



Uses of MICS data by the Planetary Child Health and Enterics Observatory (Plan-EO)

Modeling childhood diarrheal disease and its etiologies and
risk factors

Josh Colston PhD, Research Assistant Professor

UVA School of Medicine, Division of Infectious Diseases
and International Health

International Conference on MICS, University of Bristol,
UK, 2nd & 3rd September 2024

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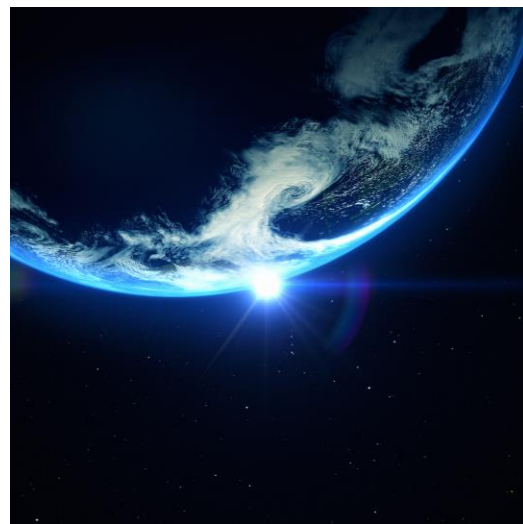
Josh Colston PhD., MSc.

**Epidemiologist and spatial
demographer specializing in:**

- Epidemiological study design
- Diseases of poverty & childhood
- Environmental and climatic exposures
- Biostatistics
- Geographic Information Systems (GIS)



Ongoing research



NIH – Provide an evidence base for the geographical targeting of enteropathogen-specific child health interventions such as novel vaccines



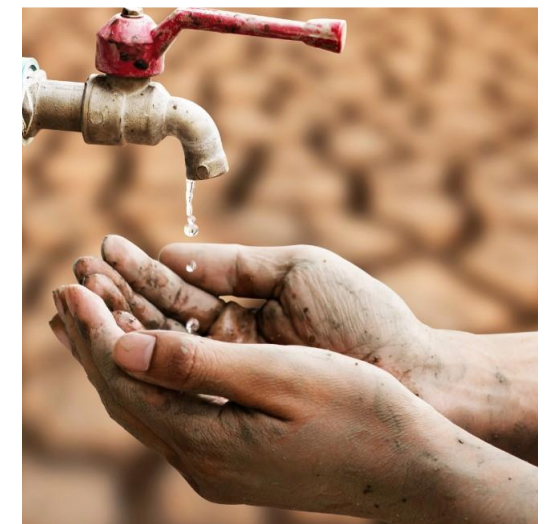
FERG

WHO – A broad-scope systematic review of global diarrheal disease etiologies



RIVERA

CDC - Acute Febrile Illness surveillance case-control study in Iquitos, Peru



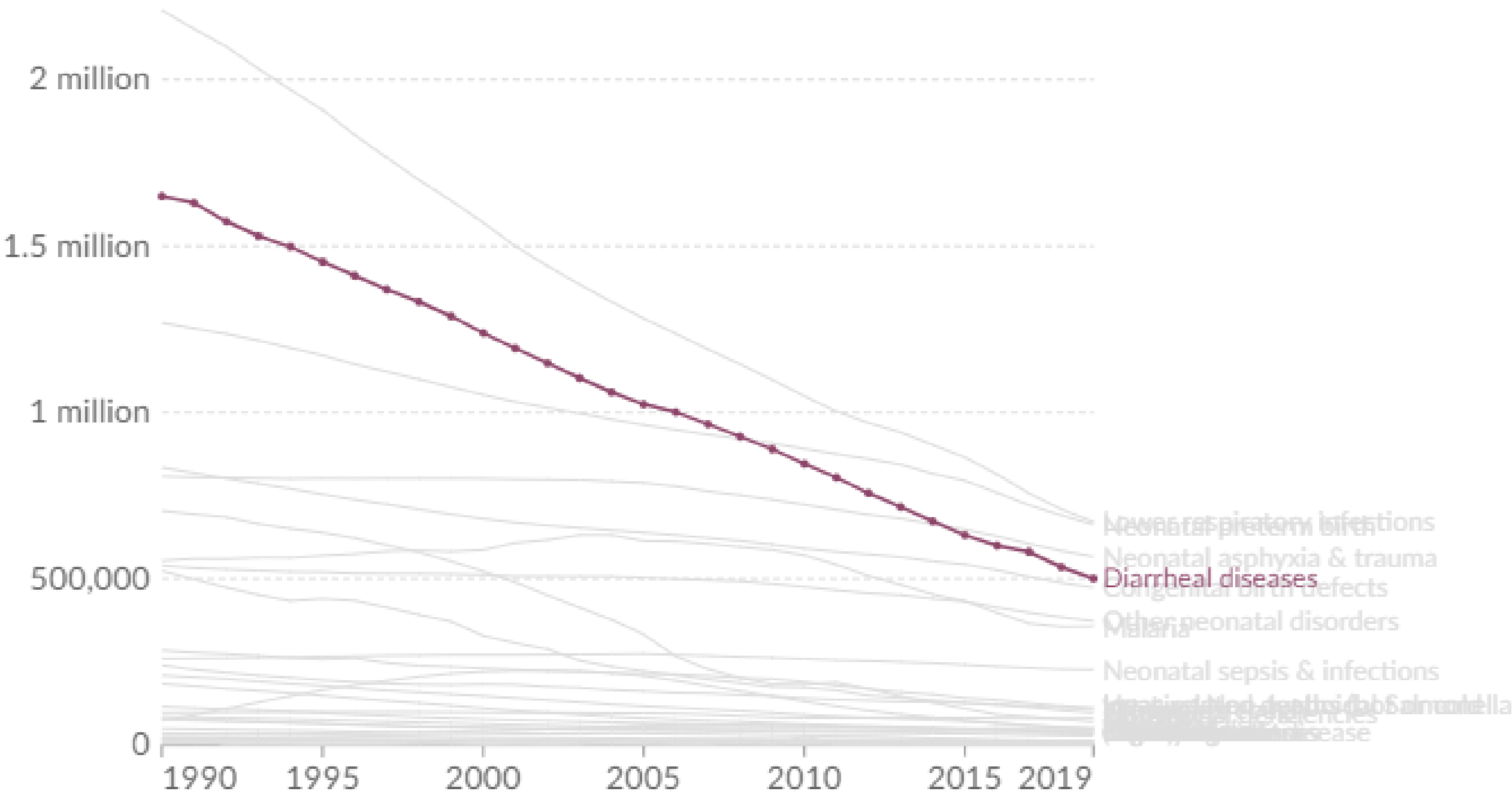
Understanding how climate change is affecting diarrheal diseases in low- and middle-income countries

Causes of death in children under five, World, 1990 to 2019

The estimated annual number of deaths from each cause. Estimates come with wide uncertainties especially for countries with poor vital registration.

[↔ Change country or region](#)

All together ▼



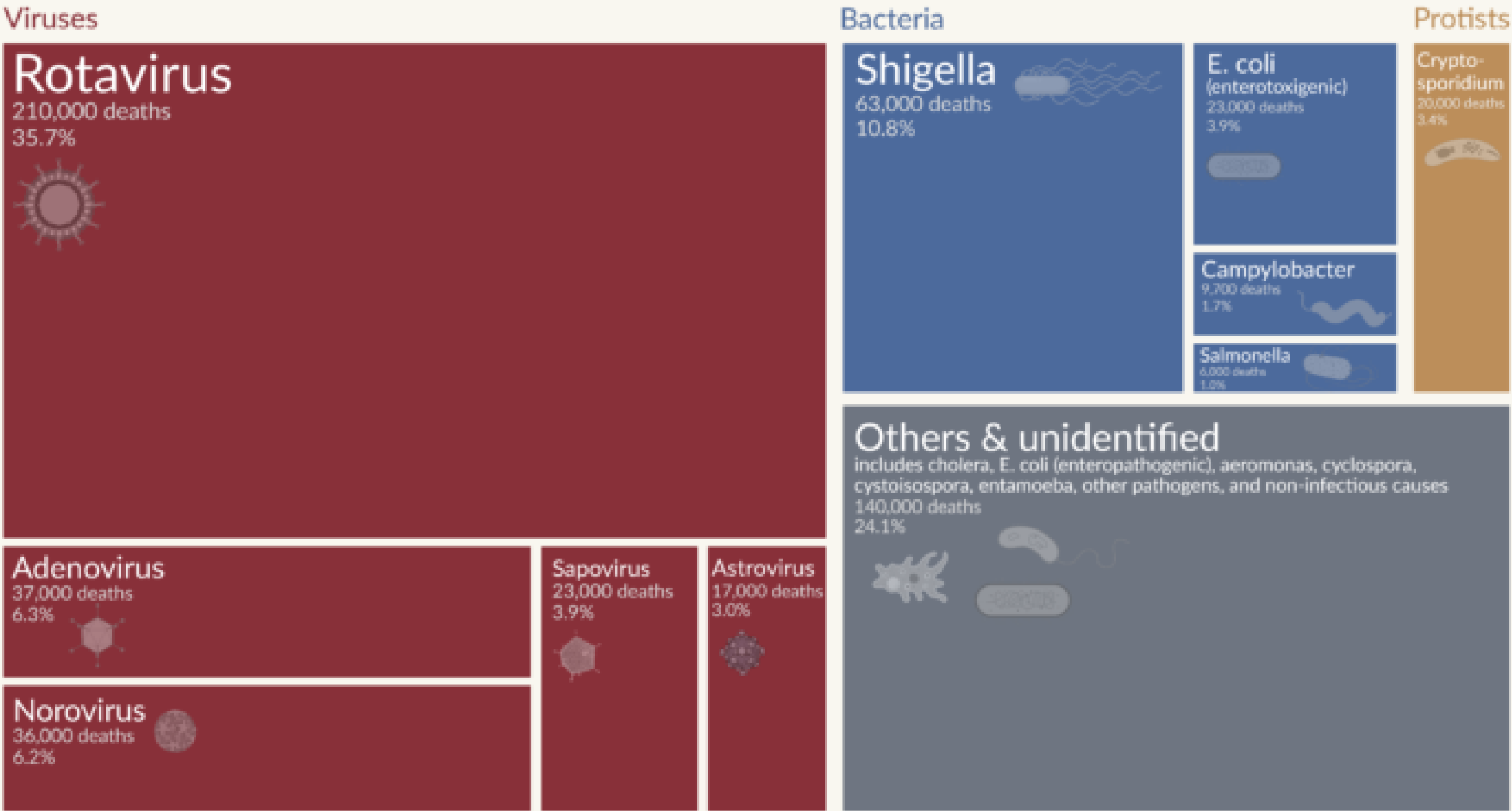
Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/causes-of-death • CC BY

Which pathogens are responsible for deaths from diarrheal disease in children?

Our World
in Data

The total size shows the estimated global number of diarrheal deaths in children under five: 580,000 deaths per year. The size of each box is proportional to the estimated share of deaths caused by each pathogen.



