Reusing abandoned Dutch-colonial architecture for medical applications

The reuse of Dutch-colonial architecture and their passive ventilation systems for medical applications in the coastal region of Java, Indonesia

Marijn Heijnis

Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft
M.Heijnis@student.tudelft.nl

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Abstract

The geography of health care systems is rarely given much importance and yet, the availability of health services to the population, in terms of hospitals, clinics and other facilities, is strongly influenced by their location. In the large cities of Java, the problems of providing adequate healthcare are immense. As Dutch-colonial buildings are available in the centre of large Javanese coastal cities, transformation of these buildings could provide a solution to the lack of health care institutions.

Natural ventilation and the implementation of shading devices prove to be most effective, passive strategies in creating a comfortable indoor environment in the Javanese coastal climate. Natural ventilation causes the risk of airborne contagion to drop much lower than by using mechanical ventilation systems. In order to create an effective natural ventilation system, the old-fashioned clinical buildings with high ceilings and large windows can serve as example of how to implement a natural ventilation strategy. The high ventilation rate, provided by historic architecture, results in a lower risk of airborne contagion.

One important factor in reusing Dutch-colonial architecture for medical purposes is the location of the building. The implementation of an inpatient ward in a Dutch-colonial building depends highly on the air quality of the surrounding area. Surgical and intensive care wards cannot be implemented in a natural ventilated interior space, as they require more specific climatic circumstances.

Keywords

Dutch-colonial architecture, natural ventilation, Javanese coastal climate, reuse, medical architecture.

I. Introduction

During the past few decades, a vast expansion of cities due to population growth and urbanization occurred. Many of these large cities are in less developed countries like Indonesia, where the problems of providing adequate healthcare are immense (Mayhew, 1986). Functions which require a lot of space, such as health care facilities, are likely to be located in the peripheral, newer neighbourhoods, where space is still available. And so, the dense core of these cities lacks medical functions.

The geography of health care systems is rarely given much importance and yet, the availability of health services to the population, in terms of hospitals, clinics and other facilities, is strongly influenced by their location (Mayhew, 1986). As Dutch-colonial buildings are available in the centre of large Javanese coastal cities, transformation could provide a solution to the lack of appropriate places for to establish health care institutions. Therefore, in this paper, the following question is answered: Can Dutch-colonial buildings in the Javanese coastal climate be repurposed as healthcare facility while using their existing, passive climate strategy?

II. Methodology

To investigate the possibility of reusing Dutch-colonial buildings in the Javanese coastal climate as healthcare facility, it is important to formulate which essential characteristics their passive climate system should hold in the Javanese coastal climate. Whether a passive climate system in Dutch-colonial buildings provide an appropriate climate for hosting a medical function, is investigated accordingly.

A concise analysis of an ancient Dutch-colonial hospital building in Semarang, compared with available Dutch-colonial architecture in the dense core of Semarang explores whether the essential characteristics – characteristics a passive climate system should hold in the Javanese coastal climate to host a medical function – are present in Dutch-colonial architecture. How passive strategies in historical architecture should be designed or restored to create an appropriate climate which can support a medical function is determined to be able to establish practical design requirements.

III. Discussion

This paper is concerned with the Javanese Coastal region, as the main historic cities of Java are situated along the northern coastline. The city-centres in the larger coastal cities hold Dutch-colonial neighbourhoods which in many cases suffer from vacancy, whereby the centres of Jakarta, Semarang and Surabaya are the most relevant ones.

Literature in the field of natural ventilation in the medical environments is limited. Existing literature substantiates promising results, but more research to examine the effects of natural ventilation systems in warm *and humid* climates on patients and personnel is needed.

1. Bioclimatic analysis of the Javanese coastal climate and its implications for passive strategies in architecture

Present-day Indonesia has multiple forms of health-care institutions. These institutions mostly use air-conditioning systems to control the interior climate. Whether these costly systems are the only way to work with the climatic properties of this region is explored in this chapter by investigating the way vernacular architecture is able to address the challenges the Javanese Coastal climate poses on the comfort of the human body.

1.1. Bioclimatic analysis of the Javanese coastal climate

In *Bioclimatic Analysis in Pre-Design Stage of Passive House in Indonesia*, Matsumoto (2017) has investigated climate characteristics of Jakarta, using a selection of bioclimatic charts: the *Olgyay Bioclimatic Chart, Givoni-Milne Bioclimatic Chart* and a *Mahoney Table*. Although this research focusses on residential architecture, the main objective of creating a comfortable indoor climate by using a passive system is relevant for any sort of building in a hot and humid climate. The advantages and limitations of these different tools are set out in *Appendix 1*.

The charts discussed here, according to Matsumoto, are appropriate tools for investigating possible strategies for designing buildings that are suitable to their local climate (Matsumoto et al., 2017). The main characteristics of the Jakarta climate are set out in Appendix 1 and are used as input for the charts. The three charts, have divergent approaches and can provide different views on architectural strategies to create comfort in the indoor environment in the Jakarta climate.

Figure 1 shows the **Olgyay Bioclimatic Chart for Jakarta**. The lines (1-12) represent the monthly minimum and maximum temperatures and the corresponding relative humidity. The chart suggests a muggy condition for every month due to the high temperature and the high levels of humidity: the minimum value of temperature resides in the comfort zone while the maximum temperature is situated outside this zone (Matsumoto et al., 2017). According to Matsumoto, the data demonstrates a need for a high level of wind to counteract the vapor pressure. To reach this, a wind velocity is recommended of 1,5 m/s. As wind speeds in most of Indonesia are greater than 3,0 m/s, the high levels of humidity do not pose a problem when making proper use of the high ventilation rate which becomes possible with natural ventilation. The shading lines in the chart, indicated by *Radiation W/*m^2, imply that a shading device is a crucial element that must be present to reduce solar gain entering the building (Matsumoto et al., 2017).

