



Institute for Health
Metrics and Evaluation

AI and verbal autopsy: Predicting pregnancy-related causes of death

Abraham D. Flaxman

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Outline

Sustainable Development Goals

Cause-of-Death Prediction

Verbal Autopsy Interviews

Generative AI for Cause-of-Death Prediction from Verbal Autopsy Interviews

Sustainable Development Goals



2024 Report

The Event

The Mission

The Work

The Goalkeepers

Introduction

Solutions

The Next Frontier

Afterword

Explore The Data

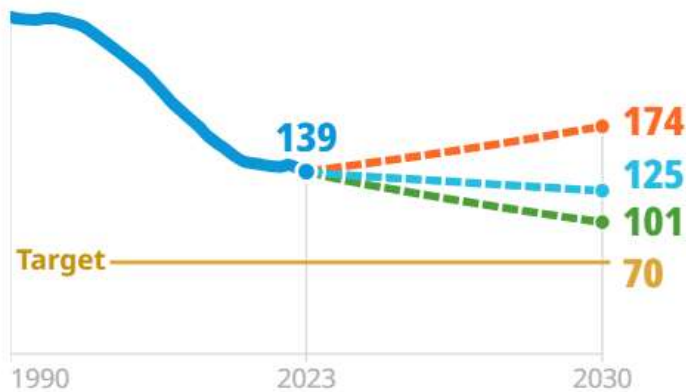
Download the Report ↓