Note: Annual estimates were made according to data from 2017 to 2018. The estimated number of deaths by each pathogen are rounded to two significant figures.
Source: Adam Cohen et al. (2022) Aetiology and incidence of diarrhoea requiring hospitalisation in children under 5 years of age in 28 low-income and middle-income countries: findings from the Global Pediatric Diarrhea Surveillance network. BMJ Global Health.
Pathogen icons from BioRender and PhyloPic.

OurWorldinData.org — Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Saloni Dattani



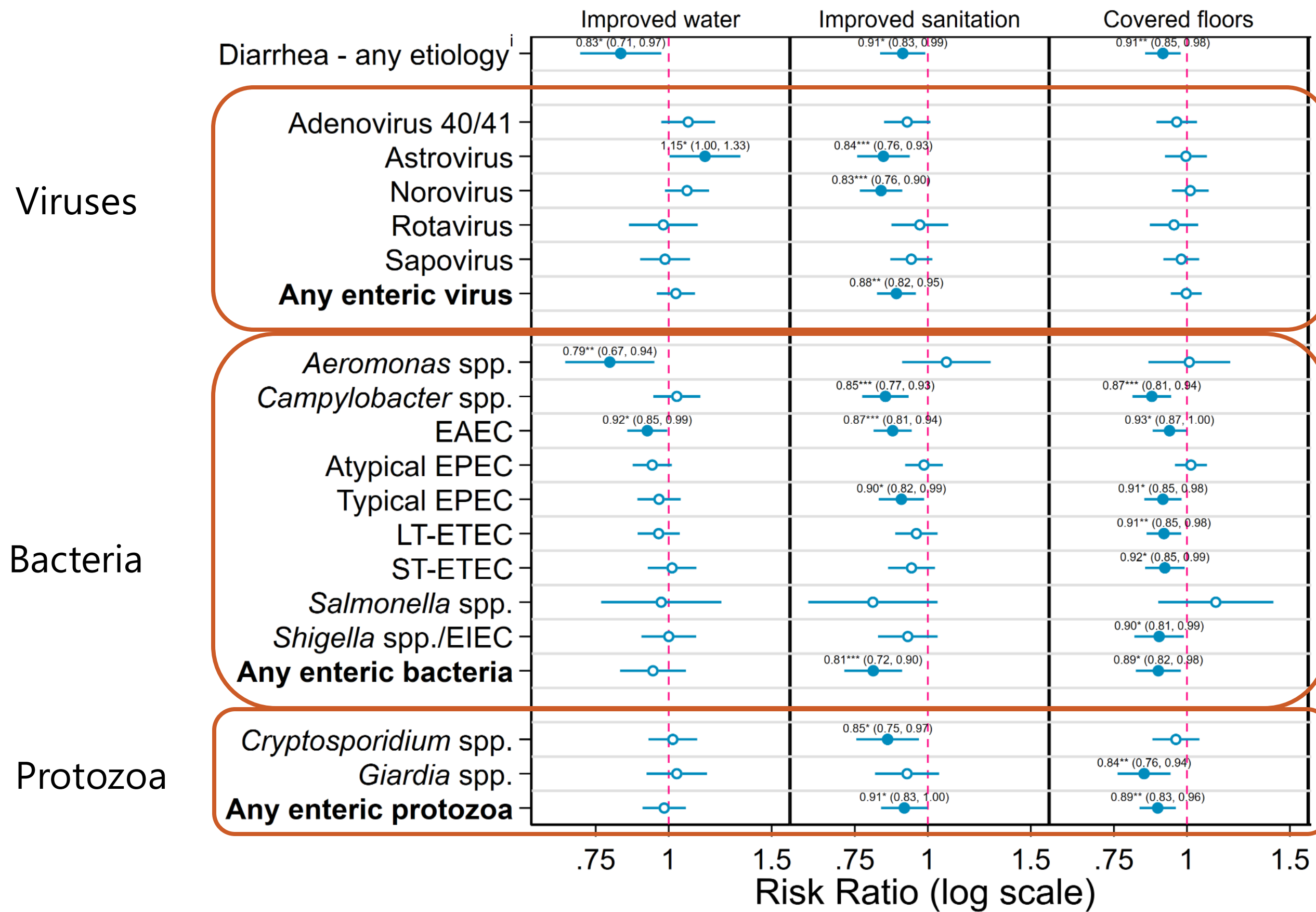
Photo Credit: PATH/Heng Chivoan, www.path.org/articles/five-ideas-global-health/





Household-
level risk
factors for
enteric
pathogen
transmission





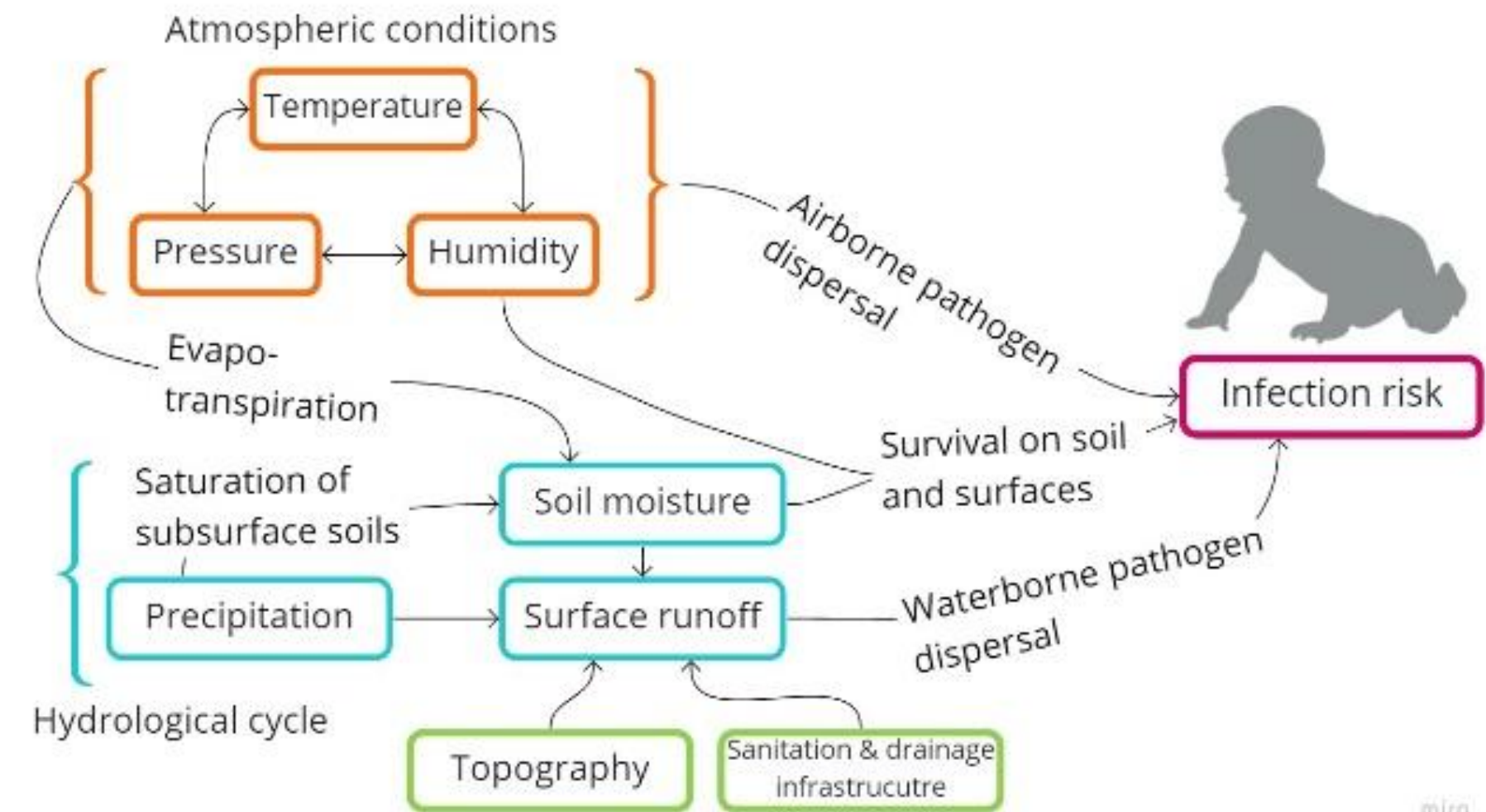
ⁱ Hazard ratio from MAL-ED sites only
 ***p < 0.001, **p = 0.001–0.01, *p = 0.01–0.05

The Planetary Child Health & Enterics Observatory (Plan-EO, “plan-ei-oh”)

Objectives

- Provide evidence base for targeting enteropathogen-specific child health interventions
- Big data approach to pathogen modeling:
 - Molecular (PCR) diagnostics
 - Earth Observation (EO)-derived environmental/climate data
 - Survey derived household and subject data
 - Geostatistical analysis
- Interactive web-based dashboard
- International consortium of investigators

www.planeo.earth

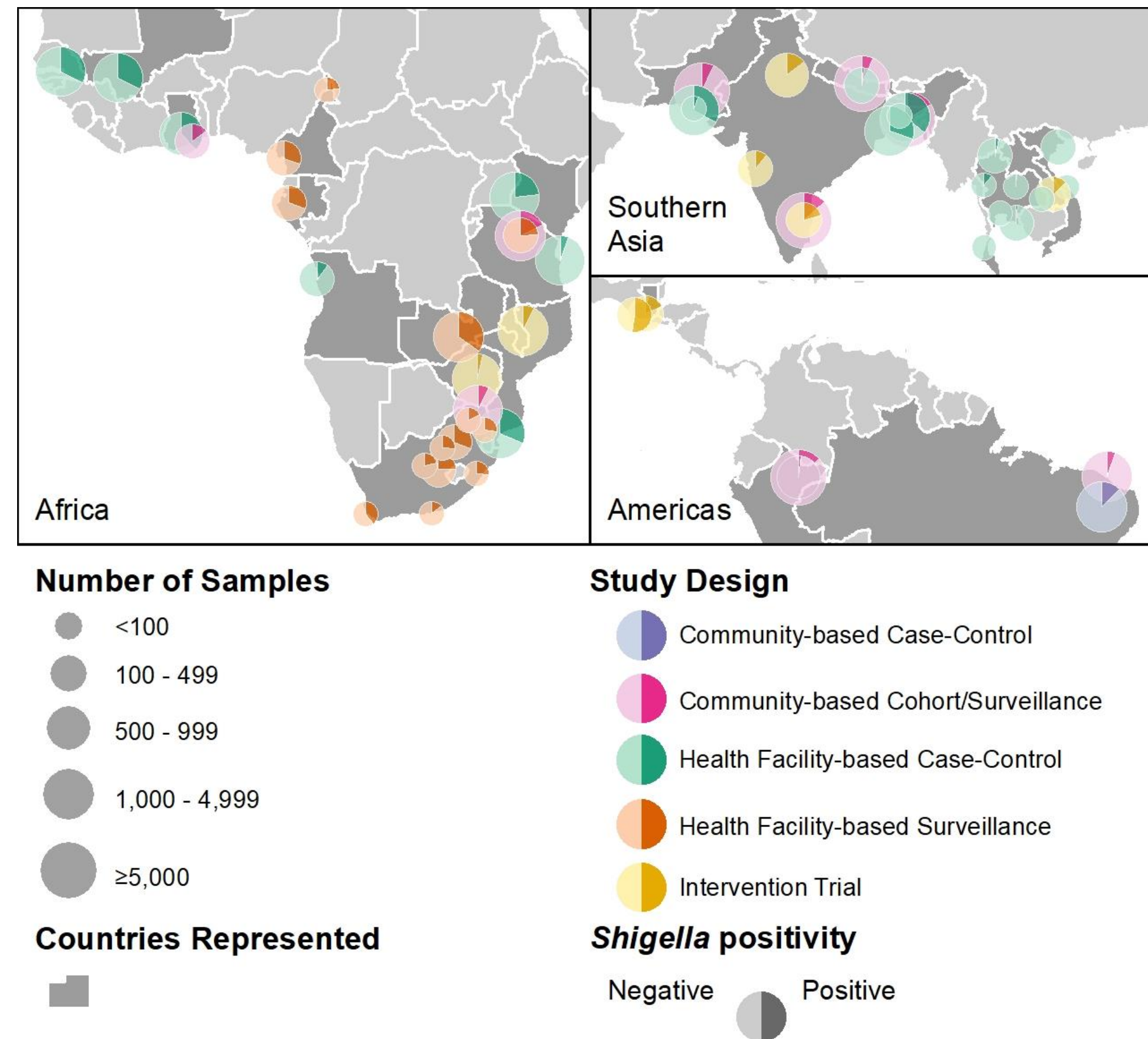


Conceptual diagram of the relationship between physical processes and enteric infection risk



