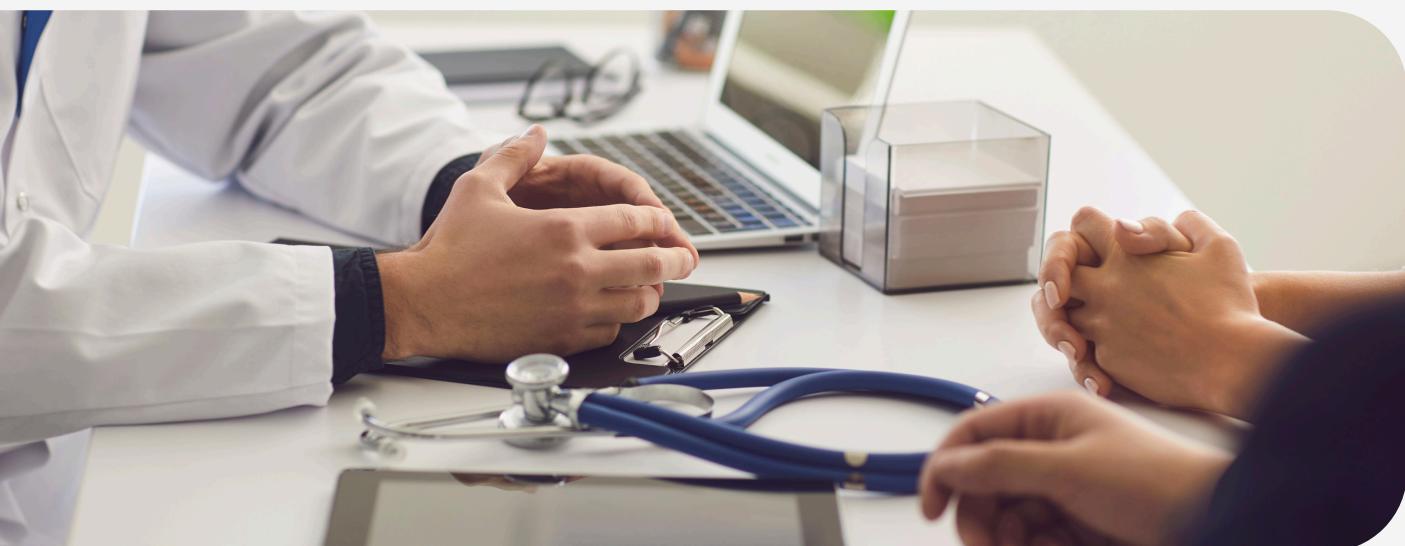


Saúde + Health Center

CASE STUDY

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Process Intelligence

Project done by Group G:

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INTRODUCTION

Saúde+ Health Center is a medium-sized private orthopedic general medicine and physiotherapy clinic. Due to its best location within an urban setting, it boasts advanced patients from all regions of the country. Both patients with and without insurance visit the clinic.

The clinic has invested significantly in digitalizing its services in recent years in such a way that both clinical and administrative events are recorded systematically in structured formats.

Despite the steady growth in the number of appointments being filled, there has been growing concern from the management team about the efficiency of operations and declining rates of patient satisfaction. One of the most significant identified processes is the medical appointment process, which is already seen as inefficient and difficult to track. Management also recognizes that they lack a good insight into the causes that lead to patient dissatisfaction, or into the impact of specific issues, such as cancellations, delays, or the occurrence of undesired activities.

In response to such issues, Process Intelligence techniques, in this case Process Mining, are applied for this project to analyze real data from the clinic. It seeks to:

- Get insight into how the appointment process is actually occurring (AS-IS);
- Verify or refute initial management assumptions;
- Review the impact of variables such as age, insurance status, patient location, and chronic disease on results;
- Identify wasteful or unnecessary activity in the process.

With Celonis software and combining detailed event log data with contextual business data, this analysis will improve process transparency, optimize processes, and benefit the Saúde+ Health Center to deliver more consistent and better quality care.

THEORETICAL BACKGROUND

Process Mining is an area that integrates business process management and data science principles with the aim of uncovering valuable and actionable insight from event logs retained by information systems. Event logs document the work process of activities executed in the course of service delivery or operation of processes, enabling organizations to observe how work is indeed being executed.

There are three broad categories of Process Mining techniques:

- Process Discovery: Builds a process model directly from event log data, exposing the actual behavior of the process without resorting to preconceived assumptions.
- Conformance Checking: Compares real-world process executions (AS-IS) against an ideal or preconceived process model (TO-BE) to detect deviations, violations, or missing steps.
- Enhancement: Improves existing models by adding performance metrics and contextual information to reveal inefficiencies, delays, and constrictions.

For this project, we used the Celonis Execution Management System (EMS) as the core platform for Process Mining. Celonis enables event log data and case-level attribute integration, along with process variant exploration, activity frequency and duration, and root cause analysis capabilities. The software supports creating dynamic dashboards that users can use to monitor key performance indicators (KPIs), follow cases, and introduce simulation-based improvements.

The relevance of Process Mining for the healthcare sector, and Saúde+ Health Center in general, is enormous. Medical consultation processes often involve multiple stakeholders (doctors, administrative staff, patients), multiple dependent systems, and high variability. Delays, cancellations, and rework are usual pain areas that do not always manifest themselves with regular reporting.

Through the combination of process recordings with event-based analysis, Process Mining allows healthcare organizations to:

- Discover and quantify inefficiencies (e.g., waiting times, unnecessary steps);
- Uncover patterns of low satisfaction;
- Test or disprove managerial assumptions;
- Support evidence-based decision-making for quality and outcome improvement.

Ultimately, Process Mining is a solid foundation for transparency, efficiency, and continuous improvement in intricate service settings such as health.

PROJECT DESCRIPTION AND GOALS

The main purpose of this project is to investigate the end-to-end medical appointment process in Saúde+ Health Center, using Process Intelligence techniques, namely Process Mining. Since the clinic is suffering from decreasing patient satisfaction and operational inefficiency, analysis within this work seeks to determine what is really happening throughout the appointment process and where improvement opportunities lie based on facts.

Using the information provided which includes, an event log (with timestamped activity for each appointment) and a case table (with contextual information such as age, region, insurance status, satisfaction score, etc.) our objective was:

- To analyze and profile the current "AS-IS" process, capturing the real sequence of activities patients follow when they attend medical appointments;
- To measure the degree of patient satisfaction, establishing the conditions, segments, or behaviors where lower satisfaction is observed.
- Assess and quantify process variation, including departures from regular flow and instances of inefficient or redundant functions;
- Quantify the impact of patient factors, including insurance coverage, age group, living area, and the presence of chronic disease;
- Formulate actionable, evidence-based recommendations to improve overall process efficiency, reduce patient frustration and enable better service delivery.

By working towards these goals, the project aims not merely to provide improved insight into clinic operational dynamics, but also to assist with its strategic aim of providing more transparent, stable, and patient-centered care.

METHODOLOGY

The data used for this analysis was provided in two structured tables:

- **Case Table:** Contextual information about each appointment case, including variables such as patient age, gender, region, insurance status, chronic condition, satisfaction score, total cost, number of previous appointments, and cancellation history;
- **Event Log:** A chronological record of all activities performed during each medical appointment, including timestamps and activity labels.