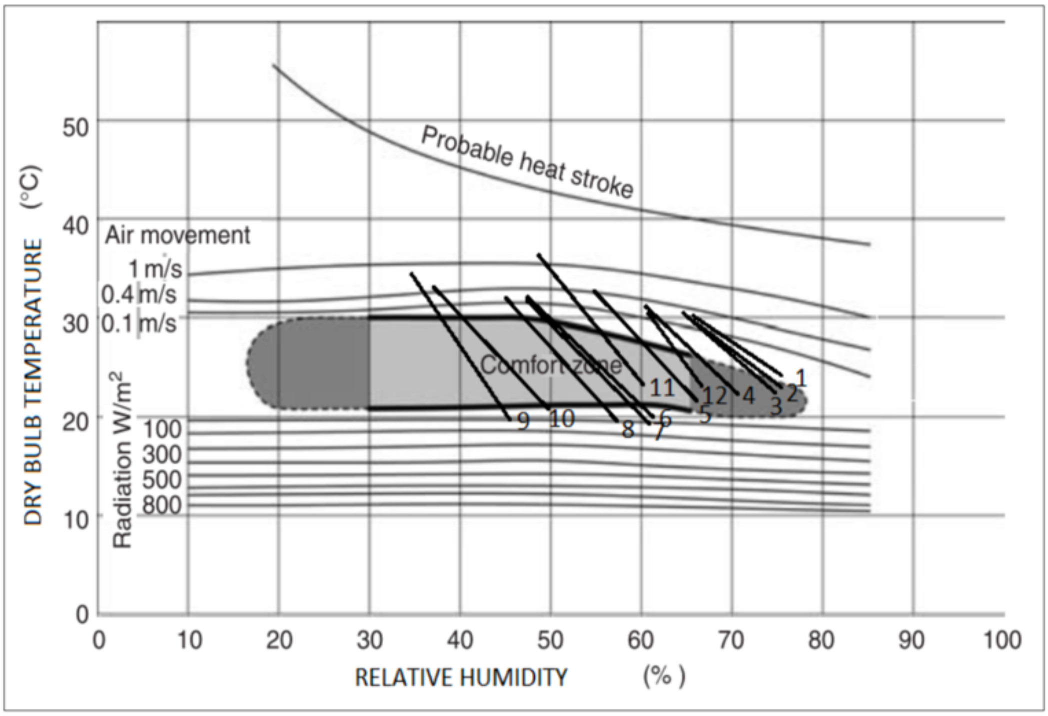

Figure 1: *Olgyay Bioclimatic Chart of Jakarta* (*Matsumoto* et al., 2017).

Figure 2 shows the **Givoni-Milne Bioclimatic Chart for Jakarta**, which is created by plotting the temperature (*Dry Bulb* in °C) and *Vapour Pressure* (kPa). Because this bioclimatic chart is based on the conditions of the outside temperature, a calculation was needed to determine the outdoor temperature capable of producing a comfortable indoor climate (Matsumoto et al., 2017). As shown in Figure 2, natural ventilation (in orange) is the most effective passive strategy for to create indoor comfort in hot and humid areas in all months (the months are indicated by blue lines, numbered 1 to 12). Other strategies are relevant, and could add extra comfort to an indoor environment, such as the use of high thermal mass (with or without night ventilation), but these strategies, after implementing natural ventilation, will not have a fundamental different effect on the indoor climate, as natural ventilation already covers most of the area which represents the indoor comfort zone, in every month.

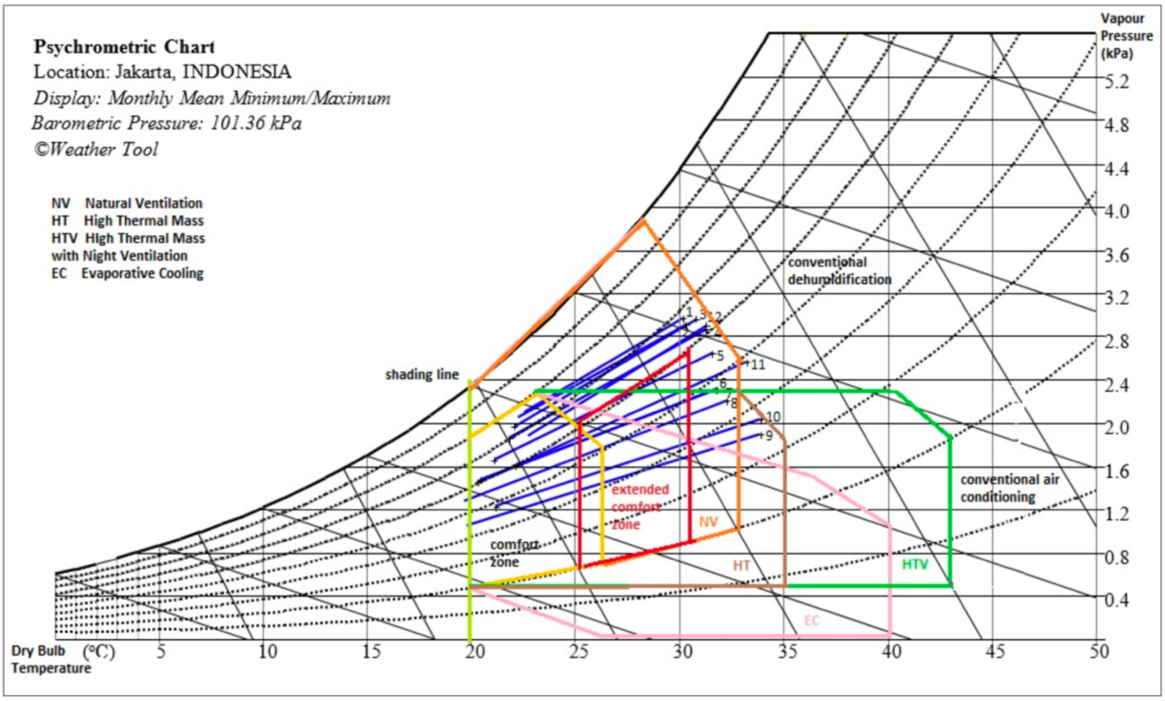

Figure 2: *Givoni-Milne Bioclimatic Chart of Jakarta* (Matsumoto et al., 2017).

Appendix 2 shows the results of the third relevant bioclimatic analysis tool, the **Mahoney Tables for Jakarta**. Design recommendations resulting from entering the input values which represent the Jakarta climate conditions, into the Mahoney Tables (see *Appendix 2*), bring forward relevant strategies (Matsumoto et al., 2017).

1.2. Results of the bioclimatic analysis

The results of these three bioclimatic charts provide a basic understanding of the measures needed to create a comfortable indoor environment in Jakarta. As seen in the Olgyay and Givoni-Milne bioclimatic charts, natural ventilation or wind penetration, and the implementation of shading devices prove to be most effective, passive strategies in creating a comfortable indoor environment in the Javanese coastal climate. Besides these recommendations, the Mahoney Table adds more strategies, by suggesting a north-south building orientation (long axis from east to west), open spacing for protection from hot wind, single banked rooms for permanent provision of air, composite openings which cover 20%-35% of the wall area at body height, positioning of the windows in north and south walls, heavy walls, a heavy roof and protection from heavy rainfall.

To be able to assess the possibility of transforming Dutch-colonial architecture into a medical function while using or restoring its passive climate system, the applicability of this system to the medical function should be reviewed first. Because natural ventilation, from al passive strategies discussed, holds the most important position in creating comfort in the coastal Javanese climate, this passive climatic strategy will have a crucial role in reusing Dutch-colonial architecture for medical applications.