Epidemiological data:

- An Individual Participant Data Meta Analysis (IPD-MA) of studies that:
 - Used PCR to diagnose \geq EID pathogens in stool samples
 - Carried out in LMICs
 - Subjects <5 years
 - Identified through literature review and professional networks and contacted with data access requests
- Study-specific datasets combined into a central database with standardized format
- So far 28 studies carried out in 43 countries
- Samples georeferenced to households, community centroids or health facilities

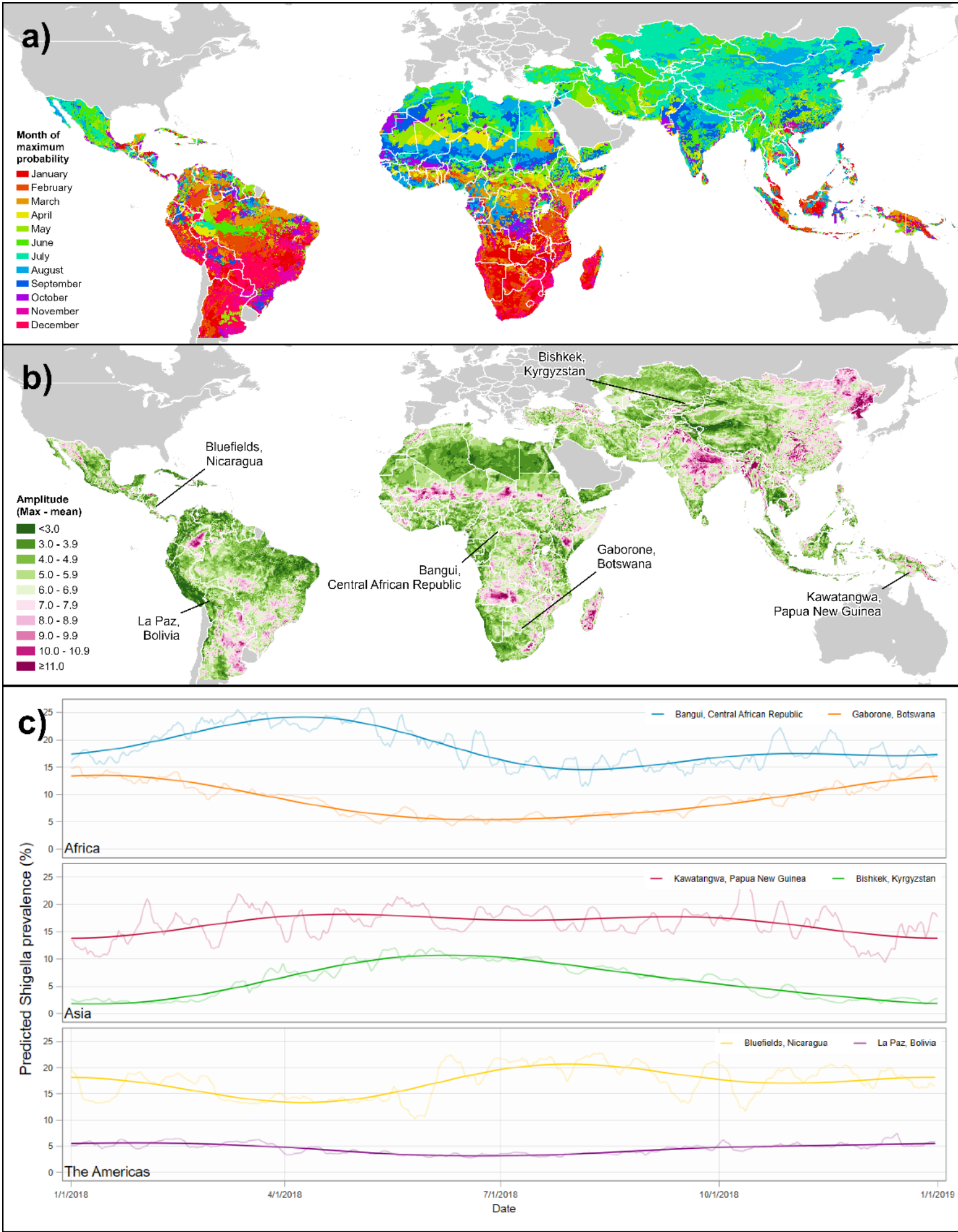
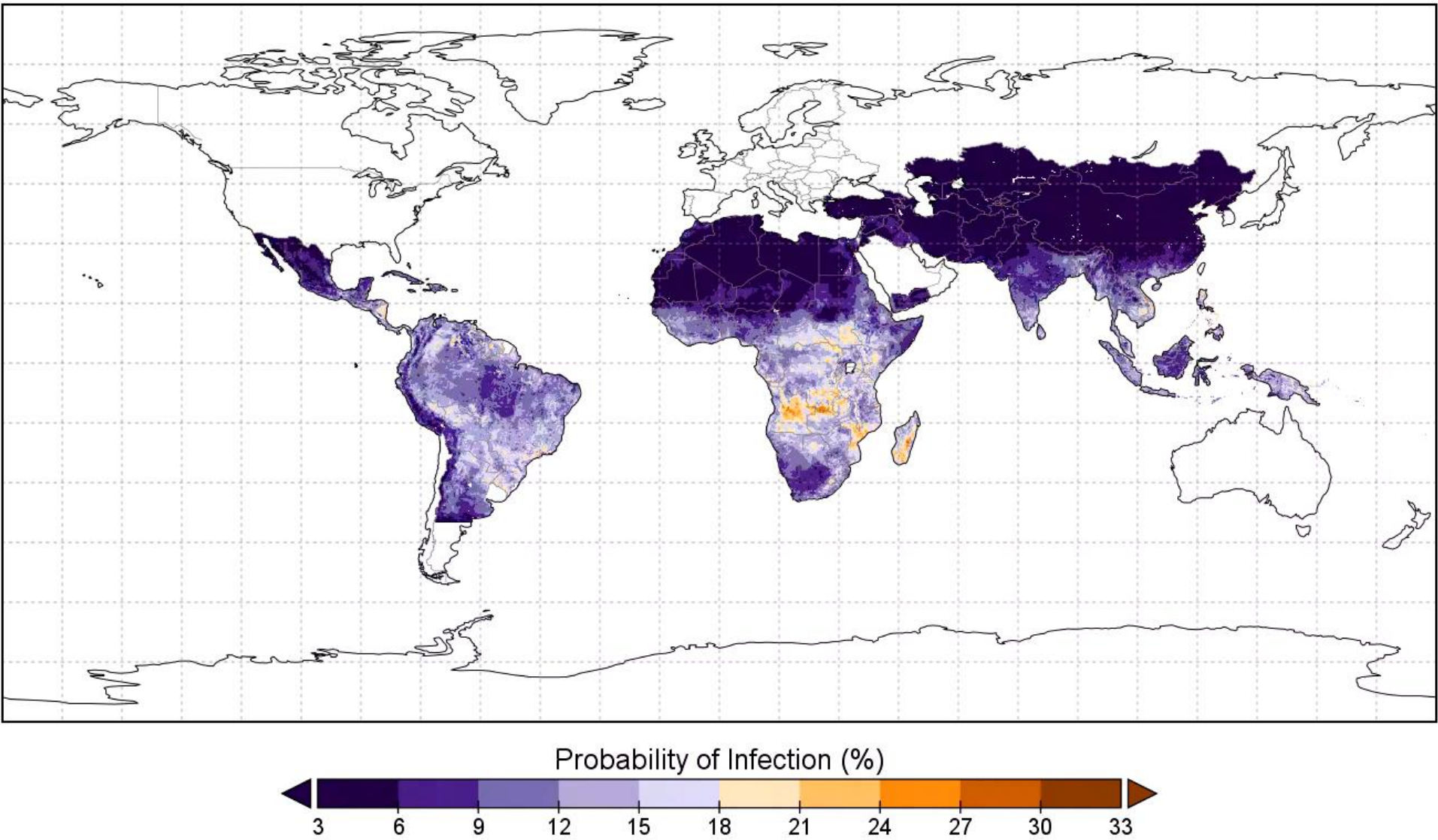


Locations of the sites and designs of the studies contributing data to this analysis, number of samples from each site included in the analysis and *Shigella*-positivity rates.

