Hospital Design Concepts and Considerations: How Clinical Engineering can help Architects in Designing Better Medical Care Facilities

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For United Architects of the Philippines
May/June 2024

Disclosures

Your speaker is:

Part of the Institute of Biomedical Engineering and Health Technologies as a consultant for device testing and regulation

Life Member of Institute of Electronics Engineers of the Philippines

Was once the Director General Services at QualiMed.

Is currently a part time faculty for Computer Engineering Program under the Electronics and Computer Engineering Department in DLSU Manila

Disclosures

What you are about to see and hear here is:

Not the official position of IBEHT nor DLSU

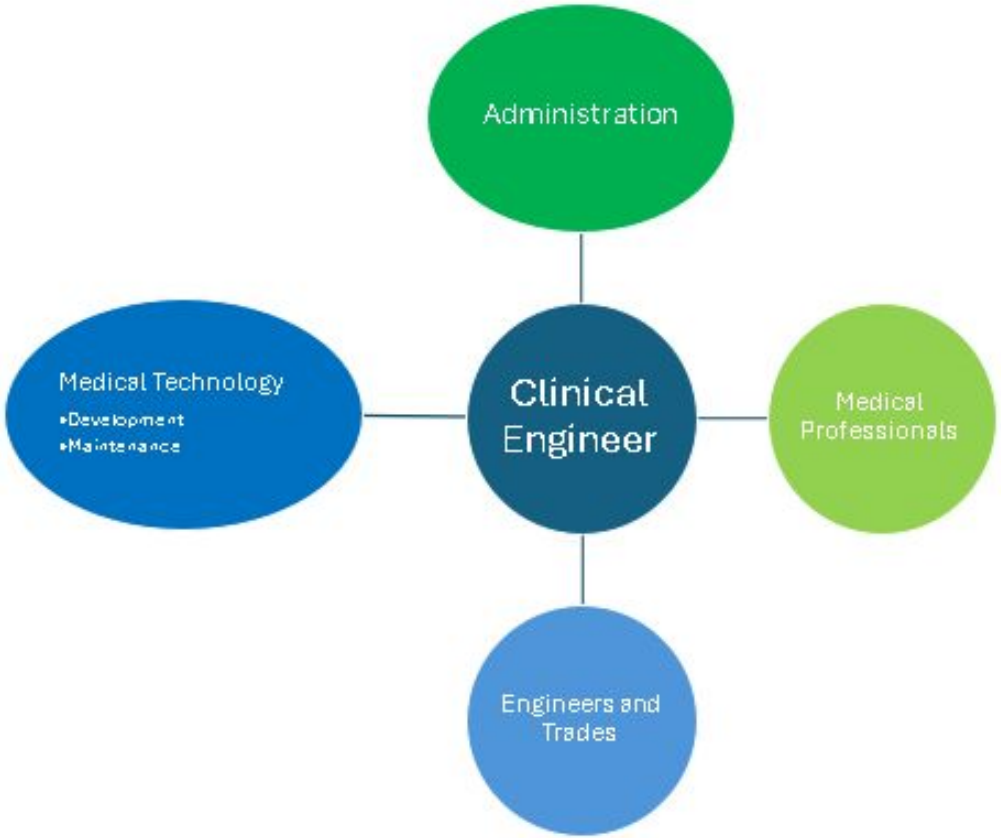
Based on the work Voltaire did under the Health Care Facilities Management Program in DMMC IHS and his work with MGHI that ended in 2018.

Materials is available online for further reading.

Clinical Engineering

Is a professional who supports and advances patient care by applying engineering and managerial skills to healthcare technology.

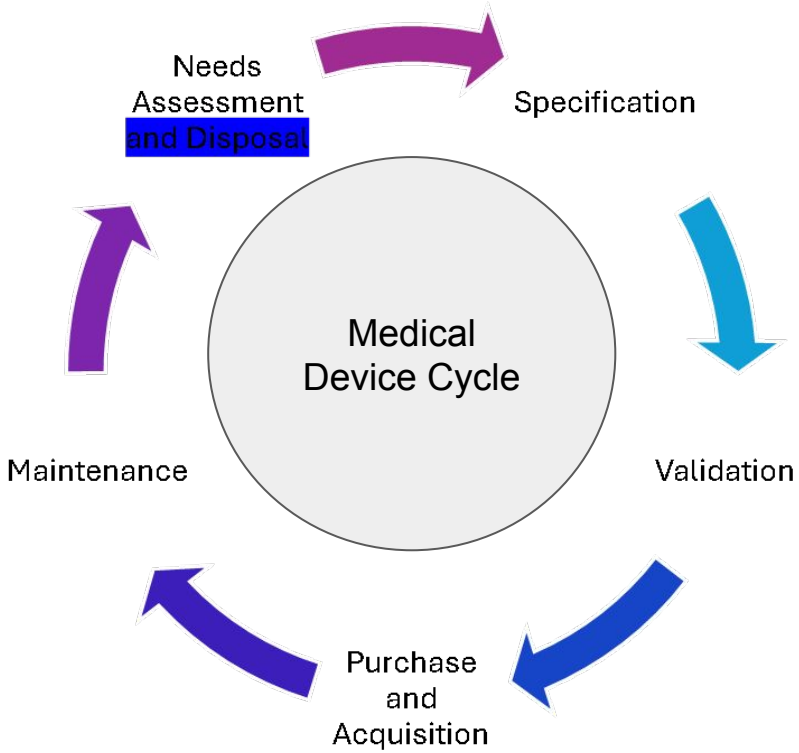
- American College of Clinical Engineering (ACCE)



Clinical Engineering

Work Flows around

- Machine Details
- Environmental Details
- Human Flow
- Material Flow
- Instrumentation
- Test Evaluation
- Management



Goal of Architects

Is to improve human life by creating:

- Timeless
- Free
- Joyous spaces for human activities.

