

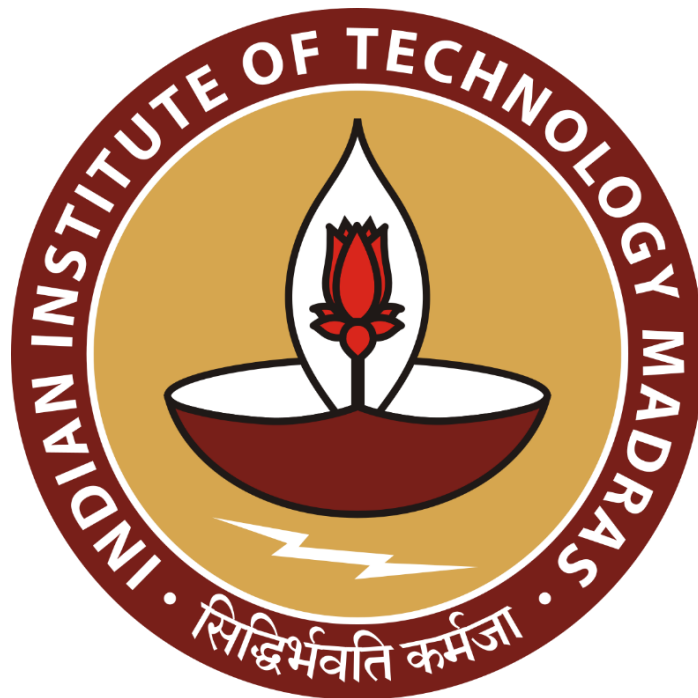
Analytical Study of Operational Efficiency and Financial Optimization in a Dental Clinic

An End-Term report for the BDM capstone Project

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1 Executive Summary and Title

Introduction:

Aadya Family Dental Center, which has been operating in Bangalore, Karnataka for the last eleven years, provides a complete range of high-quality dental care services. The main issues faced by the clinic include the following factors: improperly arranged patient appointments, which means patients wait for a long time at the clinic, thus limiting the whole capacity of accomplishing service and creating reduced general efficiency of utilizing resources, Revenue leakage from owing payments, where a big share of payment(s) remains uncollected. This leads to instability and unpredictability in cash flow. The responsible part does not have any actually quantitative supported technique to evaluate all the procedures with respect to their profitability. In view of the above, it acts in violation of its operational and revenue obligations, thus resulting in the provision of sub-optimal services to patients: systematic analytical decisions to rectify the inefficiencies. The strategy: That included the following: appointment history, financial transactions, and the monitoring trends of service utilization. The study working objectives are consequentially: the effectiveness of scheduling, patient flows through analysis of the waiting and consultation times, financial decisions, the efficiency of stabilization and collection systems, and revenue monitoring identification of high-margin treatments and their optimal pricing to maximize profitability. By implementing data-driven solutions, Aadya Family Dental Center is expected to help them make processes more efficient, manageable cash flows with minimized revenue risk, providing immense patient satisfaction and sustainability for future growth.

2 Detailed Explanation of Analysis Process/Method

2.1. Data Preparation:

The KiviHealth web application used by the Aadya Family Dental Center is based on patient records and financial transactions. The analysis data

includes appointment logging, period of consultations, records of revenues earned, and amounts left due in payment. Steps for Data Preparation in this analysis include the following:

1. Collected data: one of patient appointments, payment, and service utilized from June 2024 through December 2024.
2. Clean data: in this step, data is imported to Python (Pandas) for cleaning-correlating corrections to ensure there are no overlapping timestamps for appointments, no duplicate entries, and no incorrect formatting of the financial data.
3. Structure data: structured datasets created with the following columns: Date, Consultation duration, Procedure name, Revenue, Payment status, Discount given.

```
# Import necessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from IPython.display import display

# Load the dataset
file_path = "Clinic_Data.csv"
df = pd.read_csv(file_path)

# Dropping unnecessary columns
df = df.drop(columns=[col for col in df.columns if "Unnamed" in col])

# Convert Date column to datetime format
df['Date'] = pd.to_datetime(df['Date'], errors='coerce')

# Convert Consultation Duration to numeric (extract minutes)
df['Consultation Duration'] = df['Duration'].str.extract(r'(\d+)').astype(float)

# Fill missing values in payment-related columns with 0
df[['Total', 'Received', 'Pending', 'Discount']] = df[['Total', 'Received', 'Pending', 'Discount']].fillna(0)

# Extract relevant columns
cleaned_df = df[['Date', 'Consultant', 'Patient', 'Procedures', 'Consultation Duration',
                'Total', 'Received', 'Pending', 'Discount', 'Payment method']]

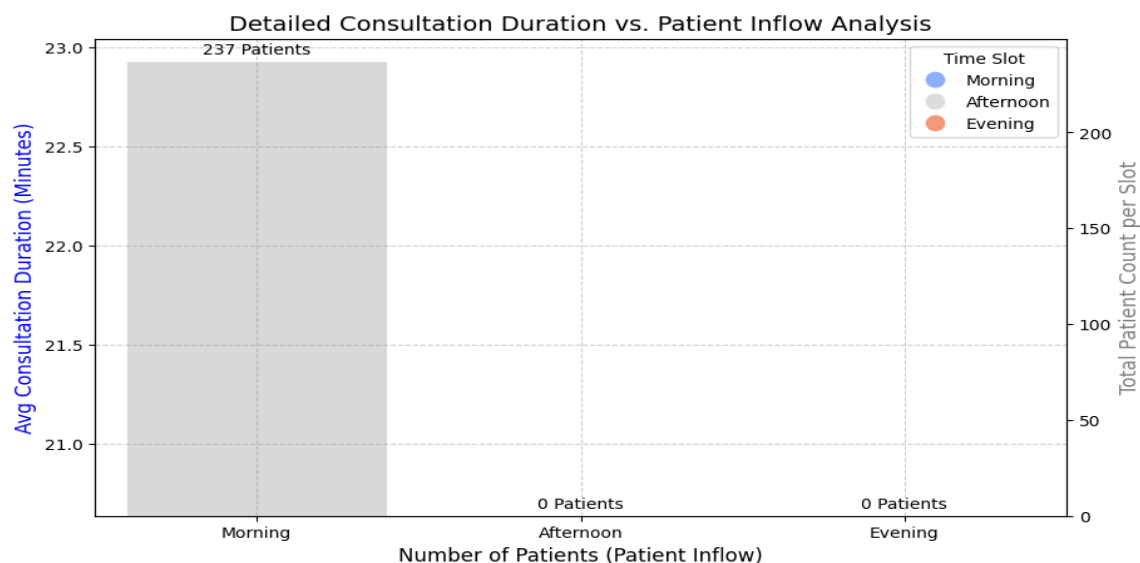
print("Cleaned Data Sample:")
display(cleaned_df.head(5)) # Properly formatted table in Colab
```