Results to date - *Shigella*

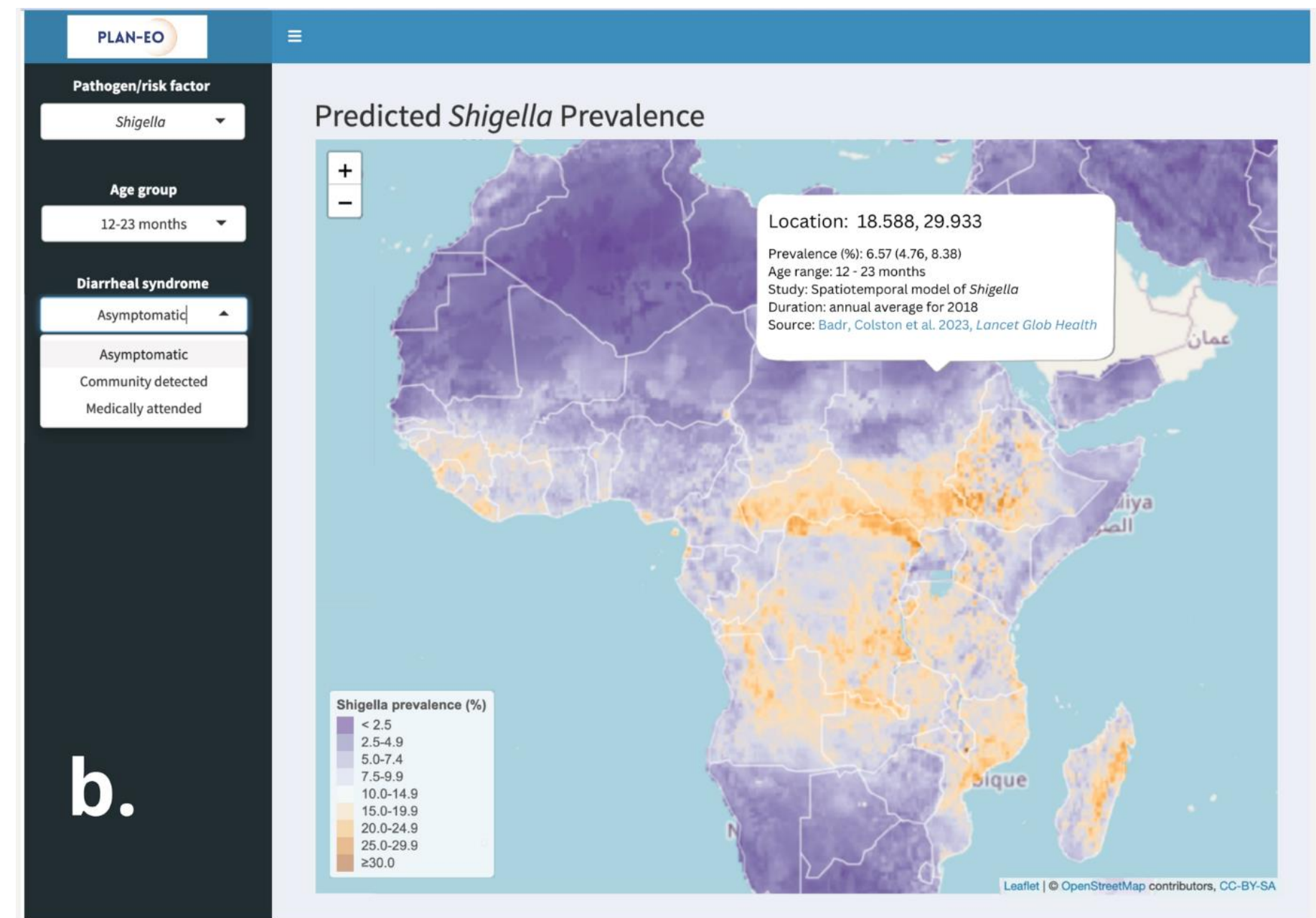
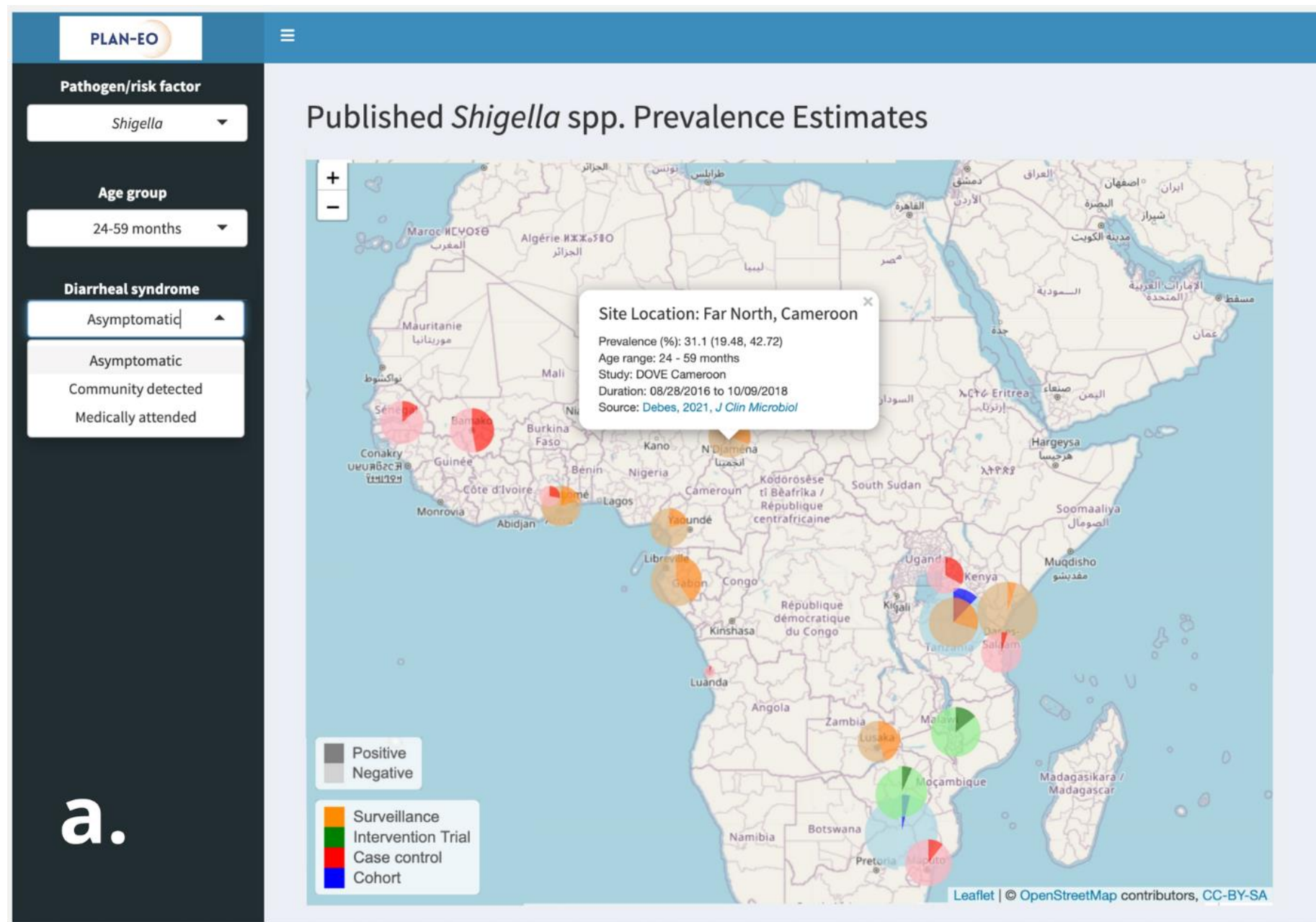
Seasonality metrics for *Shigella* positivity in asymptomatic children aged 12 – 23 months

Estimated *Shigella* prevalence in asymptomatic children aged 12-23 months old
Time: 2018-01-01 00:00




Dissemination

1. An interactive web-based dashboard – data access and visualization system; suite of interactive maps to collate and disseminate data products.
2. An international consortium of investigators – global network of collaborating researchers




Illustrative visualizations of how a). observed, and b). predicted pathogen prevalence will be displayed on the dashboard.

 OPEN ACCESS

STUDY PROTOCOL

The Planetary Child Health & Enterics Observatory (Plan-EO): A protocol for an interdisciplinary research initiative and web-based dashboard for mapping enteric infectious diseases and their risk factors and interventions in LMICs

Josh M. Colston , Bin Fang, Eric Houpt, Pavel Chernyavskiy, Samarth Swarup, Lauren M. Gardner, Malena K. Nong, Hamada S. Badr, Benjamin F. Zaitchik, Venkataraman Lakshmi, Margaret N. Kosek

Published: February 27, 2024 • <https://doi.org/10.1371/journal.pone.0297775>

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Uses of MICS data in Plan-EO

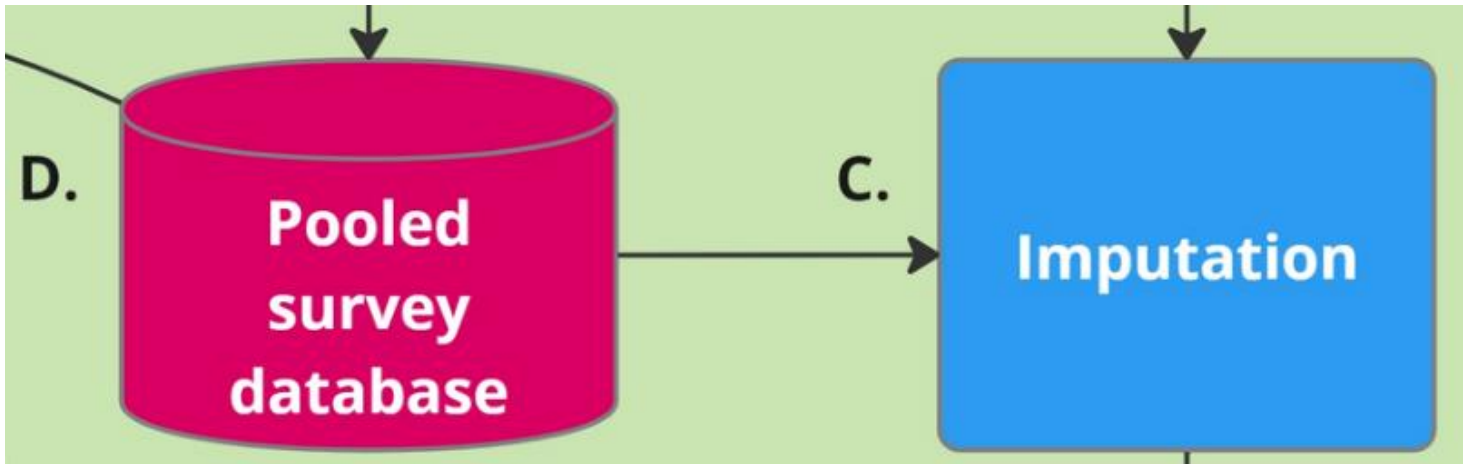
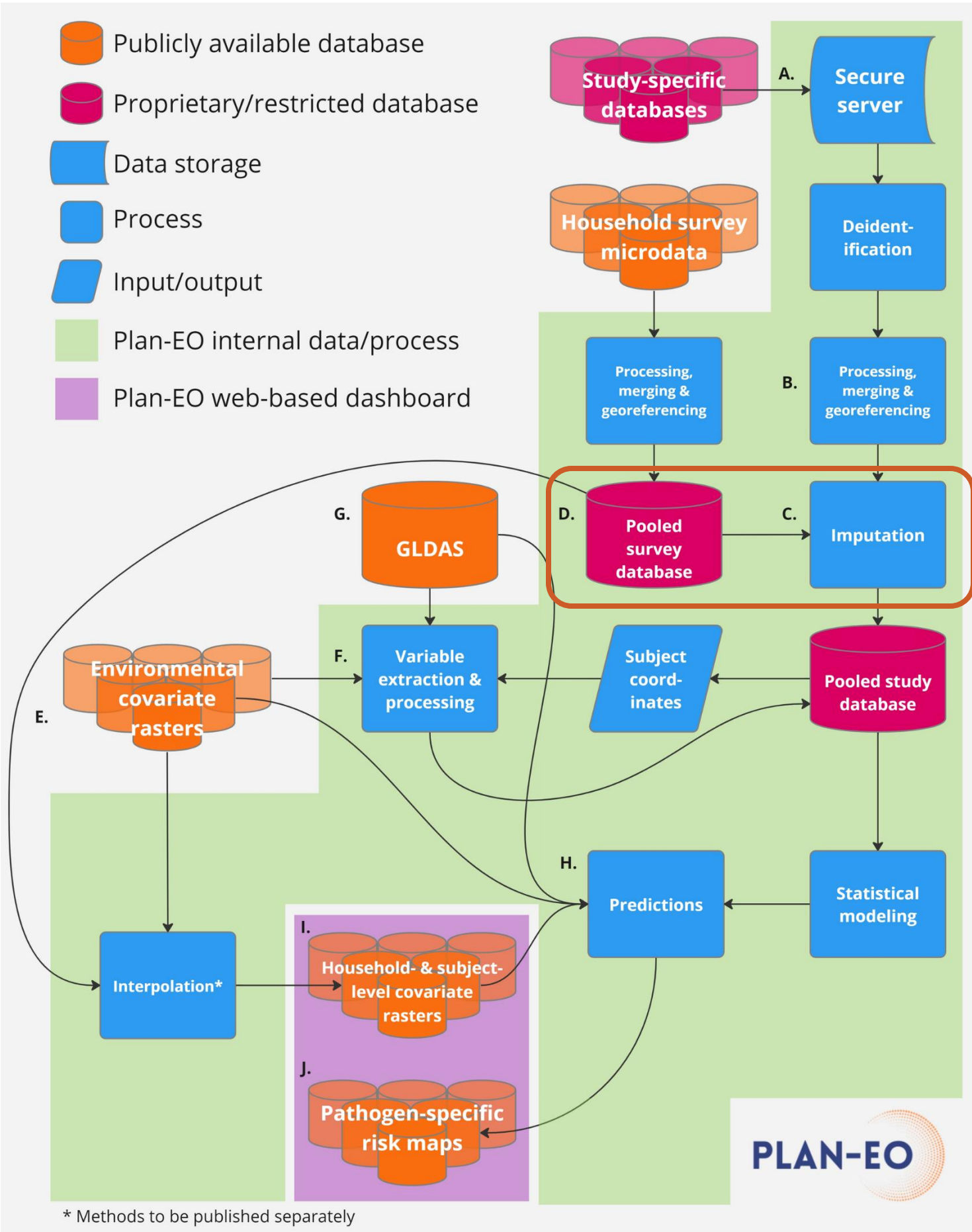


