IHME

How should we sample the world for pandemic response?

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Virtual Workshop on Geospatial Needs for a Pandemic-Resilient World presented by the Mapping Science Committee
Session: Modeling the spatial spread of disease and its local burden

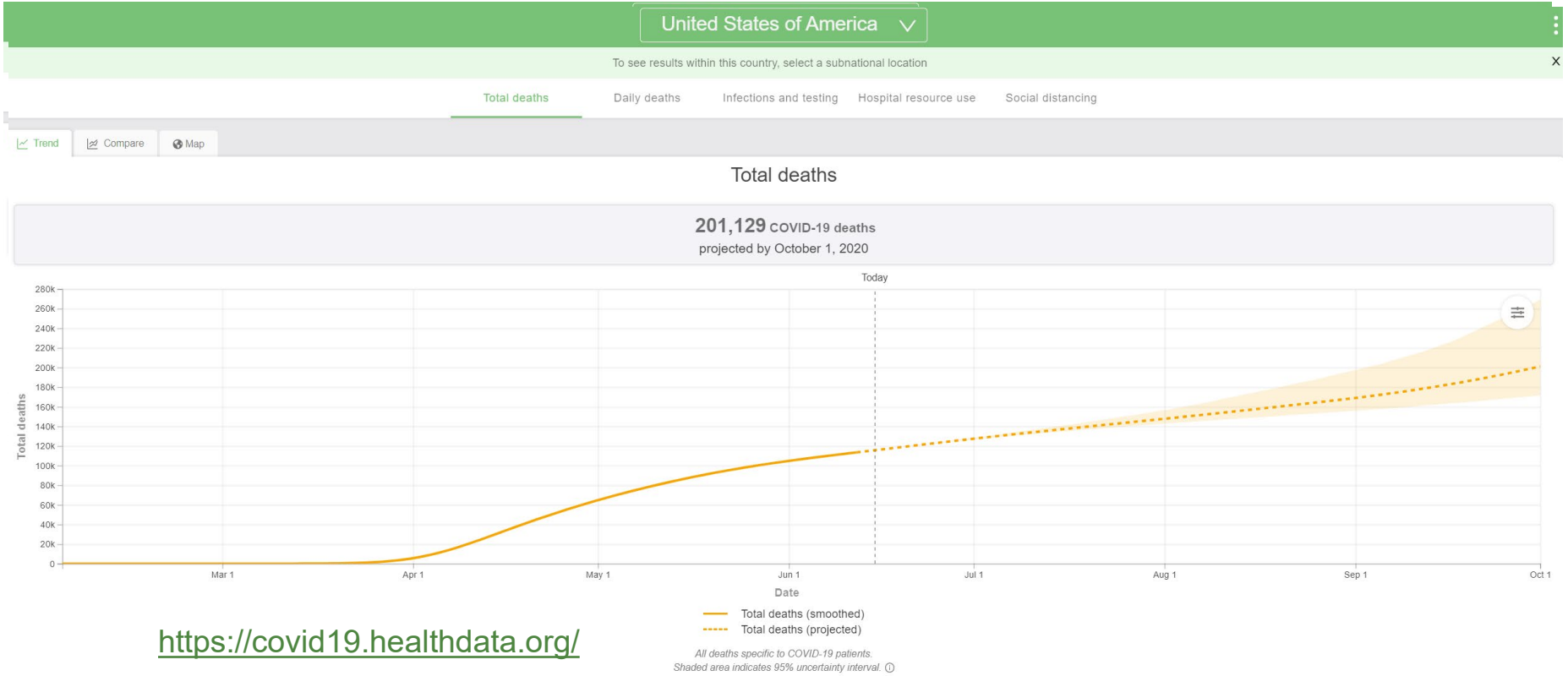
UNIVERSITY of WASHINGTON

