EVOLUTION OF INFECTIOUS DISEASE WARD DESIGN OF MALAYSIA: CASE STUDY

Presented by

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The Prophet (p.b.u.h) said, "If you hear of an outbreak of plague in a land, do not enter it; but if the plague breaks out in a place while you are in it, do not leave that place."

Al-Bukhari and Muslim Narrated by Saud

This hadith provides us two important strategies to face airborne crisis: isolation and quarantine.
ABSTRACT

Infectious disease is prevalent in all countries. Malaysia is no different. With ease of global travel and incidental migration all countries faced the phenomenon in various degree. Proactive in its preparation to manage its emergence is the key of Malaysia’s disease surveillance. This presentation focuses on the evolution of infectious disease ward design through the ages by case studies. Through historical review of old hospitals and the dos and don’ts in the sample evaluation of selected infectious disease ward of current design, findings found the odds in mitigating these infection (including hospital acquired infection (HAI)) are just too many and unknown. To date isolation rooms at each ward discipline are utilised as barrier nursing – to isolate from infection or causing infection in all hospitals. Only selected hospitals, due to budget and geography of its occurrence, purposed built wards for infectious disease were eventually built. In the convergence of the disease in one centre, health status of staff matters. Innovating balance needs for staff, patient and the extended care givers (relative), a mix approach catering all users, were formulated. Either as new and as retrofitting, on land or at higher levels, will depend on its physical requirements and placement locality. Outcome is yet to be evaluated.
STORYLINE

- INTRODUCTION
- CASE STUDIES OF INFECTIOUS DISEASE WARD DESIGN THEN AND NOW
- SUMMARY OF FINDINGS
INTRODUCTION

INFECTIOUS DISEASE IN MALAYSIA

DESIGN REVIEW
INTRODUCTION

- **Infectious disease is not an emerging disease.** Cholera, Tuberculosis, typhoid, chicken pox, measles are among the common infectious or communicable diseases that had existed and are still prevalent under surveillance. However lately these diseases had mutated to various guises crossing national borders through migration and travel. Thus it is not isolated to Malaysia alone. SARS and H1N1 are among the emergent traits that warrant a review of healthcare facilities strategic planning to facilitate management of its occurrence. The Ministry of Health Malaysia had expounded workshops to review and devise means since 2004, and are still at the helm for the unexpected.
Including the new and emerging infectious diseases, zoonotic diseases and syndromic approach of disease, SARS and avian influenza.

Source: MoH 2006
MANAGEMENT OF INFECTIOUS DISEASE FACILITIES

Source: MoH (2011) Specialty and Subspecialty

**TABLE 11**: Development Plans for Resident Specialty and Sub-Specialty Services by Region and Type of Hospitals, 10 MP

<table>
<thead>
<tr>
<th>No</th>
<th>Services</th>
<th>Region</th>
<th>Types of Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>HKL and State Hospital</td>
</tr>
<tr>
<td>A: MEDICAL SPECIALTY</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>1</td>
<td>General medicine</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory medicine</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Infectious diseases</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Rheumatology</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Hepatology</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Development of **Infectious Diseases Unit with isolation facilities**

Hospital Tumpat
Pusat Kawalan Kusta Negara (National Leprosy centre),
*Hospital Sungai Buloh

**MAJOR SPECIALIST & STATE HOSPITALS**
Hospital Sungai Buloh *
Hospital Raja Perempuan
Zainab II, Kota Bharu
Hospital Pulau Pinang
Hospital Ipoh
Hospital Umum, Sarawak
Hospital Queen Elizebath, Kota Kinabalu
Hospital Kuala Terengganu
Hospital Sultanah Aminah, Johor Bharu
Hospital Alor Setar
Hospital Melaka

*With Infectious Disease as Sub-Specialty
A modern hospital should be designed with infection control in mind. The main aim of the architect is to reduce the risk created by the human element to a minimum.