Table 3

Definitions, units and categories of the subject- and household-level covariates included in the Plan-EO database.

Variable	Definition	Units/categories
Subject-level covariates		
Feeding status	Child's breastfeeding status at the time of sample collection	Exclusively breastfed; Partially breastfed; Fully weaned
Nutritional status	Child's nutritional status at the time of sample collection calculated from their weight, height, and age at the time of sample collection	Z-scores
Household-level covariates		
Caregiver education	Educational attainment level of the child's primary caregiver [45]	None; Primary; Secondary; Tertiary
Drinking water source	Type of drinking water source used by the child's household [87]	Surface water; Other unimproved; Piped; Groundwater; Other improved
Handwashing facility	Presence and type of handwashing facility used by the child's household	None; Limited; Basic [87]
Household crowding	Number of residents per sleeping room in the child's household [88]	<2.0; 2.0–2.9; 3.0–3.9; ≥4.0
Housing construction material	Classification of materials used in the construction of the floor, roof, and walls of the dwelling in which the child resides	Natural; Rudimentary; Finished [89]
Livestock husbandry	Household ownership of livestock by species category	Poultry; Monogastric; Ruminant [90]
Sanitation facility	Presence and type of sanitation facility used by the child's household [87]	None (open defecation); Unimproved; Sewer or septic tank; Other improved [46]

Data and process flow for the Plan-EO project.



In datasets from some contributing epidemiological studies, data on subject- or household-level covariates maybe missing or not collected.

Data Editor (Edit) - [WSH_Baseline]

FileEditViewDataTools

Floors[5]

1

	Study	ISO3	Unit	Site	Urban	ID	Date	Water	Sanitation	Hygiene	Floors	Ruminant	Pigs	Poultry	Crowding	Education
1	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00001	16feb2017	UnimpW_Oth	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_No	Ptry_Yes	.	Ed_None
2	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00002	16feb2017	UnimpW_Oth	.	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Prim
3	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00003	16feb2017	UnimpW_Oth	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_No	Ptry_Yes	.	Ed_Prim
4	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00004	17feb2017	ImpW_Grd	ImpS_Oth	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Prim
5	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00005	20feb2017	UnimpW_Sif	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Prim
6	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00006	20feb2017	ImpW_Grd	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_None
7	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00007	20feb2017	UnimpW_Sif	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Prim
8	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00008	20feb2017	ImpW_Grd	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Sec
9	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00009	20feb2017	UnimpW_Oth	Open_Def	.	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	.	Ed_Prim
10	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00010	20feb2017	UnimpW_Oth	Open_Def	.	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	.	Ed_Prim
11	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00011	20feb2017	UnimpW_Sif	Open_Def	.	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	.	Ed_Prim
12	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00012	20feb2017	ImpW_Grd	Open_Def	.	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	.	Ed_Prim
13	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00013	20feb2017	UnimpW_Oth	Open_Def	.	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	.	Ed_Prim
14	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00014	20feb2017	UnimpW_Sif	Open_Def	.	Flr_Rud	Rum_No	Pigs_Yes	Ptry_No	.	Ed_Sec
15	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00015	20feb2017	UnimpW_Oth	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
16	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00016	20feb2017	UnimpW_Oth	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
17	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00017	21feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
18	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00018	21feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
19	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00019	22feb2017	ImpW_Oth	ImpS_Oth	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
20	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00020	22feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
21	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00021	22feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
22	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00022	22feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
23	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00023	23feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
24	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00024	24feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
25	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00025	25feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
26	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00026	25feb2017	UnimpW_Sif	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
27	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00027	25feb2017	ImpW_Pipe	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
28	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00028	25feb2017	ImpW_Pipe	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
29	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00029	25feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
30	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00030	25feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
31	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00031	27feb2017	ImpW_Grd	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec
32	WSH	LAO	Saravane	Saravane	Rural	WSH-LAO-Sv-00032	27feb2017	UnimpW_Sif	Open_Def	.	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	.	Ed_Sec

Survey data from the same strata in which the study sites were located are appended to the study database.

Data Editor (Edit) - [LAO2017MC6]