Institute for Health Metrics and Evaluation

Introduction

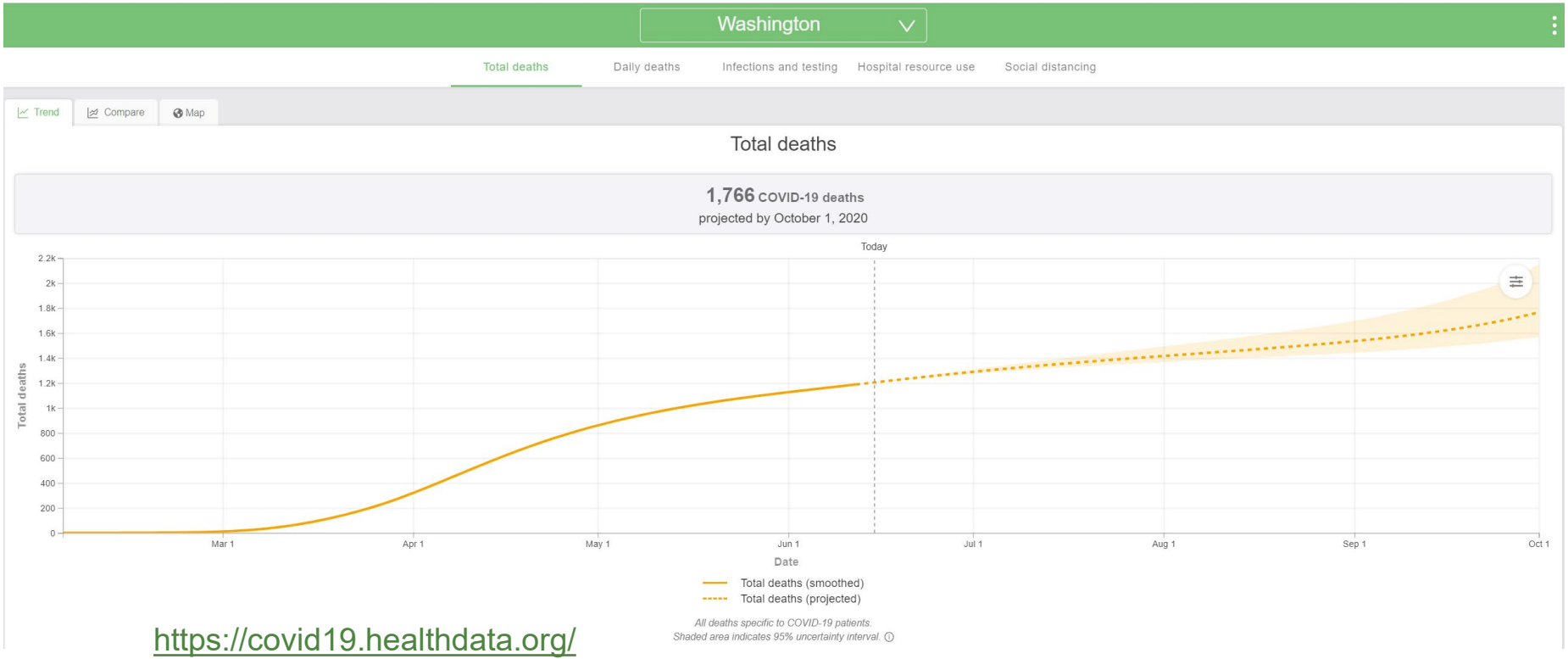
- The IHME model
  - How it works – geo-spatial?
  - Viz tools can be accessed here
  - Update schedule
  - Future steps
- Surveilling the globe
  - Global stratification
  - Population weighting
  - Examples for Africa
  - Active pushing of data

