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MEDELLÍN 2023

# Aprovechamiento de la inteligencia artificial para mejorar el diagnóstico y tratamiento del dengue

William Hoyos, PhD

# Contexto

- Dengue virus (DENV)
- Vector: *Aedes spp.*
- Salud pública
- 390M infecciones por año[1]
- 20.000 muertes[1]

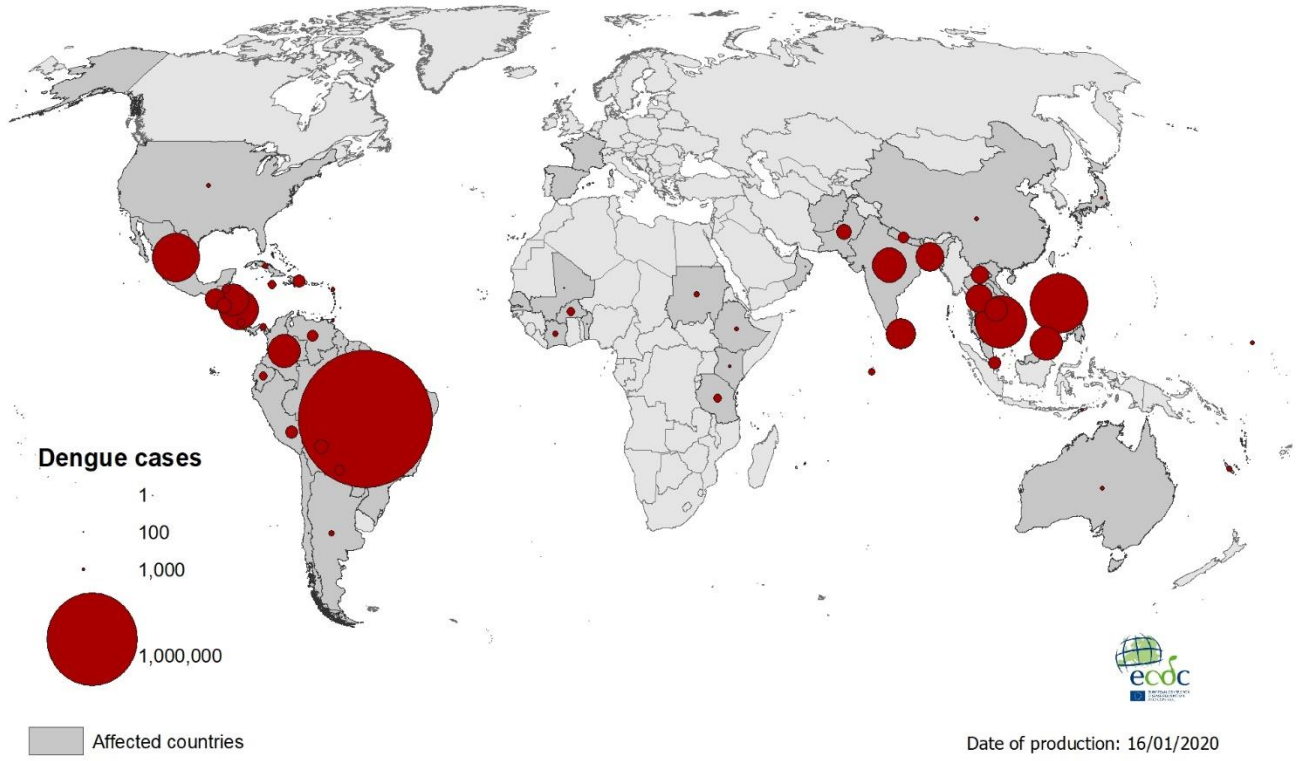



**Figura 1.** Distribución geográfica del dengue en el mundo, 2019.[2]

# Contexto

## Manejo clínico del dengue[3]

- Diagnóstico complejo
- Guías de la OMS
  - Criterios