FileEditViewDataTools

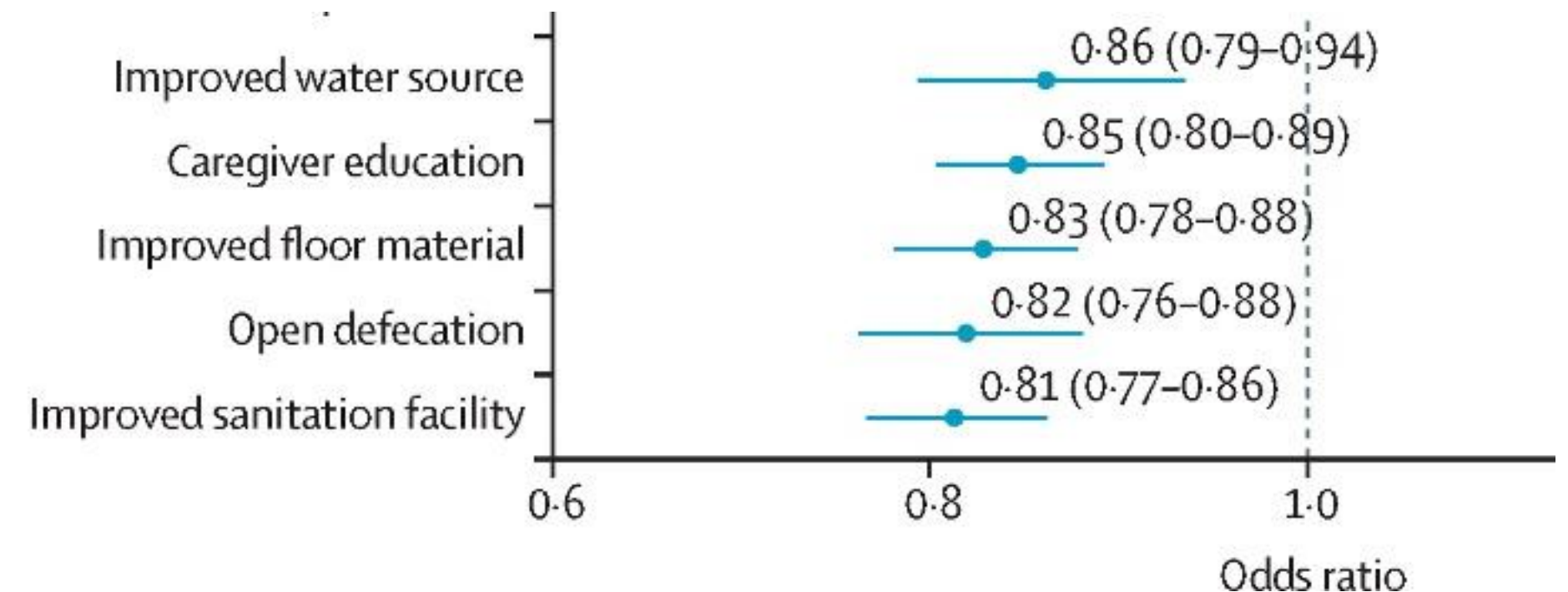
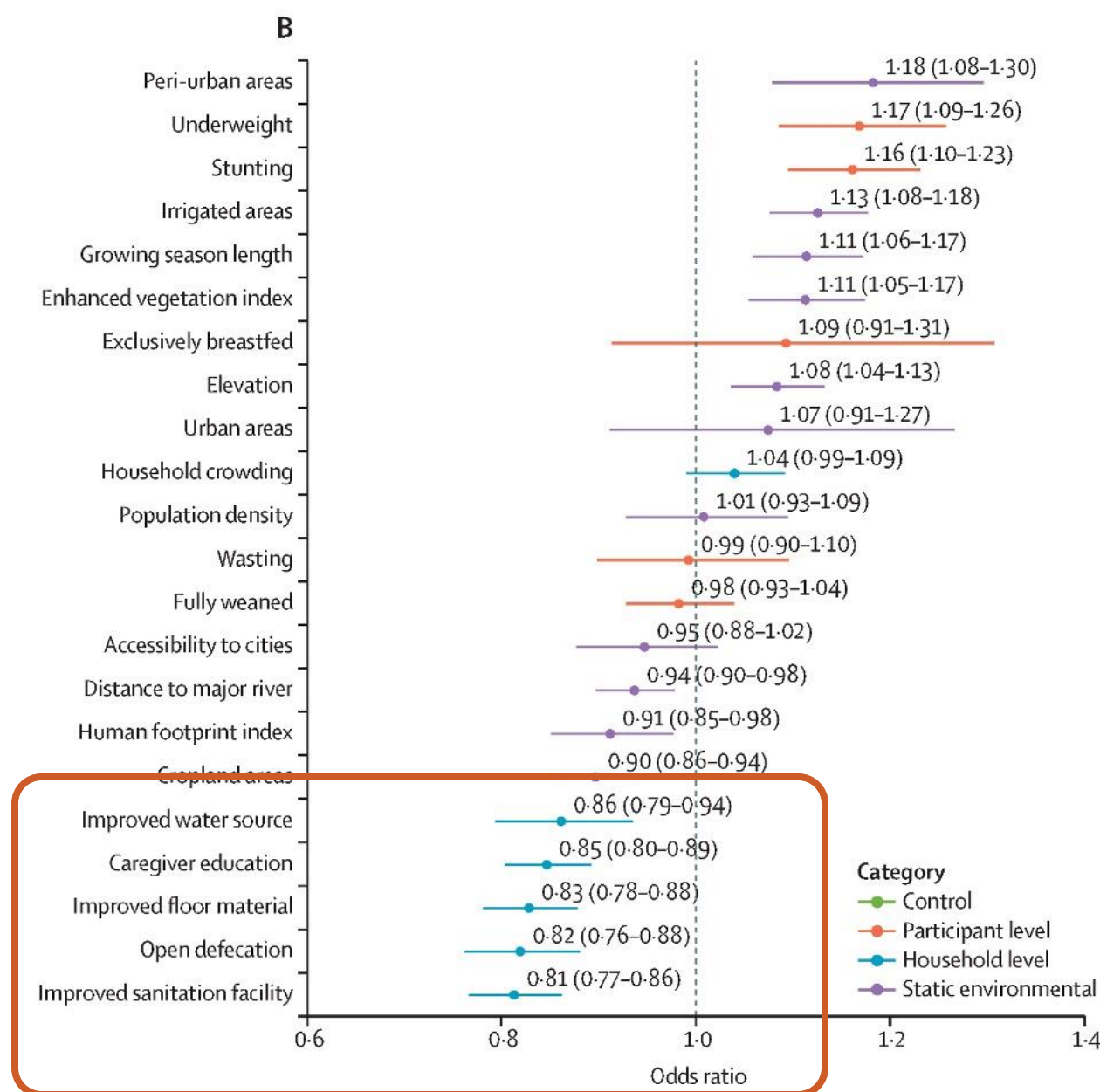
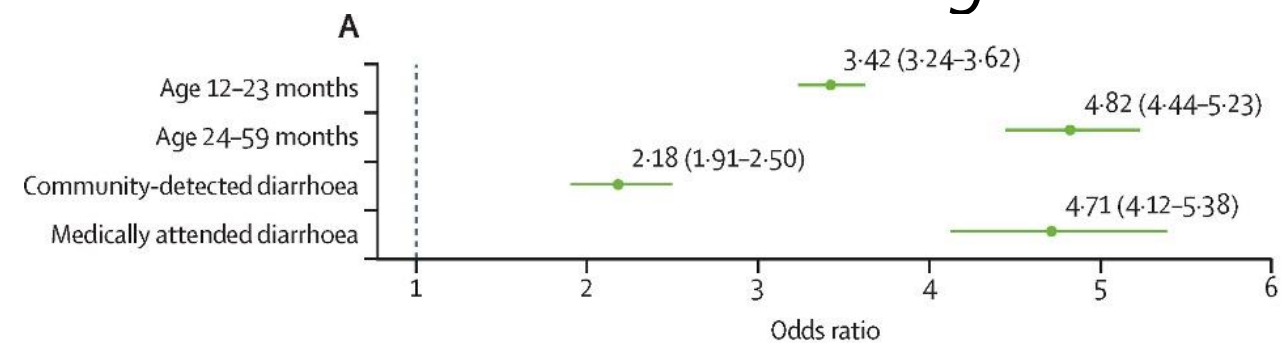
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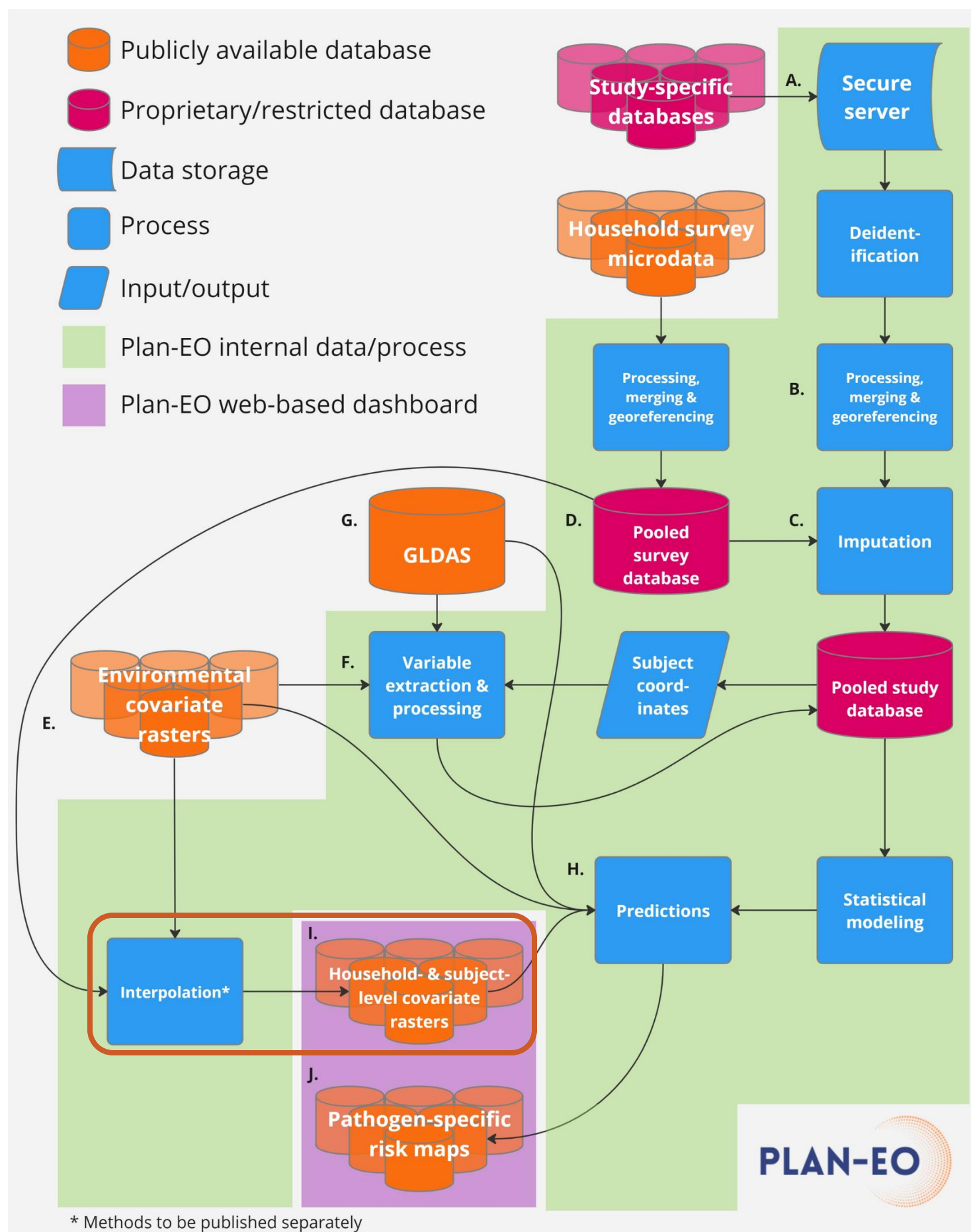
Survey

	Source	Study	ISO3	Unit	Urban	ID	Date	Water	Sanitation	Hygiene	Floors	Ruminant	Pigs	Poultry	Crowding	Education
18480	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018480	24oct2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Fin	Rum_Yes	Pigs_No	Ptry_Yes	Crđ_2_3	Ed_None
18481	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018481	24oct2017	ImpW_Oth	ImpS_Sew	Hwash_None	Flr_Fin	Rum_No	Pigs_No	Ptry_No	Crđ_3_4	Ed_Prim
18482	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018482	24oct2017	ImpW_Oth	ImpS_Oth	Hwash_Bas	Flr_Rud	Rum_Yes	Pigs_No	Ptry_Yes	Crđ_2_3	Ed_Prim
18483	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018483	24oct2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Rud	Rum_Yes	Pigs_No	Ptry_Yes	Crđ_3_4	Ed_Prim
18484	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018484	24oct2017	ImpW_Grd	ImpS_Sew	Hwash_None	Flr_Fin	Rum_Yes	Pigs_Yes	Ptry_No	Crđ_0_2	Ed_Sec
18485	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018485	24oct2017	ImpW_Oth	Open_Def	Hwash_None	Flr_Fin	Rum_No	Pigs_No	Ptry_No	Crđ_3_4	Ed_Prim
18486	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018486	24oct2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	Crđ_4_x	Ed_None
18487	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018487	24oct2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_Yes	Pigs_Yes	Ptry_Yes	Crđ_0_2	Ed_Prim
18488	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018488	24oct2017	ImpW_Oth	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	Crđ_4_x	Ed_Sec
18489	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018489	24oct2017	ImpW_Grd	ImpS_Sew	Hwash_None	Flr_Fin	Rum_No	Pigs_Yes	Ptry_Yes	Crđ_3_4	Ed_None
18490	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018490	24oct2017	ImpW_Oth	ImpS_Oth	Hwash_Bas	Flr_Fin	Rum_No	Pigs_No	Ptry_Yes	Crđ_2_3	Ed_Sec
18491	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018491	28oct2017
18492	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018492	24oct2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_3_4	Ed_None
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18495	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018495	24oct2017	UnimpW_Sif	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	Crđ_2_3	Ed_Prim
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18497	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018497	24oct2017	ImpW_Oth	ImpS_Oth	Hwash_Lim	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	Crđ_0_2	Ed_Prim
18498	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018498	24oct2017	ImpW_Oth	ImpS_Oth	Hwash_Bas	Flr_Fin	Rum_No	Pigs_No	Ptry_Yes	Crđ_0_2	Ed_Sec
18499	Survey	MC6	LAO	Saravane	Urban	LAO2017MC600018499	24oct2017	UnimpW_...	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_4_x	Ed_Prim
18500	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018500	04nov2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_4_x	Ed_Sec
18501	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018501	04nov2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Nat	Rum_No	Pigs_No	Ptry_No	Crđ_4_x	Ed_Sec
18502	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018502	04nov2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	Crđ_4_x	Ed_Sec
18503	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018503	04nov2017	ImpW_Oth	ImpS_Sew	Hwash_None	Flr_Fin	Rum_No	Pigs_No	Ptry_Yes	Crđ_0_2	Ed_Sec
18504	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018504	04nov2017	ImpW_Oth	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_2_3	Ed_Prim
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18506	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018506	04nov2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	Crđ_4_x	Ed_Sec
18507	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018507	04nov2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_Yes	Ptry_Yes	Crđ_3_4	Ed_None
18508	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018508	04nov2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	Crđ_0_2	Ed_None
18509	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018509	04nov2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_2_3	Ed_Prim
18510	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018510	04nov2017	ImpW_Grd	Open_Def	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_4_x	Ed_Sec
18511	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018511	04nov2017	ImpW_Oth	ImpS_Oth	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_No	Crđ_2_3	Ed_Prim
18512	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018512	05nov2017	ImpW_Pipe	Open_Def	Hwash_None	Flr_Fin	Rum_No	Pigs_No	Ptry_Yes	Crđ_3_4	Ed_Sec
18513	Survey	MC6	LAO	Saravane	Rural	LAO2017MC600018513	04nov2017	ImpW_Grd	ImpS_Oth	Hwash_None	Flr_Rud	Rum_No	Pigs_No	Ptry_Yes	Crđ_4_x	Ed_Prim

