Dynamic clinical decision support algorithms to manage sick children in primary health care settings in Rwanda

Project designed and implemented by

- Centre for Primary Care and Public Health (Unisanté)
- Swiss Tropical and Public Health Institute (Swiss TPH)
- Swiss Federal Institute of Technology (EPFL)

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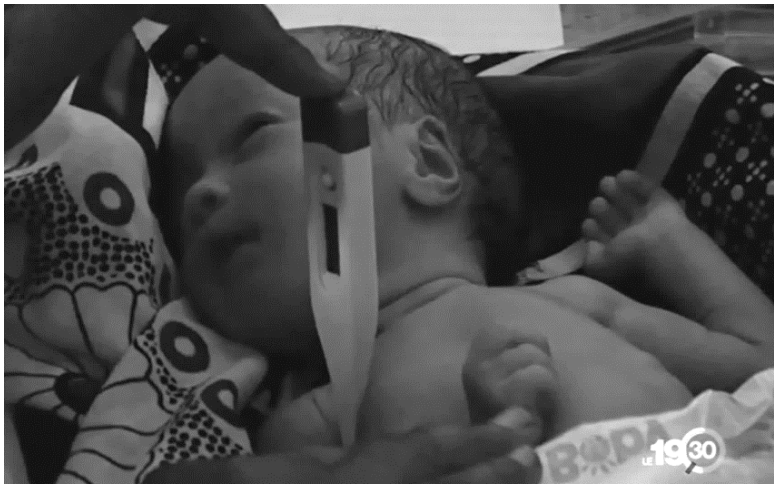
Management of sick children

Static and generic clinical guidelines cannot keep up with new evidence and can become irrelevant or even dangerous with changing epidemiology.

Children still suffer from high rates of acute infectious diseases and preventable deaths due to inadequate clinical management at the primary health care (PHC) level.

In PHC settings, health professionals rely on static and generic guidelines such as the Integrated Management of Childhood Illness (IMCI) booklet, while often lacking diagnostic tools, skills, and supportive supervision. This can lead to misdiagnoses, inappropriate prescription practices, and preventable deaths.



Nearly 5.5 million under 5 children die in low- and middle-income countries per year[1]

Overprescription of antibiotics

Antibiotic consumption in low- and lower middle-income countries increased from 8 to 18 billion defined daily doses between 2000 and 2015[2].

In the absence of diagnostic tools, clear guidance, and supervision, it is challenging for health workers in PHC settings to confidently identify the minority of children with bacterial infections needing antibiotic treatment among the predominant cases of self-limiting diseases[3].

Despite this high-volume and indiscriminate antibiotic treatment, mortality from childhood infections remains high because children with severe infections of non-bacterial origin can be missed[4].


Image credit: ePOCT study

Overprescription of antibiotics

Shown on the left is a health record of an 18-month old child who attended a health facility 12 times. Seven times the child had a fever episode and 11 times an antibiotic was prescribed.

Contributing factors

- Skills and knowledge
- Resources and infrastructure
- Culture and patient expectations
- Diagnostics and decision support

End result

- Poor patient outcome
- Antibiotic side effects
- Destruction of gut flora
- Antibiotic resistance

The WHO has identified digital health interventions and electronic clinical decision support algorithms (CDSAs) in primary health care as key accelerators in achieving the 2030 Sustainable Development Goal 3 of ensuring good health and wellbeing for all.

FABRICE COFFRINI | Credit: AFP

A key challenge is to ensure that all people enjoy the benefits of digital technologies. We must make sure that innovation and technology helps to reduce the inequities in our world, instead of becoming another reason people are left behind.

Countries must be guided by evidence to establish sustainable harmonized digital systems, not seduced by every new gadget. Ultimately, digital technologies are not ends in themselves; they are vital tools to promote health, keep the world safe, and serve the vulnerable.

