

HealthFirst Medical Clinic Appointment Optimization

Data-Driven Healthcare Operations Analysis

Executive Summary

This project addresses critical operational inefficiencies at HealthFirst Medical Clinic through comprehensive data analytics. The clinic experienced high no-show rates (7.14%), excessive wait times (44-minute average), and chronic staff overtime (30-45 minutes daily). Our analysis transformed raw appointment data into actionable insights using Python, PostgreSQL, and Power BI, delivering specific recommendations to improve patient satisfaction and operational efficiency.

Key Results: Identified patterns enabling potential 50% no-show reduction, 25% wait time improvement, and elimination of chronic overtime, representing \$225,000+ in annual operational improvements.

Business Context

HealthFirst Medical Clinic operates with 15 providers serving 36,700+ patients across 111,000+ annual appointments. The clinic faced significant operational challenges:

- **Patient Experience Issues:** 44-minute average wait times with 7.14% no-show rates
- **Resource Inefficiencies:** Daily provider overtime averaging 30-45 minutes
- **Revenue Impact:** Lost income from no-shows and operational inefficiencies

Project Objective: Analyze appointment patterns, patient demographics, and operational data to provide actionable recommendations for improving clinic efficiency and patient experience.

Technical Implementation

Data Processing Pipeline

Data Source: Raw Excel files containing appointment records, patient demographics, and operational metrics spanning 2014-2024.

Phase 1: Data Cleaning & Preparation (Python)

- **Data Quality Issues:** Inconsistent formatting, missing values, and structural problems in Excel data
- **Cleaning Process:** Standardized date formats, normalized categorical data, handled missing values
- **Data Enhancement:** Used Python pandas for data manipulation and quality improvement
- **Validation:** Implemented healthcare-specific business rules and data integrity checks

Phase 2: Database Design (PostgreSQL)

- **Schema Design:** Created normalized 10-table structure for appointment, patient, and operational data
- **Key Tables:** appointments_core, patients_master, wait_times, staff_utilization, time_slots
- **Relationships:** Established foreign key constraints ensuring data integrity
- **Performance:** Implemented indexing for analytical query optimization

Phase 3: Business Intelligence (Power BI)

- **Database Connection:** Direct connection to PostgreSQL for real-time data access
- **DAX Calculations:** Advanced measures for no-show rates, utilization metrics, and operational KPIs
- **Dashboard Development:** Five specialized dashboards addressing key operational areas
- **Interactive Analytics:** Dynamic filtering and drill-down capabilities for detailed analysis

Key Technical Challenges

Challenge 1: Data Quality Issues

- Raw Excel data contained formatting inconsistencies and missing values
- **Solution:** Python-based cleaning pipeline with healthcare-specific validation rules

Challenge 2: Complex Operational Relationships

- Multiple data entities requiring proper normalization for analysis
- **Solution:** PostgreSQL relational design with optimized schema structure

Challenge 3: Real-Time Analytics Requirements

- Need for current operational insights and performance monitoring
- **Solution:** Power BI direct query connection with optimized DAX calculations

Dashboard Architecture

1. Patient Attendance Analysis

- No-show patterns by day, month, and year
- Attendance rates and cancellation analysis
- Recommendations for patient engagement improvement

2. Wait Time Optimization

- Average wait times with peak period identification
- Day-of-week and monthly patterns
- Flow bottleneck analysis and improvement opportunities

3. Resource Utilization & Scheduling

- Time slot utilization across providers and days
- Overbooking analysis and capacity management
- Appointment duration and scheduling optimization

4. Staff Overtime Analysis

- Daily overtime patterns and trending
- Provider efficiency and workload distribution
- Cost impact assessment and reduction strategies

5. Patient Demographics & Planning

- Age group distribution and service planning
 - Demographic trends (with data quality issues identified)
 - Population-specific scheduling recommendations
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Key Findings & Recommendations

Immediate Actions (0-3 months)

Patient Engagement:

- Implement automated reminder system to reduce 7.14% no-show rate
- Enable easy online rescheduling to convert no-shows to cancellations
- Target high no-show days (Tuesday-Wednesday) with enhanced communication

Wait Time Reduction:

- Extend appointment slots by 5-10% to match actual clinical needs
- Add 10-15 minute buffers after peak hours (9 AM, 11 AM, 2 PM)
- Redistribute Thursday's heavy appointment load to Friday

Medium-Term Improvements (3-6 months)

Advanced Scheduling:

- Implement appointment complexity classification with variable durations
- Create time-block scheduling for similar appointment types
- Add graduated buffers every third appointment

Demographic Optimization:

- Schedule 65+ patients (48.67% of population) in optimal morning slots

- Extend evening hours twice weekly for working-age patients (35-64 years)
- Develop virtual follow-up options for routine appointments

Data Quality Priority

Critical Issue: Identical patient counts across all years (2015-2024) indicates data replication problem requiring immediate investigation and correction.

