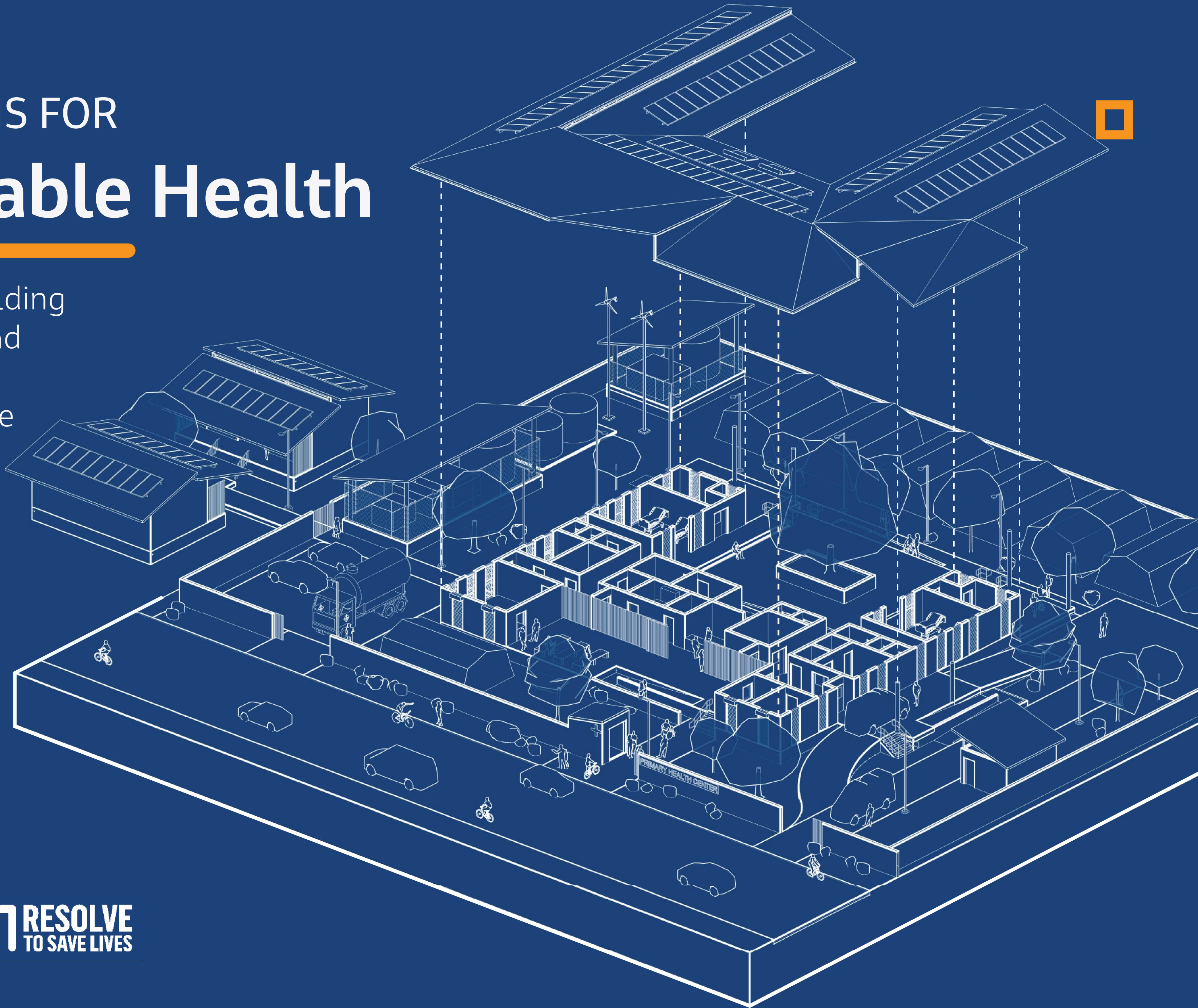
FOUNDATIONS FOR

# Sustainable Health

A blueprint for building epidemic-ready and climate-resilient primary health care infrastructure




Jacobs

RESOLVE TO SAVE LIVES

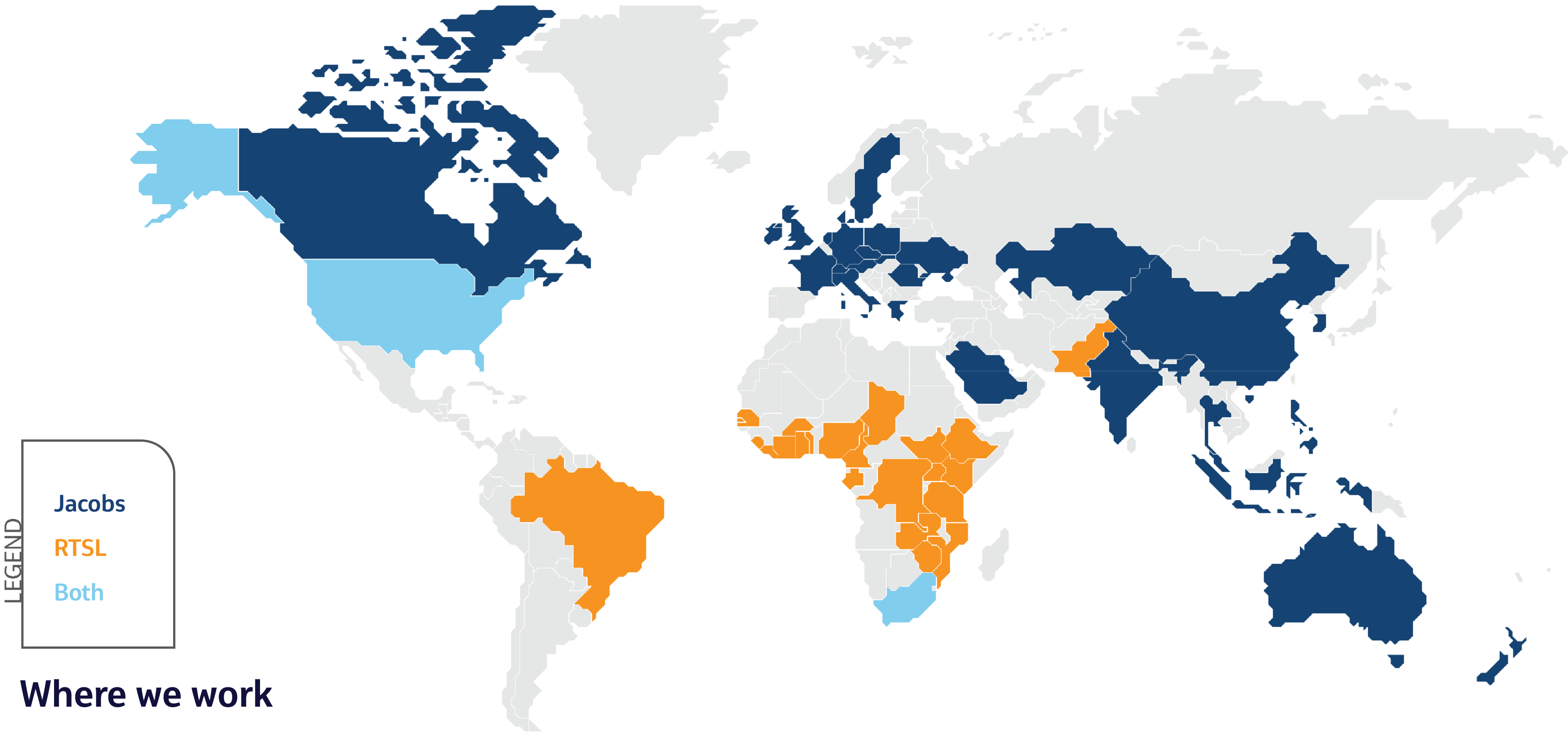
## WHO WE ARE

### Jacobs

provides services in advisory and consulting, feasibility, planning, and design, program and life-cycle management. Jacobs is at the forefront of integrating climate resilience into health infrastructure thereby safeguarding communities and enhancing public health outcomes globally.

### Resolve to Save Lives (RTSL)

is a global health organization that partners locally and globally to create and scale solutions to the world's deadliest health threats. We forge strong partnerships with governments to scale up their technical expertise, develop operational excellence, and build political will to strengthen health security systems.




**Where we work**

## Contents



# Welcome

Sustainable primary health care (PHC) infrastructure is essential for tackling the dual challenges of epidemics and climate change. This blueprint outlines actionable solutions that span the construction life cycle, and practical strategies for effective implementation at scale.

Our partnership combines Jacobs' expertise in climate-resilient health infrastructure with RTSL's knowledge in epidemic preparedness, creating a comprehensive approach to building resilient PHC infrastructure which can withstand both climate and epidemic impacts and promote sustainability.

Together we are laying the foundation for resilient PHC infrastructure that is designed to withstand climate and epidemic impacts through an all-hazard approach, promoting sustainability and ensuring the safety of communities.