Variable	Description
case_id	Case ID (appointment ID)
Patient_age	Patient age
Patient_gender	Patient gender (female, male, other)
Patient_region	Patient region (north, south, center, islands)
Has_insurance	Patient has insurance (true, false)
Total_cost	Total cost of the appointment
Chronic_condition	Patient chronic condition (none, diabetes, ...)
Satisfaction_score	Satisfaction score of the appointment (0-5)
Num_previous_appointments	Total number of previous appointments in the last 3 months
Cancellation_history	Total number of cancelled appointments in the last 3 months

Figure 1 - Case Table

Variable	Description
case_id	Case ID (appointment ID)
timestamp	Timestamp
activity	Activity name

Figure 2 - Event Log

To enable meaningful analysis, an **ETL (Extract, Transform, Load)** process was conducted with the following steps:

DATA EXTRACTION

The event log and case table were imported from the original source files. Initial verification ensured that all case_id values present in the event log had matching records in the case table. Duplicate entries and inconsistent IDs were removed to guarantee one-to-one integrity between logs and cases.

During this initial exploration, it was observed that some appointments in the case table lacked corresponding entries in the event log. To ensure data consistency and avoid analytical bias, only cases with complete information in both tables were retained. This resulted in a filtered and cleaned case table, used as the base for subsequent analysis.

DATA TRANSFORMATION

Timestamps were standardized into a consistent datetime format compatible with Celonis EMS. Activity names were also cleaned and normalized to improve readability and ensure visual consistency across dashboards.

Categorical fields such as gender, region, insurance status and chronic condition were standardized and recoded where necessary, for example binary indicators like “has chronic condition”, to facilitate segmentation, filtering and aggregation in dashboards. New columns were derived as needed to support advanced filtering and root cause analysis.

DATA LOADING

In the Celonis EMS platform:

- We defined the Event Log as the primary activity table, with the following key fields:
 - Case ID (case_id)
 - Activity (activity)
 - Timestamp (timestamp)

The Case Table was linked to the event log via the case_id, creating a one-to-one relationship that allowed case-level attributes to enrich the process analysis.

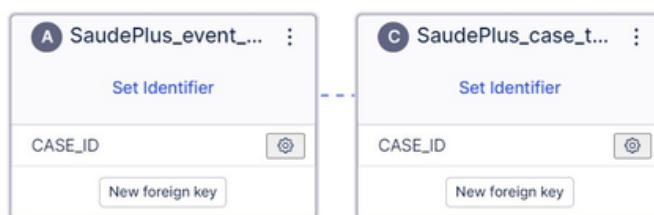


Figure 3 - Data Model

Following the data preparation and modeling, a dashboard report was created in the Celonis EMS platform in order to visualize the data provided. The analysis was refined continuously to ensure complementary insights across different views, facilitating thorough exploration and decision-making.

PROCESS ANALYSIS

The clinical care process is made up of several sequential steps with a direct impact on the patient experience, healthcare team productivity, and operational cost of the organization. In order to understand closely how these processes are unfolding in real-life, we developed segmented analysis from different vantage points through the dashboards built with the help of the Celonis platform. This analysis was divided into six main areas, each one being a main element in diagnosing the actual process ("AS-IS") of the Saude+ Health Center clinic.

Variant Explorer

Identify and understand the different paths that patients take in the care process at the Saude+ clinic, analyzing which sequences of activities are most frequent and which cause deviations, inefficiencies or rework.

Process Explorer

Visualize the actual sequence of activities carried out in the clinical care process at Saude+ and detect patterns, deviations and bottlenecks that impact care time and patient satisfaction.

Detailed Overview

Deepen the understanding of differences between patient profiles and their impact on satisfaction, cost and volume of care. It crosses multiple clinical and administrative variables to reveal hidden patterns and causal relationships.

Business Overview

Provide a global view of the performance of the Saude+ clinic, crossing operational, financial and satisfaction indicators. It summarizes the main KPIs of the care process and allows the evaluation of patterns by patient profile.

Time Analysis

Analyze the duration of appointments at the Saude+ clinic. Understand where time is being wasted, identify groups with longer appointment times and know where to act.

Process Quality & Patient Impact Analysis

Identify, quantify and contextualize undesired activities in the Saude+ care process, evaluating who the most affected patients are, how much time is lost until the deviation occurs and what the clinical and operational implications are.

VARIANT EXPLORER

The Variant Explorer offers a quantified and organized representation of the actual care delivery process of Saúde+ Health Center with high dispersion along the activity sequences accomplished in patient appointments. Out of 1,190 cases registered and 148 variants identified, the direct relationship between case numbers and variant variety demonstrates a process with operational flexibility but also with possible structural fragmentation. The cases-to-variants ratio (around 8.04) implies that for about eight patients on average, a particular path is taken.

The most frequent variant, accounting for 23.11% of all instances recorded (275 of 1,190 total instances), matches the sequence "Check-in at Reception → Return Another Day." In this pattern, the patient is checked in formally but does not receive a consultation within the same day, therefore comfortably outclassing the second most frequent variant, accounting for 16.55% of instances (197 total instances). The overall difference of 77 instances between the two versions accounts for 6.47% of the entire dataset, which indicates that early termination of the clinical process is more common than timely medical continuation, at least when measured on a per-version basis.



The variants ranking third to sixth have frequencies ranging from 4.54% to 5.38%, or 54 to 64 cases each, and show a significant drop in relative frequency following the two dominant variants. This distribution suggests the existence of two principal groupings of behavior, followed by a long tail of rarer variants.

Frequencies drop below 3.3% from the seventh position, down to 1.6% for the tenth-ranked variant in prevalence. Cumulatively, the top 10 variants account for 69.81% of all cases, and the remaining 148 variants are spread out over 30.19% of cases, reflecting intense behavioral concentration by a small number of pathways combined with extensive fragmentation in the remainder.

Figure 4 - Happy Path

VARIANT EXPLORER

Behaviorally, it is interesting that seven of the top 10 variants include the "Orthopedic Consultation" activity, affirming orthopedics as a core specialty in the operational model of the clinic. However, the most common variant rules out any clinical delivery and ends up in "Return Another Day". The existence of a high-volume non-clinical variant in conjunction with lower-frequency clinical pathways indicates an operational asymmetry where incomplete pathways dominate over any one complete clinical flow.

Furthermore, a few of the most frequent variants hold operations such as "Receive Prescription," and therefore both successful and failed process flows fall within the most common patterns.

The process visually confirms the most common variant is a short, linear sequence (Start → Check-in at Reception → Return Another Day → End), iterated 275 times without looping or deviation. While this may be a sign of efficiency in flow form, it is a failure to provide service from a clinical point of view. In contrast, the more complex and variable clinical routes which follow are mixes of consultations, tests, prescriptions, and occasional complaints, which by their nature allow for greater variability in execution time and result.

Statistically, the decrease in case number between the most frequent first variant (275 cases) and the tenth variant (19 cases) shows a 1,350% relative difference, supporting a strong skew in pathway frequency distribution. The proportion of the first to the second most frequent variants ($275/197 \approx 1.396$) shows that the interrupted path (Return Another Day) is almost 40% more frequent compared to the main completed clinical path, supporting the dominance of interrupted or delayed flows over same-day care episodes.

Incorporating measures like an Average Cost of €61.35 and a Median Customer Satisfaction of 3.9, enables positioning the extent to which process structure impacts both cost efficiency and patient satisfaction. Though cost remains unchanged on average, it is possible for it to be higher because of variants ranging from delays, repetitions or returns. The rating of satisfaction at just below the positive-to-neutral boundary suggests the influence of non-clinical variants on perceived service quality. The correlation of median-level satisfaction with high-frequency, incomplete variants affirm the influence of variant structure on the clinic's operational performance measures.

