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ORIGINAL RESEARCH ARTICLE

Time-Driven Activity-Based Costing in Healthcare: An Implementation in Dental Hospital

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Abstract

Purpose: This study aims to estimate prosthetic dental treatment costs and demonstrate that more accurate clinical cost information can be reached by using the time-driven activity-based costing method in a medical faculty hospital.
Materials and Methods: The research is a retrospective descriptive study that analyzes and assesses financial, administrative, and medical data. The population of the study is comprised of the prosthesis department of a dental hospital in 2019. Time Driven Activity Based Costing method was applied for the cost estimation of dental prosthesis treatment.
Results: After estimating the cost of the treatment, results were compared to the social security institution payment amount for dental prosthesis treatment, and total dental prosthesis treatment costs were calculated as $133.22.
Conclusions: The research findings indicate that the Time Driven Activity Based Costing approach provides more precise insights into the cost structure of dental practices and can be easily adopted by other healthcare providers.

Key words: time-driven activity-based costing; dental treatment; process map; value-based healthcare

Introduction

Health systems worldwide have sustainability concerns due to both the rising demand and the cost of healthcare services. Value-based healthcare (VBHC) may solve all sustainability issues by improving health outcomes. Improving outcomes is the only way to effectively cut healthcare costs: attaining and maintaining good health is fundamentally less expensive than dealing with poor health in a value-based system.[1] However, there are challenges to improving health outcomes, such as managing rising healthcare costs and maintaining incentives for innovation among providers, manufacturers, insurers, and employers.[2] The following equation may be used to summarize the goals of value-based healthcare[3]:

- Low Cost + High Quality + Wide Accessibility = Goals

Porter defines value in healthcare as the health outcomes attained from the service rather than the quantity of service provided.[4] Value creation is required for all stakeholders' participation, including patients, service providers, and reimbursement institutions. It is also requisite for the economic sustainability of health care. Although no country has fully implemented the VBHC, many healthcare systems worldwide have adopted it for various reasons.[5] The main argument for value-based payment, as a part of VBHC, is that decision-makers ought to assess the costs and corresponding benefits of such expenditures.[6]

Cost-assessment methodologies that provide high-quality cost information are required to implement value-based initiatives. Recently, time-driven activity-based costing (TDABC), as a cost component of VBHC, has been increasingly adopted to close the cost-information gap.[7,8]

TDABC, frequently used by health organizations, is the bottom-up micro-costing method to achieve more accurate cost information.[9]

The traditional approach to costing is known as the top-down method because it begins by aggregating cost elements and then allocating them to products/services.[10] The top-down costing approach involves allocating all expenses to cost objects by utilizing allocation keys. This approach assumes that cost objects consume all expenses and does not consider capacity usage. On the other hand, TDABC calculates cost objects based on capacity utilization rates and excludes unused capacity expenses from its calculations. TDABC is sensitive to capacity and has the ability to calculate both empty and unused capacity.[11] In fact, TDABC can be regarded as a return to the standard costing approach. Standard times for the resources utilized in activities are set, and resource expenses are allocated to the related activities based on these times. Finally, cost objects are costed based on the activities they use.[12] The method does not allow over costing as it only uses the expenses consumed by the cost object.

The Time-Driven Activity-Based Costing (TDABC) approach has been implemented across various medical fields and proce-

dures, such as emergency medicine, orthopedic surgery, pediatric surgery, cancer treatment, bypass surgery, and prostate brachytherapy.[13–20] In oral health, Resnick et al.[21–23] and Inverso et al.[24] evaluated the costs of oral and maxillofacial surgery practice and orthognathic costs were estimated. Türk and Ertaş calculated the costs of the dental prosthesis unit of an oral and dental health clinic with Fuzzy TDABC.[25] Kılıç Güngör, and Anıl Keskin analyzed unit costs of two-faceted filler, two-channel canal treatment, dental stone cleaning and orthodontic treatments with TDABC.[26] Dall'Agnol et al. analyzed orthodontic evaluation, maintenance and restoration.[27]

