labor-intensive, with 40% to 60% of the total case cost directly attributable to foreign currency-indexed biomedical implants (femoral and tibial components) (3). This transformation highlights two critical issues for healthcare administrators: where the actual costs are concentrated along the service chain, and to what extent current reimbursement tariffs cover these costs.

Türkiye's healthcare financing system is built on a multi-layered tariff architecture that determines the revenue structure of public hospitals and caters to different patient groups. The Health Practices Communique (HPC), implemented under the General Health Insurance scheme and based on fixed prices in Turkish Lira (TRY), serves as the basis for reimbursements in accordance with the principle of the social state. However, the widening gap between the rising cost of imported medical supplies, which are sensitive to exchange rates, and the fixed reimbursement rates of the HPC creates a chronic price squeeze for public hospitals. In overcoming this operational loss, the Public Health Services Price Tariff (PHSPT) applied by public hospitals for paying domestic patients and, especially, the Health Tourism Price Tariff (Annex-2A) for foreign patients gain strategic importance. Considering Türkiye's potential to become a global destination generating high added value in orthopedic surgery (4, 5), health tourism revenues, which represent the ceiling price, function as a "cross-subsidization" mechanism that compensates for financial deficits arising from the HPC.

Although previous studies have examined total knee arthroplasty costs, bundled payment systems, implant expenditure management, and reimbursement policies, most have focused on isolated components of the treatment process or on single financing mechanisms. Evidence comparing the financial implications of multiple national tariff structures through a standardized clinical pathway covering the entire continuum of care remains limited. In particular, little is known about how different reimbursement and pricing policies interact within a multi-layered healthcare financing system and how these interactions influence the financial sustainability of public hospitals.

To address this gap, the present study employs a Clinical Pathway-Based Financial Simulation model that follows the complete TKA treatment process from preoperative assessment to postoperative follow-up. By systematically integrating and comparing the HPC, PHSPT, and Health Tourism Price Tariff (Annex-2A), the study provides an evaluation of how alternative pricing policies affect hospital revenues and cost recovery capacity within the Turkish healthcare system.

MATERIALS AND METHODS

Research Design and Methodological Approach

This research is designed using a comparative cost analysis and a retrospective document review. The primary methodological approach used in the research is the "Clinical Pathway-Based Cost Simulation" model, which offers a patient-centered perspective instead of the traditional "Procedure-Based Costing" model. Costs and revenues related to the total cost of surgical procedures (TKA) are modeled through the clinical process chain, encompassing not only the main surgical package but also the steps of outpatient visit, pre-operative preparation, surgery-hospitalization-implantation, and early post-discharge follow-up (6).

The study used the "secondary data integration" technique. This technique is based on the systematic coding, matching, and analysis of legally valid, nationally binding, and auditable official price tariffs published by public authorities, without requiring primary data collection through surveys or field observations (7,8). This method is considered the "gold standard" in the health economics literature, particularly for measuring the financial impact of macro-level reimbursement policies on micro-level service providers (9).

Research Population and Sample Selection

The study population consists of all elective surgical procedures performed in secondary and tertiary level public hospitals in Türkiye and covered by the Social Security Institution (SSI) reimbursement. From this large population, a case of TKA was selected using purposive sampling. Several critical factors led to selecting TKA as the research sample, thereby enhancing the study's power to test its hypotheses. According to the first factor, TKA has become one of the most frequently performed major surgical procedures in orthopedic and traumatology clinics, driven by population aging and the increasing prevalence of obesity. According to OECD data (2025), knee arthroplasty surgeries have increased rapidly in OECD countries over the last decade. This high volume suggests that the cost analysis will have a significant budgetary impact on the system. Furthermore, TKA is a material-intensive procedure rather than a labor-intensive (physician time) one. Between 40% and 60% of the total case cost is accounted for by foreign currency-indexed biomedical implants (femoral and tibial components) (3). This characteristic provides an ideal laboratory setting for measuring the tension between "TRY-based fixed prices" (HPC) and "foreign currency-based variable costs" (Market). Because expert opinions were collected anonymously and no institutional identifiers were recorded, the geographical distribution and organizational characteristics of participating hospitals could not be examined. Therefore, the findings should be interpreted as expert-based cost assumptions reflecting tertiary public hospital experience rather than nationally representative procurement data.

