# A human-centred design approach towards development of a digital clinical decision-support system for management of hospitalised patients with dengue

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**Dengue** epidemics can rapidly increase demand in healthcare services across many endemic settings. However, there remains a lack of tools which can rapidly inform patient management and can be used at the point of care. Digital **clinical decision-support systems** (CDSS) allow for efficient organisation of care as well as improve the quality of patient management. It is important that these tools are designed for the end-user and with the healthcare setting in mind to increase adoption and usability.

## Aim

To develop CDSS to improve dengue management.

## Method

We adopted a **ground-up human-centred** design approach to identify key decision-support areas, generate ideas, build prototypes iteratively and develop main CDSS functionality.

**Process mapping** and **task analysis** were used to characterise existing dengue management at the Hospital for Tropical Diseases (HTD) in Ho Chi Minh City, Vietnam. The facility manages around **30,000** patients with dengue each year, of which 8,000-15,000 are admitted to hospital.

## Process mapping

A complete **process map** of patient management was constructed for contextual background through observation of ten consecutive adult and paediatric patients with confirmed diagnosis of dengue. [1]

## Semi-structured interviews

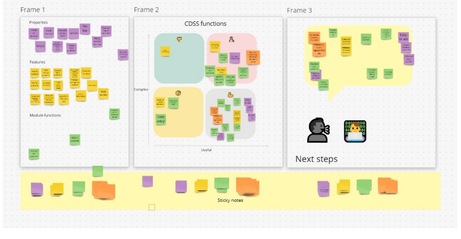
Identify **clinical reasoning** and **cognitive factors** [1]. Interviews were conducted remotely, recorded and transcribed into English for analysis. Thematic saturation was achieved after 10 interviews (5 consultants, 3 junior doctors and 2 senior doctors).

| Theme | Outcome |
|---|---|
| **Assessment** | The main clinical decision-making **stages** are: (i) initial patient evaluation (ii) disease severity and complications and (iii) re-current shock. |
| **Diagnosis** | Dengue specific **diagnostic tests and investigations** do not play a mayor role yet due to limitations in performance, turnaround time and availability. |
| **Guidelines** | Dengue management is **protocolized** by guidelines with (i) difference between adults and pediatric and (ii) limitations (e.g., re-current shock). |
| **Seasonality** | **External factors** such as workload or disease prevalence play a large role in decision making. |
| **CDSS** | Digital clinical decision-support systems are welcomed but **barriers** need to be addressed.<br>- impact on clinical skills<br>- how to use risk<br>- easy learning curve<br>- avoid duplicated data entry |

## Workshops

Following a human-centered design process to develop the user interface. First, **online** workshop to identify **priorities for dengue** management and identify the most useful functionality. Second, **in-person** workshop to **discuss** the initial **prototype**.

| CDSS functionalities |
|---|
| Data **collection** (e.g., history)<br>Data **visualization** (e.g., vital signs)<br>Simplify **patient management** (EHR) |
| Integration of dengue **guidelines**<br>Integration of **fluid calculators**<br>**Discharge summary generation**<br>Integration of **language switching** |
| **Diagnosis** of dengue on admission<br>**Severity stratification** and possible complications |




## Implementation

### Machine Learning

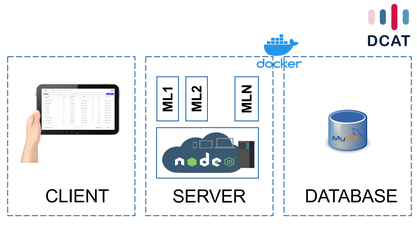
**Dengue** diagnosis was developed using previously collected data for 8,100 patients. In total 2,240 (27.7%) patients were diagnosed with dengue. Predictors were age, gender, haematocrit, platelets, white cell count and lymphocyte count. The model was XGBoost with a dynamic threshold to account for seasonality.

Prediction of **severity** was developed using previously collected data for 4,131 patients. Dengue shock syndrome was experienced by 222 (5.4%). Predictors were age, gender, weight, haematocrit and platelets over the first 48 hours. The model was an artificial neural network.

| | AUC [CI] | SPEC | SENS | PPV | NPV |
|---|---|---|---|---|---|
| **Dengue** [2] | 0.86 [0.84 – 0.86] | 0.92 | 0.56 | 0.75 | 0.87 |
| **Severity** [3] | 0.83 [0.76 – 0.85] | 0.84 | 0.66 | 0.18 | 0.98 |

### Dengue Clinical Application Tool (D-CAT)[1]

DCAT is a bespoke and rapidly scalable CDSS produced following clinical pathways, clinician's needs and usability in mind. It is a responsive **web-based** application accessible through any device.




## Conclusion

The challenges faced for digital health implementation in low- and middle-income countries (LMICs) should not simply be considered as additional barriers to be overcome, but rather require a **fundamentally different approach** from the onset.

## Future work

First generation D-CAT prototype to be presented to **stakeholders** in a workshop. Prospective evaluation of the system in two main areas (i) clinical usability of the the system and improvements to the user interface through feedback and (ii) prospective model performance, interpretability and human behavior.

Further **Integration** of D-CAT with existing **electronic health records** (EHR) and other laboratory information systems at HTD.

Explore **regulatory approval** process in Vietnam for conformity with MOH Decree 98/2022 ND-CP; that is, software as a medical device.

## References

**[1]** Huy NQ, Ming DK, et al. *Mapping patient pathways and understanding clinical decision-making in dengue management to inform the development of digital health tools*. BMC Medical Informatics and Decision Making. 2022 Aug 04 *[Under review]*

**[2]** Ming DK, Tuan NM, et al. *The Diagnosis of Dengue in Patients Presenting With Acute Febrile Illness Using Supervised Machine Learning and Impact of Seasonality.* Frontiers in digital health. 2022 Mar 14;4.

**[3]** Ming DK, Hernandez B, et al. *Applied machine learning for the risk-stratification and clinical decision support of hospitalised patients with dengue in Vietnam.* PLOS Digital Health. 2022 Jan 18;1(1):e0000005.

Process Mapping → Interviews → Workshops → Implementation → Deployment

[1] https://cdss.nguyentd.com/ with username 'test@test.com' and password '123456'