Human-Centered Design Workshops for Next-Generation Pulse Oximeters

December 2023
Next-generation pulse oximeters or multimodal (MM) devices are actively being developed with feature tradeoffs being considered.

User research in PHC settings was needed to inform decisions, and better understand and define user and health system constraints related to integrating these devices.

There was also a need to explore the use of smartphones as health screening tools.
Workshop Objectives

- Explore potential features and functions of multimodal devices and their potential for integration into IMCI care practices.
- Explore the integration of an approved multimodal device, the Masimo RadG, into existing IMCI practices.
- Explore the potential use of mobile applications in health settings.
- Develop high-level user requirements for an appropriate health-sensing smartphone application.

A researcher from IHI in Tanzania guides caregivers through an exercise Image: PATH
Workshop Methodology

Country workshops in Kenya, Tanzania, Senegal, and India included:

- Primary care providers (PCPs)
- Caregivers
- Other stakeholders in IMCI

Individual and group/plenary activities included:

- Questionnaires
- SWOT analysis
- Focus group discussions
- Card sorting

Workshop outputs included:

- Prioritized general features and functions (for future MM devices)
- Perceived facilitators and barriers to successful introduction and use of MM devices.
- Validated, general IMCI workflows and process maps.
- High-level requirements for smartphone applications for IMCI.
Workshop Participants

+ 137 participants from three stakeholder groups across four countries
+ Participants from national and sub-national health management offices, health facilities, and communities.

Distribution of users across all HCD workshops

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Cross-country learnings: Future MM devices and IMCI integration
Priority Multimodal Device Features and Integration

Future MM devices should:

- Function both as a **spot-checking and continuous monitoring device**
  - establishing the patient’s condition at **triage**
  - monitoring the patient’s condition over time during **consultation**
- Provide results in **less than 1 minute**.
- Have a minimum **12-hour battery life**.
- Require **no calibration and minimal maintenance**.
- Be integrated at **triage** and/or **consultation** into IMCI workflows.
Assessment of MM device integration in IMCI

**Strengths**
- Multiple functionalities
- Triage systems in place
- Availability of trained staff
- Can be used by untrained staff

**Weaknesses**
- Integration costs
- Training requirements

**Opportunities**
- High demand for IMCI services
- Availability of clients

**Threats**
- Portable devices are easily stolen
- Staff turnover/shortages
Activities to support uptake of the RadG MM Device

- **Train end users** and other IMCI staff using bottom-up and train-the-trainers (ToT) models.
- Provide **piloting opportunities** to generate evidence-based research.
- **Educate the community** on the purpose and use of devices to ensure buy-in.
Cross-country learnings: Smartphone use in IMCI
Priority measurements include:

- Respiratory rate (RR) and depth (if possible)
- Blood oxygen saturation
- Temperature

Above parameters are important for the early detection of pneumonia and sepsis.
Perceptions of smartphone use in IMCI

**Strengths**
- Easy to use
- Highly accessible
- Easy to integrate with other systems
- Multiple applications on a single device

**Weaknesses**
- Limited connectivity

**Opportunities**
- Integrating with national digitalization strategies/efforts
- Availability of personal devices

**Threats/Fears**
- Data privacy and security
- Loss of clinical judgment
- Misuse of devices
- Caregiver perception of decreased provider attention
- Sustainability
Recommendations
Cross-country learnings: Differences in stakeholder perceptions
Recommendations for the future

Recommendations for multimodal devices:

- Introduce MM devices in triage and/or consultation.
- Introduce MM devices using bottom-up and user-centric HCD approaches and training.
- Reinforce MM introduction with evidence-based research, including facility-based piloting.
- Leverage existing infrastructure.
- Focus on priority features.
- Educate the community on the use and purpose of devices to ensure buy-in.

Recommendations for smartphones:

- Provide training on the use of smartphone technologies.
- Ensure that device use is not a substitute for clinical judgment.
- Design solutions in alignment with country-specific data privacy and security guidelines.
- Educate the community on the purpose and use of smartphone-based health tools.
Cross-country learnings: Differences in country perceptions of MM devices

**Priorities for clinical functionality** of MM devices were driven by local disease burdens
- Stakeholders in all countries advocated for respiratory rate and blood oxygen saturation as priority measurements
- Additional clinical functionality was suggested as follows:
  - Kenya - temperature and respiratory depth
  - Tanzania – blood pressure and respiratory depth
  - India - blood oxygen saturation and hemoglobin

**Cost of future MM devices**
- PCPs suggested *confidence and cost of MM devices are correlated* – higher-priced devices are perceived to be more reliable and better quality.
- “Other stakeholders” (primarily managers) noted that *future MM devices should be relatively inexpensive* but did expect them to be higher priced than standard devices.
Appendices
Workshop Overview - Kenya

+ Workshops held over 5 days in Nairobi.
+ **30 participants** from three stakeholder groups - health management offices, hospitals, and health centers in Nairobi County.