Finally, Türkiye has the potential to become a global destination for orthopedic surgery. Orthopedic surgery, along with hair transplantation and cosmetic surgery, is among the procedures that generate the highest added value in international patient traffic (4,5). This is one of the areas where the gap between HPC and Health Tourism tariffs is most clearly evident.

Data Sources

The data used in the analysis were obtained from three key official regulations that determine the revenue structure of healthcare providers in Türkiye. Data collection was carried out in the first quarter of 2026, and the tariff versions used in the analyses are the most current texts in effect as of the study date. The first official regulation is the current HPC (10), which regulates the access and reimbursement conditions for healthcare services for citizens covered by social security. The second is the PHSPT (11), which applies to individuals not covered by social security in public health facilities and also serves as a reference for the private healthcare sector pricing. Finally, the Health Tourism Price Tariff (Annex-2A), an annex to the PHSPT, which standardizes minimum service fees for international patients (health tourism), was considered (11).

Clinical Pathway Design and Validation

To standardize and compare the heterogeneous nature of healthcare services, a standard "Clinical Pathway" has been established for the TKA process. This flowchart was designed based on the Postoperative Recovery Enhancement (ERAS) Protocols in Orthopedic Surgery (12) and, with expert guidance, on tertiary hospital practices in Türkiye. To ensure content validity, the draft flowchart was reviewed by a 10-person expert panel comprising three Orthopedics and Traumatology specialists, two Anesthesiology specialists, and five hospital billing/finance managers. Consensus within the expert panel was achieved through structured iterative review and discussion. Panel members independently evaluated the proposed clinical pathway components and resource utilization assumptions. Items receiving agreement from at least 80% of panel members were accepted without modification, whereas items not reaching this threshold were discussed collectively and revised until consensus was achieved. This process was used both for validating the clinical pathway structure and for assessing the clinical appropriateness of the material quantities included in the simulation model. The minimum medical requirements for an uncomplicated (primary) TKA case were determined, and the process was divided into three main phases (T1, T2, T3).

The Preoperative Diagnosis and Preparation (T1) phase, where the patient's suitability for surgery is evaluated multidisciplinarily, includes relevant specialist examinations, radiological/laboratory tests, and consultations. The Surgery, Hospitalization, and Implantation (T2) phase, which accounts for the majority of cost variation, includes surgical intervention, anesthesia management, clinical hospitalization, and critical implant components (femoral/tibial/patellar components and bone cement). The Postoperative Follow-up (T3) phase, covering the early 15-day period after discharge, consists of routine outpatient follow-up, wound care, and radiological examinations.

Data Analysis Methodology and Financial Simulation

Data analysis was conducted in two stages: (i) matching the procedures identified in the clinical chain with their corresponding codes in the three tariff lists (Code Matching) and (ii) simulation of the Total Tariff Price (TTP) per case according to the tariff type (Cost Simulation Per Case). To manage differences in package/service per-payment between tariffs, items included in the HPC package but not separately billed were considered "within the package"; the minimum prices specified in the guideline for Annex-2A were calculated accordingly. HPC-referenced price margin analysis and cost coverage simulation were performed using the TTP values calculated for each tariff.

When creating the TTP Calculation Model, the total financial cost of a TKA case (TTPt) for each tariff type (t) was simulated using the following mathematical model:

$$\mathrm{TTP_t} = \sum_{i=1}^{n} \left(\mathrm{PRICE_{i,t}} + \mathrm{MATERIAL\_PRICE_{i,t}} \right)$$

(*t* represents the tariff type, *i* the processing step, and *n* the total number of transactions.)