Goal of Architects

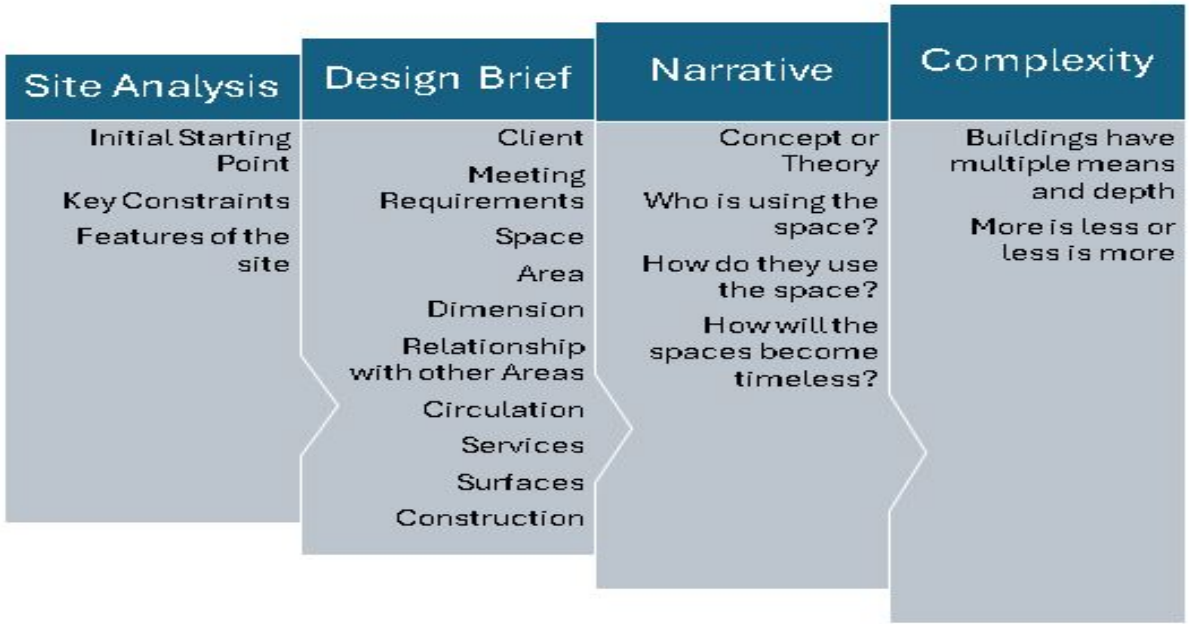
Shaping our surroundings

Influencing our well-being

Reflecting our identity

Architects

Planning of Buildings and Structures -> Initial Concept Development



Architects

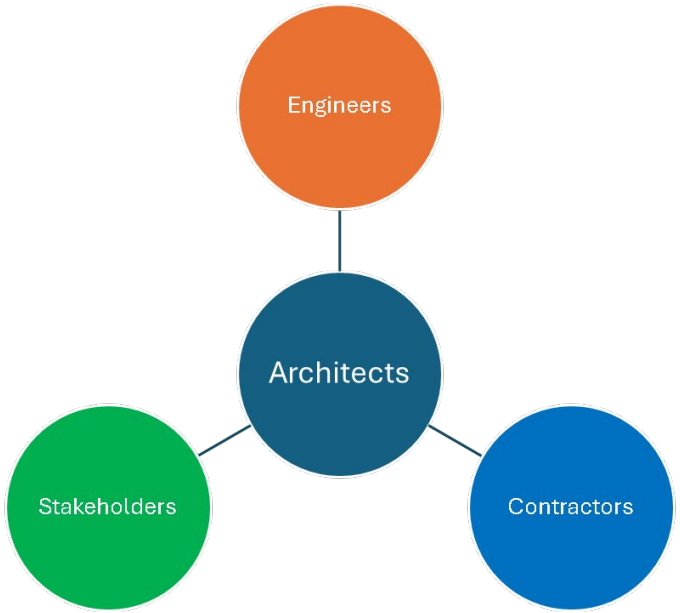
Buildings and structures

- Planning
- Design

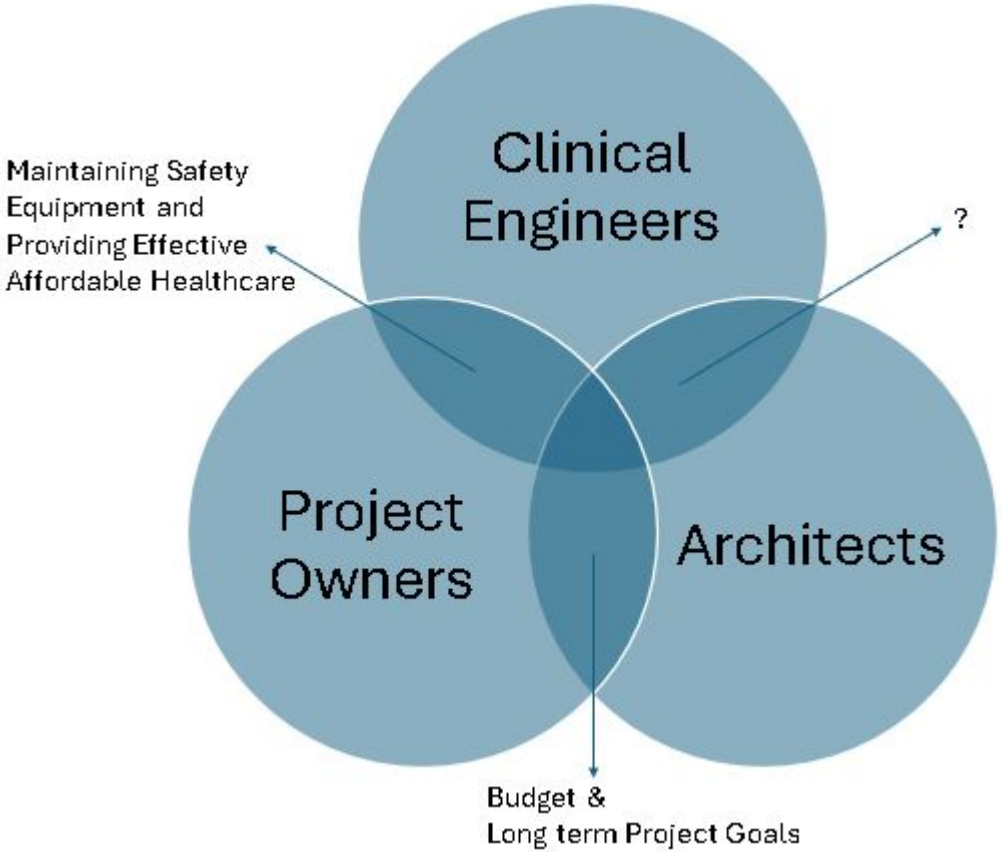
Architects

Buildings and structures

- Plans
- Designs
- Oversees the construction

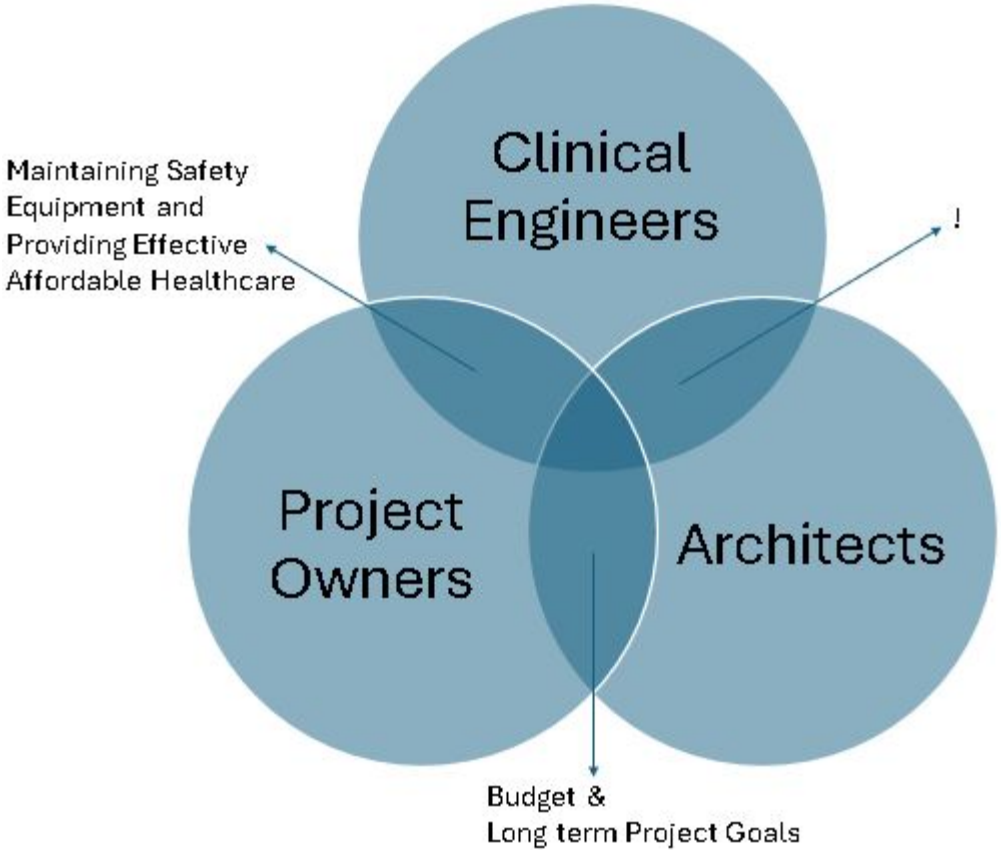


Where do interests align?



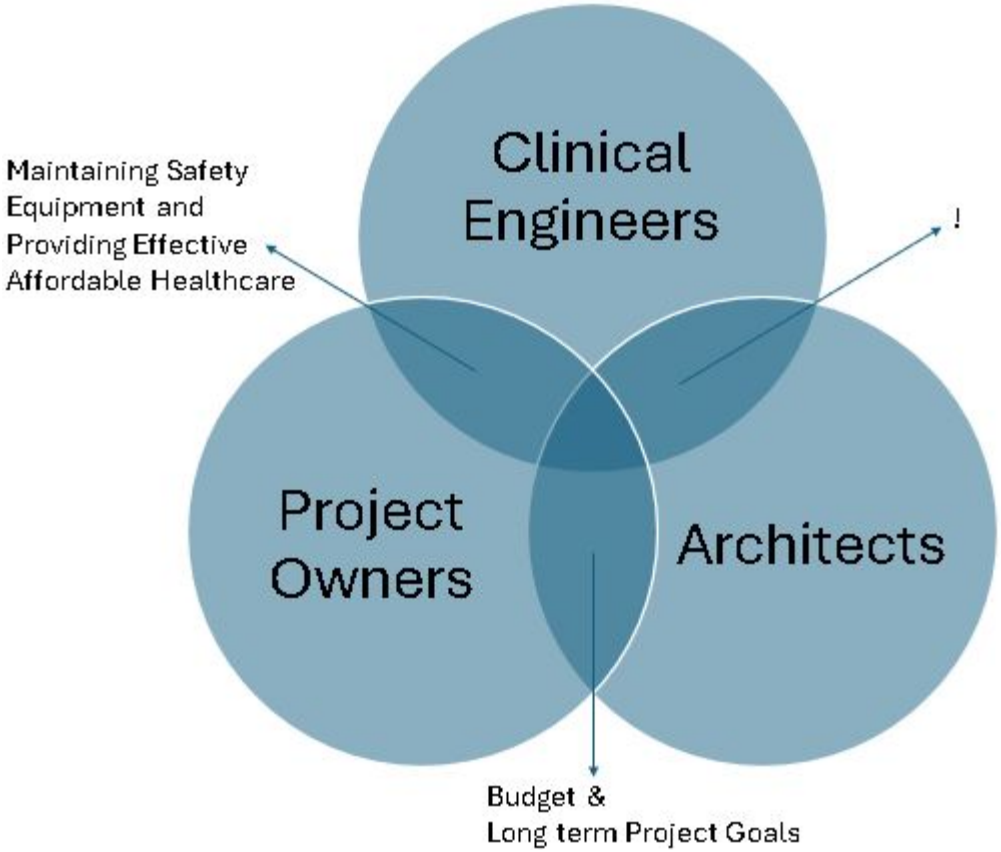
Where do interests align?

- Design Brief
- Narrative
- Schematic Design



Where do interests align?

- Design Brief
  - Technical Details
- Narrative
- Schematic Design



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- Design Brief
  - Technical Details
- Narrative
  - Human Activities
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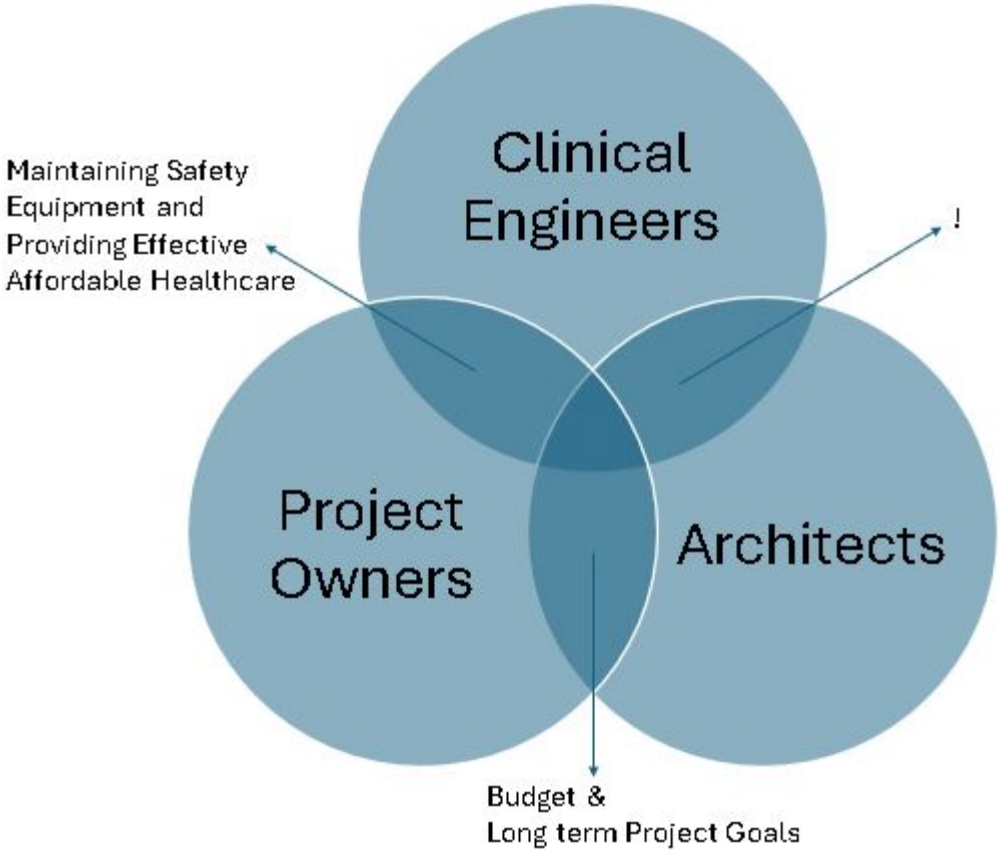
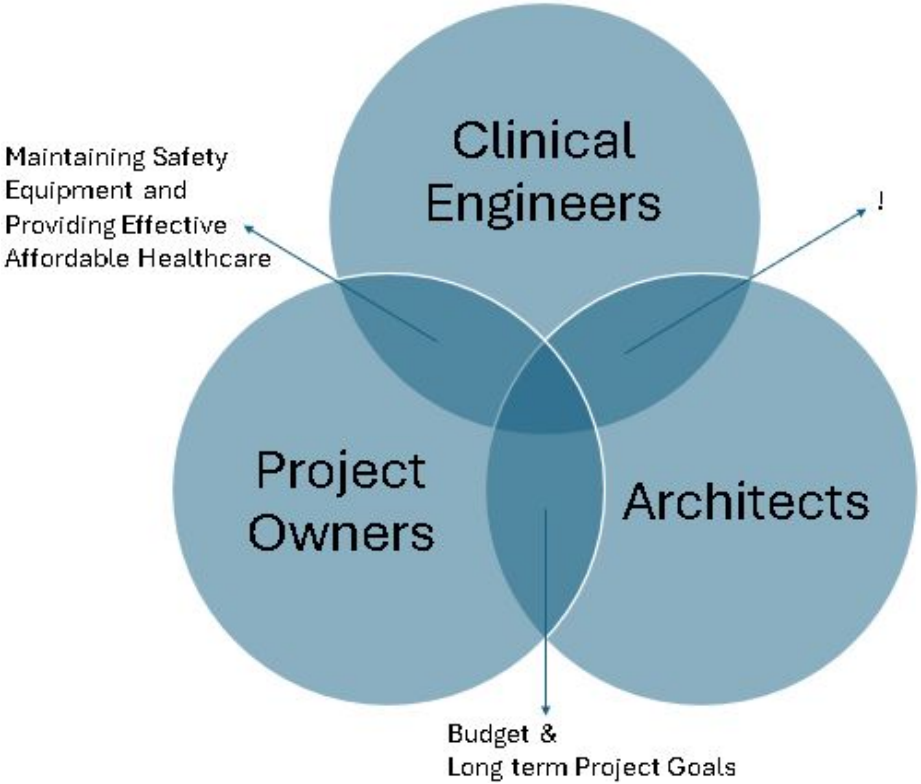


Where do interests align?