Process Variant	Number of Cases	Case Share (%)
Check-in at Reception, Return Another Day	275	23.11
Check-in at Reception, Orthopedic Consultation, Receive Prescription, Payment at Reception	197	16.55
Check-in at Reception, Orthopedic Consultation, Receive Prescription, Receive Exam Results, Payment at Reception	64	5.38
Check-in at Reception, Orthopedic Consultation, Receive Prescription, Perform Exams, Payment at Reception	59	4.96
Check-in at Reception, Orthopedic Consultation, Complaint, Receive Prescription, Payment at Reception	54	4.54
Check-in at Reception, Orthopedic Consultation, Receive Prescription, Schedule New Consultation, Payment at Reception	54	4.54
Check-in at Reception, Receive Prescription, Orthopedic Consultation, Payment at Reception	39	3.28
Check-in at Reception, Orthopedic Consultation, Payment via App, Receive Prescription	26	2.18
Check-in at Reception, Missed Turn	21	1.76
Check-in at Reception, Waiting for Doctor, Orthopedic Consultation, Receive Prescription, Payment at Reception	19	1.6

Figure 5 - Frequent Process Paths and Their Impact

PROCESS EXPLORER

The Process Explorer representation provides a structural overview of the care delivery process of Saúde+ Health Center, such as the most frequent trajectories, the sequential density of administrative and clinical activities, and the nodal points in the process. Across a dataset of 1190 clinical cases, the observed structure exhibits a strong convergence towards a trunk of standardized activities, kicked off by the entry point "Check-in at Reception", which is found in 100% of the cases and thus the absolute starting event in all the logged instances.

Activity	Number of Cases
Check-in at Reception	1190
Orthopedic Consultation	894
Receive Prescription	894
Payment at Reception	804
Return Another Day	275
Complaint	191
Receive Exam Results	185
Schedule New Consultation	152
Perform Exams	137
Payment via App	94

Figure 6 - Top Activities by Case Volume

PROCESS EXPLORER

The flow from Check-in at Reception to Orthopedic Consultation, if not always true, is typical to an extremely large degree and occurs in 664 cases, or 55.8% of total cases. This indicates that in almost 44.2% of visits, the pathway diverges from the orthopedic clinical pathway either due to routing to other departments, early closure, or administrative closings only. But the orthopedic consultation activity is repeated 894 times, which means that not all consultations are in linear sequence from Check-in at Reception, some will be by returns, indirect entry, or rebooked consultations.

Following the consultation, the activity Receive Prescription also has 894 instances, showing a 100% co-occurrence with the orthopedic consultation activity. Every case of orthopedic consultation includes a prescription phase as well, thus forming a fixed sub-sequence in the process. In only 583 of these cases does the process move from the consultation to the prescription phase directly without steps in between, which shows a direct path proportion of 65.2%. This is the finding that in 34.8% of the cases, there are other activities taking place between these two nodes, such as patient reallocation, waiting, or administrative tasks—leading to latent process complexity amidst even apparently standardized flows.



The subsequent step to Payment at Reception is observed in 804 cases, 358 of which occur immediately following the prescription phase. This means that less than half of the individuals who receive a prescription proceed directly to payment, with the implication that over half of the patients may take intermediate steps, delay the payment process, or fall out due to factors not represented in the linear flow, such as post-consultation tests or organizational policies waiving payment at that point.

The activity End, while present in all 1190 cases, is the technical closure of the process by the system and should not be mistaken for clinical reality, the actual cessation of care. The whole linear progression Check-in at Reception → Orthopedic Consultation → Receive Prescription → Payment at Reception → End occurs much less often than the summative activity frequencies imply, since there are variants with loops, reentries, skipped steps, or interrupting events such as complaints and missed appointments.

Figure 7 - Most common event flow

PROCESS EXPLORER

These exceptions are reflected in the accompanying activity frequency table. Orthopedic Consultation and Receive Prescription both occur in 894, whereas Payment at Reception falls to 804, implying that 90 patients received a prescription but didn't proceed with payment, potentially due to waived charges, external payment systems, or patient dropout. Return Another Day appears in 275 times, which exactly matches the most frequent variant identified previously using the Variant Explorer, supporting its systemic recurrence. Complaint is found in 191 times, appearing in 16.05% of the dataset and likely across numerous process steps as a non-terminal action. Receive Exam Results (185 cases) and Schedule New Consultation (152 cases) also suggest secondary flows or follow-up sub-paths that drive the clinical process ahead of the primary flow.

Along with this structural analysis is the Distribution of Patient Satisfaction, peaked mid-to-upper on the satisfaction scale. Score 4 is the modal score, at 423 cases, followed by score 3, at 373 cases, and together they represent 796 out of 1190 cases, or 66.89% of all feedback. Score 5, the highest level of satisfaction, accounts for 142 cases (11.93%), somewhat more than score 2 answers (137 cases), and far more than the lowest levels of satisfaction: score 0, with 61 cases, and score 1, with 54 cases. This distribution generates a skewed-left curve with an inturned peak at scores 3 and 4, indicating that pure dissatisfaction is relatively rare (9.6% total for scores 0 and 1), as are truly exceptional experiences (score 5).

Comparison with the observed process structure gives the distribution interpretive importance. Even with a stable central flow - Orthopedic Consultation → Receive Prescription → Payment at Reception - the number of alternative routes, discontinuity of care in principal variants (those with endings in Return Another Day included), and the non-trivial incidence of frictional activities like Complaint must slow up concentration of satisfaction at the high end of the scale. The mere ranking of score 5 as only third in terms of frequency, ranking behind scores 3 and 4, attests to the impression that although the process is generally perceived as acceptable or fair to good, it may not necessarily achieve excellence in the view of the majority of patients all the time.

BUSINESS OVERVIEW

The Business Overview presents an integrated visualization of the macro-level indicators outlining operational, demographic, and experiential dimensions of the care process at Saúde+ Health Center. Using the total of 1,190 appointments as the analytical benchmark, the key KPIs: Average Appointment Cost (€61.35) and Average Patient Satisfaction (3.59/5) - form the quantitative axis on which a multidimensional perspective of the clinical and financial environment unfolds.

The distribution of insurance status shows 683 appointments (57.4%) with uninsured patients and 507 appointments (42.6%) with insured patients. This division is not only in terms of volume: the average satisfaction of the insured patients is 4.10, while that of the uninsured community drops significantly to 3.22. The 0.88 satisfaction point difference is not negligible and is the highest satisfaction delta observed in all demographic segments in the dashboard. It implies a measurable experiential variation associated with socioeconomic or process variables involved in insurance status, and may reflect difference in terms of availability, processing time, or post-service activity.

Region	Satisfaction	Avg Cancellation	Appointments
Center	3,72	0,46	491
Islands	3,58	0,64	231
North	3,56	0,41	231
South	3,39	0,59	237

Figure 8 - Regional Appointment and Satisfaction Overview

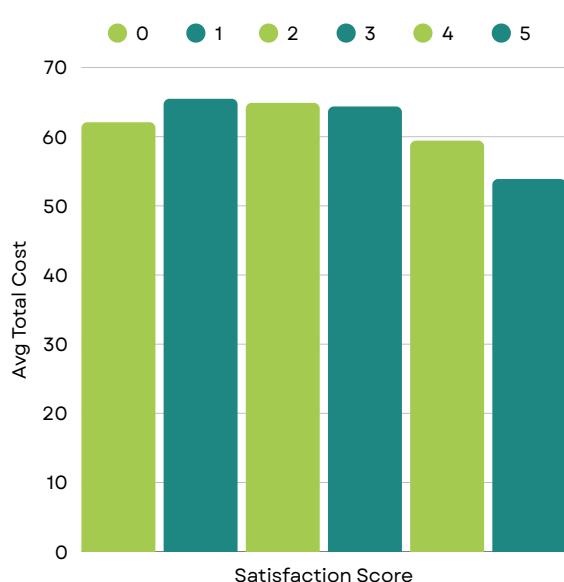


Figure 9 - Appointment Cost by Satisfaction Score

Examining the cost-satisfaction curve, the Appointment Cost by Satisfaction Score graph demonstrates a clear inverse gradient. There is a positive correlation between lower satisfaction scores and increased mean costs.