Price Margin Analysis and Cost Recovery Simulation were performed based on the obtained TTP values. In the price margin analysis, HPC prices were accepted as the "Reference Base", and the percentage deviation of PHSPT and Annex-2A prices from the HPC was calculated. This analysis calculates percentage difference margins, showing how much higher each tariff is priced than the HPC (social insurance reimbursement amount). Since the HPC is generally considered a reimbursement ceiling or reference price, the ratio of other tariffs to the HPC is an important indicator. This analysis quantitatively reveals how much different potential revenue healthcare providers can obtain from the same service for different patient groups.

$$\text{Difference Margin (PHSPT / HPC)} = \left(\frac{\text{TTPphspt} - \text{TTPhpc}}{\text{TTPhpc}} \right) \text{x } 100$$

$$\text{Difference Margin (Annex\_2A/ HPC)} = \left(\frac{\text{TTPann2A} - \text{TTP hpc}}{\text{TTP hpc}} \right) \text{x } 100$$

In the cost-coverage simulation, the recovery rate of the HPC's Operational Consumable Cost (OCC) for TKA surgery was analyzed. OCC assumptions were developed using structured expert elicitation. Opinions were obtained from ten experts working in tertiary-level public hospitals who were familiar with the clinical, billing, procurement, and reimbursement dimensions of the TKA process. To ensure anonymity and encourage unbiased responses, no institutional identifiers, personal information, or hospital names were collected.

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Expert opinions were gathered using a structured "TKA Clinical Pathway Cost Determination Form" developed by the researchers. Participants were asked to report the minimum, maximum, and most frequently encountered procurement prices for the major implant and consumable categories based on their institutional purchasing experience during the December 2025–March 2026 period. Experts were also requested to evaluate the clinical appropriateness of the material quantities used in the simulation model and to provide comments regarding the reimbursement–procurement relationship in TKA surgery.

All responses were anonymized and analyzed only at an aggregated level. To reduce the influence of extreme values and institution-specific purchasing variations, median unit cost assumptions derived from expert responses were used in the OCC calculations. Consequently, the OCC estimates were not based on a single hospital's procurement records or on brand-specific product prices, but rather on anonymized and aggregated cost assumptions obtained from experts experienced in tertiary healthcare delivery. As a result of the studies conducted, the median OCC estimate was 41,053.91 TRY (SD = 3,200.00 TRY) (Femoral Component 15,318.00 TRY; Tibial Baseplate 14,272.91 TRY; Tibial Insert 4,923.00 TRY; Patellar Component 4,735.00 TRY; Bone Cement 1,805.00 TRY), and reported values ranging between approximately 36,500.00 TRY and 46,000.00 TRY.

$$\text{Recovery Rate (\%)} = \left(\frac{\text{TTP}_t}{\text{OCC}}\right) \times 100$$

Validity, Reliability, and Research Ethics

Internal validity was supported by adherence to the clinical process chain guidelines (13), protocol compliance, and expert panel validation; external validity was supported by the use of nationally binding tariff data. Data reliability was maximized by extracting all prices and scores used in the analysis from the Official Gazette, the SSI Medula System, and the USHAŞ (International Health Services Inc.) official websites. Since the datasets are based on publicly available official documents, the analysis is reproducible. The research was found ethically acceptable by the Bayburt University Social and Human Sciences Research Ethics Committee with decision number 639 dated March 18, 2026.

RESULTS

All findings presented in this section are derived from tariff-based financial simulations and descriptive comparisons. No inferential statistical analyses were performed, and the results should be interpreted within the assumptions of the simulation model.

