Management Support to Hospital Administration

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***Abstract*— An engineer can contribute significantly to various services related to hospital administration. This report focuses on software-based services that aid decision-makers in hospital administration. Several topics including quality chart utilization, performance reporting for outpatient departments, hospital benefit simulation, and comparative analysis of hospitals within a group are explored. The project's objective is to introduce managerial topics and develop software programs to deduce meaningful conclusions for hospital management.**

Keywords—*Hospital administration, quality charts, performance reports, simulation, comparative analysis, software programs, decision support systems.*

I. Introduction

Hospital administration encompasses a wide range of activities aimed at ensuring the efficient operation of hospital services. Engineers, particularly those with expertise in software development, can contribute to enhancing hospital administration through various technological solutions. This report discusses how software programs can support decision-making processes in hospital administration by focusing on four key topics: quality charts, performance reports for outpatient departments, simulation benefits, and comparative analysis of hospitals.

II. Literature Review

Quality charts, or control charts, are essential in healthcare for monitoring service quality. Shewhart (1931) highlighted their role in identifying improvement areas [1], and Mohammed et al. (2008) found that they significantly reduce hospital-acquired infections [2].

Performance reporting is crucial for outpatient department management, impacting patient satisfaction and operational efficiency (Harper & Shahani, 2002) [3] .Regular performance reporting improves resource allocation and reduces waiting times (Lemieux-Charles et al., 2003)[4].

Simulation techniques, like those discussed by Jun et al. (1999) [5], provide a risk-free environment to test scenarios. Brailsford et al. (2009) used simulations to optimize emergency department patient flow [6].

Comparative analysis, using Data Envelopment Analysis (DEA), evaluates healthcare efficiency by assessing multiple inputs and outputs (Hollingsworth, 2003) [7]. DEA helps identify best practices and performance gaps, promoting targeted improvements (Ozcan, 2014) [8].

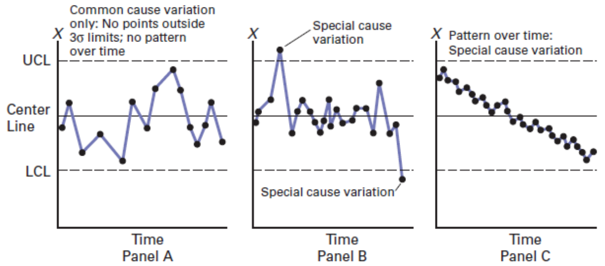
III. Quality Charts in Hospital Service Quality

A. Introduction to Quality Charts

A control chart analyzes a process in which data are collected sequentially over time. Control charts study past performance, evaluate present conditions, or predict future outcomes. They are used to identify special causes of variation, which are large fluctuations or patterns in data that are not part of a process, and common causes of variation, which are inherent variability in a process.

When these control limits are set, you evaluate the control chart by trying to find whether any pattern exists in the values over time and by determining whether any points fall outside the control limits.

A long-term overall downward trend is clearly visible. You should investigate the situation to try to determine what may have caused this pattern, Eight or more *consecutive* points that lie above the center line or eight or more *consecutive* points that lie below the center line [9].



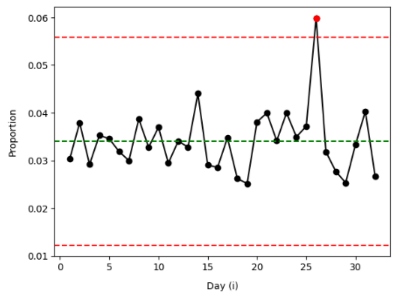
B. Application in Hospitals

By implementing quality charts, hospitals can identify trends, pinpoint areas needing improvement, and ensure compliance with healthcare standards. For example, control charts can monitor patient wait times in the emergency department, highlighting deviations from acceptable limits and prompting corrective actions.

C. Types of Control Charts

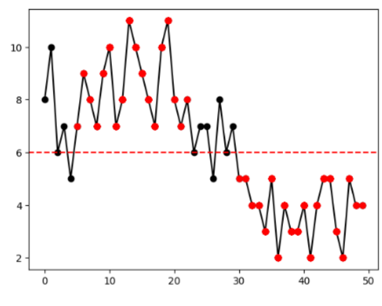
1. Control Chart for the Proportion (p Chart): Used for categorical or discrete variables, assuming a binomial distribution [9].