(Source: VKE LIM (1981)
MEDIUM OF INFECTION IMPACT TO DESIGN

TOUCH/contact

SPUTUM

AIRBORNE

FOOD

WATER BORNE

VECTOR BORNE

Blood

Needles

Droplets

Through Animals

Sexual Intercourse

Unscreened Blood Donation


Physical

Ventilation

Design of surfaces

Material use

Site/Location/adjacencies

Accessibility

Humane/cultural needs

Clinical Treatment regime

Safety to staff and patient

Operational

Clinical Treatment regime

Services
Many aspects have to be considered including ventilation, sewage disposal, hand washing facilities, clean and dirty traffic and the location of the various services.

In the wards, horizontal surfaces should be kept to a minimum as these are places where dust tends to settle. Wards should be designed such that they are easy to clean.

The design of special care units also warrants special consideration. Space should be adequate to allow for easy access of staff and equipment. One or two isolation rooms may be needed for use by either infected patients (source isolation) or hyper-susceptible patients (protective isolation).

(Source: VKE Lim (1981))
isolation and quarantine.
These strategies have been implemented for many years and even stipulated in modern guidelines such as Centre for Disease Control (CDC), World Health Organization (WHO) and Ministry of Health (MOH), Malaysia. The modern guidelines have stated that building and ventilation design of airborne infection isolation room (AIIR) is the most effective method for airborne infection control.

IS IT?
Lets find out...
FILTERING TYPES OF INFECTIOUS INFECTION IN DESIGN DECISION

Figure 2.6 Types of infection & isolation

Source: Norita Johar (2013)
DESIGN AND NON DESIGN MEASURES TO CONTROL SPREAD (MOH 2006)

(Source: Norita Johar (2013))
Lack of information on how these designated wards should be designed have sparked the need for conducting this research. Thus, additional information needs to be garnered from other sources to complement the contents of the guidelines. The contents of the guidelines are summarized in Figure 2.8.

![Table of guidelines](image)

**Figure 2.8 Guidelines**


![Summary of building and ventilation design reviews](image)

**Figure 2.16 Summary of building and ventilation design reviews**
Both building and ventilation design variables are very important in determining the feasibility of open wards for AII use. The variables are summarized in figure 2.17.

Source: Norita Johar (2013)
REVIEW WHETHER OPEN–MULTIBED OR SINGLE ISOLATION IS MORE EFFECTIVE FOR AIRBORNE INFECTION CONTROL

Norita Johar (2013)
Sungai Buloh Hospital airborne infectious isolation (AII) wards

**Figure 4.31 Internal layout use diagram**

(Norita Johar (2013))

- Visitor’s route
- Staff’s route
- Patient’s route

**Figure 4.34 Measurement in sketches**

(Norita Johar (2013))

**Figure 4.15 Internal AIIR at Ward 4C**

**Figure 4.16 Individual pressure controller at Ward 4C**

(Norita Johar (2013))
There is a combination of two types of layouts inside the ward as illustrated in figure 4.27.

**Figure 4.27 Internal zoning diagram**

**Figure 4.28 Zoning for ventilation diagram**

**Table 4: 12 Spatial summary**

<table>
<thead>
<tr>
<th>SPATIAL</th>
<th>Variables</th>
<th>Feasibility</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Orientation</td>
<td>Party Yes</td>
<td>for Ward 4B &amp; 4D</td>
<td></td>
</tr>
<tr>
<td>Vertical Location</td>
<td>No</td>
<td>Has mix vertical circulation</td>
<td></td>
</tr>
<tr>
<td>Emergency Dept.</td>
<td>Yes</td>
<td>Separate external circulation and access</td>
<td></td>
</tr>
<tr>
<td>Circulation at Core</td>
<td>Party Yes</td>
<td>For Ward 4B because it connects directly to Special Isolation Ward 4C because staff entrance is shared</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Party No</td>
<td>For Ward 4A &amp; 4C because staff from 4C need to cross public circulation to go there. No transition space between public to ward</td>
<td></td>
</tr>
<tr>
<td>Internal Zoning</td>
<td>Party Yes</td>
<td>Cross ventilation at one bay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Party No</td>
<td>No cross ventilation at 2 bays</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4: 11 Statistical summary**