## EMERGENCY-READY PHC CORE FUNCTIONS
## Ensure facilities have the infrastructure to perform

### SPEED

Rapidly detect and respond to health threats.

### SAFETY

Manage emergencies safely, protecting staff, patients, and communities.

### SURGE

Handle increased patient volume and maintain essential services.

# EXECUTIVE SUMMARY

**Primary health care (PHC) is essential for delivering equitable, accessible, and continuous health services—particularly in times of crisis. Robust infrastructure systems are foundational to enabling PHC and ensuring health systems can function effectively during health emergencies. Yet, these same infrastructure systems are increasingly vulnerable to climate shocks, and the health care sector contributes to accelerating climate change, making up 4.4% of total global emissions.**[1]

Health facilities generate environmental waste and pollution, including greenhouse gases and other harmful substances that may be infectious or toxic, posing risks to healthcare workers (HCW) and communities. Although most emissions generated in the health care sector (~70%) are attributed to supply chain goods and services, there has been increasing focus on carbon hotspots in secondary and tertiary facilities.[2]

Accordingly, initiatives to reduce the health care carbon footprint are mainly focused on hospitals and larger health facilities in high-income countries that contribute the largest share of emissions and do not consider PHC facilities in resource-constrained settings. The sheer number of PHC facilities (>2M globally) underscores the need to prioritize PHC systems for targeted improvements to lower emissions. PHC systems in resource-constrained settings offer a unique opportunity for climate-smart innovation with smaller footprints and locally appropriate designs, that need to be supported and scaled. [3]

As climate change is increasing the frequency and intensity of climate-related shocks, there has been growing attention on climate adaptation and mitigation to reduce damage to critical health infrastructure.

The World Health Organization (WHO) recently published a comprehensive overview of resources for HCW safety, health facility resilience, and sustainability, and while there are numerous resources on climate-resilient[4] and environmentally sustainable health care facilities, and separately on PHC and infection prevention and control (IPC), the guidance is siloed and divergent. Thus, there is an urgent need for integrated solutions to address these overlapping and competing priorities at the PHC level.

To address this challenge, Jacobs and RTSL are partnering in a new public-private partnership to develop a model for epidemic-ready, climate-resilient, and sustainable PHC infrastructure.

Building on RTSL's expertise in PHC and IPC, and Jacobs' expertise in climate-resilient tertiary care construction and engineering, we are focused on collating evidence-based recommendations and practical actions that will lay the foundation for climate-epidemic health, to develop a model for climate epidemic-ready PHC infrastructure.

**Everyone has a role to play in building forward better. We urge national governments to embed resilience into health and infrastructure planning. We call on donors to support integrated, scalable investments and help countries learn from what works. And we encourage facility leaders and communities to codesign and implement local solutions. Only through integrated action can we build PHC systems that are prepared, equitable, and truly resilient.**

# UNDERSTANDING THE CHALLENGE
## Primary health care infrastructure

PHC operates at the intersection of community health, epidemic prevention, and climate resilience. PHC facilities are crucial frontlines for outbreak detection and response. However, many PHC systems face significant infrastructure challenges that hinder their effectiveness.

While there is recognition of the important role of PHC systems in preparedness, many lack the necessary infrastructure for epidemic readiness and climate resilience. In many resource-constrained settings, there are not enough PHC facilities, there are challenges with geographic distribution of facilities, and PHC systems do not have the required infrastructure to deliver a comprehensive package needed to achieve universal health coverage.

There has been a focus on climate resilience at the tertiary level, yet, the number of PHC facilities (>2 million globally) underscores the importance of investing in climate resilience at the PHC level.

## PHC IN FRAGILE[4] CONTEXTS

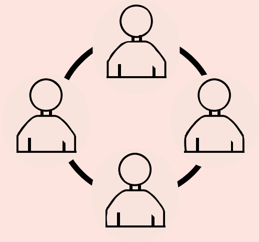
More than
**33%**
of PHC facilities do not have running water[5]

An estimated
**12-15%**
of health facilities do not have electricity[6]

Less than
**20%**
of PHC facilities have basic sanitation services[7]

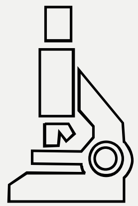
These deficiencies highlight the urgent need for investment in resilient PHC infrastructure to ensure effective health service delivery.

## Supporting the delivery of essential, emergency-ready capacities



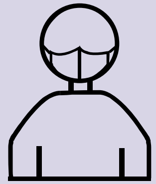
### CONNECT

Healthcare workers connect to local communities, integrating risk communication and community engagement, and strengthening community capacities for emergency prevention and response.



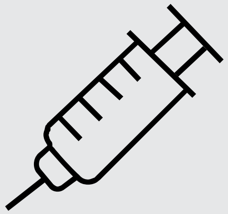
### DETECT

Healthcare workers can detect health threats by integrating early warning systems, routine surveillance, and real-time data analysis to identify emerging risks.



### PROTECT

Healthcare workers protect themselves and others by applying the correct infection prevention and control (IPC) precautions.



### TREAT

Healthcare workers can treat those affected by emergencies and have the resources needed to continue to deliver essential health services for their populations in the face of emergencies.

# UNDERSTANDING THE NEXUS
## Epidemic readiness, climate-resilience and sustainability

Figure 01 - A shady central courtyard encourages passive ventilation to the surrounding rooms and provides a place for patients, families, and staff to gather.

PHC systems need integrated solutions to adapt to climate impacts while ensuring they are prepared to respond to epidemics and emergencies and maintain essential health services.

### Interconnected Risks:

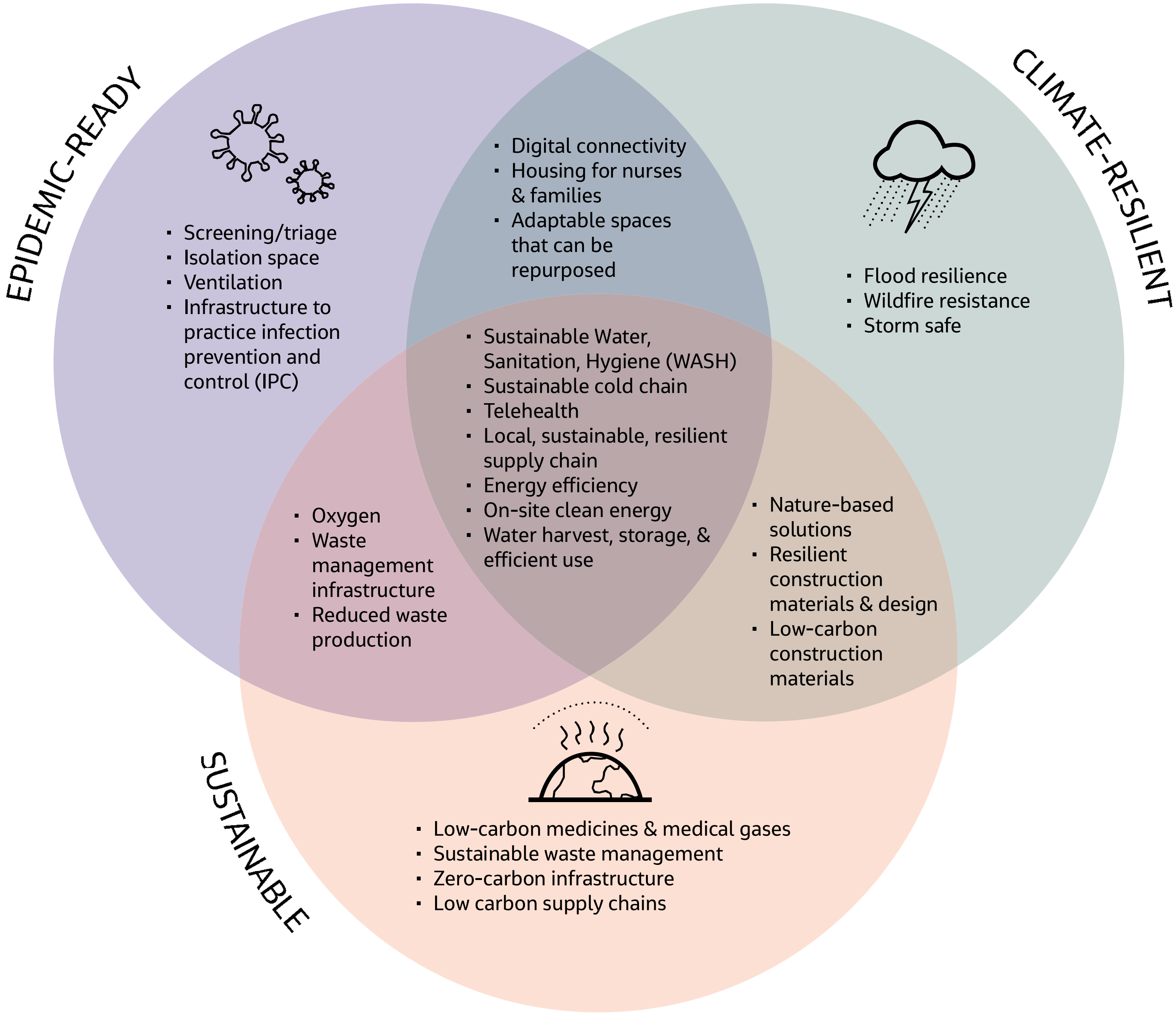
1. Climate Change: Increases the risk of extreme weather, heatwaves, and disease outbreaks.
2. Urbanization: Exacerbates conditions with overcrowded cities, poor sanitation, and pollution.
3. Globalization: Enables diseases to spread faster across borders through population movement and creates supply chain vulnerabilities.