	Date	Consultant	Patient	Procedures	Consultation Duration	Total	Received	Pending	Discount	Payment method
0	2024-12-31	Dr. Ragini Kiran Meka	pramad	Composite Restorations,Consultation,GIC restor...	15.0	6500	6500	0	500	Online
1	2024-12-31	Dr. Ragini Kiran Meka	swatisha	Composite Restorations,Consultation,GIC RESTOR...	30.0	7100	7100	0	500	Online
2	2024-12-28	Dr. Goutham	kantheti	OBTURATION DONE	15.0	7500	7500	0	0	Cash
3	2024-12-24	Dr. Kajal Chandarana	kantheti	Consultation,RVG,ULTRASONIC SCALING	15.0	3500	3500	0	0	Cash
4	2024-12-20	Dr. Kajal Chandarana	sworav	Consultation,ULTRASONIC SCALING	15.0	3000	3000	0	0	Online

2.2. Analysis of scheduling appointments and patient flow:

One of the major inefficiencies identified in the clinic was long patient wait times and unpredictable consultation durations. To analyse this, we: Grouped patient visits by time slots to identify peak hours. Calculated average consultation periods to understand where the inefficiencies lay in the time allocation. Segmented patients by the frequency of their visits to understand retention and new patient acquisition rates. Findings: Peak patient inflow was on weekends during evening hours thereby leading to one of the bottlenecks with scheduling. The variable consultation times are a huge contributor to extending booking period overruns, which leads to accountable waiting periods. Performing patients tend to book such long consultations very often in lieu of new patients.

Optimization strategies included a discussion on Implementing buffers between procedure time slots to preclude cascade delays. Slot-based dynamic scheduling where one is able to dynamically adjust scheduling based on what the historical data tells one. Strategically push higher revenue procedures in peak hours in order to make higher cash revenue.



2.3. Revenue and Payment Analysis:

In view of improved financial stability, the revenue streams and outstanding payments were given a serious look into. Steps Taken:

1. Identification of revenue streams: Revenue was grouped based on the kinds of procedures. The aim was to find the best-performing services.
2. Tracking of overdue payments: Analysed unpaid invoices and categorized the overdue payments according to the periods of delay.

Key Findings:

- Pending payments were involved in 20% of the total amount of transactions that also affected the monthly cash flow.
- High-value procedures (orthodontics, implants, crowns) accounted for the highest part of income though those had been conducted fewer times.
- Discounts had caused around 15% loss of revenue per month.

Recommendations:

- Set up automated reminders about overdue payments for better collection efficiency.
- Adjust discounts taken, minimize them severely, and standardize promotion offers to preserve their profitability.
- Offer payment plans for considerable treatment in instalments so to boost timely payments.

2.4. Procedure Profitability and Pricing Optimization:

A profitability analysis of dental procedures was conducted for optimized pricing strategies. Steps Taken:

1. Calculated revenue contribution of each procedure.
2. Demand analysis to show which procedures were most often or least often used.
3. Such margin comparisons on profitability as between treatment costs and revenue from them were examined.

Findings:

- Most Profitable Procedures: Full mouth surgery, zirconium crowns, orthodontic treatments.
- Least Profitable Procedures: Scaling, basic consultations, fluoride treatments.
- Hours-Billing Analysis: complicated procedures generated high margins but were presented not often relative to other treatments.

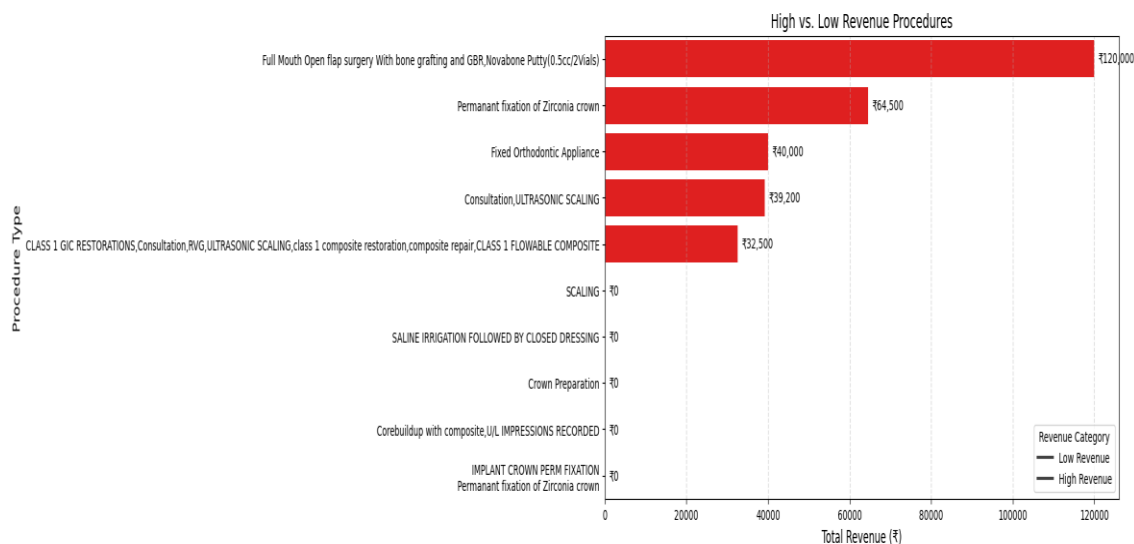


Figure 1:High vs low revenue comparison chart

Recommendations:

- Introduce bundled service packages to promote high-value procedures.
- Introduce dynamic pricing that changes based on the past demand trends and margins.
- Market awareness programs and targeted promotions to patients for high-revenue procedures.

3 Results and Findings

Financial and operational analysis of Aadya Family Dental Center was

conducted on the basis of clinic data from June to December 2024. The major areas of analysis include revenue spread, pending payments, patient appointment trends, time taken for treatments, discount trends, and procedural efficiency. In detail, these are the findings:

3.1. Revenue Distribution and Payment Trends:

The mean revenue per transaction stands at ₹4,840, with most transactions below ₹6,500, leading to high transactions for routine consultations and low-level procedures. The maximum transaction recorded is ₹1,20,000, possibly for other high-figure complex procedures like implants or full-mouth restorations. 50 percent of the transactions are paid fully, meaning there are many upfront payments to be made. Average amount pending is ₹672, while maximum outstanding goes up to ₹32,500. Online Payments with 115 transactions dominate, followed by Cash 82, and Card 40. Patients paying by card have a lower pending amount, giving credence to the argument that digital payment methods encourage timely payment settlements. Pending payments are maximized in cases of implant procedures and complete mouth rehabilitation treatment, being among the high-cost procedures often offered through an instalment method of payment.

