Health Centre Design

Malawi Health and Design Collaborative

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INTRODUCTION .01

Abstract

Malawi's Ministry of Health (MOH) is a governmental agency whose goal is to provide strategic leadership for the delivery of a comprehensive range of quality, accessible, and efficient health services to all Malawians through the creation and sustenance of a strong health system.[1] The MOH faces a variety of challenges, among them include overtaxed infrastructure and limited human resources. **For many Malawians, their first point of health-related services occurs within rural health centres. Unfortunately, research shows that these facilities are often burdened with a variety of inefficiencies that negatively affect their operation and impact patient outcomes.**[2] Despite ongoing efforts by the MOH, NGO's and private organizations, many rural communities are left without availability to adequate health care.[3] The following research reviews the MOH standard health centre design to determine existing deficiencies and possible architectural design solutions. Through evidence based analysis and a comprehensive literature review into variables shaping the current conditions of health care in Malawi, **a proposal for a new health centre prototype addressing spatial organization, infection control methods, and environmental infrastructure** is presented for the MOH and other agencies dedicated to increasing the availability to health care.

1) *Government of the Republic of Malawi. "Health Sector Strategic Plan II (2017-2022)." 2017.*
2) *"Basic Design Study Report on the Project for Improvement of Rural Health Care Facilities in the Republic of Malawi." KUME SEKKEI Co., Ltd. / EARL Consultants Inc. 2006, pp. 1–134.*
3) *Chansa, C. and Pattnaik, A. 2018. "Expanding Health Care Provision in a Low-Income Country: The Experience of Malawi". Universal Health Coverage Study Series No. 34, World Bank Group, Washington, DC.*

"Can a new health centre prototype for Malawian communities...

a. promote staff efficiency through **strategic spatial design**?

b. increase patient health using **infection control standards**?

c. improve facility efficiency with **strategic infrastructure design**?

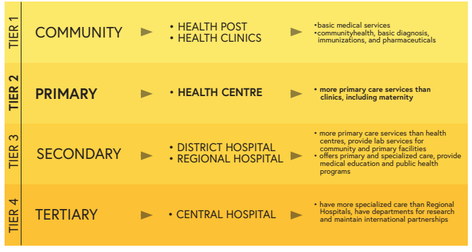
...when compared to the current baseline design?"

MALAWI HEALTH CENTRES

Services and Strategies

Services

Health centres facilities are often the first source of health care for people medical services. A health centre is considered the main institution for linking services to the people. Their main functions include outpatient consultation and treatment for varying illnesses; educational services, obstetrics-gynecology services, vaccinations, patient referral centre for hospitals, and serve as a transfer centre for data and statistics from health posts to district hospitals.[1]



(Fig 1.1) Malawi Healthcare Structure

Delivery Strategies

Health centres are classified as primary care facilities based on Malawi's four-tier healthcare system. Health services are divided into four levels based on the type of care needed. It runs on a referral system that allows patients with increasingly serious/ special conditions to be admitted to the next level of care.[3] Those levels from most basic care to the most specialized are community, primary, secondary, and tertiary. (Fig. 1.1) Health services within this tier structure are provided by the government, private for profit (PFP) and private not for profit (PNFP) sectors.[4] The PFP sector is small, but growing, and includes an array of private hospitals and clinics that range from group to solo practices.[5] The PNFP sector comprises of religious institutions, non-governmental organizations (NGOs), statutory corporations and companies.[6] One of the most prominent agencies involved in the procurement of health services and health facilities is The Ministry of Health (M.O.H.). The MOH is a governmental agency whose mission is to "provide strategic leadership for the delivery of a comprehensive range of quality, accessible, and efficient health services to all Malawians through the creation and sustenance of a strong health system". [7] As the main group making health-related decisions for the country, their job includes policy-making, standards setting, quality assurance, strategic planning, resource mobilization, technical support, monitoring and evaluation and international representation.[8] For example, the MOH aids in the provision of the Essential Health Package (EHP), which provides equal health and medical care services for all people including residents of rural villages and people living in poverty.[9]

Anchor Farms Santhe Health Centre

1-2) "Basic Design Study Report on the Project for Improvement of Rural Health Care Facilities in the Republic of Malawi." Kume Sekkei Co., Ltd. / Earl Consultants Inc. 2006, pp. 1–134.
3-6) Makaula, Peter, et al. "Primary health care in rural Malawi-a qualitative assessment exploring the relevance of the community-directed interventions approach." BMC health services research 12.1 (2012): 328.
7-8) Government of the Republic of Malawi. "Health Sector Strategic Plan II (2017-2022)." 2017.
9) "Basic Design"

HEALTH CARE CHALLENGES

Rural Health Centres

Overview
The Malawi Ministry of Health faces significant challenges to their healthcare model due to a shortage of human resources, a shortage of capital, a rapidly growing population, and inadequate facility infrastructure. In 2014, Malawi ranked 179th out of 194 countries in per capital health expenditure.[1] Though the Malawi's health expenditures are increase, still over 60% of the country's health care relies on donor driven aid, proving financial funding continues to be a predominant factor.[2]

Infrastructure
A result of limited financial funding is inadequate rural health facility infrastructure. Inefficient designs and improperly maintained facilities and equipment create unsafe facility environments, resulting in adverse patient health outcomes and satisfaction. Main problems include; high nosocomial rates, roughly 15-25% in Malawi health facilities;[3] uncomfortable interiors from lacking temperature control design strategies and inefficient spatial layouts; and long travel distances for patients due to a limited number of health facilities across the regions.

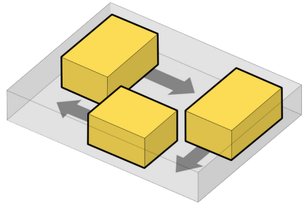
Human Resources
Human Resources is the most important factor in the delivery of successful healthcare. Malawi's healthcare crisis is a result of a severe shortage of human resources and the continued struggle of personnel retention. Poor remuneration and working conditions ultimately discourage high level staff of staying in rural health clinics, and choose to work in other countries[4] Low human resources in health facilities result in staff fatigue, long patient wait times with short patient-staff interactions, and a reliance of low-level health workers with varying levels of professional training.[5]

Population
A growing population within Malawi adds further strain to an already strained healthcare system. As of early 2020, the country has an estimated population of 19.13 million with a current growth rate of 2.7%, projecting the population to increase to over 45 million inhabitants by 2050.[6] In 2014, Malawi reportedly had only 302 doctors in the entire country, with a ratio of 29 nurses to 100,000 people.[7] Health facilities across Malawi experience moments of high patient volumes, overloading the staff and facility infrastructure.[8]

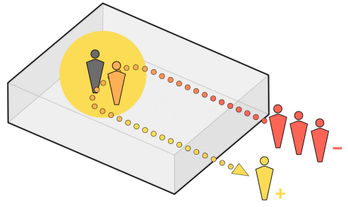
1) Jafry, M. A., et al. "Examination of Patient Flow in a Rural Health Center in Malawi." BMC Research Notes, vol. 9, no. 1, 2016, doi:10.1186/s13104-016-2144-x.
2) "Health Systems Strengthening: Malawi." U.S. Agency for International Development, 3 Nov. 2016, www.usaid.gov/malawi/global-health/health-systems-strengthening.
3) Hall, A. (1998), Editorial: Nosocomial infection in developing countries: time to learn. Tropical Medicine & International Health
*4) Muula, Adamson S. "Shortage of Health Workers in the Malawian Public Health Services System: How Do Parliamentarians Perceive the Problem?" * African Journal of Health Sciences, vol. 13, no. 1, 2008, pp. 124–130., doi:10.4314/ajhs.v13i1.30826.*
5) "Examination of Patient Flow"
6) "World Urbanization Prospects - Population Division. (n.d.). Retrieved February 16, 2020, from https://population.un.org/wup/Country-Profiles/
7-10) "Examination of Patient Flow"
11) Cronk, Ryan, and Jamie Bartram. "Environmental Conditions in Health Care Facilities in Low- and Middle-Income Countries: Coverage and Inequalities." International Journal of Hygiene and Environmental Health, vol. 221, no. 3, 2018, pp. 409–422.

ARCHITECTURAL RESPONSE

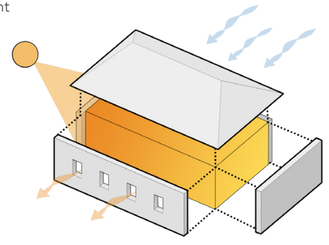
Spatial Organization Criteria
- program adjacencies
- circulation routes
- travel distances



Infection Control Criteria
- access to hand wash stations
- access to cross ventilation (A.C.H)
- areas of congestion



Environmental Infrastructure
- access to natural environments
- rain water management
- photovoltaic access
- thermal comfort



Overview
Not all these challenges can be solved with an immediate architectural response, but design decisions can be made to promote a more efficient physical environment. As a method to narrow our scope, we chose 3 architectural categories that will serve as criteria for determining the success of a health centre. We believe health centres in rural Malawi can be improved by studying their 1) spatial organization 2) infection control methods and 3) facility comfort.

Spatial Organization
Inefficiencies between program and circulation routes increase travel distances for staff resulting in increased fatigue and operational error, areas of unnecessary congestion between patients and staff, and increased patient wait times.[9] Strategic spatial organization of program and circulation routes have proven to increase efficiencies within health facilities.[10] Methods of improving spatial organization included an understanding of critical program adjacencies and allocating adequate waiting and circulation areas for both patients and staff.

Infection Control Methods
Adverse health outcomes are caused by inadequate safety protocols and inefficient environmental conditions experienced within the rural health facilities.[11] Improving occupant health, safety and satisfaction for both patients and staff is fundamental to improving the overall standard of healthcare. Key architectural strategies proven to increase health outcomes include increased ventilation for improved air quality, reducing areas of personnel congestion and strategically placed water access stations for hand washing and water disposal

Environmental Infrastructure
Environmental infrastructure is categorized as architectural components that are directly influenced by natural elements, such as the wind, sun and rain. Improving the resilience of health facility infrastructure systems increases operational efficiency and long term sustainability. Environmental infrastructure criteria include access to natural environments, rainwater management, photovoltaic access and thermal comfort.

INTENTIONS

The project's mission is routed in the understanding that more efficient health centres must be available within Malawi's rural communities. The proposal will focus on architectural components such as spatial organization, strategic infrastructure design to improve operation efficiency and methods of infection control in order to create a safe, healthy, and sustainable rural health centre for future applications. Additional consideration is given to the Sustainable Development Goals and W.H.O. guidelines for safe health facilities.

1) promote staff efficiency through strategic spatial design?

2) increase patient health using infection control standards?

3) improve facility efficiency with strategic infrastructure design?

Sustainable Development Goals[1]

Goal 3: Good Health and Well-being
Health Centres must provide care to increasing life expectancy, reducing maternal and child mortality and fighting against leading communicable diseases.

Goal 6: Clean Water and Sanitation (WASH)
Ensuring availability and sustainable management of water and sanitation for all is fundamental for a functioning health facility. Health centres must provide clean drinking water and clean sanitation to its users.

Goal 7: Affordable and Clean Energy
Ensuring access to affordable, reliable, sustainable and modern energy for all. Access to clean energy powers life-saving equipment within health centres.

Goal 9: Industry, Innovation and Infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Health Centres in rural areas should be built to withstand the test of time.

Goal 11: Sustainable Cities and Communities
Make human settlements inclusive, safe, resilient and sustainable. A health center should promote each of these characteristics within a community.

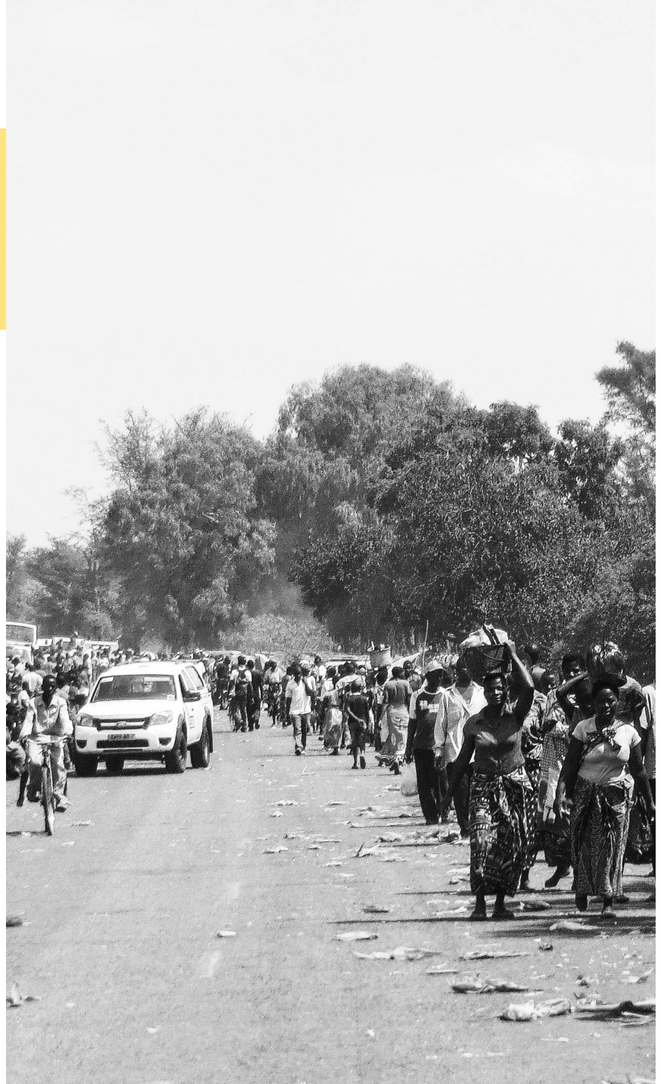
World Health Organization[2,3]

Ventilation
Air Change per Hour (ACH) requirements within health facilities prevent the spread of air borne diseases, such as tuberculosis.

Ward Design
Suggested ward layouts to reduce overcrowding and promote privacy and dignity.

Infection Control Methods
Precautionary measures used to prevent the transmission of infection. They include; hand hygiene, cleaning & disinfection, waste disposal, respiratory hygiene, sharp injury prevention, & safe injection practices.

Clean Water & Sanitation
Access to clean water for drinking, cooking & cleaning is vital in preventing the spread of disease.



METHODOLOGY

Considering the significant challenges of designing within a global context, this project grounds its design intentions around qualitative and quantitative research. Any claims or proposals shall be supported with evidence from rigorous literature reviews, existing-condition analysis and professional expertise.

Literature Review
An extensive literature review of topics related to primary health facilities in low and middle income countries was conducted. These topics include but are not limited to facility infrastructure, patient and staff health outcomes, patient and staff satisfaction and staff efficiency and retention.

Base Model Analysis
To provide a contextual understanding of actual conditions, a standard health centre design, provided by the Department of Buildings, was analyzed to serve as a baseline for our proposal.

Case Study Analysis
Analysis of exemplary designed health facilities in Sub-Saharan Africa was performed to determine variables contributing to their success.

Interviews
A series of interviews were performed with stakeholders and professionals who have firsthand experience within the chosen research topics. Discussions provided valuable advice and perspectives that could not be achieved through literature review.

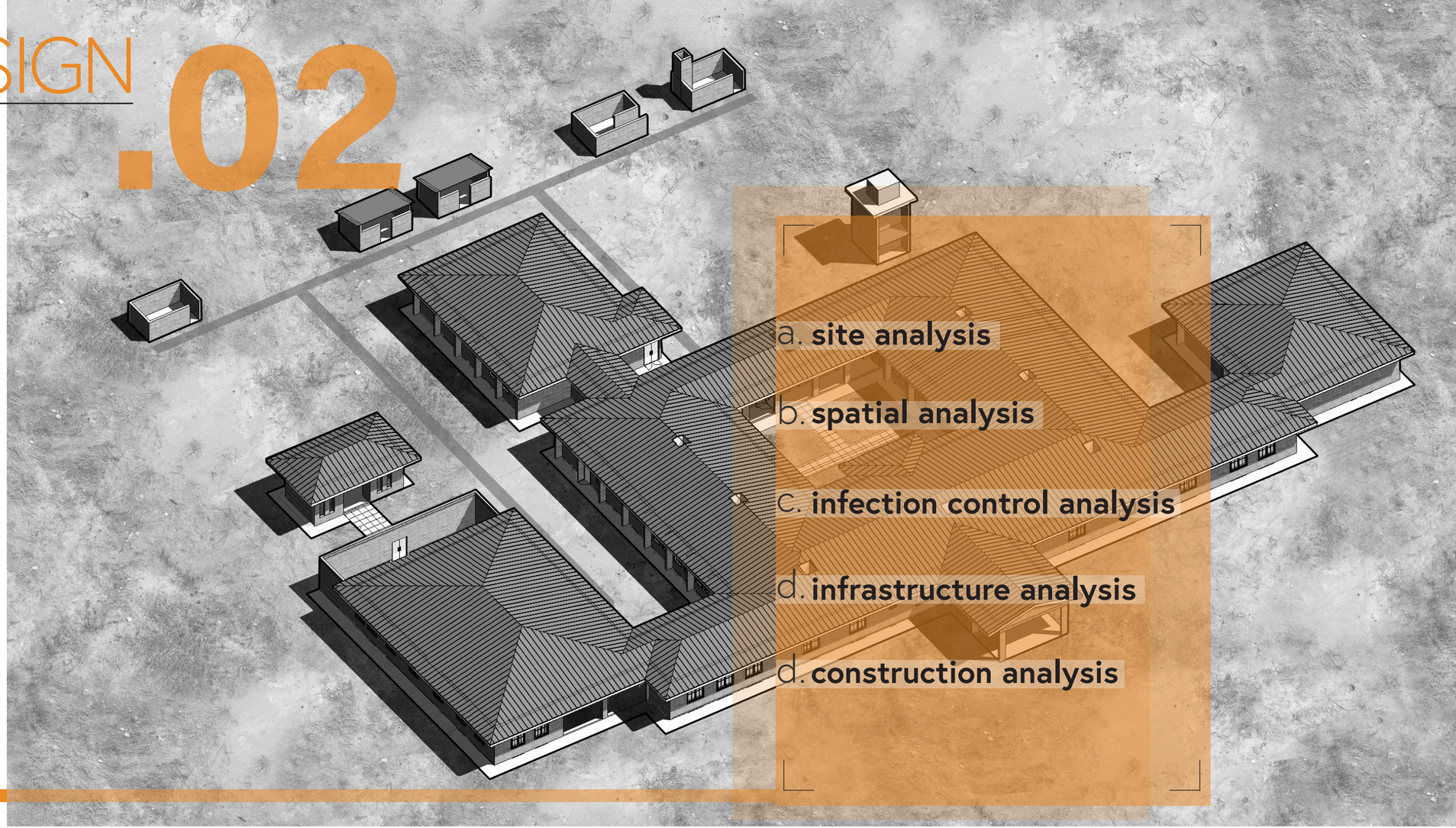
1) "Sustainable Development Goals. Sustainable Development Knowledge Platform." United Nations, United Nations, sustainabledevelopment.un.org/?menu=1300.
2) James Atkinson et al. "WHO Guidelines for natural ventilation in health care setting."
3) Hargiss, Clarice O., and Elaine Larson. "Guidelines for Prevention of Hospital Acquired Infections." American Journal of Nursing: December 1981 - Volume 81 - Issue 12 - p 2175-2182.