2. The suitability of the Dutch-colonial building's passive system to create an appropriate climate for a medical function

In modern-day Java, hospital design is based on the modern Western-style hospitals, one could find in Europe or Northern America. These air-conditioned environments do not seem to have a positive influence on patients, as they create a relative dry environment (Jilzani, F., Personal interview. 15 November, 2019). The wide dissemination of Western forms of architecture should proceed with caution, as these forms evolved from the challenge of cool climates (Olgyay et al., 2015) and ignore any climatic circumstance in the coastal Javanese region. Whether using a passive climate system – and in particular the use of natural ventilation – provides an appropriate climate for a medical function, is explored further.

2.1. Natural ventilation as prevention for airborne contagion

One important quality any ventilation system should have in a hospital environment is the prevention of airborne contagion. Natural ventilation, maximised by opening doors and windows causes the risk of airborne contagion to drop much lower than would be possible by using mechanical ventilation systems (Escombe et al., 2007). In order to create an effective natural ventilation system, the old-fashioned clinical buildings with high ceilings and large windows can serve as example of how to implement a natural ventilation strategy which protects the patient against airborne contagion (Escombe et al., 2007). In Figure 3, the effectiveness of a historic hospital design, in contrast to newer architecture, becomes clear. Historical hospital design maintains a high ventilation rate and a relative low chance on tuberculosis (TB), which is telling for other airborne diseases.

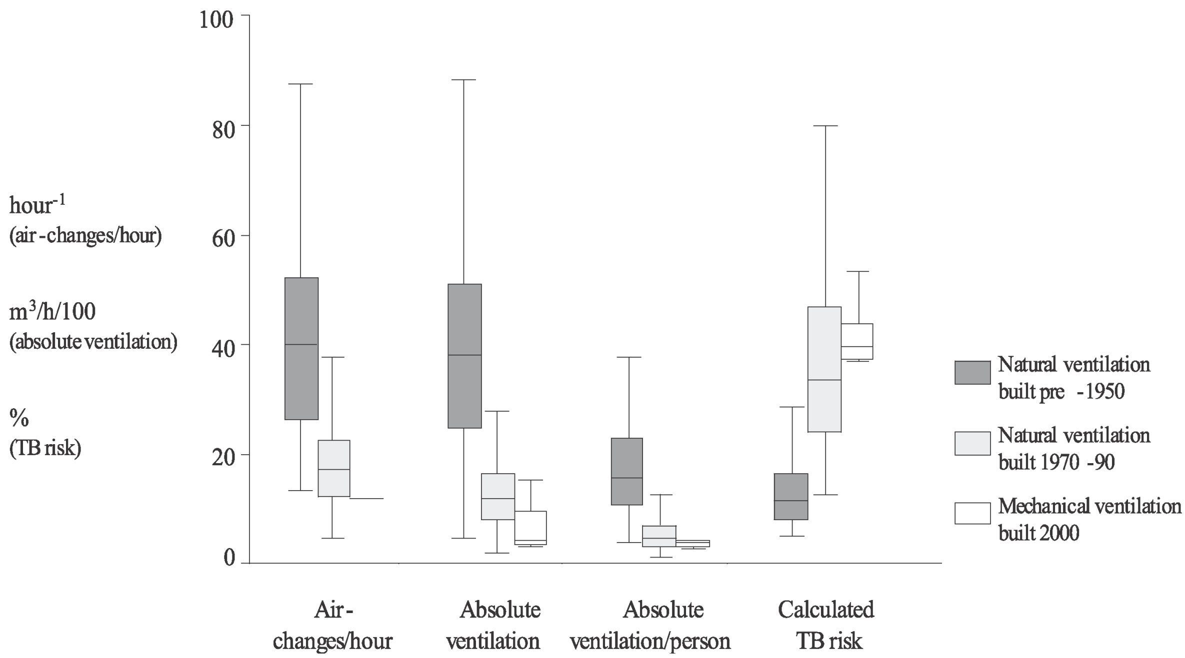

Figure 3: *Ventilation and protection against airborne TB transmission in old-fashioned, compared with modern rooms.* Ventilation and protection against airborne infection is shown for pre-1950 versus modern (1970-1990) naturally ventilated facilities, versus mechanically ventilated negative-pressure respiratory isolation rooms (Escombe et al., 2007).

The systems, present in old-fashioned clinical buildings are relatively cheap, maintenance free, and they are particularly suited to limited resource settings and tropical climates where the burden of TB and TB transmission is highest (Escombe et al., 2007). The high ventilation rate, provided by historic hospital architecture, results in a lower risk of airborne contagion, which is a substantial quality. Even more promising for the reuse of the Dutch-colonial architecture for medical applications, is the fact that disinfection of bacteria, fungi and viruses, are expressed as the equivalent effect of a certain number of air changes per hour (Adhikari & Clark, 2017), and so, a higher ventilation rate reduces the infection rate (Shajahan et al., 2019). But there is insufficient evidence for recommending a minimum ventilation rate for infection control (Salonen et al., 2013). The optimisation of more specific properties of the natural ventilation system can provide more certainty, as the air distribution pattern, position and distance of the susceptible person from source and air diffusers all influence the chance of airborne contagion (Shajahan et al., 2019).

2.2. Ancient hospital design opposed to modern systems

Walking into the courtyard of the *Pastoral Catechetical School of Saint Francis of Assisi* in Semarang, a walled-off, ancient complex on the border of the old colonial-Dutch neighbourhood *Kota Lama*, one feels like walking into an oasis in the middle of the simmering hot city. An immured plaque commemorates the establishment of one of the oldest buildings of this complex built in 1732, which at the time functioned as a hospital. Surprisingly, this old building is climatically still functioning, as a constant breeze, upon entering the building's interior spaces, enlightens the physical state of the visitor (Imelda, Sr., *Personal interview*. 3 November, 2019). The climatic situation in this historic environment is in great contrast with the small healthcare posts in the city, which are dealing with the climatic situation by using a small air conditioning system.

2.3. The adaptation of medical architecture to the tropical climate

Natural ventilation as main strategy in a hospital environment in the Javanese coastal climate proves to have many advantages for infection control. In contrast to the modern Western-style hospitals, the old-fashioned clinical buildings with high ceilings and large windows create an effective natural ventilation system, and therefore can serve as example for the implementation of a natural ventilation strategy which protects the patient against airborne contagion (Figure 4).

The fact that former hospital buildings were designed to have a comfortable indoor climate, is in line with scientific developments during their period of construction. Tropical medicine, as a truly scientific branch of medical thought and practice emerged only at the end of the nineteenth century (Duggan, 1981). In 1898, after some 300 years of European activity overseas (Arnold, 2007), the British declared war on tropical diseases (Farley, 1991). They did so, as the advent of the germ theory suggested that disease in tropical regions *was not specifically linked to climate* (Arnold, p. 304). In the Dutch East-Indies – the present-day archipelago of the Republic of Indonesia – a similar process of adaptation occurred during this period.