TDABC is a straightforward strategy that health facilities can easily put into practice. According to Kaplan and Anderson, "TDABC strives to be approximately right rather than precisely wrong."[28]The Time Driven Activity Based Costing method consists of the following steps: First, the practical capacities of human resources and equipment are determined. Second, capacity costs are determined before calculating capacity cost rates. In determining capacity expenses, personnel, equipment and space-related expenses are classified. After calculating the capacity expenses, the capacity cost rates calculation begins. In TDABC, capacity cost ratios are determined according to the practical capacities of each personnel and equipment. The capacity cost rate can also be defined as the ratio of the cost of capacity supplied to the practical capacity of the resources supplied. Only capacity costs used in production are considered, and unused (idle capacity) capacity is classified separately in the financial reports. Thus, managers have more detailed information about how all their resources are used.[28,29] In the third stage, process maps and time equations are defined to determine the amount of time necessary for resources to complete activities. Once time equations are estimated, costs are calculated by multiplying activity times with the capacity cost ratios.[28–30]

This study employs the Time-Driven Activity-Based Costing (TDABC) approach to calculate the cost of prosthetic dental treatment and also provides a clear and transparent viewpoint of the costs involved in the service process. Regarding the analysis technique which is used, this study is one of the first studies in the field of dental treatment in Türkiye. The study aimed to conduct a comparative analysis between the computed costs and the payment amount determined by the Social Security Institution Communiqué concerning healthcare practices. An additional objective of this investigation was to make a contribution to the field of cost analysis in healthcare through the implementation of contemporary costing models. This context will demonstrate the process of cost tracing with activities.

Material and Methods

The study employs the Time-Driven Activity-Based Costing approach to estimate the costs associated with dental prosthesis treatment. The data used in this study were obtained from the prosthesis department of a dental hospital in Ankara in 2019 was done. While designing the study, the estimation of practical capacity and capacity cost rate was accomplished first, and then process maps and time equations were prepared to estimate unit costs.

Practical Capacity

There are sixteen dentists, four nurses, four patient consultants, and four cleaning staffs in the prosthesis department (Table 1). Employee theoretical capacity is determined by removing weekends, public holidays, paid leave, sick leave, and reports from 365 days. Due to various factors such as personnel limitations, scheduled breaks, equipment maintenance and repairs, employee arrivals and departures, internal movements within the unit, and communication requirements, 80% of theoretical capacity is regarded as practical capacity.[30] When these rules were applied to the prosthesis department, there were 246.5 working days, and the total working time for staff was 61,920 minutes (246.5 days x 8 hours x 60 minutes = 118,320 minutes) within the scope of the study.

Table 1. Total Practical Capacity

Branch	No. Personnel	Paid Annual Leave / Sick Report	No Working Day	Total Practical Capacity (min.)
Dentist	16	387	3.558	1.365.888
Nurse	4	207	779	299.136
Patient Consultant	4	131	855	328.320
Cleaning Staff	4	137	849	326.016

The number of dentists is 16, and the total number of working days is 3,944 (246.5 x 16 = 3,944 days). There are 12 auxiliary staff members, including four nurses, four patient consultants, and four housekeeping staff, and the total number of working days for each group is 986 (246.5 x 4 = 986 days). The number of days not worked due to paid annual leave and sick leave is calculated as 387 days for physicians, 207 days for nurses, 131 days for patient consultants, and 137 days for cleaning staff. Thus, the theoretical capacity of the staff was calculated as 3,557 days (1,707,360 minutes) for dentists, 779 days (373,920 minutes) for nurses, 855 days (410,400 minutes) for patient consultants, and 849 days (407,520 minutes) for cleaning staff.