STANDARD DESIGN .02

M.O.H. Standard Design Analysis

Evidence base design (EBD) is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes.[1]

The following section presents analysis of the M.O.H.'s standard design for a rural health centre, which will be used as a baseline to illustrate and inform appropriate design guidelines and objectives for a design proposal. Santhe Anchor Farms Health Centre was chosen as the initial site for analysis because it is one of the most recently constructed health centres based off the standard design being used by the Malawi government.



a. **site analysis**

b. **spatial analysis**

c. **infection control analysis**

d. **infrastructure analysis**

d. **construction analysis**

1) *"EDAC: Evidence-Based Design Accreditation and Certification." The Center for Health Design, The Center for Health Design, www.healthdesign.org/certification-outreach/edac/about.*

CASE STUDY

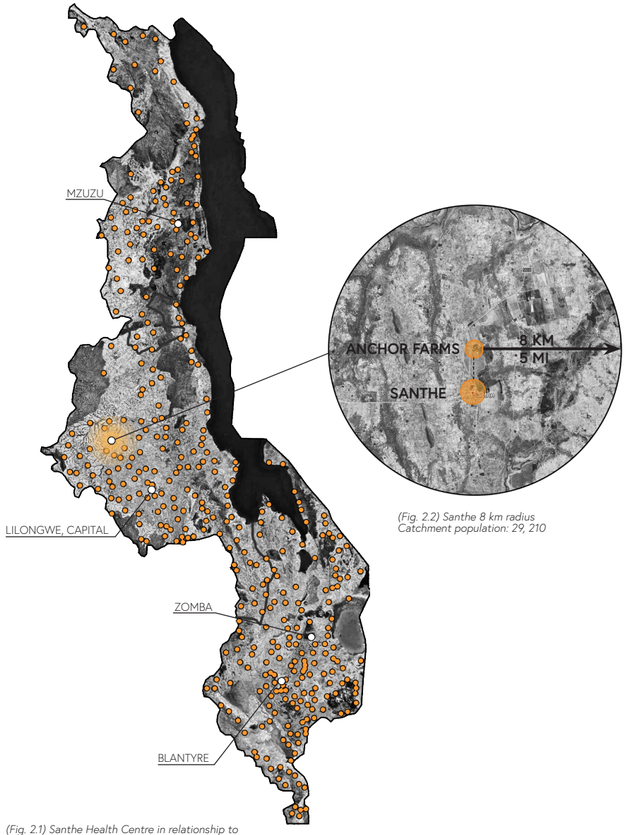
Santhe, Anchor Farms Health Centre

Location

Santhe Anchor Farms Health Centre is located in the central Malawi's Kasungu district, roughly 96 kilometers / 60 miles north, west of the capital city of Lilongwe. The rural health centre is sited on Anchor Farms, a local farm 1.5 kilometers outside of the town of Santhe. In 2008, the Clinton Development Initiative established the Anchor Farm Project to help smallholder farmers in Malawi create sustainable farming solutions and increase their income.[1] The project's success lead to the health centre's funding and construction in 2016, furthering the Clinton Foundation's goals to improve economic growth and global health and well-being.[2]

Catchment Population

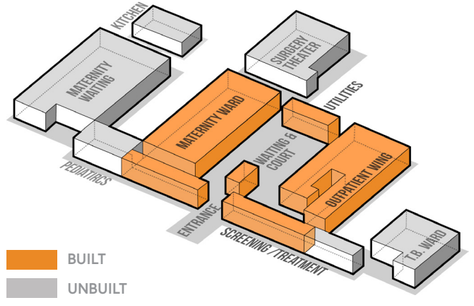
A survey conducted in 2013 showed the Santhe's health centre has a catchment population of 29,210 people, a considerably high population considering a health centre is mean to serve an average population of 10,000 people.[3] Health centres can serve higher populations when located in urban areas.[4] Santhe is among the many of health facilities serving larger populations than their infrastructure can handle. This matter will only worsen as Malawi's population increases. To reduce facility overload and sparse facility locations, the MOH set forth a policy that every Malawian should reside within an 8km/5mile radius of a health facility.[5] (Fig. 2.2) The proportion of population living within an 8km radius to a health centre or hospital is roughly 70% in the Kasungu district, meaning 30% of the population is underserved.[6] Figure 2.1 illustrates the limited number of health centres located in the central and northern regions of Malawi.[7]



(Fig. 2.1) Santhe Health Centre in relationship to relative locations of Malawi's 417+ health centres.

(Fig. 2.2) Santhe 8 km radius
Catchment population: 29, 210

(Fig. 2.3) As-built drone image of Santhe's Anchor Farms Health Centre



(Fig. 2.4) As-designed massing diagram illustrating built vs unbuilt conditions

Built vs Unbuilt

Anchor Farms Health Centre was constructed based on a standardized plan provided by the Department of Buildings (DOB), a governmental agency that oversees design and funding within government construction projects. The 1,800m^2 / 20,000ft^2 deign is intended to serve as the standard for future health centres across the country. The as-built condition reflects only part of what the government intends to build on the site. It is important to note that the maternity waiting ward, surgery theatre and tuberculosis ward were not constructed due to limited funding. Constructed program includes a maternity ward, outpatient care ward and general screening areas. (Fig.2.4) Plans to construct the remaining program will come during a later phase. Additionally, modifications were done during construction to reduce the overall size, reducing program dimensions, layouts, and corridor widths to an actual size of roughly 880m^2/9,500ft^2.[8] (Fig.2.3)

Expansion

Health facility services often reflect the need of the surrounding community, catchment population, and human resource availability.[9] Considerations for program expansion is common within a facility design, as construction may occur in phases due to financial and human resource availability. When funding and human resources do become available, expansion commonly occurs through outward, incremental growth, adding entire wards or department blocks. For example, Santhe may construct the surgery theater once a trained surgeon is on staff.

1-2) Walker Morris. "Clinton Development Initiative." Clinton Foundation, July 14, 2016. https://www.clintonfoundation.org/our-work/clinton-development-initiative
3-4) Makwero, Martha T. "Delivery of Primary Health Care in Malawi." African Journal of Primary Health Care & Family Medicine, vol. 10, no. 1, 2018, doi:10.4102/phcfm.v10i1.1799.
5-6) "UNICEF Health Facility Mapping." UNICEF Annual Report, Malawi. (2016)
7) Rassool, Kevin. " Health Facilities in Malawi." Arcgis.com, Feb. 2013, www.arcgis.com/home/webmap/viewer.html?webmap=e983da49edf34aacbfeda525ed918729.
8) Harnish, Christopher. "Santhe Health Centre." Oblique Site Scan, 19 June 2019.
9) Pachilova, Rosia. " The Effect of Ward Typologies on Quality of Care". Bartlett School of Architecture. June 12, 2018.

SITE ANALYSIS

13°24'50.8"S 33°23'26.5"E

Notes

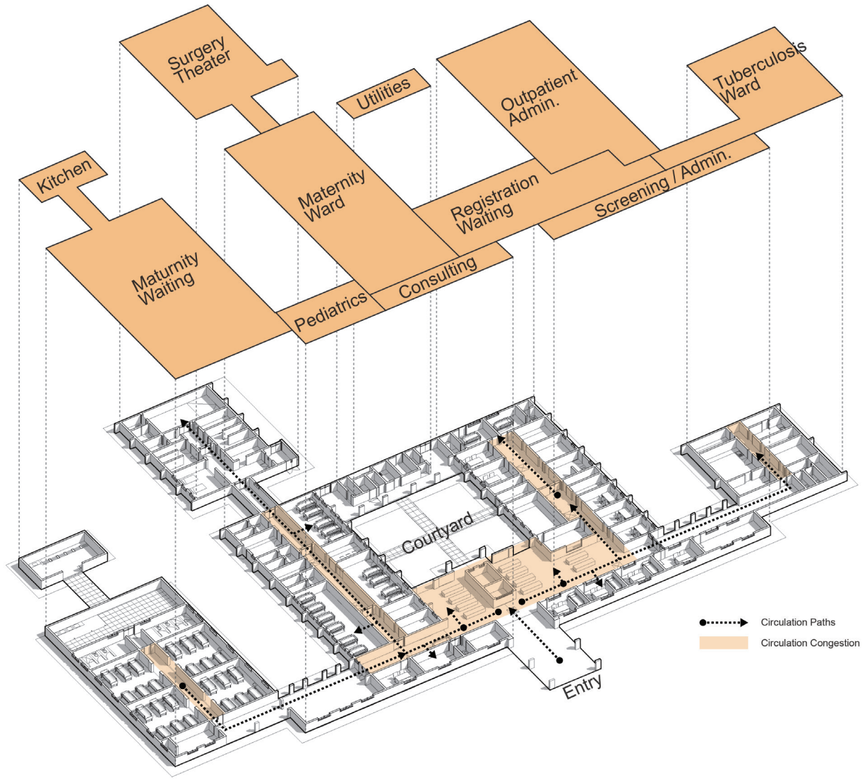
- prevailing winds from the east
- large area to south-east for potential expansion
- clearly defined vehicular traffic routes
- adjacent staff housing
- safe distance away from main highway
- close proximity to farm community
- separation of sanitation services bar
- exterior waiting areas under vegetation

Climate

Santhe, Malawi has a warm and temperate climate. Over the course of the year, the temperature typically varies from 52°F to 86°F and is rarely below 47°F or above 91°F. The hot season lasts from September November, with an average daily high temperature above 84°F. The cool season lasts from June to August, with an average daily high temperature below 76°F. Lilongwe experiences extreme seasonal variation in monthly rainfall, with a 6 month rainy period from October to May. Malawi may experience periods of drought, followed by intense rainfall.

SPATIAL ANALYSIS

Santhe Health Center Circulation



(Fig. 2.5) Holistic diagram illustrating Santhe Health Center's program layout and frequent circulation routes

Overview

- create clearly defined entries
- consideration of courtyard/gathering space
- short travel distances between frequently used program
- service bar divided between frequently used program
- efficient department adjacencies
- arrangement program to reduce circulation congestion
- allocate waiting areas during patient influx
- separate circulation routes for staff and patients
- reduce dead-end corridor condition

Typology

The MOH first phase design is based on a courtyard typology, where the outpatient services ward, maternity ward, utilities bar and waiting areas surround a centralized, open air court. This inward typology provides easier means of safety, using the building as the main security envelope. Circulation within the facility is centralized to a single spine connecting each programmatic wing. Each wing is configured in a double-loaded corridor arrangement for efficient travel distances and reducing overall building footprint size.

Critical Adjacencies Distances

	m	ft
Waiting → Triage	5.5	18
Waiting → T.B.	30	98
Waiting → Prenatal	25	82
Waiting → Pharmacy	7	23
Prenatal → Delivery	15	50
Delivery → Postnatal	20	65
Delivery → Surgery	25	82

Staff Circulation

A typical rural health centre is run by medical assistant supported by other health workers including nurse-midwives, both with over a year of professional training, as well registry clerks, drug store clerks, health surveillance assistants who have varying levels of experience.[1] Due to limited staff availability, circulation through the facility should be as efficient as possible to decrease staff "burnout" and patient wait times. Methods include designing separate circulation routes for staff or increasing corridor width. The MOH standard does not have separate circulation routes but varying corridor widths. Figure 2.5 illustrates areas that may create moments of congestion for both the staff and patients during times of high patient volume.[2] During such cases, patients are forced to wait outside or in the crowded interior.

Patient Circulation

Patients are immediately directed to registration and adjacent waiting areas upon entry. Distances to screening areas and outpatient services are short, but distances to the maternity and tuberculosis wards are increased to account for sound and the risk of nosocomial infection. Dead end corridor conditions reduce the efficiency of patient flow, forcing occupants to circulate back through the entry sequence. Consideration for allocating sufficient waiting spaces, exit routes, and clearly defined areas or triage may help increase efficiency for patient circulation amongst the facility.

Critical Adjacencies

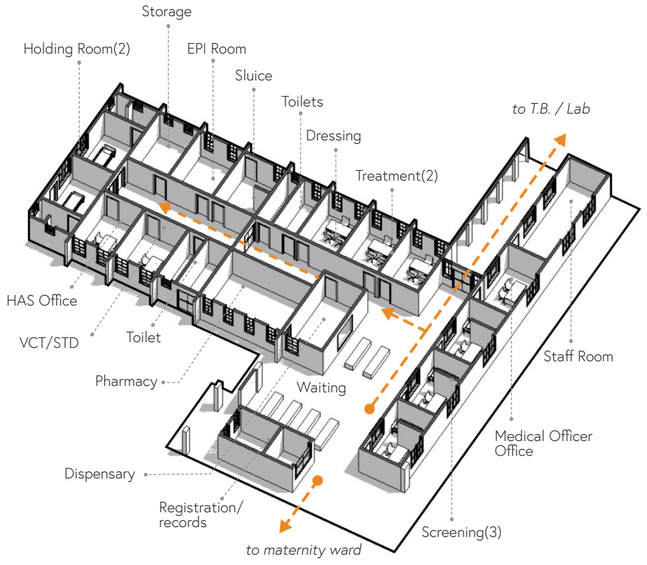
Distances between registration, screening, and pharmacy are short, allowing for efficient outpatient services. Though these distances are short, configuration and location of program increase the risk of creating congested waiting areas. Consideration for separate entry points and waiting areas for maternity and tuberculosis wards should be considered to decrease the risk of cross contamination amongst patients in the main waiting areas.

1-2) Chimphepo, H., Massah, G., Ngoma, S., Sako, M., Ngoma, J. MOH, DOB, KCH. (2019, October 19). Skype Interview.

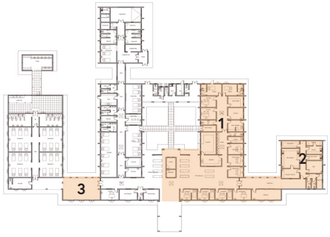
3) Jiang, Shan, and Stephen Verderber. "On the Planning and Design of Hospital Circulation Zones." HERD: Health Environments Research & Design Journal, vol.10, no. 2, 2016, pp. 124–146., doi:10.1177/1937586716672041.

SPATIAL ANALYSIS

Outpatient /Administration Ward



(Fig. 2.6) Outpatient program analysis (1)



Program Square Meters | Feet

**totals represent sum of program and circulation*

	m^2	ft^2
Outpatient Services	**300**	**3225**
Screening/Triage (3)	12	125
Pharmacy	16	170
General Store	12	125
Treatment Room	12	125
Sluice Room	7	75
Sterile Room	12	125
Drug Store	24	260
Holding Rooms (2)	16	170
STD Treatment Room	12	125
EPI Room	12	125
Water Closet (2)	5	50
Administration	**370**	**3980**
Waiting / Registration	270	2900
Staff Lounge	20	150
Offices (2)	12	125
Tuberculosis Ward	**174**	**1850**
Main Lab	25	265
Office	14	145
Specimen Room	12	125
Storage (2)	15	160
Sluice Room	6	65
Dark Room	5	50
Waiting Area	50	550
Pediatrics	**80**	**160**

Overview

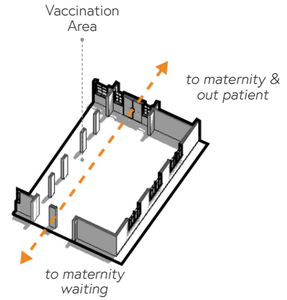
- large/safe space for children vaccination and check-ups
- reduce corridor congestion while maintaining patient privacy
- promote immediate patient screening
- promote separation of T.B. ward and natural ventilation

Services

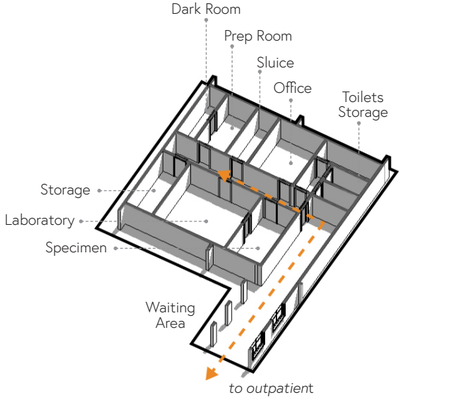
The most common services offered in outpatient are for pediatrics, HIV patients, and patients suffering from respiratory illnesses, such as tuberculosis. On average, over 50% of patients visiting health centres in Malawi each week are children.[1] Programmatically, the pediatric department (POPD) is located close to entry in a semi enclosed area to accommodate large patient volume and addition family members contributing to the child's well-being. Though the MOH scheme places the pediatric block near the entry, it is disconnected from the main outpatient waiting area.

The second most common user group area patients with HIV. Almost 11% of individuals between the ages of 15 and 64 in Malawi are living with HIV.[2] Providing treatment, testing and education areas within the facility remains the most common approach to providing access and preventative services.[3] MOH scheme places treatment rooms within the double loaded corridor to create better patient privacy and staff efficiency, but increases risk of occupant congestion.

The tuberculosis ward aids in the treatment of respiratory illness. A regional report in Malawi, screening of patients entering health facilities for T.B. symptoms was not conducted routinely.[4] To promote healthy facilities, patients should be screened and separated from others in congested waiting areas. The T.B. ward should especially consider natural ventilation in lieu of mechanical systems to reduce the risk airborne transmission. A laboratory is incorporated into the ward to allow testing of patients sputum, though professionals suggest separating the lab to create easier/safer access for staff.



(Fig. 2.7) Pediatric program analysis (2)

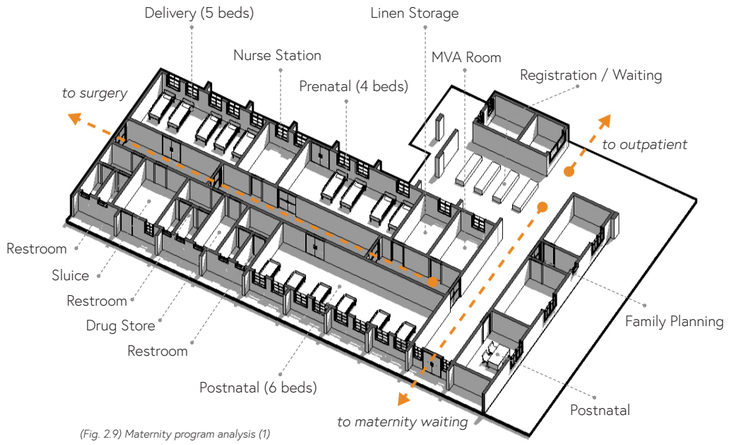


(Fig. 2.8) T.B. ward program analysis (3)

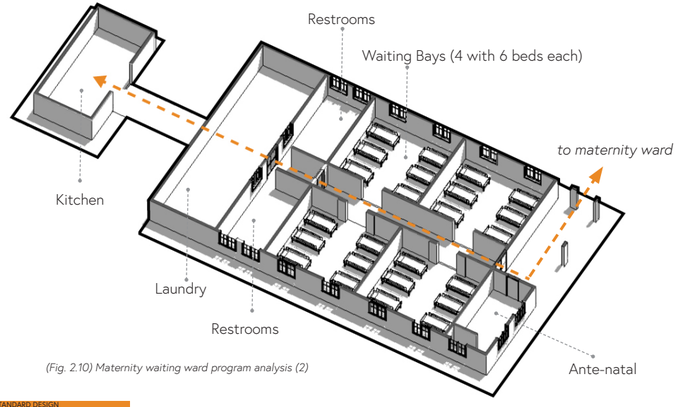
1) Jafry, M. A., et al. "Examination of Patient Flow in a Rural Health Center in Malawi." BMC Research Notes, vol. 9, no. 1, 2016.
2-3) Patel, Pragna et al. "Integrating HIV and Hypertension Management in Low-Resource Settings: Lessons from Malawi." PLOS Medicine 15, no. 3 (July 2018).