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Distribution of Participants

Participant distribution by gender

Distribution of Kenya HCD workshop participants by gender
Workflow Map and MM Device Integration points

IMCI workflow in health facilities in Kenya (validated by workshop participants)

Key:
- ♦ Decision
- ★ Point of MM integration
Future MM devices should:

+ Be used for **triage** to establish the patient’s condition and at **consultation** for continuous measurement over time.
+ Function as a **spot-checking and continuous monitoring** device.
+ Provide results in **under 1 minute**.
+ Require **no calibration** and **minimal maintenance**.
+ Health facilities may need devices at **multiple points** of the clinical assessment.
### Assessment of RadG device integration in IMCI

#### Strengths
- Triage system in place and staffing to utilize devices
- Device acceptability
- Multiple functions
- Portable and durable
- May reduce workload
- Long battery life
- Relatively affordable
- Requires minimal training

#### Weakness
- High initial cost of integration
- Limited availability and accessibility
- Specific training needed for less skilled medical staff
- Lack of blood pressure and weight measurements

#### Opportunities
- Improve the quality of care
- Regulatory approvals in place

#### Threats
- Shortage of staff
- Lengthy familiarization process
- Potential of theft due to portability
- Loss of clinical judgment
- Can be used in many locations and contexts - will require multiple devices per facility.

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**TIMCI HCD workshops - Kenya**
Facilitators and barriers to integration of RadG in IMCI

**Key Facilitators**
- Ease of use.
- Multiple functionalities.
- Less skilled staff (CHW, volunteers) can utilize with appropriate training.

**Key Barriers**
- More expensive than pulse oximeters.
- Staff turnover/shortages staff could impact use.
- Small, portable devices can be stolen.

Stakeholders suggested utilizing a train-the-trainer model to support device uptake.
Mobile technologies and smartphone use in IMCI

Participants noted:

- Accessibility of smartphones and their potential to improve the efficiency of IMCI processes.
- **Respiratory rate (RR), blood oxygen saturation**, and **temperature** as priority parameters, important in the early detection of pneumonia and sepsis.
- Need for additional **respiratory depth measurement** which is currently observed by chest movement.
# Key perceptions of smartphone use in IMCI

## Strengths
- Accessible and portable
- Multiple applications and uses
- Capacity to store and share information
- Easy to integrate
- Easy to use and navigate
- Easy to access to guidelines
- Reduces use of paper
- Enables easy communication
- Availability of electricity
- Triage system in place

## Weaknesses
- Internet access is variable and may require purchase of additional data services.
- Potential delays in service
- Current EMR not geared to IMCI
- Duplication of records/Manual registers
- Wrong readings/Reliability
- Data loss
- Standardization/Quality Control difficulties
- Distractions/interruptions on personal devices
- Misuse of official smartphones
- Usability of smartphones
- Lack of built-in clinical support

## Opportunities
- Availability of personal devices
- Interoperability
- Used by non-medical personnel
- Relatively affordable compared to health measurement tools
- Easy adaptability/Low training requirements
- Health facilities have smartphones and tablets
- Leverage pre-existing accountability practices
- Leverage health promoters for awareness

## Threats
- Infection prevention and control measures may not be adhered to.
- Misuse of facility devices for personal use
- Loss of clinical judgment
- Perceived a lack of attention from PCPs and loss of patient-provider relationship.
- Theft.
- Cybercrimes and potential loss of data.
- Confidentiality/privacy of data
- Lack of integration among programmes/systems
- Lack of power back-up systems
Variable internet access and connectivity may affect usage and necessitate the use of paper records in addition to smartphone-based tools.

Data privacy and security.