Day (i)	Sponges Produced (n_i)	Nonconforming Sponges (X_i)	Proportion (p_i)
1	690	21	0.030
2	580	22	0.038
3	685	20	0.029
4	595	21	0.035
5	665	23	0.035
6	596	19	0.032
7	600	18	0.030
8	620	24	0.039
9	610	20	0.033
10	595	22	0.037
11	645	19	0.029
12	675	23	0.034
13	670	22	0.033
14	590	26	0.044
15	585	17	0.029
16	560	16	0.029



2. Control Chart for an Area of Opportunity (c Chart): Suitable for discrete count data with a low probability of occurrence, assuming a Poisson distribution [9].

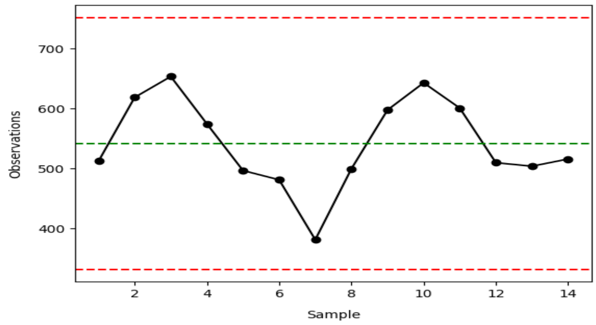
Week	Number of Complaints
1	8
2	10
3	6
4	7
5	5
6	7
7	9
8	8
9	7
10	9
11	10
12	7
13	8
14	11
15	10
16	9
17	8



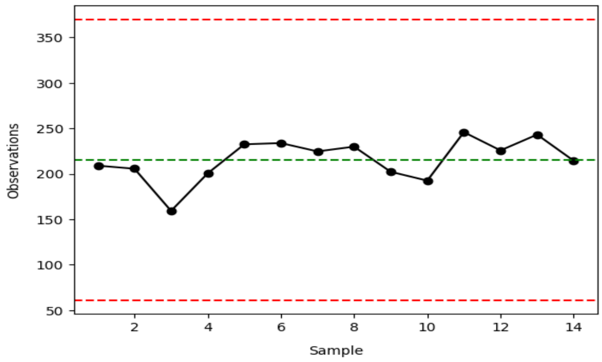
3. Control Chart for the Range and the Mean: Assumes a normal distribution, suitable for small sample sizes [10].

	Observations (Sec.)								
Sample	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9
1	261	598	192	712	727	796	557	565	356
2	735	874	423	361	762	708	398	818	364
3	704	593	892	874	793	580	574	423	476
4	803	302	728	606	631	743	297	295	614
5	774	659	250	498	341	274	880	274	668
6	597	831	457	749	354	533	201	673	196
7	756	379	269	241	210	820	227	200	383
8	257	711	535	790	279	857	238	550	303
9	528	372	815	323	348	792	607	592	736
10	647	716	851	896	302	440	613	806	461
11	281	856	659	454	494	888	701	882	603
12	271	470	484	292	579	730	229	762	391
13	224	591	826	537	878	696	437	367	277
14	216	629	640	417	282	719	263	745	464

x̄ Chart



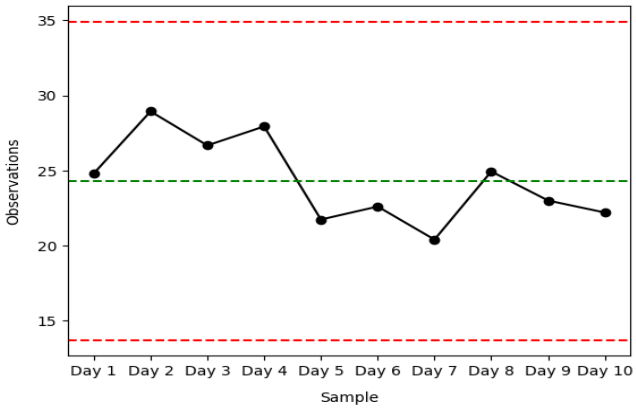
R Chart



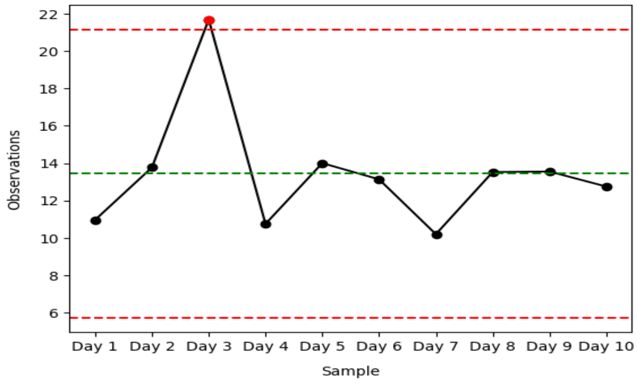
4. Control Chart for the Mean and the Standard Deviation: More accurate and stable for large sample sizes [10].

