Application of Computer-aided Facility Simulation on Layout Design to Improve Patient Flow, Thermal Comfort and Safety

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Facility Management Department
Administrative Services Division
Kwong Wah Hospital / TWGHs Wong Tai Sin Hospital
Sustainable Facility Design Management

- Ever-changing / Ever-increasing Demand / Need
  - Change in Service functions
  - Change in Technology requirement
  - Change in Workflow
  - Change in Capacity
  - Change in Standard
  - Change in Space requirement
  - Change in User / Customer; etc
Sustainable Facility Design Management

“Fit for Purpose” of a Building diminished with time.

Technological demand

Functional demand

Building Capacity (value)

refurbish refurbish refurbish replace

“Status quo”

Facility Services

Maintenance

Handover Operation against time
Early Stages and Limitations

- Initial complaint in 2005
  - “Stuffy air” on 3/F Outpatient Building of KWH owing to overcrowding

- Limitation to cope with overcrowded condition
  - Space (no. of consultation rooms)
  - Clinical staff arrangement
  - Means of escape
  - Vertical transportation; lift, stair case
  - Technical constraints e.g. Headroom, HVAC, power provision, FS provision; etc
Formation of the Project

- Proposal made in 05/06
- Project Planning
  - Committee formed in early 2006 with all departments heads / representatives of Outpatient Building
  - $2M bid under 8100MX in 06/07
- Implementation
  - Oct 2006 to Oct 07 in Phases for G/F, 2/F 3/F of Outpatient Building
Objective of the project

- Aims to demonstrate how to apply FM tools in enhancing operational sustainability
  - Quantitative queuing model & capability planning
  - Layout and workflow analysis

- and solve the problems of the Outpatient Department in Outpatient Building which was built in 1999
  - Overcrowding during peak hours
  - Poor air quality
  - Limited capacity of MOE
Basic theory & methodology in Health Care Capacity Planning

Cost of Service Capacity

Waiting Line Cost

Optimum capacity

Healthcare Service Capacity

Total Cost
Basic theory & methodology in Health Care Capacity Planning

- Parameters in planning capacity
  - Arrival rate \((a)\)
  - Service rate \((s)\)
  - Average no. of patients waiting for service \((Lq)\)
  - Average no. of patients in the building \((L)\)
  - Average time patients wait in line \((Wq)\)
  - Average time patients spend in the building \((W)\)
  - Service time \((1/s)\)
  - Building utility \((p)\)

- No. of patient in waiting area: \(L = Lq + a/s\)
  where \(Lq = a^2 / (u(u-a))\)

Reference: Quantitative Methods in Health Care Management Techniques and Applications by Yasar A. Ozcan
Assumptions for Capacity Forecast

- No. of patients at each timeslot rely on the patients’ quota
- Waiting time at each counter accords with the survey conducted at peak hour
- All patients arrived on time
- No relatives/ friends accompany the patients (based on actual observation)
- Duration of “Waiting for registration” is shortened to 0 min when the smart card is used
- Sample size = 10 patients were followed to observe the average waiting time per day (for procedures with short waiting time, over 100 data was collected)
Patient Flow Analysis

- **Registration** (2/F or 3/F)
  1. Travel to SOPD from main entrance (lift / staircase)
  2. Waiting for registration (queue)
  3. Registration & patient identification (queue)

- **Clinical Consultation** (2/F or 3/F)
  4. Waiting for consultation (waiting hall)
  5. Receive consultation (consultation room)
Patient Flow Analysis

- **Appointment & Payment** (2/F or 3/F)
  6. Travel to appointment counter (waiting hall)
  7. Make appointment (queue)
  8. Travel to Shroff (waiting hall)
  9. Pay for medication (queue)

- **Receiving Medication** (G/F)
  10. Travel to G/F (lift / staircase)
  11. Present payment receipt and prescription at Pharmacy (queue)
  12. Wait for dispensary (waiting hall)
  13. Get the medication (queue)
# Patient Flow Analysis (waiting time)

## Previous (Jan 06)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Location</th>
<th>Duration</th>
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</tr>
</thead>
<tbody>
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<td>2/F or 3/F</td>
<td>0:22:36</td>
<td>Waiting for registration</td>
<td>?</td>
<td>0:00:00</td>
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<td>G/F</td>
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**Time spent on 2/F or 3/F**  1:00:44  
**Time spent on G/F**  0:35:41  
**Total**  1:36:25

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**Time spent on 2/F or 3/F**  ?  
**Time spent on G/F**  ?  
**Total**  ?
WAITING AREA

Area: 310 sq. m
Seat: 217
Max.Capacity: 300P

Area: 340 sq. m
Seat: 279
Max.Capacity: 350P

Appointment Office on 3/F
Registration to G/F
Shroff to G/F
# Waiting Times according to Workflow

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**Time spent on 2/F or 3/F**

- 0:37:10

**Time spent on G/F**

- 0:36:23

**Total**

- 1:13:49
Project implementation by Phases

Comparison 3/F Patient Flow (Expected VS Outcome)
### Summary of Patient Flow after Changing the Layout Design

<table>
<thead>
<tr>
<th>Location</th>
<th>Normal Period</th>
<th>Peak Hour (2-4pm)</th>
<th>Maximum Record</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Expected</td>
<td>Actual</td>
</tr>
<tr>
<td>G/F</td>
<td>70</td>
<td>110</td>
<td>180</td>
</tr>
<tr>
<td>2/F</td>
<td>55</td>
<td>70</td>
<td>95</td>
</tr>
<tr>
<td>3/F</td>
<td>65</td>
<td>80</td>
<td>120</td>
</tr>
</tbody>
</table>

* Patient number round up to 5 persons
Summary of Air Quality after Changing the Layout Design

<table>
<thead>
<tr>
<th>Location</th>
<th>Average CO₂ Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>* Actual</td>
</tr>
<tr>
<td>G/F</td>
<td>973.60</td>
</tr>
<tr>
<td>2/F</td>
<td>897.45</td>
</tr>
<tr>
<td>3/F</td>
<td>947.21</td>
</tr>
</tbody>
</table>

* 10 pts at waiting area for sampling on each floor
Outcome of the Project

- 20% increase in patient seating capacity
- Shifting of patient flow pattern in Outpatient Building
- Reduce 15-60% patients’ staying on same floor during peak hours
- 5% reduction of average Co2 concentration
Application of Quantitative Forecasting Tools in Facility Planning

- Demonstrate a successful application in outpatient facility

- Application in Healthcare Service Planning
  - Layout planning in outpatient buildings, inpatients buildings say AED, public waiting halls, Pharmacy, cashier, etc;
  - Rationalization existing workflow with outdated layout & limited space but rising demand on service capacity
Application of Quantitative Forecasting Tools in Facility Planning

- Optimum solution for management decision
- Select Right Approach to Guarantee Quality Outcome to meet the Demand

Demand of Building Users

Facility Management Motivators:
- Amenity
- View
- Décor
- Space provision
- Furniture standard
- Communal provision

Maintenance Factors:
- Controlled access; Health
- Operational reliability
- Environmental condition

Physiological Needs
- Security/Safety
- Social belonging
- Ego-status
- Self-fulfillment
Facility Management

- “the process by which an organization delivers and sustains support services in a quality environment to meet strategic needs”

  - Centre for Facilities Management
Thank you