Smartphones and emerging technologies, such as AI, may replace healthcare workers and limit human-to-human interaction.
Tanzania HCD Workshop
Summary of Findings
Workshop Overview - Tanzania

- Workshops held over 5 days in Dar-es-Salam.
- **31 participants** from three primary stakeholder groups - regional health departments, local health partners, health facilities and TIMCI study health centers in Pwani province.
Workflow Map and MM Device Integration points

IMCI workflow in health facilities in Tanzania validated by workshop participants
## Perceptions of current IMCI practices and tools

### Strength
- Good quality of service at the health facilities
- Availability of health care providers
- Adequate workspace
- Good relationship between providers and caregivers
- Experienced and well-trained providers/medical professionals
- Easy access to health facilities

### Weakness
- No dedicated RCH/MCH buildings in some facilities
- Insufficient doctors
- Lack of medical devices and equipment
- Long queues to access services

### Opportunities
- Government policies support modern medical devices and equipment
- Existing health facilities in local areas where devices can be used
- Large number of children with upper respiratory tract infections

### Threats
- Long waits
- Lack of information and education on new devices
- Lack of security
Priority MM Device Features and Integration

Future MM device recommendations:

- Function both as a **spot-checking and continuous monitoring device** establishing the patient’s condition at **triage** and for monitoring the patient’s condition over time during consultation.
- Provide results in **less than 1 minute**.
- Have a minimum **12-hour battery life**.
- Require **no calibration and minimal maintenance**.
- Facilities may need devices at multiple points of the clinical assessment.
## Assessment of RadG integration in IMCI

### Strengths
- Availability of professionals
- Availability of functional triage systems
- Large number of patients at facilities who need the device
- Availability of power/electricity
- Good medical care to integrate devices into
- Availability of infrastructure/buildings

### Weaknesses
- Untrained professionals/PCPs cannot use the device
- Inadequate human resources

### Opportunities
- High interest/need for device
- Availability of clients in need of device
- Pre-existing infrastructure to accommodate the services
- Staff is eager to use new technologies

### Threats
- Acceptability by caregivers
- Devices unavailable locally
- Lack of spare parts and local maintenance options
- Shortage of trained staff due to transitions
- Lack of resources to procure devices
- Failure to get approval from local regulatory agencies
- Negative attitudes of PCPs towards device use
- Difficult to purchase due to procurement policies/bureaucracy

RadG device use being tested (Photo: PATH)
Facilitators and barriers to RadG integration in IMCI

Key Facilitators:
- High need/interest in MM devices
- High patient load requires efficient and integrated devices
- Availability of professional PCPs

Key Barriers:
- Shortage of trained staff due to staff turnover/transitions
- Negative attitudes towards device use by PCPs
Activities to support uptake of the RadG MM Device

- **Train end users** and other staff using bottom-up and train-the-trainers (ToT) models.
- Provide **piloting opportunities** to generate evidence-based research.
- **Educate the community** on the purpose and use of devices to eliminate fear/mistrust and support adoption.
Summary of findings for MM devices: Tanzania

+ MM devices will:
  • reduce wait and service times
  • improve the quality of service
  • assist with monitoring patients at various stages of the treatment process
  • guide the referral process through early detection of symptoms

+ Concerns about uptake:
  • availability of infrastructure and personnel to support successful integration
  • caregiver and community mistrust and fear
Priority measurements for smartphones in IMCI

Participants noted:

- High penetration of smartphones. Little training required to integrate into IMCI.
- Respiratory rate (RR), blood oxygen saturation, and blood pressure as priority parameters.
- Need for additional respiratory depth measurement - currently observed by chest movement.
# Mobile technologies and smartphone use in IMCI

## Strengths
- Wide availability of smartphones
- Network connectivity
- Availability of power/electricity
- Availability of human resource for health
- Availability of other digital platforms already in use

## Weakness
- Caregivers may feel they are not getting attention from PCPs using mobile technologies
- Reliable internet access may be costly, and a limited resource

## Opportunities
- Pre-existing knowledge among PCPs
- Pre-existing digital platforms that can support use of mobile technologies
- Existing policies, such as independence of health facility budgeting/division-making, which may support the use of mobile technologies
- Availability of professionals that are capable of using the technology
- Caregiver awareness on use of new technologies in PHC

## Threats
- Portability of the device makes it easy to steal
- PCP misuse of devices for other purposes
- Lack of backup power
- Lack of funds/resources
- Limited internet connectivity in rural areas
Concerns about smartphone use in IMCI

+ Lack of internet connectivity or data bundles may impact usage. Supplemental paper-based records may also be required.
+ Portable devices are easily stolen.
+ **Data privacy and security.**
+ Additional research is required on the use of smartphones in IMCI. PCPs are encouraged to follow existing protocols unless provided with evidence for different guidelines.
+ Fear that smartphones and emerging technologies may replace healthcare workers and limit human-to-human interaction.
Senegal HCD Workshop
Summary of Findings
Workshop Overview - Senegal

- Workshops held over 5-days in Dakar.
- **36 participants** across three primary stakeholder groups - health management offices and health posts in Mbour, Joal, Thiadiaye, Thies, and Tivaouane Districts.