During the establishment of a historic hospital building in Semarang (the *Pastoral Catechetical School of Saint Francis of Assisi* in Semarang, Figure 4), prior to the introduction of the germ theory of disease, it is therefore apparent that these interior spaces were built in such a way, so that they adapt to the local climate as much as possible. In Figure 4, the natural ventilation system becomes visible as main characteristic of Dutch-colonial architecture.

Figure 4: *The modern climatic design of the Pondok Indah Bintaro Hospital in Jakarta (on the left), compared with the historic climatic design of the Pastoral* Catechetical *School of Saint Francis of Assisi in Semarang (on the right).* Own work.

3. The design or restoration of a passive climate system in colonial architecture which is repurposed as a medical building

As natural ventilation in historical architecture in coastal Java seems to be effective in serving a medical function, the way in which an existing natural ventilation system in Dutch-colonial architecture can provide an appropriate climate for a medical function, is examined by comparing the aforementioned historical hospital building in Semarang with a vacant Dutch-colonial building in Semarang. Furthermore, design steps are formulated to install or restore a natural ventilation system in a Dutch-colonial building in the Javanese coastal climate.

3.1. Design and context of Dutch-colonial architecture

Mrs. Imelda, one of the sisters living in the collection of buildings that make up the *pastoral catechetical school of Saint Francis of Assisi* in Semarang, admires the design of the historic interior spaces of these buildings. She is familiar with the typical modern medical environment as well, as she delivers medicine to such hospitals in Semarang. In contrast to the modern hospital environments, the climate in the old hospital building, is very comfortable (Imelda, Sr., *Personal interview*. 3 November, 2019). Modern architecture, according to Sister Imelda, offers a ceiling height of only three metres. The old building, she continues, has ceiling heights of five metres (Figure 8). This is important she adds, for the purpose of the indoor ventilation flows. The outside air is cooled down and freshened by the surrounding gardens, after which it enters the former hospital's interior spaces. Sister Imelda's observations seem to agree with design strategies in old-fashioned hospital design which provide a relative high ventilation rate, discussed by Escombe (2007), and shown in *Figure 3*.

Promising, when speaking about the possibility of using Dutch-colonial architecture for medical applications, is that these climatic strategies of this ancient hospital building are not unique, and can be recognized in other Dutch-colonial architecture. In Figure 5, a comparison is made in climatic design, between the historic hospital building and a former Dutch-colonial office building. These two buildings use a similar approach in creating a natural ventilation system, while blocking direct sunlight from the interior space. To do this, the context of the buildings play an important role.

The influence of the context on a natural ventilation system becomes apparent in Figure 5. The location of the Dutch-colonial architecture is a significant factor in the design process, as the air quality around the medical institution will determine the air quality in its interior spaces. A bad air quality through malodorous air pollutants will have a negative effect on the patient, and some toxins (e.g. lead, solvents) cause behavioural disturbances (e.g. self-regulatory ability, aggression) (Evans, 2003). The reuse of a Dutch-colonial building for a medical application by using a natural ventilation system, also depends on the existence of greenery around the building, to cool and (partly) clean the incoming air.

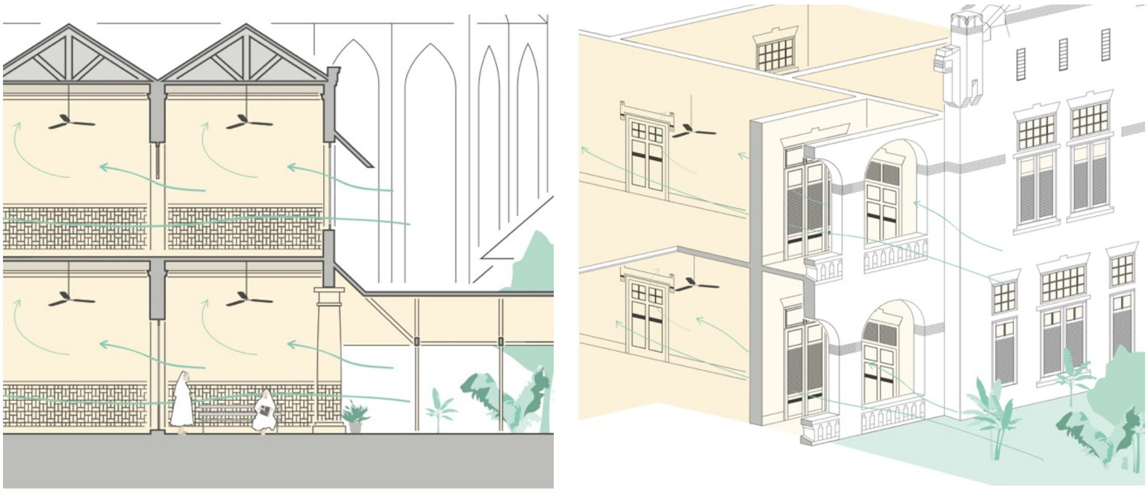

Figure 5: *Section of the climatic situation of the pastoral catechetical school of Saint Francis of Assisi in Semarang in comparison with the climatic situation of the former office building Javahout in Semarang.* Own work.

3.2. Required design steps

Salonen (2013) has set out basic design steps for designing a naturally ventilated building for infection control. These steps are: 1. selecting the desired airflow pattern, 2. identifying the main driving forces, and 3. sizing and locating openings. The following paragraphs elaborate on these design steps in order to determine the best possible design strategy for the transformation or restauration of Dutch-colonial buildings into medical buildings.

3.3. The establishment of an airflow pattern

An airflow pattern can be established by mechanical fans or by creating the appropriate architectural design. Mechanical fans could be installed in windows, to create a negative pressure difference. In this way the airflow direction is completely manageable and a pattern can be created that is most likely to extract microorganisms from the indoor environment, as much as possible. A negative pressure protects the health of the workers, patients and visitors from airborne diseases (Salonen et al., 2013). However, the high ventilation rates which the Javanese coastal climate provides, in this way, will not be used to full extend, as the mechanical system cannot create ventilation rates as high as a completely natural ventilation system. This means that an airflow pattern should be determined, not by mechanical fans, but by architectural design based on the best possible airflow pattern which is provided by natural forces, which provide a higher ventilation rate.

3.4. Pressure differences and the dimensioning and positioning of openings

Whether a natural ventilation system is able to reach all spaces in a building to supply fresh air, relies on pressure differences. These differences can be caused by wind or the buoyancy effect, created by temperature differences or differences in humidity (Walker, 2012). As temperature and humidity differences are difficult to generate in the Javanese coastal climate which is particularly warm and humid all year round, pressure differences are most practical to establish by using a natural ventilation flow based on wind.