Expected Impact

Operational Improvements

- **No-Show Reduction:** Target 50% decrease (7.14% to 3.5%) = \$150,000 annual revenue recovery
- **Wait Time Improvement:** 25% reduction (44 to 33 minutes average)
- **Overtime Elimination:** \$75,000+ annual savings through optimized scheduling

Patient Experience Enhancement

- Reduced wait times improving satisfaction scores
- Better appointment availability through optimized scheduling
- Enhanced communication reducing appointment confusion

Strategic Benefits

- Data-driven operational decision making
- Scalable analytics infrastructure for growth
- Competitive advantage through superior efficiency

Technical Deliverables

Database Infrastructure: Normalized PostgreSQL schema supporting comprehensive healthcare operations analysis

Analytics Platform: Power BI dashboards with real-time connectivity and advanced DAX calculations

Operational Insights: Five specialized dashboard areas providing actionable recommendations for immediate implementation

Quality Framework: Data validation and monitoring systems ensuring ongoing analytical accuracy



Summary

09/12/2014



01/12/2024



Total No-show

6,615

Average Waiting Time
(minutes)

44.09

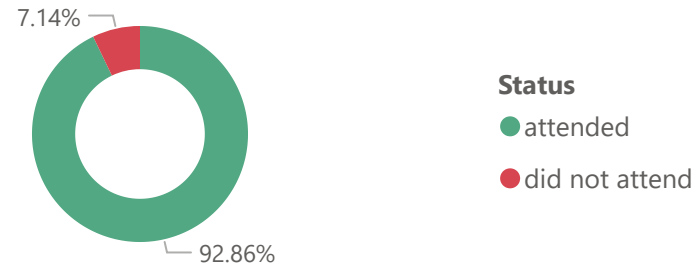
Total Appointment

111.49K

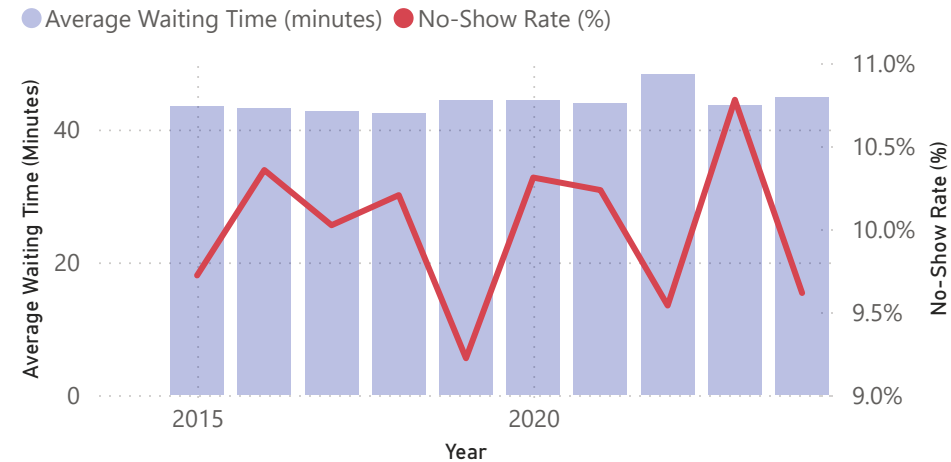
Total Patients

36.70K

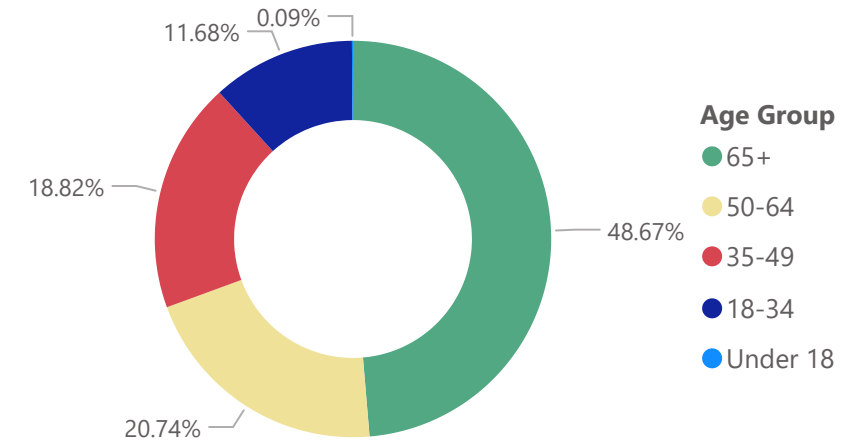
Appointments (Attended vs. No-show)



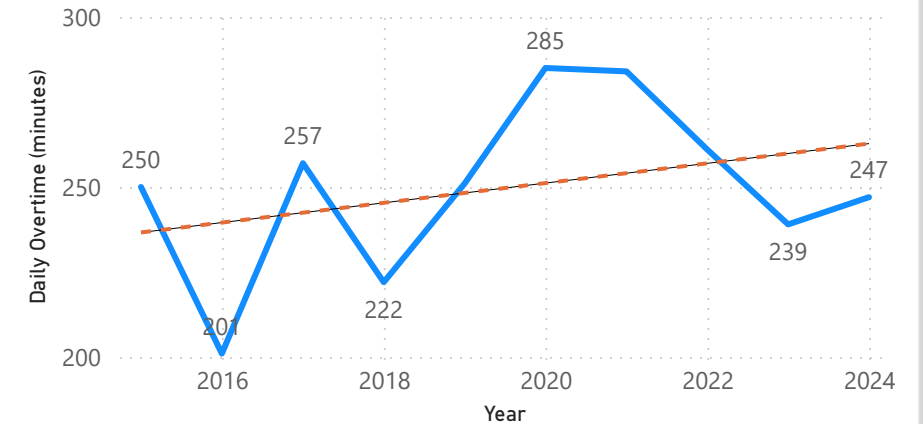
Impact of Waiting Time on No-Show Rate (Yearly)