COVID-19 visualization tool



https://covid19.healthdata.org/

COVID-19 visualization tool



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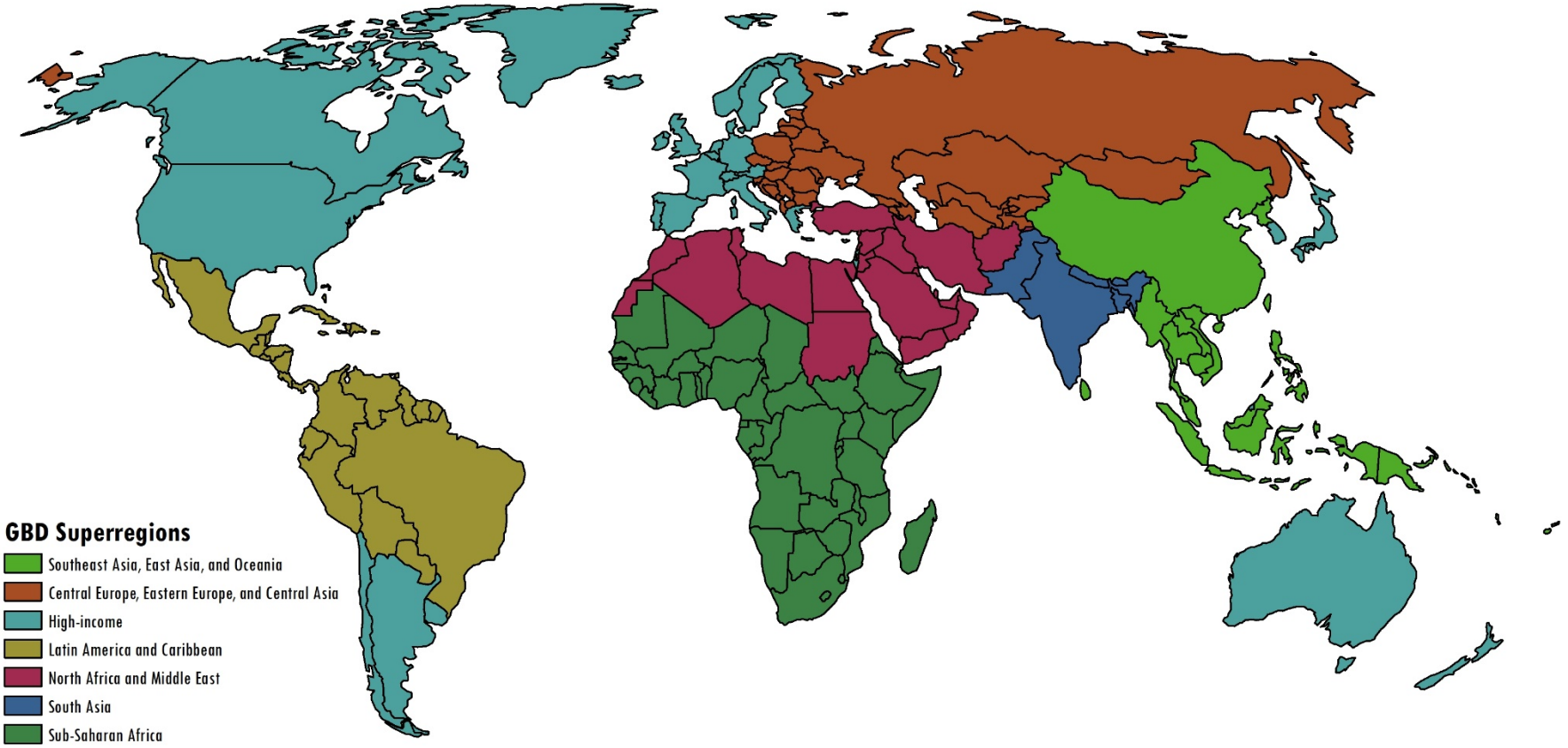
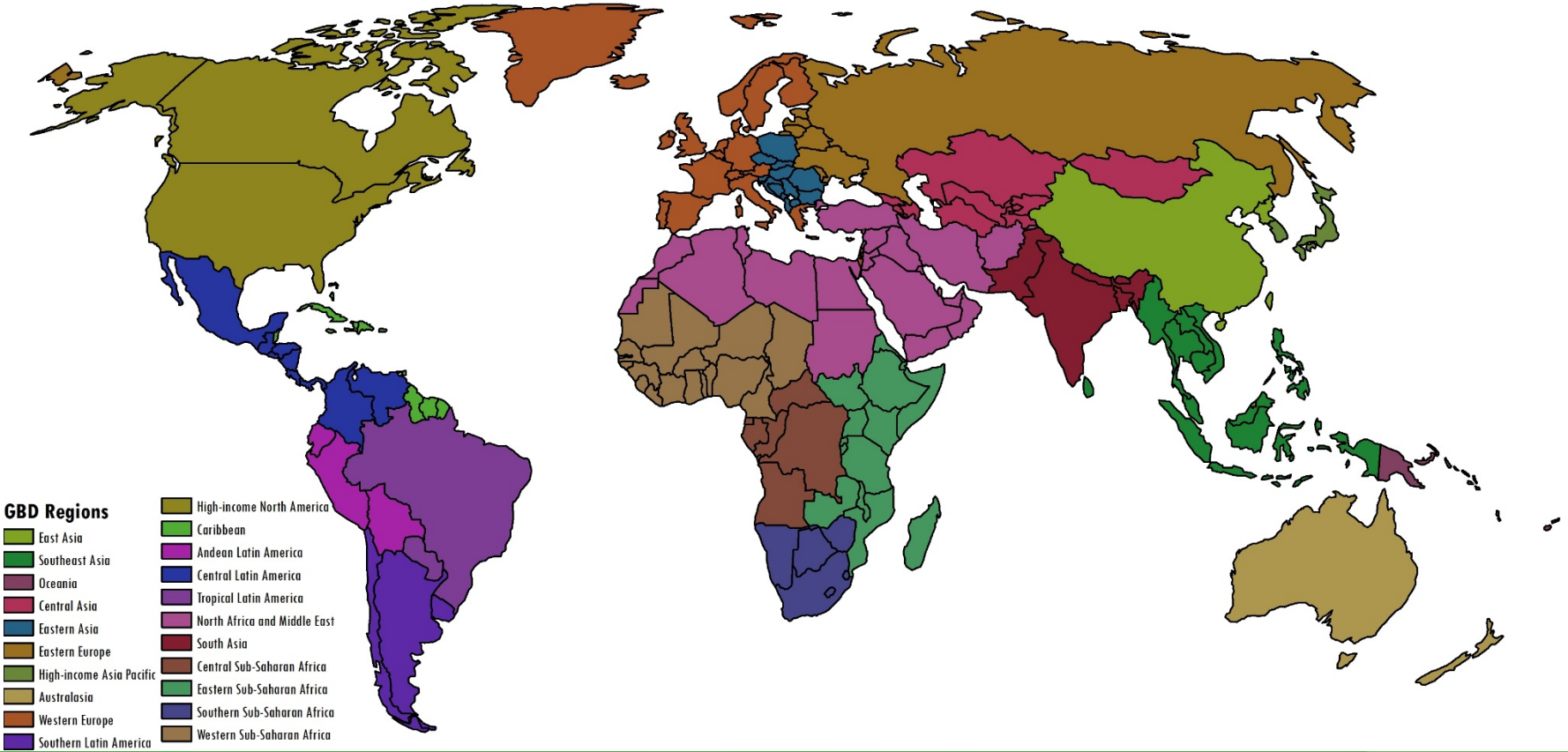
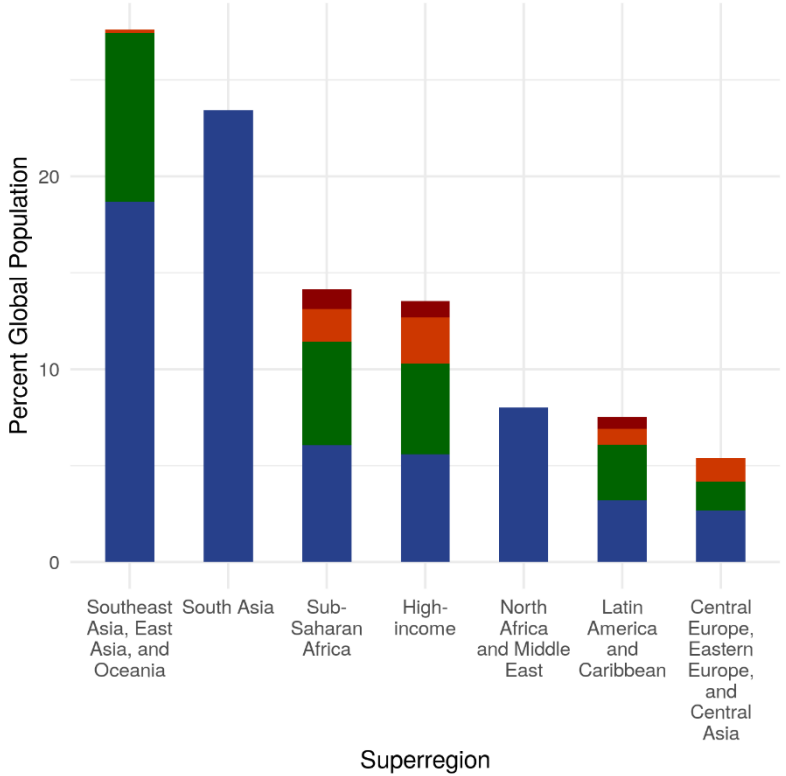
Maps