These factors interact and amplify each other, making health emergencies more frequent, complex, and harder to control. Given these interconnected and escalating risks, there is a growing need for health systems to adopt comprehensive strategies that address multiple types of emergencies in an integrated way.

### All-Hazards Approach:

Our all-hazards approach recognizes that while the sources of hazards may vary, they often present similar challenges to health systems, requiring a unified set of preparedness measures and response strategies. The Epidemic Ready Primary Health Care (ERPHC) framework has already laid a strong foundation for emergency preparedness and response specifically for epidemics.[8]

By expanding this framework beyond outbreaks, PHC facilities can strengthen their capacity to prevent, detect, and respond to a wider range of emergencies, including natural disasters, mass casualty incidents, environmental hazards, and other public health threats.


EPIDEMIC-READY
▪ Screening/triage
▪ Isolation space
▪ Ventilation
▪ Infrastructure to practice infection prevention and control (IPC)
CLIMATE-RESILIENT
▪ Flood resilience
▪ Wildfire resistance
▪ Storm safe
▪ Digital connectivity
▪ Housing for nurses & families
▪ Adaptable spaces that can be repurposed
▪ Sustainable Water, Sanitation, Hygiene (WASH)
▪ Sustainable cold chain
▪ Telehealth
▪ Local, sustainable, resilient supply chain
▪ Energy efficiency
▪ On-site clean energy
▪ Water harvest, storage, & efficient use
▪ Oxygen
▪ Waste management infrastructure
▪ Reduced waste production
▪ Nature-based solutions
▪ Resilient construction materials & design
▪ Low-carbon construction materials
SUSTAINABLE
▪ Low-carbon medicines & medical gases
▪ Sustainable waste management
▪ Zero-carbon infrastructure
▪ Low carbon supply chains

# A Call to Action

To ensure PHC facilities are equipped to manage the growing risks of epidemics and climate-related shocks, national governments, donors, and health facilities must align and integrate efforts. This includes harmonizing infrastructure investment, empowering health workers, and embedding resilience into everyday service delivery.

## NATIONAL GOVERNMENTS

**Diagnose and Prioritize:** Conduct assessments using diagnostic tools to identify infrastructure vulnerabilities to both epidemic and climate risks.

**Convene Across Sectors:** Establish coordination mechanisms between health, environment, infrastructure, and energy sectors to design joint strategies that address shared vulnerabilities.

**Plan and Budget for Resilience:** Integrate climate resilience and epidemic readiness into national health strategies, PHC operational plans, and infrastructure investment frameworks.

## DONORS AND DEVELOPMENT PARTNERS

**Set Standards for Support:** Require climate and epidemic vulnerability assessments as part of PHC infrastructure funding proposals and provide technical assistance where needed.

**Invest in Learning:** Fund pilot projects that demonstrate integrated, context-specific solutions and evaluate them for impact, scalability, and cost-efficiency.

**Scale What Works:** Prioritize expansion of successfully integrated models through national systems, budget alignment, and capacity building.

## HEALTH FACILITIES AND LOCAL HEALTH AUTHORITIES

**Assess and Act:** Identify infrastructure gaps and vulnerabilities at the facility level.

**Co-Design with Communities:** Involve local communities and health workers in designing infrastructure upgrades that reflect lived experience, cultural norms, and practical needs.

**Operationalize Resilience:** Develop and implement facility-level operations plans and advocate for resources and policy support.

**Share What Works:** Document, evaluate, and disseminate effective models of integrated PHC infrastructure strengthening.

## ALIGN

Align tools and guidance for epidemic preparedness, climate resilience, and health care sustainability to integrate planning, maximize resource efficiency, and leverage synergies across sectors. Coordination across sectors to improve funding efficiency and response effectiveness.

## INVEST

Invest in unified strategies to address climate change impacts and future epidemics into policies and investments. Invest in sustainability to ensure ongoing efficiency and minimize PHC impacts.

## EMPOWER

Strengthen PHC resilience by training health workers, community leaders, and policymakers. Equip them to address climate-related health risks and adopt new, more sustainable technologies and practices. Engage communities for culturally relevant adaptation and sustainability strategies.

## IMPLEMENT

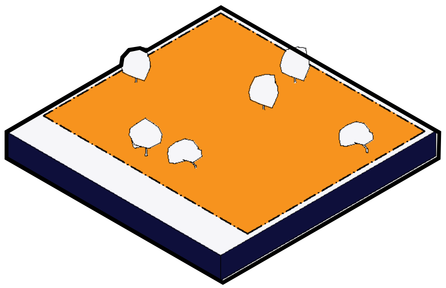
Conduct assessment of existing infrastructure gaps to identify high priority areas for refurbishment and new PHC infrastructure built based on aligned epidemic and climate standards.

# DESIGN BUILDING BLOCKS
## For a primary health care facility

A systems approach emphasizes strengthening of the interconnected elements of PHC systems to ensure they are prepared for epidemics, able to withstand the impacts of climate change, and capable of providing quality care over time. It involves understanding the essential services, their locations, and how each element contributes to the facility's overall function.

Effective layout and design ensures optimal patient flow, efficiency, and adaptability during health emergencies and climate-related shocks. Additionally, this approach prioritizes sustainability in design, development, and routine operations to minimize impacts on local ecosystems and PHC systems' overall carbon footprint.

Key considerations include the strategic placement of patient care areas, sanitation facilities, ventilation systems, water supply, and energy efficiency or clean energy solutions. A well-designed facility enables flexible, resilient infrastructure that can adapt to both routine healthcare needs and urgent crises, ensuring uninterrupted delivery of essential services.



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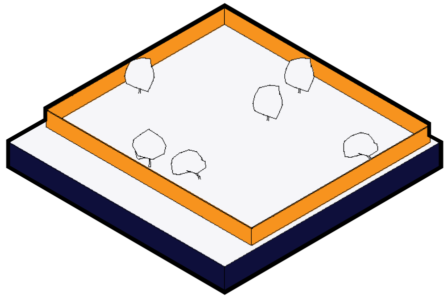
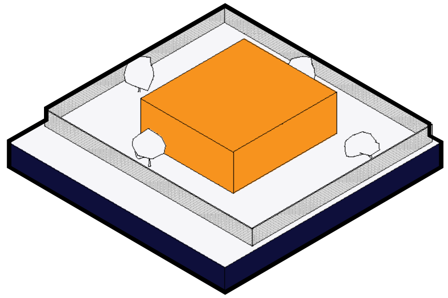
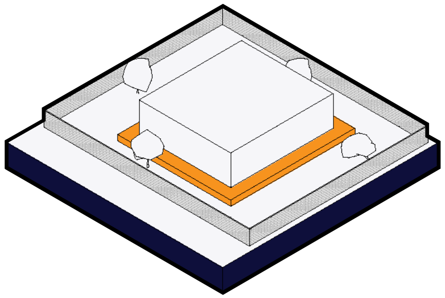