The amount of ventilation will depend on the dimensions and the positioning of openings in the building (Walker, 2012). Openings between rooms such as transom windows, louvers, grills, or open plans are techniques to complete the airflow circuit through a building (Walker, 2012). Large openings cause the airflow pattern and the airflow direction to become unstable (Salonen et al., 2013).

3.5. Climatic influences and patient satisfaction

The physical healthcare environment in a hospital building can have a beneficial impact on patients' healing processes (Dijkstra et al., 2006; Choi et al., 2012; Shajahan et al., 2019) and this complex environment has a significant impact on patients' physical and psychological well-being (Choi et al., 2012). Important components in an indoor environment which have a beneficial effect on patients are greenery and light. The view on greenery in a hospital causes patients to feel more comfortable, and there seems to be a positive relation between a view on greenery and the perception of wellbeing (Hamed et al., 2017).

Patients benefit from bright, sunny interiors, and consequently, these patients have a shorter stay in such environments (Beauchemin & Hays, 1996). Even more telling is the case of an obstetric ward in New-Guinea, where after adding awnings which severely limited the intensity of natural light, the rate of clinical jaundice cases increased from 0.5% to 17% (Barss & Comfort, 1985). When reusing or installing a passive climate system into Dutch-colonial architecture, attention should be given to the aforementioned issues.

3.6. The surgical environment and the use of natural ventilation

Climate in a hospital, in some departments, is vital for the patient's wellbeing while other departments are more focussed on the overall wellbeing and can accept a wider variation in climatic circumstances. In a surgical environment, the patients' wellbeing requires different strategies from strategies which are appropriate in an inpatient environment. Concluded from field experiments performed in a medical centre in central Taiwan, patients' physical strength significantly affected their thermal requirements (Hwang et al., 2007), and so, in an operation room, low ambient temperatures are critical for patient's wellbeing. As the required temperature for the patient lays lower than the outside temperature in the Javanese coastal regions, natural ventilation in the surgical environment cannot be an option.

IV. Conclusion

This research which is concerned with repurposing Dutch-colonial buildings in the Javanese coastal climate as healthcare facility, while using a passive climate strategy, has led to some interesting insights, wherein natural ventilation takes in a crucial role.

Natural ventilation shows to be the most important factor in a passive system in the coastal Javanese environment. In the Javanese coastal climate, the average wind speed is more than sufficient to sustain a natural ventilation system. Sufficient daylight in the interior is very important for patient's recovery and reducing TB risk. A consideration should take place for the use of shading devices, while enough daylight is entering the interior space. Other passive climate strategies than the aforementioned natural ventilation system and shading devices, can add comfort but will not have a fundamental different effect on comfort level of the indoor climate.

Natural ventilation proves to be very effective in preventing airborne contagion. Natural ventilation systems in historical buildings prove to be most efficient in doing so, as they enable a high ventilation rate. Dutch-colonial buildings on Java, in many cases, seem to fit these requirements, as their design characteristics include high ceilings and large windows, which are requirements a natural ventilation system depends on.

Three steps can be used to create or restore a natural ventilation system in the Dutch-colonial architecture to create a suitable climate for the patient:

1. A desired airflow pattern should be selected. To create a sufficient ventilation rate in the building's interior spaces, the architectural design has to function as a climate system in itself and should therefore follow the desired airflow pattern.

2. The main driving forces in the natural ventilation system should be identified. To create an effective air flow, which follows the aforementioned, desired airflow pattern, pressure differences which can be created by wind or the buoyancy effect, temperature differences or differences in humidity are needed.

3. The openings in the building should be dimensioned and located according to the requirements of the previous steps. The amount of ventilation will depend on the size and the placement of openings in the building.

Dutch-colonial architecture, provided that it is equipped with a working natural ventilation system, or the basic design strategies to implement one, can be repurposed as healthcare facility. An inpatient ward would suit this climatic and medical adaptation. A surgical or intensive care ward however, requires lower temperatures and air filtration, so that these parts of the hospital environment cannot be part of a reused Dutch-colonial building which relies on a passive climate system.

The implementation of an inpatient ward in a Dutch-colonial building depends highly on the air quality of the surrounding area. Pollutants may create an unhealthy environment in the natural ventilated interior space, and therefore some Dutch-colonial buildings, could be unsuitable for a health care function.

Practice will ultimately have to show whether a natural ventilation system of a Dutch-colonial building will actually be efficient in creating an appropriate medical environment. The research results presented in this paper about reusing a Dutch-colonial building, under the conditions mentioned in the conclusion, offer a positive outlook.

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Appendix 1: *Input bioclimatic charts*
Appendix 2: *Mahoney Tables Jakarta*
Appendix 3: *Personal Interviews*:

Imelda, Sr. (3 November, 2019). Personal interview: *Sister Imelda, Pastoral Catechetical School of St. Francis of Assisi, Semarang.*

Jilzani, F. (15 November, 2019). Personal interview: *dr. Faraida Jilzani, Rumah Sakit Pondok Indah (RSPK, Bintaro), Jakarta.*

Psari, E. (15 November, 2019). Personal interview: *arch. Eri Psari, a2 Associated Architects, Jakarta.*

Appendix 1: Input bioclimatic charts

	Olgyay Bioclimatic Chart	Szokolay Bioclimatic Chart	Givoni–Milne Bioclimatic Chart	Mahoney Table
Monitored ambient variables	1. Dry bulb temperature 2. Relative humidity	1. Dry bulb temperature 2. Wet bulb temperature 3. Relative humidity 4. Absolute humidity	1. Dry bulb temperature 2. Wet bulb temperature 3. Relative humidity 4. Absolute humidity 5. Vapor pressure	1. Monthly mean min, max and average temperature 2. Monthly mean min, max and average relative humidity 3. Precipitation
Strategy proposed/ Design recommendation	1. Solar radiation 2. Air movement 3. Shading	1. Natural ventilation 2. Passive heating 3. Evaporative cooling 4. Indirect evaporative cooling 5. Thermal mass 6. Thermal mass with nigh ventilation	1. Natural ventilation 2. Passive heating 3. Active heating 4. Humidification 5. Conventional dehumidification 6. High thermal mass 7. High thermal mass with night ventilation 8. Evaporative cooling 9. Conventional/mechanical air conditioning	1. Layout 2. Spacing 3. Air movement 4. Openings 5. Walls 6. Roofs 7. Outdoor space 8. Rain protection
Advantage	1. The chart is applicable in hot humid areas 2. Suitable for residential building	1. Define two comfort zones	1. Mainly used for residential buildings	1. Provide much more and different points of view for design recommendation than the bioclimatic chart
Limitation	1. Only provides limited design recommendation	1. The relative humidity should not exceed 90%	1. Windows are closed during the daytime for thermal mass	2. The thermal comfort limit assumes no heat gain or loss due to ventilation or insulation

"*Summary of climatic analysis tools for building design purposes*" (Matsumoto, p.3).