<table>
<thead>
<tr>
<th>STATISTICAL</th>
<th>Variables</th>
<th>Target Respondents</th>
<th>Feasibility</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection control</td>
<td>Doctors &amp; Nurses</td>
<td>No</td>
<td>Only if the wards are retrofitted first</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patients &amp; Visitors</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineers</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient Monitoring</td>
<td>Doctors &amp; Nurses</td>
<td>Yes</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patients &amp; Visitors</td>
<td>Yes</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Users</td>
<td>Doctors &amp; Nurses</td>
<td>No</td>
<td>Only if salutogenic elements are implemented first</td>
<td></td>
</tr>
<tr>
<td>Comfort</td>
<td>Patients &amp; Visitors</td>
<td>No</td>
<td>Implemented first</td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>Doctors &amp; Nurses</td>
<td>No</td>
<td>Only if safe interactions are implemented first</td>
<td></td>
</tr>
<tr>
<td>Visiting</td>
<td>Patients &amp; Visitors</td>
<td>No</td>
<td>Implemented First</td>
<td></td>
</tr>
</tbody>
</table>

(norita Johar (2013)
FINDINGS

• That…. **open ward is not feasible and preferred for All** use in terms of safety & infection control, user's comfort and safe visiting.
• Open ward is only feasible and preferred in terms of patients monitoring.
• Planning for isolation is especially critical considering the centrality and the facts that SBH uses central core for vertical circulation that requires segregation of infected and non infected users which is not possible in SBH due to vertical location and limited access to the wards.
• Likewise, horizontal segregation is also impossible since the design congregate all users at the central core to move up and down the hospitals.
NATURAL OR MECHANICAL OR BOTH?

- Environmental controls (EC) are important to prevent the spread and reduce the concentration of infectious droplet in the air.

- A variety of simple to complex EC can be used to reduce the number of aerosolized infectious droplet nuclei in the work environment.

The simplest and least expensive technique is by maximizing natural ventilation through open windows.

MOH (2012)

DESIGN guidelines
BY MOH(2012) ON STAFF /HEALTH CARE WORKERS (HCW) SAFETY upon many contracted tuberculosis on duty……

More complex and costly methods involves the use of mechanical ventilation i.e. local exhaust ventilation (LEV) and negative pressure rooms which may include HEPA filtration to remove infectious particles and the use of ultraviolet germicidal irradiation (UVGI) to sterilize the air.
Whenever possible, the patient should face directly into the opening of the hood to direct any coughing or sneezing into the hood.

**Diagram 3.1.** Natural ventilation; free flow of ambient air in and out through open windows

This is not recommended for highly pathogenic organism e.g. SARS virus and toxic chemicals.

**Diagram 3.2.** An enclosing booth designed to sweep air past a patient with tuberculosis disease and collect the infectious droplet nuclei on a high efficiency particular air (HEPA) filter

Source: Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* In Health-Care Settings, 2005. MMWR Recommendations and Report. CDC, 30th December 2005 / 54(RR17);1-141

Source: MOH (2012)
SECONDARY

- Control airflow to prevent contamination of air in areas adjacent to source (All Room) and cleaning the air by using ‘high efficiency particulate air’ (HEPA), filtration or ‘ultraviolet germicidal irradiation’ (UVGI).

Source: Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* In Health-Care Settings, 2005. MMWR Recommendations and Report. CDC, 30th December 2005 / 54(RR17), 1-141

MOH(2012)
CASE STUDIES OF INFECTIOUS DISEASE WARD DESIGN THEN AND NOW

LITERATURE REVIEW, DESIGN EXPERIENCE EVALUATION
Hospitals designed in this period tried their best to avoid deep plans and at roofs, and to provide wider corridors and patient areas with access to natural daylight, and more space for respite.
The COLONIAL HOSPITAL
LAYOUT PLAN AND POSITION
OF INFECTIOUS DISEASE WARD
BLOCK