SPATIAL ANALYSIS

Maternity/ Maternity Waiting Ward



(Fig. 2.9) Maternity program analysis (1)



(Fig. 2.10) Maternity waiting ward program analysis (2)

Program Square Meters | Feet

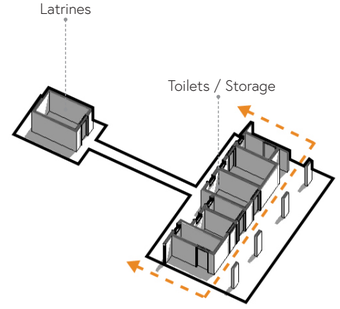
**totals represent sum of program and circulation*

	m^2	ft^2
Maternity Services	**315**	**3400**
Prenatal	35	380
Postnatal	50	550
Delivery	35	380
MVA Room	10	107
Family Consulting (2)	12	125
Nurse Station	12	125
Linen Storage	10	110
Drug Store	7	75
Restroom (2)	10	107
Maternity Waiting	**380**	**4090**
Waiting Bay (4)	40	435
Ante Natal	17	180
Restroom (2)	20	215
Kitchen	35	380
Laundry	65	725
Surgery	**165**	**1775**
Main Theater	35	380
Recovery Room	20	215
Sluice Room	5	50
Sterile Room	7	75
Storage	10	125
Anesthetist Office	8	85
Restroom (2)	15	160
Service Bar	**70**	**750**
Toilets (3)	3	32
Storage	12	130
Incinerator	10	107
Latrines (2)	20	215

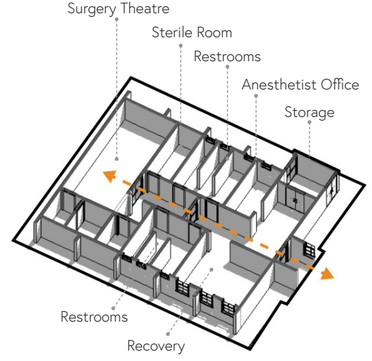
Overview
- promote patient privacy and comfort
- strategic placement of nurses station for efficient work flow
- access to natural environments
- adjacent to emergency surgery theatre

Services

Malawi faces one of the highest rates of maternal mortality rates. According to the World Bank, in 2015, the maternal mortality ratio in Malawi is 634:10,000[1] As an initiative to improve child mortality rates, health centres offer low-risk maternity care. MOH scheme provides a maternity ward with a prenatal room 4 beds), delivery room (5 beds), postnatal room (6 beds), a centralized nurse station, and other supporting program such as MVA rooms, sluice rooms, rest rooms, family planning consultation offices. Ward sizes and bed count varies depending on catchment population and immediate need. A maternity waiting ward lies adjacent to the maternity ward to accommodate expecting mothers and their guardians. Key design strategies within the maternity ward take into account the safety, comfort and privacy of mothers, while promoting efficient operations for nurses. In the event of an emergency caesarean section, a surgery theatre is placed near the delivery room. An additional services for the maternity and outpatient wards such as toilets, storage, kitchen, incinerators, etc. are located between or behind the wards.



(Fig. 2.11) Service bar program analysis (3)

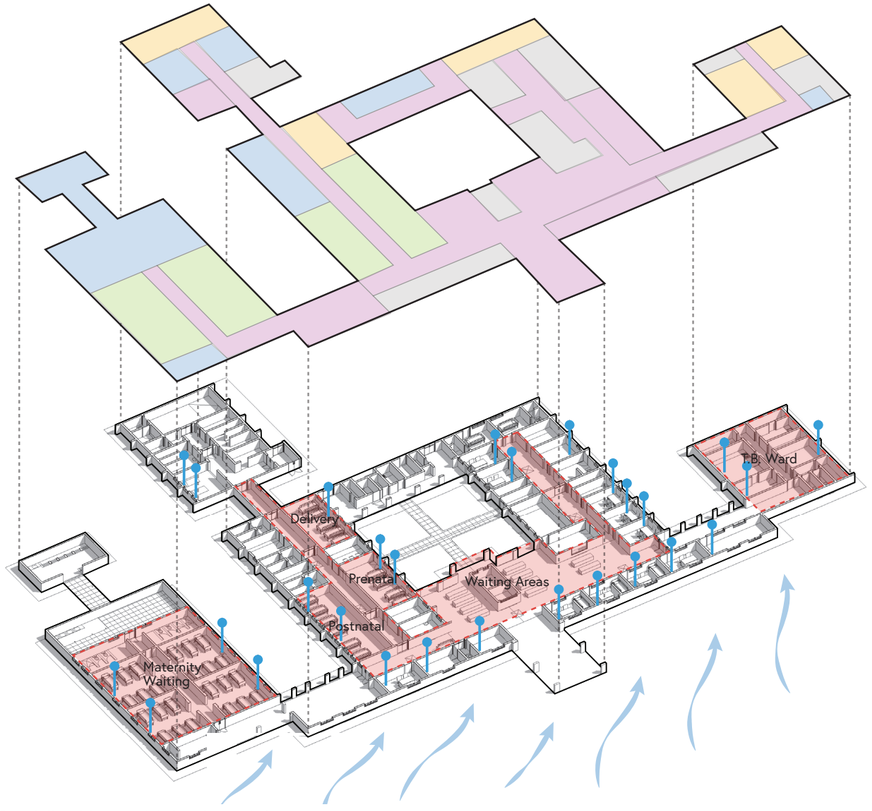


(Fig. 2.12) Surgery theatre program analysis (4)

1-2) Chimphepo, H., Massah, G., Ngoma, S., Sako, M., Ngoma, J. MOH, DOB, KCH. (2019, October 19). Skype Interview.
3) Jiang, Shan, and Stephen Verderber. "On the Planning and Design of Hospital Circulation Zones." HERD: Health Environments Research & Design Journal, vol.10, no. 2, 2016, pp. 124–146., doi:10.1177/1937586716672041.

INFECTION CONTROL ANALYSIS

Ventilation - Handwash Stations



Number of Sinks per Program

Maternity Ward	12
Outpatient Ward	6
T.B. Ward	3
Administration	5

Handwash Stations

WHO Recommended Minimum ACH

12 ACH	
10 ACH	
8 ACH	
6 ACH	
2 ACH	

Infection Hotspots

(Figure 2.13) WHO Recommended ACH and potential Infection Hotspots

Overview

- allocate handwash stations near infection hotspots
- open waiting areas for proper ventilation
- oriented facility towards prevailing winds
- double loaded corridors lack adequate ventilation
- windows alone may not provide adequate ventilation
- poorly maintained handwash stations harbor bacteria

Ventilation

Proper air ventilation strategies can reduce the risk of airborne nosocomial infections within health facilities.[1] Stale or slow-moving air creates stuffy, uncomfortable environments and increases the chancing of acquiring infections through airborne transmissions. Rural facilities often do not have the means necessary to supplement mechanical systems for constant air control, therefore utilizing passive strategies with the natural wind is common.[2] Keep waiting areas and corridors open to the air allows access to fresh air. The MOH standard allocates covered, open air waiting areas, oriented in-line with the eastern prevailing winds. Air change per hour (ACH) is used to determine areas that are at potential risk from airborne infections due to inadequate air flow by calculating how much air moves in and out of a space per hour.[3] For a positive pressure room — the ratio of the volume of outdoor air flowing into a given space in an hour divided by the volume of that space.[4] The rule of thumb to prevent infection in high risk areas is 12 ACH.[5] The standard design scheme utilizes single-sided ventilation with operable windows, which depend on outside wind to circulate air within the program. This strategy does not guarantee proper ACH by the WHO standards.[6]

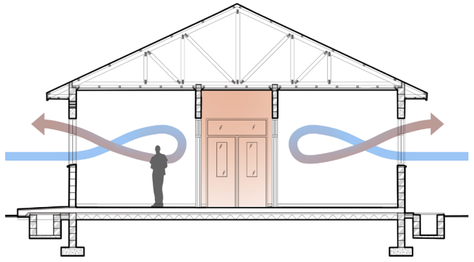


Fig. 2.14 Section illustrating operable window ventilation.

Infection Hotspots

The outpatient and maternity corridor conditions within the standard health centre are considered infection hot spots due to the limited amount of air moving through the space. Double loaded corridors should be open on either end to allow air flow, reducing the potential congestion of airborne pathogens. Other potential infection risk areas include the maternity ward and waiting areas.

Handwash Stations

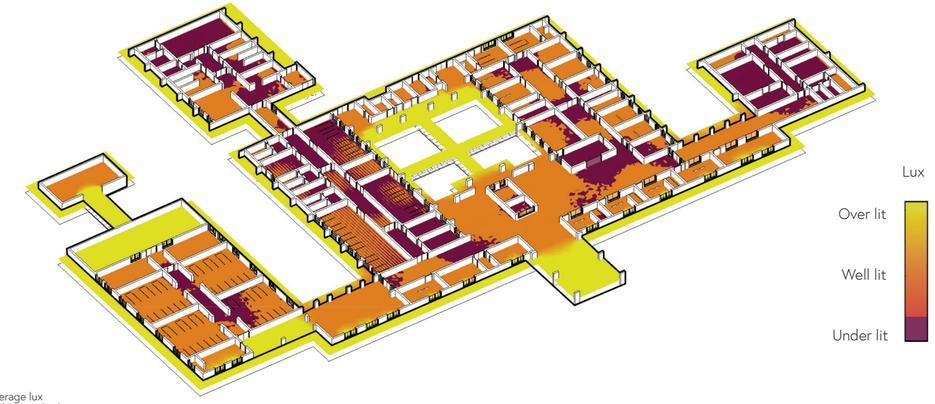
Increasing frequency of hand washing by staff and patients will greatly improve the hygienic practices and reduces the risk of spreading disease.[7] Health facilities typically integrate handwash stations, sluice rooms and water closest within program to promote hand washing and proper disposal of contaminated liquids. These stations can harbor bacteria and other infectious diseases when not properly maintained.[8] Day-to-day operations done by nurses and staff will inform locations for strategic hand wash stations.

1-6) World Health Organization. (2009). Natural Ventilation for Infection Control in Health-Care Settings.

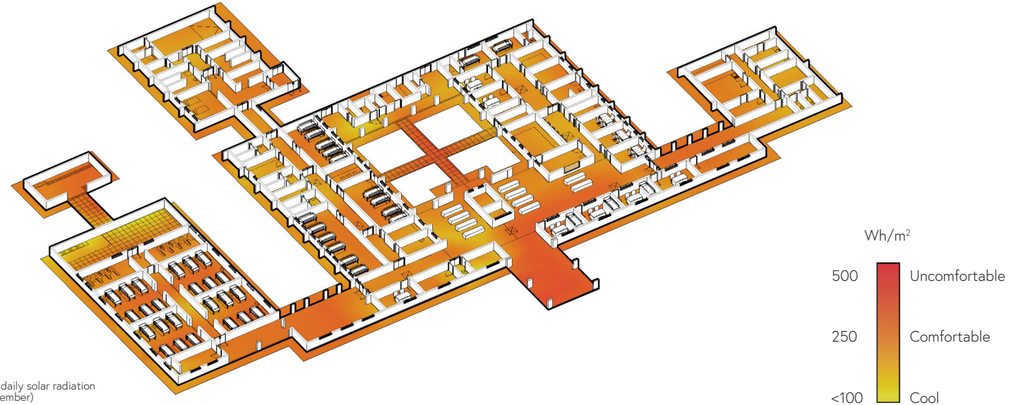
7-8) Controlling Hospital-Acquired Infection: Focus on the Role of the Environment and New Technologies for Decontamination Stephanie J. Dancer Clinical Microbiology Reviews Oct 2014, 27 (4) 665-690; DOI: 10.1128/CMR.00020-14

THERMAL COMFORT ANALYSIS

Daylight - Solar Radiation



(Fig. 2.15) Average lux
Summer (April-November)



(Fig. 2.16) Average daily solar radiation
Summer (April-November)

Overview

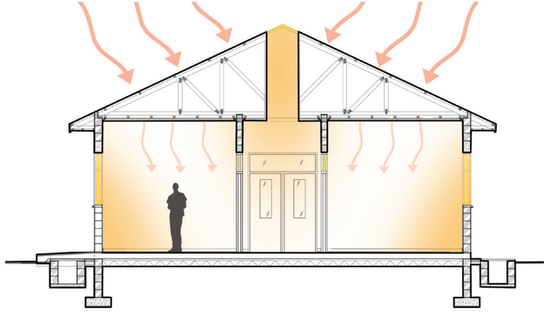
- program along exterior wall are well lit
- skylights in corridors increase daylight access
- imbalanced lighting increases need for artificial lighting
- program may become uncomfortable from radiant heat gain
- reduce thermal gain by shading perimeter walls

Thermal Comfort

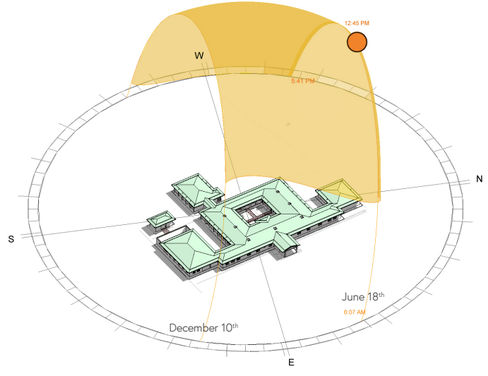
Studies show that rural health facilities experience high indoor temperatures due to limited temperature controlling mechanics, such as air conditioners or fans, and building methods that do not properly utilize passive cooling techniques.[1] Exposure to high ambient temperature is associated with adverse human health effects and decrease staff efficiency due to fatigue.[2] High indoor temperatures are typically attributed to both solar radiation through the roof and sun-exposed walls. Figure 2.16 illustrates areas that may feel uncomfortable due to high amounts of solar radiation. Figure 2.17 illustrates the standard's use of a drop ceiling, creating an air barrier to reduce radiant heat gain from the metal roof. Other methods to reduce indoor temperature include large roof overhangs to shade windows and walls and increased air ventilation to move hot air out of the building.

Natural Daylight

Studies show there is a critical lack of lighting in the health facilities within Malawi.[3] Adequate day lighting during the day reduces reliance on artificial lighting which in turn reduces energy needs. The double loaded corridor creates a central circulation core which allows program to be push along the exterior wall, enabling each room to access daylight and exterior views. This condition normally eliminates any daylight from reaching the main circulation corridor. The MOH facility however implements skylights and transom windows over doors to let natural light into the corridor. Though these strategies are used thoughout, Figure 2.15 illustrates areas that may still be over or under lit.



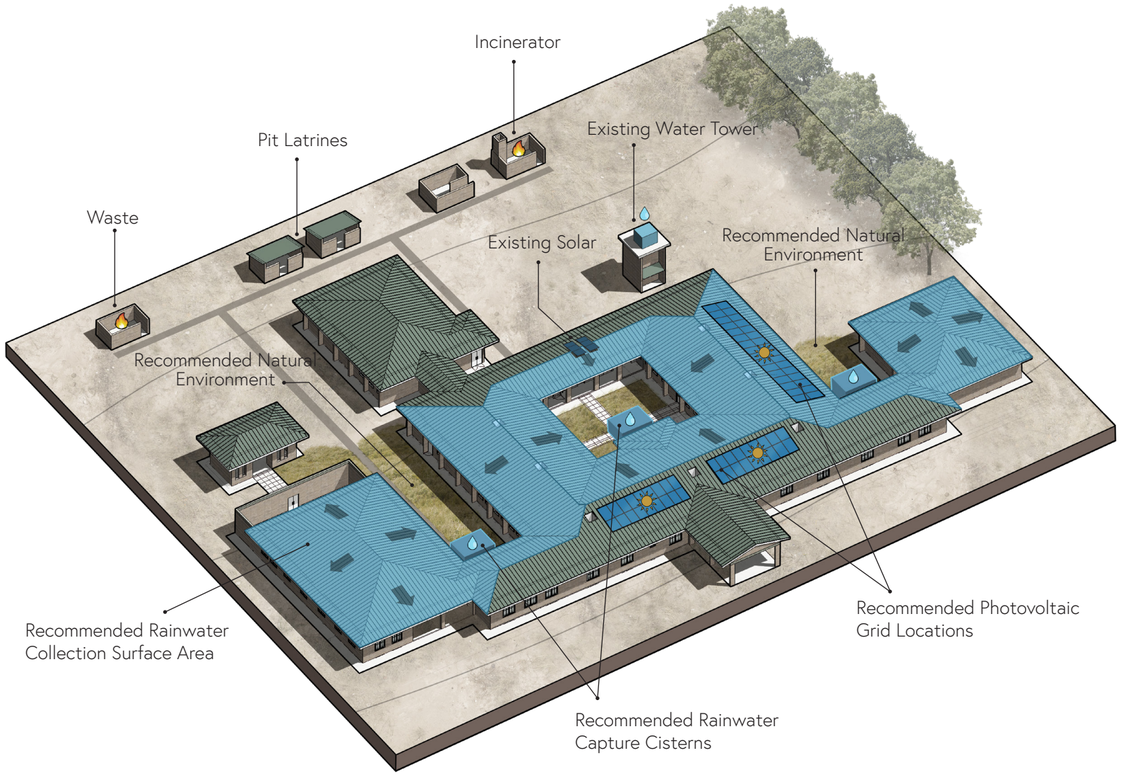
(Fig. 2.17) Natural daylight section
through maternity ward corridor



(Fig. 2.18) Sun location over Santhe's
health centre through December - June.

1-2) Wright, C. Y., Street, R. A., Cele, N., Kunene, Z., Balakrishna, Y., Albers, P. N., & Mathee, A. (2017). Indoor Temperatures in Patient Waiting Rooms in Eight Rural Primary Health Care Centers in Northern South Africa and the Related Potential Risks to Human Health and Wellbeing. International journal of environmental research and public health, 14(1), 43. https://doi.org/10.3390/ijerph14010043.
3) Suhlrie, L. et al. (2018). The role of energy in health facilities: A conceptual framework and complementary data assessment in Malawi. Plos One, 13(7). doi: 10.1371/journal.pone.0200261

INFRASTRUCTURE ANALYSIS



(Fig. 2.19) Exisiting and recommended environmental infrastructure systems

Overview
- reduce facility blackouts by mandating photovoltaic grids
- implement water management to support WASH protocol
- implement hardware that adapts to differing climates
- provide natural landscapes to promote patient healing
- provide maintenance plans for future facility operation

Electricity
Electricity is required for lighting, refrigeration, water supply, sterilization, ICT and staff housing when applicable. Though 70% of health facilities are connected to the government's electric grid, they typically experience interrupted access with consistent blackouts throughout the year.[1] While 96% of health centres have already turned to solar power, many of the systems are inefficient with only 57% of the PV systems being functional.[2] Added inefficiencies come from the lack of long term management and maintenance of these systems.[3] To reduce system complexity, it is recommended that each facility should have a unique micro grid that suits its exact needs, rather than a standard system that is applied to all facilities.