Results to date - *Shigella*

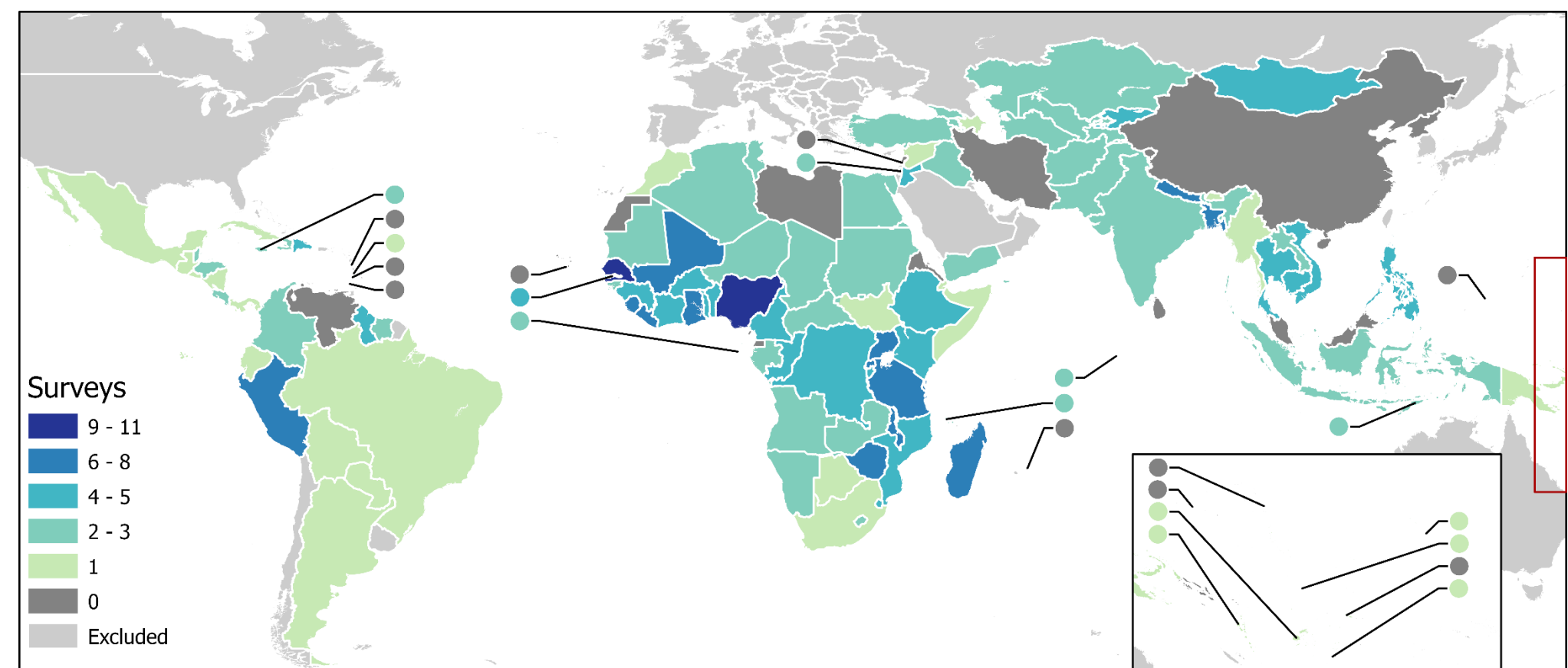
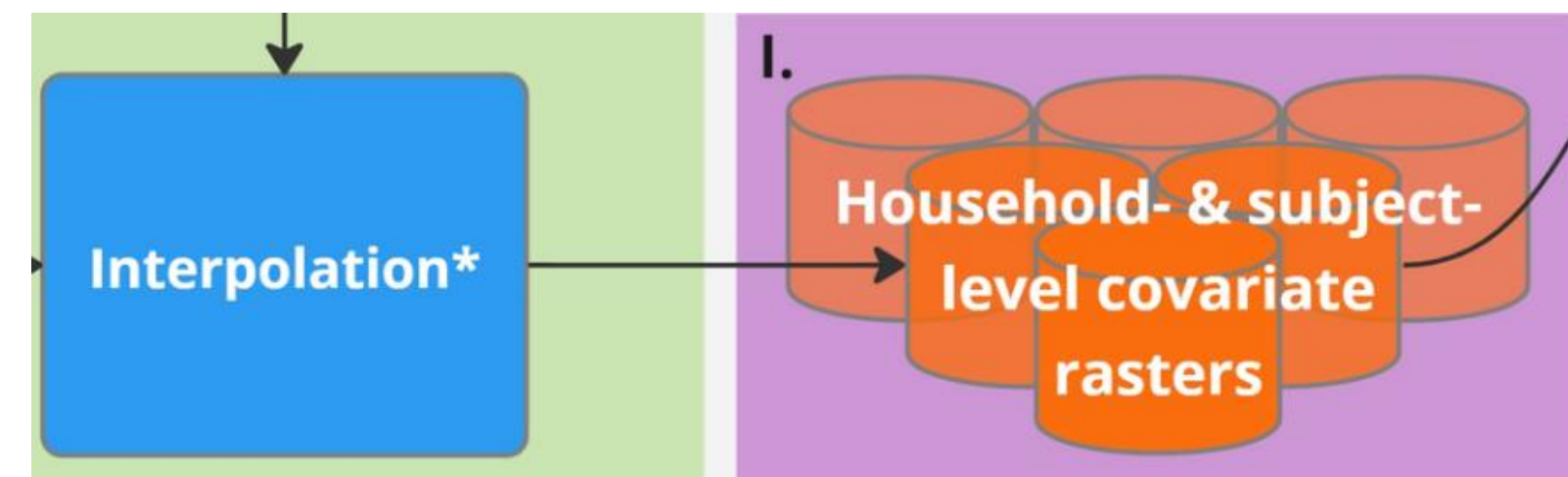
Probabilities and odds ratios of *Shigella* infection predicted for each variable in the model.





Data and process flow for the Plan-EO project.

Uses of MICS data in Plan-EO

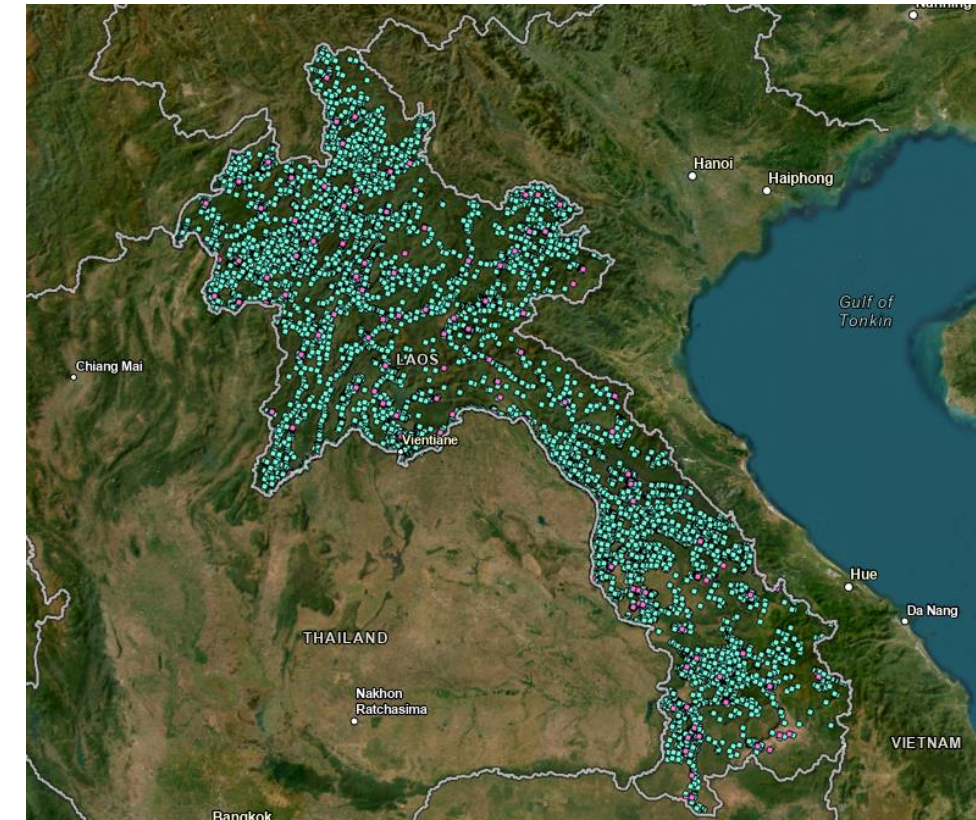


Number of nationally representative household surveys included in input dataset by country for included LMICs

Georeferencing MICS clusters



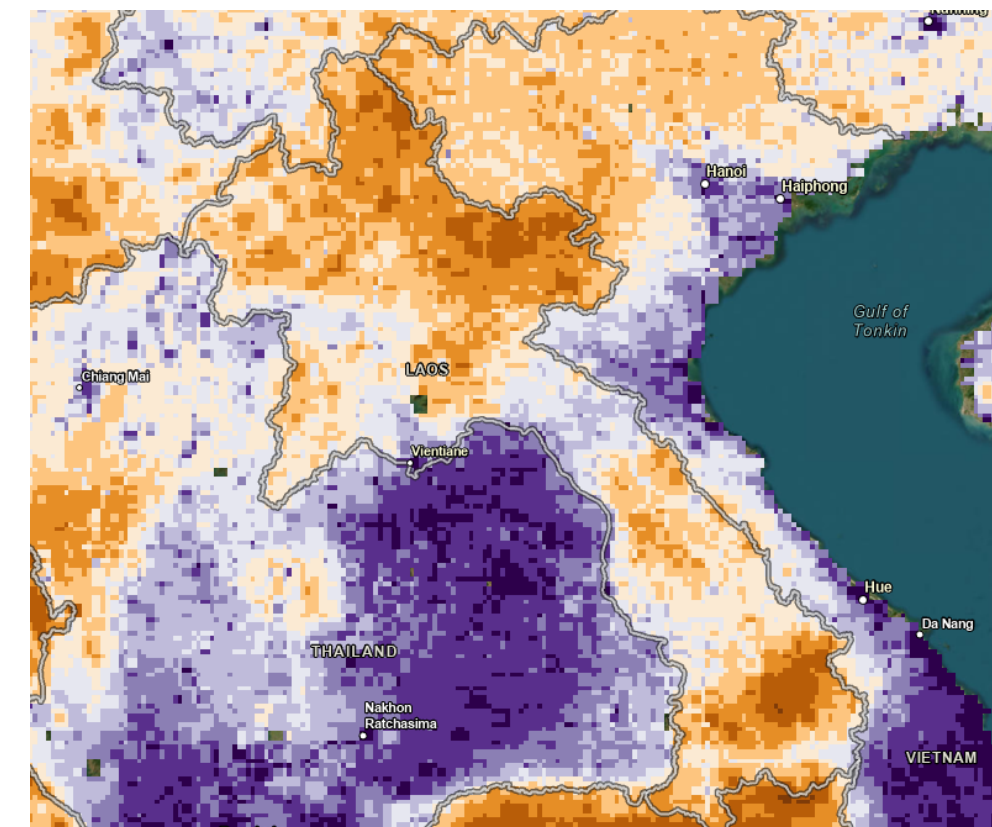
Survey strata for Lao PDR MICS6:
18 regions ×
urban/rural