The old Sungei Petani Hospital

Main entrance
SPECIAL UNITS

SUNGAI BULOH LEPROSY CENTRE – garden colony
A City Isolated

CASE STUDY 1

KOTA BHARU HOSPITAL TUBERCULOSIS/INFECTIOUS DISEASE WARD (demolished in 2008)

LOCATION OF THE TB WARD ON HOSPITAL SITE AS AN ISOLATED BLOCK

Source: Norwina Mohd Nawawi (2010)
The study had noted the use of ventilated concrete bricks as infill, overhang, ceiling height, width of the building, cross ventilation, use of mechanical fans and other details that address the nature of the origin of use as naturally ventilated buildings of both buildings. Writings on the history of the architecture and its many uses from tuberculosis ward to drug and infectious disease ward for the hospital.
Source: Norwina Mohd Nawawi (2010)
Tuberculosis Ward designed in 1930s in Kota Bharu Hospital

Source: Norwina Mohd Nawawi (2010)
CASE STUDY 3

TELUK INTAN CENTRE FOR INFECTIOUS DISEASE (CID)-RETROFITTED

Image © 2017 DigitalGlobe
© 2017 Google

(Source: Cipta Teguh Arkitek)
4th level of Teluk Intan Hospital, Perak (Retrofitting existing ward to Infectious Disease Ward)
(Source: Cipta Teguh Arkitek)

4 BEDDED BAY | NOT TO SCALE

(Source: Cipta Teguh Arkitek)
2 BEDDED BAY | NOT TO SCALE

(Source: Cipta Teguh Arkitek)
BUILDING
SERVICES AREA | NOT TO SCALE

(Source: Cipta Teguh Arkitek)
TYPES OF ISOLATION BED ROOMS IN TELUK INTAN INFECTIOUS DISEASE WARD DESIGN

(Source: Cipta Teguh Arkitek)
FINDINGS

- Similar to Sungai Buloh Hospital, the location of the ward is vertical and on the 4th floor, the highest level of the hospital as an isolation.
- The ward was formerly a 28 bed medical ward retrofitted to 3 types of beds room – isolation, 2 bed, 3 bed as cohort admission.
- Circulation of the patient, staff and visitors is limited to the central corridor and the vertical transportation.
- The positive points lies on its isolation position where non relevant staff, public will not venture without appropriate safeguards.
CASE STUDIES 4

HOSPITAL TUMPAT, KELANTAN
TUMPAT CENTRE FOR INFECTIOUS DISEASE (CID)
PURPOSE BUILT

Ground Floor Plan

Roof plan

TUMPAT CID

Vehicle direct access

(source: Cipta Teguh Arkitek)
8 Single isolation rooms  1 – 2 beds isolation room  2 – 4 beds isolation rooms

Source: Cipta Teguh Arkitek TUMPAT CID
infectious disease ward evolution: case study.

SINGLE BED ISOLATION ROOM

TUMPAT CID  Source: Cipta Teguh Arkitek

2 BED ISOLATION ROOM

4 BED ISOLATION ROOM
FINDINGS

• LOCATED AS AN ISOLATION ENTITY WITH OWN DIRECT VEHICLE ACCESS
• ON THE GROUND/LANDED
• WITH MORE SINGLE BED ISOLATION ROOMS PROVIDED
• SERVICE/CLEANING ACCESS FROM THE OUTSIDE CORRIDOR
• STAFF, PATIENT & VISITORS ENTER ON SAME ENTRANCE
SUMMARY OF FINDINGS

• **Infection control is primary concern for patient, staff and visitors within the facility from HAI and outside to avoid pandemic**

• **There is no right or wrong design but appropriate for the nature of infection and problems associated with space, ventilation, location and whether the facility is purpose built, retrofit wholly, upgraded from existing operationally**

• **This research focus on design and its implication only from physical observation and thus cannot conclude on the various method and operation that the hospital put in their service to ensure treatment is continued and infection is under control**

• **These designs had delivered its worth to occasional disease occurrence and will be reviewed as and when necessary.**
THANK YOU FOR LISTENING

MALAYSIA
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