Water Management
Main uses for water include flushing toilets, washing equipment, cleaning treatment rooms, hand wash stations and hydration of patients with the potential for irrigation systems. Water is typically attained through bore holes and elevated water towers, though rain water collection may increase water access due to its abundance during the rainy season. Rainwater harvesting requires infrastructure such as large cisterns to collect the water which must be light-proof and mosquito proof, a downspout system to drain all water to the cisterns as well as making sure the surfaces stay clean to keep the rainwater clean. Strategic placement of cisterns within Santhe's design could utilize existing roof gutter and downspouts to collect non-potable water.

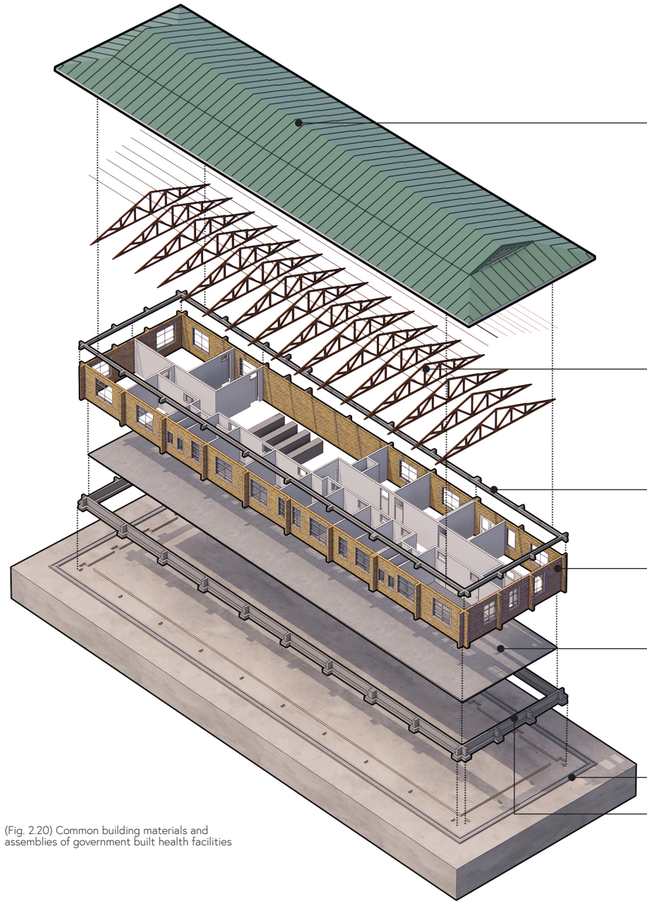
Sanitation
Proper sanitation reduces the risk of spreading infectious diseases in treatment areas.[4] Current sanitation protocol includes using an incinerator and waste pits located away from the facility. Increasing availability of water to disinfect treatment areas and strategic waste storage can greatly improve facility operations and occupant health.

Healing Environments
Exposure to landscapes and natural environments are shown to reduced stress, improve attention capacity, facilitating recovery from illness, ameliorating physical well-being in elderly people, and behavioral changes that improve mood and general well-being.[5] These effects have been addressed by means of viewing natural landscapes during a walk, viewing from a window or experiencing vegetation around work environments.[6] Consideration for landscaped areas can be incorporated near waiting areas, open air corridors and holding wards. Figure 2.20 illustrates potential natural landscapes in between program blocks and waiting areas.

System Maintenance
Proper system maintenance is required to increases efficiency and functionality of health facilities. Nonimplemented standards for maintenance often lead to failed or broken systems. Plans that promote routine system monitoring my help increase initiatives to improve the overall effectiveness of the equipment. Consideration should be given to infrastructural components that may be easily replaced or repaired by the local community, such as windows, screening systems, and doors.

1-3) Suhlrie, L. et al. (2018). The role of energy in health facilities: A conceptual framework and complementary data assessment in Malawi. Plos One, 13(7). doi: 10.1371/journal.pone.0200261
4) Montgomery, M., Hayter, A., Gaya, S., & Amongin, I. (2019). Water, Sanitation, and Hygiene in Healthcare Facilities. Water, Sanitation, and Hygiene in Healthcare Facilities.
5-6) Velardea, M.D., Fryb, G., & Tveitb, M. (2007). Health effects of viewing landscapes – Landscape types in environmental psychology.

CONSTRUCTION & MATERIALS



(Fig. 2.20) Common building materials and assemblies of government built health facilities

Roofing: Standing Seam Metal Hip Roof

+ structurally rigid against seismic activity and wind loads
+ durable against heavy rainfall
+ light weight compared to tile / masonry
- increased cost for material shipment
- prone to leaking
- increases radiant heat transfer
- requires interior thermal enclosure / ceiling

Common Alternatives

- concrete
- corrugated metal
- terra-cotta tile

Roof Structure: Wood Truss / Wood Framing

+ common construction methods / low skill
+ light weight
+ low cost material shipping
+ fast construction
- requires ceiling ventilation
-/+ supports timbering industries (deforestation)

Alternatives

- light gauge steel truss
- rebar truss

Wall Structure: Concrete Ring Beam

+ required component of load bearing walls
- increase concrete requirement

Common Alternatives

- pressure treated wood

Bearing Wall: Stabilized Soil Block (SSB)

+ common masonry construction / low skill
+ increased efficiency over kiln brick
+ manufacture on site
+ combats deforestation
+ thermal mass
- requires specialized manufacturing training
- higher cost compared to kiln brick

Common Alternatives

- cinder block
- adobe
- concrete
- kiln brick
- rammed earth

Foundation: Concrete Slab / Foundation / Gutter

+ common construction method
+ fast construction
+ durable
- increases concrete requirements
- less environmentally sustainable

Overview

- common material pallet provides efficient assemble
- alternative materials may solve construction problems that arise from environmental issues
- rural sites can be difficult to access with machinery
- limited funding influences design and construction

Industry

The majority of construction projects occurring in Malawi are located in urban areas. Medium to large scale construction is typically done by foreign affiliated corporations or contracted to specialized companies based out of Lilongwe or Blantyre.[1] Rural health centre projects pose a variety of challenges for constructability due to their proximity to material manufacturers and construction companies. The cost of transportation increase as distances to project sites increase.[2] Poor road infrastructure in rural Malawi also pose challenges for efficient and timely delivery of materials, equipment and labor.[3] Materials used for the construction of health centres can typically be procured within Malawi's urbanized areas or from adjacent countries. Large orders or timber or steel must be imported, as Malawi does not have a steel industry and faces timber shortages from deforestation.[4] Using local labor for the delivery of a rural project often strengthens the identify of the project to the community, though contracted workers are required for specialized work.[5]

Materials & Construction

Government-built health centres consists of both on-site and off-site attained materials. Materials such as masonry block, metal roofing, concrete, plaster, and other forms of locally sourced hardware, are common in rural health centres. Metal roofing is the most common because it is durable, lightweight, and can be imported from adjacent countries. Roof structure is typically composed of some form of light wood framing carpentry or truss framing. Wood framing for the roof assembly is commonly used because it is fairly inexpensive and requires low skill compared to alternative options. Alternatives such as steel trusses increase durability and speed of assembly but increase transportation cost due to foreign importation. Both interior and exterior walls are typically built out of some form of masonry, as this is the most common for of construction in Malawi. Locally sourced earth for stabilized soil blocks or rammed earth wall assemblies is a common technique to reduce material transportation cost while strengthening the buildings ties to the local community. Though cement and aggregate are less sustainable then earth derived materials, they are commonplace and required in all construction, particular for foundation work.[6] Single level construction is common due to the increased cost of materials and coordination to build vertically compared to horizontally. Interiors finished within a health centre must be durable and easy to clean.

Funding

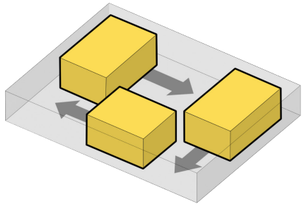
Primary sources of funding for health centres is provided by government agencies such as Ministry of Health, or by non-governmental agencies such as the Christian Health Organization. Over 60% of healthcare funding is being driven by donors, making Malawi one of the most dependent healthcare sectors in the world.[7] Rural construction projects are often subjected to limited financing; therefore, strategies are often used to cut costs. An approach that secures more sustainable financing and increases current spending efficiencies is needed to strengthen the overall health system.

1) "Malawi Hospital Architecture." PDF. Department of Buildings, Malawi.
2) Ibid.
3) Chirwa, D., Samwinga, V., & Shakantu, W.W. (2011). "Timely project delivery: a case study of Malawian educational projects".
4) Lall, Somik V, et al. "Explaining High Transport Costs within Malawi - Bad Roads or Lack of Trucking Competition ?" The World Bank, 1 July 2010.
5) Bah E.M., Faye I., Geh Z.F. (2018) "The Construction Cost Conundrum in Africa. In: Housing Market Dynamics in Africa." Palgrave Macmillan, London.
6) "Malawi Hospital Architecture"
7) Health Systems Strengthening: Malawi." U.S. Agency for International Development, Nov.2016, www.usaid.gov/malawi/global-health/health-systems-strengthening.

DESIGN STANDARD CONCLUSION

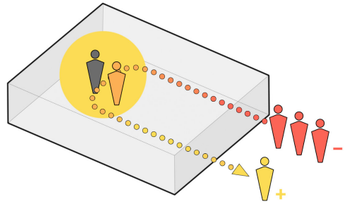
SPATIAL ORGANIZATION

- strategic arrangement of program can increase staff efficiency
- operation congestion occurs in screening and triage areas. Strategic placement of triage in front of facility can greatly reduce patient wait times
- decreasing travel distances for staff can reduce fatigue
- provide separate waiting areas for high risk patients
- separate staff/patient circulation routes improve facility operations



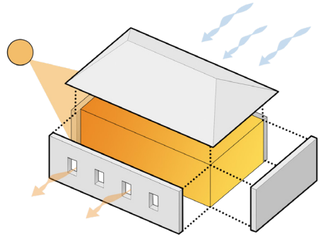
INFECTION CONTROL

- rural facilities lack adequate ventilation systems to prevent airborne acquired infections
- using natural/passive techniques can improve staff and patient satisfaction and health outcomes
- hand washing and proper hygiene protocol improves health outcomes
- sinks must be placed in strategic locations and must be maintained



ENVIRONMENTAL INFRASTRUCTURE

- mechanical systems are difficult to power due to sporadic access to electricity
- resilient infrastructure can improve overall operations and efficiency of a health facility.
- building envelope attributes to thermal comfort
- natural environment increase patient and staff satisfaction and health outcomes
- captured rainwater management can help improve WASH protocol



DESIGN GUIDELINES .03

The following section presents conclusions and guiding principles for design of a health centre based on findings from medical publications, interviews, case studies and analysis of the M.O.H. standard health centre design. Conclusions were drawn on program adjacency. Infection control, infrastructure systems, material considerations & daylight.

a. **program adjacencies**

b. **infection control**

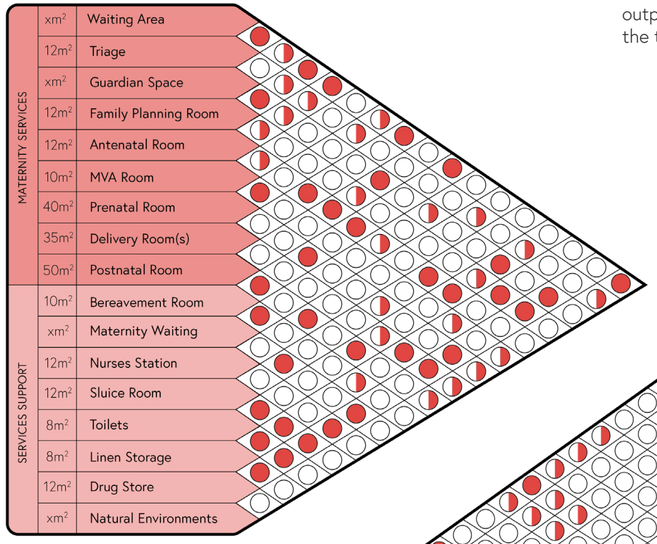
c. **infrastructure systems**

d. **material consideration**

e. **interior daylight**

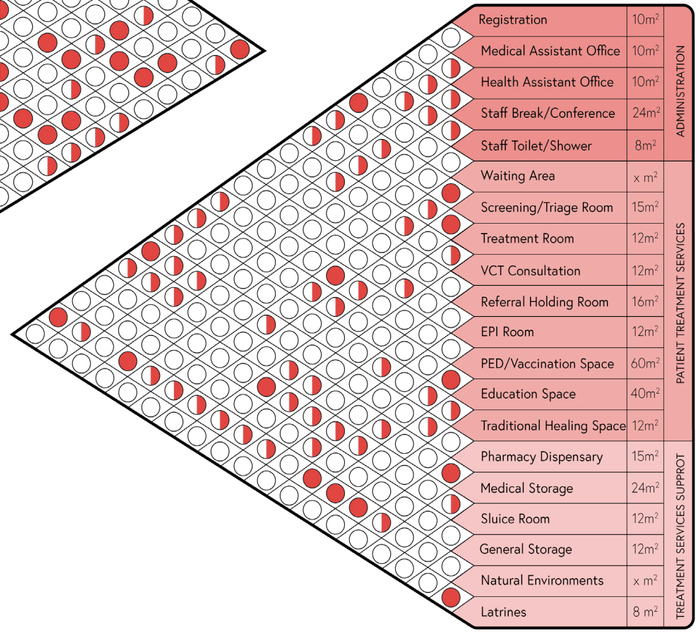
PROGRAM ADJACENCIES

MATERNITY PROGRAM



Critical program adjacencies area determined within the outpatient and maternity ward, considering these are the two primary services offered within a health centre.

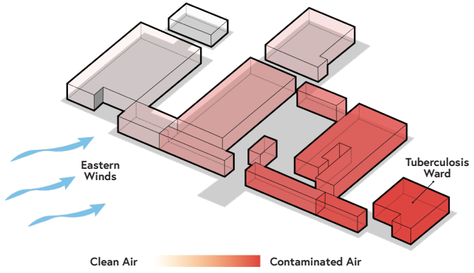
OUTPATIENT PROGRAM



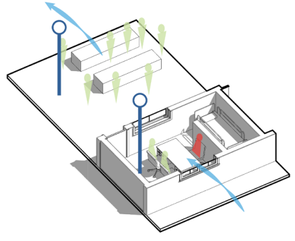
- Adjacent
- Semi Adjacent
- Not Adjacent

INFECTION CONTROL

Natural Ventilation & Hand Wash Stations

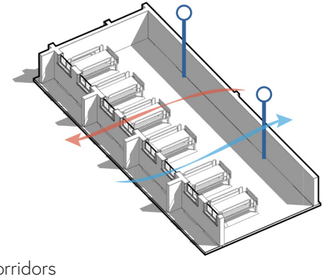


Macro Scale Ventilation
When arranging program, it is important to place the department with the highest risk of transferring airborne infections away from the facility and in the direction of the prevailing winds. This reduces the risk of airborne cross contamination.



Waiting/Treatment/Screening

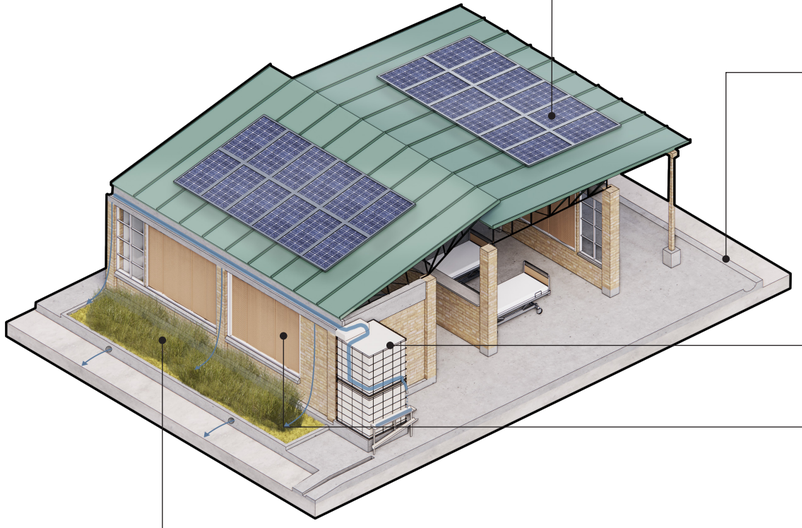
Micro Scale Ventilation & Handwash Station
To protect patients and staff from cross contamination, interaction should occur in spaces parallel to air flow. Waiting areas should be open to increase natural airflow. Handwash stations should be accessible to patients and staff.



Ward/Corridors

Micro Scale Ventilation & Handwash Station
Wards and corridor should have some form of cross ventilation, moving warm, stale air out of the building. A minimum of 1 wash station per 4 bed should be available within each ward.

INFRASTRUCTURE SYSTEMS



Photovoltaic Systems

mandatory solar to power health facility systems

Rain Water Management

diversion of rainwater to prevent flooding during heavy rainfall

Rain Water Collection

designated cisterns for rainwater collection and irrigation

Locally Fabricated Hardware

vernacular component that adapt to site's climate

Natural Environments

adjacent natural landscapes to promote patient well-being.