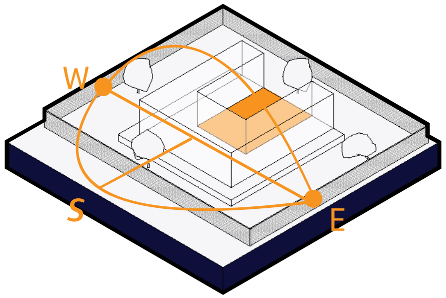
02 | SECURITY & SAFETY



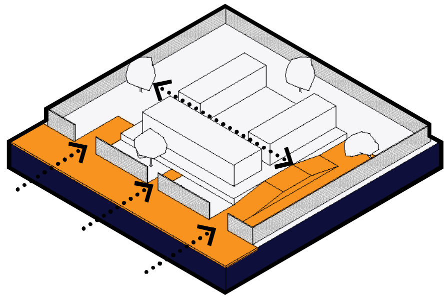
03 | BUILDING FOOTPRINT



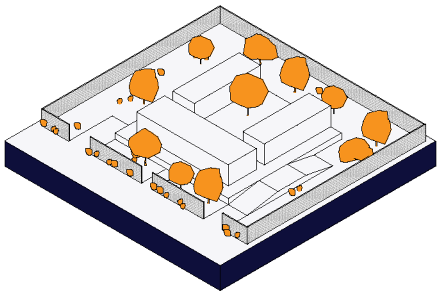
04 | RAISED PLATFORM



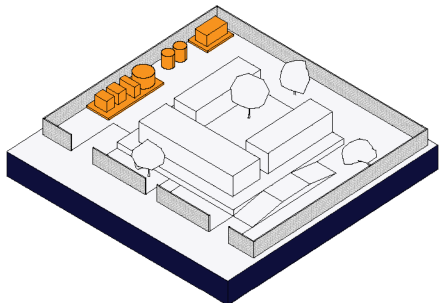

05 | COURTYARD & ORIENTATION



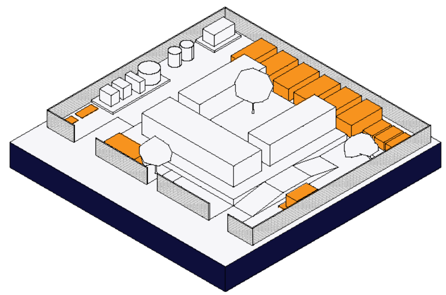
06 | ACCESS & EGRESS



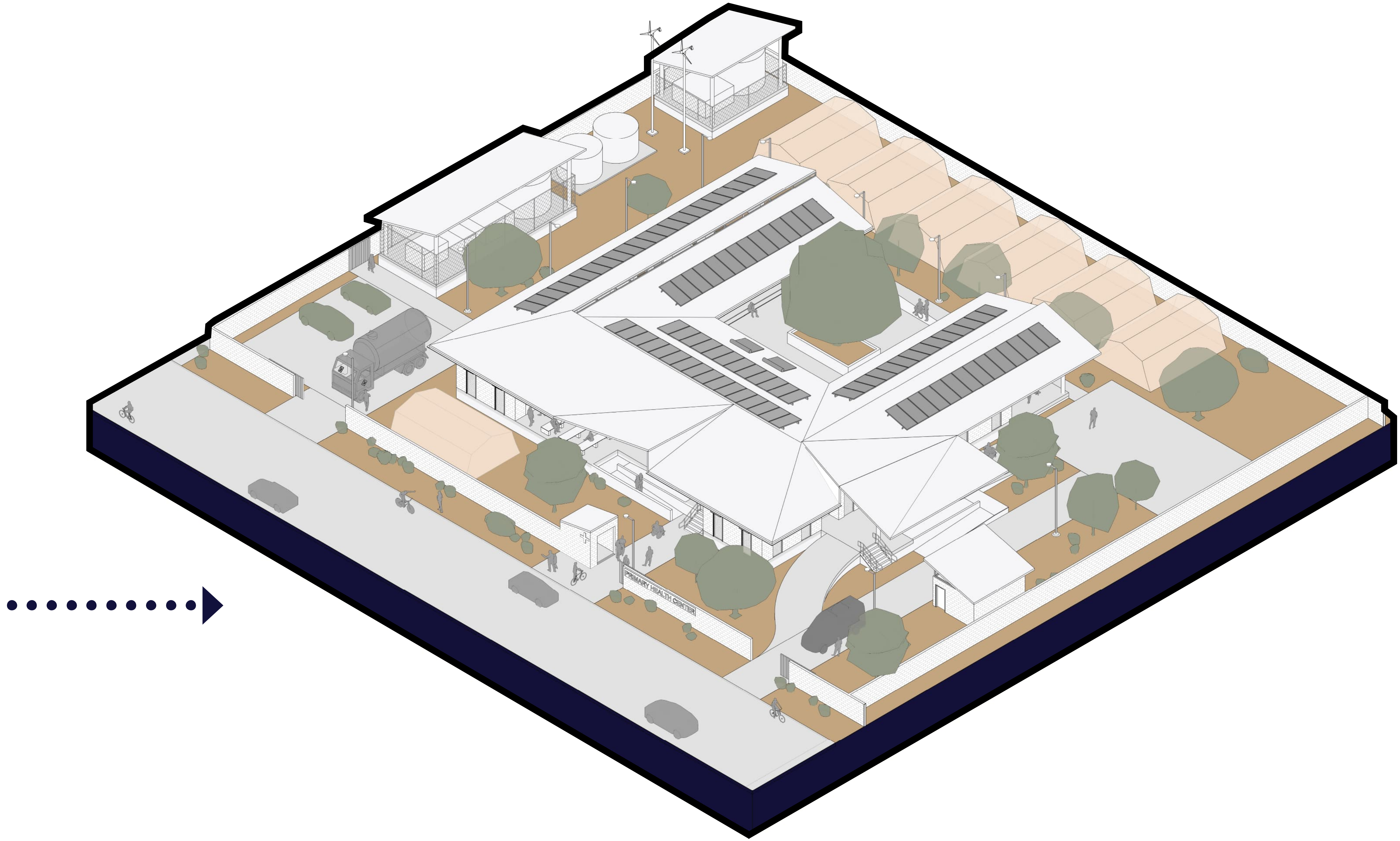
07 | LANDSCAPING



08 | SITE INFRASTRUCTURE



09 | SURGE CAPACITY


PRIMARY HEALTH CENTER

# ANATOMY OF A
# Primary health care facility

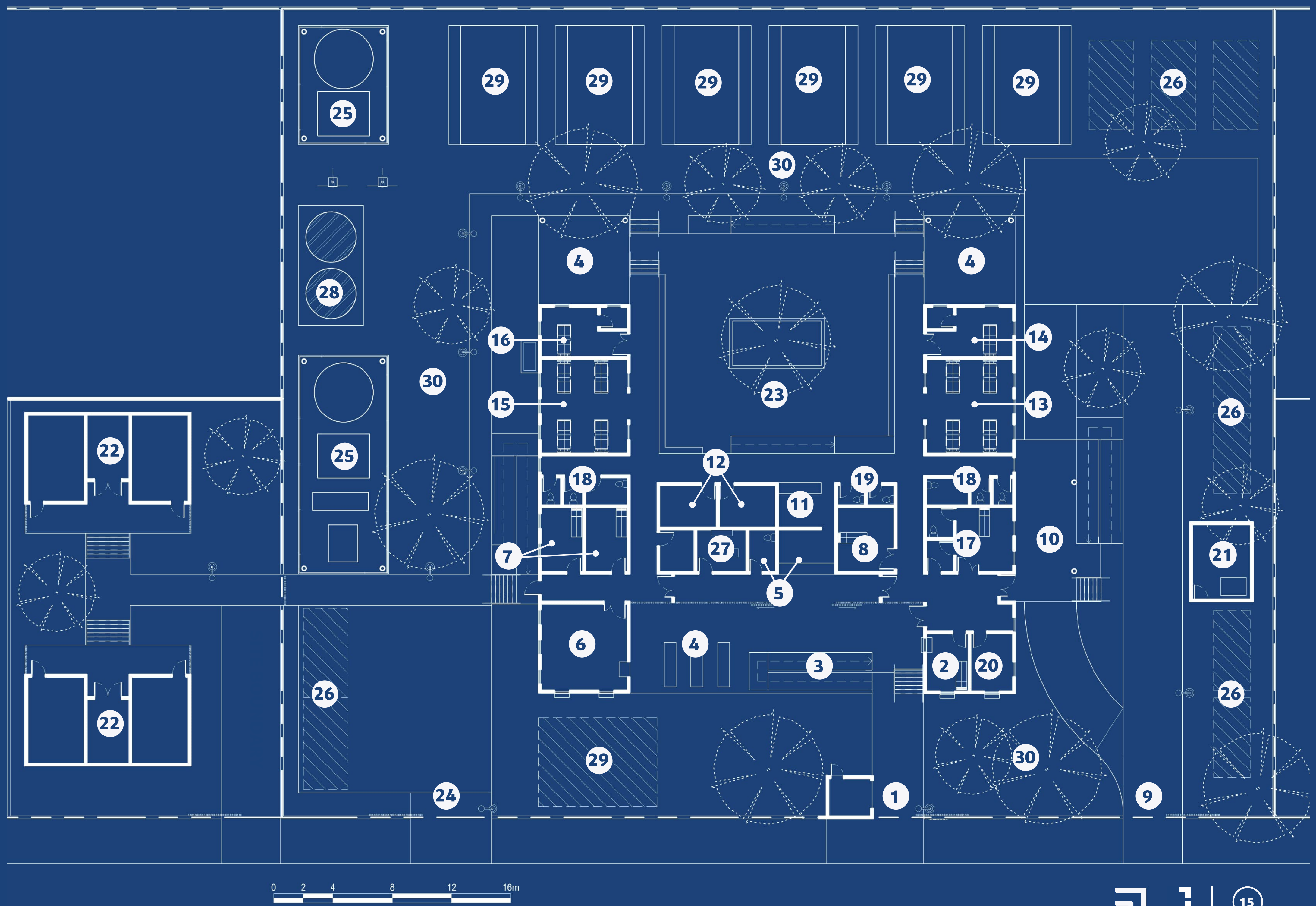
This is a concept plan for a prototype PHC facility serving an estimated population of 10,000 - 20,000. The facility is managed by healthcare workers and provides both in- and out-patient services, with some specialized services offered such as maternity, and a 24-hour emergency treatment capacity.

Planning enables the separation of clinical flows to manage infectious patients, including the use of temporary expansion space to provide additional isolation or surge capacity.