The difference between the highest priced group (score 1, €65.49) and lowest priced group (score 5, €53.88) is €11.61, or 18.1% of an appointment's average cost, and confirms that perceived value increases with decreasing resource intensity and cost. This inverse correlation can be interpreted as evidence for more lengthy, more complex, or admin-heavy appointments with less favorable perceptions - especially in case of uncompleted clinical issues or waits.

BUSINESS OVERVIEW

In the context of long-term health diseases, patients are distributed as follows:

- None: 61.18% of the visits (728 cases), satisfaction 3.56
- Diabetes: 14.71% (175 cases), satisfaction 3.64
- Asthma: 9.83% (117 cases), satisfaction 3.71
- Hypertension: 9.83% (117 cases), satisfaction 3.47
- Others (Heart Disease): 4.45% (53 cases), satisfaction 3.93

This breakdown shows that while patients with no chronic condition are the largest, their average satisfaction is below the world's average, and even below the patients with asthma, diabetes, or heart disease. Strikingly, the patients with heart disease, the smallest group, have the highest average satisfaction (3.93), even above the general insured patient average. In contrast, hypertensive patients, of the same volume as asthma cases, report the lowest level of satisfaction (3.47) of the chronic condition subgroups, supporting the idea that clinical complexity is not the sole determinant of satisfaction—perceived quality and care trajectory subtleties are also at work.

Geographically, the Center leads with 491 appointments and a 3.72 level of customer satisfaction followed by the South and North with lower volumes of 237 and 231 cases, respectively, and customer satisfaction levels of 3.39 and 3.56. The Islands with 231 cases have a satisfaction level of 3.58 but the largest cancellation rate of 0.64 which may cross-cut service accessibility or follow-up logistics. These regional variations reveal moderate but real spatial differences in appointment management dynamics and patient experience.

Finally, low satisfaction cases (scores 0–2) total 252 cases, or 21.17%. This is compared to 423 cases (35.55%) for score 4 and 142 cases (11.93%) for score 5. Overall, high scores (4 and 5) total 47.48% of responses, illustrating a bimodal satisfaction situation in which roughly one in five patients are dissatisfied and nearly half rate positively—with cost efficiency approximating the latter most closely.

DETAILED ANALYSIS

The Detailed Analysis dashboard supplements the macro-level KPI's with behavioral intelligence that interprets trends in patient volume, visit rate, chronic condition impact, and satisfaction/cost dynamics. The substructure integrates temporal behaviors, cancellation effects, and demographic splits by layers, giving an actionable insight into how the Saude+ Health Center could enhance its patient journey and operational efficiency.

The most striking pattern observed is the distribution of appointment volume throughout the week. The appointments build up steadily after Monday (the low point with 154 appointments) and reach their highest point during the weekend, with Saturday receiving the highest number of appointments at 200, followed closely by Sunday at 176. The trend shows that a high volume of patients either prefer or are available only for weekend visits, possibly because of work or other obligations during the week. The large weekend volumes require deliberate rebalancing of staff and resources to maintain quality of service through these periods of increased demand. Tuesday is also an unusual outlier for a weekday, with 173 appointments, raising the hypothesis of an early-week peak in health-seeking activity after the weekend.

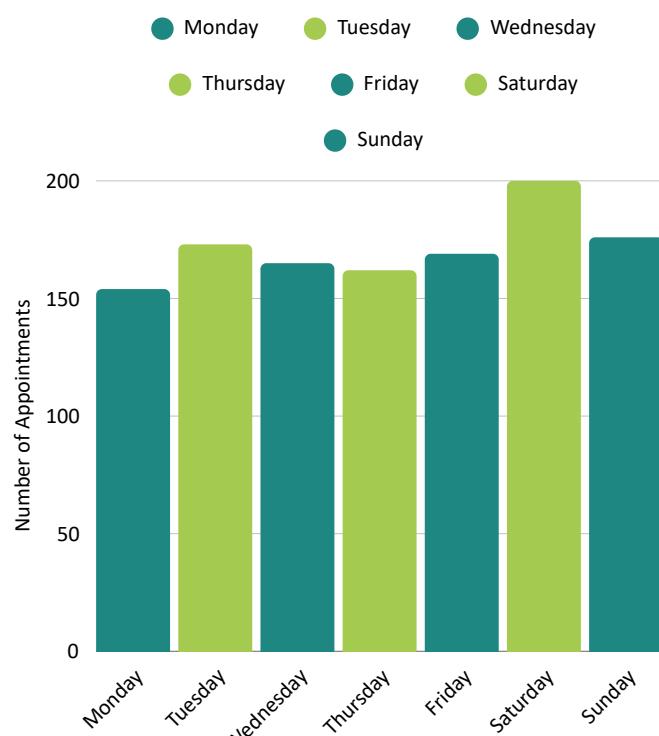


Figure 10 - Appointment Volume by Day of Week

DETAILED ANALYSIS

Satisfaction by cancellation histories provides additional insight into patient experience. Patients who kept all appointments were most satisfied, with an average of 3.64. Patients who had one cancellation had lower satisfaction, at 3.48, while patients who had two or more cancellations picked up slightly to 3.52. Although the differences are not drastic, the trend is apparent: cancellations even when cleared appear to have an adverse impact on patient perception. These findings demonstrate the importance of appointment stability and suggest a potential benefit in supplementing electronic reminders, flexible scheduling, or focused support for those with a previous history of cancellations.

Examining the frequency of patient visits provides further behavioral insights. New patients (152 cases) provide the highest average satisfaction (3.67) and the lowest average cost per visit (€60.72). However, return patients with one to two visits (640 cases) provide somewhat lower satisfaction (3.61) and have the highest average cost (€62.04). The trend is true for super frequent patients—three or more visits—who not only experience the lowest satisfaction rating (3.54) but also receive care at a modestly lower expense (€60.50). The negative relationship suggests that additional touchpoints don't translate into a greater experience. Instead, it may be an indication that follow-up visits are correlated with unresolved issues or chronic complications that lead to patient fatigue as well as administrative burdens. The high prices for regular users strengthen the case for efficient, individualized follow-up care that reduces unnecessary duplication and improves continuity of care.

Patient Type	Avg Satisfaction	Appointment Volume	Avg Cost (€)
First-Time	3.67	152	60.72
Frequent (1-2)	3.61	640	62.04
Super Frequent	3.54	398	60.50

Figure 11 - Satisfaction, Volume, and Cost by Patient Visit Frequency

DETAILED ANALYSIS

In exploring the interaction between geography, insurance status, and chronic illness, there is a multifaceted picture. Insured patients tend to have greater satisfaction and lower appointment fees in all areas. Interestingly, insured patients in the North and Islands have satisfaction levels of 4.23 and 4.13 respectively with relatively low costs. In comparison, uninsured patients in the South (satisfaction 2.33), North (2.74), and Islands (2.86) not only experience much less satisfaction but also more expensive appointments particularly in the South, where the average cost is the highest at €66.36. These disparities echo the Business Overview results and suggest systemic barriers to uninsured populations, most notably involving delayed access, limited care, or increased complexity in navigation of the healthcare system.

Chronic condition information overlay both complicates and thickens the picture. Diabetes and asthma are illnesses that cut across both insured and uninsured populations, with wide variability in satisfaction outcomes. Among them, asthma patients with insurance in the Center region are most satisfied (4.27), and diabetes patients without insurance in the South are one of the least satisfied (2.92). These differences point to both the buffering effect of insurance as well as the heterogeneity in quality and coordination of care across conditions and regions. Notably, hypertensive South patients who are insured have a satisfaction score of 4.26, which suggests that even complicated chronic illnesses can result in good experiences where the delivery of care is improved.