Monthly mean air temperature (°C).

Month	J	F	M	A	M	J	J	A	S	O	N	D
Monthly mean max	30	30	31	31	32	32	32	32	34	34	33	31
Monthly mean min	23	22	22	22	21	20	20	20	20	21	22	23
Monthly mean range	7	8	9	9	11	12	12	12	14	13	11	8

Monthly mean relative humidity (%).

Month	J	F	M	A	M	J	J	A	S	O	N	D
Monthly mean max a.m.	96	95	93	94	91	90	89	87	85	86	90	92
Monthly mean min p.m.	64	62	61	57	52	46	45	41	32	33	43	57
Average	80	78	77	75	72	68	67	64	59	60	66	74
Humidity group	4	4	4	4	4	3	3	3	3	3	3	4

Monthly amount of rainfall.

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rain fall (mm)	622	147	184	204	101	257	257	61	50	110	197	339	2528

"*Result of Bioclimatic analysis"* for the climate in Jakarta (Matsumoto et al., 2017)

Appendix 2: Mahoney Tables Jakarta

AMT	>20 °C		15–20 °C		<15 °C	
Humidity Group	Day	Night	Day	Night	Day	Night
1	26–34	17–25	23–32	14–23	21–30	12–21
2	25–31	17–24	22–30	14–22	20–27	12–20
3	23–29	17–23	21–28	14–21	19–26	12–19
4	22–27	17–21	20–25	14–20	18–24	12–18

Table 9. Temperature diagnosis.

Month	J	F	M	A	M	J	J	A	S	O	N	D	AMT
Monthly mean max (°C)	30	30	31	31	32	32	32	32	34	34	33	31	27
Day comfort upper (°C)	27	27	27	27	27	29	29	29	29	29	29	27	
Day comfort lower (°C)	22	22	22	22	22	23	23	23	23	23	23	22	
Monthly mean min (°C)	23	22	22	22	21	20	20	20	20	21	22	23	
Night comfort upper (°C)	21	21	21	21	21	23	23	23	23	23	23	21	
Night comfort lower (°C)	17	17	17	17	17	17	17	17	17	17	17	17	
Thermal stress day	H	H	H	H	H	H	H	H	H	H	H	H	
Thermal stress night	H	H	H	H	O	O	O	O	O	O	O	H	

Table 10. Determination of humid and arid indicator. H, Hot; O, Comfortable; C, Cold.

Indicator	Thermal Stress		Monthly Rainfall	Humidity Group	Monthly Mean Temperature Range
	Day	Night			
H1(Air movement essential)	H H			4 2, 3	 <10 °C
H2 (Air movement desirable)	O			4	
H3 (Rain protection)			Over 200 mm/month		
A1 (Thermal storage)				1, 2, 3	>10 °C
A2 (Outdoor sleeping)	 H	H O		1, 2 1, 2	 >10 °C
A3 (Cold season problem)	C				

Table 11. Humid and arid indicator.

Indicator	J	F	M	A	M	J	J	A	S	O	N	D	Total
H1(Air movement essential)	√	√	√	√	√							√	6
H2 (Air movement desirable)													
H3 (Rain Protection)	√			√		√	√					√	5
A1 (Thermal storage)						√	√	√	√	√	√		6
A2 (Outdoor sleeping)													
A3 (Cold season problem)													

Comfort limit in Jakarta (Matsumoto et al., 2017).

Indicator Total							Recommendation
H1	H2	H3	A1	A2	A3		
6	0	5	6	0	0		
Layout							
			0–10			*	1. Buildings orientated north-south (long axis from east-west) to reduce exposure to the Sun
			11–12		5–12		
					0–4		2. Compact courtyard planning
Spacing							
11–12							3. Open spacing for breeze penetration
2–10						*	4. As A3, but protect from cold, hot wind
0–1							5. Compact planning
Air Movement							
3–12						*	6. Rooms single-banked. Permanent provision for air movement.
1–2			0–5 6–12				7. Double-banked rooms with temporary provision for air movement
0	2–12 0–1						8. No air movement requirement.
Size of the Openings							
			0–1		0		9. Large openings, 40%–80% of wall area
			0–1		1–12		10. Medium openings, 25%–40% of wall area
			2–5 11–12		4–12		
			6–10			*	11. Composite, 20%–35% of wall area
			11–12		0–3		12. Very small openings, 15%–25% of wall area
Position of the Opening							
3–12						*	13. In N and south walls at body height
1–2			0–5 6–12				14. In N and south walls at body height and also in internal walls
0	2–12						
Protection of Openings							
		0–2 0–2			3–12 0–2		15. No special protection necessary 16. Exclude direct sunlight
		3–12			0–2 3–12	*	17. Protect from rain and direct sunlight 18. Protect from rain
Walls							
			0–2 3–12			 *	19. Light and low heat capacity walls 20. Heavy walls, over an 8-h time lag
Roofs							
			0–5 6–12			 *	21. Light insulated roofs 22. Heavy roofs; over an 8-h time lag
Outdoor Sleeping							
				2–12			23. Space for outdoor sleeping required
Rain Penetration							
		3–12				*	24. Protection from heavy rain needed

Design recommendations resulting from entering values of Jakarta climate conditions into the Mahoney Tables (* relevant strategies according to Matsumoto et al.) (Matsumoto et al., 2017).

Element	Recommendation
Layout	Buildings orientated from north-south (long axis from east-west) to reduce exposure to the Sun
Spacing	Open spacing for protection from hot wind
Air movement	Rooms single-banked. Permanent provision for air movement.
Size of openings	Composite, 20%–35% of wall area
Position of openings	In N and S walls at body height
Protection of opening	Protect from rain and direct sunlight
Walls and floors	Heavy walls, over an 8-h time lag
Roofs	Heavy roofs, over an 8-h time lag
Outdoor sleeping	Space for outdoor sleeping is not needed
Protection from heavy rain	Protection from heavy rain is needed

Recommendations for building design in Jakarta after according the results of the Mahoney Tables (Matsumoto et al., 2017).

Appendix 3: Personal interviews

Personal Interview: Sister Imelda, Pastoral Catechetical School of St. Francis of Assisi 3 November 2019, Semarang

Figure 6: *Sister Imelda.* Personal archive, 2019

The building exists out of a complex with multiple buildings and courtyards. There is a lot of breeze in the hallways and on the courtyards in between the building volumes. A similar airflow is present in the interior of the buildings.

Sister Imelda, who knows a lot about the history of the building, guides us around the building which was clearly the most important and oldest in the direct area. While situated in front of a gate, this building has a typical Dutch-colonial classicist front façade. Walking around the building, we arrive at a courtyard, situated in the middle of the school. This courtyard functioned as aula.