Structural Analysis of the Total Knee Replacement Treatment Process Chain Pricing

The standard procedure chain for TKA treatment consists of three main phases: Preoperative Diagnosis and Preparation (T1), Surgical Procedure (T2), and Postoperative Follow-up (T3). The basic procedure codes used for these phases, their point/price equivalents, and the consistency between tariffs are presented in Table 1, Table 2, and Table 3. Phase T1 includes orthopedic specialist examination, radiological imaging, anesthesiological risk assessment (ASA scoring), cardiological risk assessment, and laboratory tests.

Table 1. TKA pathway - preoperative diagnosis and preparation (T1) price comparison (TRY)

Transaction name	HPC code	HPC fee (TRY refund) HPC score x coefficient-0.593	PHSPT (TRY) (paying patient)	Ann-2A minimum (TRY) (health tourism)
Orthopedics and traumatology examination	p520030	317.00	300.00	470.00
Two-view knee radiography (AP/lateral)	801773 (Ann-2/B)	59.23*	85.00	130.00
Magnetic resonance imaging (MRI) arthrography, knee	R104560 (Ann-2/B)	1,145.86	605.00	910.00
Pre-Op laboratory panel (whole blood count, aPTT, biochemistry, viral markers)	L10xxxx 90xxxx (Ann-2/B)	379.02*	535.00	815.00
ECG -electrocardiogram	530100 (Ann-2/B)	16.65*	25.00	35.00
Anesthesiology and resuscitation consultation	520010 (Ann-2/B)	33.17*	110.00	205.00
Cardiology consultation (risk assessment)	520010 (Ann-2/B)	33.17*	110.00	205.00
Total T1 price (TRY)		**1,462.86**	**1,770.00**	**2,770.00**

*According to HPC, the examination fee is included as a package price; Therefore, it is not included in the total T1 price

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Table 2. TKA pathway - comparison of surgical procedure and medical supplies (T2) prices

Transaction name	HPC code	HPC fee (TRY) HPC score x coefficient-0.593	PHSPT (TRY)	Ann-2A minimum (TRY)
TKA (surgical procedure)	P612420 (Ann-2/C)	22,861.50	29,310.00	43,965.00
Standard bed tariff (4 days stay x unit price)	510010 (Ann-2/B)	889.43*	1,200.00*	1,880.00
General anesthesia	550200 (Ann-2/B)	7,316.44*	10,160.00*	15,240.00
Femoral component (CoCrMo alloy)	AP2300 (Ann-3/F1)	11,265.10*	19,407.36	19,407.36
Tibial baseplate (titanium alloy)	AP2660 (Ann-3/F1)	8,704.85*	18,083.27	18,083.27
Tibial insert (UHMWPE polyethylene)	AP2490 (Ann-3/F1)	5,491.74*	6,237.26	6,237.26
Patellar component	AP2420 (Ann-3/F1)	2,112.21*	5,999.08	5,999.08
Bone Cement (Antibiotic-enhanced PMMA - 40g) AP3180 (Ann-3/F1)		1,068.90*	2,286.87	2,286.87
Total T2 price (TRY)		**22,861.50**	**81,323.84**	**113,098.84**

*According to HPC and PHSPT, TKA (Surgical Procedure) is included in the price; Therefore, it is not included in the total T2 price

Table 3. TKA pathway - post-operative follow-up (T3) price comparison

Transaction name	HPC code	HPC Fee (TRY)	PHSPT (TRY)	Ann-2A Minimum (TRY)
Post-op outpatient clinic check-up	520030 (Ann-2/B)	0	0	470.00
Two-view knee radiography (AP/lateral)	801773 (Ann-2/B)	59.23*	70.00	130.00
Dressing and stitch removal	530580 (Ann-2/B)	31.26	45.00	75.00
Total T3 price (TRY)		**31.26**	**115.00**	**675.00**

*According to HPC, TKA is included in the transaction fee; Therefore, it is not included in the total T3 price

Table 1 presents the tariff values assigned to the preoperative diagnosis and preparation phase (T1) under the three pricing systems. The total T1 tariff amount was calculated as 1,462.86 TRY under HPC, 1,770.00 TRY under PHSPT, and 2,770.00 TRY under Annex-2A. Differences among tariff systems were observed for all major T1 components, including specialist examination, imaging procedures, consultations, and laboratory tests.