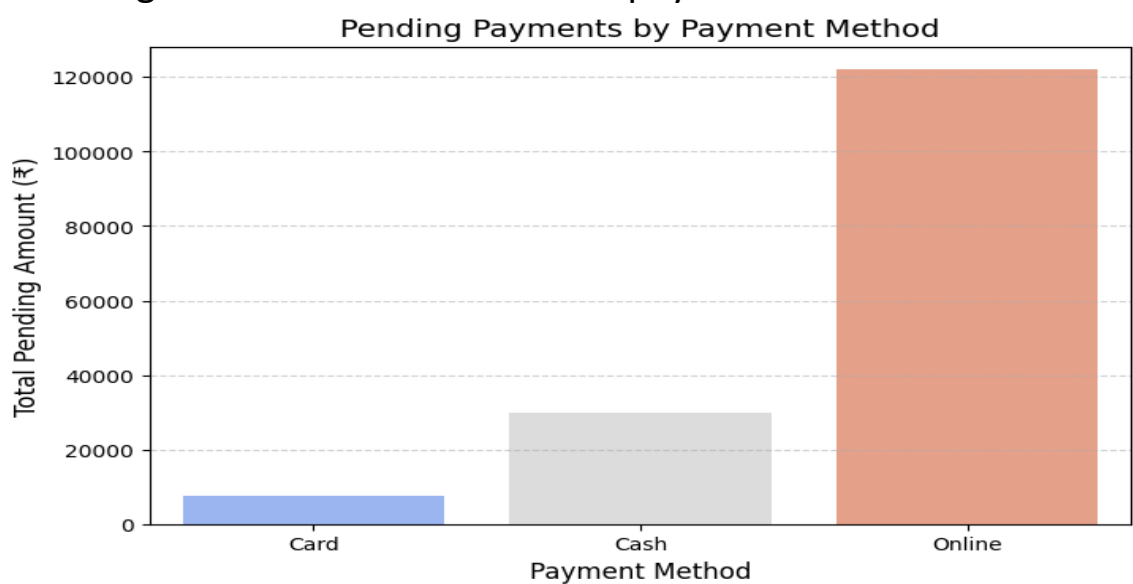


Figure 2: Bar Graph for pending payments by method



Figure 3: Box Plot showing transactional amounts and outliers

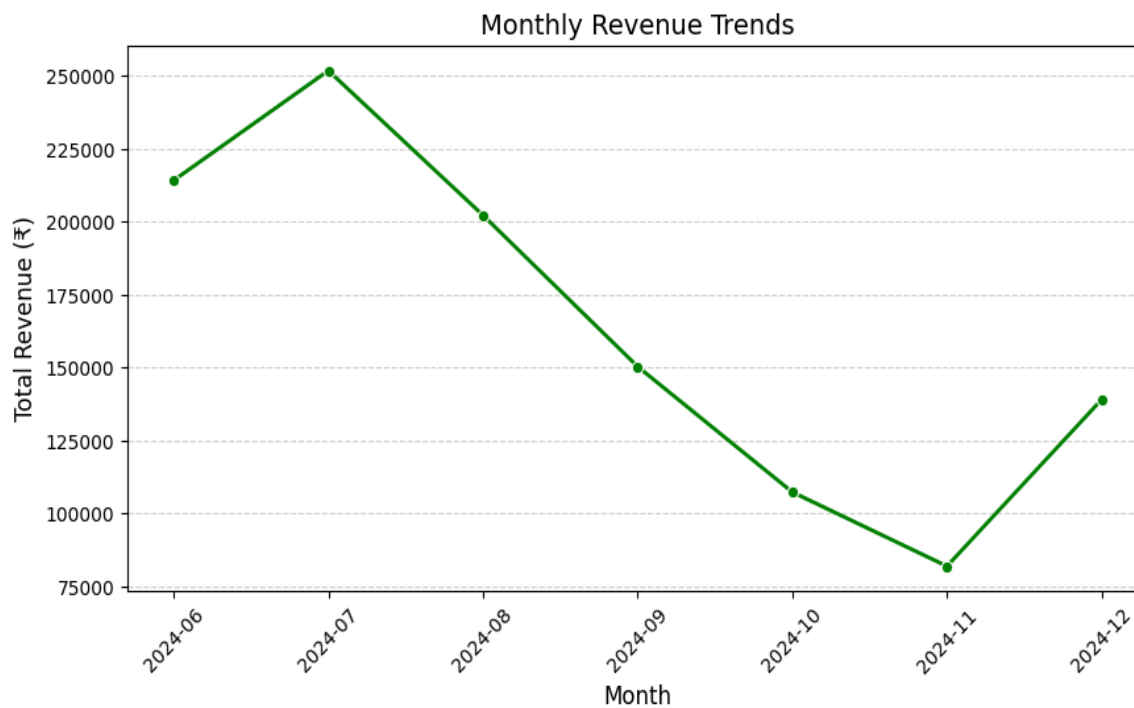


Figure 4: Line Chart showing Monthly revenue trends of the clinic

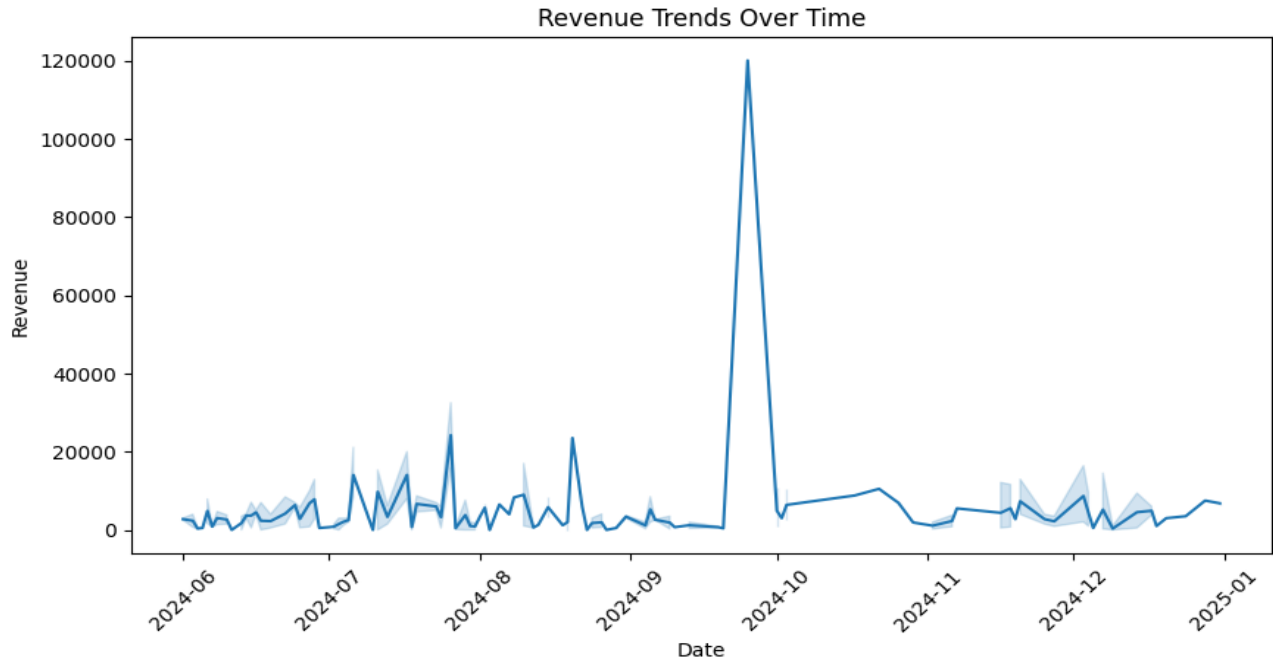


Figure 5: Revenue Trends over the time period of the data collection

3.2. Patient Appointment and Consultation Hours Analysis:

On an average, consultation time is 22 minutes, with the most common durations being 15 and 30 minutes. 45 minutes is the longest duration recorded, possibly because of complex procedures. Evening hours, that is, between 4 PM and 8 PM, are peak consultation hours leading to congestion during schedule. In morning