Good Health & Well-Being

Maternal Mortality

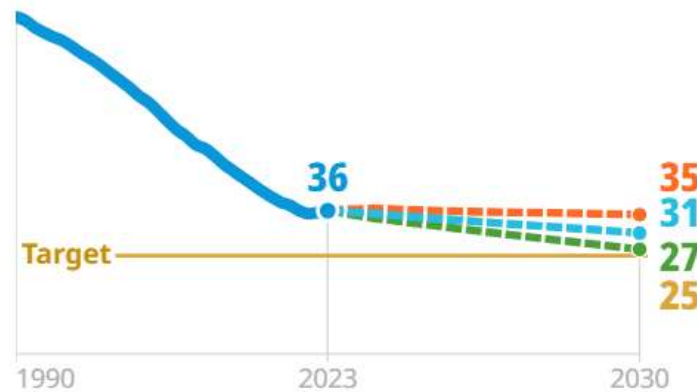
Maternal deaths per 100,000 live births



Good Health & Well-Being

Under-5 Mortality

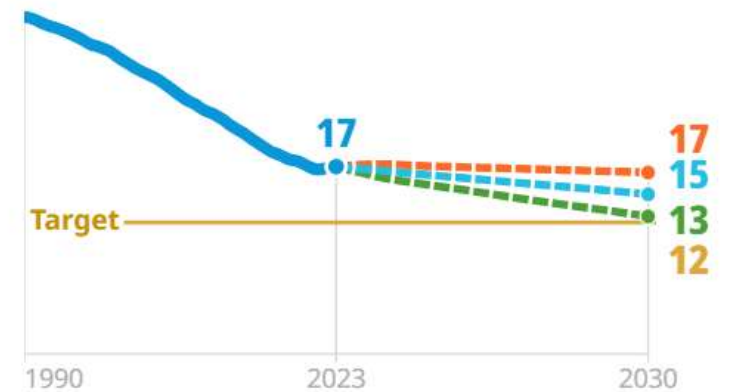
Under-5 deaths per 1,000 live births



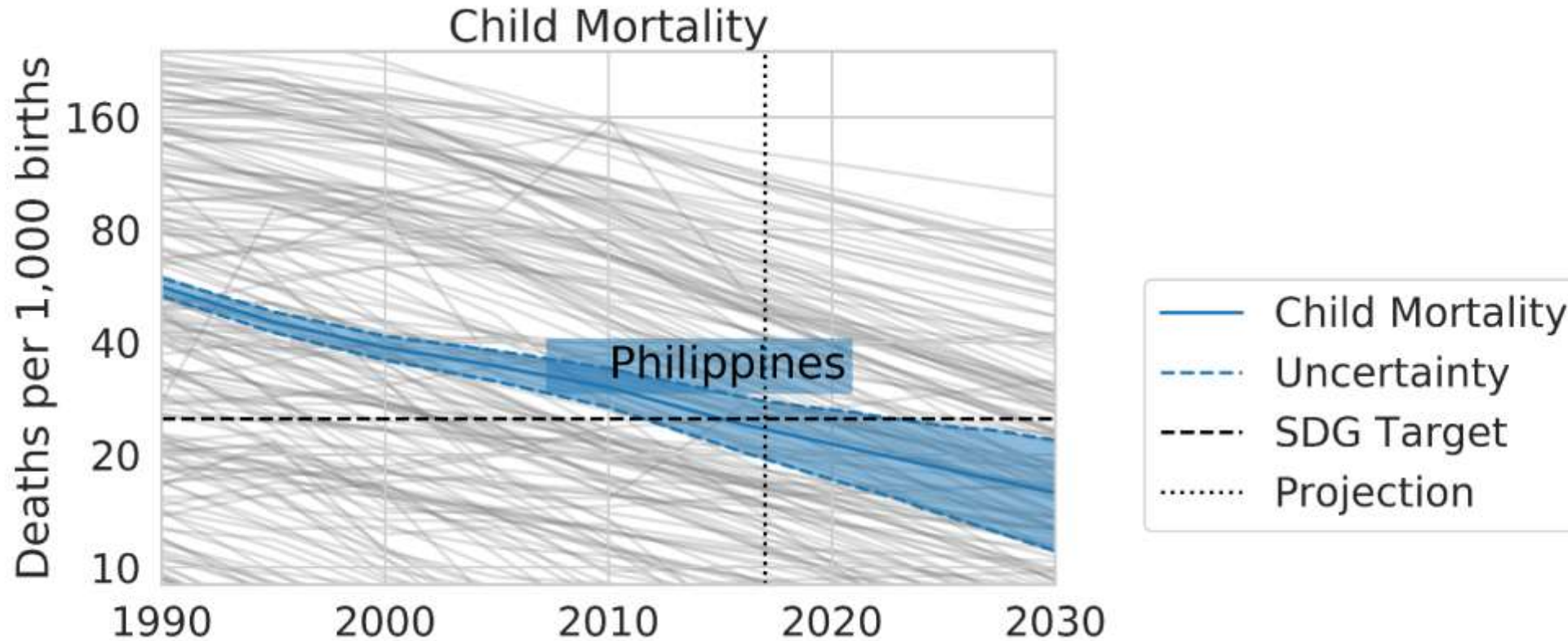
Good Health & Well-Being

Neonatal Mortality

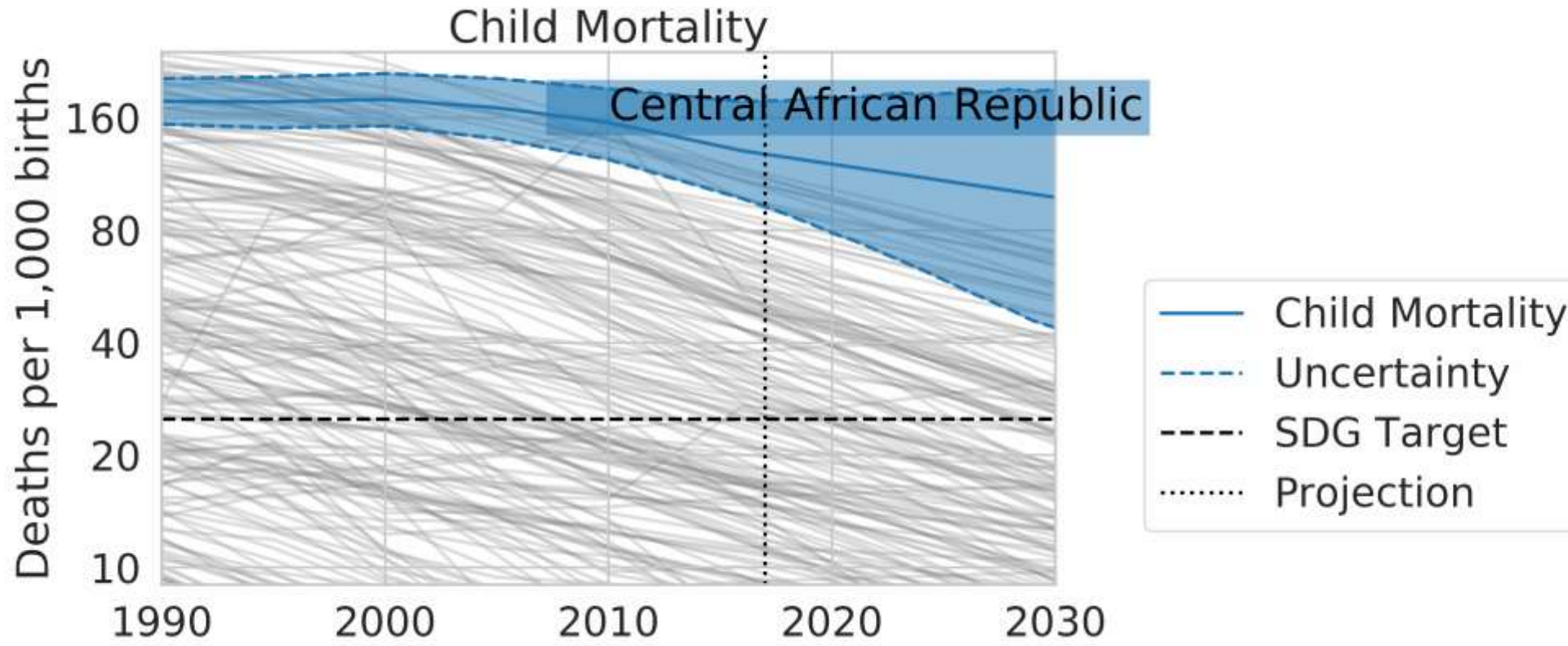
Neonatal deaths per 1,000 live births



Global Burden of Disease Projections



Global Burden of Disease Projections



Outline

Sustainable Development Goals

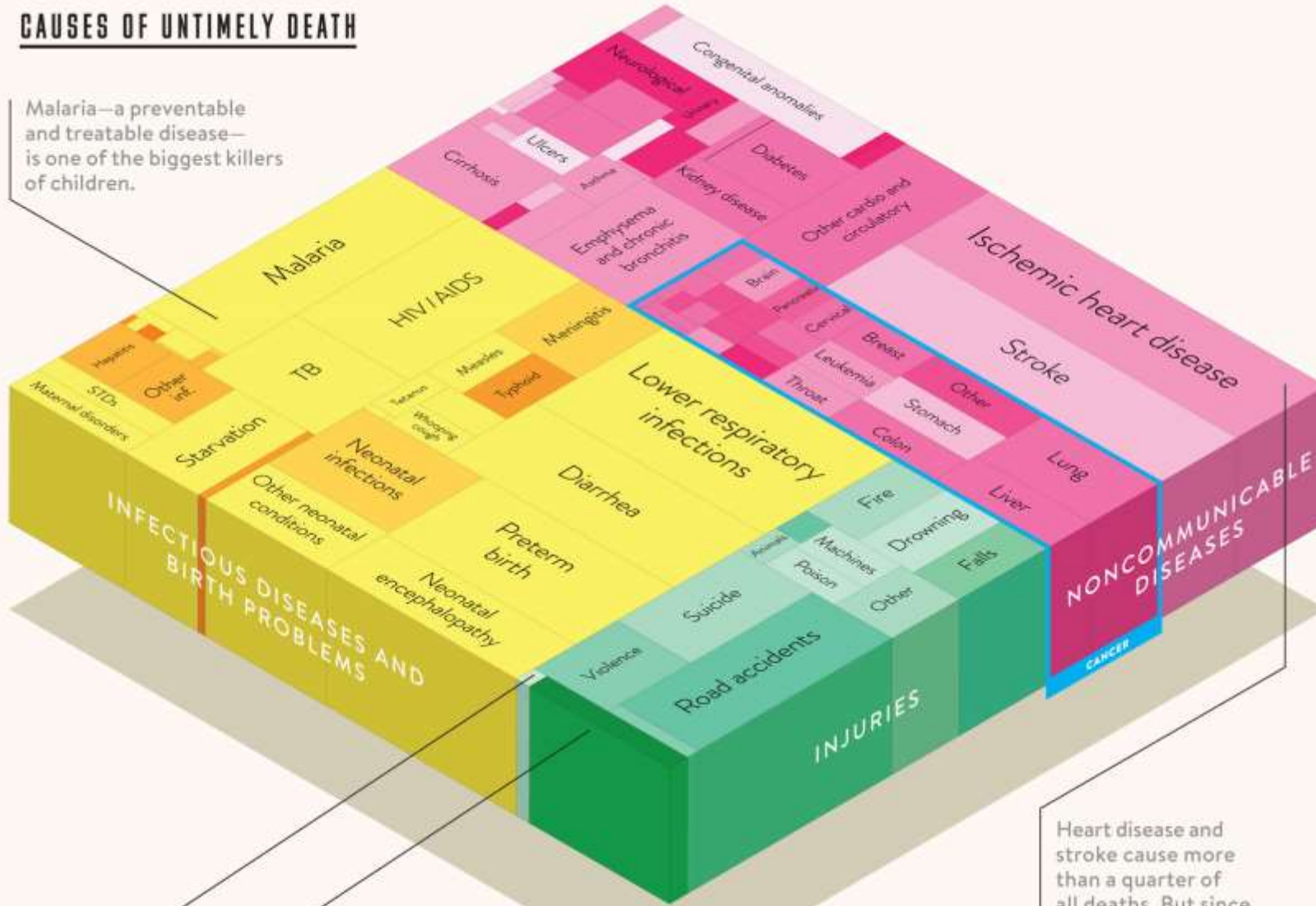
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CAUSES OF UNTIMELY DEATH

Malaria—a preventable and treatable disease—is one of the biggest killers of children.



War casualties account for just 0.05 percent of total life-years lost annually.

Natural disasters are by far the fastest-growing contributor to the death toll.

Heart disease and stroke cause more than a quarter of all deaths. But since they hit mainly older people, the cost in years of life lost is relatively small.



Interactive, regularly updated version: vizhub.healthdata.org

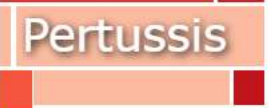
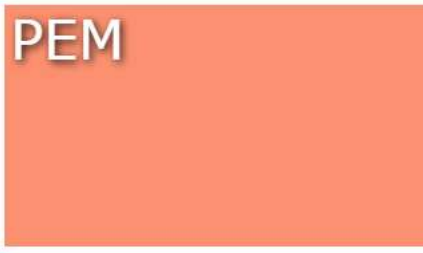