Patient Count by Age Group



Yearly Trend: Daily Staff Overtime Minutes





Attendance

09/12/2014

01/12/2024

Total No-show

6,615

Total Show

86K

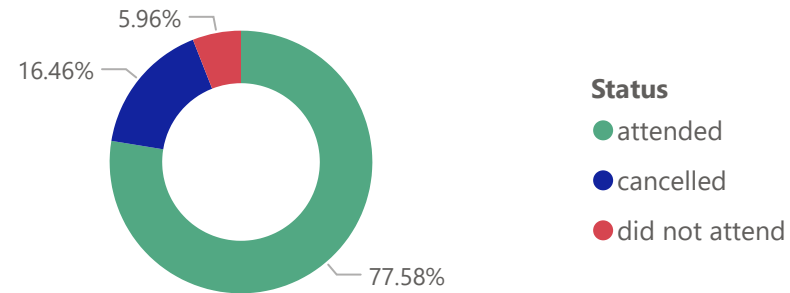
Total Appointment

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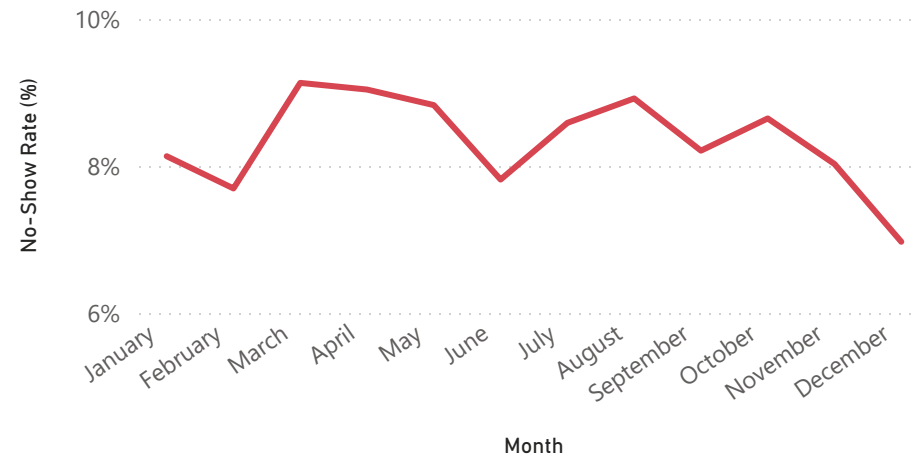
Total Patients

36.70K

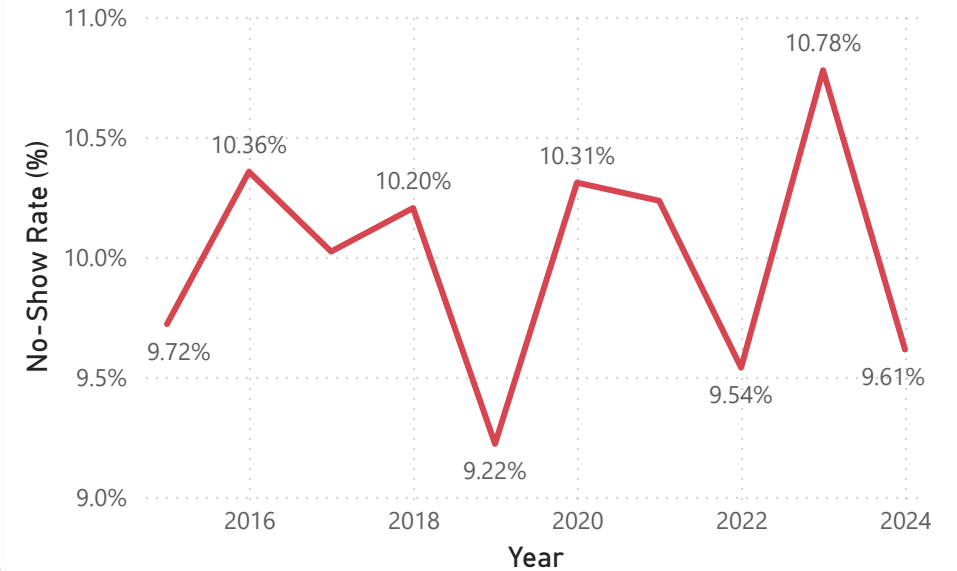
Appointments (Attended vs. Cancelled vs. No-show)