GBD Superregions
Southeast Asia, East Asia, and Oceania
Central Europe, Eastern Europe, and Central Asia
High-income
Latin America and Caribbean
North Africa and Middle East
South Asia
Sub-Saharan Africa

Maps


GBD Regions
East Asia
Southeast Asia
Oceania
Central Asia
Eastern Asia
Eastern Europe
High-income Asia Pacific
Australasia
Western Europe
Southern Latin America
High-income North America
Caribbean
Andean Latin America
Central Latin America
Tropical Latin America
North Africa and Middle East
South Asia
Central Sub-Saharan Africa
Eastern Sub-Saharan Africa
Southern Sub-Saharan Africa
Western Sub-Saharan Africa

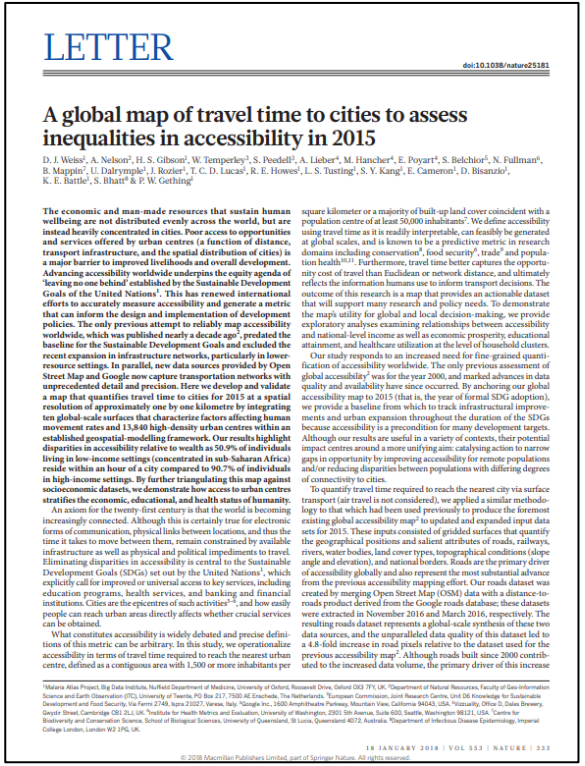
Population by Superregion and Region



Super-region	Region	Percent of Total Population	Population (Millions)	Countries	# of Surveillance Sites (total=2000)
Southeast Asia, East Asia, & Oceania	East Asia	18.8	1473.2	3	377
	Southeast Asia	8.7	681.5	13	174
	Oceania	0.2	13.5	18	3
South Asia	South Asia	23.4	1825.9	5	467
Sub-Saharan Africa	**Western Sub-Saharan Africa**	**6**	**472.9**	**19**	**121**
	Eastern Sub-Saharan Africa	**5.4**	**421.5**	**15**	**108**
	Central Sub-Saharan Africa	**1.7**	**136.3**	**6**	**35**
	Southern Sub-Saharan Africa	**1**	**79.5**	**6**	**20**
High-income	Western Europe	5.6	437.1	25	112
	High-income North America	4.7	366.3	2	94
	High-income Asia Pacific	2.4	187.1	4	48
	Southern Latin America	0.9	67.2	3	17
	Australasia	0.4	29.8	2	8
North Africa & Middle East	North Africa & Middle East*	8	624.3	22	160
Latin America & Caribbean	Central Latin America	3.2	251.3	9	64
	Tropical Latin America	2.8	220.2	2	56
	Andean Latin America	0.8	64.4	3	16
	Caribbean**	0.6	48.2	20	12
Central Europe, Eastern Europe, & Central Asia	Eastern Europe	2.7	209.1	7	53
	Central Europe	1.5	113.8	13	29
	Central Asia	1.2	95.9	9	25

Site Selection Methodology

- Hospital catchment areas calculated using an accessibility cost-distance surface (see Weiss *et al.*, 2018)
  - Hospital dataset with 4839 facilities (WHO Malaria Surveillance facility list for sub-Saharan Africa)
- 50% of sites placed based on the highest population catchments in a given country (aim to be representative of urban populations)
- 50% of sites placed based on the largest catchment areas (aim to be representative of rural populations) and sample the fill area of a nation
- For uneven site allotments, preference was given to high population catchments