South Sudan
Both sexes, <5 years, 2021, Deaths

Congenital

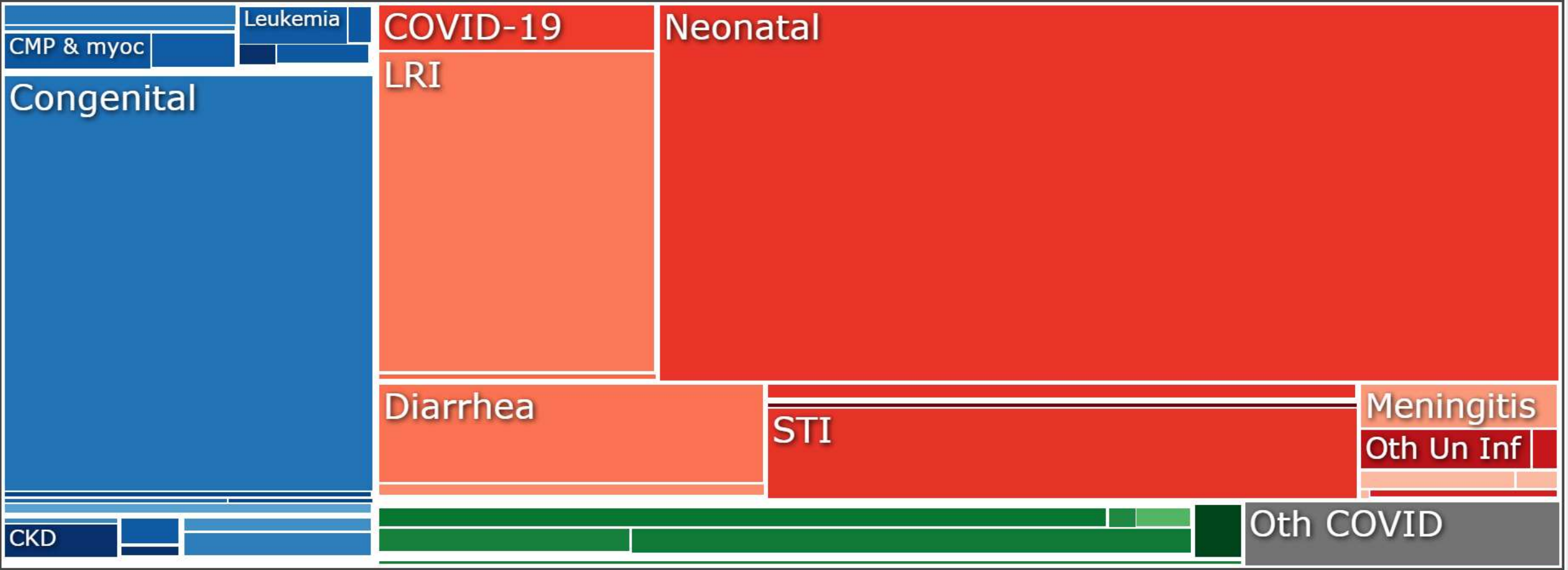
SIDS

CKD

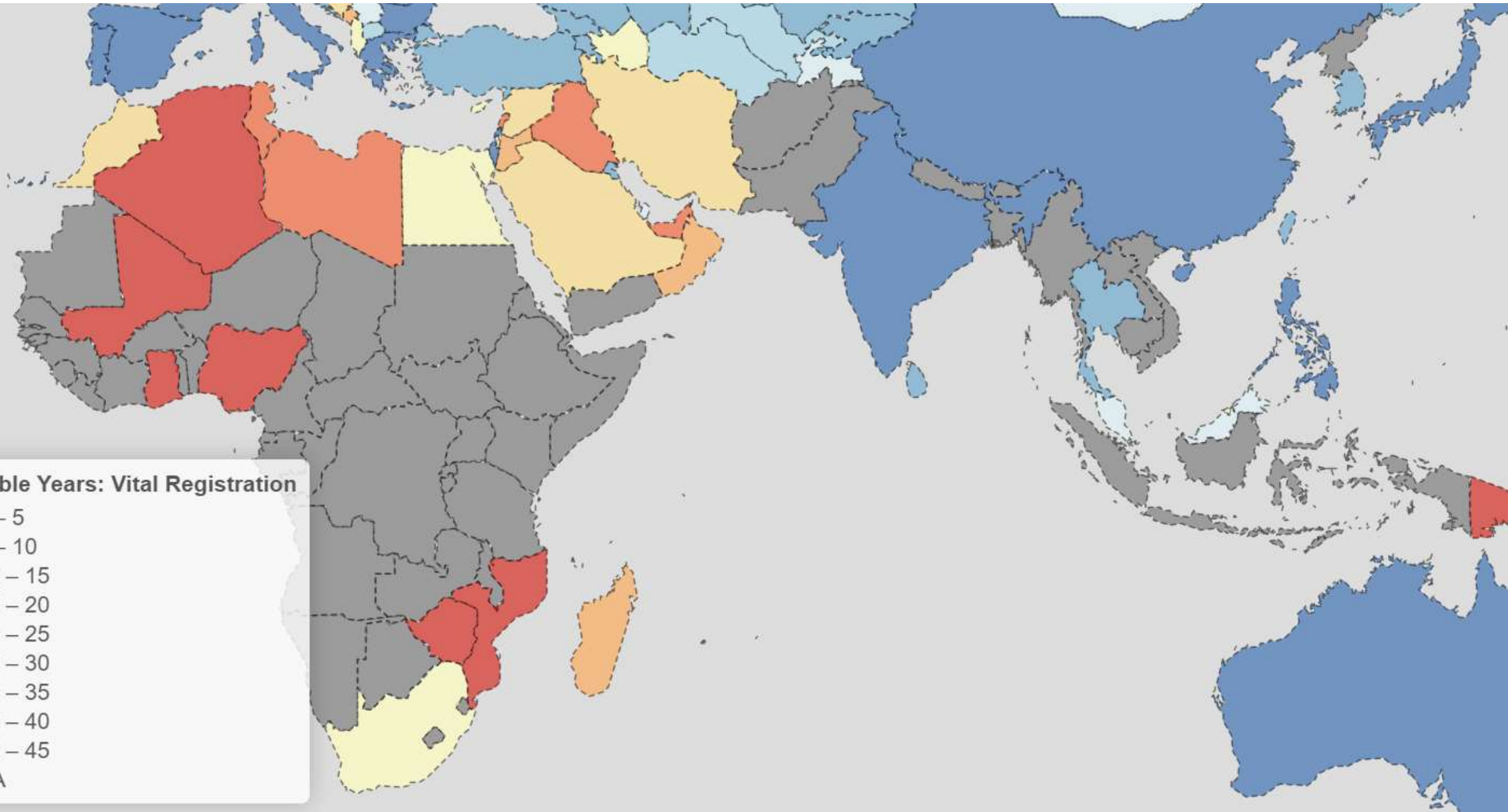




Fiji
Both sexes, <5 years, 2021, Deaths



The best data for this comes from vital registration systems



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Verbal Autopsy (VA) Interviews to fill the gap



What is a verbal autopsy?

Method to assess the cause of death based on an interview to a relative or person familiar with the events that lead to death

Questionnaires may include close and open questions

Two stage process:

- Interview of the deceased's family using a standard, brief questionnaire to gather information on signs and symptoms experienced before death
- Diagnosis of cause of death based on this information.



History

Projects in Asia and Africa in the 1950s and 1960s used systematic interviews by physicians to assess causes of death

Field workers at the Narangwal project in India labeled this technique “verbal autopsy” (VA)

The method spread and developed during the 1970s, when WHO suggested lay reporting of health information by people with no medical background

Milestones:

- Million death study (1998-2014)
- Population Health Metrics Research Consortium study (PHMRC) (2009-2015)
- Development of:
 - Validated questionnaires (WHO, PHMRC).
 - Electronic data collection platforms
 - Automated methods for the analysis of verbal autopsy (InterVA, SmartVA, InSylico)

Example of VA questions

SECTION 5
MODULE 1. GENERAL ILLNESS LEADING TO DEATH
SPECIFIC QUESTIONS TO ELICIT SYMPTOMS AND SIGNS OF THE LAST ILLNESS

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
501	Did _____(NAME) have fever during her last illness?	YES.....1 NO2 DON'T KNOW.....8	502 502

SECTION 4. DESCRIPTIVE REPORT OF ILLNESS AND EVENTS THAT LED TO THE DEATH