- Design Brief
  - Technical Details
- Narrative
  - Human Activities
- Schematic Design
  - Special Considerations not on Government Manuals



Design Brief Compilation: Pain points

1

Processing Time

Getting User Intentions
and
Processing ideas
Takes Time

2

Varied Designs

DOH Guidelines, Foreign Design Guidelines, Missing Guidelines

3

Time to Generate Designs

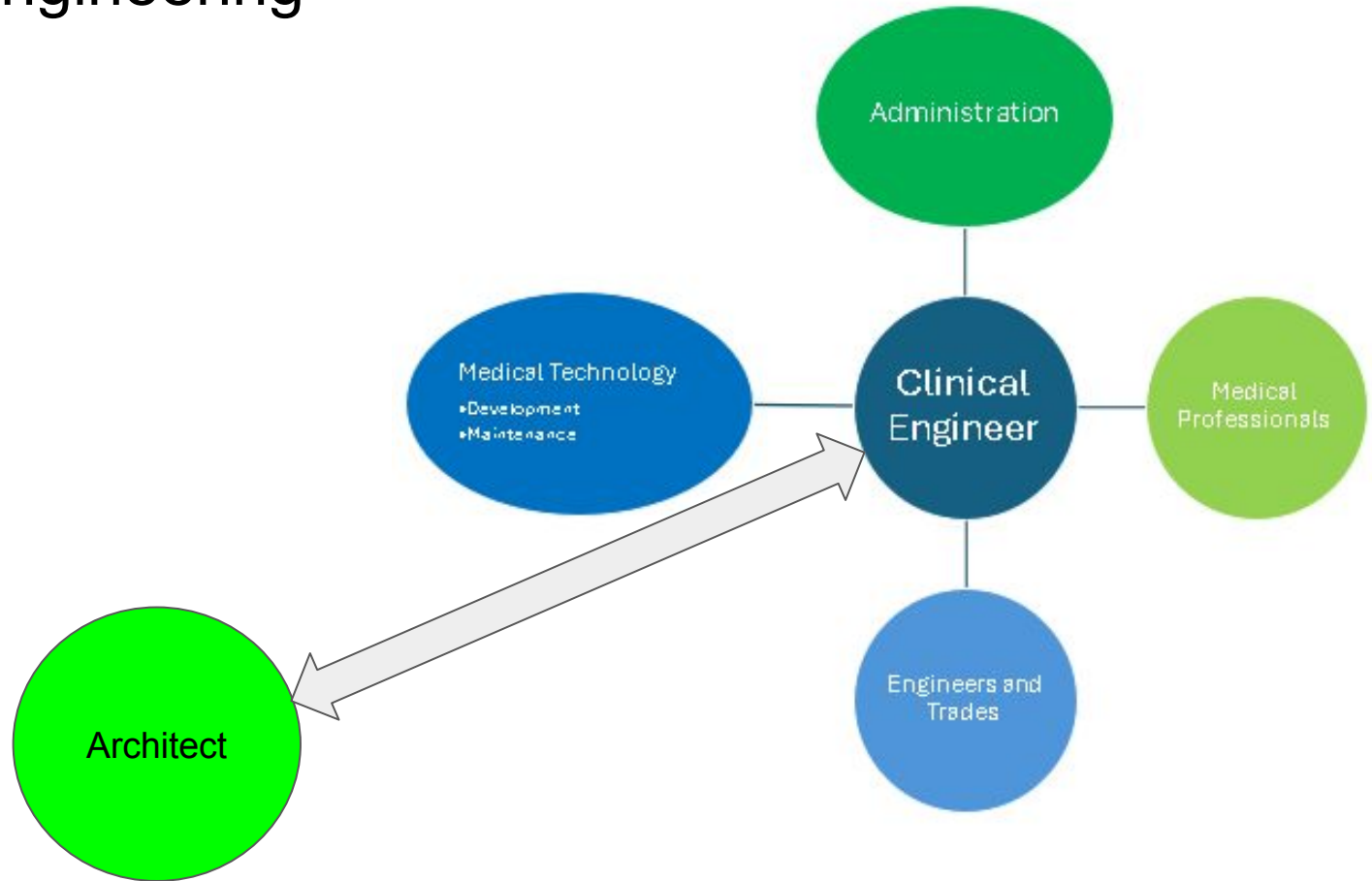
Quickly generating a design still requires around 15-30 days of work for a full sized hospital.

4

Consultations with Users

Presenting Layouts and getting feedback becomes an issue

Clinical Engineering



Starting the Design Brief Inputs

- Setting Details
- WHO Rules on Hospital Design
- DOH Rules on Spaces
- Creating a Logical Concept of how to use the details
- Generating Designs out of these details

Clinical Engineering view point

Generally Speaking Design as an exercise is based on the declaration of what are the:

- Functional Areas
- Maximum Number of Patients Per Area
  - Temperature Conditions
- Equipment per Area
  - Thermal Considerations
  - Surface Requirements

DOH Rules on Hospital Design

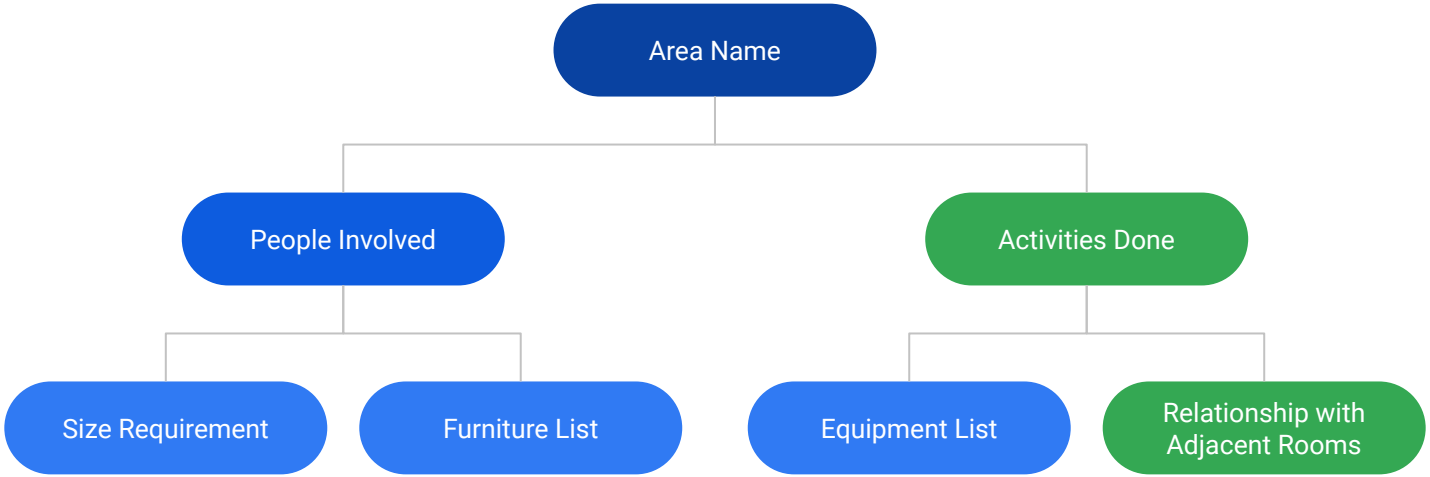
Room A Data Sheet Functional Design Requirements

Room B Data Sheet Technical Design Requirement

Room C Data Sheet Direct Service Requirement

Reference: Manual on Technical Guidelines for Hospitals and Health Facilities Plan

Room A Datasheet: Functional Requirements



Hospital Internal Zoning Fundamental Idea

1. Public Areas
2. Private Areas with Public Access Entry and Exit Points
3. Private Areas with limited Access and Entry/Exit Privileges

Hospital Internal Zoning Fundamental Idea

1. Public Access Areas
    a. Cafeteria
    b. Lobby
    c. Cashier
    d. Security Office
    e. Building Administration
    f. Parking
    g. Breast Feeding Area
    h. HMO Offices
2. Private Areas with Public Access Entry and Exit Points
3. Private Areas with limited Access and Entry/Exit Privileges

Hospital Internal Zoning Fundamental Idea

1. Public Access Areas
2. Private Areas with Public Access Entry and Exit Points
    a. Employees Lounge
    b. Speciality Departments with Outpatient Patrons
        i. Dialysis Center
        ii. Radiology Departments
        iii. Clinical Laboratory Departments
        iv. Physiotherapy Clinics
        v. Eye Centers
        vi. Emergency Medicine Departments
    c. Employee Locker and Dressing Rooms
    d. Maintenance Workshops and Machine Rooms
    e. Medical Records
    f. Doctors Offices
    g. Back Offices for Administration
3. Private Areas with limited Access and Entry/Exit Privileges

Hospital Internal Zoning Fundamental Idea

1. Public Access Areas
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    a. Operating Theatre Complex
    b. Intensive Care Complex
    c. Patient Rooms
    d. Potable Water Treatment Facilities
    e. Wastewater Treatment Facilities
    f. Oxygen Manifolds
    g. Power Generation Facilities

Hospital Internal Zoning Fundamental Idea

1. Public Access Areas
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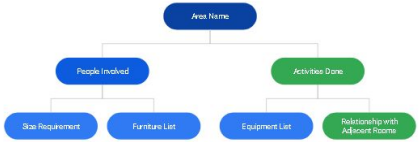
    - Potable Water Treatment Facilities
        i. FDA (DOH) Administrative-Order-No.-2017-0010.pdf
    - Wastewater Treatment Facilities
    - Power Generation Facilities