(Fig. 3.1) Infrastructure Design. Anthony Ella, 2019 Chris Harnish Design 9 Studio

MATERIAL CONSIDERATION

Structural & Building Envelope

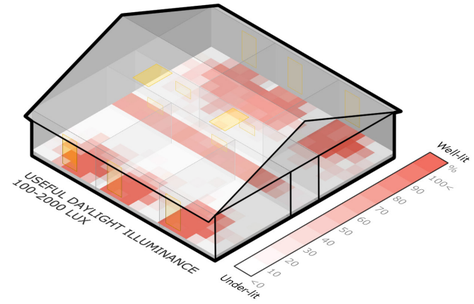
	Light Gauge Metal	Wood	Concrete	Corrugated Steel	Fired Bush Brick	Sun Dried Bricks	Stabilized Soil Block (SSB)	Rammed Earth	Cinder Block
Material Availability	●●○○○	●●●●●	●●●●○	●●●●●	●●●●●	●●●●●	●●●●○	●●●●○	●●●○○
Construction Speed	●●●●○	●●●●○	●●●○○	●●●●○	●●●●○	●●●●○	●●●●○	●○○○○	●●●●○
Durability	●●●●●	●●●●○	●●●●●	●●●●○	●●●○○	●●●○○	●●●●○	●●●●○	●●●●○
Labor Availability	●●○○○	●●●●○	●●●○○	●●●●●	●●●●●	●●●●●	●●●●○	●●○○○	●●●●○
Environmental Impact	●●●●○	●●●○○	●●○○○	●●●●○	●●○○○	●●●●○	●●●●○	●●●●○	●●●●○

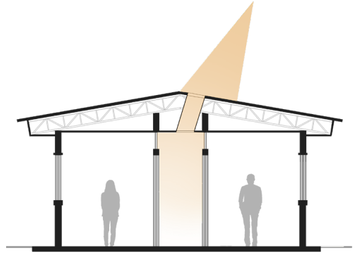
INTERIOR DAYLIGHT CONDITIONS

Useful Daylight (LUX)

Corridor Section

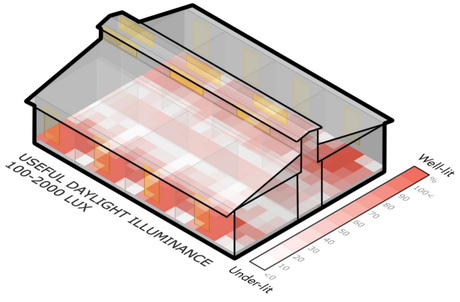
Gable Roof with Skylight

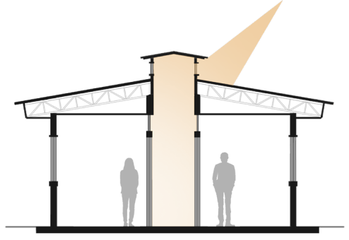




- double loaded corridor scheme typically decreases light access to the corridor, while skylights can aid in bringing in light.
- gable roof can have varying overhangs to block direct light
- transom windows located on interior walls allows light to filter through to the corridor

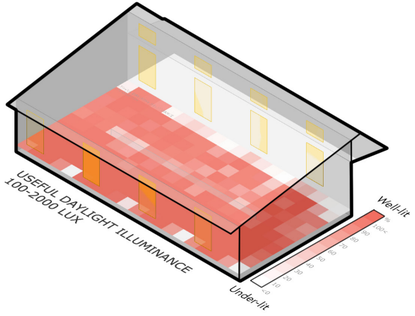
Double Clerestory

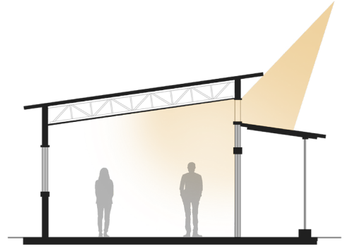




- this clerestory gathers light from two sides as opposed to one, bringing in daylight no matter its orientation.
- this section provides optimal operable ventilation using the stack effect.
- tall exterior windows bring daylight deep into the interior spaces

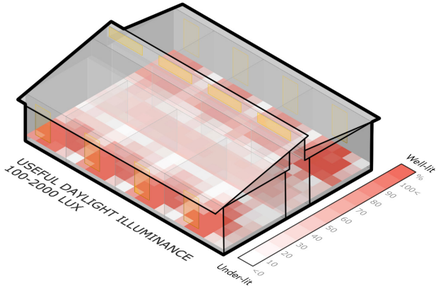
Shed Roof Clerestory (1)

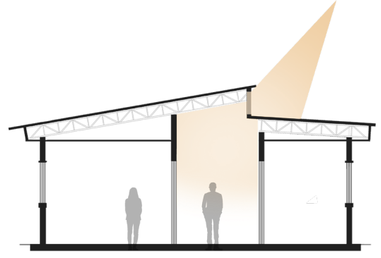




- one of the most well lit sections with the highest percentage of useful daylight
- exterior circulation corridor is naturally lit and ventilated
- amount of sunlight depends on buildings orientation to sun

Shed Roof Clerestory (2)





- double loaded corridor scheme illuminated from clerestory
- increased light penetration compared to skylight
- clerestories can be replaced with vents to increase ventilation

DESIGN GUIDELINES

ROOF CONDITIONS
- thermally enclosed roof, block radiant heat gain
- shading overhangs north-west and southwest to reduce heat gain.
- sky lights and clerestories to increase interior daylight
- consideration of standard materials (wood vs steel roof assembly)
- covered outdoor space to promote exterior waiting
- cover walkways where necessary

INFECTION CONTROL
- orientation facility to prevailing breezes
- create high - and low-pressure zones to move air
- wide corridors to reduce areas for personnel congestion
- wash stations near treatment and service areas
- sanitation blocks placed away from public areas, easy access

SECURITY
- use portions of building mass to contribute to the security envelope
- planter boxes, sliding gates, and brick weave as boundaries
- privacy walls, partial walls

OCCUPANT COMFORT
- reducing radiation – thermal gain from sun/roof
- large overhangs to shade nw-sw
- access to natural light to reduce electricity use
- creating barriers to reduce noise between program
- natural ventilation to move warm air
- integrate planting into program and waiting spaces
- allow plants to provide areas of shading

CORRIDOR LAYOUT
- follow standard corridors widths for daily use
- provide separate staff circulation in high congestion areas
- create multiple waiting areas specific to treatment areas
- encourage single loaded corridors
- reduce dead end corridor conditions

PROGRAM ADJACENCIES
- close pyroxenites between patient waiting and outpatient services
- fluent circulation through triage
- direct way finding axes
- close proximites between maternity, post-natal and nurse stations
- pediatric near entry for quick visits, accommodate large patient volume
- privacy for HIV treatment
- pharmacy near entry and administration

INFRASTRUCTURE SYSTEMS
- promote designs that incorporate photovoltaic power
- use gutters and downspouts to navigate water to storage cisterns
- efficient navigation to waste disposal areas
- incorporate building components that can be replaced when damaged

DESIGN PROPOSAL

.04

The following section presents a design proposal for a new health centre standard. Work in this section involved application of the concluded design guidelines. The M.O.H. standard design is compared to the design proposal around areas of master planning, program adjacency, infection control and daylight.

a. **masterplan**

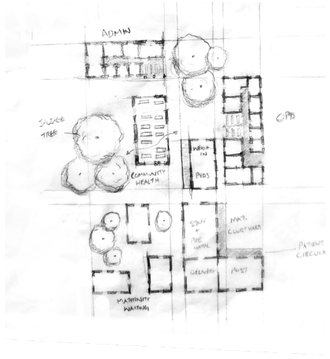
b. **spatial analysis**

c. **infection control analysis**

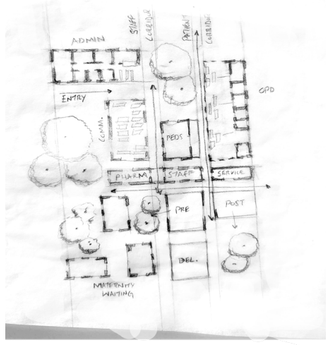
d. **daylight analysis**

e. **infrastructure**

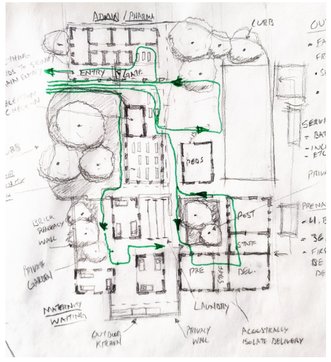
MASTERPLAN STUDY



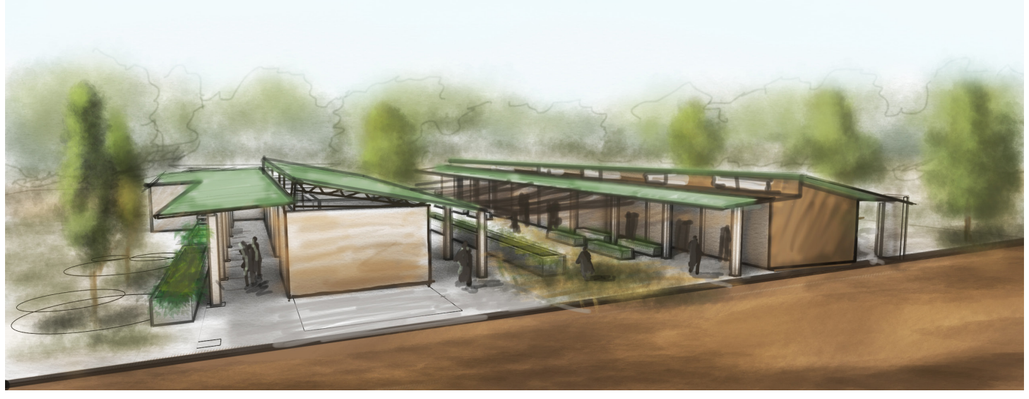
Initial Sketch 01



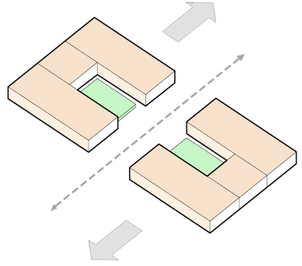
Initial Sketch 02



Initial Sketch 03

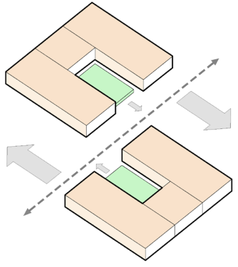


PARTI



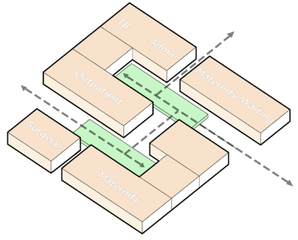
Double Courtyard

This scheme separates program along an axis, each program has their own respective courtyard.



Shift

The program then shifts along the main circulation axis, further separating the two programs, outpatient and maternity.

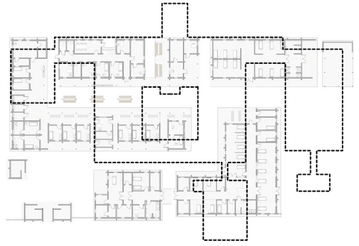


Expand

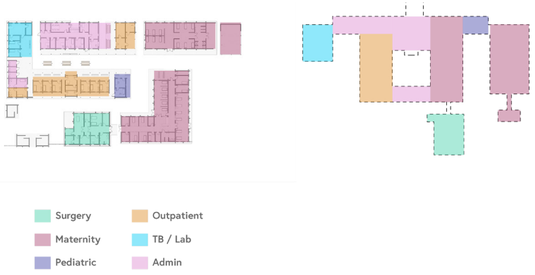
By expanding the program and courtyards, new axes of circulation are created. Adjusting these axes leads to a rich environment of circulation paths and pocket courtyards.

MASTERPLAN LAYOUT

Standard Site Comparison



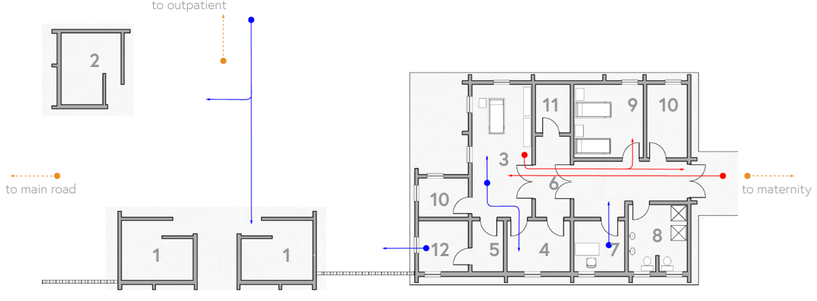
Standard Program Comparison



Surgery-Service

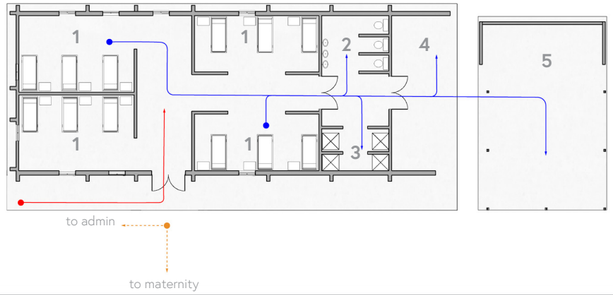
Incinerator	1
Waste	2
Theatre	3
Sterile	4
Sluice	5
Prep	6
Office	7
W.C.	8
Recovery	9
Storage	10
Packing	11
Autoclave	12

Staff
Patients
Adjacency



Maternity Waiting

Waiting Ward	1
W.C.	2
Showers	3
Laundry	4
Kitchen	5



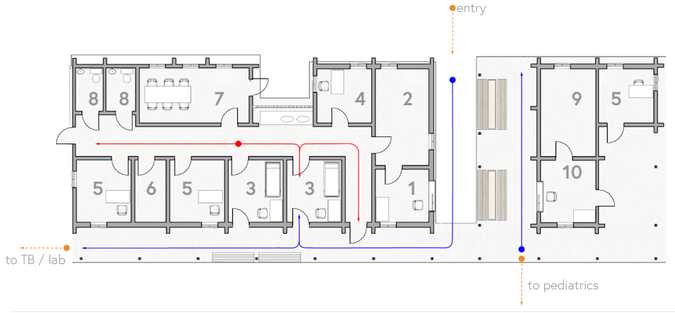
Maternity

Pre-natal	1
Triage	2
MVA	3
Post-natal	4
Nurse Station	5
Delivery	6
Recovery	7
Drug Store	8
Storage	9
Sluice	10
Linens	11
W.C.	12
Waiting	13

Staff
Patients
Adjacency

Admin-Dispensary

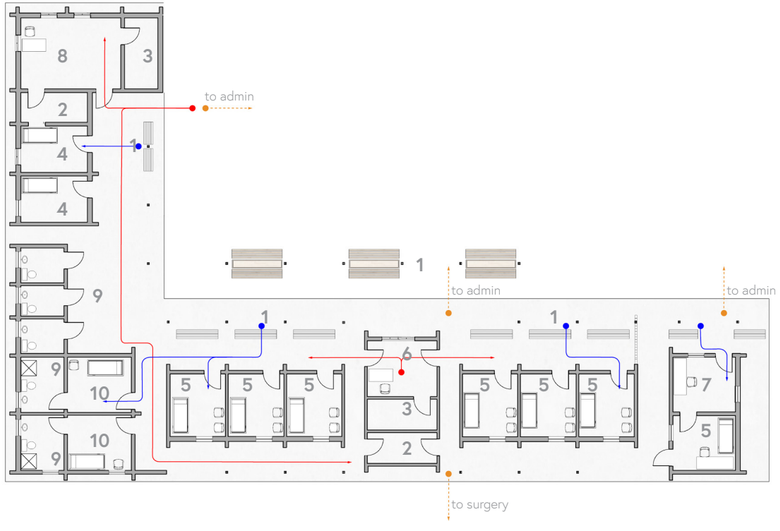
Reception	1
Records	2
Screening	3
HSA Office	4
Office	5
Storage	6
Staff Room	7
W.C.	8
Pharmacy	9
Dispensary	10



Outpatient-TB

Waiting	1
Sluice	2
Storage	3
Isolation Room	4
Treatment	5
Nurse Station	6
Weigh-In	7
Lab	8
W.C.	9
Holding	10

Staff
Patients
Adjacency



"A **defined entry** surrounded by natural vegetation in collaboration with the geometry of the building creates a **secure threshold** upon approaching the health centre's reception."

Entry

COMPARATIVE SPATIAL ANALYSIS

Outpatient / Administration Ward

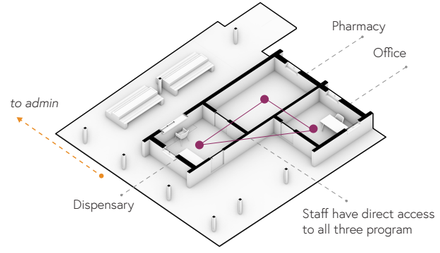
Program Square Meters | Feet

**totals represent sum of program and circulation*

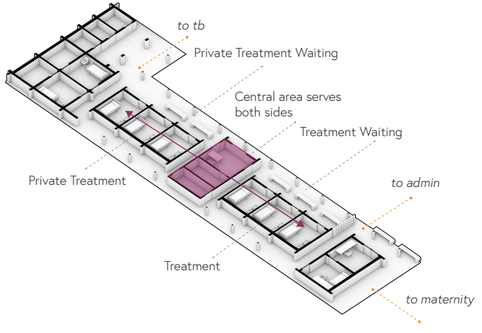
			Standard Design	
	m^2	ft^2	m^2	ft^2
Outpatient Services	**572**	**6157**	**300**	**3225**
Screening/Triage (2)	11	118		
Pharmacy	17	182		
Nurse Station	12	125		
Treatment Room	12	125		
Sluice Room	6	65		
Lab	20	215		
Drug Store	6	65		
Holding Rooms (2)	12	125		
STD Treatment Room	12	125		
Weigh In	11	118		
Water Closet (2)	8	86		
Administration	**322**	**3465**	**370**	**3980**
Waiting / Registration	24	258		
Staff Lounge	22	236		
Offices (2)	12	125		
Tuberculosis Ward	**130**	**1400**	**174**	**1850**
Main Lab	24	258		
Specimen Room	14	150		
Sluice Room	9	97		
Waiting Area	8	86		
Pediatrics	**78**	**840**	**80**	**860**

Critical Adjacencies Distances

	m	ft	m	ft
Waiting → Triage	7	23	10	33
Waiting → T.B.	3	10	30	98
Nurse → Treatment	5	16	15	49
Nurse → Sluice	7	23	5	16
Waiting → Dispensary	2	6	1	3
Pharmacy → Dispensary	1	3	1	3
Nurse → Consulting	4	13	3	10