Robust building systems, with built-in redundancy to cover interruptions to supply, allow the facility to maintain operations and communications as conditions change.

Having an adaptable space allows the facility to respond effectively to a variety of crises, such as an influx of patients with infectious diseases or a mass casualty situation. This adaptability enables the facility to plan ahead, establish appropriate controls, and implement models of care to minimize the spread of infections. The redundancies in digital infrastructure ensure that the center maintains capability to report notifiable diseases to public health authorities.

1. Main entry with gate & shelter for waiting or security
2. Triage
3. Ramped entry to facility for equitable access
4. Covered outdoor deck for waiting, gathering & education
5. Reception & public toilet
6. Pharmacy, dispensary, & vaccination center
7. Consultation rooms
8. Treatment room
9. Ambulance entry
10. Covered ambulance parking
11. Staff base
12. Clean & dirty utility
13. Women's & children's ward (4-bed)
14. Birthing room
15. Men's ward (4-bed)
16. 1-bed patient room
17. Isolation room with anteroom entry & private ensuite
18. Patient bathrooms
19. Staff bathrooms
20. Nurse unit manager's office
21. Disposal room and waste management equipment
22. Staff accommodation on adjacent site allows for safe evacuation
23. Open courtyard
24. Logistics & services entry
25. Services compound - Water tank, pumps, fuel, & generator
26. Temporary additional container storage
27. Communications room & main switchboard
28. Sewage treatment & black water irrigation
29. Temporary portable shelter for additional surge capacity
30. Shaded landscaped outdoor space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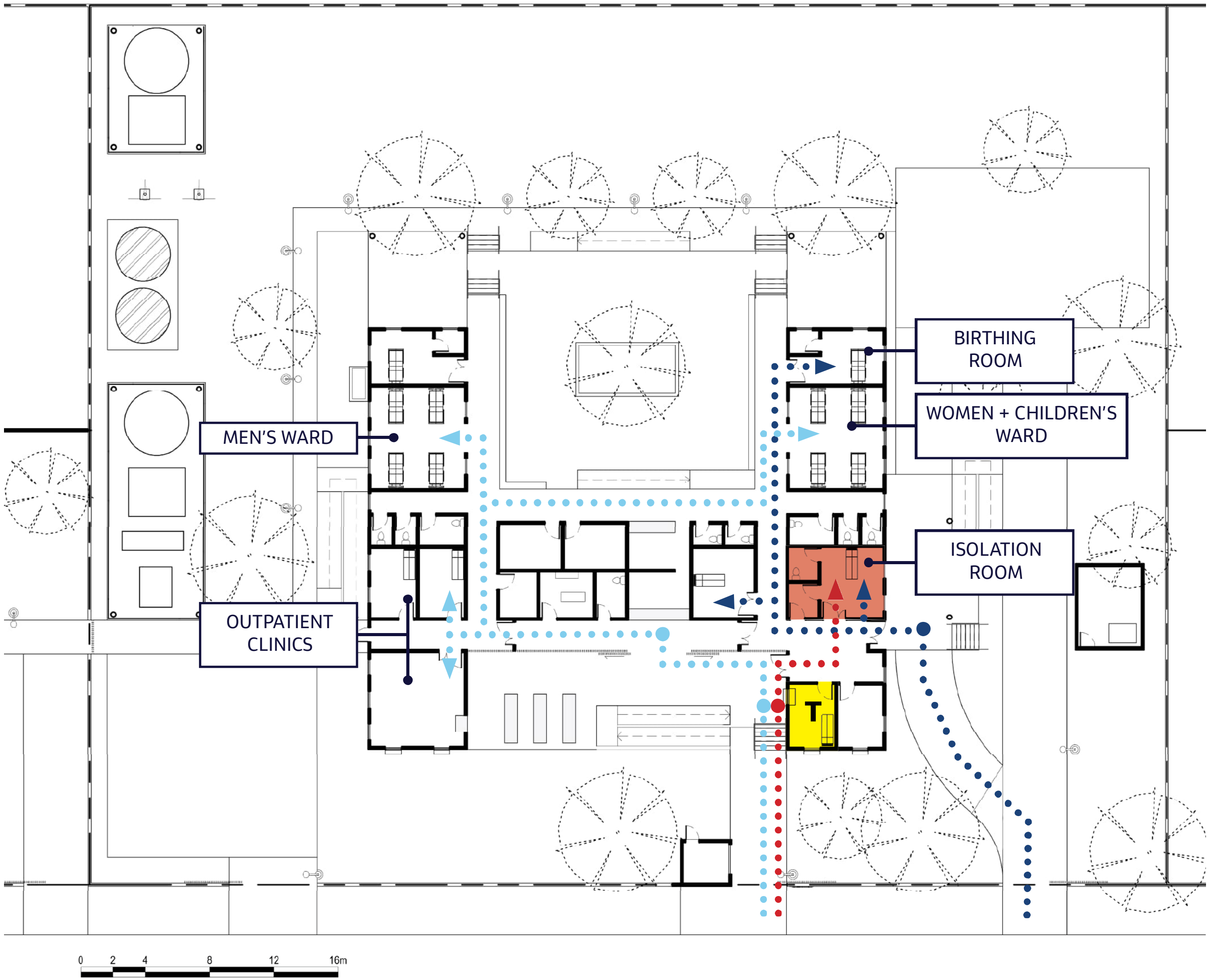
# Everyday

## PATIENT FLOW DIAGRAM

General patients enter the site via the main entrance and proceed to triage for assessment, where they are then directed to outpatient services or to the main reception if accessing the wards.

Infectious patients are intercepted at triage and can be taken immediately to the adjacent dedicated isolation room to prevent the spread of infection.

Ambulance patients enter via the dedicated ambulance bay and are received at triage, where they can be directed to the isolation room if infectious, or taken to the nearby treatment room, with mothers in labor transferred to the birthing suite.




**Legend**

- General
- Ambulance
- Infectious
- T Triage

# Surge

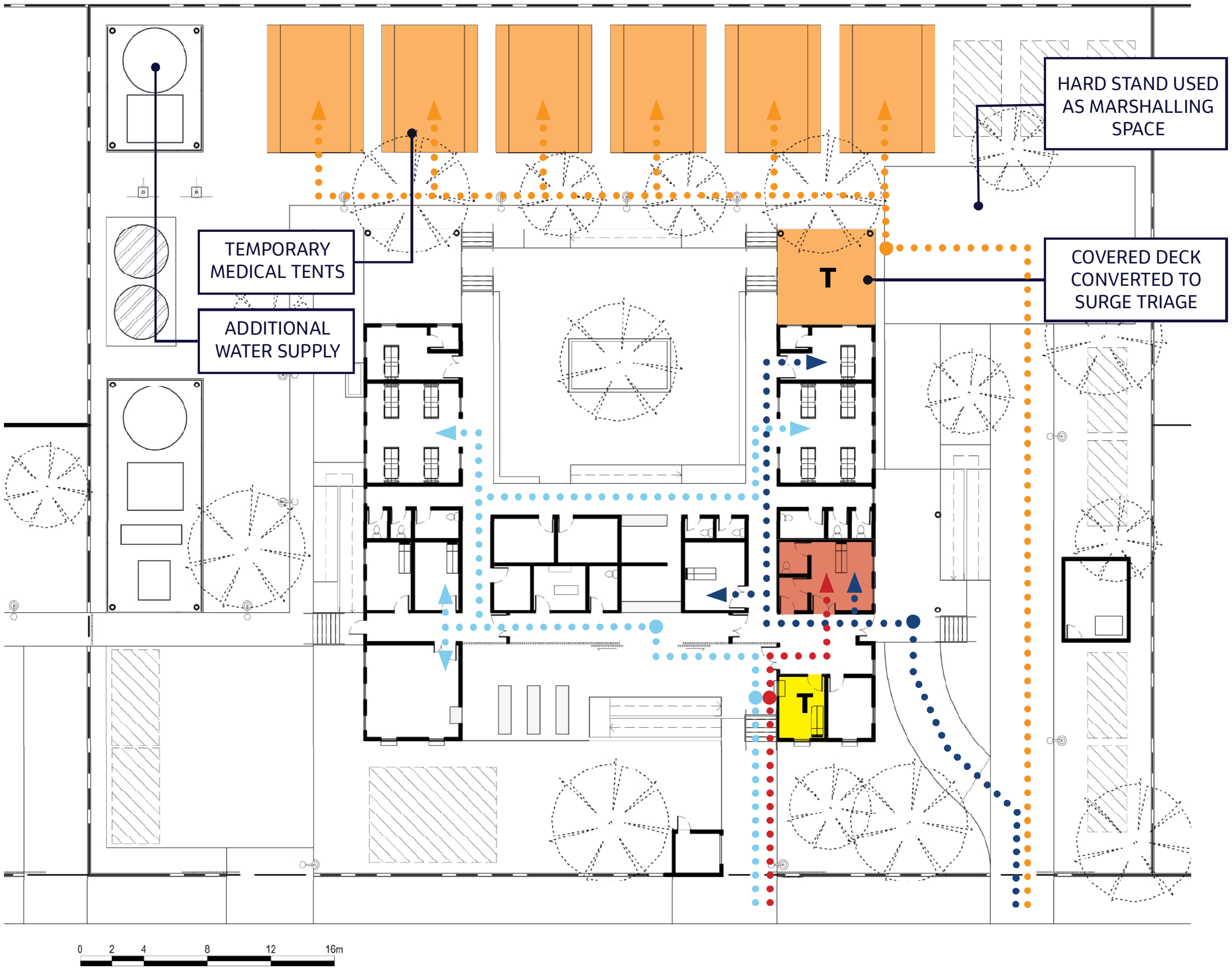
## PATIENT FLOW DIAGRAM

In addition to the flows in the standard mode of operation, the PHC facility has the ability to manage surge capacity during incidents such as disease outbreaks, extreme weather events or natural disasters, where the site is required to deal with far greater numbers of patients.