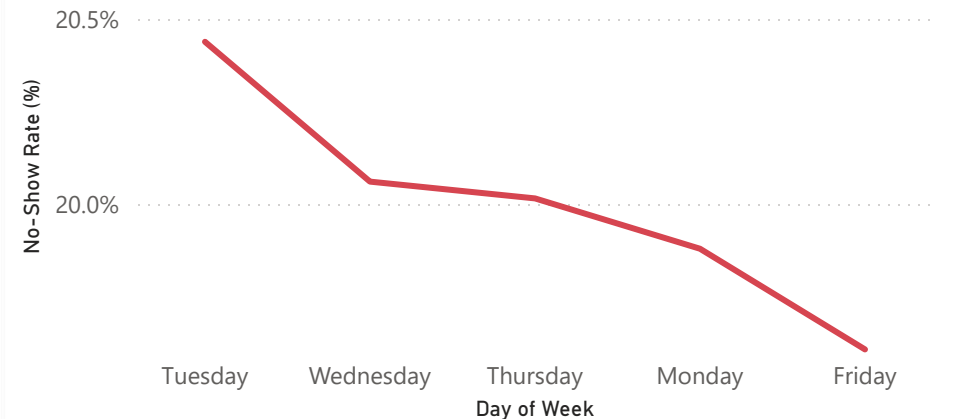
Monthly No-Show Rate



Yearly No-Show Rate



Daily No-Show Rate





Patient Wait Times

09/12/2014



01/12/2024



Average Waiting Time
(minutes)