Sample	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10	Patient 11	Patient 12	Patient 13	Patient 14	Patient 15
Day 1	36	6	30	14	23	34	40	37	21	8	36	28	17	15	27
Day 2	28	3	40	40	23	4	42	31	41	25	29	9	40	40	39
Day 3	49	3	7	4	48	7	52	43	45	34	5	3	55	5	40
Day 4	26	36	13	25	25	20	44	29	45	19	40	21	38	28	10
Day 5	6	25	42	28	28	27	13	22	44	3	4	34	35	8	7
Day 6	7	5	22	41	14	8	18	43	29	23	26	35	35	30	3
Day 7	14	14	14	16	17	20	22	31	39	23	7	43	22	13	11
Day 8	15	23	12	16	43	43	36	33	16	5	27	43	34	3	25
Day 9	24	5	8	18	17	36	41	37	30	35	4	5	35	36	14
Day 10	29	22	15	32	18	17	33	21	3	6	13	43	33	42	6

x̄ Chart



S Chart



D. Selection of Control Chart

1) Attribute data (also called qualitative data) are data that can be classified into categories or groups, such as colors, names, brands, etc. Attribute data cannot be measured numerically, but they can be counted or compared(C-chart & P-chart) [11].

2) Variable data (also called quantitative data) are data that can be measured numerically, such as height, weight, age, temperature, etc. Variable data can be divided into discrete data and continuous data, depending on whether they have finite or infinite values (X-bar & R chart, X-bar & S chart) [11].

IV. Performance Reporting for Outpatient Departments

A. Importance of Performance Reports

Performance reports provide a comprehensive overview of departmental efficiency and effectiveness. For outpatient departments, these reports highlight key performance indicators (KPIs) and trends, allowing supervisors to optimize processes and allocate resources effectively.

- Key Attributes (**Patient number**, **Waiting time**, **Service time for patient**)
- Observations (**Number of patients in queue, Number of patients in system, Working time of clinic, Service time of clinic**)

B. Data Collection

Data is collected from various sources to evaluate outpatient queues and performance metrics such as patient number, waiting time, and service time [12].

clinic type	Mean waiting time(min)	Mean service time (1/μ) min	mean # of patients
gastrology	65	9.2	8.5
endocrinology	86	12	11
pulmonary	68	11.2	8
cardiology	66	7.8	9
hematology	65	10.4	10
urology	62	7.1	13
nephrology	103	16.4	8.5
dermatology	37	6.2	10
ent	39	6.7	11
pediatric	41	9.4	6.5
dental	40	19	5
orthopedic	60	5.7	19
general surgery	61	7.5	12
neuro surgery	59	8.1	12
opthalmology	43	9.3	10
obst/gyn	64	10.3	6.5
vascular surgery	48	7.8	13
internal med.	60	9.1	6
nerology	71	11.7	9.5
thorathic surgery	52	11.3	6

C. Full Data Analysis

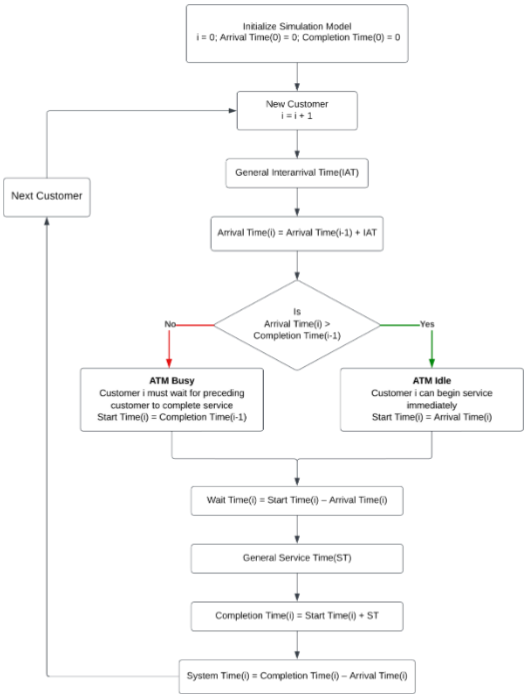
Software programs can automate the collection and analysis of data, generating detailed performance reports. These reports help supervisors make informed decisions regarding resource allocation, staff training, and process improvements.