LETTER

doi:10.1038/nature25181

A global map of travel time to cities to assess inequalities in accessibility in 2015

D. J. Weiss[1], A. Nelson[2], H. S. Gibson[3], W. Temperley[3], S. Peedell[3], A. Lieber[4], M. Hancher[4], E. Poyart[4], S. Belchior[5], N. Fullman[6], B. Mappin[7], U. Dalrymple[1], J. Rozier[1], T. C. D. Lucas[1], R. E. Howes[8], L. S. Tusting[1], S. Y. Kang[6], E. Cameron[1], D. Bisanzio[9], K. E. Battle[1], S. Bhatt[8] & P. W. Gething[1]

The economic and man-made resources that sustain human wellbeing are not distributed evenly across the world, but are instead heavily concentrated in cities. Poor access to opportunities and services offered by urban centres (a function of distance, transport infrastructure, and the spatial distribution of cities) is a major barrier to improved livelihoods and overall development. Advancing accessibility worldwide underpins the equity agenda of 'leaving no one behind' established by the Sustainable Development Goals of the United Nations[1]. This has renewed international efforts to accurately measure accessibility and generate a metric that can inform the design and implementation of development policies. The only previous attempt to reliably map accessibility worldwide, which was published nearly a decade ago[2], predated the baseline for the Sustainable Development Goals and excluded the recent expansion in infrastructure networks, particularly in lower-resource settings. In parallel, new data sources provided by Open Street Map and Google now capture transportation networks with unprecedented detail and precision. Here we develop and validate a map that quantifies travel time to cities for 2015 at a spatial resolution of approximately one by one kilometre by integrating ten global-scale surfaces that characterize factors affecting human movement rates and 13,840 high-density urban centres within an established geospatial-modelling framework. Our results highlight disparities in accessibility relative to wealth as 50.9% of individuals living in low-income settings (concentrated in sub-Saharan Africa) reside within an hour of a city compared to 90.7% of individuals in high-income settings. By further triangulating this map against socioeconomic datasets, we demonstrate how access to urban centres stratifies the economic, educational, and health status of humanity.