Dr. Tedros Adhanom Ghebreyesus

Director General, World Health Organization

Evolution of the CDSA

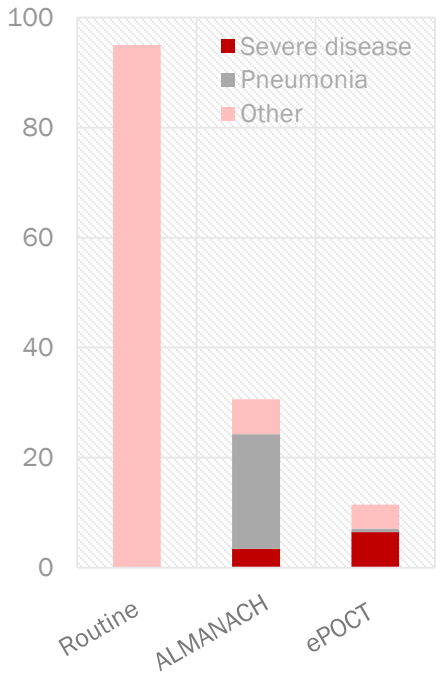
Our research group has been developing and validating electronic CDSAs since 2010.

The **first-generation** algorithm for the management of childhood illness (ALMANACH) was trialed in Tanzania in 2010-2011. The content of ALMANACH was largely based on IMCI guidelines.

ALMANACH achieved improved clinical cure (from 92% to 97%) and decrease in antibiotic prescriptions (from 84% to 15%) as compared to routine care[5].

The **second-generation** algorithm called ePOCT, 'electronic Point of Care Tests' was also trialed in Tanzania in 2014-2016. In addition to symptoms and signs, it made use of several POC tests to help detect children with severe infections.

The use of ePOCT resulted in higher clinical cure (98%) as compared to ALMANACH (96%) and routine care (95%) and further reduced antibiotic prescription to 11%, as compared to ALMANACH (30%) and routine care (95%) – results shown on the right[4].



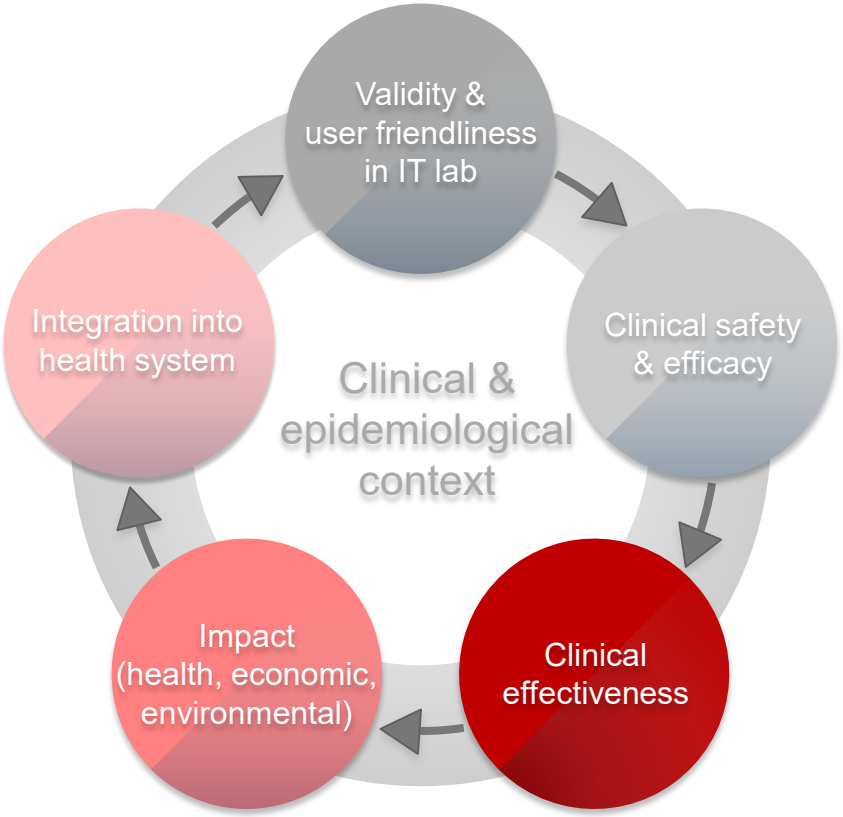
Evolution of the digital CDSA ecosystem

The DYNAMIC project will implement a **third-generation** CDSA called ePOCT+.

Its medical content has been expanded to cover not only febrile children aged 2 months to 5 years (IMCI age range) but the entire pediatric age range (1 day to 14 years).

The CDSA will be accompanied by other electronic tools to facilitate uptake and integration into the health system and ensure sustainability.

The project will include economic and environmental evaluations and other operational research activities.