44.09

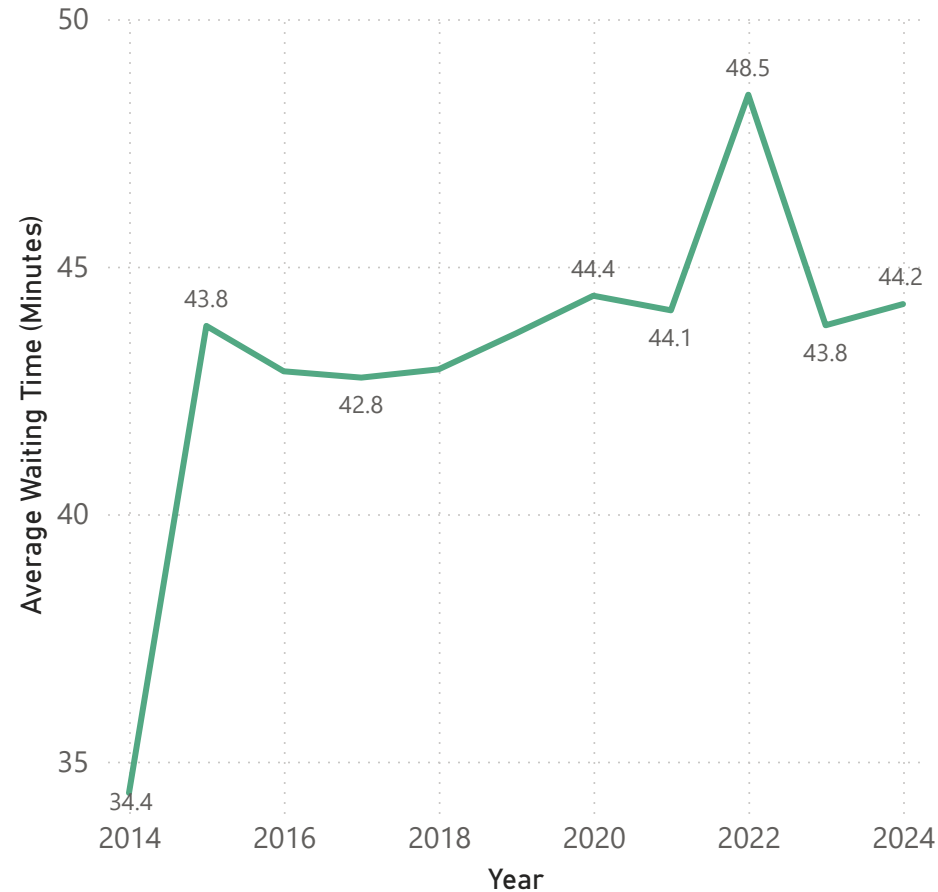
Max Waiting Time

297.30

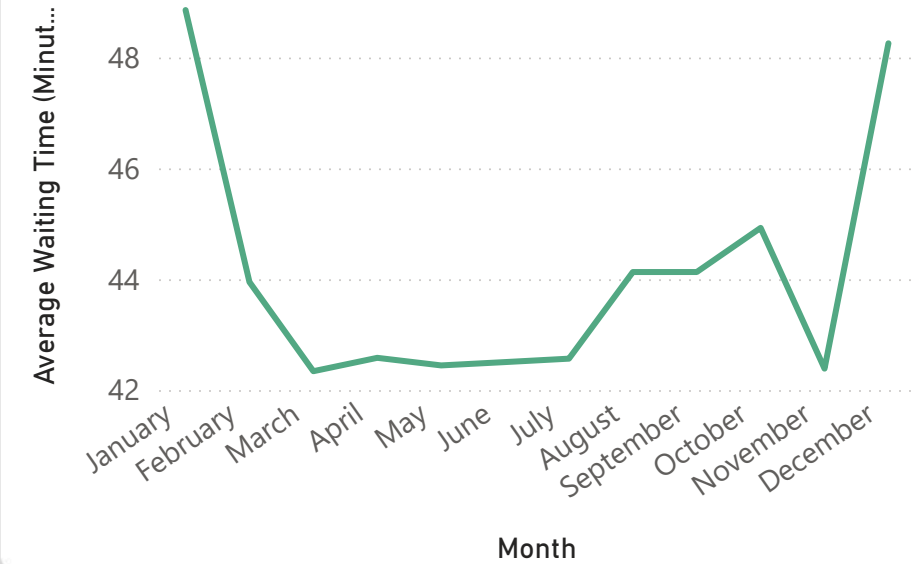
Min Waiting Time

0.60

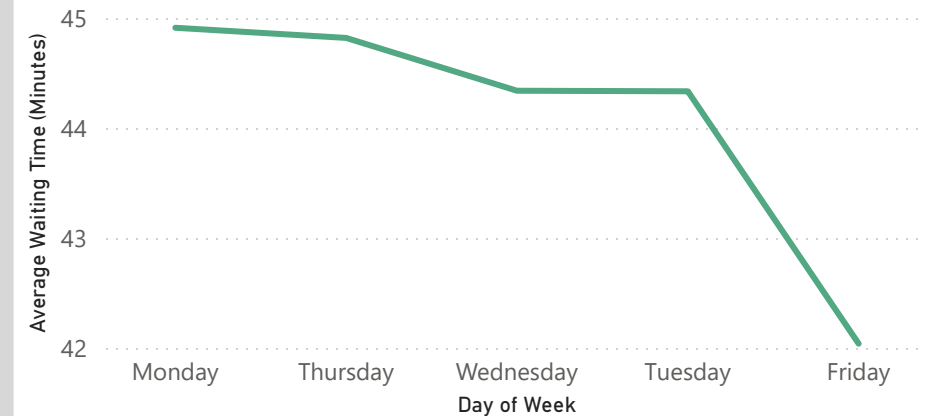
Average Patient Waiting Time by Year



Average Patient Waiting Time by Month



Average Patient Waiting Time by Day of Week





Overbooking & Time Utilization

Select Year / Quarter / Month

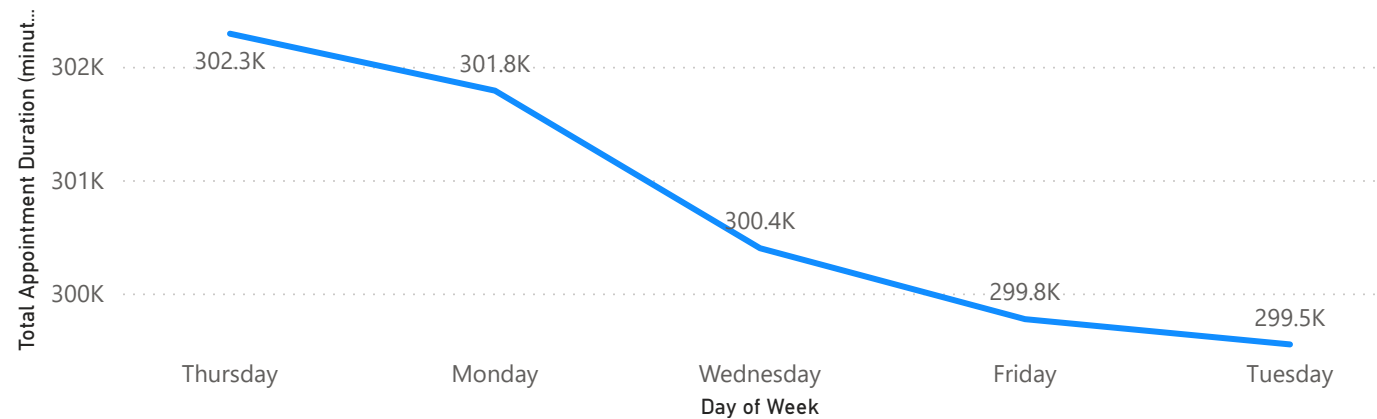
All



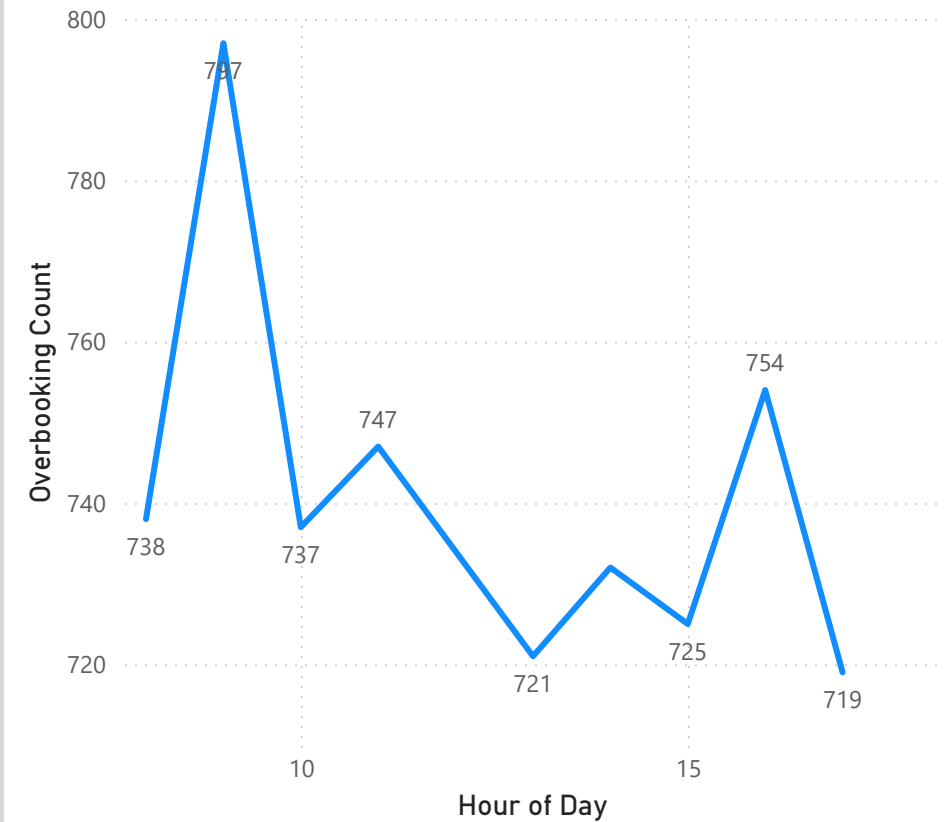
Time Slot Utilization by Day of the Week

Day of Week	8	9	10	11	12	13	14	15	16	17	Total
Friday	3.19	3.18	3.13	3.23	3.22	3.20	3.16	3.23	3.19	3.25	31.99
Monday	3.17	3.20	3.22	3.19	3.17	3.15	3.17	3.20	3.21	3.23	31.91
Thursday	3.20	3.15	3.19	3.18	3.19	3.19	3.20	3.17	3.19	3.16	31.81
Tuesday	3.19	3.19	3.19	3.17	3.18	3.19	3.20	3.15	3.14	3.18	31.77
Wednesday	3.20	3.19	3.13	3.20	3.15	3.16	3.17	3.21	3.19	3.23	31.84
Total	15.96	15.90	15.86	15.96	15.92	15.89	15.90	15.96	15.92	16.05	159.32