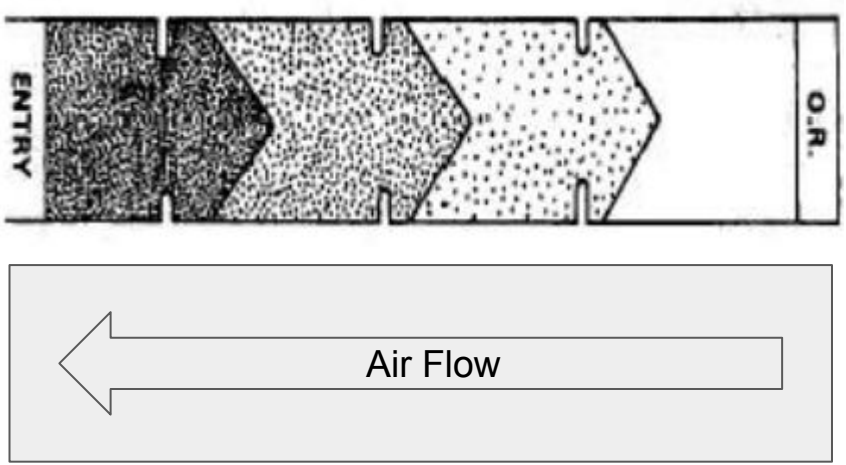
Hospital Internal Zoning DOH Rules



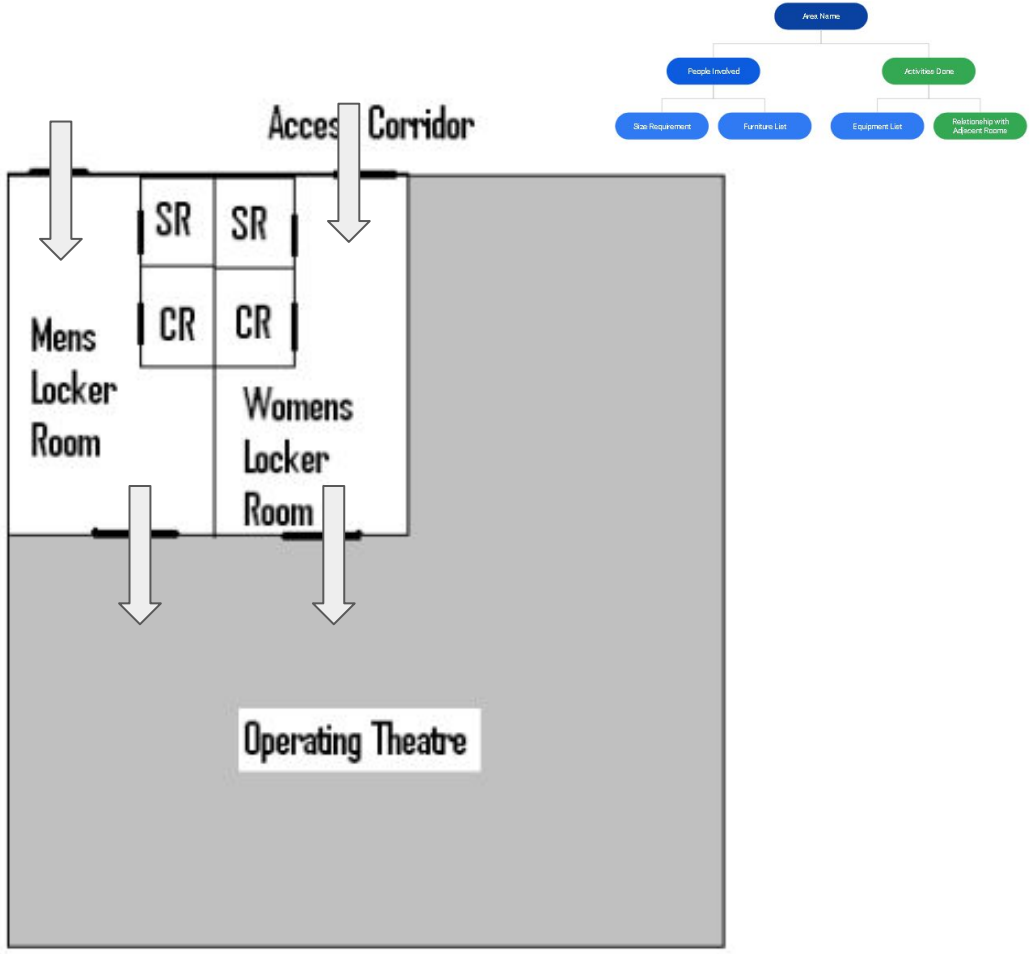
Zones DOH	Departments						Normal Traffic
Outer	ER	OPD	Admin Office	Accounting			Immediately Accessible
Second	Laboratory	Pharmacy	Radiology	Dialysis	Blood Bank		Near Outer Zone
Inner	Nursing Care Areas	Patient Rooms					With Restricted Access to
Deep	ICU	OR	NICU	DR			Away
Service	Motor Pool	Dietary	Housekeeping	Maintenance	Genset	Laundry	Away

Source: Planning and Design Guidelines Hospital page 3

Concepts of Sterility of Areas



Concepts of Sterility



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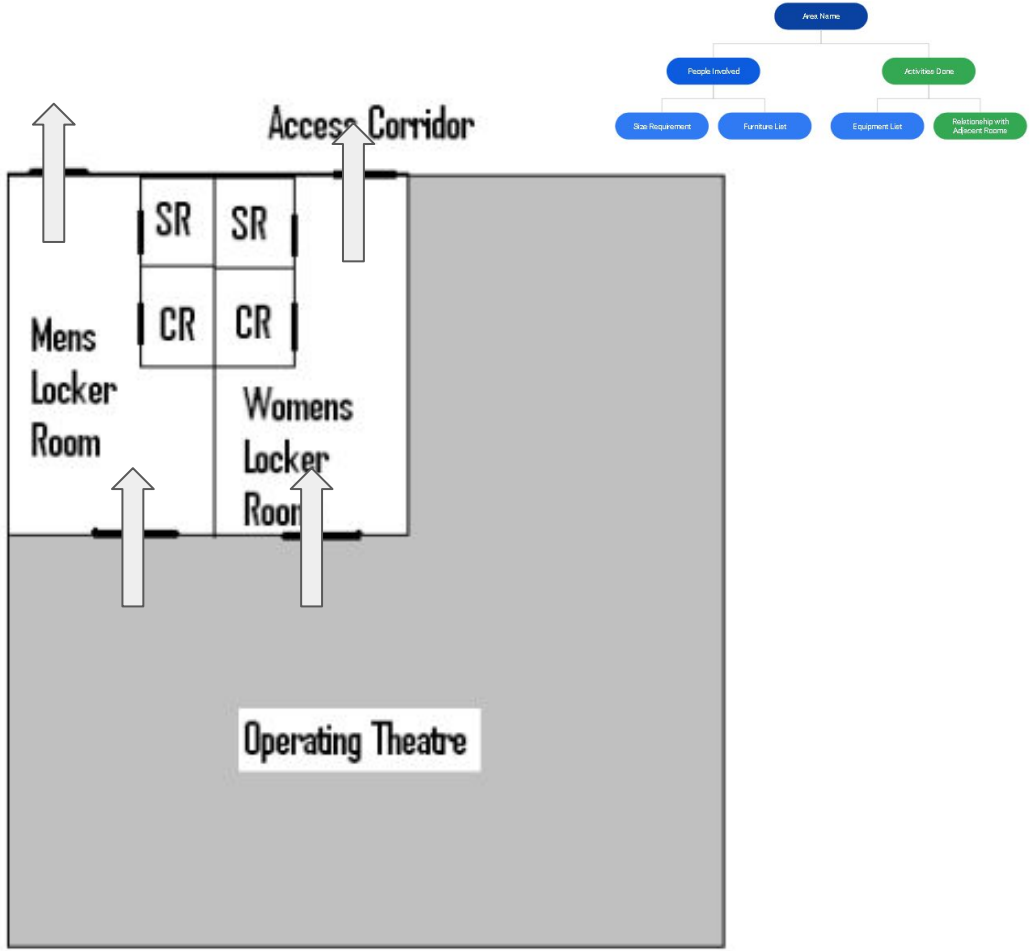

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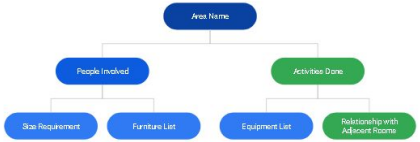

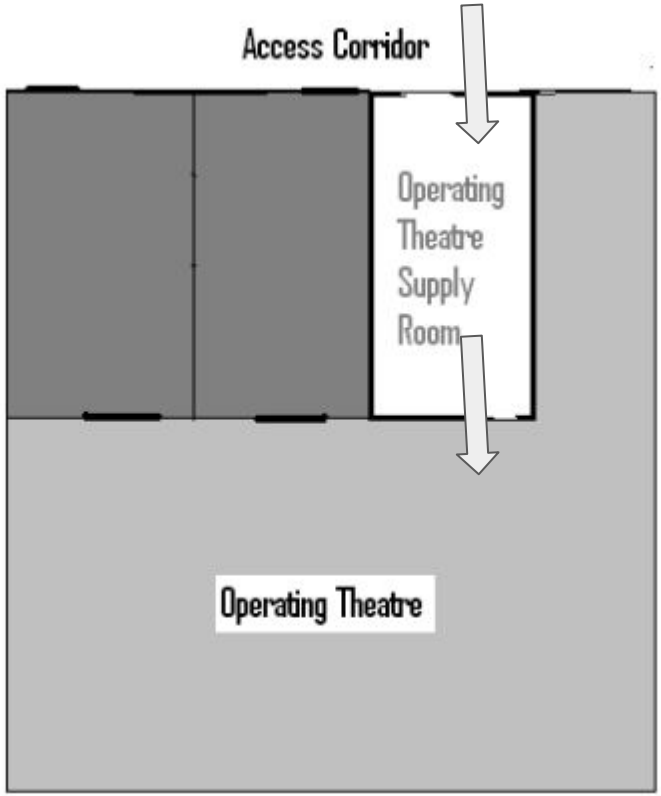

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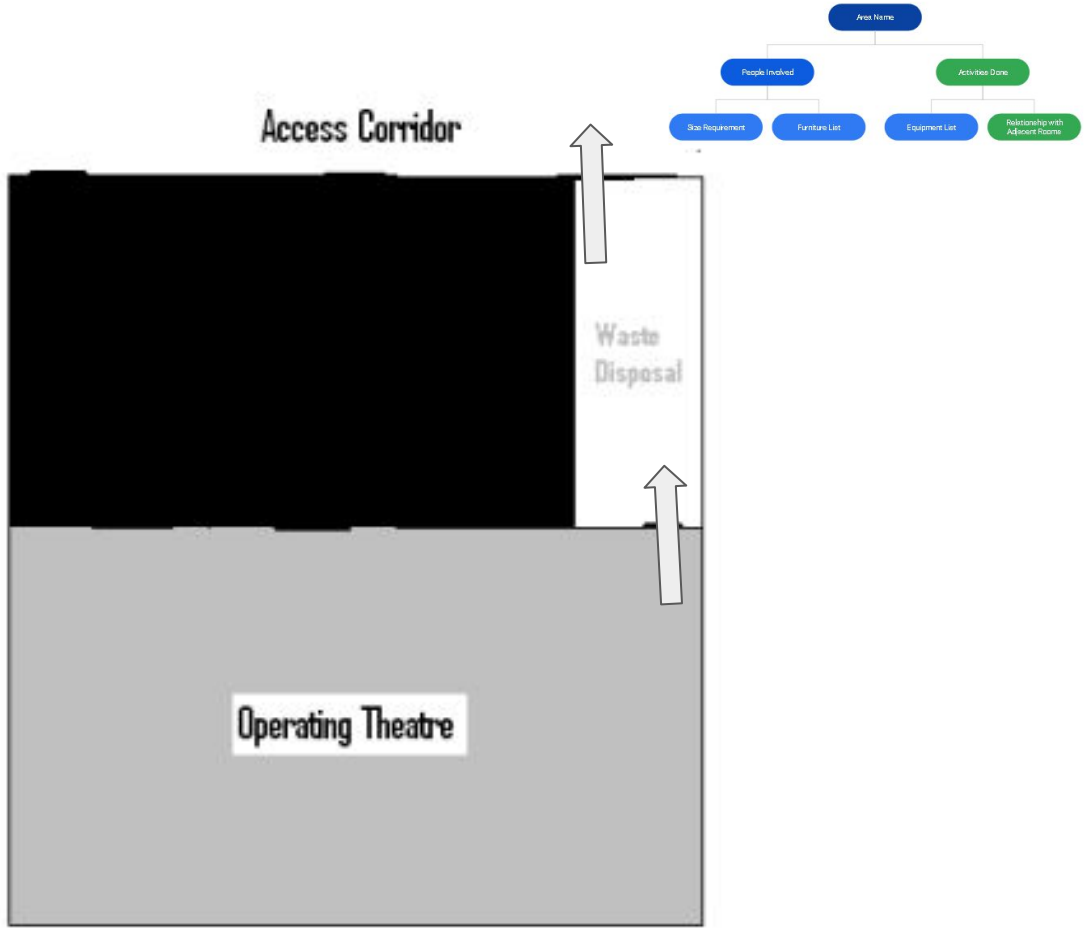