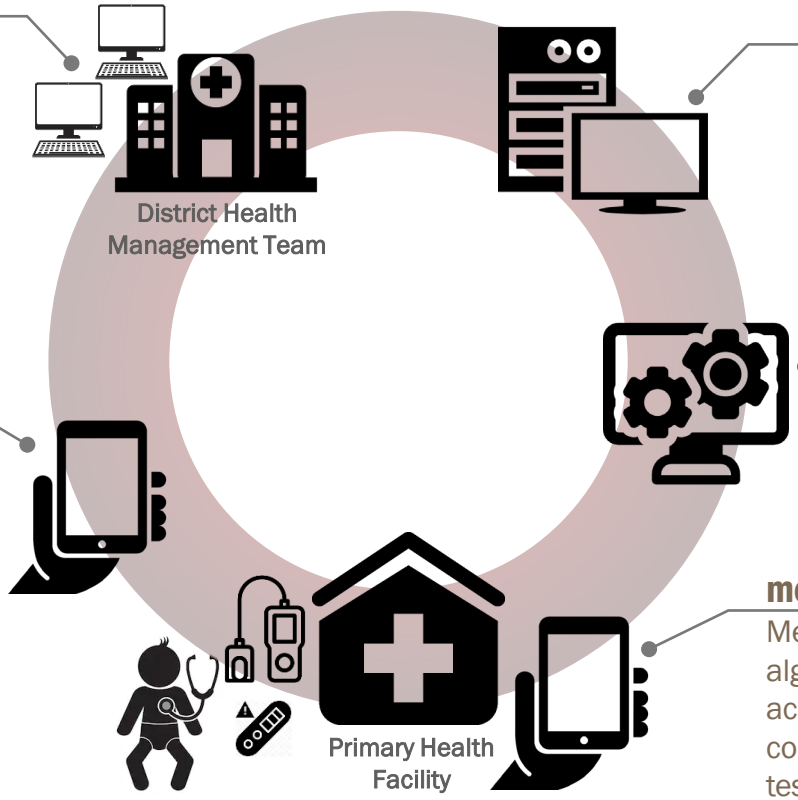
Project objectives

- **Improve the integrated management of children with an acute illness** through the provision of an electronic CDSA to clinicians working at PHC level.
- **Improve the diagnostic and prognostic accuracy of the CDSA** across spatiotemporal variations in epidemiology and resources through machine learning analyses of patient-level data.
- **Enhance the health management information system** for monitoring and evaluation and supportive supervision through innovative analysis and visualization of patient-level data.
- **Create a framework for the implementation of dynamic CDSAs** and supporting tools for large-scale, sustainable, and clinically responsible use of machine learning and data science in digital health.

The goal of the DYNAMIC project is to improve quality of care and promote antibiotic stewardship using an electronic CDSA that helps front-line health workers manage sick children

Digital ecosystem

medAL-*outbreak*
Displays syndromic surveillance and performance indicators of primary health facilities



medAL-*data*
Central server stores patient-level data from the system

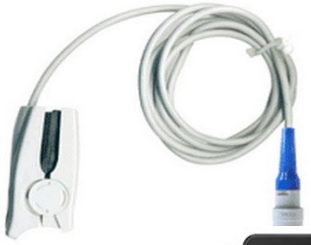
medAL-*creator*
Medical Algorithm Creator used to program the algorithm (ePOCT+) and adapt it to local conditions

medAL-*monitor*
Enables health workers to self-audit their clinical practices

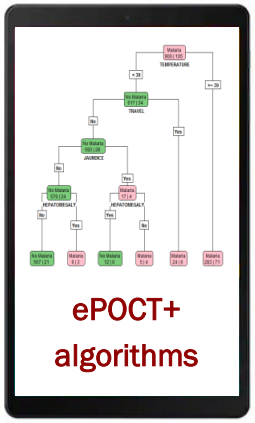
medAL-*reader*
Medical Algorithm Reader displays the algorithm (ePOCT+) on the tablet, accepts inputs from the clinical consultation, pulse oximeter and POC test results. Displays eLearning content.