Broader grouping of satisfaction and cost by type of condition generates a clear hierarchy of experience. Cardiac patients, even though only 53 out of the total of 1,190 cases, have highest satisfaction (3.93) and lowest cost (€58.32). This suggests that clinical pathways for cardiac treatment are perhaps well structured and could be an example to follow. Conversely, hypertension and asthma patients are higher in cost and lower in satisfaction, implying inefficiency of logistics or clinical operations. The public with no chronic illnesses, while they represent the majority (728 cases), has a low satisfaction rating of 3.56, barely lower than the world average.

In general, the data from this dashboard point out a number of strategic priorities. To begin with, capacity planning must account for peak weekend appointment times, with adequate personnel and equipment. Second, even minor disruptions such as appointment cancellation can compromise patient trust and require more engagement and communication. Third, high volumes of high-frequency patient visits are both an expense and satisfaction risk and therefore need care path optimization. And finally, insurance coverage remains the greatest determinant of patient satisfaction, and uninsured groups continue to be underserved on experience and efficiency.

By combining temporal behavior, visit frequency, regional profiles, and chronic condition profiles, this dashboard does not just show what is occurring in the patient journey but why. These insights provide data-supported evidence for redesigning patient-centered care, satisfaction improvement, and operational performance enhancement within the Saude+ Health Center network.

TIME ANALYSIS

The Time Analysis reveals a temporal decomposition of the clinical process in Saúde+ Health Center, identifying the quantitative organization and variation of appointment durations. The target measure, Average Appointment Duration, is 41.07 minutes, ranged between the lowest observed appointment (3 minutes) and highest (94 minutes). The spread graphically demonstrates extensive heterogeneity within the appointment population, necessitating segmentation further to uncover underlying temporal dynamics.

The histogram of appointment durations demonstrates a right-skewed, non-normal distribution with the majority of cases grouped in a compact temporal band. The mode is located near the center of the middle-duration segment, a central plateau that represents the most common appointment durations. Farther from this peak, appointments dwindle gradually, forming a long-duration, stretched-out tail that reflects less frequent, more prolonged periods of care.

Most strikingly, the absence of a large short-duration cluster implies short appointments do not dominate this database and suggests a process organization where consultations must be detailed or administratively burdensome. This temporal pattern exhibits a clinical rhythm accommodating standardization around moderate lengths with scope for a smaller set of longer sessions presumably attached to complex cases or procedural delays.

There are significant variations in the breakdown of the length of appointments by region among patients. The shortest average appointment length is 26 minutes for the Center region, while the Islands, North, and South regions have significantly longer lengths of 50, 52, and 53 minutes, respectively. The difference between the Center and South is as high as 27 minutes, more than double that of the Center's average.

This contrasting drama suggests a clear geographic imbalance in temporal resource allocation, possibly resulting from differences in appointment density, local demand, availability of clinicians, or scheduling capacity. The Islands–North–South trio, whose medians fall within a narrow 3-minute bracket, forms a consistent temporal group with a central tendency of approximately 51.6 minutes, highlighting increased homogeneity in the periphery compared to time compression in the center.

Broken down by age group, the trend in average appointment length varies from a linear pattern and instead adopts a non-monotonic time profile. The patient age group 46–65 creates an apparent outlier with an average appointment time of only 29 minutes, which radically differs from the general mean of 41.07 minutes as well as from their surrounding cohorts.

TIME ANALYSIS

These 46–65 patient consultations are 23 minutes shorter than those of the 31–45 group (52 minutes) and 22 minutes shorter than those for the 65+ group (51 minutes), countering expectations that chronic or older patients would require longer consultations. By contrast, patients in the 18–30 group are mid-range with a mean duration of 48 minutes, tracking closely behind the older groups and reinforcing the outlier status of the 46–65 group. These inequalities raise interpretive issues regarding age-based care scheduling tactics, case complexity assumptions, or clinical triage reasoning biased towards advantage or preferential treatment of middle-aged patients.

The table to "Time from Check-In to Consultation" supports the above findings as sample case durations such as 37, 34, and 29 minutes intersect with both the overall mean and the values placed against the 46–65 category. This micro-level intersection at the level of cases illustrates that despite having a dataset with high variance, there exists micro-level regularity in some demographic groups consistent with patterns at the level of population.

Generally, the chronological organization of care at Saúde+ Health Center is marked by a right-skewed duration distribution, regionally-induced time allocation differentials, and demographic anomalies. The aggregation of appointment durations within the 55–65-minute range evident from the histogram contrasts with the drastically truncated paths of certain subgroups, particularly those from the Center region and the patients aged 46–65. This intersection of dense temporal clusters with steeply reduced outlier patterns reveals a multidimensional organization defined by scheduling algorithms, geographic location, and patient population. These findings offer a data-driven foundation for monitoring how time is expended and directed within the clinical setting, and provide a measurable yardstick against which future evaluations of efficiency can be measured.

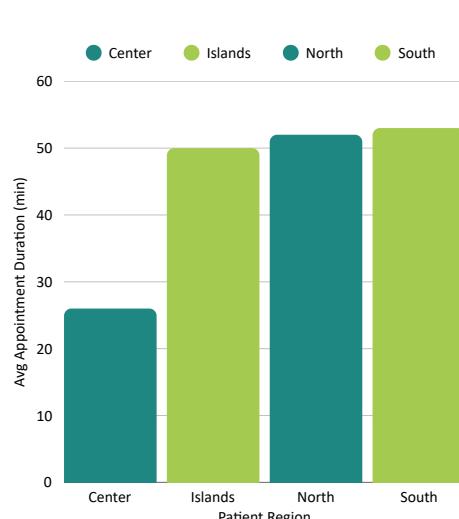


Figure 12 - Avg Appointment Duration by Patient Region

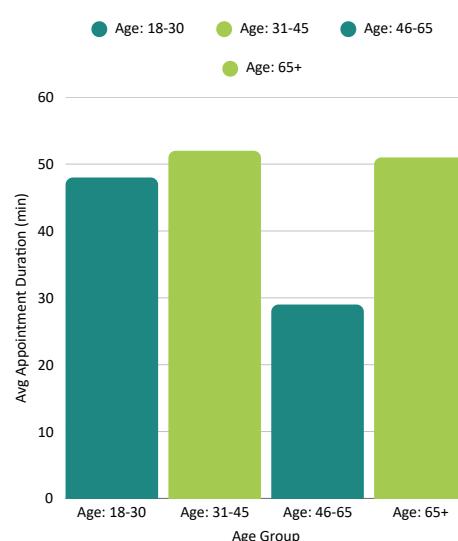


Figure 13 - Avg Appointment Duration by Age Group

QUALITY & IMPACT ANALYSIS

The Undesired Activities dashboard offers focused insight into procedural breakdowns and patient journey disruption at the Saúde+ Health Center, with a total of 713 cases involving one or more undesired event. These from complaint and missed turns through system failure and consultation cancellations are significant operational pain points influencing both service efficiency and patient satisfaction.

The breakdown of categories of unwanted activity by frequency shows the most common disruption to be "Return Another Day" with 275 cases. This is followed by patient complaints (191 cases) and the need to organize a new consultation (152 cases) both involving failure to resolve in first visit or inefficient processing. Other less frequent but significant events include cancellation of appointments (49), long waiting times for physicians (77), and missed opportunities (21). Although less frequent, system failures, while happening merely in 5 instances, deserve consideration since they contribute such a disproportionate amount to time.