Pharmacy Program Analysis



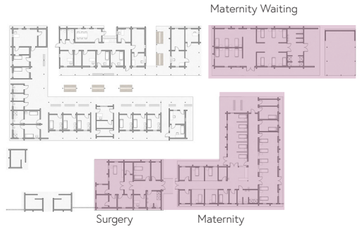
OPD Program Analysis

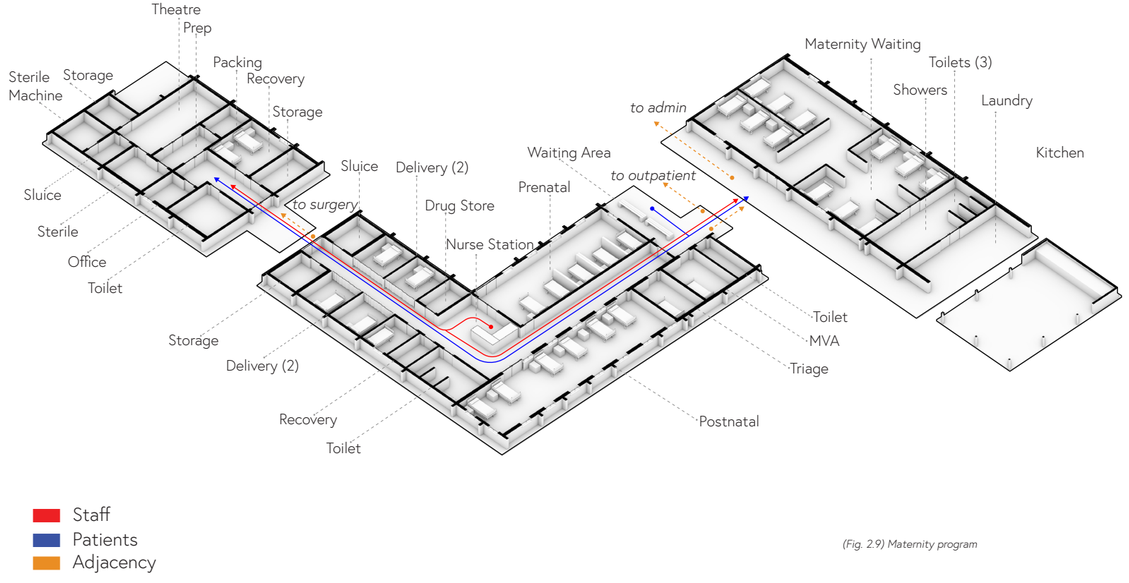
Outpatient

Maternity Wing

COMPARATIVE SPATIAL ANALYSIS

Maternity/ Maternity Waiting Ward





(Fig. 2.9) Maternity program

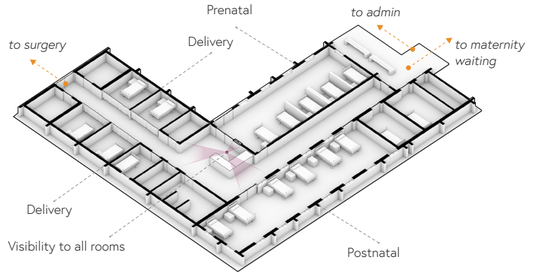
Program Square Meters | Feet

**totals represent sum of program and circulation*

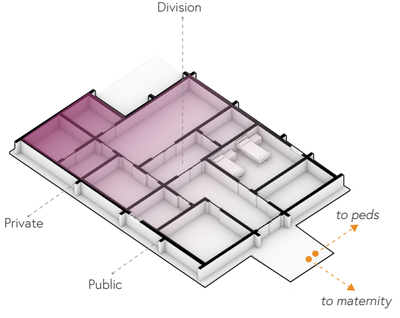
			Standard Design	
	m^2	ft^2	m^2	ft^2
Maternity Services	**556**	**5985**	**315**	**3400**
Prenatal	63	678		
Postnatal	83	893		
Delivery	42	452		
MVA Room	14	150		
Family Consulting (2)	11	118		
Nurse Station	18	194		
Linen Storage	6	65		
Drug Store	6	65		
Restroom	8	86		
Maternity Waiting	**494**	**5317**	**380**	**4090**
Waiting Bay (4)	30	323		
Restroom	37	398		
Kitchen	89	958		
Laundry	71	764		
Surgery	**262**	**2820**	**165**	**1775**
Main Theater	28	302		
Recovery Room	17	183		
Sluice Room	5	54		
Sterile Room	11	118		
Storage	17	183		
Anesthetist Office	7	75		
Restroom	16	172		
Service Bar	**55**	**592**	**70**	**750**
Toilets (2)	8	86		
Storage	7	75		
Incinerator	10	107		
Latrines	15	161		

Critical Adjacencies Distances

	m	ft	m	ft
Waiting → Prenatal	4	13	5.5	18
Nurse → Prenatal	3.5	11	30	98
Nurse → Postnatal	10	32	25	82
Nurse → Delivery	10	32	7	23
Prenatal → Delivery	10	32	15	50
Delivery → Postnatal	14	45	20	65
Delivery → Surgery	11	36	25	82



Maternity program analysis



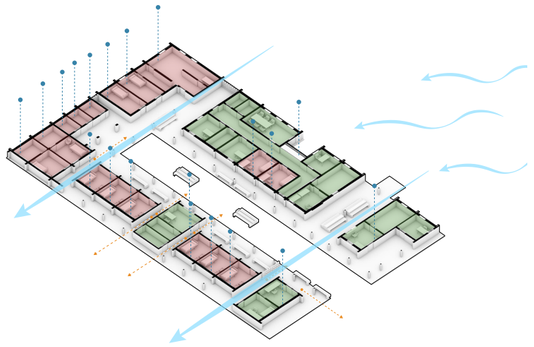
Surgery Theater program analysis

SITE SECTION

Admin/ OPD

INFECTION CONTROL ANALYSIS

Ventilation - Handwash Stations



Administration - Outpatient

Proper Hand Hygiene is the most effective Infection control method. Administration,nurse station, registration and Pediatrics are considered non-infectious were staff can relax precautions. Breaks in building form creates axis for air circulation.

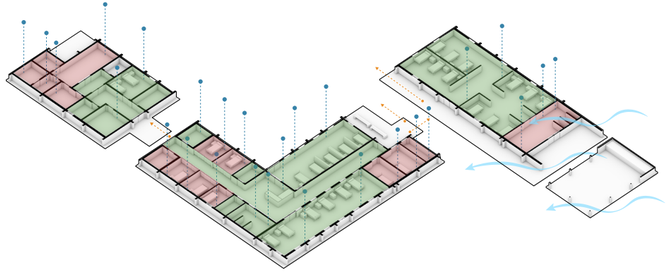
Number of Sinks per Program

Maternity Ward	16
Outpatient Ward	10
T.B. Ward	3
Administration	3

"Clean" - Non Infectious

Infection Hotspots

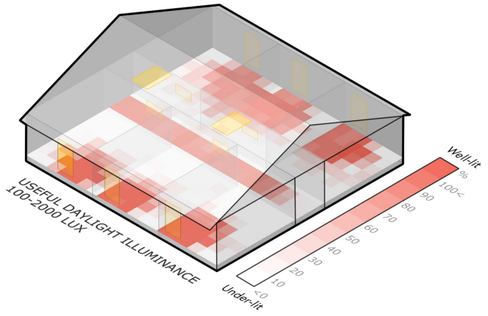
Wash stations



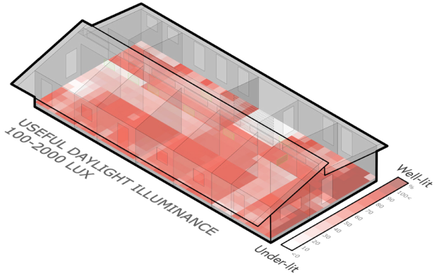
Maternity Ward - Maternity Waiting

Building form encourages air circulation at all times to prevent possible spread. "1 sink per 3 beds" was the rule in strategically locating wash stations in wards. Sink location is informed by nurse and patient day-to-day operations.

COMPARATIVE DAYLIGHT ANALYSIS

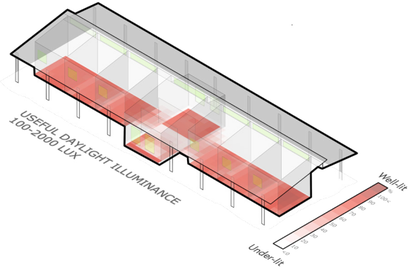


MOH Standard Form Design



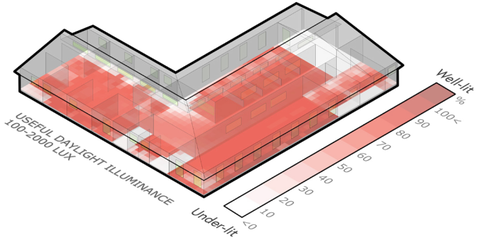
Administration

This section uses a clerestory and an elongated roof overhang that covers a circulation path. The use of a brick weave wall above the wash station allows more daylight through to the corridor. The clerestory windows bring day light into the corridor, office and screening spaces. This section has a higher percentage of well lit spaces than the standard building section used.



Outpatient

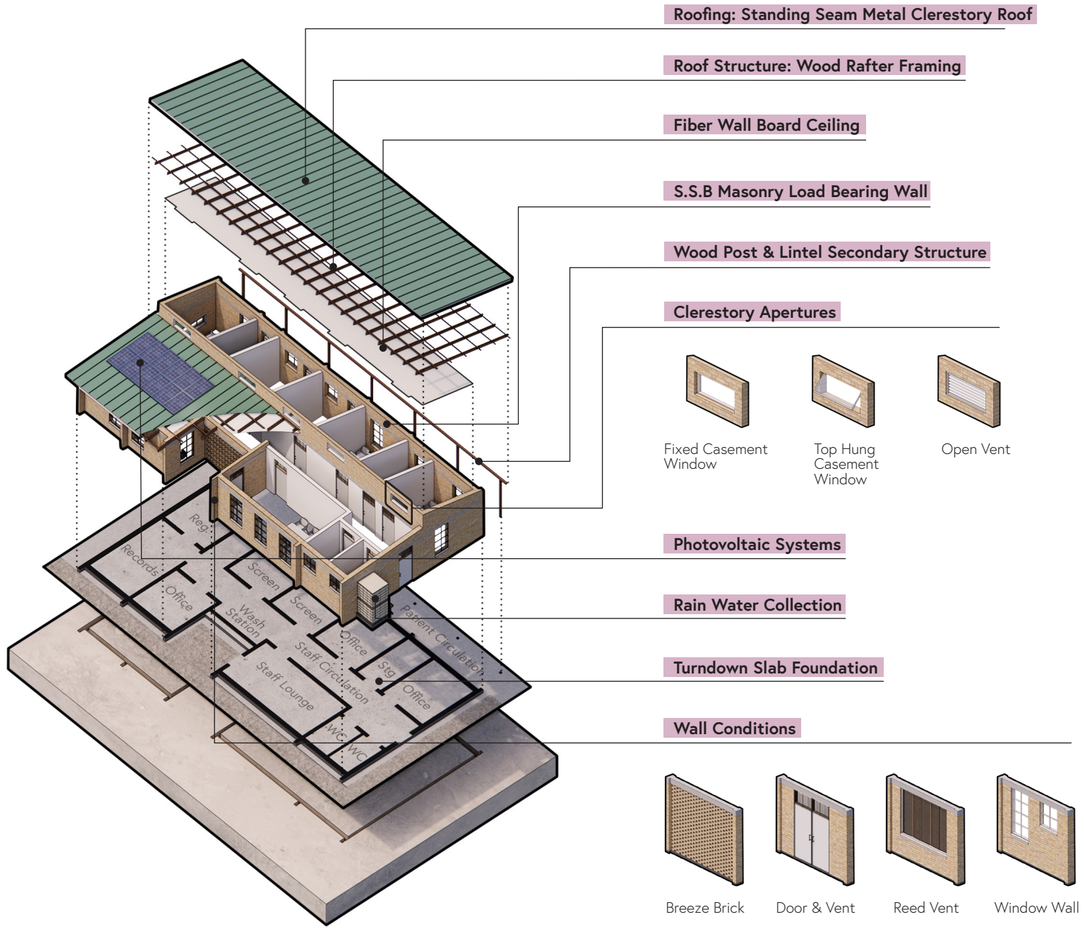
With the outpatient program being much smaller in comparison to its roof size, a clerestory was utilized in this program as well. The deep overhangs provide excellent outdoor waiting space for treatment and separate therapy areas. The central nurse station has windows surrounding the block to provide both views to patients and day lighting.



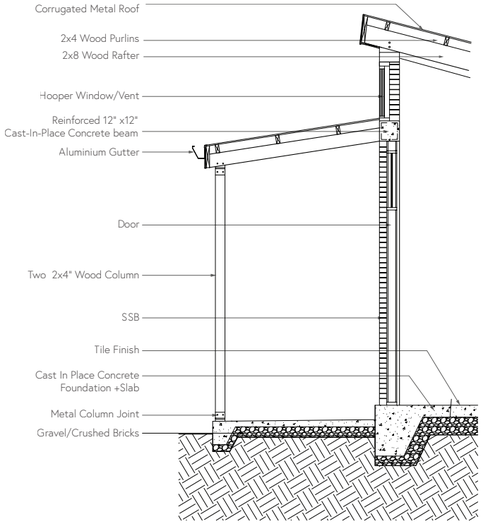
Maternity

The L-shape in this scheme uses a wrap around clerestory to bring daylight into the corridor. Many glass windows, which allow the nurses full view of patients, also let the daylight filter throughout many interior spaces. For private delivery rooms, high windows are used to keep the privacy of the patients. The open wards or pre and post natal are filled with windows and each have access to their own walking gardens.

INFRASTRUCTURE ANALYSIS

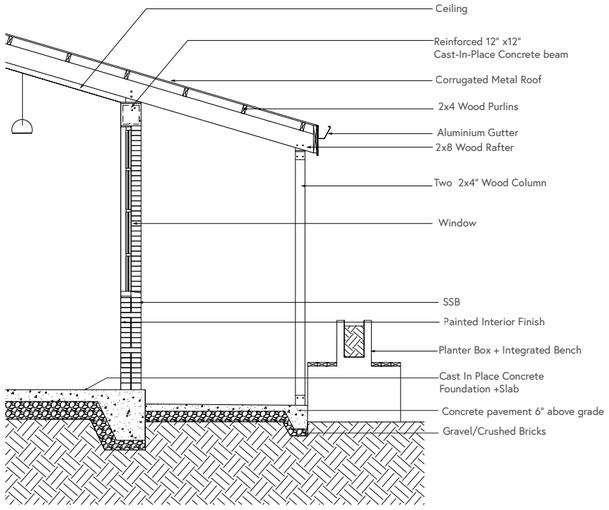


ASSEMBLIES



<u>Administration</u>

- ventilation
- daylight/shading
- thermal comfort
- rainwater capture



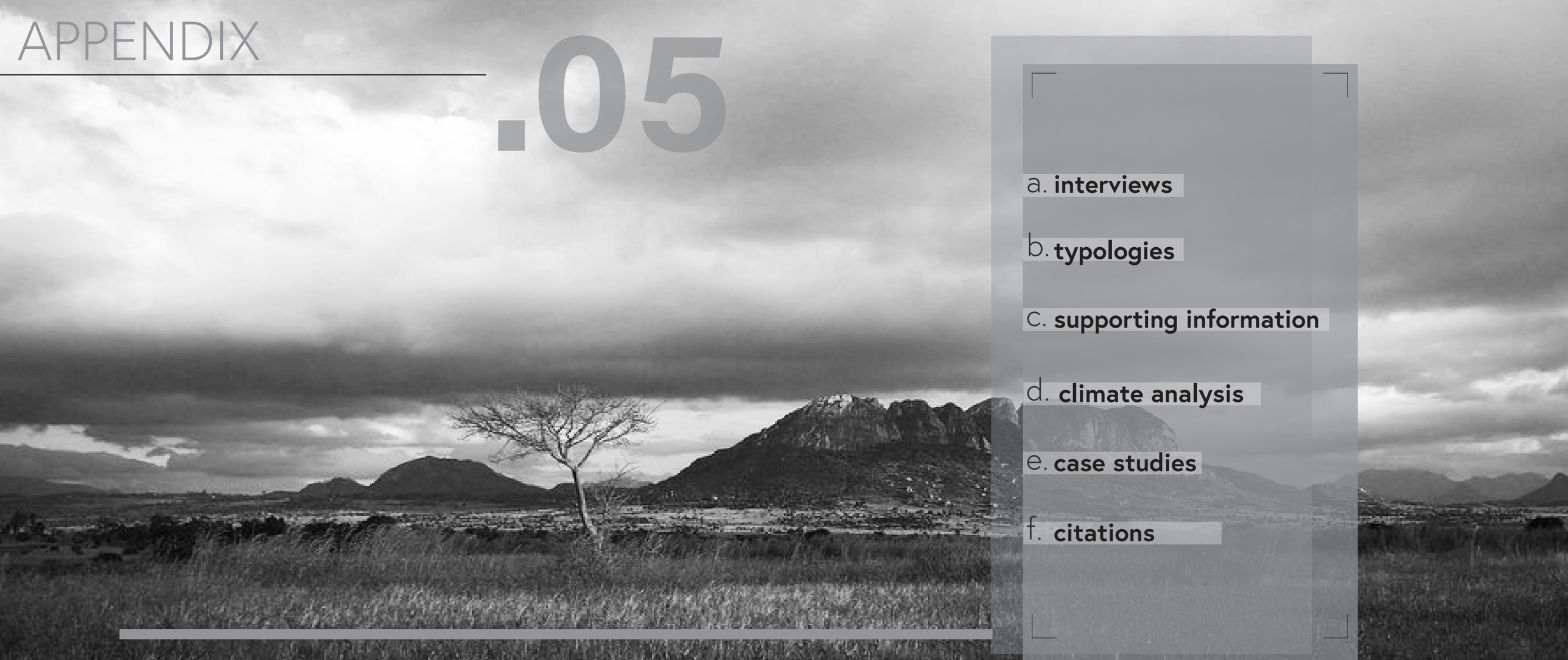
<u>Outpatient</u>

- ventilation
- daylight/shading
- thermal comfort
- rainwater capture
- privacy

REFLECTION

Healthcare design in this context has implications that are felt all throughout the community. The research brought to light issues that could be addressed with an architectural solutions. The design sought to address concerns after speaking with stakeholders within the Ministry of Health, Department of Buildings, and varying medical professions.

APPENDIX .05



a. **interviews**

b. **typologies**

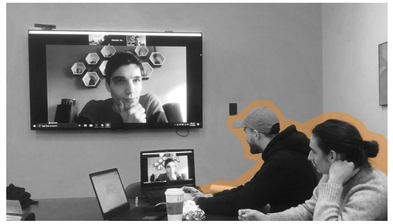
c. **supporting information**

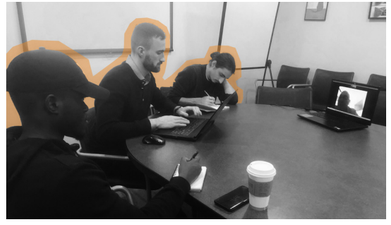
d. **climate analysis**

e. **case studies**

f. **citations**

INTERVIEWS





BRYAN ENSLEIN

-Principle of Global Build Collaborative
-Former USAID Engineer Advisor

"What are some factors that may go into creating a resilient facility within a rural setting?"

- effective engineering is key for a resilient H.C.
- prove design interventions will improve patient staff health outcomes.
- proper method of "handing off" to those operating the facility.
- there should be an emphasis on programmatic needs.

Effective engineering is key to promoting resilience. New facility designs must be proven to have a greater impact on patient and staff health outcomes and satisfaction when compared to the standard design. When analyzing necessary programs and components of a building, present data in such a way that is obvious. Simplified designs often have greater success because the utility of building is easily understood. To further the resilience of a facility, be sure to have a proper method of "handing off" the project for those operating the facilities.

Focus efforts on programmatic needs of a facility. Allocation of space for operations is vital through a buildings lifespan because the needs of the patients and staff may grow overtime. Lastly, create a building that sparks incentives to care for the building.

PETER

-Former Head of Ministry of Health

"What is an important aspect to designing a health centre?"

- a health center should adapt to its climate
- roof design is important for shading
- consider needs of community
- budget/funding restrictions.
- prove structural viability
- prove design decisions with hard data, lit. reviews & surveys.

A health facility should be adaptive to its climate. Too often, conditions within these facilities are unpleasant due to improper ventilation and roof insulation. Creating a roof that adapted to different weather conditions would greatly improve internal operations and patient/staff satisfaction. Unfortunately, health centre design is typically an afterthought. Due to the nature of funding and construction, little adaptive design is done. Design a facility that takes into account the wants and needs of a community. They are the main stakeholders, therefore they should be key informants to a successful design.

While making design decisions, it is important to prove your intentions with hard data, medical literature reviews and surveys to show that your design performs better. The structural integrity of your design is also important to prove that it can stand the test of time and serve the community.

STEPHANO VATTERONI

-South African based architect
-Renovation of Queen Elizabeth Central Hospital

"What have been some guiding principles when designing within a health facility?"

- create space that will be valued for a long time
- staff and patient flow between program is critical
- way finding is important to orient patients in the right direction
- proper water filtration, sanitation systems & constant electricity are steps towards resiliency

One must create a place that will be valued over a period of time and is full of energy, positive energy that promotes the activities within a space. Beauty is a fundamental component to every piece of architecture, but within a health facility, it is critical to focus on the flow and circulation between spaces. A patient must know they are in the right areas for proper treatment. Proper organization is necessary to promote efficiency for both the patients and staff.