After calculating the theoretical capacity, it is presumed that 20% of the personnel are not actively engaged in service processes because of training, meals, and breaks. The practical capacity is computed by reducing the theoretical capacity by 20%. The practical capacity time for the dentist is 1,365,888 minutes, the nurse 373,920 minutes, the patient consultant 328,320 minutes, and the cleaning staff 326,016 minutes (Table 1).

1.Capacity Cost Rate

In Table 2, the capacity costs of the resource groups are presented. There are 18 telephones, 20 computers, 7 printers, and 16 air conditioners in the prosthesis unit and the personnel area is 252 m^2. There are also 120 lamps and 18 heater cores in the unit. Resource expenses are allocated by considering salaries and fringe benefits by branch, malpractice insurance, depreciation expenses for equipment used by personnel, outsourced benefits and services such as cafeteria expenses, and the number of equipment used. In addition, cost groups such as building maintenance, repair, d4epreciation, water, and housekeeping are classified as space-related expenses and allocated according to the occupied area. Heating, electricity, IT, and communication expenses are allocated to related groups by considering the number of lamps, air conditioners, heater cores, telephones, and computers. The capacity cost ratios for the dentist, nurse, patient consultant, and cleaning staff are $0.30/minute, $0.17/minute, $0.12/minute, and $0.07/minute, respectively.

Total capacity expenses are calculated as 411,104.35$ for the dentists and 39,797.22$ for the patient consultants. The unit capacity cost rate ($/min.) is calculated by dividing the capacity expenses by the capacity of the related branches. The dentist capacity cost rate is calculated as 0.30$/min and for a patient consultant as 0.12$/min (Table 2).

2.Process Map and Time Equations

Professionals were interviewed to prepare process maps for prosthesis treatment, and information was collected about workflows and activity times. After the preparation of the process maps, the activity time estimations were completed, and time equations were established.

Time Equation of Prosthesis Treatment Process:

Table 2. Total Personnel Expenses and Capacity Cost Rates ($/min)

	Dentist	Nurse	Patient Consultant	Cleaning Staff
Personnel-Related Data				
No. Personnel	16	4	4	4
Occupancy	243	6.15	9	
Telephone	16	1	1	
PC	16		4	
Printer	5		2	
Air-Conditioner	16			
No. Lamp	112	4	4	
Heater	16	1	1	
Personnel-Related Expenses				
Salary, bonus and fringe benefit Wages and salaries	391,686	51,228	37,884	21,650
Malpractice insurance	1		-	
Office expenses	612	153	153	
Information technology and other office equipment depreciation (PC, printer, air-conditioner)	1,966		298	
Communication expenses	147	9	9	
IT Center – Information Technology Center	3,815		954	
Meal	124	31	31	31
Energy to	8,219	79	79	
Water	851	213	213	213
Heat	1,702	106	106	
Space-Related Expenses	1,982	50	69	
TOTAL EXPENCES ($)	**411,104**	**51,870**	**39,797**	**22,047**
Capacity (min)	**1,365,888**	**299,136**	**328,320**	**326,016**
Capacity Cost Rate ($/min)	**0.30**	**0.17**	**0.12**	**0.07**

- Total Process Time (300 min.)= (230Dccr Nccr + 20PCccr + 50CSccr)

The process time for dental prosthesis treatment is 300 minutes, of which the dentist and nurse spend 230 minutes, the patient consultant 20 minutes, and the cleaning staff 50 minutes.

3.Unit Costs

The unit costs of prosthesis treatment were determined by multiplying branch capacity cost rates by the activity times. Also, full cost information is obtained through the inclusion of the costs of consumables and materials utilized during the intervention. Based on the given information, the costs associated with a Total Dental Prosthesis Single Jaw can be calculated as follows: $0.30 x 230 min. D + $ 0.17 x 230 min. N + $ 0.12 x 15 min. PC + $ 0.07 x 50 min. CS + $ 19.22 for consumables and materials. The total cost of this procedure amounts to $133.22.