Function of Rooms and Areas related to each other

0	**ER**	• ER has separate entrance and exit - Has a quick means to reach Operating Complex for Major Surgery
0	**Admin, Business Office,Admitting**	• Located near Main Entrance
2nd	**Management Office**	• Can be in more private areas
Deep	**Operating Theatre**	• The surgical service shall be located and arranged to prevent non-related traffic. • The operating room shall be as remote as practicable from the entrance to provide asepsis. The dressing room shall be located to avoid exposure to dirty areas after changing to surgical garments. • The nurse station shall be located to permit visual observation of patient movement

Function of Rooms and Areas related to each other

Deep

Delivery / Birthing Complex

- Shall be located and arranged to prevent non-related traffic.
- Shall be remote as practicable from the entrance to provide asepsis.
- A dressing room shall be located to avoid exposure to dirty areas after changing to surgical garments.
- A nurse station shall be located to permit visual observation of patient movement.
- The nursery shall be separate but immediately accessible from the delivery room.

Inner

Nursing Service

- Shall be segregated from public areas.
- The nurse station shall be located to permit visual observation of patients.
- Nurse stations shall be provided in all inpatient units of the hospital with a ratio of at least one (1) nurse station for every thirty-five (35) beds.
- Rooms and wards shall be sufficient size to allow for work and patient movement.
- Toilets shall be immediately accessible from rooms and wards.

Example of Room Listings Based on Activity listed by Staff PT Department

Area	Purpose
Work Charting Area	Area that holds records and can be used to obtain vital signs for patients prior to exercise sessions
Treatment Rooms	Rooms that hold equipment and fixtures that enable intervention or preparation work
Exercise Areas	General Areas where exercises can be done
Toilet	Area that can be used for staff and patient needs
Physiatrist Office	Area to hold consultations with patients

Analysis for Needs

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What is missing from the list?

- Holding Area for Patients
- Area to Hold Clean Supplies
- Area to Hold Dirty and Spent Supplies
- Breakroom for staff to have a meal

Analysis for Needs

Rm #	Area	Purpose
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9	Break room	Area where staff can eat

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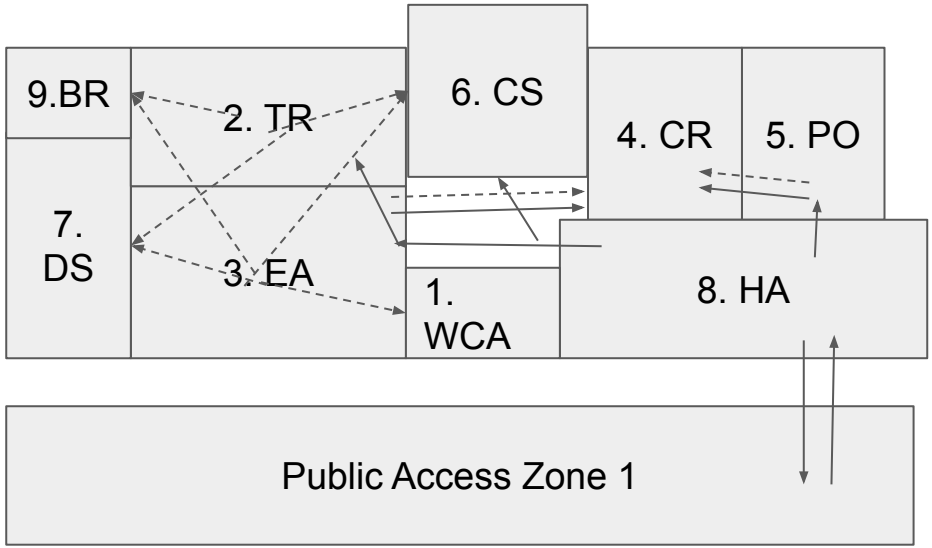

Patient Flow

Staff Flow

Movement of People

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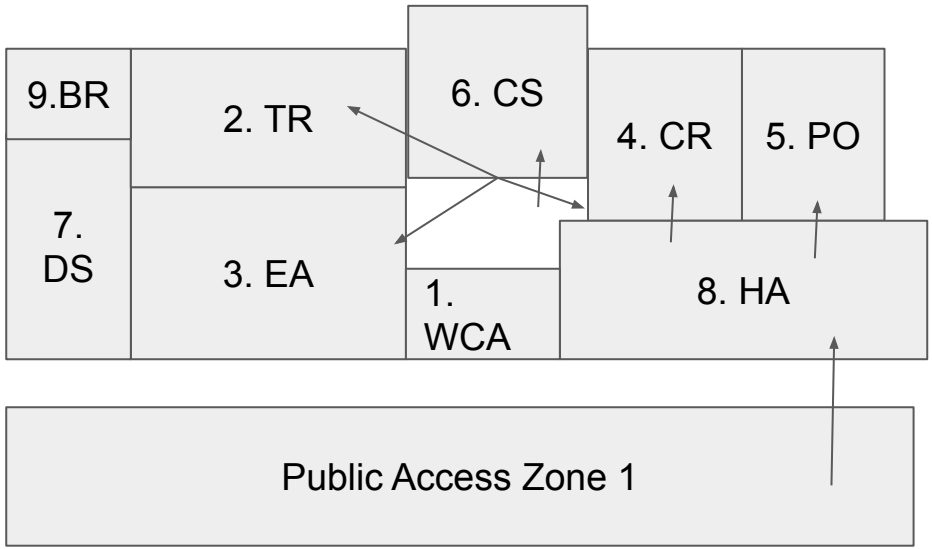

Clean Supplies

Movement of Supplies and Materials

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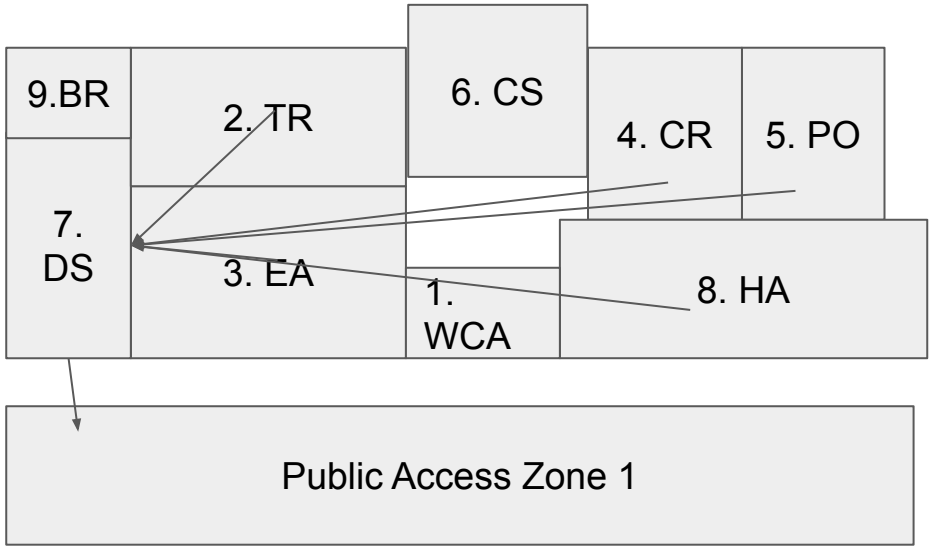

Dirty Supplies & Waste Materials

Movement of Supplies and Materials

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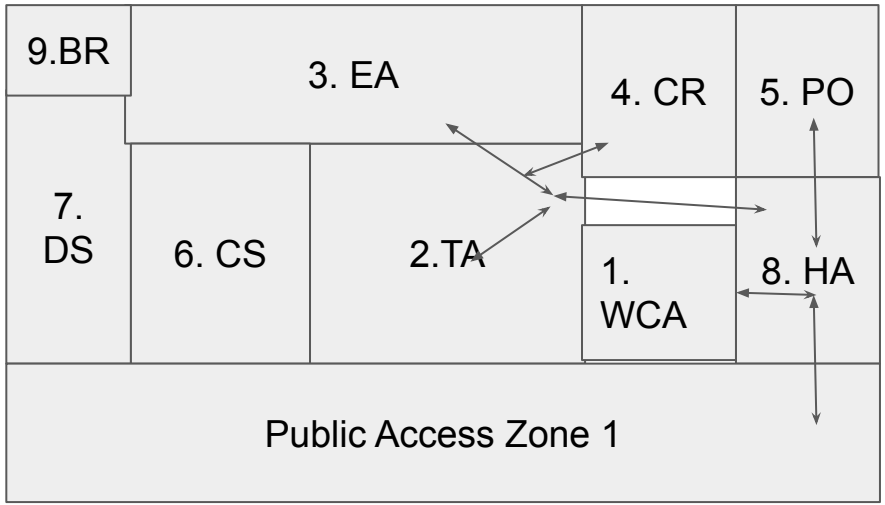

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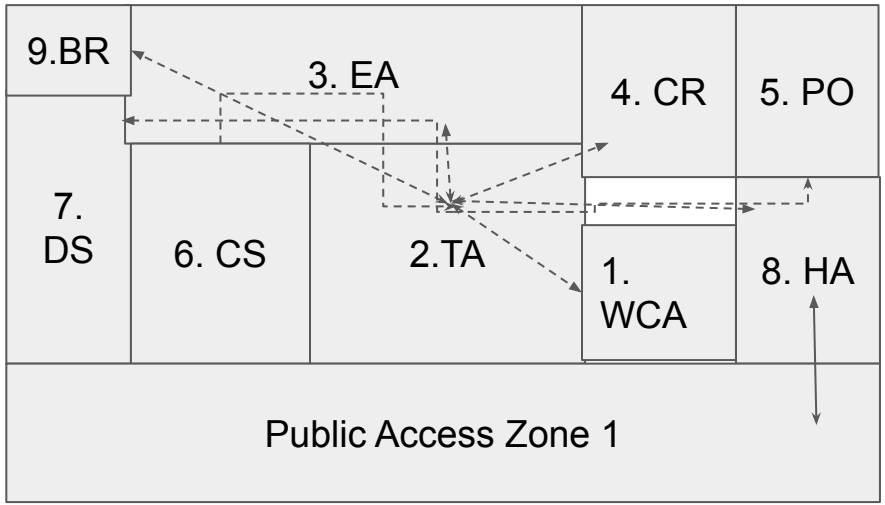