Total Appointment Duration by Day



Peak Overbooking Hours





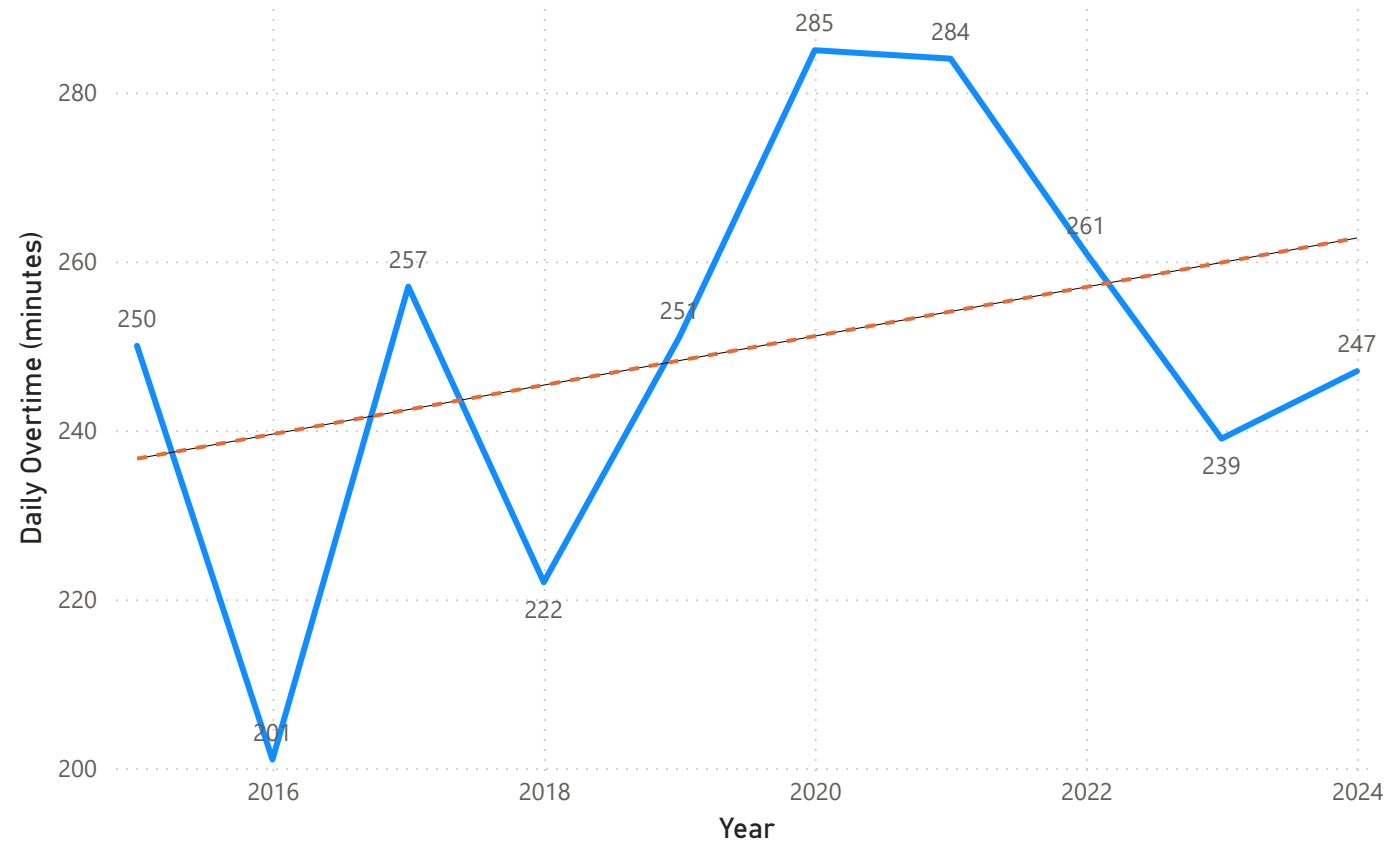
Staff Overtime Insights

Select Year / Quarter / Month

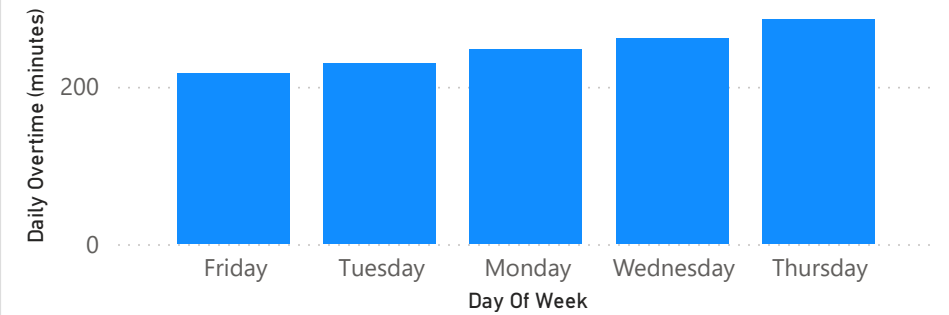
All



Daily Overtime Trends Over the Years



Daily Overtime Minutes by Day of Week



Total Daily Slots(15 Doctors)