Results

It was determined that the total cost of the prosthetic dental treatment was 133.22 dollars, with the following cost components: The costs incurred in the dental practice were distributed among various personnel as follows: $69 was allocated to the dentist, $39.1 to the nurse, $2.4 to the patient consultant, and $3.5 to the cleaning staff. In addition, consumables and materials expenses amounted to $19.22 (Table 3).

Discussion

The fact that the TDABC technique gives detailed information about the costs of processes and activities is one of the strengths of the study. Process maps and activity costs facilitate the comparison of processes and costs across the hospital. Furthermore, this methodology facilitates comprehension of expenditures and resource consumption. One of the limitations of the study pertains to the inability to calculate capacity utilization rates due to the observation of only one type of case. Additionally, another limitation involves the lack of knowledge regarding medical device usage and other axillary service expenses, such as radiology and laboratory expenses. Since the majority of the direct and indirect materials used in oral and dental health services are imported, fluctuations in exchange rates can result in cost variations.[26] Hence, the cost estimations were conducted in US dollars to yield more comprehensible results for the researchers.

Türk and Ertaş conducted a similar study with the Fuzzy TDABC method, calculated the total dental prosthesis single jaw for 2014 and found the unit cost as $125.7.[25] According to a healthcare practices communiqué, the Social Security Institution (SSI) pays $26.45 for the dental prosthesis treatment.[31] Despite omitting certain cost elements in the analysis, this amount is still far from meeting the expenses associated with dental prosthesis treatment. Similarly, Erkol and Ağırbaş used the activity-based costing method to calculate the costs of cardiovascular surgery operations and compared those expenses to the cost of SSI bundles. They also found that the SSI payment amount didn't cover operations costs.[32] The SSI makes pricing rules without using cost analysis; and the inappropriate pricing methods lead to inaccurate pricing decisions and the determination of service prices are over or underpriced. The price mechanism can cause the loss of hospitals or reimbursement institutions such as SSI.[33] On the other hand, the vast majority of public and private hospitals need a cost accounting system, and cost analyses must be conducted consistently. Under these circumstances, interested parties will continue criticizing SSI reimbursement fees.[32]

Traditional costing methods calculate costs using the general ledger, one of the accounting books. Managers and healthcare professionals have trouble understanding the general ledger's usage of a chart of accounts, whereas activity-based costing techniques employ a chart of activities. Activity-Based Costing (ABC) enables a distinct perspective on revenues, budgeted funding, and costs by translating general ledger data into activities and processes.[34] In the study, activity costs are shown transparently on the process