V. Simulation in Hospital Management

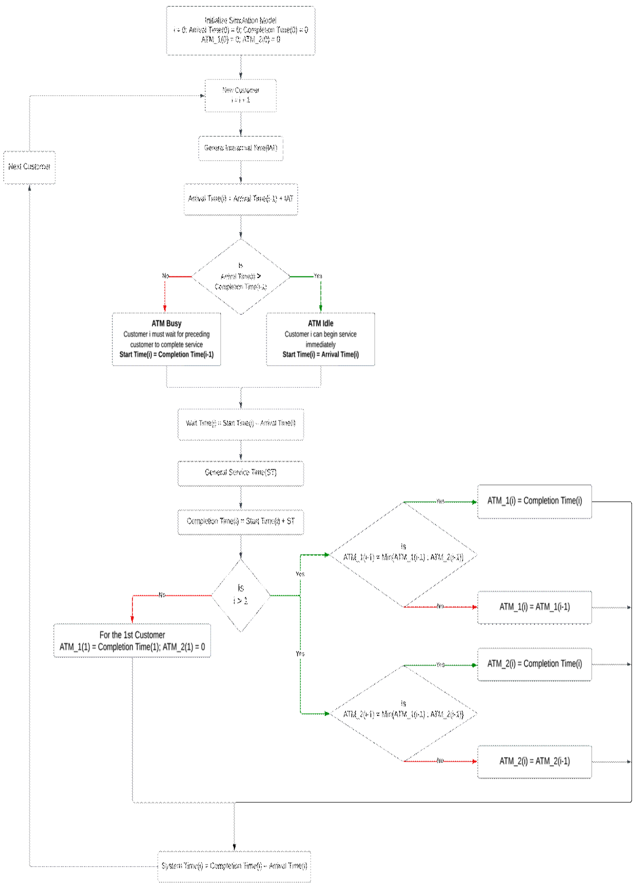
A. Role of Simulation

By creating a virtual model of hospital processes, administrators can experiment with different scenarios, predict outcomes, and make informed decisions without disrupting real-world operations.

1. Flow chart of one clinic waiting line simulation



2. Flow chart of two clinic waiting line simulation

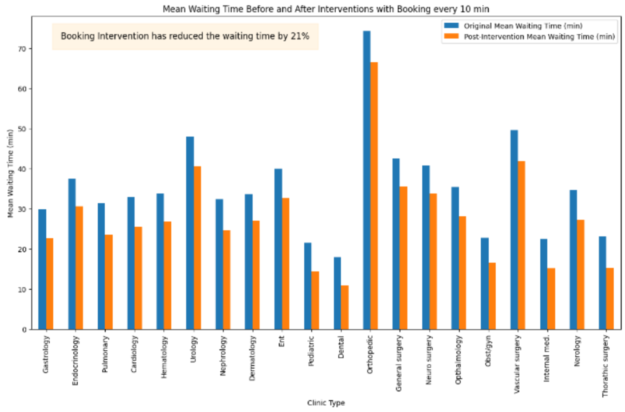


B. Applications in Hospitals

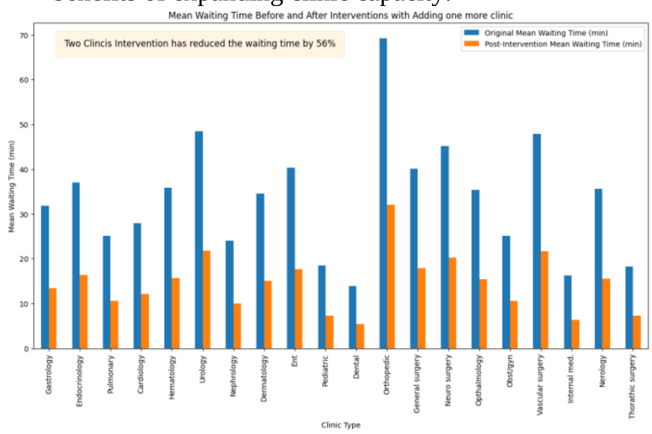
Simulations can be used for scheduling optimization, resource allocation planning, and reducing waiting times in outpatient clinics.

C. Reducing Waiting Times in OPD Clinics

1. **Booking System Simulation**: By simulating a booking system with appointments scheduled every 10 minutes, hospital managers can evaluate its effectiveness in reducing waiting times. The simulation showed a 21% reduction in waiting times, providing a clear justification for implementing the booking system.