401. Explain to the respondent that we would like to hear the details about everything that happened during the last illness before _____ death starting from the beginning of the illness and also about what happened during the final hours of the woman's death.

Verbatim:

501B	How was the fever like?	HIGH.....1 MILD2 DON'T KNOW/UNSURE.....8	
501C	Was the fever continuous or on and off?	CONTINUOUS.....1 AFTER EVERY 1 - 2 DAYS.....2 AT NIGHT ONLY3 OTHER7	

Example VA interview (cause known from PHMRC study)

Deceased was 53 Year Old Male, with:

- Asthma
- Heart Disease
- Hypertension
- Ankle Swelling
- Puffiness of the Face, All Over His Body
- Cough, Produced Sputum

Underlying Cause:
COPD

- Difficulty Breathing - On-and-Off, Worse in Walking Position
- More than Usual Protruding Belly
- Used Tobacco
- Drank Low Amount of Alcohol
- Free Text: Asthma, Breath, Heart, Lung, Swell, Water

Our baby girl was born in a hospital. After two months, she started to have coughing problems and a fever. We took her to the hospital. A doctor tested the baby and said her condition was very serious. We were sent to another hospital, where she was given oxygen and glucose. The doctors later informed us that they could not be certain she would survive. Our baby had fits. She lost consciousness and she died.

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Generative AI refers to the use of artificial intelligence techniques to create or generate new content, such as images, videos, text, music, or any other form of media.

Examples: ChatGPT, Claude, Gemini, Stable Diffusion, Sora

Chatbots are Statistical Language Models

Lifting the curtain, a little, generative AI chatbots are not magic. What are they?

$$p(w_n | w_1, w_2, \dots, w_{n-1})$$

Where each w_i is a “token”, like a word.

Language Models can predict cause of death

prompt1 = “Hi ChatGPT. Today I would like you to act as an automated verbal autopsy algorithm.

I will provide you with a transcript of a verbal autopsy interview, and I would like you to predict the underlying cause of death, from a list I will provide.