### Distribution of stakeholder

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### Participant distribution by gender

- **Male**: 61.1%
- **Female**: 38.9%
Workflow Map and MM Device Integration points

The IMCI workflow in health posts in Senegal, validated by workshop participants
### Perceptions of current IMCI practices and tools

#### Strengths
- Good reception in health facilities
- Accessibility of IMCI services
- Good communication
- Good quality of care
- Availability of staff
- CDSA availability
- Good health post hygiene

#### Weakness
- Clients are sometimes neglected
- Lack of equipment
- Limited competencies of service providers
- Lack of qualified personnel
- Discontinuity of care
- Unavailability of certain drugs

#### Opportunities
- Availability of Philanthropists/Potential funders
- Preventive policies
- Commitment of local/regional authorities
- Presence of community health mutual/health insurance

#### Threats
- Non payment of CMU/Government U5 facility support
- Lack of security
- Socio-traditional beliefs
- Rumors lead to late use of services
- Influence of mothers-in-law
Priority MM Device Features and Point of Integration

Recommendations for future MM devices:

- Provide results in less than 1 minute.
- Have a minimum 12-hour battery life.
- Requires little calibration and maintenance.
- Used on children of all ages.

- Integrated at consultation in smaller health posts and at triage in larger facilities.
Assessment of RadG integration in IMCI

**Strengths**
- Availability of trained IMCI staff
- Availability and frequent use of POs
- Good organization of services
- Good security systems
- Availability of the vital parameters children register
- Demand for modern diagnostic tools
- Decision support

**Weakness**
- Staff turnover
- Non-involvement of midwives
- Limited availability of devices for newborns
- Non-use by on-call staff
- Inadequate material management
- Insufficient training

**Opportunities**
- Strong community buy-in
- Frequent, formative supervision
- Good partner engagement
- Child health a priority in national policies
- Effective communication mechanisms
- IMCI approach implemented
- Senegal digital strategy.
- Periodic review of management tools
- MM data use for further research

**Threats**
- Labour strikes.
- Staff turnover
- Lack of maintenance
- Overreliance on devices
- Limited device availability
- Withdrawal of partner support.
- Unavailability of funding
- Device cost
Facilitators and barriers to RadG integration in IMCI

Key Facilitators
- Availability of trained IMCI staff
- Community acceptance
- Stakeholder engagement

Key Barriers
- Lack of trained personnel
- Staff turnover
- Device maintenance
- Withdrawal of partner support
- Overreliance on devices in lieu of clinical evaluation
Ensuring uptake of the RadG

- **Train providers first** using a bottom-up approach.
- Provide **piloting opportunities** to PCPs to generate evidence before scaling to additional sites and stakeholders.
Priority measurements for smartphones in IMCI

Participants noted:

- Accessibility and ease of use.
- **Respiratory rate** and **blood oxygen saturation** as priority parameters.
- 60% of consultations are due to respiratory diseases.
SWOT on Mobile technologies and smartphone use in IMCI

Strength
• Ease of use and accessibility of information
• Improved care/decision support
• Timely data collection
• Smartphones used in services
• Potential for e-learning
• Good device design/quality
• Improved patient follow-up
• Online and offline use
• Ability to integrate multiple apps
• Harmonization of support
• Good provider/patient interaction
• Provider commitment
• Good connectivity

Weakness
• Negative client perception
• Unequal access to connectivity
• Multiple devices used by providers
• Work overload
• Risks of data loss
• Theft / misuse

Opportunities
• National digitalization strategy
• Interoperability with DHIS2
• Partner commitment
• Availability of funding
• Enterprise architecture
• TFP engagement in digitalization
• Good internet environment
• Easy access to mobile data
• Possibility of data transmission
• Integration of applications
• Good penetration

Threats
• System bugs
• Data loss
• Theft/loss/damage of devices
• Software security issues
• Multiplicity of tools integrated into smartphones
• Lack of device maintenance policies
• Weakness in sustainability strategies
Perceptions of smartphone use in IMCI

Positive
- Fast, easy access to information
- Facilitates communication
- Reinforces provider knowledge and practices
- Improves quality of care
- Builds trust
- Decision support
- Facilitates follow-up
- Reduces medication
- Improves organization of services

Negative
- Loss of information
- Provider required to provide information on the purpose of tablet
- Potential for misuse
- Time-consuming – wait times
- Lack of qualified personnel
- Unsustainable
Key challenges and concerns of smartphone use in IMCI

- Potential benefits: improved quality of care, better-organized services, and ease of integration with other systems.
- Data privacy and security
- Overreliance on technology and the ability of providers to make clinical decisions.
India HCD Workshop
Summary of Findings
Overview

- Workshops over 3-days in Uttar Pradesh
- **40 participants** across the three stakeholder groups - health management offices, hospitals, and health centers in Uttar Pradesh State.