Another vital component to health facilities is patient privacy. Allowing separated spaces for patients to maintain a sense of privacy creates a safer and more comfortable place for them.

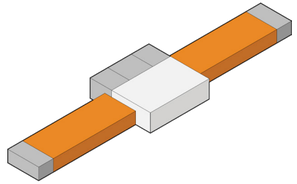
Other services relating to a facilities infrastructure is vital Proper water filtration, sanitization systems, and a source of constant electricity should be the first steps towards resilient, functioning health facilities.

TYPOLOGIES

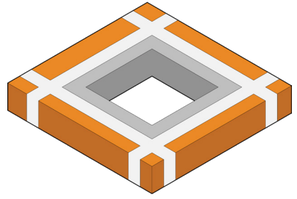
Patient Areas
Staff Areas
Circulation

Single Module

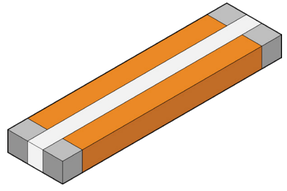
Nightingale
+ natural daylight
+ staff efficiency
+ natural ventilation
- infectious disease control
- patient privacy
- circulation efficiency



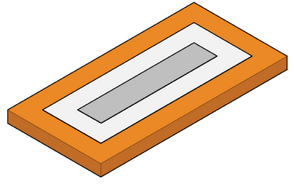
Courtyard
+ natural daylight
+ staff efficiency
+ circulation efficiency
+ infectious disease control
+ patient privacy
+ natural ventilation
+ natural landscapes
- way finding



Corridor
+ natural daylight
+ staff efficiency
+ infectious disease control
+ patient privacy
- natural ventilation



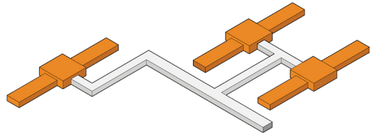
Racetrack
+ natural daylight
+ staff efficiency
+ circulation efficiency
+ infectious disease control
+ patient privacy
- natural ventilation



Expansion

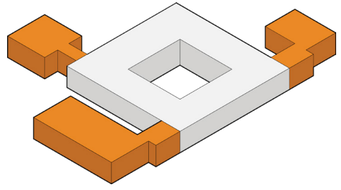
Nightingale
•population based

+ modular expansion
+ central axis
+ areas for expansion
- increase travel distances
- requires large plot of land
-/+ wayfinding



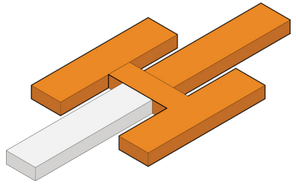
Courtyard
•department based

+ close proximity
- areas of expansion
- corrdinated construction
- staff circulation
- wayfinding

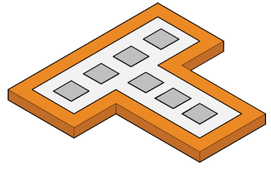


Corridor
•population based

+ linear organization
+ modular expansion
+ staff circulation
+ patient interaction
- patient circulation



Racetrack
+ efficient circulation
+ staff efficiency
- corrdianted construction
- costly



Nightingale Typology
The Nightingale ward was first used in the 1860's during the Crimean War, as a means of treating large amounts of injured soldiers with very little staffing.[1] The organization consists of a central hub for nurses and healthcare professionals, open wards for patients, and sanitary stations and auxiliary stations on the ends of the wards. The design was geared more for efficiency than comfort.[2] Circulation is based off an open, double loaded corridor circulating through the center of the open ward from one medical hub to another. Nightingale typologies allow for a large amount of natural day lighting due to its linear form. Proper ventilation in this typology is futile to reduce the spread of infection

Courtyard Typology
The courtyard typology was first constructed in the 1970's as a means to provide natural day lighting to both staff and patient areas.[3] The traditional organization of a courtyard typology has the central corridor bordered with staffing areas, while the exterior perimeter is occupied by patient areas. This particular organization allows for direct access from staffing areas to patients. Patient rooms in this typology vary in size from medium wards to private rooms. Like the original intention, this typology is natural day lighting and ventilation is accessible from almost every room.

Corridor Typology
The corridor typology is popular in European and American hospitals for its efficiency. This typology was adopted in 1960 for its efficiency, allowing for staff to quick navigate and circulate between patients and supporting program.[4] Improved privacy with more sectioning of rooms that reduce large open wards to rooms of around a dozen or so. Medical stations are typically located at the ends and middle of the corridor. The linear configuration of the corridor typology also indicates a very clear direction of movement. The central double loaded corridor allows for improved worker interactions and some of the quickest patient interactions.[5]

Racetrack Typology
Racetrack typologies are defined by placing critical program in the center core of a facility. [6] Staff areas are places on the outside corners and patient areas in the middle with circulation in between the two blocks allowing for simple and available access between the two.

Expansion
Designs for health centres must anticipate the possibility of expansion for future departments or population growth within the catchment area.[7] It is important to note that health centres and any expansion is limited to a single floor. Construction typically involves building outward rather than upward. Limited infrastructure regarding horizontal travel (elevators/lifts) makes circulation for staff and patients difficult during emergency situations. Expansion typically occurs in phasing, where supporting departments such as surgical wards, outpatient wards, etc. are constructed at a later time when funds are available. Varying methods of expansion correlate to the space available and departments required to serve the surrounding population. Modular expansion is the simplest and most efficient method compared to added components illustrated in the courtyard expansion. Unfortunately, modular expansion requires large amounts of land which may not be a viable option depending on the health centres location. Therefore, methods of expansion that promote efficient operation within the health centre must be explored early in the design phase.

1) Pachilova, Rosia. " The Effect of Ward Typologies on Quality of Care". Bartlett School of Architecture. June 12, 2018.
2) "Basic Design Drawings". PDF. Malawi Department of Buildings.
3) Verderber, Stephen, and David J. Fine. "Healthcare architecture in an era of radical transformation". Yale University Press, 2000.
4-7) "The Effect"

HOSPITAL ACQUIRED INFECTIONS

PROBLEM SUMMARY

- Patients do not seek care for fear of infection at the point of care
- Waiting areas are not conducive to proper ventilation
- Prevention guidelines need to be monitored

Introduction

Health-care-associated infection (HAI) is a major global safety concern for both patients and health-care professionals. In sub-saharan Africa & specifically Malawi, it is a major issue. It is defined as an infection occurring in a patient during the process of care in a health-care facility that was not manifest at the time of admission. This includes infections acquired in the hospital and any other setting where patients receive health care and may appear even after discharge. HAI also includes occupational infections among facility staff. These infections, often caused by multiresistant pathogens, take a heavy toll on patients and their families by causing illness, prolonged hospital stay, potential disability, excess costs and sometimes death.

Prevention Guidelines

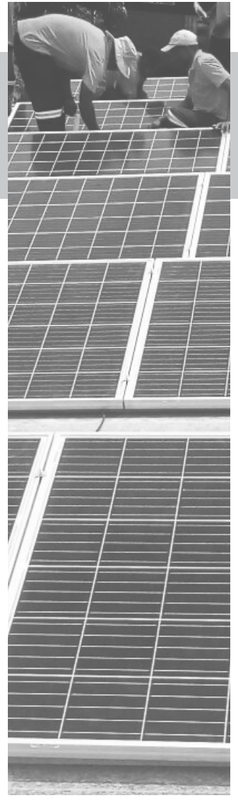
Hand hygiene is the standard and the most effective measure in reducing risk of transmission. All patients & staff should be provided adequate clean water and soap or hand sanitizer. Isolation is an effective method in ensuring physical separation from other patients in a health facility. Such isolation has been associated with a decrease in cross transmission of organisms.[1] Infection Control Methods (I.C.M) are standard precautionary measures carried out by health professionals to ensure infections do not get transmitted. Personal protective equipment like clean gloves, clean gowns, mask and eye protection should be used to access risk of the contaminated surface before any health care activity. Proper ventilation is a proven method used to reduce the risk of nosocomial infection. The W.H.O. recommends a minimum ACH for different spaces in a health facility, to prevent cross contamination.

Bed Spacing

Appropriate spacing and layout of beds can significantly minimize transmission of airborne infection and cross contamination among patients.[2] Corridors are usually culpable in the transmission of nosocomial infection. This risk increases when they are not properly ventilated or designed. Double loaded corridors pose a higher risk because of how poorly ventilated they can be if not properly designed. The corridors in health centres should not serve as extensions of waiting areas during peak periods. Organized triage management is important to identify patients with possible airborne diseases. Seating should accommodate the expected amount of patient loads and accompanying family members and guardians.[2] Waiting areas should be configured in ways to avoid congestion and overcrowding.

1) Marik, P. E. (2014). Hospital Acquired Infections and Their Prevention. Evidence-Based Critical Care, 213–257. doi: 10.1007/978-3-319-11020-2_16
2) Nejad, S. B., Allegranzi, B., Syed, S., Ellis, B., & Pittet, D. (2011). Health-care-associated infection in Africa: a systematic review. Bulletin of the World Health Organization,89(10), 757–765. doi: 10.2471/blt.11.088179

INFRASTRUCTURE



PROBLEM SUMMARY

- Energy is intermittent, with constant black outs
- PV is widely accepted, movement to micro grids
- WASH protocol needs to be implemented and monitored to achieve success
- Maintenance plans are required for all systems

Energy Systems

Electricity is required in six essential categories for healthcare in this context. Lighting, refrigeration, water supply, sterilization, ICT and staff housing when applicable are the major categories that have energy demands in health centers.[5]
These depend on factors such as provision of night time services, child vaccination services and quantity of outpatient visits. Health centers typically are connected to the national grid, which has interrupted access and experiences consistent blackouts throughout the year. While solar seems like a viable alternative, many centers have already turned to solar to power themselves, these systems are inefficient with only 57% of PV systems being functional.[5] While they provide critical power to 31% of rural facilities, long term management and maintenance of these systems is not given enough thought. Similar to the additive approach of expansion within hospitals, there are often five to six PV systems at a facility with only about three of them operational at one time. This results in many inefficiencies through a lack of uniformity and communication. The attitude of Malawi officials is to connect to the grid when a facility is within 5 km of connection point, to adopt new PV micro grids that replace dysfunctional, insufficient systems that previously could not support demand.[6]

Water Systems

The W.H.O. program called Water, Sanitation and Hygiene (WASH) is a standard that is being implemented in healthcare facilities across LMIC's.[4] Malawi has been the subject of a few WASH protocols to assess the current infrastructure challenges of hygiene as well as an initiative to improve WASH through facility-level action.[3] WASH Facility Improvement Tools (FIT) is a tool being used to define a framework that monitors implemented plans and identifies areas for quality improvement. There are recommendations to be followed for WASH that Malawi acknowledges it is deficient in and plans to improve in areas such as water quantity, access, quality and similar metrics with sanitation.[3] These will be the standards that we will measure our case studies against.

Maintenance

In seeing the additive nature of construction in this context, it is recommended that each facility should have a unique micro grid that suits its exact needs, not a standard system that is applied to all facilities. This reduces the system complexity and resets the energy system. In other cases it is advised that facilities attach to the national grid where the government can provide energy and maintenance systems.

3) Ofori-Kuma, Magdalene Mathews, and Tsion Gebreyesus. WASH in Health Care Facilities UNICEF Scoping Study in Eastern and Southern Africa .
4) Water, sanitation and hygiene in health care facilities: practical steps to achieve universal access. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO.
5) Suhlrie L, Bartram J, Burns J, Joca L, Tomaro J, et al. (2018) The role of energy in health facilities: A conceptual framework and complementary data assessment in Malawi. PLOS ONE 13(7): e0200261.
6) HEALTH FACILITY ENERGY NEEDS ASSESSMENT MALAWI COUNTRY SUMMARY REPORT . 2015.

CONSTRUCTABILITY

PROBLEM SUMMARY

- Limited material palette
- Keep cost per sq. m. low so program can expand
- Alternative materials can solve construction problems that arise from environmental issues
- Rural sites can be difficult to access

Materials

Government projects tend to cut as much material cost as possible, opting for more program space or medical technology. In doing so, the material palette is limited to a certain set of items such as locally sourced masonry blocks, plaster, sheet metal and concrete, with additional materials being imported as required. The delivery of these materials comes from either on site or off site methods. On site materials are created from sources within the vicinity of the construction site.[8] These would include some alternative materials such as SSB's, volcanic rock and more typical mud brick. While off site implies materials that come from a manufacturer or supplier. The major cities of Mzuzu, Lilongwe and Blantyre are where materials are typically sourced. Product delivery must be carefully considered as many rural sites are difficult to access, due to inadequate road infrastructure.

Alternatives

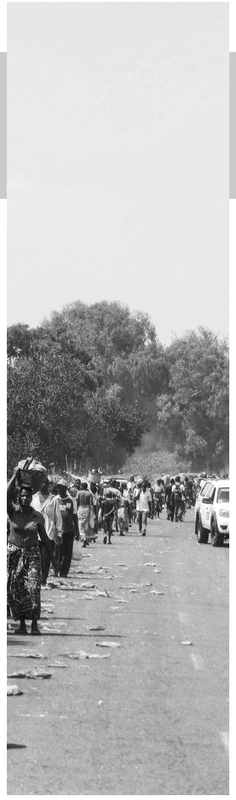
Typical construction in the country uses sun dried or burnt bricks, which contribute heavily to the deforestation in the country. Trees are cut down for wood that fires kilns to create bricks. Suggesting alternative materials can reduce the negative effects of construction.[9] Materials outside the typical palette are used dependent on site conditions, whether the project is privately or publicly funded and other external factors. Soil Stabilized bricks (SSB) are constructed from local soil, water and small amounts of cement as a binder, which is then air dried.[9] This alternative doesn't require kiln firing and has been used by firms such as MASS and ASA for health centered projects in this context. Rammed earth is similar where local soil is used with cement then rammed into a framework, much like concrete to form a solid mass.[10] Timber is used for roof framing for most government health projects, most of which is coming from outside the country. Light gauge steel can be used to replace timber as a construction alternative.

Financing

Over 60% of healthcare funding is being driven by donors, making Malawi one of the most dependent healthcare sectors in the world.[7] An approach that secures more sustainable financing and increases current spending efficiencies is needed to strengthen the overall health system.

7) "Health Systems Strengthening: Malawi." U.S. Agency for International Development, 3 Nov. 2016, www.usaid.gov/malawi/global-health/health-systems-strengthening.
8) Lall, Somik V.; Wang, Hyoung; Munthali, Thomas. 2009. Explaining High Transport Costs within Malawi - Bad Roads or Lack of Trucking Competition? (English). Policy Research Working Pa-per; no. WPS 5133. Washington, DC. World Bank
9) Cassani, Matilde, et al. "Safer House Construction Guidelines." Issuu, Bureau TNM; Department of Lands, Housing and Urban Development; World Bank Group, 2 Oct. 2016.
10) Dabaieh, M. (2014). Building with Rammed Earth -A practical experience with Martin Rauch

FACILITY ACCESS



PROBLEM SUMMARY

- Average time to a health center is 1-2 hour walk
- Inadequate infrastructure discourages travel
- Improve availability of transport to centres
- Anchor Farms Santhe is located 8 mi away from the next center and 30 mi away from the district

Introduction

Majority of Malawians often travel to health centers by walking. Due to long travel distances, they tend to not visit a health center for treatment or delivery but opt to visit the nearest traditional healer instead. In order to address this issue, there needs to be more health infrastructure built for easy access and to meet the needs of Malawi's growing population. This infrastructure includes quality roads and bridges that do not erode during rainy seasons and an increase in the number of available facilities.

Travel Distance / Accessibility

Catchment areas depend upon the location of the hospital, the type of hospital, and they vary throughout the region since the population is unevenly distributed. The catchment area for a typical health center ranges from 3,000- 30,000 people depending on its location.[11] The Ministry of Health has increased their efforts in making facilities more available to meet the needs of their growing population but access is still limited and often these facilities are overcrowded & overworked. Rural areas with little to no access to health centers should have priority when locating these new facilities.[12] Lack of suitable transport, finances and prolonged travel time to a health care centre, all pose barriers to timely access of healthcare. Improving the availability of transport between rural health centres and district hospitals, and between the district and central hospitals, could help overcome the transportation barriers to health care.

Anchor Farms Santhe

The Santhe Health Center in the Kasungu district has a catchment population of 29,210 people.[11] This is near the higher end of the catchment areas for health centers. Other nearby facilities include the Mkhota health center which is about 7.8 mi away and has a catchment population of 15,813 patients.[11] The nearest secondary care location is the Dowa community hospital located 15 mi away from Santhe. The closest tertiary facility is located 30.4 mi away which is the Kasungu District Hospital.[13] This shows the difficulty of access to these facilities when the primary mode of transportation is by foot

11) "Health Facilities in Malawi ." ArcGIS. Accessed February 2, 2020. https://www.arcgis.com/home/webmap/viewer.html?webmap=7291e221b59e4b9586b-5de56ef306374.
12) Government of the Republic of Malawi. "Health Sector Strategic Plan II (2017-2022)." 2017.
13) (n.d.). Retrieved from https://www.arcgis.com/home/webmap/viewer.html?webmap=7291e221b59e4b9586b5de56ef306374

PATIENT OUTCOMES

PROBLEM SUMMARY

- Services provided must conform to international standards such as W.H.O. and MoH
- Factors of care turn into quantifiable metrics to measure success against
- Natural environments expedite recovery times

Quality of Care

The quality of care rendered to patients can positively/negatively impact patient health outcomes. Quality of care can be influenced by the following: Availability of resources, Good triage management, proper day lighting, well vented spaces, comfortable occupiable spaces, healing landscapes etc. The WHO defines quality of care "the extent to which health care services provided to individuals and patient populations improve desired health outcomes. In order to achieve this, health care must be safe, effective, timely, efficient, equitable and people-centred."[14]

Factors of Care

Safe delivery of health care that minimizes risks and harm to service users, including avoiding preventable injuries and reducing medical errors. **Effective** services provided, based on scientific knowledge and evidence-based guidelines. **Efficient** delivery of health care in a manner that maximizes resource use and avoids waste. **Equitable** health care that does not differ in quality according to personal characteristics such as gender, race, ethnicity, geographical location or socioeconomic status. **Human centric** care that takes into account the preferences and aspirations of individual service users and the culture of their community.[15]

Healthcare Outcome Metrics

Mortality is the most important health outcome measure. **Safety of care** pertains to medical mistakes and includes Hospital Acquired Infections (HAIs). **Patient Satisfaction** assesses the patient's experience and perception of their healthcare. **Effectiveness of Care** measures compliance with best practice care guidelines. & achieved outcomes (e.g., lower readmission rates for heart failure patients). **Timeliness of Care** assesses patient access to care. Overcrowding has been associated with increased inpatient mortality, increased length of stay, and increased costs for admitted patients.[15]

Environmental Health Outcomes

The effects of environmental design on patient health outcomes has become a popular topic within the medical world. Based on the numerous past studies about evidence based healthcare design, it can be concluded that built environment aspects such as audio environment and visual environment had a positive influence on patients' health outcomes. These studies showed that there were decreases in pain, stress levels and anxiety when patients were exposed to music, natural murals and plants.[16] These interventions are inexpensive to implement, proving to be an effective solution that can be applied to most circumstances.