  - Basados en severidad

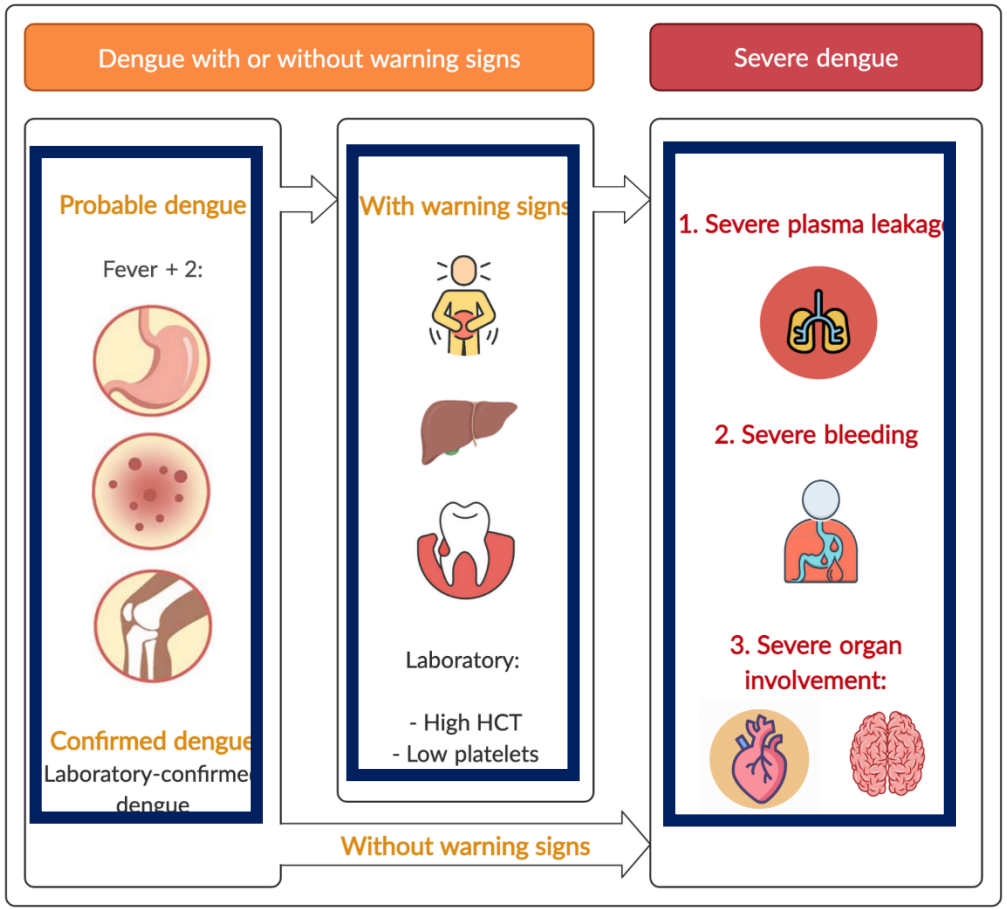



**Figura 2.** Criterios para diagnóstico de dengue. Adaptado de las Guías de la OMS.[4]

# Contexto

## Manejo clínico del dengue[1]

- Tratamiento paliativo
  - Paracetamol
  - Rehidratación
  - Hospitalización
- Dificultad para tratar pacientes

**Figura 3.** Pediatric patients affected by dengue virus.*

# Contexto

- Manejo clínico del dengue
- Errores en los datos
- Dificultades para el diagnóstico y tratamiento
- Ciclo de tareas de análisis de datos