2. **Additional Clinic Simulation**: Adding one more clinic to handle the patient load was simulated, revealing a 56% reduction in waiting times. This significant improvement underscores the potential benefits of expanding clinic capacity.



VI. Comparative Analysis of Hospitals

A. Purpose of Comparative Analysis

Comparative analysis of outpatient clinics serves several critical purposes in healthcare management, particularly in reducing patient waiting times. By systematically evaluating and comparing the performance of different clinics, administrators can identify performance gaps, benchmark best practices, optimize resources, ensure equity in service delivery, and support accreditation and compliance.

B. Methodologies

1. **First Method**: Normalization and Matrix Comparison

Overview: This method involves creating and normalizing input-output (I/O) matrices for each clinic, computing a maximum matrix, and using these normalized matrices to rank the clinics.

Steps:

- Generate conversion matrices for all clinics by applying the I/O matrix function to each clinic's data.
- Compute a maximum matrix by finding the maximum value for each cell across all clinics' matrices. This matrix serves as a benchmark for the best observed performance in each aspect of service delivery.
- Normalize each clinic's matrix by dividing its elements by the corresponding elements in the maximum matrix. This step ensures that all clinics are compared on a level playing field.
- Calculate the mean and standard deviation of the flattened lists for each clinic. Rank the clinics based on these statistics to determine their relative performance.

Example of 13 clinics: Sorted according to the mean.

Hospitals	Mean
A	0.79133
B	0.56542
C	0.65138
D	0.46181
E	0.79799
F	0.71789
G	0.42400
H	0.68500
I	0.58979
J	0.52927
K	0.59810
L	0.74671
M	0.51503

→

Hospitals	Mean
E	0.79799
A	0.79133
L	0.74671
F	0.71789
H	0.68500
C	0.65138
K	0.59810
I	0.58979
B	0.56542
J	0.52927
M	0.51503
D	0.46181
G	0.42400

D, and G less performance

2. **Second Method**: Data Envelopment Analysis (DEA)

Overview: This method employs Data Envelopment Analysis (DEA) using linear programming to evaluate the efficiency of each clinic compared to others.

Steps:

- Create inequality constraints representing the relationship between inputs and outputs for each clinic. These constraints are used to formulate the optimization problem.
- Define bounds and equality constraints for the variables involved in the optimization problem.
- Define an objective function to find a feasible solution that maximizes the efficiency score of each clinic.
- Use linear programming to solve the optimization problem for each clinic. This step involves finding the optimal set of weights that maximize the ratio of weighted outputs to weighted inputs.
- Evaluate the efficiency of each clinic based on the solution of the linear programming problem. Clinics with efficiency scores close to 1 are considered relatively efficient, while those with lower scores are identified as inefficient.

Example of 13 clinics: Sorted according to the mean.

Hospitals	Mean	SD	E
A	0.79133	0.209	1
B	0.56542	0.328	1
C	0.65138	0.227	1
D	0.46181	0.238	0.924
E	0.79799	0.190	1
F	0.71789	0.110	1
G	0.42400	0.270	1
H	0.68500	0.238	1
I	0.58979	0.238	1
J	0.52927	0.234	0.955
K	0.59810	0.179	0.963
L	0.74671	0.126	1
M	0.51503	0.215	1

→

Hospitals	Mean	SD	E
E	0.798	0.19	1
A	0.7913	0.209	1
L	0.7467	0.126	1
F	0.7179	0.11	1
H	0.685	0.238	1
C	0.6514	0.227	1
K	0.5981	0.179	0.963
I	0.5898	0.238	1
B	0.5654	0.328	1
J	0.5293	0.234	0.955
M	0.515	0.215	1
D	0.4618	0.238	0.924
G	0.424	0.27	1

K, J, and D are Inefficient hospitals because $E < 1$

C. Comparison of Methodologies

Both methods aim to evaluate and compare the performance of clinics to identify areas for improvement and enhance overall efficiency. The normalization and matrix comparison method provides a more detailed comparative analysis with insights into average performance and variability, while the DEA method offers a robust, optimization-based efficiency evaluation. The choice between these methods depends on the specific goals of the analysis and the available computational resources.

VII. Conclusion

Engineers can significantly enhance hospital administration through the development and implementation of software programs. By focusing on quality charts, performance reporting, simulation, and comparative analysis, this project demonstrates how software solutions can support decision-making processes and improve hospital operations. The findings provide valuable insights that aid in the continuous improvement of hospital services.

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