The T2 phase, the surgical procedure stage, is the main cost center of the treatment. This phase includes the TKA process, hospitalization, and accommodation services related to the surgery, anesthesia, and consumables, as well as the cost of the implant, which is the most expensive component of the procedure. According to PHSPT and Annex-2A, the costs of medical supplies provided by service providers are invoiced by adding 15% operating expenses, 1% treasury deduction, 1% Social Services and Child Protection Agency deduction, and 8% VAT to the purchase price (11).

Table 2 presents tariff values for the surgical procedure, hospitalization-related services, and implant components included in the T2 phase. When service fees are examined, the HPC fee for TKA Surgery procedures (22,861.50 TRY), representing the surgeon's labor, risk, and operating room use, is approximately half the equivalent in the Annex-2A tariff (43,965.00 TRY). Although the total reimbursement amount foreseen for a TKA Set (Femoral Component, Tibial Baseplate, Tibial Insert, Patellar Component, Bone Cement) in the HPC

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Annex-3/F1 list is 28,642.80 TRY, it is included in the TKA Procedure fee as a "package price", and the amount paid to the hospital within this scope is 22,861.50 TRY. However, considering the average purchase prices of the same set, the hospital's cost (purchase price / - OCC) has been calculated at approximately 41,053.91 TRY.

The difference between the estimated OCC (41,053.91 TRY) and the HPC T2 tariff amount (22,861.50 TRY) was calculated as 18,192.41 TRY. Hospitals are forced to transfer funds from their revolving budgets to finance this loss. In contrast, the same implant set can be priced at 52,013.84 TRY for a foreign patient billed under the Annex-2A tariff.

The T3 phase, which covers the 15-day early recovery period after surgery, includes outpatient follow-up appointments, suture removal, wound dressing, and control X-rays. According to HPC regulations, a certain period (usually 15 days) after surgery is considered a "follow-up period", and no separate payment is required for procedures performed during this time.

Total Tariff Prices (TTP) and Macro Comparison

The TKA Case-Based TTP, obtained by combining all phases (T1 + T2 + T3), represents the final revenue entering the healthcare provider's coffers. This data is the most critical indicator for the hospital's financial sustainability.

Table 4 summarizes total tariff prices obtained by combining the T1, T2, and T3 phases under each tariff system. The middle tier (PHSPT), at 83,208.84 TRY, covers costs and leaves a reasonable operating profit. The highest TTP value was observed under Annex-2A (116,543.84 TRY), followed by PHSPT (83,208.84 TRY) and HPC (24,355.62 TRY).

Tariff Comparison and Relative Price Differences

As a result of the analyses, the Annex-2A/HPC price margin was calculated as 378.51%, while the PHSPT/HPC margin was calculated as 241.64% (Table 5).

Cost Coverage Simulation

In the final stage of the study, a "Loss/Profit Simulation" was conducted based on the hospital's OCC for TKA surgery.

The recovery rate under HPC was calculated as 59.33%. The recovery rates under PHSPT and Annex-2A were 202.68% and 283.88%, respectively. The simulation in Table 6 shows that the HPC can only cover 59.33% of the TKA case cost, with the remaining 40.67% financed by the hospital's revolving fund.

Figure 1 visually demonstrates the substantial gap in cost coverage across tariffs, with HPC remaining below the OCC threshold while PHSPT and Annex-2A exceed full cost recovery.