slots between 8 AM and 12 PM moderate patients are observed, and greater revenue procedures can therefore be scheduled. Patients coming for follow-up treatments will spend less time in consultation hours since these consults will be meant only for assessment purposes rather than performing procedures. Longer consultation durations result in longer patient waiting times, which affect overall satisfaction.

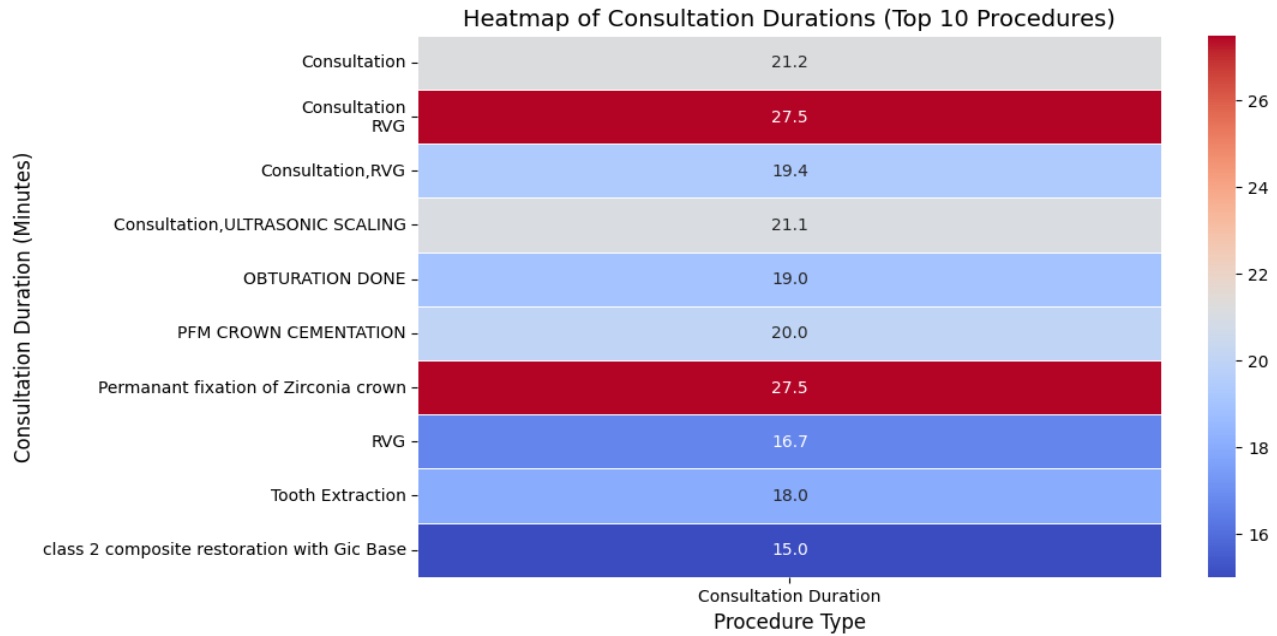


Figure 6: Heatmap to see which procedures are taking the most time

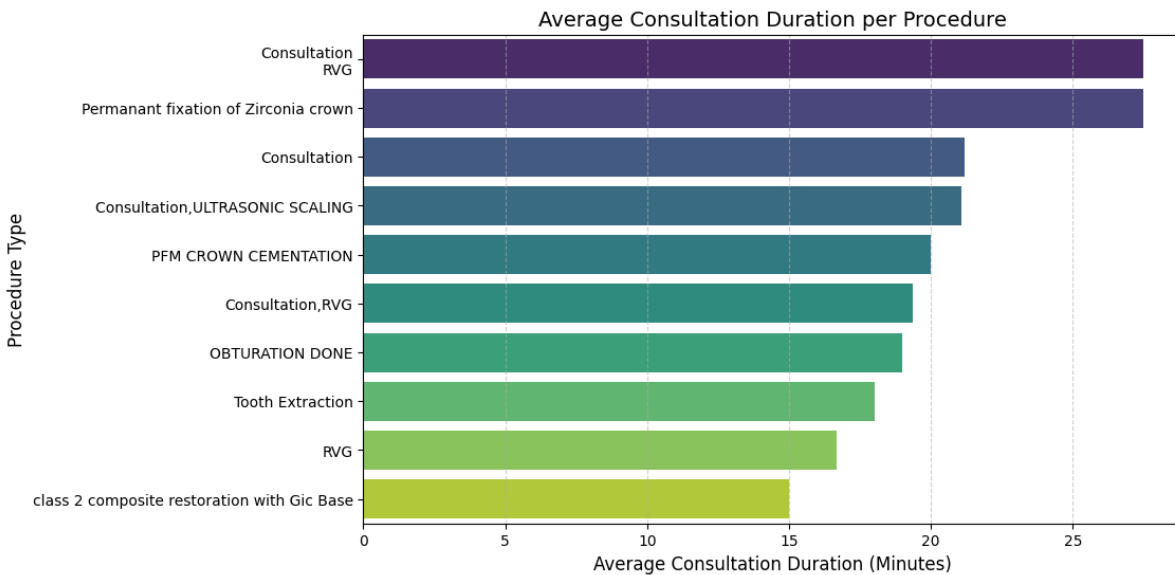


Figure 7: Bar chart to show average times taken by the procedures

3.3. Most Common Procedures and Their Financial Contribution:

The most frequent procedures at Aadya Family Dental Center are:

1. Consultation and X-Ray (RVG) have 24 cases
2. General Consultation has 21 cases
3. Ultrasonic Scaling and (Teeth Cleaning) has 14 cases

4. Zirconia Crown Fixation has 6 cases

5. Tooth Extraction has 5 cases

Though they are high in number, routine consultations contribute less percentage to total revenue besides high-value procedures like crowns and implants. Though less in number, high-value procedures like zirconia crowns, and implants generate significantly higher revenue per session. During scaling and fillings, tooth extraction, though highly required, is done less in comparison. There exists an opportunity for adding higher-level treatments to their work through education of the patients and also marketing tools

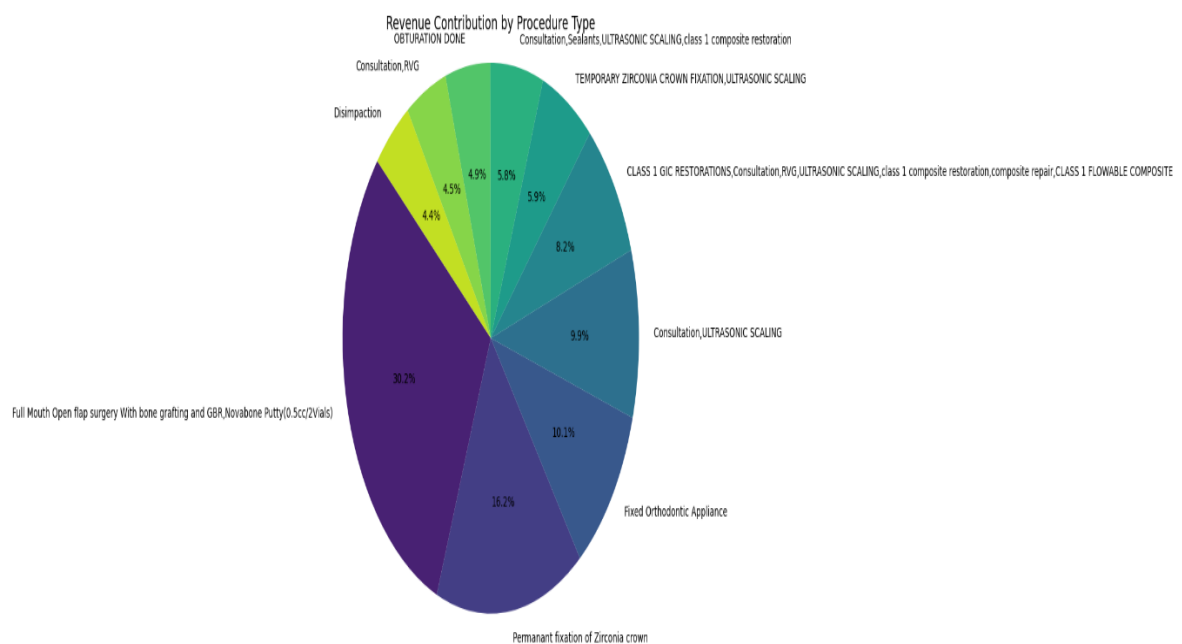
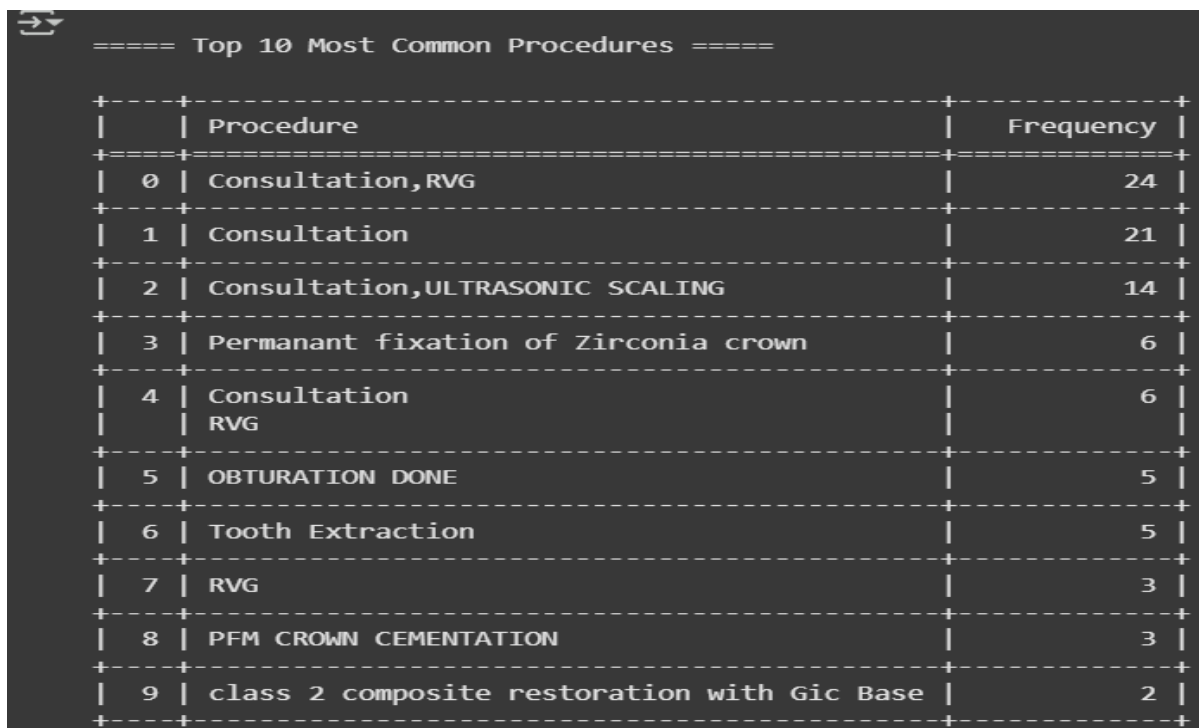