14) What is Quality of Care and why is it important? (2017, February 16). Retrieved from https://www.who.int/maternal_child_adolescent/topics/quality-of-care/definition/en/
15) Tinker, A. (2019, June 7). The Top 7 Healthcare Outcomes Measures. Retrieved from https://www.healthcatalyst.com/insights/top-7-healthcare-outcome-measures
16) Laursen, J., Danielsen, A., & Rosenberg, J. (2014). Effects of Environmental Design on Patient Outcome: A Systematic Review. HERD: Health Environments Research & Design Journal, 7(4), 108–119. doi: 10.1177/193758671400700410

STAFF AVAILABILITY

PROBLEM SUMMARY

- Clinical care is provided by Health surveillance assistants (HSA) who have inadequate training
- Staff leave for better work environments
- Low retention rates can be combated with quality housing, training and staff spaces

Introduction

Malawi faces a severe shortage of health workers, a factor that has contributed greatly to high maternal mortality in the country. Most clinical care is performed by mid-level providers (MLPs). Demotivating factors within the Malawian health system are pushing them into private, non-governmental, and other non-health related positions. Health facilities in rural communities are typically understaffed resulting in a disproportional staff-to-patient ratio. Due to the strain on human resources in healthcare, higher trained staff are placed in tertiary health care facilities, leaving the health center to be mainly managed by a head nurse and few medical assistants.

Low Retention Rates

According to a study carried out in Malawi that involved 84 health care professionals to narrate an incident that had happened during the past three months which had made them seriously consider leaving their job, it was discovered that 58 respondents (69%) indicated they had experienced a demotivating incident in the previous three months that had made them seriously consider leaving their job.[17] The most commonly cited critical factors were being treated unfairly or with disrespect, lack of recognition of their efforts, delays and inconsistencies in salary payments, lack of transparent processes and criteria for upgrading or promotion, and death of patients. The study concluded that staff motivation and an enabling environment are crucial factors for retaining MLPs in the Malawian health system.[18]

Staff Satisfaction

To encourage highly trained staff to move and work in rural areas, there needs to be adequate resources available for them to work, ability to do in-service training & appropriate pre-service training & Housing. Based on the findings from literature we reviewed, there is an outcry for better human resource management practices such as performance appraisal. Health workers felt that they were inadequately supervised, with no feedback on performance.[19]

17 Chimwaza, W., Chipeta, E., Ngwira, A., Kamwendo, F., Taulo, F., Bradley, S., & Mcauliffe, E. (2014). What makes staff consider leaving the health service in Malawi? Human Resources for Health, 12(1). doi: 10.1186/1478-4491-12-17
18 Ludwick, T. (n.d.). Improving motivation, retention, and effectiveness of community health workers. doi: 10.22215/etd/2010-09393
19 Manafa, O., Mcauliffe, E., Maseko, F., Bowie, C., Maclachlan, M., & Normand, C. (2009). Retention of health workers in Malawi: perspectives of health workers and district management. Human Resources for Health, 7(1). doi: 10.1186/1478-4491-7-65

CLIMATE ANALYSIS

MZUZU CITY
NORTHERN REGION

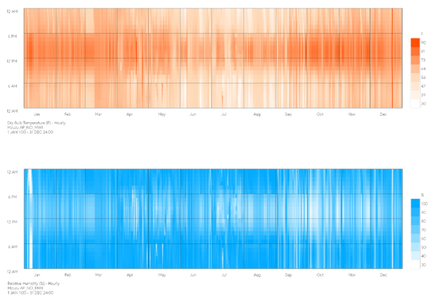
REGIONAL ANALYSIS

- Most humid and highest elevation
- Coldest temperature ranges
- Frequent summer winds from the Southeast
- Radiation from North during summer
- Heating with thermally massive assemblies
- Exterior circulation paths extends program
- Wind protected / sun exposed spaces desired

Climate Conclusions

The Northern region, on average, experiences the highest humidity and rainfall with lower, more comfortable temperatures. Winds in this region come from all directions , with summer winds coming from the southwest. This region experiences heat stress in about 21% of hours annually, compared to 59% comfortable hours and 2% cold stress. From this analysis, we can conclude design guidelines such as passive solar heating during winter hours especially. Vegetation should be avoided near the passive gain windows as to not block any gains. Shaded buffer zones such as covered circulation paths can extended working areas past the building envelope. This region is higher in altitude and has similar precipitation to the southern regions, about 1400 mm annually. Building enclosure needs to be considered more in this region as it experiences colder temperatures. Throughout all regions the building assemblies will change to better adapt to that regions microclimate.

Winter Summer



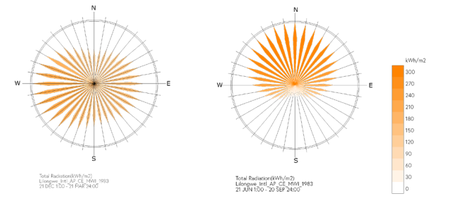
LILONGWE
CENTRAL REGION

REGIONAL ANALYSIS

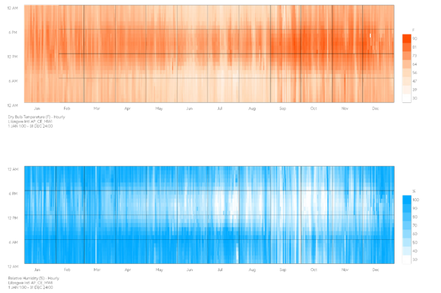
- Temperature midland, lowest annual humidity
- Most average of the climates and elevation
- Frequent summer winds from the East
- Wind protected / sun exposed spaces desired
- Most comfortable outdoor hours
- Lightweight construction with breathable assemblies

Climate Conclusions

Lilongwe is centrally located and is in the midland temperate zone. Winds in this region come predominantly from the east with higher velocities during the summer. This region experiences outdoor heat stress in only 21% of hours annually, compared to 61% comfortable hours and .9% cold stress. From this analysis, we can conclude design guidelines such as lightweight construction and thermally massive slab on grade. This is the most comfortable environment in Malawi, typical guidelines would include large overhangs to prevent overheating and operable windows to promote quality ventilation. Using the climatic heat to create the stack effect for ventilation through roof monitors works well in this climate. Exterior wind protected areas can serve as extensions of program, in this case waiting areas can spill outside into covered areas. Finally thermal mass materials that are exposed to lower winter sun are recommended for heat dispersion during the times of cold stress.



Winter Summer



CLIMATE ANALYSIS

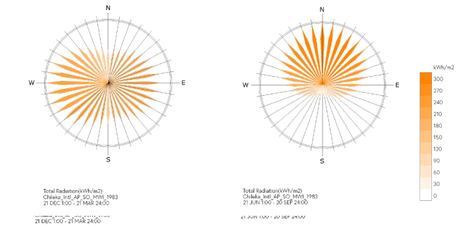
BLANTYRE
SOUTHERN REGION

REGIONAL ANALYSIS

- Hottest and driest summers
- Infrequent but strong winds from all directions
- Lightweight, breathable construction with thermally massive floor slabs
- Block western solar gains with vegetation
- Screened wall assemblies with high ventilation rates and sun shading mechanisms

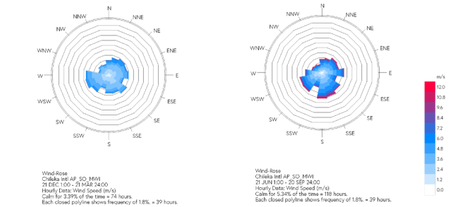
Climate Conclusions

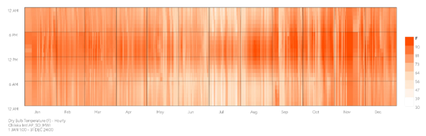
The Southern region, on average, experiences the hottest temperatures and lowest humidity of all the analyzed regions. Winds in this region come from all directions throughout the year, with summer winds having higher velocities than winter. This region experiences outdoor heat stress in about 31% of hours annually, compared to 57% comfortable hours and 1% cold stress. From this analysis, we can conclude design guidelines such as extended overhangs of roofs and screened areas to reduce direct solar gains. Lightweight, breathable construction with high ventilation and thermally massive slabs are used as vernacular in this area and should be considered for passive construction. West faces should be shaded by deciduous trees and have little glazing. Due to being in the southern hemisphere, the majority of glazing should lie on the Northern side of the building. As with all healthcare buildings in this context, natural ventilation should be prioritized to flush air into spaces such as open wards, corridors and other hot spots.

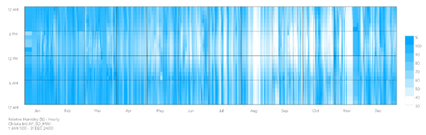


Winter

Summer







KINTOBO HEALTH CENTRE

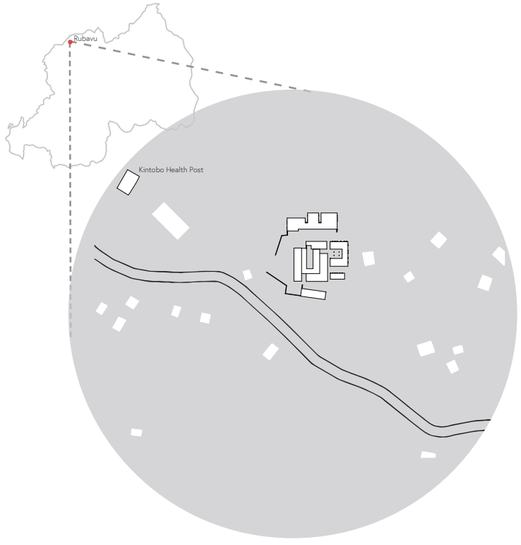
Case Study

Location: Nyabihu District, Rwanda
Type: Health Centre
Year: 2014-2016
Bed Count: 23
Size (sq m): 1500 sqm on 2500 sqm plot
Cost (per sq m): $315 per sq m ($470,000)
Services Offered: *Maternity, OPD, HIV Treatment, Male and Female Wards, Open Kitchen, Vegetable Garden, Lab, Pharmacy, Library & Classrooms Inpatient & Outpatient*

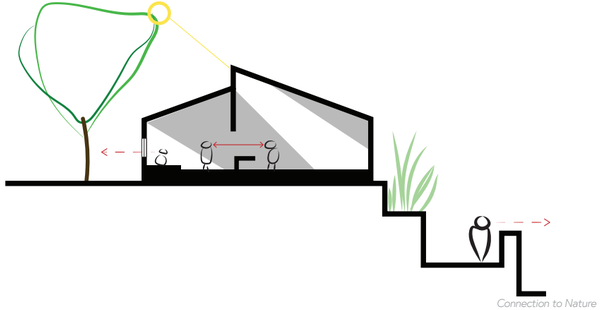
The Kintobo Health Centre was It was designed by ASA +TAMassociati in the Northern providence of Rwanda. It's design is driven by topographical architecture where the natural surrounding landscapes have a strong influence in the design. The health centre was built on top of a hill and is seen as a strong symbolic symbol since one has to climb to it or be brought by their family to get there.[1]

This project has many key aspects to it. It takes humanization, landscape and functionality into huge consideration. The involvement of the natural landscape is used as a natural healing venture. The wards, and maternity buildings are specifically placed so that they are guaranteed a nice view to the interior courtyards or surrounding valleys.[1]

There are a few important takeaways about the Kintobo Health Centre. One of them being its connection to nature and how they have integrated the building into the site itself. Another being the ratio of outdoor to indoor space and how the air flow between each helps to reduce the probability of transferring infectious diseases. Lastly, the community aspect of it and how they involved them throughout the whole process and acknowledged their needs rather than just building however they seemed fit.



Health Centre Plan



Connection to Nature

Kintobo Entrance

Corridor to Nutrition Block

Kintobo Gathering Area

View of Pergola

Nutrition Area Entrance

1) "Kintobo Health Center: Asa Studio: Active Social Architecture Studio, (25 Oct. 2017). TAMassociati." Archilovers. www.archilovers.com/projects/217160/kintobo-health-center.html#info.

CONSTRUCTION

The main construction materials were found close to the site, which reduced the costs of transportation and opened up job opportunities to neighboring communities. The main walls are built out of volcanic stones which were found on site during excavation, the exterior pavers and blocks are produced on site.

PROGRAM EFFICIENCY

Organized in four different levels that follow the natural slope of the land: the entrance and the Maternity, the OPD courtyard and nutrition block, the ward courtyard, and the laundry area.
The programmatic organization of functions and circulation together with a flexible layout, means a better accessibility to each functional department.

INFECTION CONTROL

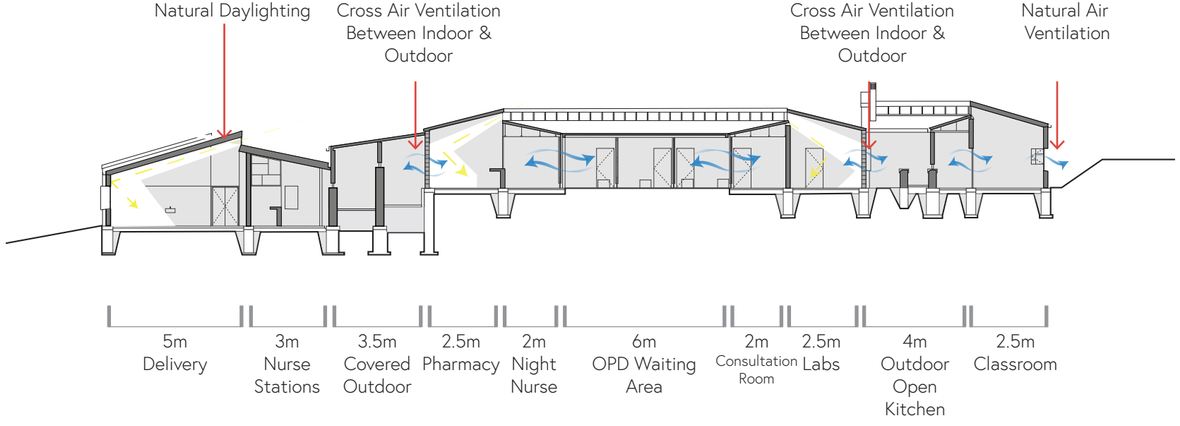
The Health Centre is connected to the piped water and the electricity but the integration of passive systems guarantees the Centre to operate off the grid when the power gets cut and there is lack of water pressure.

INFRASTRUCTURE RESILIENCE

Ventilation Strategies:
- Natural Cross ventilation achieved throughout the courtyards distribution
Day lighting Strategies:
- Sustainable design solutions to control and distribute natural light each room through windows sheds and skylights
Healing Landscapes / Garden

Health Centre Plan

Health Centre Construction



RUGERERO HELATH CENTRE

Case Study

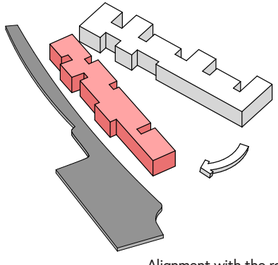
Location: Rubavu District Rwanda
Type: Health Centre
Year: 2016-2018
Bed Count: 19
Size (sq m): 3200 sqm on 6000 sqm plot
Cost (per sq m): $140 per sq m ($440,000)
Services Offered: *Pediatric Ward, Maternity, Family Planning, Vaccination & Nutrition, Lab, HIV & Consultation, Inpatient & Outpatient*

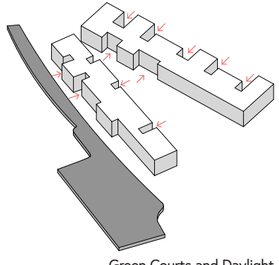
The Rugerero Health Centre was built in Rwanda and was designed to serve 35,000 people.[1] This health centre's entire design concept was focused on providing an improved health centre facility but still incorporating locally sourced materials and involving the community throughout the entire design. This health centre was also built to help reduce infant mortality and disease and infections in Rwanda, increase education in nutrition, and increase the mothers well-being.

This Rugerero Health Centre takes its minimal budget and turns it into maximum space. It carries out accessibility throughout the entire building with ramps and smooth surfaces. Natural light, landscape views, and material quality are used throughout to enhance the healing process, offer a relaxing atmosphere, and a nice work environment for its valleys.[1]

The Rugerero Health Centre incorporates green spaces into its centre and has fixed its self to match the alignment of the existing roads. It stands across the street from shops, police station, and the public square. The green courts in this health centre help to supply natural daylight. The centre is broken into two separate blocks each with their own level of privacy.

Site Plan


Alignment with the road


Green Courts and Daylight

1) *"Rugrero HC." Rugerero HC, activesocialarchitecture.com/rugerero-hc.*


Entrance with Ambulance Ramp


Delivery Block


View of the Courtyard Gathering Space


Women's Inpatient Wards


Connection Corridor Between two buildings

CONSTRUCTION

Materials are locally sourced fired bricks, stone foundations, metal roofing and wood ceilings, this helps with the reduction of the final building cost
Source of Funding: Partially funded by local government, fund raising initiated by Health Builders.

PROGRAM EFFICIENCY

The programs are arranged in two main blocks connected by a central corridor.
- The entry block hosts reception and waiting areas, nutrition, vaccination, triage, consultations, labs, and administration.
- The upper block hosts wards, isolation and nurse rooms, laundry and maternity.

INFECTION CONTROL

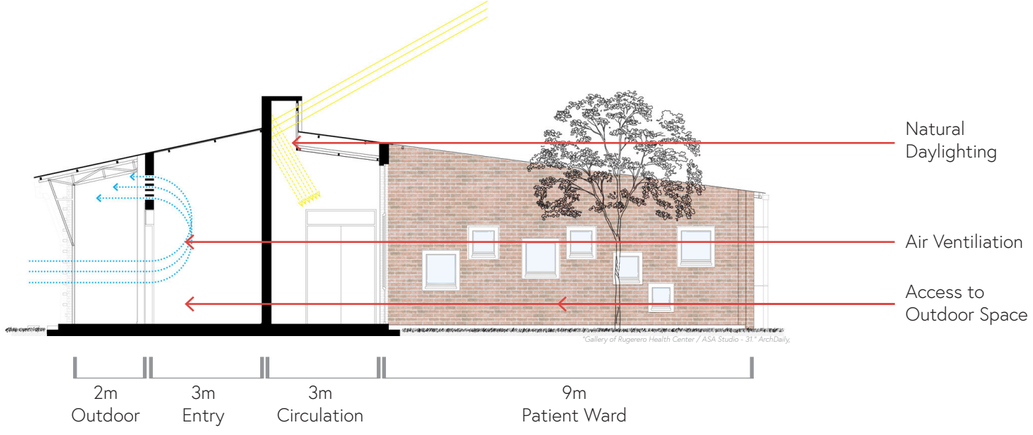
Rainwater collection two underground water tanks that collect 70.000L of rain
Flushing toilets connected to separate septic tanks are integrated into the project and are fed of rain water by gravity.

INFRASTRUCTURE RESILIENCE

Ventilation Strategies:
- Through the use of wall perforations, operable windows, skylights and green patios.
Day lighting Strategies
- Through the use of wall perforations, shading devices and skylights.

Health Centre Plan

Nutrition and Waiting Area



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