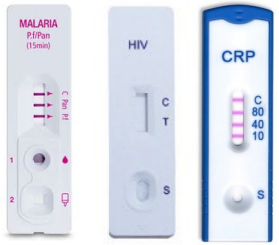
Zooming in on the consultation

Hemoglobinometer



Pulse oximeter





Rapid diagnostic tests
(Malaria, HIV, C-reactive protein)

Clinical signs &
symptoms

The Conversation, December 11, 2019

Urine dipstick

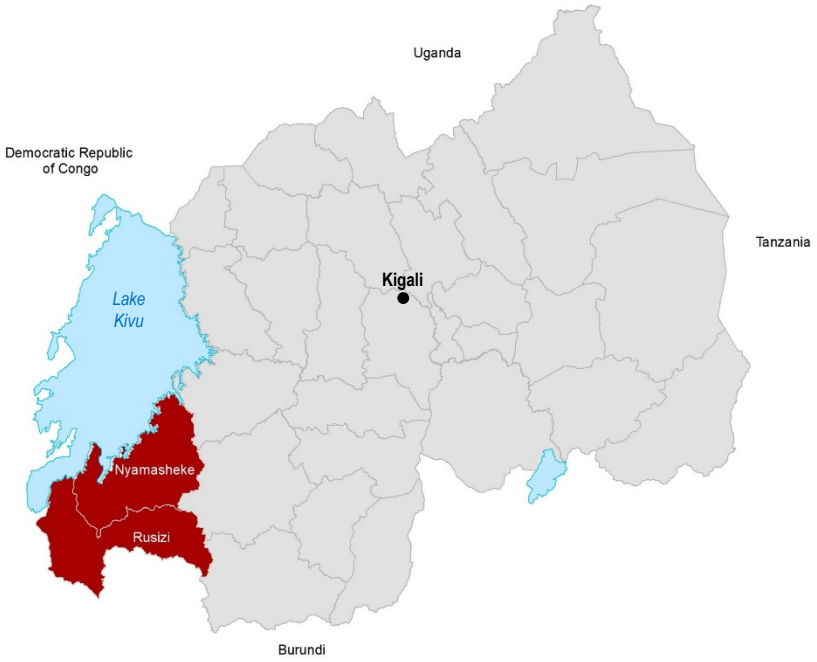
Tablet-based application accepts clinical signs and symptoms, measurements and test results, algorithm provides recommendations for diagnoses, treatments, management and referral.

Study area

The study will be conducted in 32 primary health facilities in Rusizi and Nyamasheke districts of the Western Province, bordering Lake Kivu, DRC and Burundi.

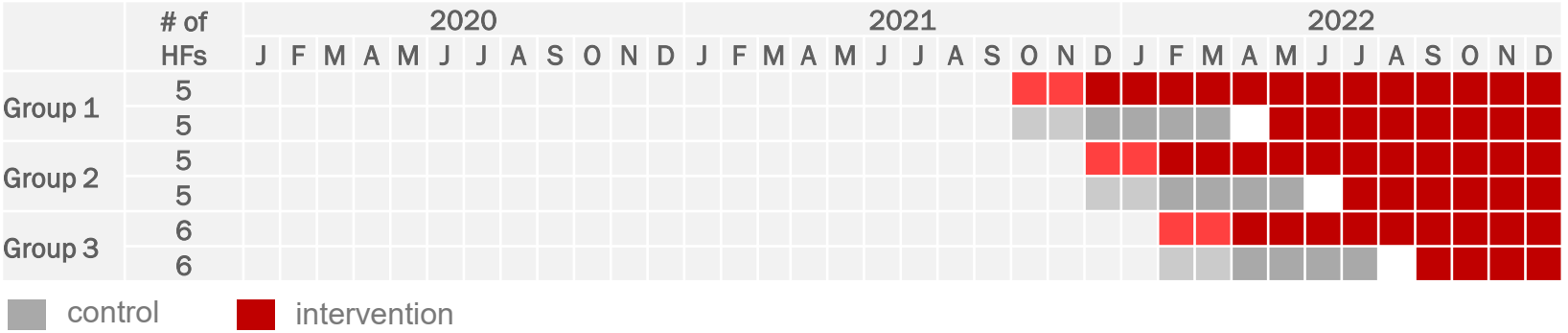
The Western Province is largely rural (88%)[6] and has some of the highest rates of extreme poverty in Rwanda (21.6%)[7].

Rusizi and Nyamasheke districts were selected due to their higher rates of fever and respiratory conditions (2019 HMIS data), and greater diversity of health conditions due to borders with Lake Kivu along its north-western edge and a national forest along the south-eastern edge.