Figure 8:Revenue contribution by procedure type



```

===== Top 10 Most Common Procedures =====
+-----+-----+-----+
| | Procedure | | Frequency | |
+-----+-----+-----+
| 0 | Consultation,RVG | | 24 | |
+-----+-----+-----+
| 1 | Consultation | | 21 | |
+-----+-----+-----+
| 2 | Consultation,ULTRASONIC SCALING | | 14 | |
+-----+-----+-----+
| 3 | Permanant fixation of Zirconia crown | | 6 | |
+-----+-----+-----+
| 4 | Consultation | | 6 | |
| | RVG | | | |
+-----+-----+-----+
| 5 | OBTURATION DONE | | 5 | |
+-----+-----+-----+
| 6 | Tooth Extraction | | 5 | |
+-----+-----+-----+
| 7 | RVG | | 3 | |
+-----+-----+-----+
| 8 | PFM CROWN CEMENTATION | | 3 | |
+-----+-----+-----+
| 9 | class 2 composite restoration with Gic Base | | 2 | |
+-----+-----+-----+

```

Figure 9: Most common procedures

3.4. Discount and Repercussions on Revenue:

- Average discount per transaction is ₹372
- Maximum discount recorded is ₹9,900

Larger discounts are attached to high-value treatments adversely affecting overall profitability. Patients that pay cash get slightly higher amounts of discount than those that use digital payment means. Similar common procedures, that of scaling and consultations, have reduced the profits of those of high-volume service. There can be structured concessions created with tiers of discounting for good revenue, yet affordability of the procedure remains the same.

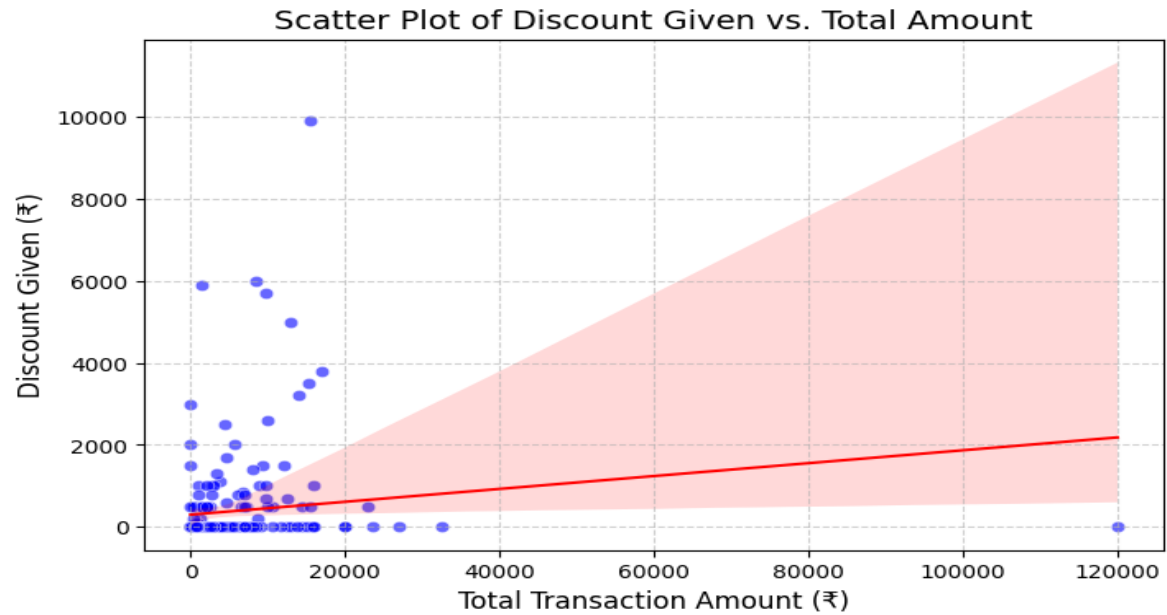


Figure 10: Scatter plot to show trend of discounts

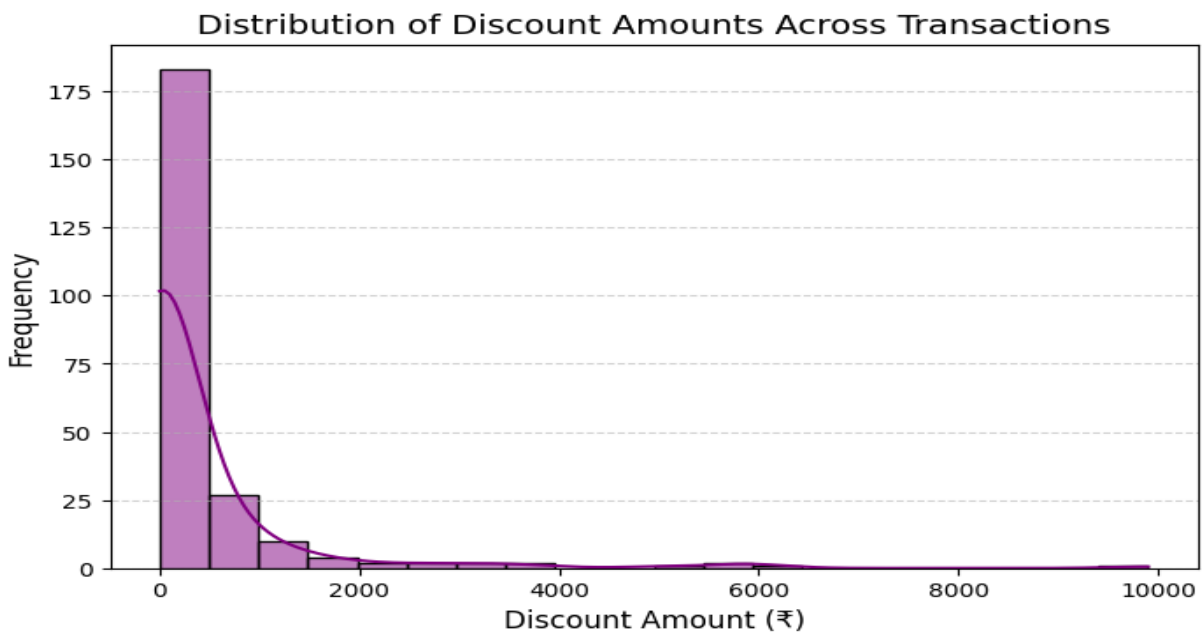


Figure 11: Histogram to show common discounts and outliers

3.5. Payment Collection Efficiency and Delayed Payments:

The bulk of outstanding balances are tied to high-value treatments such as implants, orthodontics, and full-mouth rehabilitations, also over 30% of outstanding payments remain unpaid after 30 days. Those paying in instalments more often than not have late payments. The

implementation of automated reminders and follow-ups would have a positive effect on collection rates.