On this side of the old building, a plaquette is visible, which commemorates the start of the construction of the building, that from 1732 would function as a hospital. Sister Imelda explains that the sisters produce – but also receive from other congregations – Western medicine, which is used to provide the Saint Elisabeth Hospital in Semarang from medical supplies. When we enter the old building, the amount and the force of the natural ventilation was striking. In every space within this building a pleasant breeze was present.

In the main room of the building, which is used as a music room, I ask Sister Imelda whether she likes the design of the complex, or whether she would prefer to live in a more modern environment where the interior spaces are cooled by mechanical air conditioning systems. She tells me that her current environment is very comfortable and that she knows these modern environments from the Saint Elisabeth Hospital among others. She continues explaining how she dislikes modern architecture, as it only offers a ceiling height of three metres. This building, she continues, has ceilings as high as five metres. This is important she adds, so that the air can travel easily through the buildings.

We left the old building and continued our tour through the complex. Exemplary of the climatic strategy of the complex are open structures – a sort of canopy structure – which was placed over the main walking routes so that no one needs to walk in the direct sunlight. As we walk towards the chapel, which was built in a neo-gothic style these canopies, besides their shadow providing function, seem to highlight vista's and capture the main directions of the complex. In the chapel, many ventilators provided some breeze. After the afternoon service is finished, Sister Imelda points out a rope which was hanging against the wall, underneath one of the Gothic, stained glass windows. These stained glassed windows – because of the variations in their colouring – can very well have a positive influence on the penetration of the direct sunlight, and in a similar way, the heath from outside. Proudly, Sister Imelda pulls the cord and slowly all separate stained-glass windows open. The whole window, without losing any esthetical attraction, now functions more as louvre.

Personal Interview: dr. Faraida Jilzani, Pondok Indah Bintaro Hospital 15 November 2019, Jakarta

Bintaro Jakarta is a place where private developers are working on neighbourhoods designated for the middle and upper class in Jakarta.

In the hospital I meet Eri Apsari, an architect whose main focus is healthcare design in Jakarta. She works for the company *A2 associated architects*. I will have the opportunity to talk with her in detail about her work later, but first we walk to the elevators and meet our guide through the hospital: dr. Faraida Jilzani. With permission of the hospital's board, she guids us through the different wards and public spaces. Interesting about the hospital is that it has a special ward for acupuncture, which you don't particularly see in hospitals in Western countries. Nevertheless, other traditional healthcare or medicine is not allowed by national law in hospitals according to dr. Jilzani.

dr. Jilzani (left) talking to architect Eri Psari (right). Personal archive, 2019

We walk towards the elevator and go to the first floor. Here, we walk past the pharmacy into the first spaces, which are meant for acupuncture. The treatment rooms in this hospital, at the same time function as consulting spaces and resemble those we know in Western-Europe. Architect Apsari explains that the layout of the room was not representative for most hospitals in Indonesia, as the board of this particular hospital is relatively modern. You can notice this for example from the way the desk of the doctor is placed not in-between the patient and the doctor as would have been preferable in the past to establish a certain respectful relationship between the doctor and the patient. In this hospital the doctor's desk is placed adjacent to a wall, so he sits next to the patient. According to Apsari this enhances the trust between a doctor and a patient.

As we walk on towards other wards on this floor, dr. Jilzani explains that most wards have a relatively large waiting area. This is because Indonesian people are very much involved in the wellbeing of their family. If somebody gets sick, people do not visit the hospital on their own, but preferably with family. On other floors, where one can find the long-stay rooms, family becomes an even more important theme. The last ward we walk past is a ward that I had requested explicitly in advance of my visit, as this part of the Indonesian healthcare system – according to the literature I consulted prior to my visit – has a bad reputation. It is the mental health section of the hospital which exists of no more than one psychiatrist. We walk on as all treatment spaces on this floor, even the one meant for mental treatment, is designed to be very flexible in use and so, they are not much different from the rest.

As we move up to the second floor, we enter the delivery ward. The Pondok Indah Bintaro hospital, is specialized in obstetrics, and therefore this ward is relatively large. A small shop for family members and friends to buy presents is present. The rooms on this floor are varying, ranging from standard to very luxurious delivery rooms. The most luxurious room is a private one, which again is based on the Indonesian Ideal of including the family by making space for comfortable chairs around the bed.

On the next floor, we enter a ward which is specialized in care for children, as is immediately recognizable for its colourful furniture. Apsari comments on the large waiting room: 'we found it very important not to aim all chairs in the waiting rooms of the hospital towards a screen, as is common in hospital waiting rooms'. The personal interaction is clearly an important theme in this hospital design.

As we walk on and take the elevator to the highest, public floor, we enter the long-stay rooms, together with the intensive care. As seen before in the hospital also on this floor there is a distinction between luxurious rooms and more common rooms. dr. Jilzani explains that the Pondok Indah Bintaro hospital offers VIP rooms, VVIP rooms, VVVIP rooms and S(super)VVVIP rooms. She explains how the higher class rooms are most popular. The patients of this hospital are accepting a higher rate, as long as they get more privacy and comfort.

As we walk by one of these more luxurious rooms, we see the female members of (assuming) the family of a patient sitting around the bed. The rooms are quite closed off. Jilzani explains that women prefer their privacy because their religion requires them to wear a headscarf in the presence of men. They can also request to be helped by female nurses. In this ward one can find a small prayer room, to provide the patients from a place to profess their religion.

The intensive care ward is preceded by a waiting room. Here, the waiting room is relatively small and sober. In the hospital a general policy is pursued to not allow people staying there in the night, although they make exceptions. dr. Jilzani adds to this that by night, the chairs of this particular waiting room make place for improvised beds, so that family is able to stay in the hospital during the night.

After our tour through the hospital we go back to the atrium. I sit down with dr. Jilzani, and have the opportunity to ask some questions regarding my experiences during the last weeks in Indonesia, wherein I spoke to many residents of Semarang about their healthcare situation. I ask her whether the Indonesian social insurance system, called JKN (*Jaminan Kesehatan Nasional* or Indonesian National Health Insurance) – which BPJS (*Badan Penyelenggara Jaminan Sosial* or Social Insurance Administration Organization) administers – has a good control of the health situation in Indonesia. dr. Jilzani replies by explaining the situation in less affluent areas, where she had to work in a hospital which was working with the BPJS system to gain experience. Doctors, according to dr. Jilzani, have to choose multiple shifts, BPJS shifts and non BPJS shifts can be combined in a career.

Although BPJS is spreading throughout the country to the people who need it, the system has issues regarding its functionality. For example, the Indonesians do not have a good relationship with Western medicine. They rely on traditional systems which they have been introduced with by their family. Only in the worst cases, when the traditional medicine does not help and they have no other choice, lower income citizens will seek help in a hospital. But in this stage the illness must already be extremely uncomfortable for them to resort to this last option. In these situations, also the family doctor (the Indonesian equivalent of a GP) is skipped, and they go straight to the hospital. This situation makes the BPJS shifts for doctors very hard.