The impact of these events transcends volume but also the duration of time it takes for such interruptions to happen. "System Errors" occur, on average, 38.2 minutes after check-in, which not only makes them rare but extremely time-consuming too. Similarly, activities like scheduling new consultations (34.96 min), resolution of lacking information (33.7 min), and cancellation of consultations (33.38 min) are likely to happen long after the appointment process has started, bringing more agony to patients who have already wasted time on their visit. By contrast, waiting to see the doctor (8.35 min) and returning another day (5.83 min) are more likely to occur early and reflect most likely problems identified in triage or registration times.

Undesired Activity	Cases Affected	Avg Time to Occurrence (min)
Return Another Day	275	5.83
Complaint	191	30.55
Schedule New Appointment	152	34.96
Waiting for Doctor	77	8.35
Consultation Cancelled	49	33.38
Missed Turn	21	5.81
Incomplete Information	10	33.7
System Error	5	38.2

Figure 14 - Satisfaction, Volume, and Cost by Patient Visit Frequency

QUALITY & IMPACT ANALYSIS

With an eye to age groups, the 46–65 age group is disproportionately affected, with over 420 unwanted activities belonging to this group. This is more than half again the number of unwanted activities of the 31–45 age group and more than six times the number of 18–30-year-olds. Whereas this may be a reflection of added clinical complexity in older patients, it also identifies an opportunity for intervention in middle-age and older populations through simpler communication, previsit preparation, and support navigation.

Cross-matching the data to health condition profiles, there is a mirroring imbalance. While 59.75% of the cases are accounted for by patients with no chronic conditions that have been registered, the other 40.25% account for diabetes (14.87%), asthma (10.52%), hypertension (9.96%), and the rest. This suggests unwanted activity is not a function of chronic illness complexity alone, but a function of system-wide issues represented by all patient segments.

The overall distribution of unwelcome activities over the course of a day is uniform across days, but small drops later in the observation period can be attributed to diminished patient load or more consolidated process settling toward the end of the cycle. However, the total frequency of over 700 interrupted cases underscores drastic changes in scheduling semantics, information validation, and service design.

By experience duration, the median time to unwelcome activity in most categories averages 30 to 38 minutes—a long wait for already engaged patients. Such breaks not only deny satisfaction but likely add administrative burden through redundant consultation, rebooked visits, and higher complaint levels.