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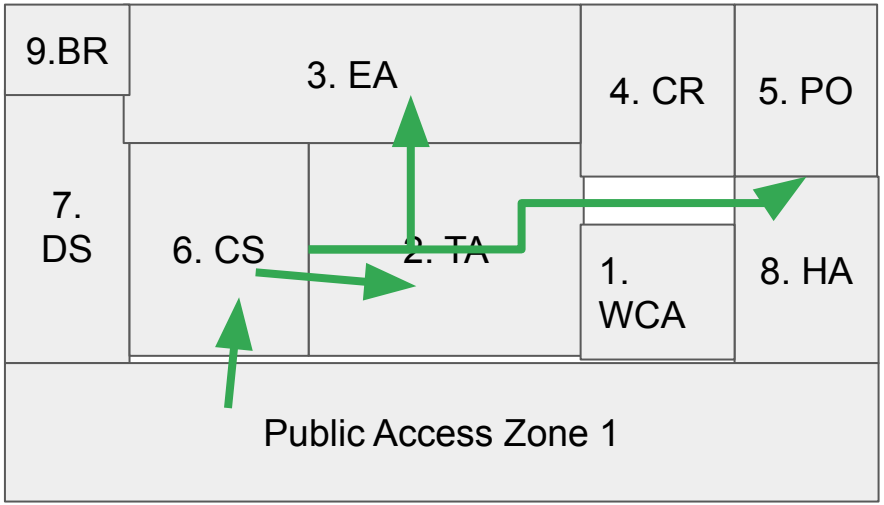

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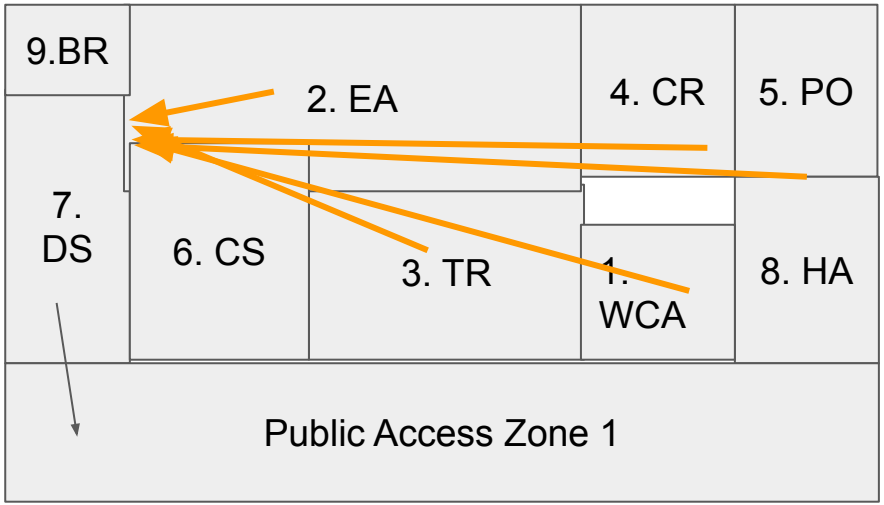
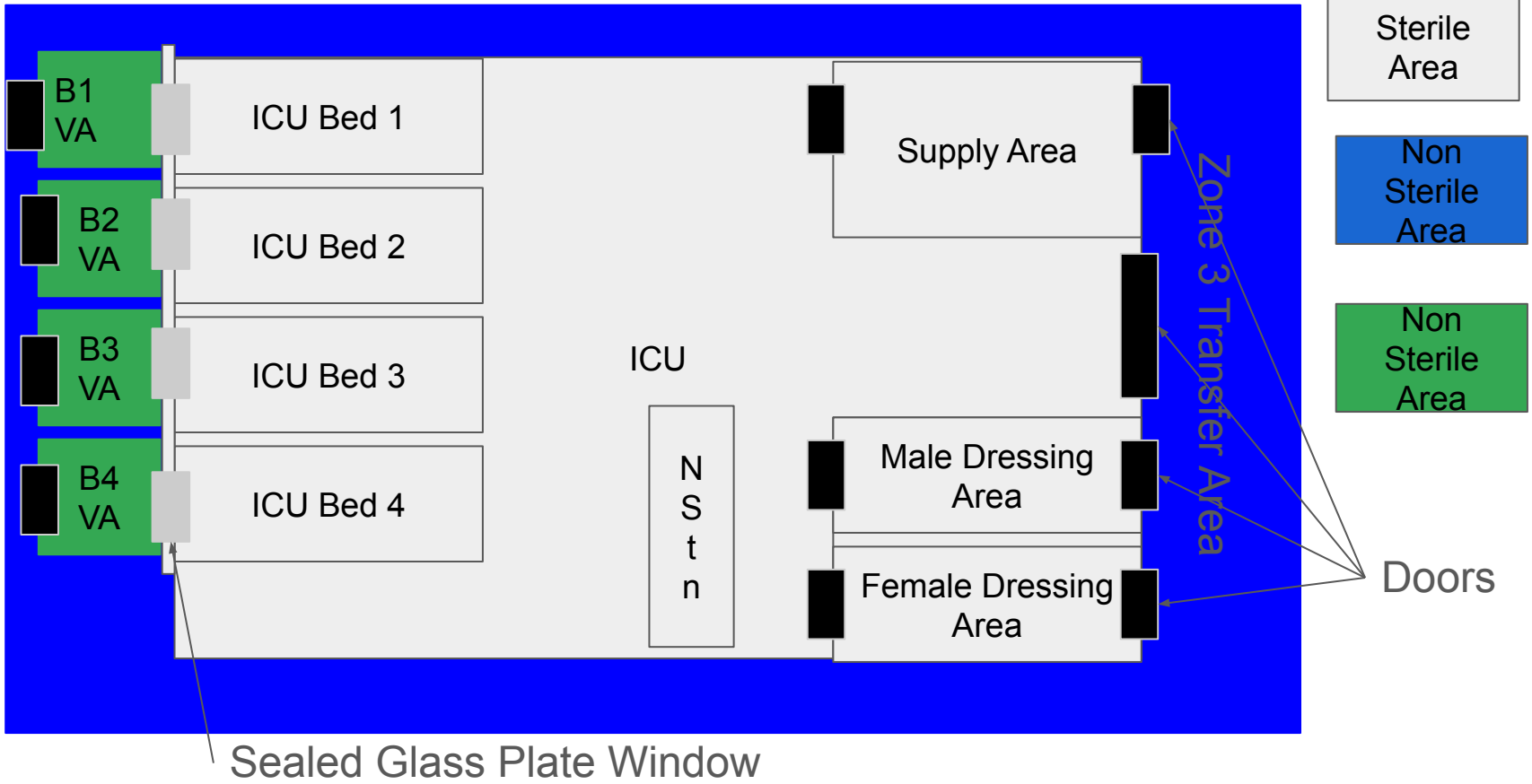


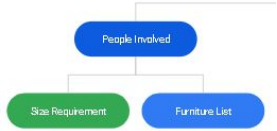
← Dirty Supplies & Waste Materials

Movement of Supplies and Materials

Intensive Care Unit Functional Design Idea



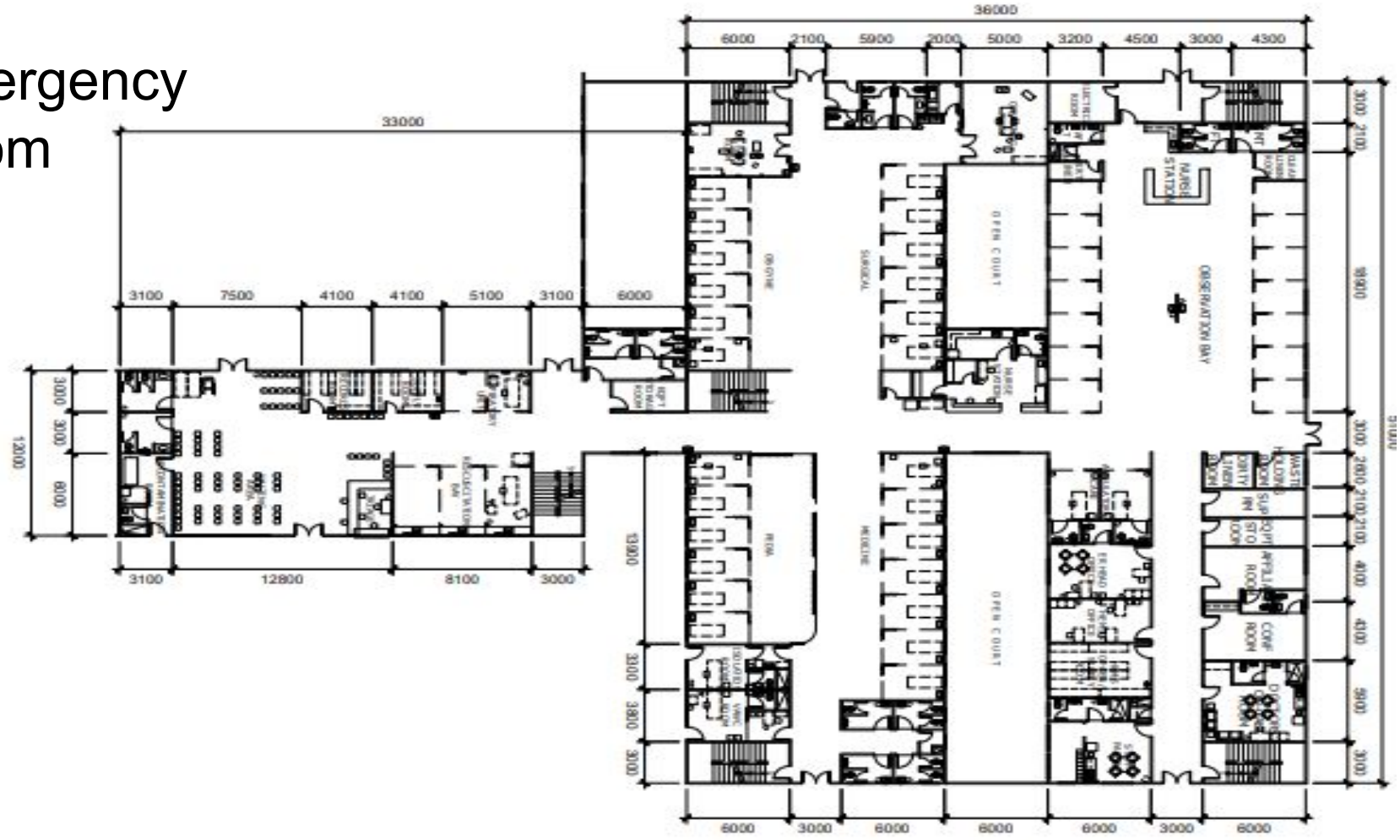
Planning and Design Guidelines Hospital page 4