In this situation, there is no distinction between generations. In present-day Indonesia the older generation as well as the younger ones do not trust Western medicine and rather stick to the more familiar traditional systems. The relatively new BPJS system does not change this situation much. This situation relates to beliefs and therefore is difficult to change. For the higher educated Indonesians, the situation is completely different. They are more familiar to Western medicine and have the money to not rely on BPJS, but instead to use private insurances. Before they go to a hospital, they search on google for what they might have and come to the hospital with some understanding of their situation.

Another important issue in the Indonesian healthcare system is the mental health care. Telling for this particular specialization is the size of the mental ward, as seen in this particular hospital, where the most affluent – and assumable the highest educated people of the city – come. I ask dr. Jilzani whether the size of the ward represents the state of mental health care in Indonesia. She explains that in Indonesia, people assume that mental care only is intended for diseases like schizophrenia. In this particular case, even high educated Indonesians do not go to this section of the hospital even though they might for example be suffering from depression or sleeping problems. Exemplary for the state of mental health in Indonesia is the fact that the topic is sensitive even for doctors who within the hard reality of Indonesian hospitals (not only on Java but even more for *Doctors Without Borders* who work in remote places in Indonesia) are struggling with resulting mental issues, and do not use this particular ward. Although a doctor's work is hard in Indonesia, most people do not see mental health care as an option. The people who use the mental health ward in this hospital are Western people, from who many come from a nearby British School.

Climatic design of the hospital

As seen earlier in an ancient hospital in Semarang, hospitals used to be naturally ventilated. In the Pondok Indah Bintaro hospital, not unlike other modern hospitals on Java, all spaces are mechanically ventilated. Which of these systems would be preferable for the patient's wellbeing?

dr. Jilzani tells that the tropical climate by itself does not have a bad effect on a patient. Actually, if anything creates a bad effect on the patient it is the mechanical air-conditioning system. We prefer patients to be in fresh air. But in the case of Pondok Indah Bintaro Hospital natural ventilation could never accomplish this, due to the high rates in air pollution in Jakarta. We have an open-air terrace in the building where patients like to walk. But the environmental circumstances would not allow patients to stay in such conditions for a longer period.

I thank dr. Faraida Jilzani for her help which put all other data in perspective, and start to interview Eri Apsari, the architect of this hospital.

Personal Interview: Eri Apsari, a2 Associated Architects Jakarta
15 November 2019, Jakarta

http://www.associatedarchitects.id/project/a2-office/

Old hospitals have many courtyards and work with natural ventilation. Was there ever any consideration to design a hospital which incorporates natural ventilation in present-day hospital designs? Apsari explains that the fact that plants cannot survive in this mechanically conditioned air is telling for the wellbeing of the patients. Malls also have to deal with this situation. There, it is also difficult to grow plants; if they do survive they will not grow further as plants simply rely on fresh air. Plants are very difficult to grow inside an airconditioned space and in a similar way this air has a negative influence on the patients. As bacteria and viruses will spread easier by the air conditioning systems patients are exposed to these bad influences. Opening up the system to a (partly) natural ventilation system is not realistic in Jakarta as the city air condition is very bad.

In a general situation, where you would find fresh air around a hospital, a partly natural ventilated system would not make sense as you would have to insulate and install mechanical ventilation systems for a limited space Apsari continues. When you would insulate a building and install ventilation systems, it would make more sense to do it for the whole building all at once. And so, if you would prefer a hybrid system you will have to come up with a creative solution to convince the developer. Next to a passive climate system, are there other ways to make a hospital more sustainable? Apsari explains that the hospital is experimenting with creating circular waste streams. But this, of course can only be done for the non-chemical contaminated waste streams.

Socio-cultural design

In an Indonesian hospital, religion and culture are important design factor wherein the needs of a patient are something you should incorporate into the spatial design and in the planning of the wards. The future users of the building could have many backgrounds. There are specialized private hospitals which serve patients with a specific religion for example. According to Apsari there are many people who assume that a Islamic or Christian patient cannot profess their faith in a private non-religious hospital. But of course this does not make any sense as the hospital wants to offer the best care and includes these kinds of services into the design.

As we walk through the hallways we see a family sitting next to the bed of a patient. They seem to be all women and Apsari explains that female Islamic patients prefer to have male and female visitors separated so that they know when to weir their hijab. They can also request to be helped by female personnel.

In the Indonesian culture, the family of the patient is expected – and mostly demands – to help the patient. This means that there is always a family member or friend with the patient in the room. Regulations regarding the design and lay-out of the room therefore cannot be strict. This culture also becomes very visible in the waiting room of the Intensive Care ward. Here, family members are present all the time and therefore need extra space. By night the chairs can be put aside and matrasses are put down on the floor. A special focus during the design process of this hospital was also requested by the developer in the Paediatric Ward. As the hospital is specialized in paediatric care, the waiting rooms had to be designed accordingly. You can see the difference in colours, set-up and atmosphere.

Apsari explains that the various cultural and religious preferences of the patients also means that there should be a certain flexibility to the design and the services that the hospital offers. In order to serve people from all backgrounds in the limited space in a hospital, Apsari once designed a religious space which could be transformed according to the needs of the user. The space she designed would be a Buddhist temple, a church with a cross against depicted on sliding doors (hiding the Buddhist altar) and when you would close the curtains which also hides the cross, the remaining empty room with prayer rugs would serve as mosque.

Medicine

In Indonesia, it is forbidden by law, for hospitals to provide traditional medicine. But in some cases, people still prefer to use the traditional forms besides the Western medication. For example, during chemo therapy, traditional Chinese medicine (TCM) is expected to reduce the side effects. But to do so, the patient has to acquire the traditional medicine outside the hospital. It would depend on the doctor whether this has to happen in secret.

This hospital operates for privately insured – middle and upper class – patients. There is no separate ward for BPJS patients. But many hospitals in Indonesia do have a separation and in this way also provide healthcare for BPJS-insured patients. As more people get access to the BPJS system, middle class hospitals loose about thirty percent revenue because of people starting to use BPJS instead of private insurances.

The wards in these hospitals that serve BPJS patients are not stimulated to provide the best healthcare. They are compensated not for the quality of their care but for the quantity. In this way, a hospital is financially stimulated to have as many occupied beds as possible. This means in the most cases that there is no attention for individual care and success in treatments but rather for filling as many beds as possible. Some wards are even difficult to enter because of this phenomenon. According to Apsari some of the first and most important interventions which the government should consider is to not pay the hospitals per occupied bed and to create more PUSKESMAS posts. These posts which are run by a general practitioner could serve patients earlier in the process and keep them out of hospitals. Now the PUSKESMAS posts are nothing more than regular spaces, and they are not particularly designed.