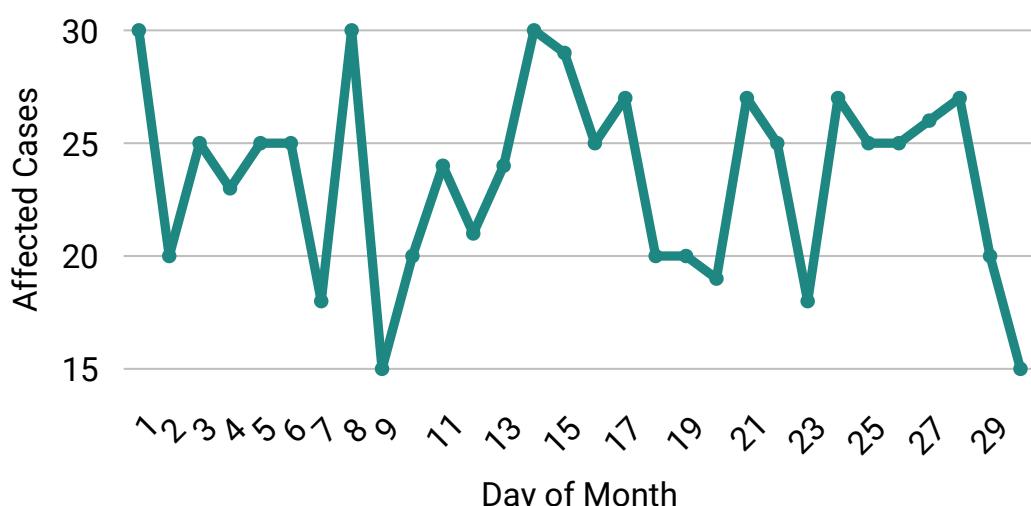


Figure 15 - Daily Volume of Cases with Undesired Activities

VISUALS OF THE PROJECT

Cover Page

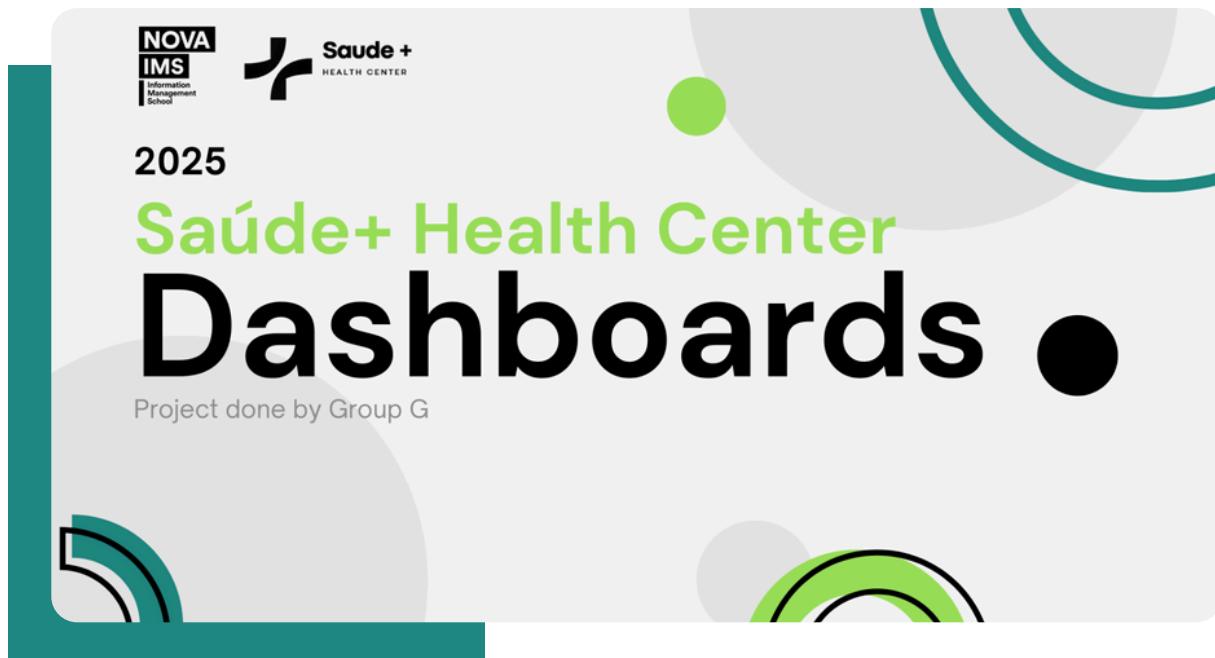


Figure 16

Variant Explorer

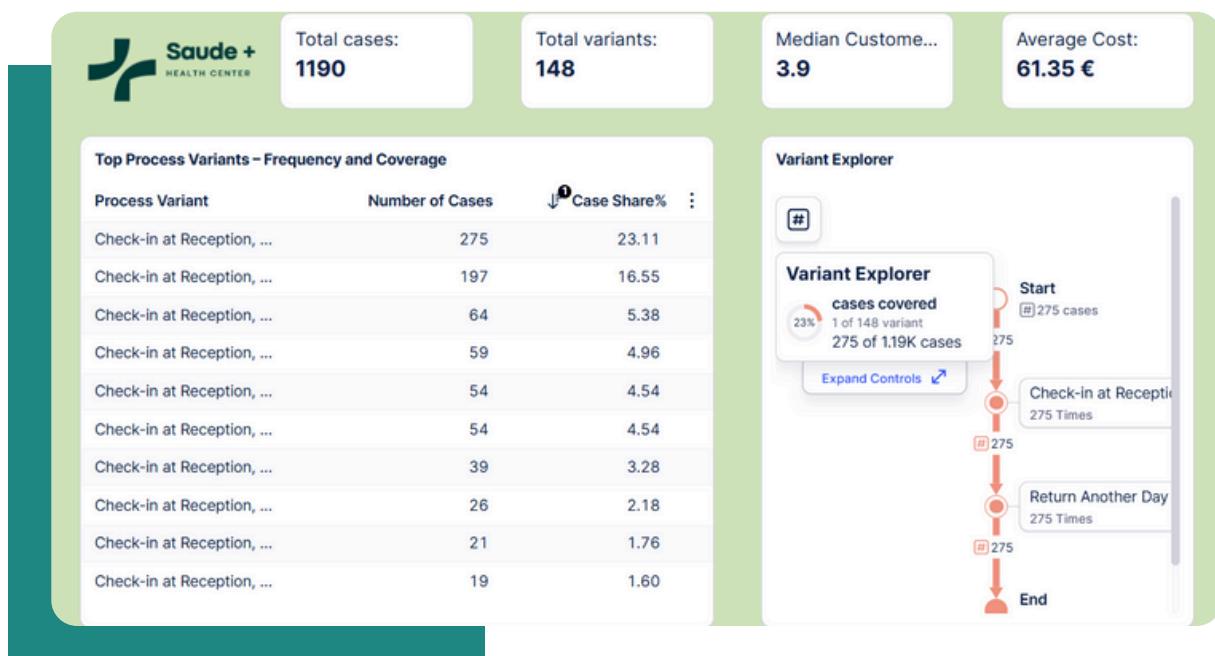


Figure 17

VISUALS OF THE PROJECT

Process Explorer



Figure 18

Business Overview

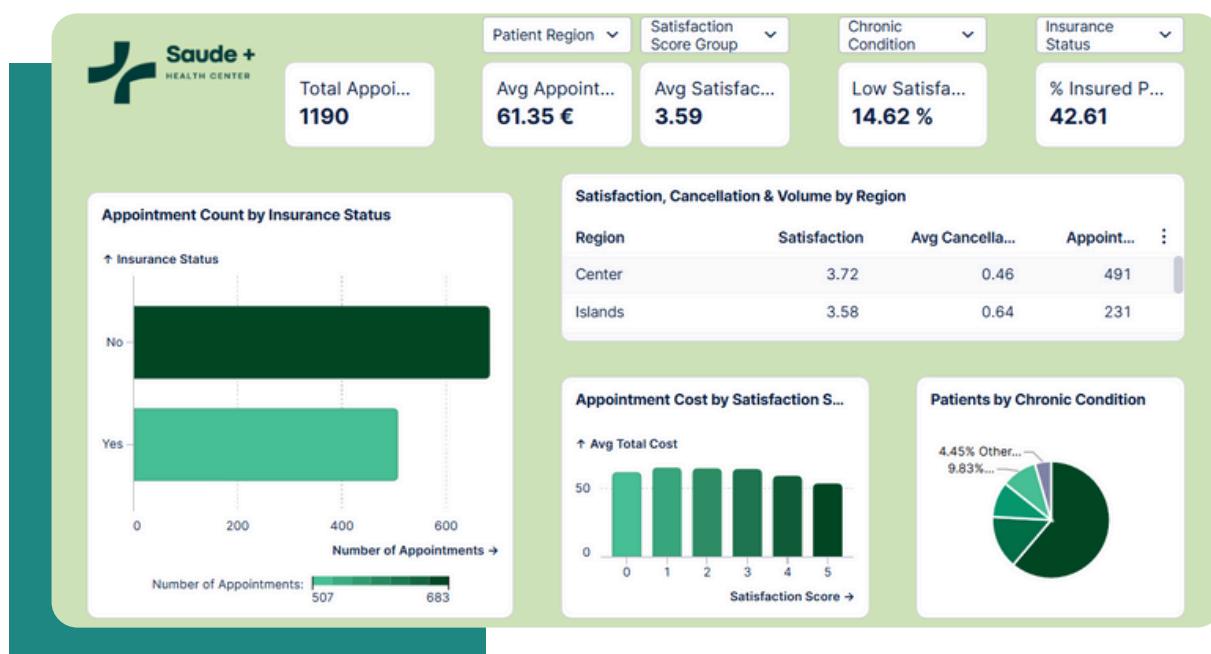


Figure 19

VISUALS OF THE PROJECT

Detailed Analysis



Figure 20

Time Analysis



Figure 21

VISUALS OF THE PROJECT

Quality & Impact Analysis

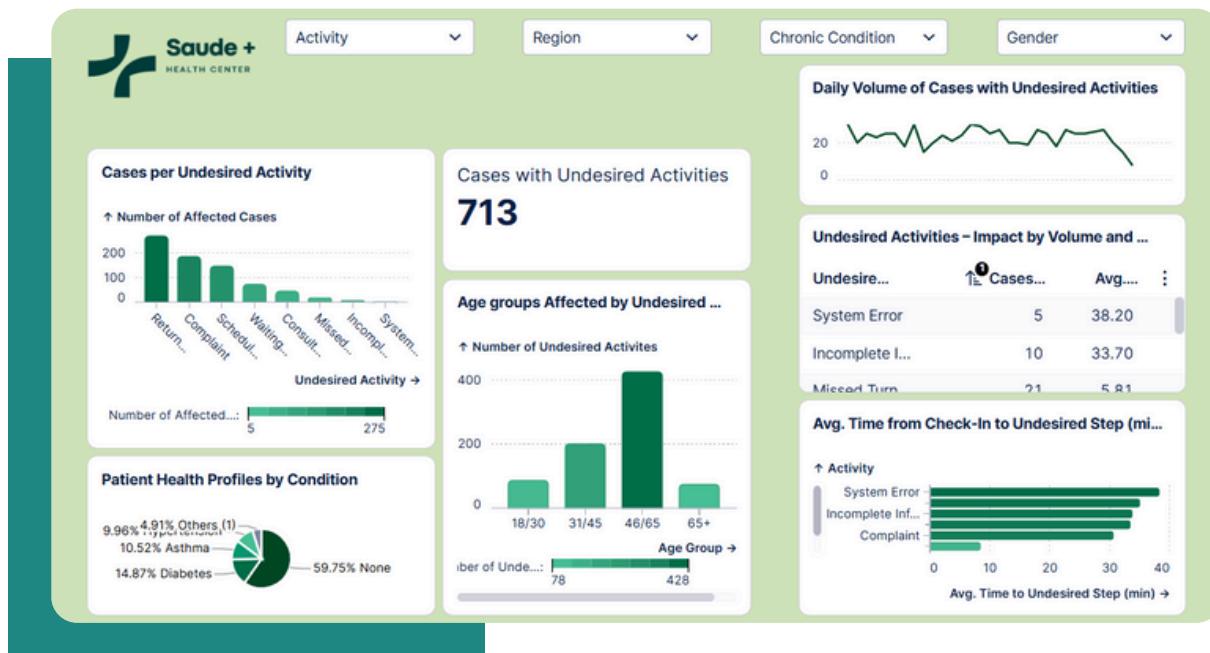


Figure 22



Value Generated and Final Recommendations

Value Generated

The use of Process Mining techniques with Celonis in Saúde+ Health Center led to a paradigm shift in the way the clinic could understand, monitor, and improve its patient appointment process. By translating raw event log data into tangible knowledge, this analysis made visible structural inefficiencies, process deviations, and behavioral clusters that were unseen by management before.