**Figura 4.** Metaphorical representation of decision-making.*

# Metodología

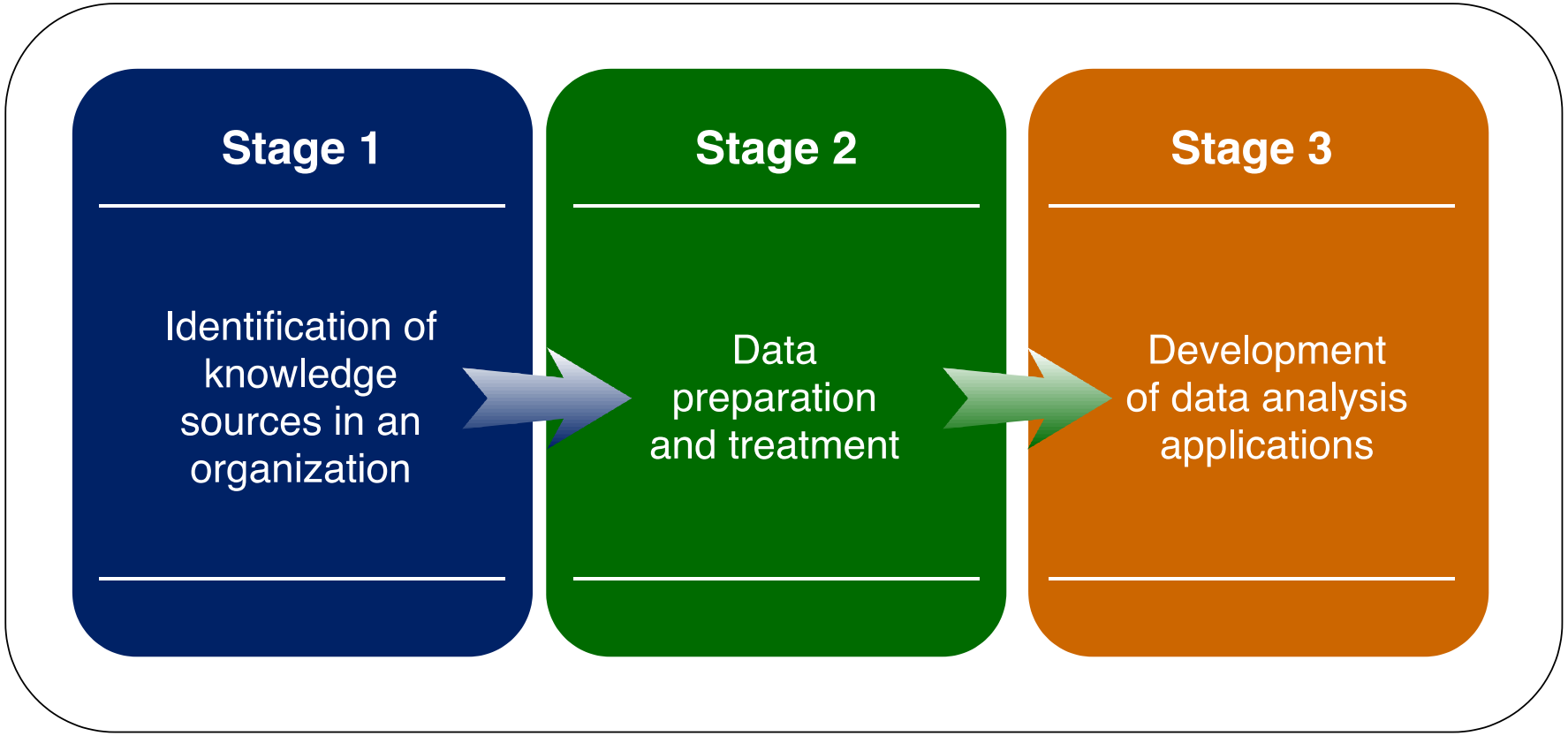



**Figura 5.** Diagrama de la metodología MIDANO

# Ciclo autónomo de tareas de análisis de datos

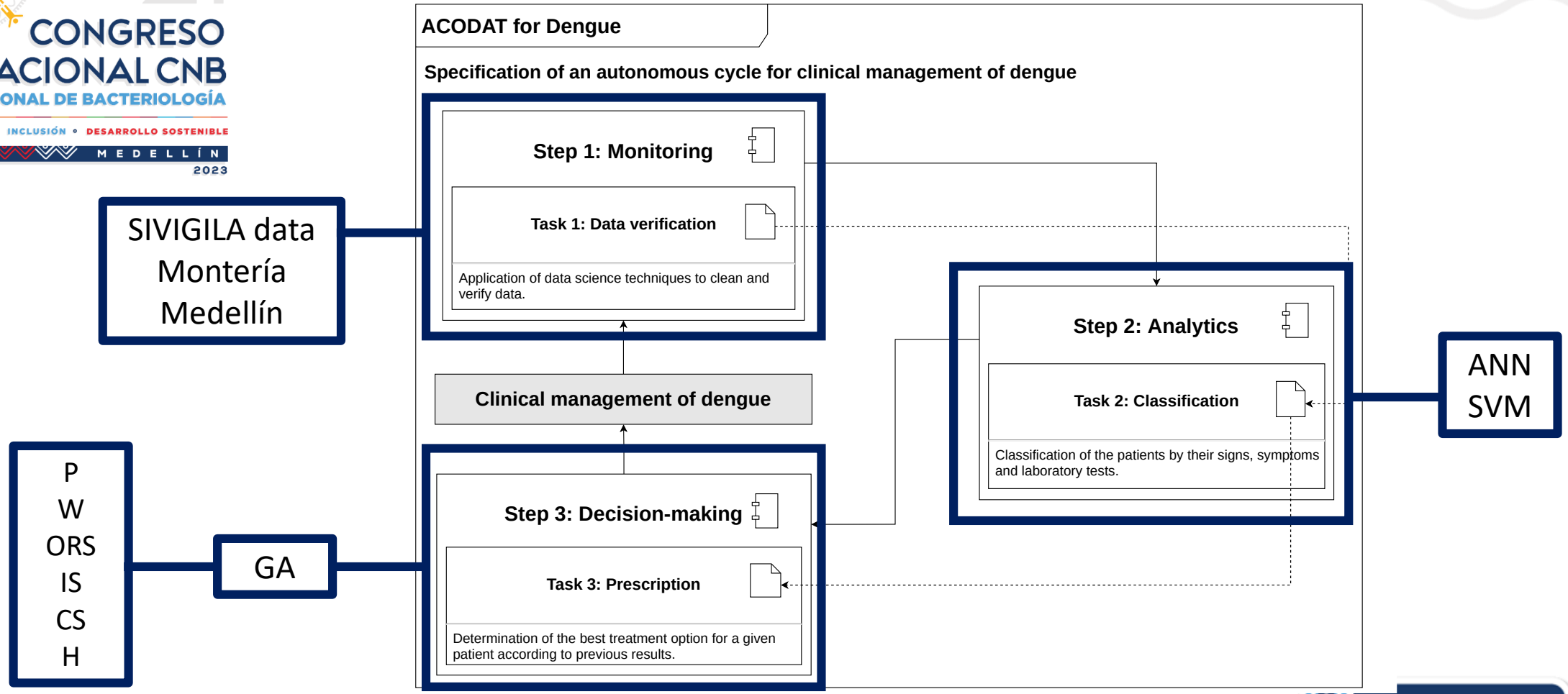



**Figura 6.** ACODAT para el manejo clínico del dengue.

# Variables usadas para la construcción de los modelos

Dataset

Target = severidad

- Sin signos de alarma
- Con signos de alarma
- Severo

**Tabla 1**. Algunas variables usadas para desarrollar los modelos.

| Concept name | Type of variable | Description |
|---|---|---|
| Age | Demographic | Time elapsed since the birth of an individual |
| Fever | Sign/symptom | Increase of body temperature |
| Cefalea | Symptom | Pain and discomfort located in any part of the head |
| Pain BE | Symptom | Pain behind eyes |
| Myalgias | Symptom | Muscle aches |
| Arthralgias | Symptom | Joint pain |
| Rash | Sign/symptom | Skin exanthema |
| Abd pain | Sing/symptom | Intense pain, located in the epigastrium and/or right hypochondrium |
| Vomit | Symptom | Violent expulsion by the mouth of what is contained in the stomach. |
| Lethargy | Sign/symptom | State of tiredness and deep and prolonged sleep |
| Hypotens. | Sign | Excessively low-blood pressure on the artery wall |

# Desempeño del modelo para clasificar

**Tabla 2.** Resultados e hiperparámetros de los modelos de clasificación.

| Model | Hyperparameters | Accuracy | F1-Score |
|---|---|---|---|
| ANN | • 256 hidden units<br>• ReLU<br>• Adam<br>• $\alpha = 0.01$ | 0.979 | 0.978 |
| SVM | • Radial kernel<br>• C = 10<br>• $\gamma = 10$ | 0.981 | 0.981 |

# Desempeño del modelo para prescribir tratamiento

**Escenario clínico 1:** paciente de 65 años con: fiebre, cefalea y mialgias.

**Tabla 3.** Resultados de clasificación y prescripción para un paciente con dengue sin signos de alarma.

| Variables (age, signs, symptoms and laboratory tests) | | | | | | | | | | | | | | | | | | | | Dengue type | Treatment options | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | V13 | V14 | V15 | V16 | V17 | V18 | V19 | V20 | V21 | V22 | P | W | ORS | IS | CS | H |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| Classification task ↓ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | - | - | - | - | - | - |
| Prescription task ↓ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |

# Desempeño del modelo para prescribir tratamiento

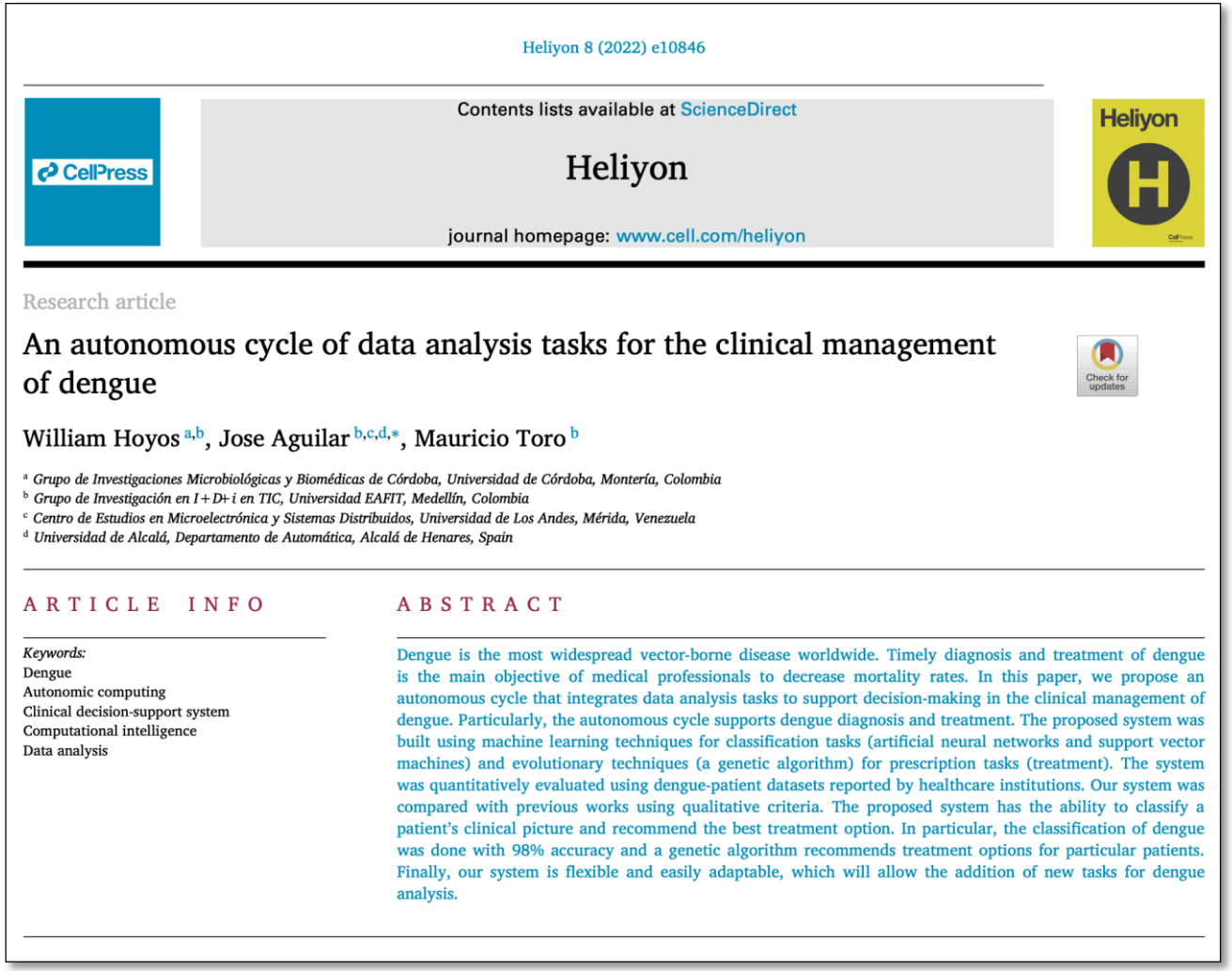
**Escenario clínico 2**: paciente de 35 años con: cefalea, mialgias, artralgias, vómitos, dolor abdominal.

**Tabla 4.** Resultados de clasificación y prescripción para un paciente con dengue con signos de alarma.

| Variables (age, signs, symptoms and laboratory tests) | | | | | | | | | | | | | | | | | | | | Dengue type | Treatment options | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 | V13 | V14 | V15 | V16 | V17 | V18 | V19 | V20 | V21 | V22 | P | W | ORS | IS | CS | H |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| Classification task ↓ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | - | - | - | - | - | - |
| Prescription task ↓ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 |

# Conclusiones

- Propusimos un ciclo autónomo de tareas de análisis de datos para el manejo clínico del dengue.
- Excelente desempeño para clasificar a los pacientes según el tipo de dengue.
- Nuestro método prescriptivo recomienda las mejores opciones de tratamiento para el dengue.



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Research article

# An autonomous cycle of data analysis tasks for the clinical management of dengue

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ARTICLE INFO

*Keywords:*
Dengue
Autonomic computing
Clinical decision-support system
Computational intelligence
Data analysis

ABSTRACT

Dengue is the most widespread vector-borne disease worldwide. Timely diagnosis and treatment of dengue is the main objective of medical professionals to decrease mortality rates. In this paper, we propose an autonomous cycle that integrates data analysis tasks to support decision-making in the clinical management of dengue. Particularly, the autonomous cycle supports dengue diagnosis and treatment. The proposed system was built using machine learning techniques for classification tasks (artificial neural networks and support vector machines) and evolutionary techniques (a genetic algorithm) for prescription tasks (treatment). The system was quantitatively evaluated using dengue-patient datasets reported by healthcare institutions. Our system was compared with previous works using qualitative criteria. The proposed system has the ability to classify a patient's clinical picture and recommend the best treatment option. In particular, the classification of dengue was done with 98% accuracy and a genetic algorithm recommends treatment options for particular patients. Finally, our system is flexible and easily adaptable, which will allow the addition of new tasks for dengue analysis.