An axiom for the twenty-first century is that the world is becoming increasingly connected. Although this is certainly true for electronic forms of communication, physical links between locations, and thus the time it takes to move between them, remain constrained by available infrastructure as well as physical and political impediments to travel. Eliminating disparities in accessibility is central to the Sustainable Development Goals (SDGs) set out by the United Nations[1], which explicitly call for improved or universal access to key services, including education programs, health services, and banking and financial institutions. Cities are the epicentres of such activities[3–5], and how easily people can reach urban areas directly affects whether crucial services can be obtained.

What constitutes accessibility is widely debated and precise definitions of this metric can be arbitrary. In this study, we operationalize accessibility in terms of travel time required to reach the nearest urban centre, defined as a contiguous area with 1,500 or more inhabitants per square kilometer or a majority of built-up land cover coincident with a population centre of at least 50,000 inhabitants[2]. We define accessibility using travel time as it is readily interpretable, can feasibly be generated at global scales, and is known to be a predictive metric in research domains including conservation[6], food security[6], trade[7] and population health[10,11]. Furthermore, travel time better captures the opportunity cost of travel than Euclidean or network distance, and ultimately reflects the information humans use to inform transport decisions. The outcome of this research is a map that provides an actionable dataset that will support many research and policy needs. To demonstrate the map's utility for global and local decision-making, we provide exploratory analyses examining relationships between accessibility and national-level income as well as economic prosperity, educational attainment, and healthcare utilization at the level of household clusters.

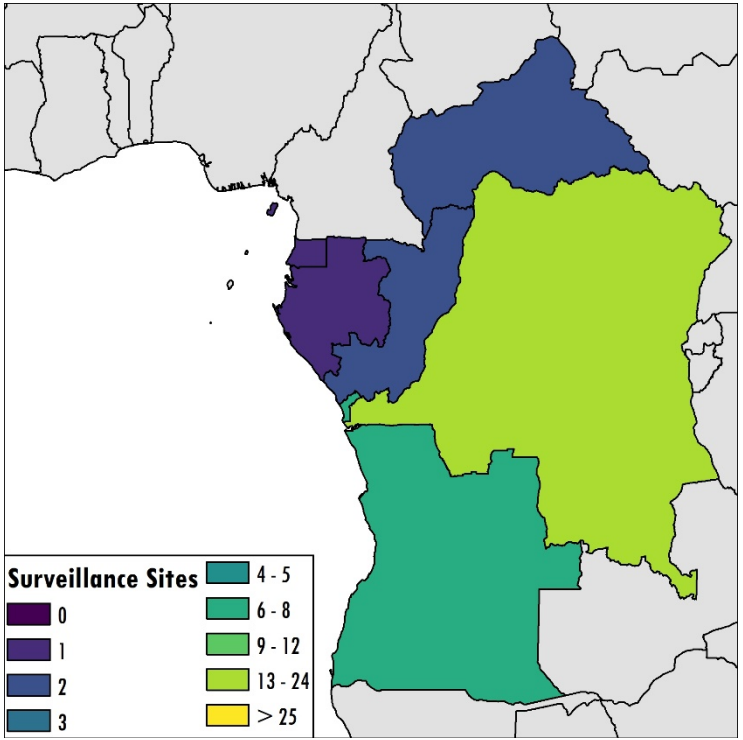
Our study responds to an increased need for fine-grained quantification of accessibility worldwide. The only previous assessment of global accessibility[2] was for the year 2000, and marked advances in data quality and availability have since occurred. By anchoring our global accessibility map to 2015 (that is, the year of formal SDG adoption), we provide a baseline from which to track infrastructural improvements and urban expansion throughout the duration of the SDGs because accessibility is a precondition for many development targets. Although our results are useful in a variety of contexts, their potential impact centres around a more unifying aim: catalysing action to narrow gaps in opportunity by improving accessibility for remote populations and/or reducing disparities between populations with differing degrees of connectivity to cities.