Space	Area in Square Meters
Administrative Service	
Lobby	
Waiting Area	0.65/person
Information and Receiving Area	5.02/staff
Toilet	1.67
Business Office	5.02/staff
Medical Records	
Work Area	5.02/staff
Storage Area	4.65
Office of the Hospital Administrator	5.02/staff
Office of the Chief of Hospital	5.02/staff
Conference Room	1.40/person

0.806mx0.806m

Emergency Room



Room Sizes as based on occupancy

Emergency	Room Size in square meters	Comparable Space		Comparative Occupancy / Ratio to Rm Type		Comments
Waiting Area & Triage	138	0.65	/person	212.3076923	persons	Within Specification
Decontamination Room	19	4.65	/scrub area	4.086021505	scrub area	Within Specification
Resuscitation Bay	41	33.45	/OR	1.225710015	patient - staff team	Within Specification
Staff Pantry	16	4.65	/Staff in Social Service Area	3.440860215	Dietary Work Areas	Within Specification
Isolation Room	38	33.45	/OR	1.136023916	patient - staff team	Within Specification
VAWC Room	20	33.45	/OR	0.597907324	patient - staff team	Too Small
Treatment Cubicle (Pedia)	23	7.43	/bed	3.095558546	Beds	Within Specification
Treatment Cubicle (Medical)	10	7.43	/bed	1.34589502	Bed	Within Specification
Treatment Cubicle (OB-GYNE)	10	7.43	/bed	1.34589502	Bed	Within Specification
Treatment Cubicle (Surgery)	10	7.43	/bed	1.34589502	Bed	Within Specification
Nursing Station	21	5.02	/station	4.183266932	Stations Equivalent	Within Specification
Delivery Room	24	33.45	/DR	0.717488789	DR	Too Small
Scrub-Up/Sub-Sterile	9	4.65	/scrub area	1.935483871	scrub area	Within Specification
Minor Operating Room	31	33.45	/OR	0.926756353	OR	Too Small
HEM Office and Supply	44	4.65	/area for Storage	9.462365591	Storage Rooms	Within Specification
ER Head Office	28	5.02	/staff in Office of the Chief of Hospital	5.577689243	Staff Members	Within Specification
Doctors On Call Room	36	9.29	/Private room with Toilet	3.875134553	Private Rooms	Within Specification
Ambulatory Care	29	7.43	/bed	3.903095559	Beds	Within Specification
Observation Bay	9	7.43	/bed	1.211305518	Beds	Within Specification
Equipment Storage	9	4.65	/area	1.935483871	Areas	Within Specification
Wheeled Stretcher Area	18	1.08	/stretcher	16.66666667	Stretchers	Within Specification
Janitors Closet	4	3.9	/closet	1.025641026	Closets	Within Specification

Room Sizes as based on occupancy

Emergency	Room Size in square meters	Comparable Space		Comparative Occupancy / Ratio to Rm Type		Comments
Waiting Area & Triage	138	0.65	/person	212.3076923	persons	Within Specification
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Isolation Room	38	33.45	/OR	1.136023916	patient - staff team	Within Specification
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Treatment Cubicle (Pedia)	23	1.08	/stretcher	21.2962963	stretchers	Within Specification
Treatment Cubicle (Medical)	10	1.08	/stretcher	9.259259259	stretchers	Within Specification
Treatment Cubicle (OB-GYNE)	10	1.08	/stretcher	9.259259259	stretchers	Within Specification
Treatment Cubicle (Surgery)	10	1.08	/stretcher	9.259259259	stretchers	Within Specification
Nursing Station	21	5.02	/station	4.183266932	Stations Equivalent	Within Specification
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Doctors On Call Room	36	9.29	/Private room with Toilet	3.875134553	Private Rooms	Within Specification
Ambulatory Care	29	7.43	/bed	3.903095559	Beds	Within Specification
Observation Bay	9	1.08	/bed	8.333333333	Beds	Within Specification
Equipment Storage	9	4.65	/area	1.935483871	Areas	Within Specification
Wheeled Stretcher Area	18	1.08	/stretcher	16.66666667	Stretchers	Within Specification
Janitors Closet	4	3.9	/closet	1.025641026	Closets	Within Specification

DOH Rules on Hospital Design

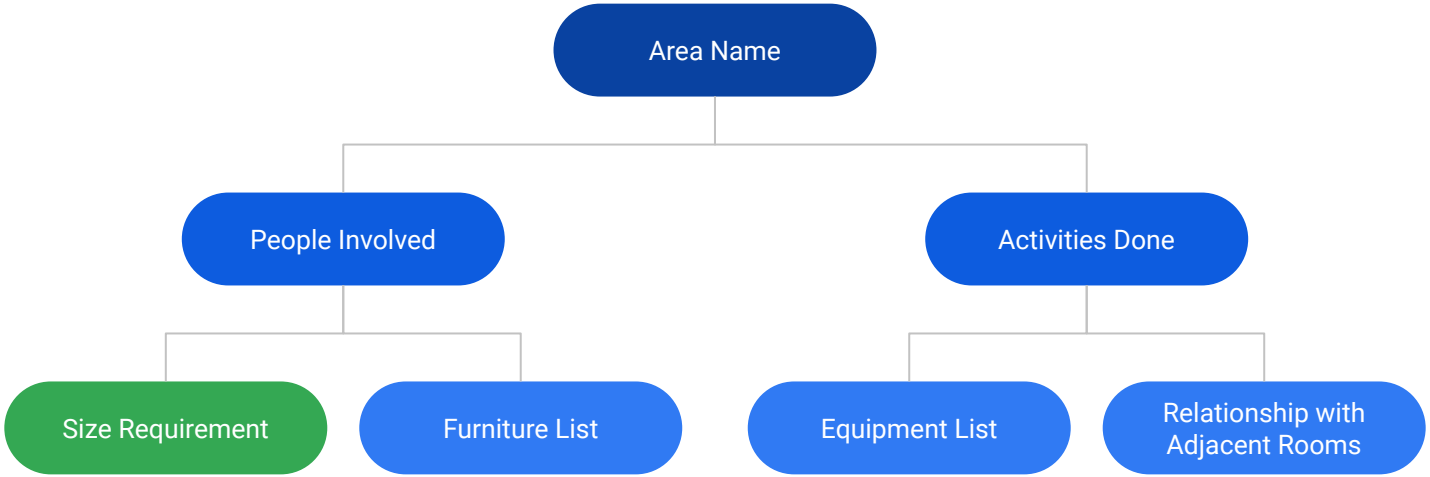
Room A Data Sheet Functional Design Requirements

Room B Data Sheet Technical Design Requirement

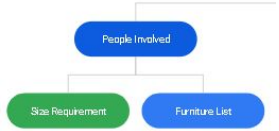
Room C Data Sheet Direct Service Requirement

Reference: Manual on Technical Guidelines for Hospitals and Health Facilities Plan

Room B Datasheet: Technical Requirements

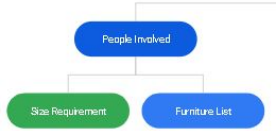


Planning and Design Guidelines Hospital Page 5



Space	Area in Square Meters
Staff Toilet	1.67
Housekeeping Area	5.02/staff
Laundry and Linen Area	5.02/staff
Maintenance Area	5.02/staff
Garage Area	9.29
Supply Room	5.02/staff
Waste Holding Room	4.65
Pharmacy	15.00
Dietary	
Dietitian Area	5.02/staff
Supply Receiving Area	4.65
Cold and Dry Storage Area	4.65
Food Preparation Area	4.65
Cooking and Baking Area	4.65
Serving and Food Assembly Area	4.65
Washing Area	4.65
Garbage Disposal Area	1.67
Dining Room	1.40/person
Staff Locker Room and Toilet	2.32
Social Service Area	5.02/staff
Cadaver Holding Room	7.43/bed
Clinical Service	
Emergency Room	
Waiting Area	0.65/person
Toilet	1.67
Nurse Station	5.02/staff
Examination and Treatment Area with Lavatory/Sink	7.43/bed
Observation Area	7.43/bed
Equipment and Supply Storage Area	4.65
Wheeled Stretcher Area	1.08/stretcher
Outpatient Department	
Waiting Area	0.65/person
Toilet	1.67
Admitting and Records Area	5.02/staff
Consultation Area	5.02/staff
Examination and Treatment Area with Lavatory/Sink	7.43/bed
Dental Clinic	8.36/dental chair
Surgical and Obstetrical Service	
Major Operating Room	33.45
Recovery Room	9.29
Delivery Room	33.45
Labor Room and Toilet	9.29
Sub-sterilizing Room	4.65
Sterile Instrument, Supply and Storage Area	4.65
Anesthesia Storage Area	4.65
Scrub-up Area	4.65
Clean-up Area	4.65
Male Dressing Room and Toilet	2.32
Female Dressing Room and Toilet	2.32
Nurse Station	5.02/staff

Planning and Design Guidelines Hospital Page 6



Space	Area in Square Meters
Wheeled Stretcher Area	1.08/stretcher
Janitor's Closet	3.90
Nursery	
Pathologic Room	3.72/bassinet
Premature Room	3.72/bassinet
Work Area with Sink	4.65
Viewing Area	3.90
Breastfeeding Area	3.72/bassinet
Nursing Unit	
Private Room with Toilet	9.29
Semi-Private Room with Toilet	7.43/bed
Female Ward with Toilet	7.43/bed
Male Ward with Toilet	7.43/bed
Isolation Room with Toilet	9.29
Nurse Station with Work Area and Lavatory/Sink	5.02/staff
Treatment Room with Lavatory/Sink	7.43/bed
Central Sterilizing and Supply Room	
Receiving and Releasing Area	5.02/staff
Work Area	5.02/staff
Sterilizing Room	4.65
Sterile Supply Storage Area	4.65
Nursing Service	
Office of the Chief Nurse	5.02/staff
Staff Locker Room and Toilet	2.32
Ancillary Service	
Laboratory	
Toilet	1.67
Clinical Work Area with Sink	10.00
Pathologist Area	5.02/staff
Radiology	
Waiting Area	0.65/person
Dressing Area	1.67
Toilet	1.67
X-Ray Room not equipped with table (2.5m x 3m)	7.5
X-Ray Room with stationary patient table (3.5m x 4.0m)	14.0
X-ray Room equipped with tilting patient table (4.5m x 4.5m)	20.25
Dark Room	4.65
Film File and Storage Area	4.65
Radiologist Area	5.02/staff
Pharmacy	15.00