**Figura 7.** Captura del artículo publicado

**¿Cómo podemos construir un modelo con diferentes entidades de salud sin vulnerar la privacidad y seguridad de los datos de los pacientes?**

# Contexto

- Google en 2017[1]
- Modelos locales
- Modelos globales
- Privacidad

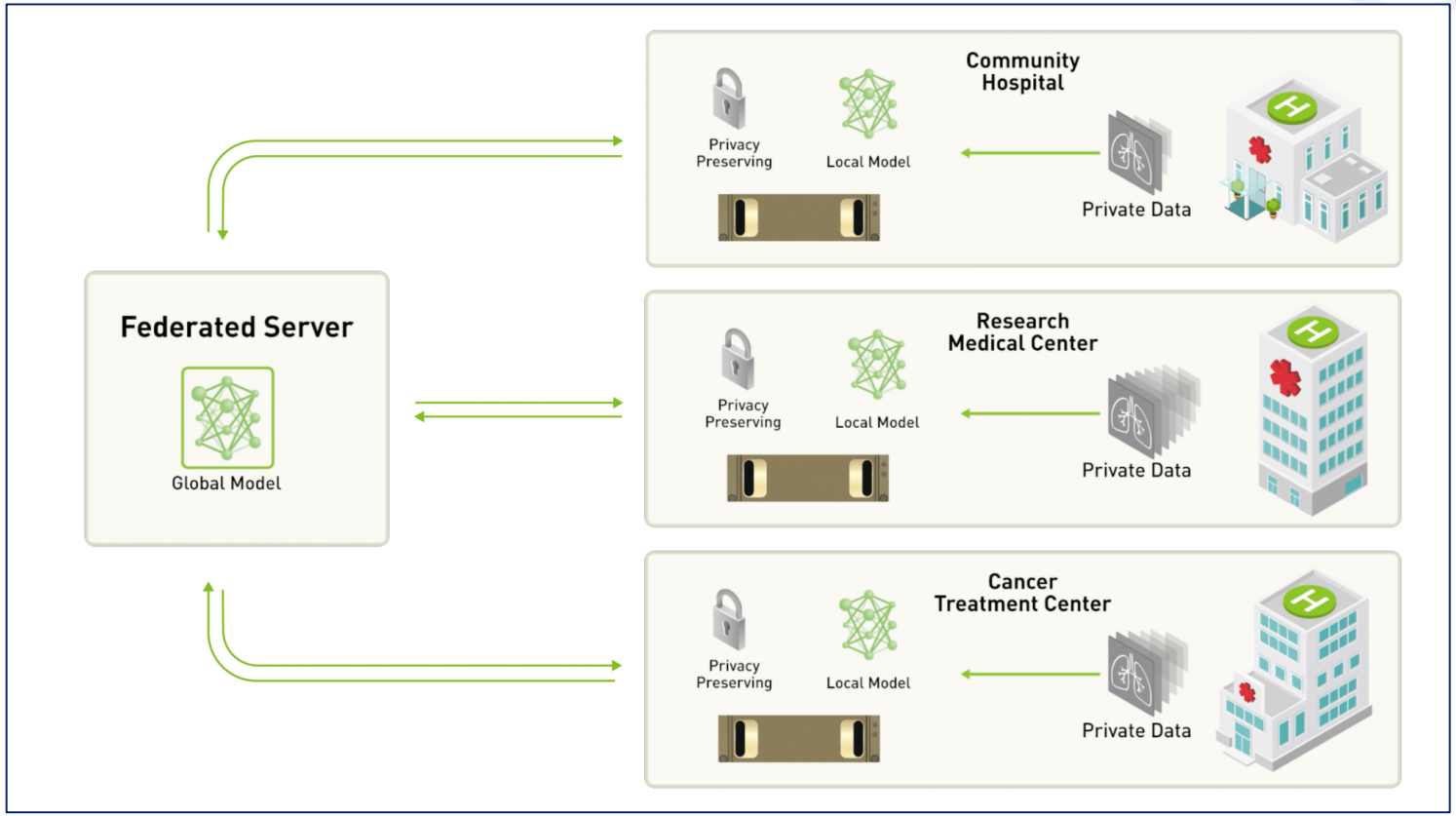



**Figura 8.** Representación esquemática de aprendizaje federado.

# Metodología

- Modelos locales
- Proceso de agregación

$$W_{ij}^{G} = \frac{1}{n}\sum_{c=1}^{n} W_{ij}^{c}$$

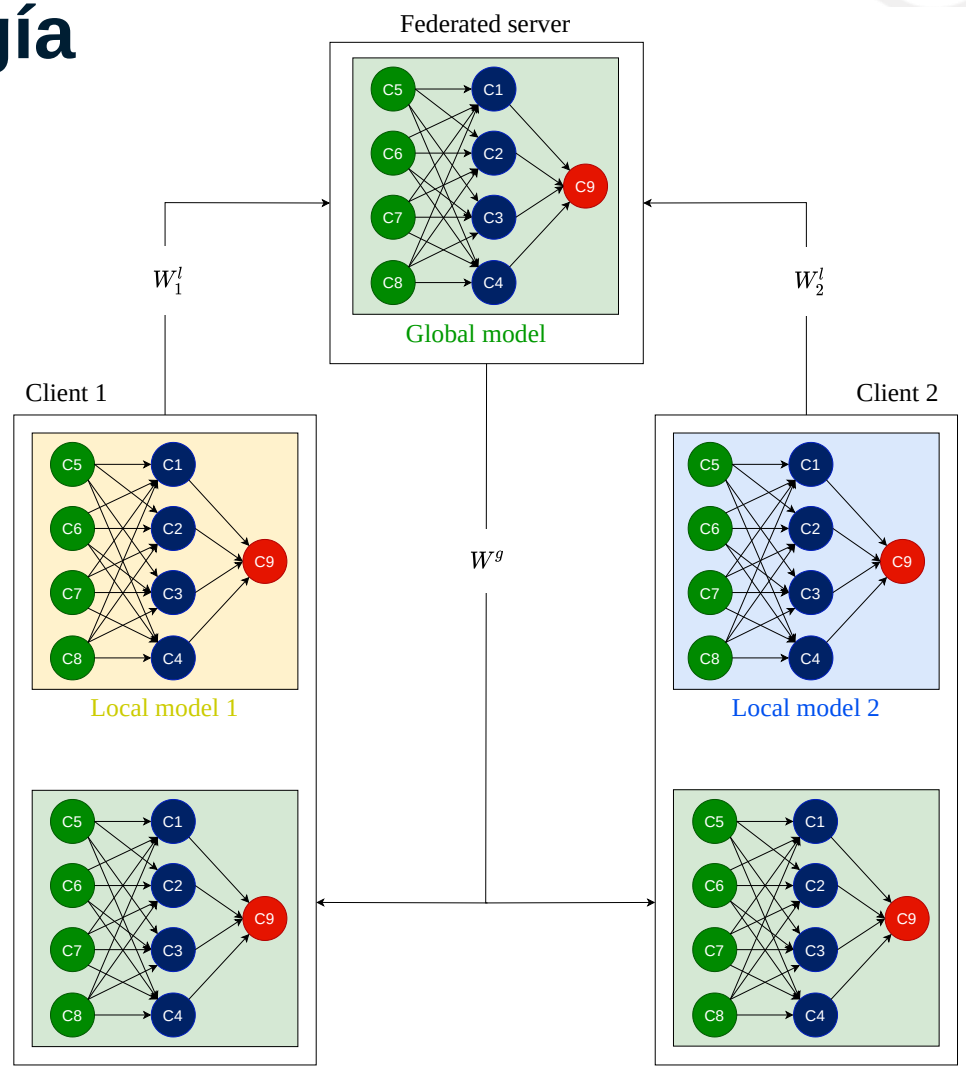



**Figura 9.** Aprendizaje federado para dengue.[2]

# Resultados

**Tabla 5.** Resultados de aprendizaje federado para dengue.

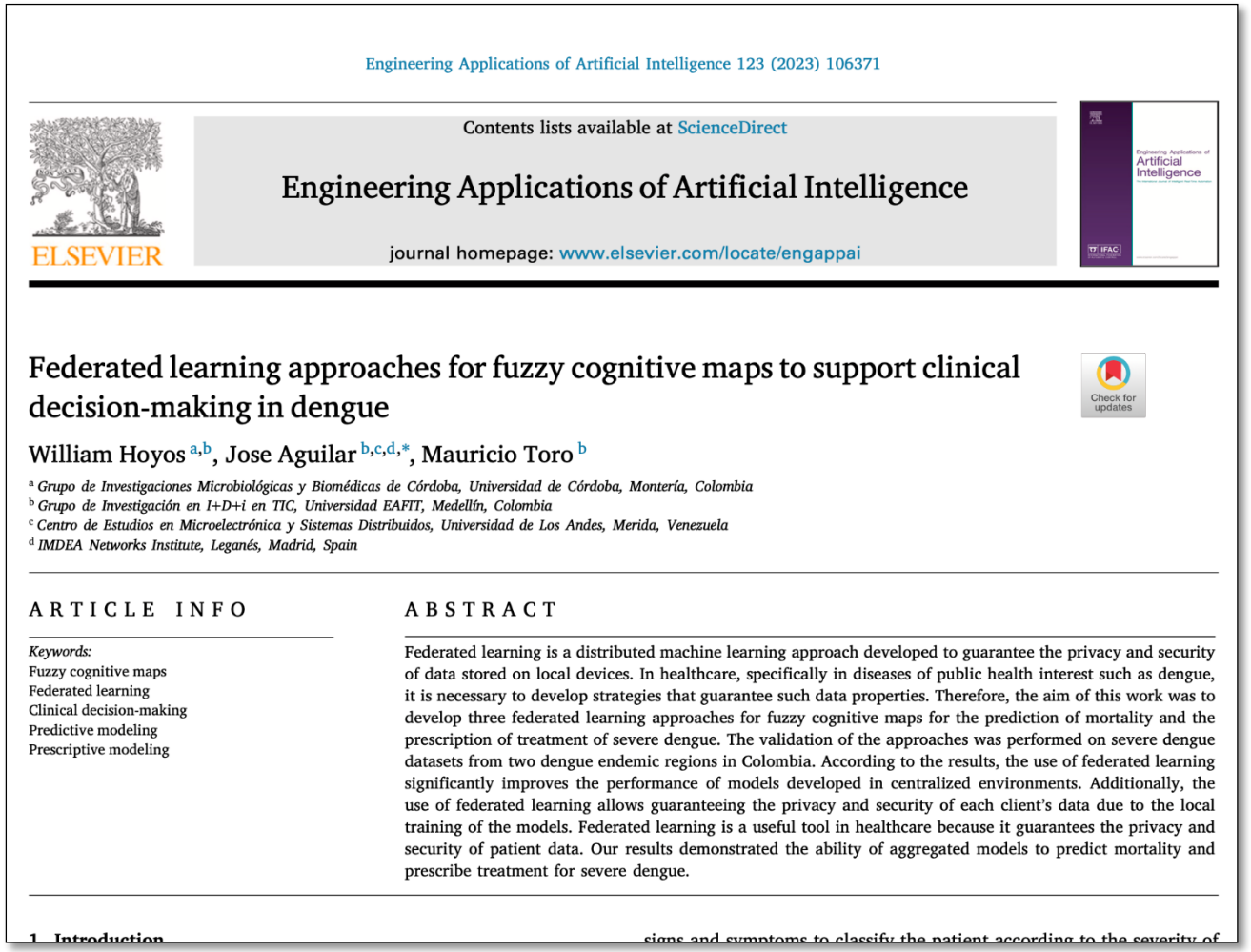
| Data type | Model | Data configuration | Task | Accuracy |
|---|---|---|---|---|
| Signs, treatment options and target | Local 1 | Local data from Medellín | Prediction | 0.68 |
| | | | Prescription | 0.87* |
| | Local 2 | Local data from Córdoba | Prediction | 0.74 |
| | | | Prescription | 0.86* |
| | Global federated | NA | Prediction | **0.76** |
| | | | Prescription | **0.96*** |
| | Global non-federated | Centralized data | Prescription | 0.88 |