### Distribution of participants

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![Participant distribution by gender](image)

- **60.0% Male**
- **40.0% Female**
Assessment of RadG integration in IMCI

**Strengths**
- Identify sick child.
- Test life threatening diseases.
- Multimodality
- Time saving
- Non-invasive
- Can be used by a non-professional.
- Useful for triage.
- Works well
- Patients want investigations to be done first.

**Weakness**
- High cost and maintenance.
- Time to measure readings especially Hb and RR in busy OPD
- Lack of support staff.
- Challenging to use in high volume settings.
- Hb parameter can be inaccurate
- Unstable reading on fidgety children.
- A lot of probes will become a problem
- Looks complicated and might take time to understand
- Moisture effect on devices
- Might break if it falls.
- Lack of awareness among patients

**Opportunities**
- Willingness to adapt and use.
- Proper treatment guidelines
- Useful in the field; can share data at health centers
- Patient satisfaction
- Timely screening of large populations and objective in readings.
- Useful in urban/rural sector and government facilities
- Simple device with many functions.
- Useful to global programs as anemia control/detection tool
- Quick referral from CNC to higher centers
- Data for diagnostic and use of data studies.

**Threats**
- Subject to charging failures and electronic interferences
- Electricity problems in rural areas (PHC)
- Difficult to use in high-load settings.
- Lengthy repair and maintenance
- Cost of procurement
- Cheaper devices already available
- Interferences with sunlight and water/moisture
- Human behavior
- Data hacking
- Inaccuracies can lead to wrong clinical decisions.
- Government policies
- Miss or over-diagnose if device provides inaccurate results
Priority MM Device Features and Point of Integration

Recommendations for future MM devices:

- Function as a **spot-checking** and **continuous monitoring** device allowing PCPs to act quickly and efficiently to reduce patient load.
- Integrated at **designated triage areas** – patients prefer consultation to be conducted first.
- Provide results in **less than 1 minute**.
- **Accurate and compatible** with current clinical measurement methods.
- Used for all ages.
- Require minimal maintenance.
- Minimum **7-year shelf life** to reduce financial burden.
Priority measurements for smartphones in IMCI

Participants noted:

+ **Blood oxygen saturation** and **hemoglobin** as priority parameters.
+ **Blood oxygen saturation** allows for timely interventions for pneumonia.
+ **Hemoglobin** is a nationwide issue that faces barriers in measurement including frequent stockout issues with the current means of measurement.
Caregiver perceptions on smartphone use in IMCI

**Positive**
- Fast, easy access to information
- Verify parameters and share information with caregivers and beneficiaries
- Confirmation of diagnosis or treatment
- ABHA- ID patients don’t need physical documents and doctors can access their information easily.
- Telemedicine by CHO and can be used for referral at periphery facilities.
- Paper trail is on one smartphone and is portable for ASHAS.
- ASHAS and ANMS can use it to take pictures as proof when in the field.

"Smartphones have become an integral part of daily life. Easy availability of information and other services." - Caregiver

**Negative**
- Misuse- personal
- Distractions
- Compromise provider/ patient connection
- Caregivers not confident that doctors are listening
- Doubt the accuracy of information that the doctor is putting in the smartphone since they can’t see
- Patients confused as they are not informed about referral process
- Training and refresher courses required.

"Too much dependency on the smartphone can lead to loss of clinical judgement." - Other stakeholders
SWOT on Mobile technologies and smartphone use in IMCI

**Strengths**
- Families can use smartphones to sense abnormalities and alert HCPS.
- Parameters are often not measured can be systematically documented.
- Many patients in facilities, this can help with workload.
- Valid data since it can’t be manipulated.

**Weakness**
- Reduced provider patient interaction
- Dependency can lead to loss of clinical judgement.
- Confidentiality might be breached due to loss of data.
- Work can be disrupted if phones left at home.
- Internet failures

**Opportunities**
- Increase the accuracy of diagnosis algorithms.
- Screening and referral are made easy at the periphery.
- CHWs can be trained.
- Referral will be a requirement as records are there to show.

**Threats**
- Technology failure
- Overuse and over reliance
- Loss of clinical decision making
- Budget concerns
- Clinical skills might be lost.
- Electricity and power failures
- Cyber attacks.