The open space around the main building is crucial in providing space to erect temporary shelters on-site to manage the increased numbers. Covered spaces at the end of the ward wings typically used for gathering or family spaces can be set up as surge triage points to feed the temporary spaces.

Vehicles can access this zone via the ambulance entry, and reach the back of the site where space is also provided for temporary containerized support spaces.

Additional water supply at the rear of the site also services patient care in this area.




**Legend**

- General
- Ambulance
- Infectious
- Surge
- T Triage

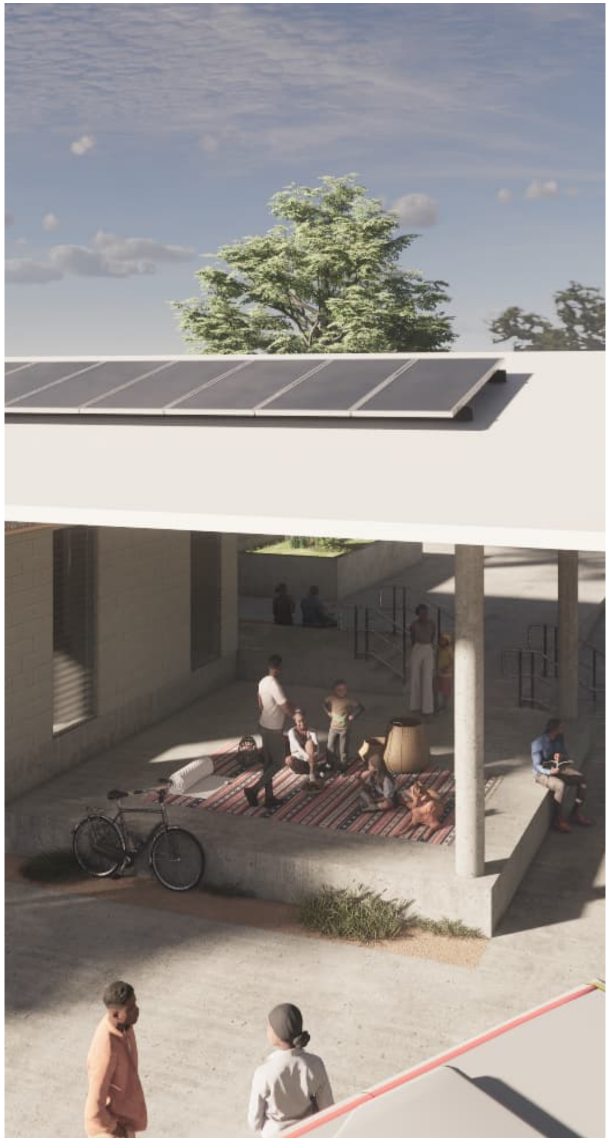


Figure 02 - Covered decks provide flexibility for family groups to gather and meet while family members are receiving treatment, and can be reconfigured to work as triage spaces during periods of surge capacity.

Planning Considerations

Design and Delivery

# Adaptable design and building materials

Vernacular buildings use local materials and traditional methods, making them sustainable and cost-effective. They improve health and comfort with better ventilation and natural lighting, while preserving cultural heritage and offering resilience to local environmental challenges.

### Site Selection

Consider risks from natural disasters, existing utility connections (including renewable sources), and access to transport. Beyond these risks, also consider environmental strains or existing conditions that should not be exacerbated (e.g., water-stressed areas).

### Local Industry

Review local market capacity for skilled trades and materials, design accordingly, and reduce transport-associated carbon emissions.

### Vernacular Buildings

Traditional building typologies offer lessons in working with the local conditions and offer a familiar design language.

### Local Regulatory Environment

Understand local authority planning codes and regulations to ensure that the design can be delivered efficiently and without delays.

### Sustainable Materials

Choose low-embodied-carbon, durable, and repairable materials.

### Climate Resilience

Elevate for flood resilience, plant trees to reduce local ambient temperature, use deep overhangs to provide shade, and protect openings against cyclones and wildfire – create a refuge.

### Loose-Fit

Design buildings that can adapt to changing needs, use spaces that can be quickly reconfigured to isolate infected patients and reduce cross-contamination.

Figure 03 - Operable glass louvers combined with insect screening can be used to promote natural ventilation and passive cooling.
*Photo credit: Jacobs.*

# Ventilation and airflow systems

WHO recommends an airflow of at least 60 liters per second per patient in naturally ventilated rooms, which can be achieved through well-placed windows and vents. (Note: 80 – 160 l/s/patient is required for airborne precautions).

WHO, 2021

## Planning Considerations

### Climate Adaptation

Consider temperature and humidity control, especially in regions with extreme heat or high moisture levels.

### Energy Efficiency

Assess the ability to use low-emission materials and renewable energy sources to reduce carbon footprints and operational costs.

### Hybrid Ventilation Systems

Plan to prioritize natural ventilation (e.g., windows, vents) when possible while integrating mechanical systems (e.g., isolation rooms).

## Design and Delivery

### Natural Ventilation

Windows should ideally have adjustable openings and be protected with insect screens to prevent vector-borne disease transmission.

### Courtyards

The use of internal courtyards in building designs can be used to stimulate passive airflow.

### Isolation

Include systems that can create negative airflow (negative pressure if possible) rooms to isolate infectious patients and prevent disease transmission.

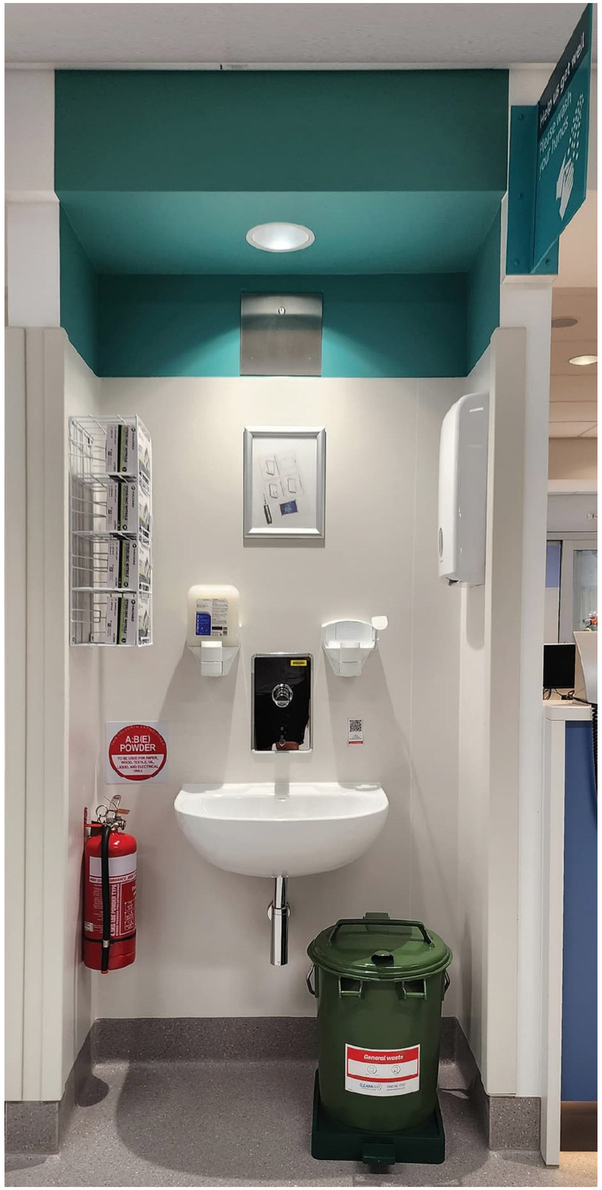


Figure 04 - Purposeful graphic devices can be used to mark handwash stations to drive a culture of good hygiene practices.
*Photo credit: Jacobs.*

# Hand hygiene facilities and emergency equipment

> Appropriate hand hygiene prevents up to 50% of avoidable infections acquired during healthcare delivery, including those affecting the health workforce.
>
> WHO, 2025

## Planning Considerations

### Handwash Stations

Provide adequate numbers of stations at points of care, waste areas, near toilets, exits, entrances, waiting rooms, and dining areas.