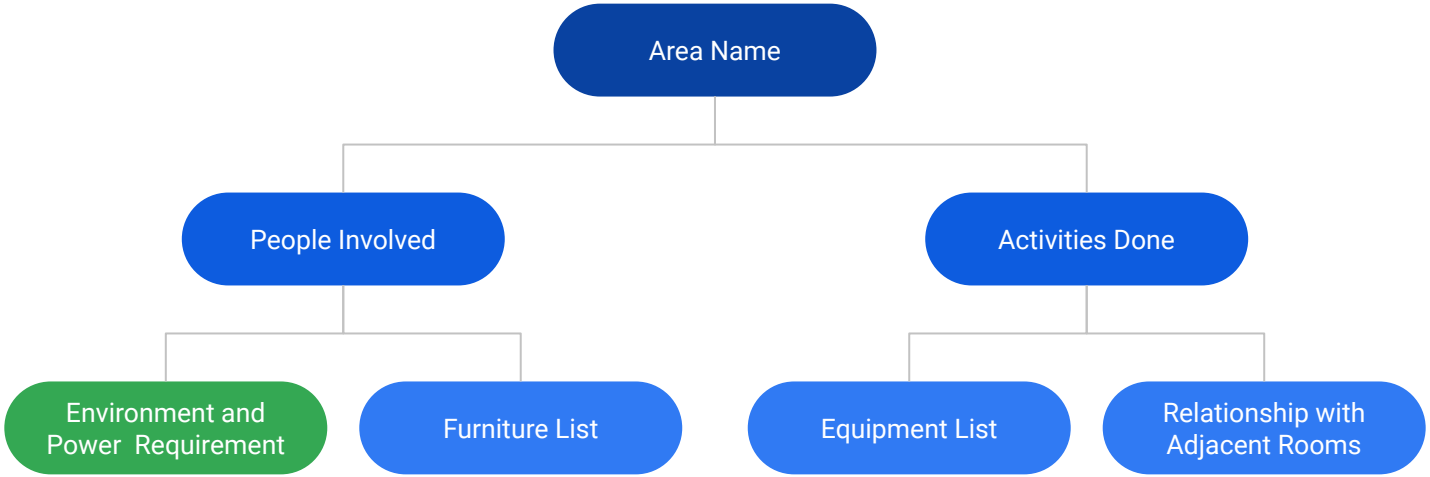
Circulation Space

Circulation Space is space allotted to make it easier for people to move around.

The DOH Standard doesn't have this in place but the recommendation from the Veterans Hospital System in the US is around 20% of the total needed amount is added for Circulation Space.

No. of Physicians:	1	2	3
Business Office	12 x 14 = 168	16 x 18 = 288	16 x 20 = 320
Office Manager	10 x 12 = 120	10 x 12 = 120	10 x 12 = 120
Waiting Room	14 x 16 = 224	14 x 20 = 280	14 x 20 = 280
Toilets	2@ 7 x 8 = 112	3@ 7 x 8 = 168	3@ 7 x 8 = 168
Staff Lounge	10 x 12 = 120	10 x 12 = 120	12 x 12 = 144
Storage	6 x 8 = 48	6 x 8 = 48	8 x 8 = 64
Consultation Room	12 x 12 = 144	2@ 12 x 12 = 288	3@ 12 x 12 = 432
Exam Rooms[a]	2@ 8 x 12 = 192	4@ 8 x 12 = 384	6@ 8 x 12 = 576
Nurse Station	8 x 10 = 80	10 x 10 = 100	2@ 8 x 10 = 160
Cysto/Exam (no X-Ray)	—	12 x 12 = 144	2@ 12 x 12 = 288
Cysto (with X-Ray)[b]	12 x 24 = 288	12 x 24 = 288	12 x 24 = 288
Dressing Rooms	2@ 12 SF = 24	2@ 12 SF = 24	4@ 12 SF = 48
Recovery	6 x 8 = 48	8 x 8 = 64	8 x 8 = 64
Laboratory	8 x 10 = 80	10 x 10 = 100	10 x 10 = 100
Subtotal	1648 ft²	2416 ft_2	3052 ft²
20% Circulation	330	483	610
Total	1978 ft²	2899 ft²	3662 ft²

Room B Datasheet: Technical Requirements



Air Temperature Per Area

DOH Planning Guide for 100 Bed Hospital

Cold - below 10 Celsius
Cool - 10 -15 Celsius
Temperate - 15 - 27 Celsius
Hot - 27 -38 Celsius
Very Hot - above 38 Celsius

DOH Materials Provide no absolute measure of normal temperature that should be maintained in common areas

WHO Design for Western Hospitals suggest 21 degrees Celsius for common areas regardless of outside conditions should be maintained by the ACU

Machines in Specialty Procedure area’s typically will determine the working temperatures for those area’s hence consult your Clinical Technology Officers & Equipment Manufacturers on this item.

Sound Specification Per Area

Type of Space	Acoustical Requirements	Acceptable Equivalent Noise Level Range (db)
- intensive care areas, recovery areas	- quiet surrounding must be maintained - for listening to faint musical sound	20-30
- large meeting and conference rooms, executive offices and conference rooms for 50 people	- for good listening	35-40
- bedrooms, sleeping quarters	- for sleeping, resting and relaxing	35-45
- private and semi-private offices, small conference rooms, classrooms, libraries	- for good listening conditions	40-45
- lounging areas and similar spaces	- for conversing or listening to radio and TV	45-55
- large office, reception areas, waiting areas, dining areas, cafeterias	- for moderately good listening conditions	45-60
- lobbies, laboratory work spaces, general secretarial areas	- for fair listening conditions	50-55
- light maintenance shops, office and computer equipment rooms, kitchens and laundry areas	- for moderately fair listening conditions	55-70

Mechanical Ventilation

DOH States in their manual that some areas may require air ventilation this is based on

- Volume Cubic meter / hr-person
- Air Velocity m/hr

Veterans Affairs Hospital Design guidelines use a different air ventilation metric

- Air Changes / hour
- Liter / sec

Mechanical Ventilation

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- Air Velocity m/hr

DOH Manual has not specification on Ventilation Requirements

Veterans Affairs Hospital Design guidelines use a different air ventilation metric

- Air Changes / hour
- Liter / sec

Areas	Desired Value	
Lockers / Dressing Rooms	34	Air L/sec
Recovery Rooms	12.75	cubic metre / hour
	6	Air Changes / hour
Sterile Areas	12	Air Changes / hour
Common Areas	12.75	cubic metre / hour

Lighting

Divided into two areas of concern

- Navigation Lights
  - Normal Lighting Fixtures for corridors
  - Emergency Lighting Fixtures for Rooms and Corridors
- Task Lights - OSHA Guidelines state this as 500 Lux for reading, writing and delicate work
- Colour Rendering

Lighting

Divided into two areas of concern

- Navigation Lights
  - Daylight
  - Normal Lighting Fixtures for corridors
  - Emergency Lighting Fixtures for Rooms and Corridors
- Task Lights -
  - OSHA Guidelines state this as 500 Lux for reading, writing and delicate work
- Colour Rendering - White Lights are preferred
- Black Out -
  - Specific to areas where substances or processes are light sensitive.
  - No longer too much needed in hospitals due to advent of digital X-ray acquisition technology)

DOH Rules on Hospital Design

Room A Data Sheet Functional Design Requirements

Room B Data Sheet Technical Design Requirement

Room C Data Sheet Direct Service Requirement

Reference: Manual on Technical Guidelines for Hospitals and Health Facilities Plan

Direct Services in Room for Hospitals

1. Electricity
2. Waste Disposal
3. Cold Water
4. Hot Water
5. Gases
    a. LPG
    b. Oxygen
    c. Compressed Air
    d. Nitrogen
    e. Carbon Dioxide

Direct Services in Rooms: Interactions and Materials Selection

1. Loads that are passed thru an area / corridor or sustained load in a room
2. Chemical Compounds / Energy Sources used in an area - determines what type of surface/Structure to use for a specific room
3. Spillage - Type and Temperature of Liquid.
4. Abrasion
    a. Amount of Foot Traffic
    b. Wheel Traffic
5. Impact Considerations when loads and people hit walls or doors
6. Sizes of Equipment being brought in - Door Sizes Beyond Normal
7. Maintenance Consideration

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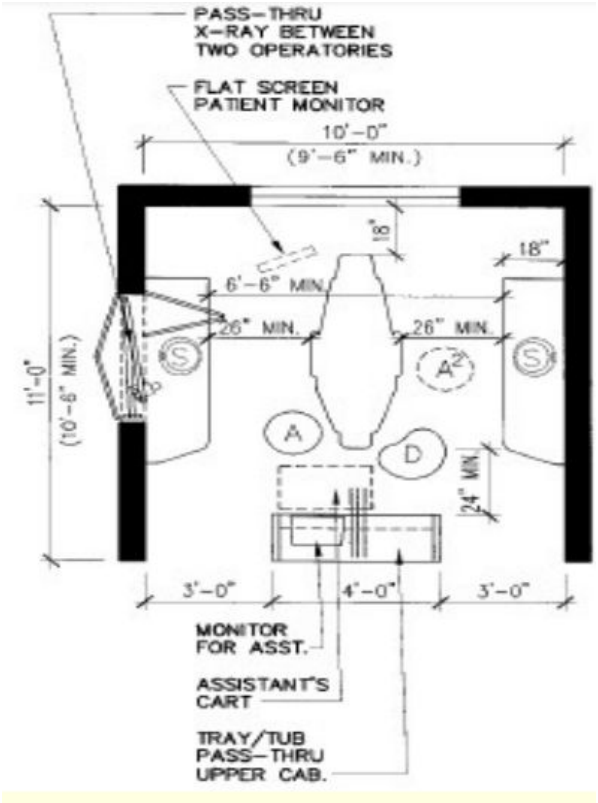
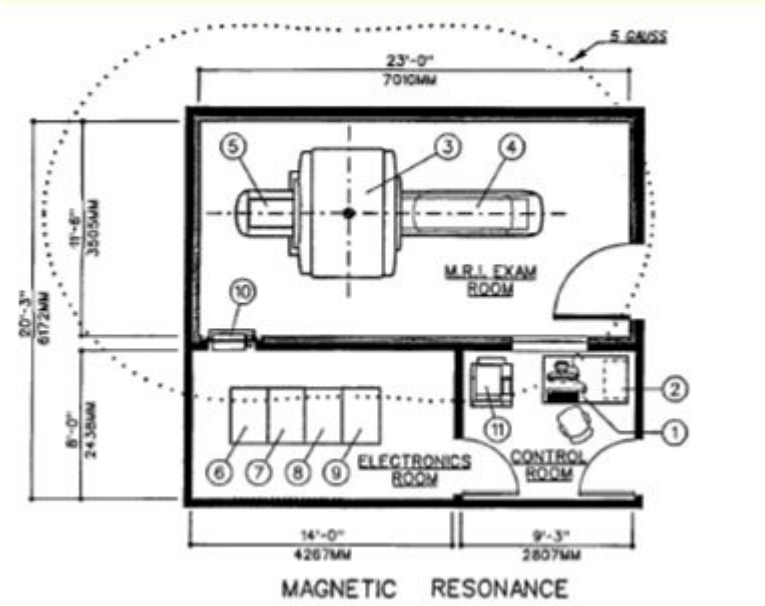


Direct Services in Rooms: Interactions and Materials Selection



1. **Loads that are passed thru an area / corridor or sustained load in a room**
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Conclusions

It's a possible great benefit if an architect can work with a clinical engineer for an assigned project to help with the design brief and schematic design. But the irreplaceable skill to abide by the space requirement and meet the real world considerations on real estate is the problem is where Architects can do best with and together with Clinical Technology Officers, Engineers and Medical Professionals to make the working spaces more effective and efficient form a human point of view.