# Conclusiones

- Desarrollamos enfoques de aprendizaje federado para apoyar la toma de decisiones en el manejo clínico del dengue.
- Los enfoques propuestos aseguran la privacidad de los datos.
- Los enfoques propuestos muestran alternativas a los enfoques propuestos en la literatura.

# Limitaciones y trabajos futuros

- No se disponía de otras variables sobre el dengue.
- Añadir otras variables, como las citocinas y el recuento de células sanguíneas, podría ayudar a comprender mejor el proceso de manejo clínico del dengue.
- El número de regiones utilizadas para la modelización.
- Utilizar un mayor número de ciudades podría mejorar el rendimiento de los modelos propuestos.
- Estos son sistemas de apoyo y no reemplazan la labor del profesional médico.



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# Federated learning approaches for fuzzy cognitive maps to support clinical decision-making in dengue

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ARTICLE INFO

*Keywords:*
Fuzzy cognitive maps
Federated learning
Clinical decision-making
Predictive modeling
Prescriptive modeling

ABSTRACT

Federated learning is a distributed machine learning approach developed to guarantee the privacy and security of data stored on local devices. In healthcare, specifically in diseases of public health interest such as dengue, it is necessary to develop strategies that guarantee such data properties. Therefore, the aim of this work was to develop three federated learning approaches for fuzzy cognitive maps for the prediction of mortality and the prescription of treatment of severe dengue. The validation of the approaches was performed on severe dengue datasets from two dengue endemic regions in Colombia. According to the results, the use of federated learning significantly improves the performance of models developed in centralized environments. Additionally, the use of federated learning allows guaranteeing the privacy and security of each client's data due to the local training of the models. Federated learning is a useful tool in healthcare because it guarantees the privacy and security of patient data. Our results demonstrated the ability of aggregated models to predict mortality and prescribe treatment for severe dengue.

1. Introduction ... signs and symptoms to classify the patient according to the severity of

**Figura 10.** Captura del artículo publicado.

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# Muchas gracias

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