Populated
settlements in Lao
PDR (from
Humanitarian OSM)



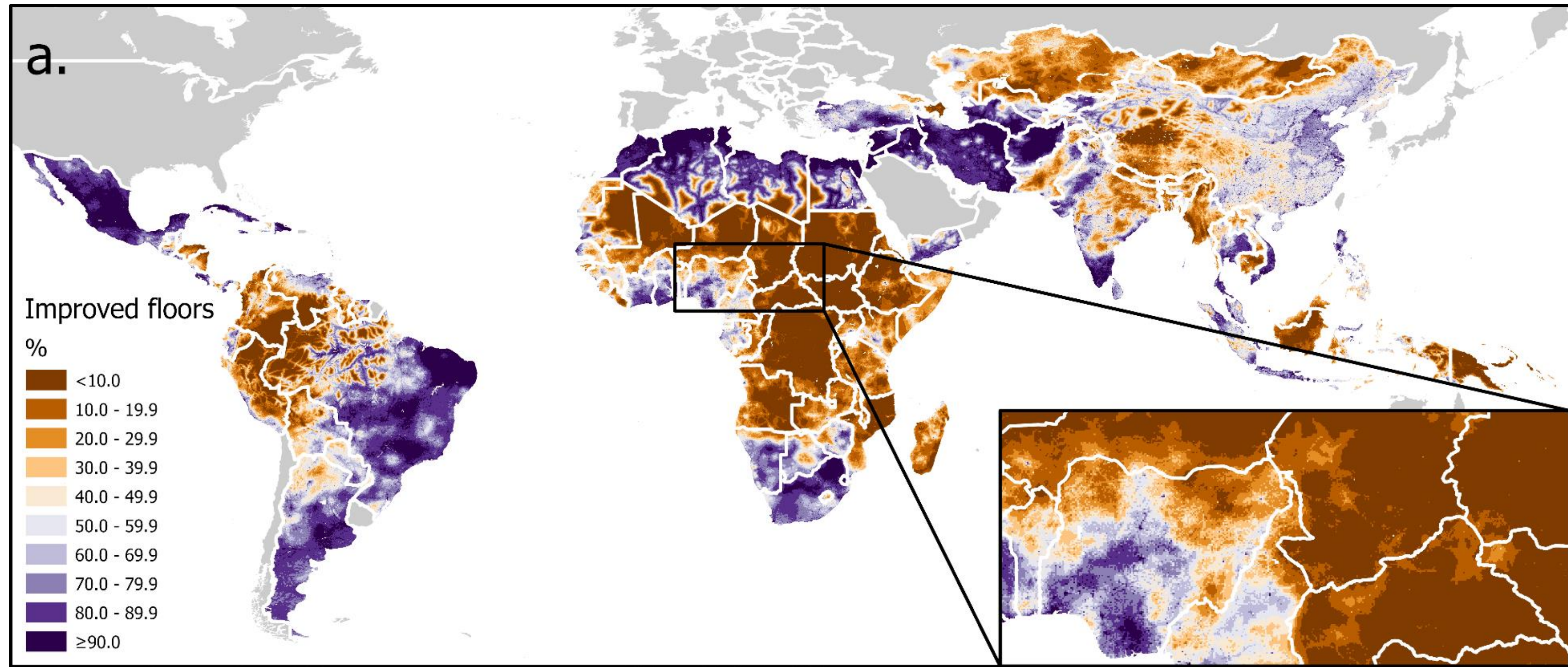
MICS clusters
assigned to
settlement locations
with probability
proportional to
population size



INLA models fitted
to map predicted
coverage

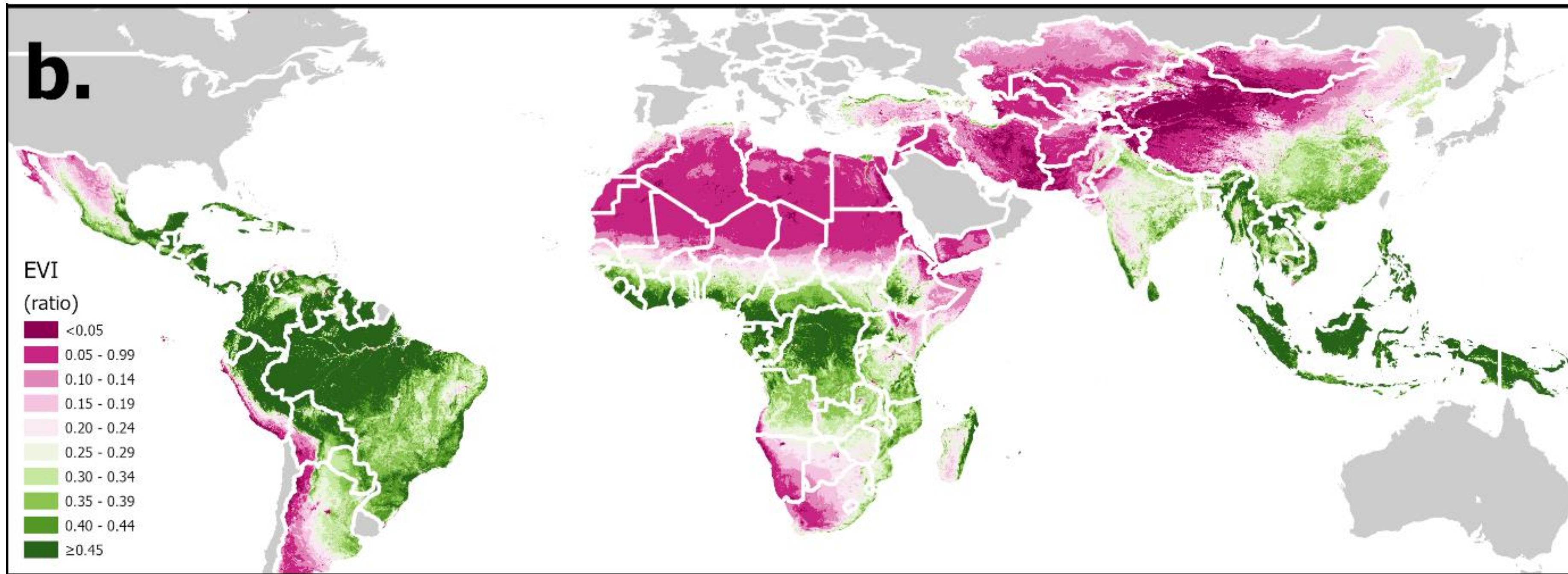
Covariate data (1/3): Household & subject data

Prevalence of finished floors in Low- and Middle-Income Countries – interpolations based on household survey data and environmental covariates



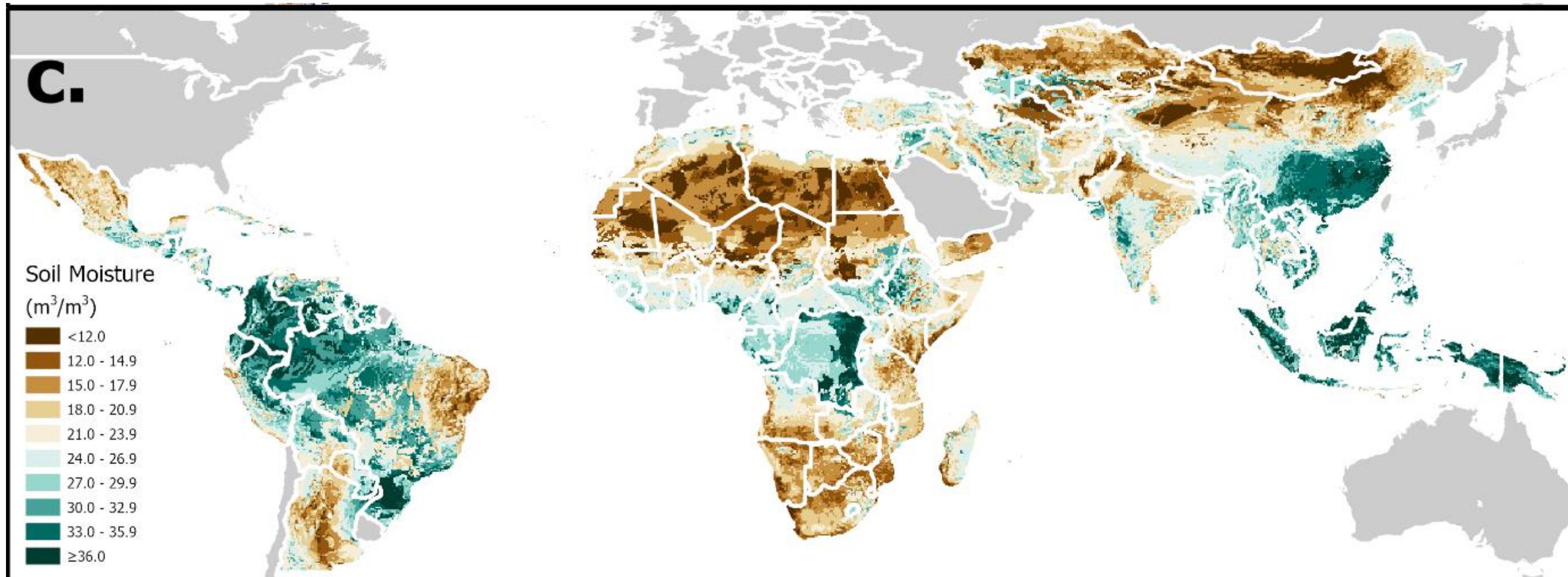
Covariate data (2/3): Static environmental

Enhanced Vegetation Index (EVI) in Low- and Middle-Income Countries



Covariate data (3/3): Time-varying hydrometeorological

Annual average soil moisture in Low- and Middle-Income Countries (GLDAS, soon to be supplemented with ERA5-Land)



Conclusions

- MICS is a source of critical data inputs for Plan-EO
- The initiative serves as a use case for the invaluable data products that the programme provides.

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Protocol: doi.org/10.21203/rs.3.rs-2640564/v2

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