1. Revelation of Execution of Fragmented Process

One of the most important discoveries from the analysis was the observation of high patient pathway variability. The process, although seemingly linear in the wide sense, showed high dispersion in real-world actual implementation. Some patients followed streamlined administrative pathways that omitted clinical service delivery altogether. This kind of fragmentation erodes both the clinic's operations efficiency and the service guarantee, and it suggests a divorce between intended care pathways and real-world implementation.

2. Visibility Into Latent Process Complexity

Even though there was a dominant treatment pathway, the research found that patients diverged from it through breaks, like "Waiting for Doctor". These divergences were not random but systematic activities that were embedded in the process. Flow between key activities had a tendency to have hidden handoffs that extended the patient journey unnecessarily, with potential dissatisfaction, confusion, and overuse of resources as a consequence. This complexity, now uncovered, provides a map for simplification and standardization.

3. Identification of Experience-Impacting Behaviors

The study showed that some process patterns, particularly those marked by interruption or delay, are consistently associated with poorer patient experiences. For example, repeated follow-ups, and rebookings emerged as frequent sources of friction. This offers the clinic a new understanding: that patient perception is not only governed by clinical outcome but also by coherence and predictability of flow.

4. Operational Blind Spots Exposed

The breakdown identified the operational blind spots where system delays, coordination failures, or communication failures occur. The frequency and timing of these activities revealed the hidden load on staff and patients and showed the need for more proactive process orchestration.

Value Generated and Final Recommendations

5. Segmentation-Based Insight for Personalized Improvement

By segmenting data by patient demographics, geographic area, insurance, and chronic conditions, the analysis escaped surface-level averages. Instead, it showed that the same process is felt differently by each of several patient profiles, both in flow behavior and quality perception. This level of detail opens the door to intervention designed for each patient profile - a shift away from mass-process management to smart, profile-driven care design.

6. Enhanced Process Visibility for Strategic Decision-Making

In addition to its implications for tactical inefficiencies, the overall process transparency generated by this project has strategic implications. It presents the clinic's management with a dynamic data-driven view to track and evaluate real-time operations in real-time. This not only strengthens governance and accountability but also allows for scenario testing, impact forecasting, and quick response to operational points of stress.

Final Recommendations

Based on the detailed findings above, we propose the following data-driven recommendations for operational and patient experience improvement:

1. Redesign Patient Triaging at Entry Point

To reduce the high rate of appointment cancellations, the clinic can implement pre-consultation triage actions at the time of booking, possibly using digital intake or AI-facilitated routing. This would prevent low-value consultations and improve continuity of care.

2. Enable Real-Time Deviation Monitoring

Apply Celonis real-time alerting to detect cases that stray from clinical "happy paths" or entering high-risk streams. This permits proactive visit intervention, rather than reactive redress after dissatisfaction has already been established.

3. Adjust Weekend Resource Allocation

As weekends see maximum patient volumes on weekdays, workforce and resource planning needs to be realigned accordingly to cater to this peak volume without compromising the quality of care in maximum pressure time slots.

Value Generated and Final Recommendations

4. Special Pathways for Uninsured Patients

Create individualized protocols for the uninsured patients, e.g., fast-tracks, streamlined processes, and open communication. This may cure the precipitous drop in satisfaction and efficiency among this group.

5. Simplify Follow-Up for High-Frequency Patients

Multiple-visit patients had decreased satisfaction and higher average costs. This calls for individualized care pathways, such as bundled follow-up, coordinated treatment plans, and electronic touchpoints (e.g., telehealth), which will suppress redundancy and improve patient experience.

6. Add Mid-Process Checkpoints

Since most unwanted behaviors are prompted 30–38 minutes from checking into the hospital, we suggest adding a process checkpoint—a quick working check to verify progress, identify delays, and initiate corrective action if needed.

Strategic Impact

These suggestions aim to bridge the distance between clinical performance and patient-outcomes emphasis. Through taking advantage of real-time analysis, redescribing significant process nodes, and segmenting care pathways, Saúde+ can achieve:

- Improved patient satisfaction (especially among uninsured and chronic patients)
- Reduced process fragmentation and unnecessary administrative loops
- Better alignment between cost and perceived care value
- Enhanced operational agility and predictive response

The adoption of Process Mining as a continuous monitoring framework positions Saúde+ for sustainable service excellence, aligning business performance with clinical mission and patient trust.

LIMITATIONS

Despite the valuable insight that this Process Intelligence project provided into the Saúde+ Health Center's appointment process, there were some limitations faced in analysis that must be considered when interpreting the results:

- **High Process Fragmentation and Incomplete Pathways**

Most appointments followed short, non-clinical alternatives such as "Check-in → Return Another Day," indicating high levels of process fragmentation. This made it difficult to follow consistent patient pathways and lowered the clinic's ability to provide continuity of care.

- **Overrepresentation of Administrative Activities**

Process data had numerous administrative flows (e.g., scheduling, complaints, rebookings), while complete clinical sequences were comparatively rare. This skewness can misrepresent the actual pattern of medical care provision and led to underrepresentation of clinical quality indicators.

- **Uneven Satisfaction and Cost Across Patient Segments**

Though patient satisfaction and cost metrics were analyzed in depth, there were drastic disparities that were revealed based on region, insurance, and chronic condition group. The project did not, however, incorporate qualitative data to explain why the disparities are taking place, which diminished the possibility of providing tailored solutions.

- **Missing Process Context and External Factors**

The analysis relied exclusively on structured logs and did not account for contextual problems such as staffing shortages, no-show appointments, or scheduling policies. These unlogged realities likely influenced key findings (i.e., inordinate wait times or appointment dropouts), but could not be directly quantified or addressed.

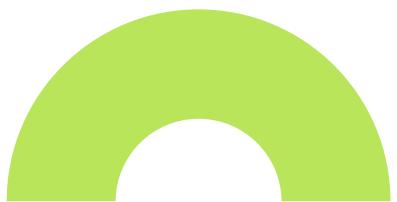
- **Lack of Real-Time Behavioral Data**

The analysis was based solely on historical event logs and snapshot satisfaction scores. Without access to real-time behavior or sentiment data (e.g., in-visit feedback, in-browse system notifications), it was not feasible to capture patient frustration points in real time or measure the emotional path traveled by patients through the process.

- **No Analysis of Resource Utilization**

The project did not include data on the use of resources (i.e., room availability, staff time, equipment utilization) that are central to a process delay, bottleneck, and inefficiency analysis from an operating standpoint. As a result, some of the root causes for extended appointment times cannot be quantified.

CONCLUSION



The implementation of Process Intelligence at the Saúde+ Health Center has been a significant project, revealing critical inefficiencies and data-driven insights that were previously invisible to management. With Celonis Process Mining, the project revealed an extremely fragmented appointment process with premature cancellations, administrative detours, and inconsistent pathways of care. These trends not only constrain operational efficiency but also adversely affect patient satisfaction and continuity of care.

In spite of the resource investment of the clinic in digital infrastructure, the study revealed the necessity of more standardization and more coherence in operations flow. Such important behaviors as "Return Another Day" and repeated rebookings were defined as systemic problems instead of outliers, more frequently associated with lower satisfaction ratings and increased costs. By contrast, clinical pathways that were optimized usually involved improved patient experiences and increased productivity of resources.

By distinguishing the data along demographic and clinical dimensions, the project was more clearly able to see dramatic variation in experience, especially among uninsured patients and those in remote locations emphasizing the importance of equity and tailored design in healthcare delivery.

This project highlights the key contribution of Process Mining in healthcare environments. Not only did it map the real patient journey, but it also provided actionable advice for restructuring an appointment process more patient-focused, leaner and more resilient. Going forward, the Saúde+ Health Center is ideally positioned to make strategic changes based on these insights, thereby guaranteeing that operational visibility is turned into improved health outcomes.