Table 4. Total revenue per case and tariff differences in TKA

Tariff	Diagnosis and preparation (T1)	Surgery and hospitalization (T2)	Postoperative follow-up (T3)	Total tariff price (TTP)
HPC (SSI)	1,462.86	22,861.50	31.26	**24,355.62**
PHSPT (paying patient)	1,770.00	81,323.84	115.00	**83,208.84**
Ann-2A Min. (health tourism)	2,770.00	113,098.84	675.00	**116,543.84**

Table 5. Price margin analysis (%) based on HPC references

Tariff comparison	Difference originating from T1 phase (%)	Difference originating from T2 phase (%)	Difference originating from T3 phase (%)	TTP difference (TRY)	Price margin rate (%)
PHSPT/HPC	20.99%	255.72%	267.88%	+58,853.22	**241.64%**
Ann-2A Min/HPC	89.36%	394.71%	2059.31%	+92,188.22	**378.51%**
Ann-2A Min/PHSPT	56.50%	39.07%	486.96%	+33,335.00	**40.18%**

Table 6. Capacity of tariffs to cover operational consumable cost (OCC)

Tariff	TTP (TRY)	Profit/loss situation (TRY)	Recovery rate (%)	Results
Average (OCC)	41,053.91	0	100%	Reference
HPC	24,355.62	-16,698.29 (LOSS)	59.33%	Below cost pricing
PHSPT	83,208.84	+42,154.93 (PROFIT)	202.68%	Above cost pricing
Ann-2A (Min.)	116,543.84	+75,489.93 (PROFIT)	283.88%	Above cost pricing

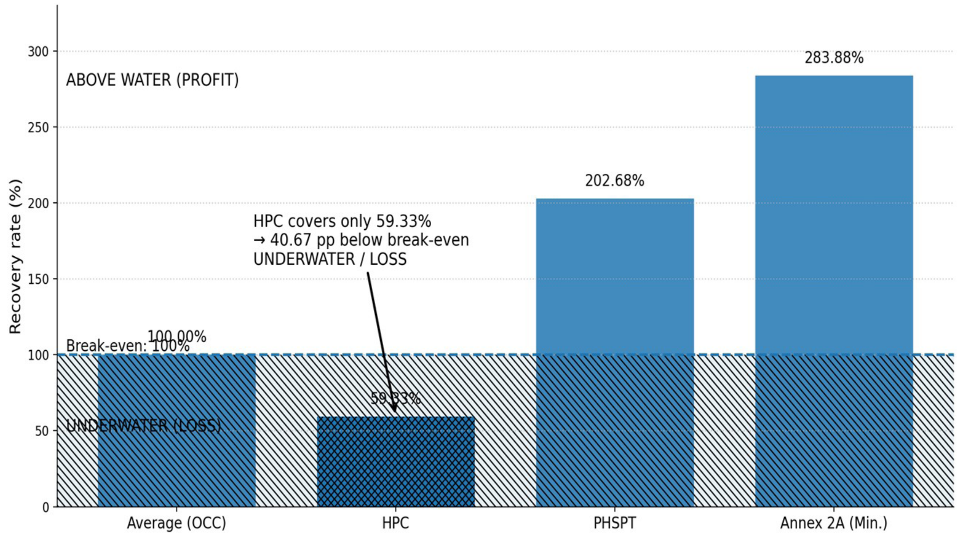

Figure 1. Tariff coverage rates (cost coverage)

DISCUSSION

This study demonstrates how the multi-layered tariff structure in Türkiye's healthcare financing system shapes the financial sustainability of public hospitals through a high-volume, material-intensive surgical procedure, such as primary TKA. The findings reveal that the HPC, representing the Social Security Institution's reimbursement, creates a significant "price squeeze" due to its inability to keep pace with the rising rate of exchange rate-sensitive implant costs; conversely, the PHSPT and, especially, Annex-2A tariffs effectively balance the HPC-related deficit through a "cross-subsidization" mechanism. The descriptive findings presented in Tables 4–6 indicate substantial differences in reimbursement levels across tariff systems. While the HPC tariff generated the lowest total tariff price (24,355.62 TRY), considerably higher reimbursement amounts were observed under PHSPT (83,208.84 TRY) and Annex-2A (116,543.84 TRY). These differences highlight the extent to which reimbursement outcomes may vary depending on the applicable pricing framework. As illustrated in Figure 1, substantial differences were observed in cost-recovery rates across tariff systems, with Annex-2A and PHSPT exceeding the estimated OCC threshold while HPC remained below full cost recovery.