I believe that this death was a maternal death, meaning the death of a woman during pregnancy or within 6 weeks of either abortion or birth. It is a death from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

INTERVIEW:

{interview_transcript}

THINK IT THROUGH:

Now I would like to know what you think happened, based on this evidence. Please use all the relevant evidence from the interview to explain the underlying cause of death and the chain of events that led to this death. Please do your best to answer this, even if you are uncertain.”

interview_transcript = "Adult1234

Q: Did respondent give consent?

A: Yes

Q: What is the sex of the respondent?

A: Male

...

Q: Now can you please tell me in your own words what happened?

A: the deceased had been 3 months pregnant. 2 days ago, a sharp pain began in the abdomen of the deceased. she had not excreted since 2 days. the womb of the deceased was later cleaned at the [HOSPITAL]. it was found, that the womb had ruptured, and the poison had spread into the intestines."

AI Response: "Based on the evidence provided in the interview, I believe the underlying cause of death was likely an abortion complication, specifically a uterine rupture leading to sepsis. Here's the chain of events that I believe led to this death:

1. The deceased was 3 months pregnant.
2. She underwent an abortion procedure, as indicated by the response "Yes" to the question "Did decedent die during an abortion?"
3. Two days before death, she developed sharp abdominal pain, which is consistent with a uterine rupture.
4. She also experienced constipation ("she had not excreted since 2 days"), which could be a sign of peritonitis or bowel obstruction secondary to the uterine rupture.

prompt2 = “Great, thank you very much. Now I would like you to select the most likely underlying cause of death from a list of causes. Please do your best to answer this, even if you are uncertain, but if there simply is not enough information to identify the subcause, then answer that you are unable to determine from this information.

UNDERLYING MATERNAL SUBCAUSE:

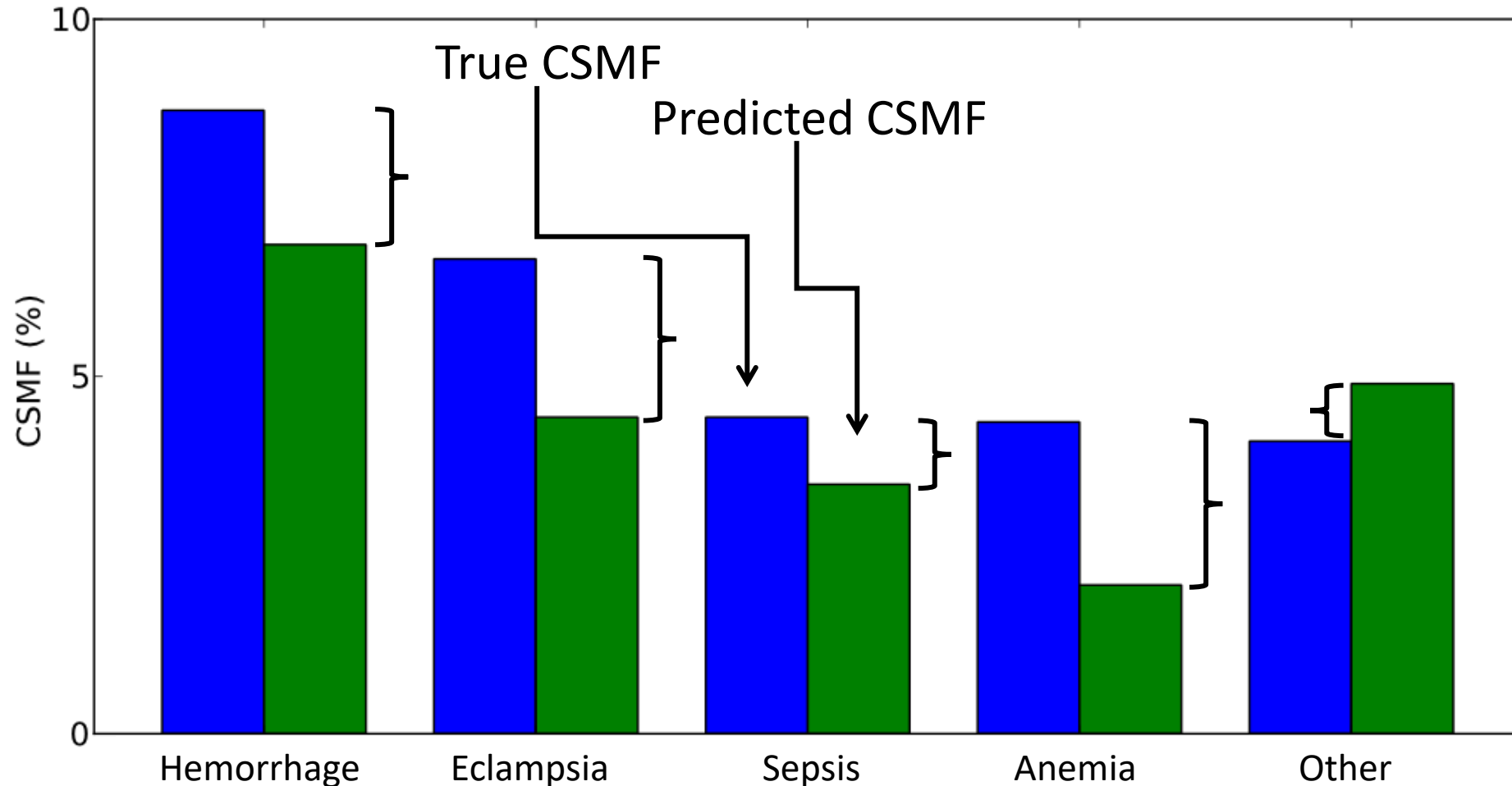
- (a) Anemia
- (b) Hemorrhage
- (c) Sepsis
- (d) Eclampsia
- (e) Obstructed Labor
- (f) Other Defined Causes of Death as a Consequence of Pregnancy
- (g) Not a maternal death
- (h) Unable to determine from this information