540

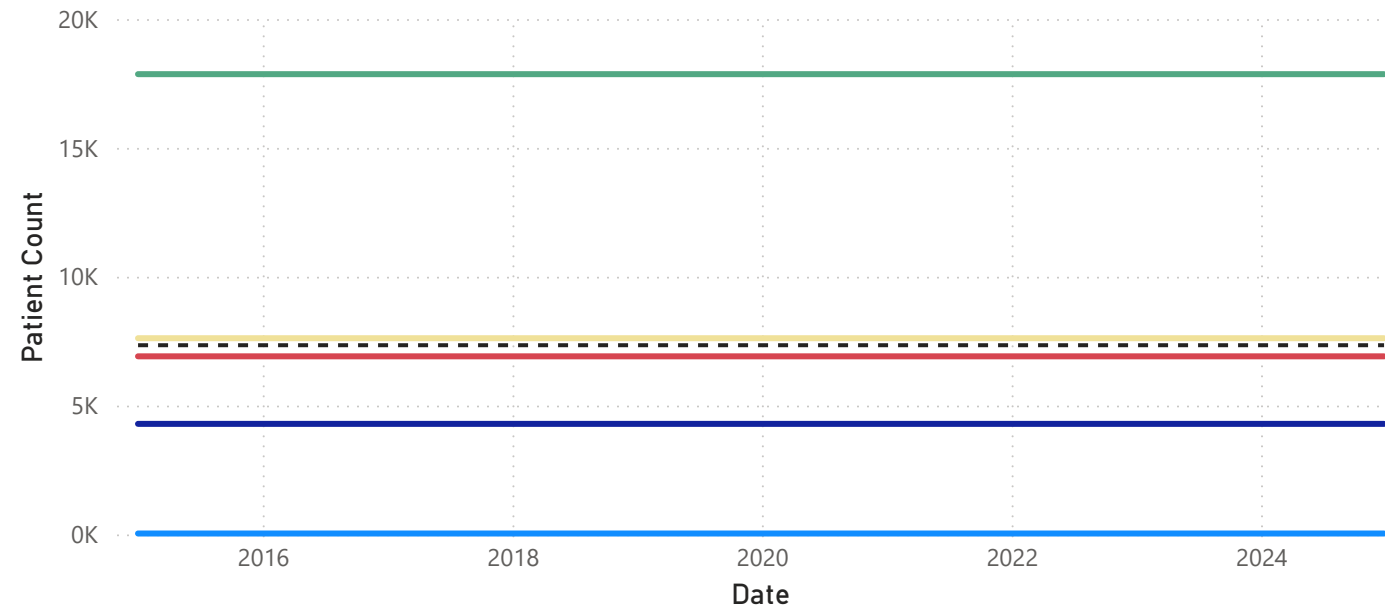




Patient Demographics Change

Patient Count by Date(Year, Quarter, Month) and Age Group

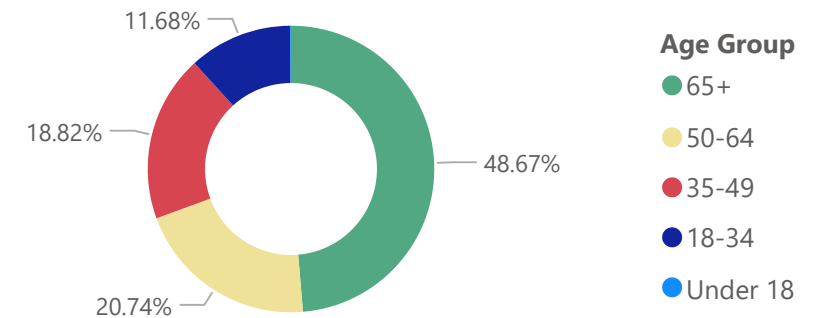
Age Group ● 18-34 ● 35-49 ● 50-64 ● 65+ ● Under 18



Zero Year-over-Year Difference

Based on the data presented in the table "Patient Count by Date(Year, Quarter, Month) and Age Group", the patient counts for each age group and the total patient count are the same across all the years from 2015 to 2024.

Patient Count by Age Group



Year	18-34	35-49	50-64	65+	Under 18	Total
2015	4287	6908	7611	17859	32	36697
2016	4287	6908	7611	17859	32	36697
2017	4287	6908	7611	17859	32	36697
2018	4287	6908	7611	17859	32	36697
2019	4287	6908	7611	17859	32	36697
2020	4287	6908	7611	17859	32	36697
2021	4287	6908	7611	17859	32	36697
Total	4287	6908	7611	17859	32	36697





Recommendations 1: Attendance

Attendance

Key Takeaways:

- The clinic has a **7.14% no-show rate**, leading to lost revenue and inefficiencies
- Cancellations also make up a small but notable portion of missed appointments
- No-show rates tend to be higher on certain days of the week

Recommendations:

- Implement a reminder system (calls, texts, or emails) to reduce no-show rates
- Offer easy rescheduling options to encourage cancellations rather than no-shows
- Analyze patterns to optimize scheduling on high no-show days





Recommendations 2: Patient Wait Times

Patient Wait Times

Key Takeaways:

- Average wait time is **44.09 minutes**, with a peak of **297 minutes** in extreme cases
- Higher wait times may contribute to patient dissatisfaction and possible no-shows
- Wait times fluctuate by day and month, with certain periods seeing significant spikes

Recommendations:

- Adjust staff schedules to reduce peak wait times
- Improve patient flow by streamlining check-in and processing times
- Set realistic appointment durations to prevent excessive delays





Recommendations 3: Overbooking & Time Utilization

Overbooking & Time Utilization

We offer the following recommendations to address the issue of medical staff regularly working 30-45 minutes beyond their scheduled hours:

Key takeaways & Recommendations

Adjust Appointment Slot Duration: The Time Slot Utilization data shows consistent averages around **3.20 hours per practitioner across all hours of the day**. Consider extending appointment slots by 5-10% to better reflect actual time needed for patient care.

Implement Time Buffers Between Peak Hours: The Peak Overbooking Hours graph shows significant spikes, particularly around **hour 9 (approximately 800 overbooking instances)**. Add 10-15 minute buffer periods following the 9:00, 11:00, and 14:00(after lunch) time slots to allow practitioners to catch up

Day-Specific Scheduling Adjustments: Thursday begins with the **highest appointment duration (302.3K minutes)** but declines throughout the week. Redistribute appointment load from early week to later week days, particularly Friday which shows capacity for additional bookings





Recommendations 4: Staff Overtime Insights

Staff Overtime Insights

Key Takeaways:

- Persistent overtime averaging 30-45 minutes per day affects provider well-being and operational costs
- Data indicates systemic scheduling issues rather than individual provider inefficiency

Recommendations:

Implement Graduated Scheduling: Add 10-minute buffer periods every third appointment, Creates natural recovery time throughout the day also maintains overall appointment capacity and prevents cascading delays.

Appointment Type Classification System: Categorize appointments by complexity, allocate time based on historical duration data, move beyond one-size-fits-all appointment durations and match scheduling to actual clinical requirements.

Time-Block Scheduling: Group similar appointments together, designate specific portions of each day for different appointment types.





Recommendations 5: Patient Demographics Change

Patient Demographics Change

Key Takeaways

Data Quality Issue: The dashboard shows identical patient counts across all years (2015-2024) for each age group, indicating a significant data quality problem rather than actual demographic stability.

65+ Population Dominance: The 65+ age group represents nearly half (48.67%) of all patients, requiring specialized consideration in scheduling practices.

Recommendations:

Data Quality Remediation: Immediately investigate and correct the data replication issue showing identical patient counts across all years, implement data validation protocols to ensure accurate demographic tracking.

Senior-Focused Scheduling: Dedicate morning appointment blocks for 65+ patients when mobility and cognition are typically optimal, extend appointment durations for complex geriatric cases and ensure facility accessibility meets the needs of this predominant demographic.

Working-Age Accommodation: Introduce extended evening hours twice weekly to serve the 39.56% of patients in the 35-64 age range. Develop virtual care options for routine follow-ups to minimize work disruption.