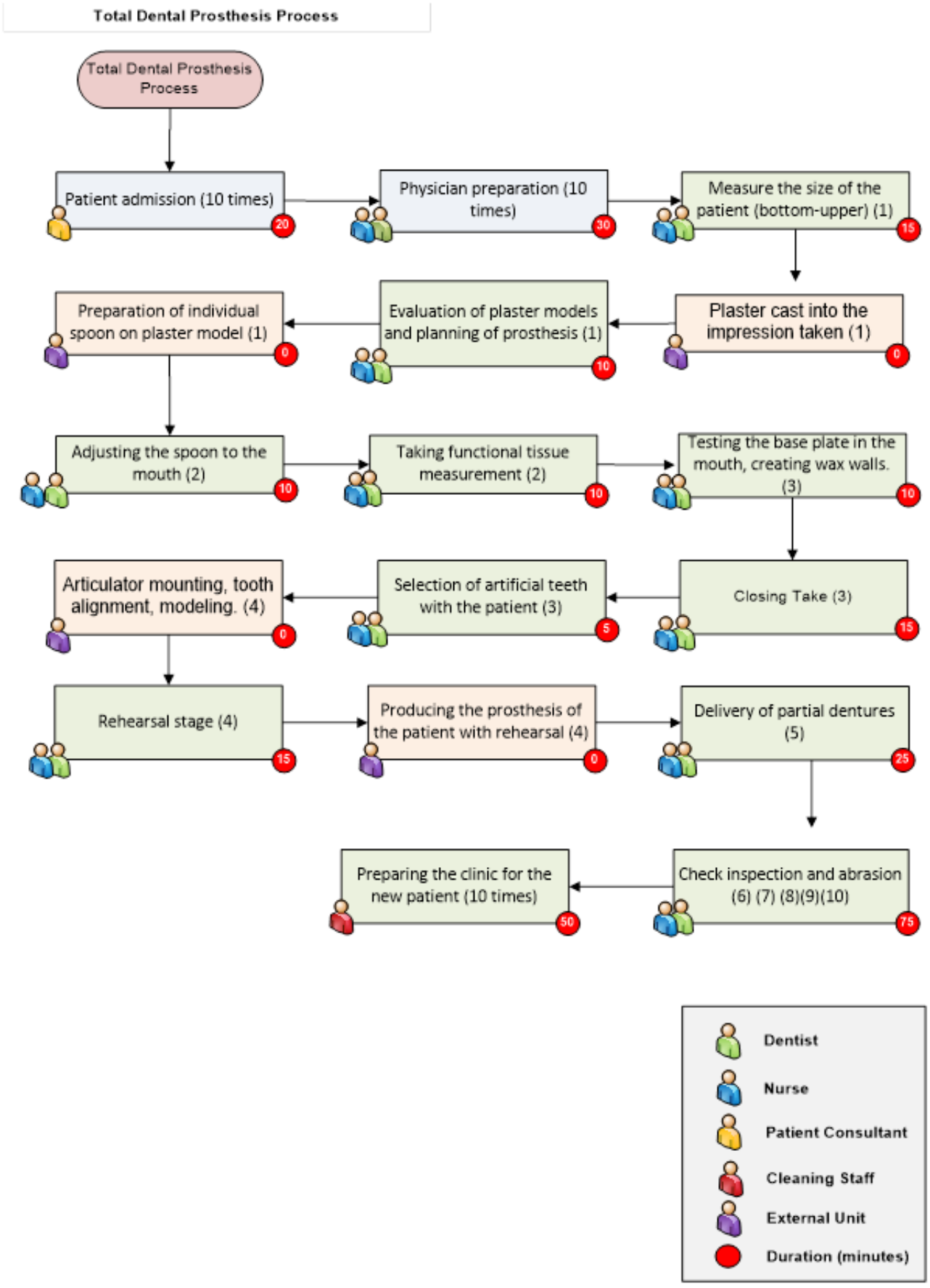

Figure 1. Process Map – Total Dental Prosthesis Process

Table 3. Total Dental Prosthesis Single Jaw Consumables and Material Uses

Consumables/Material Name	Unit Price ($)	Unit	Quantity	Price ($)
Alginate (for single jaw)	0.88	Piece	1	0.88
Zinc Oxide Original Impression Material (For single measure)	2.64	Piece	1	2.64
Wax	0.88	Piece	2	1.76
Kerr	3.17	Piece	1	3.17
Set tooth (Single jaw)	2.12	Piece	1	2.12
Acrylic (Hot) (For single prosthesis)	3.53	Piece	1	3.53
Baseplate (Beam)	0.88	Piece	4	3.53
Polishing materials	0.88	Piece	1	0.88
Plaster	0.71	Piece	1	0.71
Total				**19.22**

map according to the employees' groups. Improving the activity durations and removing non-value-added activities during the treatment process can result in cost savings without affecting the quality.

Conclusion

Activity-Based Costing provides accurate cost data and enhances the process by increasing the visibility of costs and activities. It also generates valuable cost information for value-based health and payment systems, one of the most popular approaches in use today. Finally, capacity use is also made clear, which is useful for managers.

The study provided a clear and transparent presentation of the treatment process for dental prosthesis. In the study, only the cost of the dental prosthesis treatment was calculated, but it is planned to evaluate all departmental activities in future studies. Consequently, improvement activities within the framework of evidence-based medicine will support the provision of value-based health services.

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