Sequential rollout

The intervention will be introduced into the health facilities gradually using a **parallel cluster randomized controlled trial** study design. Gradually, 10-12 health facilities (half intervention and half control) will be added to the study in three groups (starting with a pilot period in two facilities). In the intervention health facilities, the tablet-based CDSA will guide the health workers through the consultations with sick children, supported by additional POC tests. In the control health facilities, health workers will conduct consultations in a routine manner, but will record some data using a tablet-based data collection form. After four months, control facilities will receive the intervention.



Main study

The objective of the main study is to achieve a reduction in antibiotic prescriptions without compromising on the cure rate.

In both the intervention and control facilities, each eligible child (aged 1 day to 14 years presenting with any acute condition) whose caregiver provides written informed consent will be registered in an electronic database using a tablet. In intervention health facilities, all clinical information from the consultation will be stored in the tablet and the study database. In the control health facilities, only the final diagnoses, laboratory test results, management and treatment plan will be recorded using a case report form. After 7 days following the consultation, all children (in both arms) will receive a follow-up phone call to determine the child's condition.

- **Primary outcome:** % of children prescribed an antibiotic at day 0
- **Secondary outcome:** % of children cured at day 7


Image credit: ePOCT study

Operational research

The objective of the mixed-methods operational research studies is to evaluate the implementation context and potential for scale-up and integration of the intervention into the health system.

Throughout the study, operational research will be conducted using mixed methods approaches, including:

- Health facility assessments
- Quality of care assessments (matched observation of clinical consultations and client exit interviews)
- Quantitative surveys with caregivers and health workers
- Qualitative in-depth interviews with caregivers, health workers, members of DHMT, and other stakeholders
- Focus group discussions with health workers and community members

Community Eye Health Journal, 2012

Machine learning

In latter stages of the study, different versions of the algorithms (identified by machine learning) may be deployed in geographic locations with an ongoing outbreak or for special patient sub-groups.

Two main types of machine learning methods will be employed:

- **Supervised classification and correlation:** aims to create algorithms that better predict the value of a labeled feature (e.g. more accurate prediction of the outcome for a malnourished child which the addition of an HIV test result)
- **Anomaly detection:** aims to find unusual clusters of values for a certain place, time, or person, and is the basis of outbreak detection and discovering erroneous data inputs.

As patient-level data accumulate in the study database, machine learning methods will be used to improve prognostic capacity of the algorithms for various epidemiological conditions and patient sub-groups.

Capacity building

Kenya Medical Association, January 2018

E-learning modules will be installed on the tablets to promote continuous learning and professional development.

The modules will be embedded into the consultation flow as well as a repository of content made available for reference.

The modules will contact instructional videos, images (e.g. to aid in recognizing various skin conditions), sound clips, and written explanations. In latter stages of the project, the content may be converted into a more interactive format.

Dashboards with targeted indicators will enable self-auditing of clinical practices and quality improvement.

Dedicated platforms (medAL-*monitor* and medAL-*outbreak*) will be used to display syndromic surveillance and quality of care indicators.

The objective of the platform is to promote dialogue and a quality improvement process between the health workers in the health facilities and the District Health Management Team conducting supportive supervision and mentorship.

Interoperability

In latter stages of the project, interoperability with existing eHealth tools, such as medical records and health management information systems, will be explored.

ePOCT+/medAL-*reader* is a clinical decision support system and not a medical record system.

However, the team recognizes that clinical information entered into the application creates a duplicative data entry workflow for the health care provider.

As such, we are committed to implement IT interoperability standards such as FHIR, as well as testing specific use cases of information exchange between the following systems:

- OpenMRS an open-source medical record system
- dhis2 an open-source health management information system

Impact

200,000

Anticipated number of children managed

88%

Anticipated reduction in antibiotic prescriptions

3%

Anticipated increase in cure rate

Apart from sick children managed with ePOCT+, the project has many other direct and indirect beneficiaries.

Direct: 200 health workers will benefit from improved clinical skills, 20 members of DHMT will benefit from the use of MedAL-*monitor* and MedAL-*outbreak*; 50 individuals will benefit from additional IT and/or machine learning skills.

Indirect: Up to 780,000 people, or the entire population of the intervention districts will benefit indirectly from less exposure to infectious diseases due to better cure rates of sick children, reduced drug pressure and likelihood of antibiotic resistance due to reduced antibiotic prescriptions, and reduced risk of illness due to more effective outbreak detection and response.

team

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Swiss Tropical and Public Health Institute

Schweizerische Eidgenossenschaft
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