### Educate

Provide signage (including graphics) to promote proper handwashing and hygiene practices.

### Clean Water

Ensure that all hand hygiene stations have access to clean water for effective handwashing.

### Oxygen

Provide reliable access to medical-grade oxygen that functions even in extreme conditions. Priority should be given to solar-powered oxygen concentrators, low-energy devices, and oxygen delivery systems that minimize waste through appropriate flow regulations. Backup systems, ideally renewable or low-carbon, must be in place for emergencies or high-demand periods.

## Design and Delivery

### Station Placement

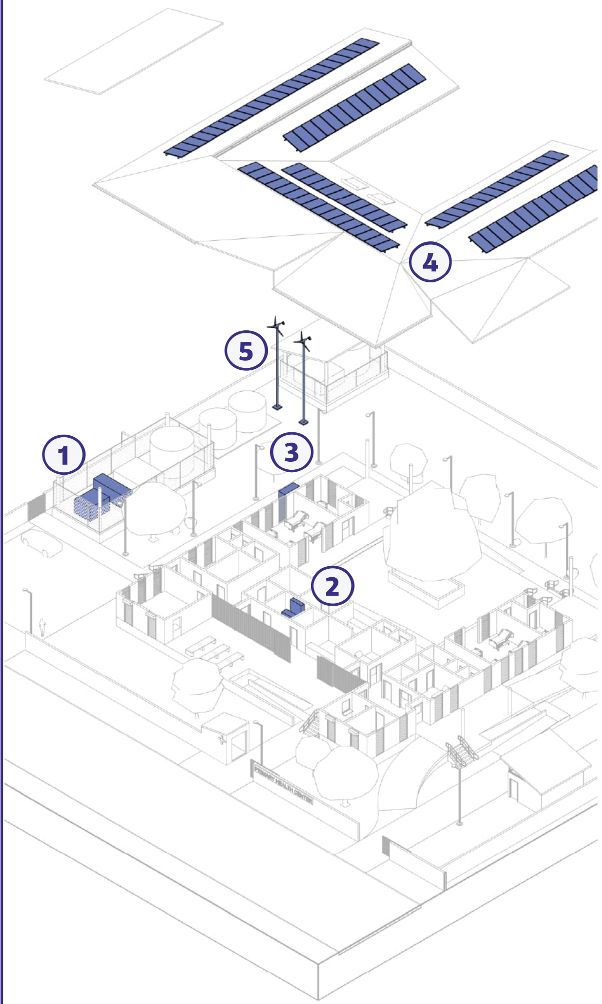
Handwashing facilities or alcohol-based hand rubs should be within 5 meters of key areas, including entrances, exits, patient rooms, and common areas, with a reliable water supply and soap.

### Foot-Operated Doors

Install foot-operated doors in high-traffic areas to minimize touchpoints and contamination risk.

### Hand Drying

Provide both air dryers and paper towels, with a preference for air dryers to support sustainability and reduce waste.




1 - Backup generator & fuel storage
2 - Main switchboard
3 - Battery storage
4 - Photovoltaic cells (solar panels)
5 - Wind turbines

Figure 05 - Potential energy generation systems in a PHC facility.

# Energy efficiency and renewable energy

> Close to 1 billion people in low- and lower-middle-income countries are estimated to be served by healthcare facilities without reliable electricity or with no electricity access at all.
>
> WHO, 2023

## Planning Considerations

### Feasibility for Renewable Energy

Assess sunlight for solar, wind for turbines (ideal in coastal areas), and water flow for hydropower.

### Redundant Energy Sources

Plan for backup power using solar, wind, hydro, biomass, or generators. Consider battery storage for renewable energy.

### Fuel Agreements

Ensure agreements for continuous fuel delivery during prolonged outages.

### Fuel Storage

Ensure fuel tanks can store 72-96 hours of fuel, are accessible by mini tanker, and are secured against theft.

## Design and Delivery

### Energy Efficiency Measures

Install low-flow plumbing fixtures and occupancy sensors to reduce energy demands.

### Lighting

Use LED lighting and energy-efficient equipment with automatic controls to save energy.

### Renewable Generation Opportunities

Install photovoltaic panels in feasible locations for solar power. For run-of-river hydroelectricity, utilize flowing water sources for hydroelectric power.

### Biomass Feedstock

With limited capabilities, use biodiesel, renewable natural gas, or propane. For advanced capabilities, consider renewable diesel and electrification. The best approach involves electrification with renewables and/or battery storage.

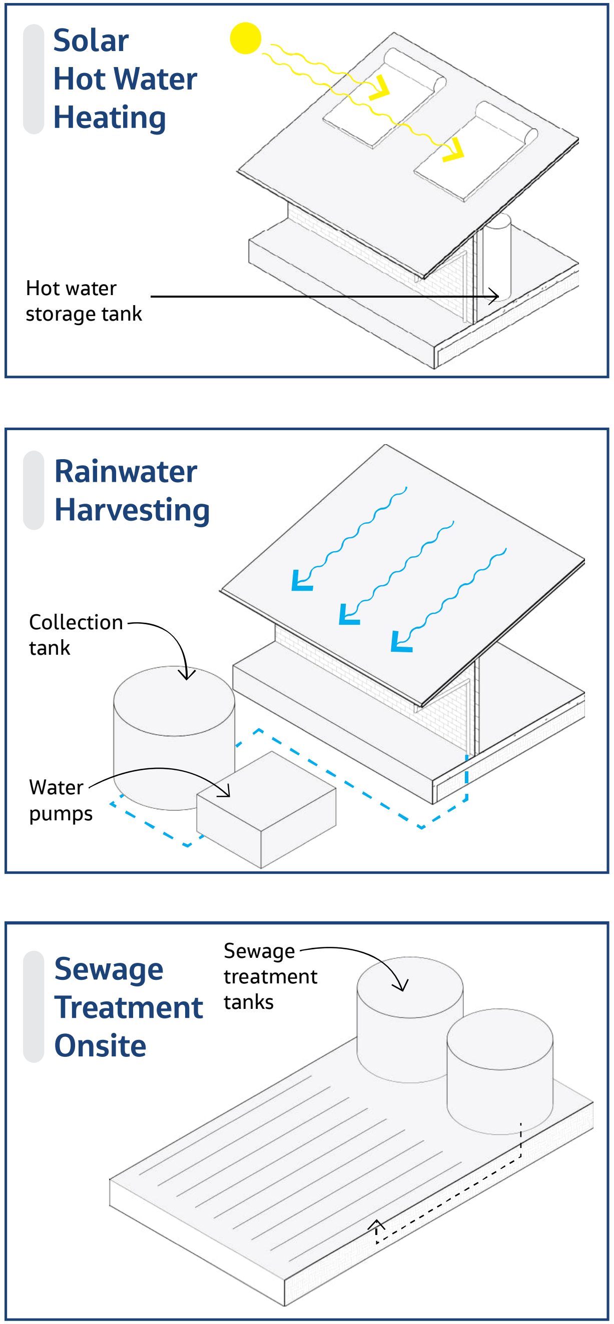



Figure 06 - Sustainable water solutions.

# Reliable access to water

In 2021, over 2 billion people lived in water-stressed countries, which is expected to be exacerbated in some regions as a result of climate change and population growth. Some 1 million people are estimated to die each year from diarrhea as a result of unsafe drinking water, sanitation, and hand hygiene.

WHO, 2023

## Planning Considerations

### Local Climate Conditions

Consider factors like droughts and floods in water infrastructure planning.

### Reliable Water Sources

Consider water sources like boreholes, recycled water, and municipal supply. Recycled water options, such as A/C condensate capture or rainwater harvesting, reduce freshwater demand but often require energy-intensive processes like pumping and treatment.

### Water Treatment

Plan for backup water filtration systems in case local sources become contaminated.

### Power Sources for Pumps

Evaluate options such as solar, grid electricity, and manual pumps to ensure reliable operations. In regions with unreliable electricity grids, prioritize solar-powered water pumps.

### Redundancy

Use storage tanks or multiple water sources to ensure a continuous supply during shortages.

## Design and Delivery

### Water Treatment

Use energy-efficient, low-waste solutions like reverse osmosis with efficient membranes, UV purification to kill bacteria without chemicals, and carbon filters. In areas with limited electricity, consider gravity-fed filtration systems that do not require power.

### Develop Robust Drainage Systems

Manage heavy rains, prevent waterlogging, and reduce contamination risks.

### Water Tank Placement

Ensure tanks are strategically located to maximize available space, provide easy access for maintenance, and refilling and avoid contamination.