PLEASE RESPOND WITH ONLY THE LETTER OF THE CORRECT OPTION!”

AI Response: “c”

Quality metric: Cause-specific Mortality Fraction Accuracy

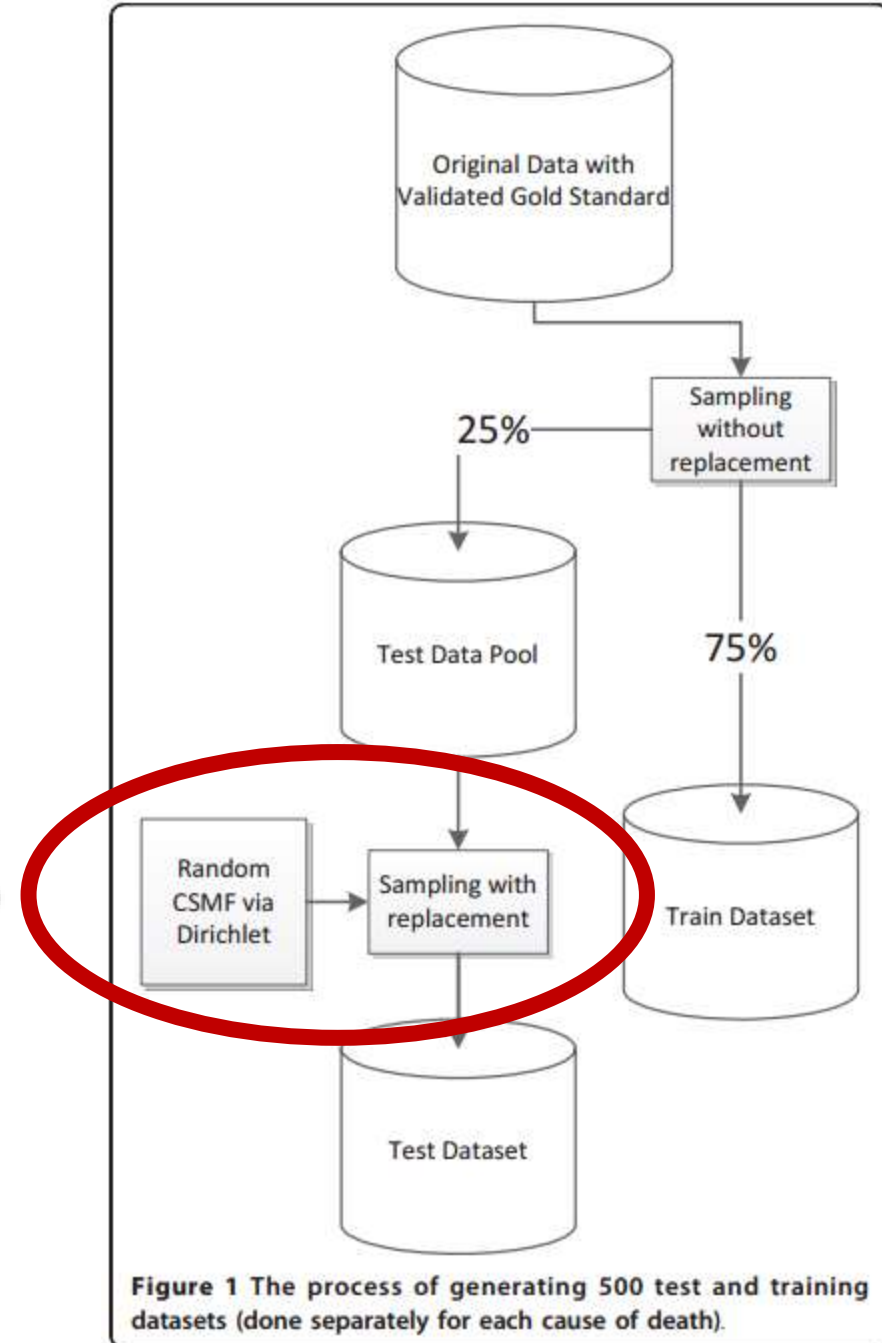
$$\text{CSMF Accuracy} = 1 - \frac{\sum_j |\text{CSMF}_j^{\text{true}} - \text{CSMF}_j^{\text{pred}}|}{\text{CSMF Max Error}}$$



Out-of-sample validation is essential in AI predictions

To prevent being misled by overfitting evaluation must not allow any information about the test dataset to be used in training.