A review of the literature reveals that TKA surgery is among the elective procedures with the greatest budgetary impact, particularly as the population ages (1). According to the findings, the average OCC for a TKA case in the T2 phase, encompassing surgery and implantation, is 41,053.91 TRY, whereas the HPC's package price for this phase is only 22,861.50 TRY. This strongly aligns with the finding highlighted by Dorling et al. (2023), which states that TKA costs are primarily indexed to technology and materials rather than surgical labor. Internationally, it is known that package pricing and Diagnosis-Based Procedure (DRG) systems are insufficient in the face of high-tech medical material costs; this puts healthcare providers in a bind between cost control and clinical quality. Current evidence shows that while implant prices decreased between 2009 and 2021, the decrease in total costs and hospital payments was not proportional. This indicates that there may not be a significant improvement in out-of-pocket patient payments and that the disconnect in cost transparency persists (14). In this context, while findings suggest that implant price standardization and flexible implant payment strategies can reduce cost pressure (15,16), the main factor increasing vulnerability in Türkiye is the direct sensitivity of high-cost medical supplies to exchange rates and the rigid TRY-based fixed-price logic of the HPC. The simulation results further demonstrated that the estimated OCC for a standard TKA implant set (41,053.91 TRY) exceeded the corresponding HPC reimbursement amount by 18,192.41 TRY. Although this difference was derived from simulation assumptions rather than hospital accounting records, it may indicate a potential mismatch between reimbursement levels and implant-related expenditures in material-intensive procedures.

The study's quantitative results clarify the potential impact of tariff design on hospital behavior. The cost-coverage simulation showed that the HPC tariff recovered 59.33% of the estimated OCC, whereas recovery rates reached 202.68% under PHSPT and 283.88% under Annex-2A. These findings suggest that tariff design may substantially influence the financial performance associated with TKA service provision. This difference (378.51% Annex-2A/HPC difference margin) makes public hospitals more dependent on health tourism revenue, potentially putting them in a difficult financial situation. Although the present study did not directly evaluate hospital-level financial flows, the observed differences in reimbursement levels may suggest the existence of a potential cross-subsidization mechanism whereby revenues generated from higher-priced tariff categories contribute to offsetting deficits associated with lower-reimbursed services.

Another important implication concerns capacity allocation. Developing countries like Türkiye attract international patients by providing high-quality, low-cost services, thereby generating significant additional revenue for the system (17). While Türkiye's potential to become a global player in orthopedic surgery (4,5) seems highly rational at the macroeconomic level, at the micro level (hospital management), this situation risks creating a "capacity allocation" dilemma between domestic and foreign patients. The Annex-2A tariff generated approximately 4.79 times the revenue associated with an equivalent TKA case reimbursed under HPC. While the present study did not directly examine patient scheduling behavior, resource allocation practices, or waiting times, such differences may create economic incentives that influence institutional decision-making regarding operating room utilization, bed capacity, and service prioritization (18,2). This possibility warrants further empirical investigation.

From a methodological perspective, the clinical process chain-based cost simulation, encompassing all T1–T3 processes, reveals hidden costs compared to classical approaches by making embedded items visible. Furthermore, the study's design, using code-matching of officially approved tariffs by public authorities for secondary data analysis, strengthens the external validity and reproducibility of the research results (7).