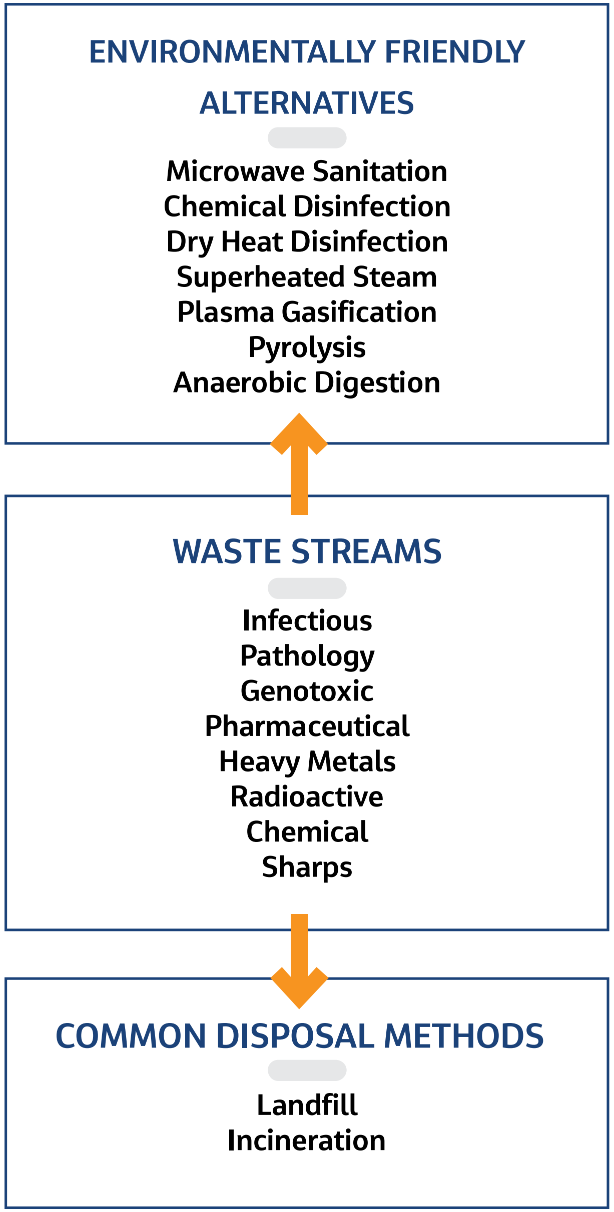



Figure 07 - Common methods of waste disposal in low-income countries are burning and burying, but alternative technologies exist and should be considered in the design and planning of new or existing facilities.

# Waste management and sanitation

> In low-income countries, over 90% of waste is often disposed in unregulated dumps or openly burned.
>
> World Bank, 2022

## Planning Considerations

### Waste Storage and Segregation

Assess the local climate risks and topography, ensure site is above flood levels, and provide sufficient space and processes to separate waste types to prevent cross-contamination.

### Mortuary Procedures

Plan to use modular structures like shipping containers with air conditioning as temporary morgues to store corpses, especially during outbreaks of infectious diseases.

### Overflow Planning

Consider storage for extra waste generated during outbreaks of climate-related events and sewers and septic tanks are built to be above expected flood levels.

### Reduce Reliance on Burning

Develop waste management plans incorporating appropriate infrastructure and invest in cleaner alternatives to incineration for waste treatment.

## Design and Delivery

### Sanitation Facilities

Make sure buildings have enough facilities to meet the needs of patients and staff.

### Decontamination and Disposal

Use steam (e.g., autoclaving) or other non-burn technology for infectious waste. If non-incineration isn't feasible due to lack of reliable resources, use autoclaves where possible, or an on-site incinerator as a last resort.

### Decentralized Wastewater Treatment Systems

These on-site systems provide sanitation and use black water for below-ground irrigation to remove bacteria.

### Incineration

Ensure no open burning and choose the lowest emitting incinerator option feasible, such as controlled air, excess air, or rotary kiln incinerators. Place the incinerator chimney high enough to avoid intakes and conduct wind studies for optimal placement. Combine incinerator usage with renewable fuel or electricity if possible.

### Waste Storage

Design a well-ventilated space and use strong and impermeable liners, implementing robust drainage systems, constructing protective barriers like berms, and incorporating monitoring systems to detect potential breaches or leaks.

Figure 08 - Shaded areas provide places for family groups to wait, and a forum for health education and vaccination.

## Communication and connectivity

Connectivity challenges also remain in the least developed countries (LDCs) where only 35 percent of the population is estimated to be online.

UN, 2021

Planning Considerations

**Assess Local Infrastructure**

Identify existing mobile networks, radio stations, satellite access, and broadband availability and assess capability for activities such as emergency communications, telemedicine, and real-time surveillance for early warning.

**Assess Local Conditions**

In areas vulnerable to severe weather events, wireless connectivity such as 5G networks or satellite-based internet systems may offer additional reliability to traditional wired infrastructure.

**Data Storage Strategies**

Establish data storage strategies, including multi-site backups (on-premises and cloud-hosted) to protect critical information and use offline-first mobile applications that sync when connectivity is available.

Design and Delivery

**Redundant Connectivity**

Establish backup communication systems (mobile networks, satellite links, and emergency radio frequencies).

**Energy Efficiency**

Implement energy-efficient power solutions (e.g., solar with battery storage) to support uninterrupted digital access.

**Telemedicine**

Integrate telemedicine capabilities to maintain patient care, reduce crowding, and lower travel-related emissions.

## Maintenance and repair

The benefits of planned maintenance include minimizing unplanned downtime and costs caused by unexpected equipment failures, extending the lifespan of an asset, and improving workplace safety.

IBM, 2023

Figure 09 - The use of simple building systems and materials simplifies maintenance and repair over the life of the asset.
*Photo credit: Jacobs.*

### Operational Sustainability

- Establish a funded plan for ongoing operation and maintenance.
- Conduct scheduled inspections to prevent system failures and healthcare disruptions.
- Train local staff in water, waste, energy, oxygen, and IT system operations and maintenance to ensure sustainability and adaptability.

### Environmental Management

- Use automated building management systems to regulate airflow and optimize energy efficiency.
- Regularly inspect ventilation systems, ducts, and natural air pathways to keep them unblocked and functional. Replace and clean air filters and mechanical components to maintain efficiency.
- Conduct regular microbial and chemical contamination testing to ensure safe water. Prevent flooding and contamination by maintaining drainage systems.

### Storage and Restocking

- Establish a secure area for IT devices to protect them from theft and damage.
- Maintain a spare parts pool in a secured area to ensure routine maintenance can be performed.
- Restock soap and alcohol-based hand rub (ABHR) consistently. Inspect and maintain sinks, dispensers, and hand hygiene stations regularly.

### Monitoring and Compliance

- Monitor energy use, supply, and demand using tracking tools and expand backup power as needed.
- Ensure compliance with environmental and safety regulations through signage, staff education and routine monitoring.
- Regularly test and update backup IT systems and digital platforms to prevent disruptions in digital connectivity during infrastructure failures.

### Equipment Maintenance and Cleaning

- Regular cleaning of autoclaves, photovoltaic arrays, wind turbines, fuel storage, generators, etc.
- Ensure waste storage areas and bins are regularly cleaned to prevent infestation of disease-spreading vermin.

# BUILDING RESILIENT PHC FOR EVERYDAY CARE AND CRISIS RESPONSE

**PHC is the backbone of every health system and the frontline for epidemic detection and climate-related emergencies. Yet, in many resource-constrained settings, PHC infrastructure remains dangerously underprepared. For too long, improvements have been made in silos—one partner funds solar panels, another installs internet connectivity—but without a coherent strategy, agreed minimum standards, or the systems needed to ensure PHC facilities can consistently deliver quality care.**

This fragmented approach leaves communities vulnerable. Health workers cannot do their jobs without reliable power, clean water, functional sanitation, and basic communications systems. PHC facilities must be equipped not only for routine care but also with the flexibility and structural resilience to continue operating during crises—whether it's a heatwave, flood, or disease outbreak.

Climate change, urbanization, and globalization are amplifying the frequency and complexity of health emergencies. These risks interact and compound one another, placing unprecedented stress on health systems. By taking a user-centered approach to infrastructure design and aligning clinical best practices with climate-resilient infrastructure standards, we can ensure PHC facilities are equipped to withstand a wide range of threats while maintaining essential services.

We must do better. Now is the time to align funding, coordinate across sectors, and commit to minimum infrastructure standards that protect essential health services, no matter the crisis.

This will require a new approach—one that embraces innovation, collaboration, and shared responsibility. Everyone has a role to play in building forward better. We urge national governments to embed resilience into health and infrastructure planning. We call on donors to support integrated, scalable investments and help countries learn from what works. And we encourage facility leaders and communities to co-design and implement local solutions. Only through integrated action can we build PHC systems that are prepared, equitable, and truly resilient.

We welcome your reflections on these recommendations and encourage you to share whether they resonate with your in-country experience.

*Do they align with the challenges and priorities you face in building climate-resilient health systems?*

*Are there critical gaps or opportunities we may have overlooked?*

**Your insights are essential to ensuring future guidance is grounded in reality and responsive to country needs.**


Figure 10 - Artist's impression of PHC facility concept design.

# Notes

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## How is your primary health care system gearing up to tackle the dual threats of epidemics and climate change?

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