Unusual part here →



AI beats Human Experts in Individual- and Population-Level Quality of Predicting Pregnancy-related Causes of Death

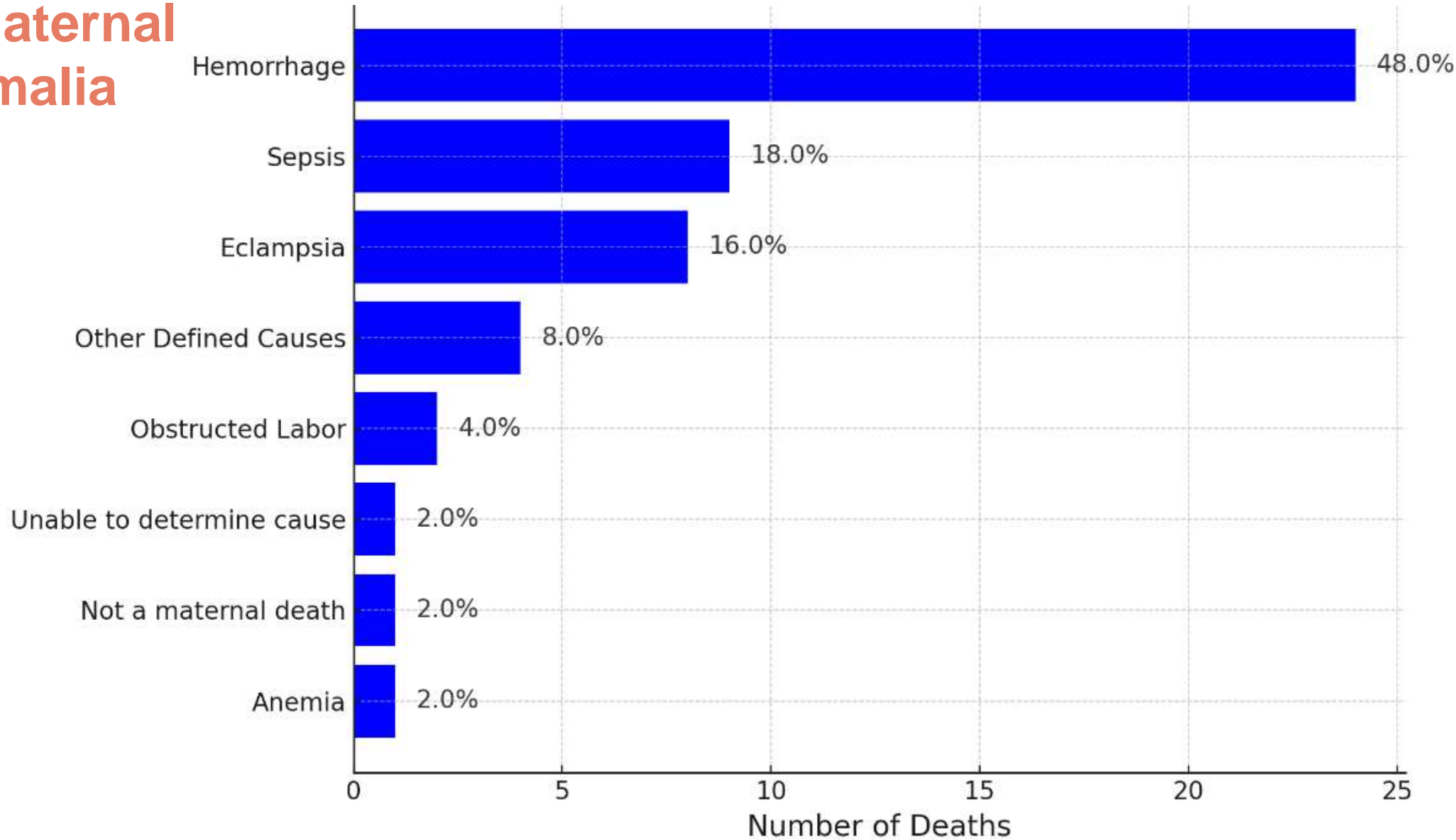
		CCC	CSMF Accuracy
(Human) Doctors		23	50
Direct Prompt	ChatGPT	26	54
	Claude	29	52
Chain of Thought	ChatGPT	31	58
	Claude	28	63

Real-world Application

- 50% of all deaths worldwide have no cause of death (CoD) assignment.
- Over half of maternal deaths occur in Sub-Saharan Africa.
- In Somalia, the maternal mortality ratio (MMR) is 692 per 100,000 live births (Demographic Health Survey (DHS) - 2021).
- The system in Somalia has significant gaps in the registration of mortality data, particularly regarding maternal mortality, across both rural and urban areas.



Causes of Maternal Death in Somalia



Summary and Next Steps

1. To reach Sustainable Development Goals we need to bend the curves
2. Cause-of-Death Prediction can inform this strategy
3. Verbal Autopsy Interviews provide the best evidence for CoD prediction
4. Generative AI allows better Cause-of-Death Prediction from Verbal Autopsy Interviews than previously possible