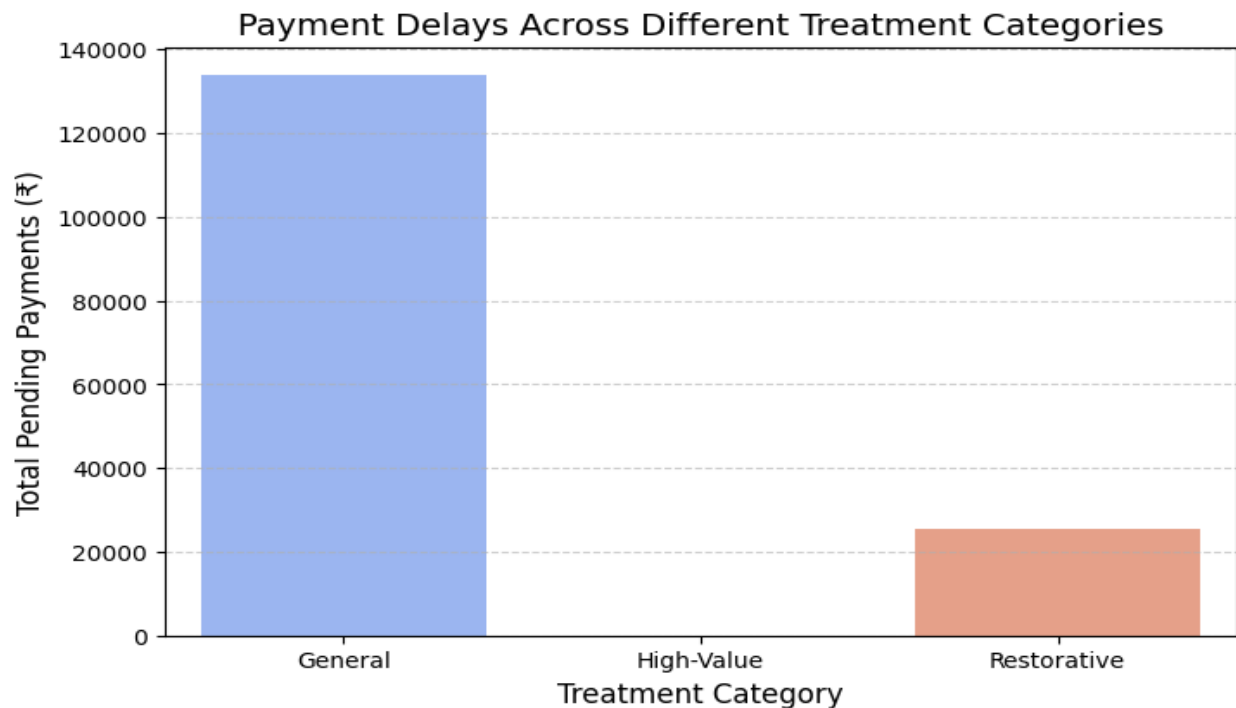


Figure 12 :Bar Chart Shows which treatment categories have the highest delayed payments.

===== Top 10 Procedures with Outstanding Payments =====

Procedures	Pending
18 CLASS 1 GIC RESTORATIONS,Consultation,RVG,ULTRASONIC SCALING,class 1 composite restoration,composite repair,CLASS 1 FLOWABLE COMPOSITE	32500
71 Consultation,RVG,class 2 composite restoration with Gic Base,composite sealant	15900
82 Corebuildup with composite,Impressions taken for Zirconia crown,class 1 composite restoration	15600
64 Consultation,RVG,Surgical Extraction,impaction	15400
46 Composite Restorations,Consultation,ULTRASONIC SCALING,class 1 composite restoration,composite sealant	10500
109 POST ORTHODONTICS COMPOSITE REMOVAL,ULTRASONIC SCALING,class 1 composite restoration	8500
1 ACCESS OPENING DONE,CLASS 2 REPAIR WITH FLOWABLE COMPOSITE,PFM CROWN TEMPORARY CEMENTATION,RVG	7800
88 Crown Preparation,FIBER POST AND CORE,composit build up,CLASS 2 COMPOSITE RESTORATION	7600
77 Consultation,ULTRASONIC SCALING	7500
47 Composite Restorations,RVG,Temporary ZOE Restoration,composite sealant	7400

Figure 13: table to help identify which procedures have the highest outstanding payments

4 Interpretation of Results and Recommendation

An assessment of the operational and financial aspects of Aadya Family

Dental Center lead to several key optimization insights. Despite the clinic's financial stability, revenue collection, appointment scheduling, pricing strategy, outstanding payments, and distribution of services mishandled have negatively affected the clinic's revenues and operations. The performance of the clinic, once fixed, will enhance patient experience, increase financial sustainability, and optimize operations. Below is an interpretation of the results with specific recommendations, all based on insights that come from the data itself.

4.1. Solutions and Recommendations for Identified Problem

Statements:

Problem 1: High Outstanding Payments and Revenue Collection Issues:

The identification of patients with payments that are either excessively dormant or where the final amount owing for treatments received is questionable has become an alarming and severe concern. Findings include that:

- Over 30 percent of all outstanding payments have surpassed 30 days in age
- High-value treatments that have accounts payable include implants and full mouth rehabilitation probably due to expense
- Much more pending dues resulted in cash payments when compared to online transactions.

Recommendations and solutions include:

- Structured payment plans for each patient with automated reminders and predated due dates
- Financial penalties could be exercised in a constructive mechanism to settle overdue payments.
- Implement partial prepayment for any high-value treatment to reduce burden on the customers.
- Create dashboards in real-time tracking the performance of collections

toward pending balances.

- Offer discounts for patients willing to pay their entire dues upfront for the treatment before commencing.

Problem 2: Inefficient Appointment Scheduling and Consultation

Overruns:

Key Findings:

- Peak hours congestion from 4 PM to 8 PM affects longer waits.
- Morning slots from 8 AM to 12 PM are unutilized and can be used to balance patient flow.
- Time taken by one consultation could vary from one minute to hours more in certain cases.

Solutions and Recommendations:

Suggested strategies for improvement include: a dynamic scheduling system to allocate longer-duration procedures to morning time slots. The introduction of some buffer time between difficult treatments to cater for overruns and delays, and discounts for services during low-demand periods if introduced will be very beneficial to equalize the distribution of patients. This will also ensure that appropriate time slots become more efficient through the use of empirical data of past performance to inform consultation time. AI-enabled scheduling software could, instead, be used to dynamically assign optimal time slots based on previous appointment patterns.

Problem 3: Underutilization of High-Value Procedures

Key Findings:

Routine procedures make up the overwhelming majority of patient visits however, they account for little of the total revenue. High-value treatments are although very profitable yet they remain highly underutilized. Tooth extraction and zirconia crowns show low frequency of utilization versus revenue opportunity (i.e for the revenue that these 2

procedures can bring, they are not being suggested or being implemented by the clinic and the patients).

Solutions and Recommendations: Patient education on high-value treatments by using in-clinic and digital marketing campaigns.