In conclusion, while the current tariff architecture creates a balance in the short term by compensating for the deficit originating from the HPC with Annex-2A/PHSPT, it is not sustainable in the long term. Unless policy design shifts to a model that separates physician/surgical service fees from implant costs and includes dynamic reimbursement components sensitive to cost shocks, the increase in health tourism revenues could become a systemic barrier to timely and equitable access for domestic patients. From a broader health policy perspective, the findings highlight the importance of periodically reassessing reimbursement structures for procedures that depend heavily on imported medical technologies. Ensuring consistency between reimbursement policies and evolving procurement costs may contribute to both financial sustainability and equitable access to healthcare services.

Limitations of the Study

This study has some limitations due to its methodological design and the nature of its data sources. The analysis focuses on "direct medical costs". "Indirect costs," such as general hospital operating expenses (electricity, heating, cleaning), depreciation allowances, and administrative staff salaries, were excluded from the analysis because they vary widely across hospitals. The analysis is based on an ideal and complication-free "Primary TKA" process. Infections, implant loosening, or conditions requiring revision were excluded from this study to avoid distorting the standard deviation. The health tourism tariff sets a "minimum price". Since the extent to which hospitals exceed this minimum price (the actual treatment price) is considered a trade secret, the minimum prices in Annex-2A were used in the analysis. This may have led to a conservative estimation of health tourism revenues; however, even in this form, there is a clear difference between the minimum price and the HPC. Despite these limitations, the study provides an important policy and financial analysis that clarifies the comparative structure of healthcare pricing mechanisms in Türkiye.

CONCLUSION

This study compared the financial implications of HPC, PHSPT, and Annex-2A tariffs for Primary TKA procedures in public hospitals using a clinical pathway-based financial simulation model. The findings suggest that fixed-price reimbursement mechanisms may be challenged by procedures that rely heavily on imported implant technologies and exchange-rate-sensitive procurement costs. The observed differences between tariff structures may indicate the potential existence of a cross-subsidization effect whereby higher-priced reimbursement categories contribute to offsetting deficits associated with lower-reimbursed services. The findings may reflect a policy trade-off between maintaining accessibility through lower reimbursement levels and supporting financial sustainability through alternative pricing mechanisms.

In light of these findings, policy recommendations can be grouped along three axes. First, in the package pricing approach under the HPC, physician/surgical service fees and high-tech implant costs should not be combined in the same basket; implant costs should be separated from the procedure package (carve-out model) and updated with dynamic indexation components sensitive to exchange rates and inflation. This approach is consistent with evidence indicating that the sustainability of package payments in material-intensive surgeries can be strengthened with implant payment strategies (19).

Secondly, to limit the risk of the high margin created by Annex-2A shifting capacity allocation decisions against domestic patients, future policy discussions may consider mechanisms to monitor capacity allocation between domestic and international patients in institutions where medical tourism activities constitute a substantial proportion of service provision. Previous literature has raised concerns regarding the possibility that rapid growth in medical tourism could influence service availability for local populations (20,21); however, this issue was not directly examined in the present study and requires further empirical investigation.

Thirdly, if regulations are not implemented in these areas, the increasing reliance on higher-priced tariff categories may create financial dependencies that warrant ongoing monitoring from both sustainability and equity perspectives. Therefore, a dynamic, segmented reimbursement design should not be delayed for procedures that rely heavily on imported materials, such as TKA.

To the best of current knowledge, this study is among the analyses in Türkiye to compare HPC, PHSPT, and Annex-2A tariffs simultaneously within a standardized TKA clinical pathway

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framework. By integrating tariff structures with pathway-based financial simulation, the study contributes to the growing literature on healthcare financing, reimbursement policy, and hospital sustainability.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
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Ethical Approval
The study protocol received approval from the Bayburt University Social and Human Science Research Ethics Committee (Decision No: E-51694156-050.04-355402, Date: 18.03.2026).

Informed Consent
Informed consent was not required for this study as it solely analyzed official documents rather than patient data.

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