Consultations bundled with high-revenue treatments. Provide different financing options for expensive treatments. Optimizing the pricing of our services based on demand trends and ensuring they are competently but profitably priced. Staff training to suggest high-value treatments proactively for whom they are indicated.

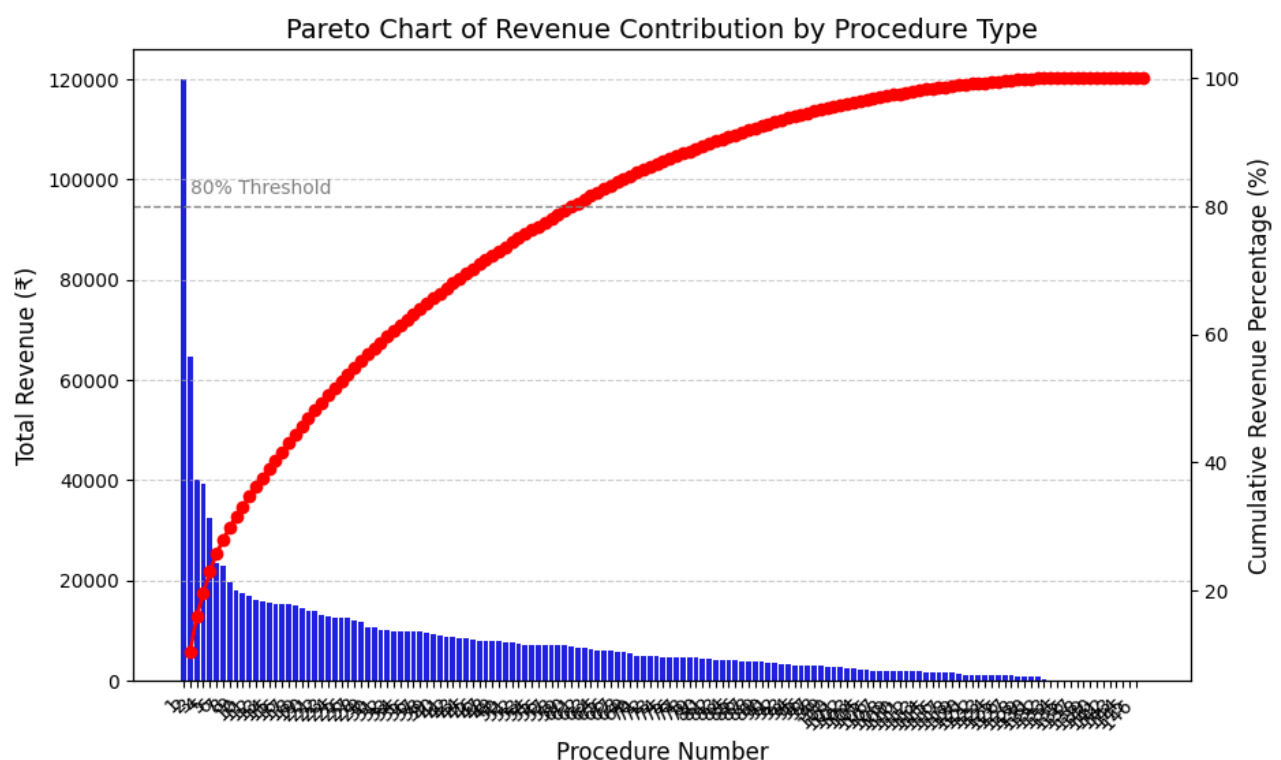


Figure 14: The Pareto chart to show the revenue contribution of each procedure.

The Pareto chart illustrates the 80/20 principle nicely, showing how just a handful of high-value procedures becomes a mega contributor to a small portion of practice revenue—a perfect reason to increase their frequency.

4.2. Additional Recommendations for Operational and Financial Optimization:

1. **The promotion of digital payment should be made more attractive:**
Small incentives should be given to the patients for online payment

methods rather than cash. This will help reduce outstanding balances, improve collection rates, and expedite financial transactions.

2. **Set up Automated Payment Reminders:** Sending SMS to the patients and also sending them emails when the payment is due would greatly ease collection problems. To ensure that payments are done on time, it is always helpful to have a reminder in place that also will cut the problem of delinquent payments.
3. **Flexibility in Instalment Plans:** Consider introducing flexible instalments for those high-cost procedures so that they are affordable and the default risk is lowered. Terms should be well defined, and there should be automatic reminders to avoid an unstable financial situation.
4. **Create a Financial Help Program:** Some of the more expensive procedures can have a financial help program where they can avail assistance in case the procedure is out of their budget this will ensure that the clinic does not lose customers due to affordability and will also gain trust and respect in the community, clear guidelines and structure should be set up to decide who is eligible for the financial help program.
5. **Optimize the structure for giving discounts:** A tiered structure of discounting should ensure that high-revenue procedures receive limited discounts, while, on the other hand, promotional offers are smartly used for those underperformed treatments.
6. **Regularly Audit Discount Trends:** Periodically review particular discounting behaviour to ensure that revenue is not leaking while still allowing proper alignment of discounts with financial goals. Understand how the patients respond to discounts to strategically encourage change.
7. **Stimulate Bulk Prepayments:** Giving small incentives for patients who prepay for several sessions or the entire treatment plan good in terms of inducing liquidity and shrinking possibilities of default or pending payments.
8. **Bundle Treatment Packages:** Group consultations, cleaning, and cosmetic treatments so that they become cost-effective packages,

leading to the adoption of high-value services.

9. **Use AI Scheduling Systems:** Optimally schedule appointments through the use of AI software avoiding congestion at peak times, thereby optimizing the flow of patients throughout the day.
10. **Build Customer Relationships by CRM System:** Patient history should be kept using a CRM system to follow up with better communication, thus enhancing the overall patient experience.
11. **Use Analytics for Decision-Making:** Historical patient cohort trends suggestions with respect to payment habit and treatment frequency take strategic decisions hence financial planning and service offerings highly optimized.

Conclusion:

This study reveals the inadequacies in payment collections, service utilization, scheduling, and discounting strategies of Aadya Family Dental Center. Implementing the above-recommended solutions and recommendations will result in greater revenue collection by optimized installment plans and financial monitoring support, improve patient scheduling to reduce congestion and increase consultations, marketing, educating, and pricing strategies would encourage high-value treatments; and guaranteed profitability through structured discounting policies and much-improved adoption of digital payment solutions. In a nutshell, by utilizing data-driven insights and operational improvements suggested, the clinic will be able to attain their lifelong financial sustainability and patient satisfaction.

Important Links:

[Final Notebook](#)

[Clinic Data](#)

[BDM Project Folder](#)

Thank you for the opportunity