To quantify travel time required to reach the nearest city via surface transport (air travel is not considered), we applied a similar methodology to that which has been used previously to produce the foremost existing global accessibility map[2] to updated and expanded input data sets for 2015. These inputs consisted of gridded surfaces that quantify the geographical positions and salient attributes of roads, railways, rivers, water bodies, land cover types, topographical conditions (slope angle and elevation), and national borders. Roads are the primary driver of accessibility globally and also represent the most substantial advance from the previous accessibility mapping effort. Our roads dataset was created by merging Open Street Map (OSM) data with a distance-to-roads product derived from the Google roads database; these datasets were extracted in November 2016 and March 2016, respectively. The resulting roads dataset represents a global-scale synthesis of these two data sources, and the unparalleled data quality of this dataset led to a 4.8-fold increase in road pixels relative to the dataset used for the previous accessibility map[2]. Although roads built since 2000 contributed to the increased data volume, the primary driver of this increase

[1]Malaria Atlas Project, Big Data Institute, Nuffield Department of Medicine, University of Oxford, Roosevelt Drive, Oxford OX3 7FY, UK. [2]Department of Natural Resources, Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands. [3]European Commission, Joint Research Centre, Unit D6 Knowledge for Sustainable Development and Food Security, Via Fermi 2749, Ispra 21027, Varese, Italy. [4]Google Inc., 1600 Amphitheatre Parkway, Mountain View, California 94043, USA. [5]Vizzuality, Office 0, Dales Brewery, Gwydr Street, Cambridge CB1 2LJ, UK. [6]Institute for Health Metrics and Evaluation, University of Washington, 2301 5th Avenue, Suite 600, Seattle, Washington 98121, USA. [7]Centre for Biodiversity and Conservation Science, School of Biological Sciences, University of Queensland, St Lucia, Queensland 4072, Australia. [8]Department of Infectious Disease Epidemiology, Imperial College London, London W2 1PG, UK.

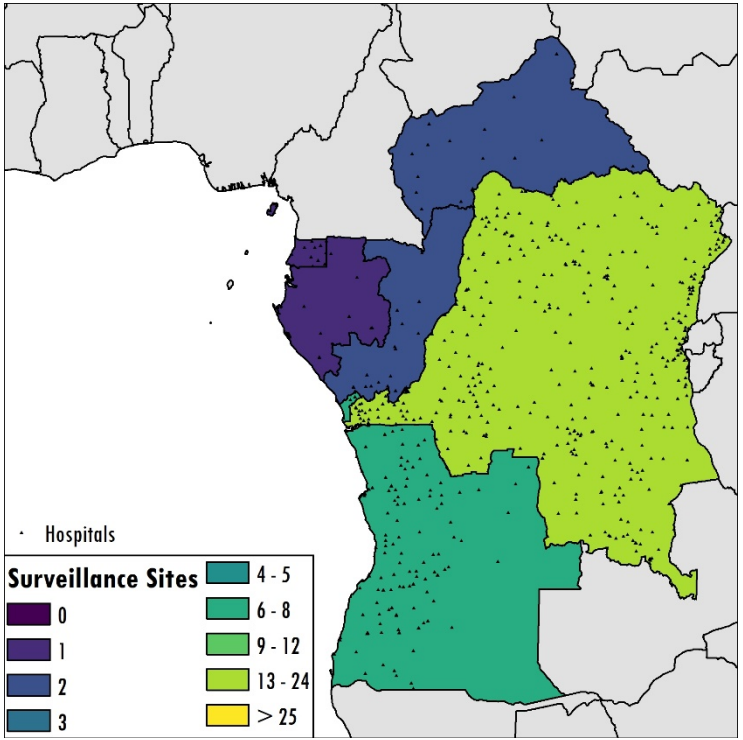
Central Sub-Saharan Africa

Country	Sites
Democratic Republic of the Congo	21
Angola	8
Central African Republic	2
Congo	2
Gabon	1
Equatorial Guinea	1



Central Sub-Saharan Africa

Country	Hospitals
Democratic Republic of the Congo	435
Angola	150
Central African Republic	20
Congo	26
Gabon	16
Equatorial Guinea	18



Central Sub-Saharan Africa

Country	Sites	Hospitals
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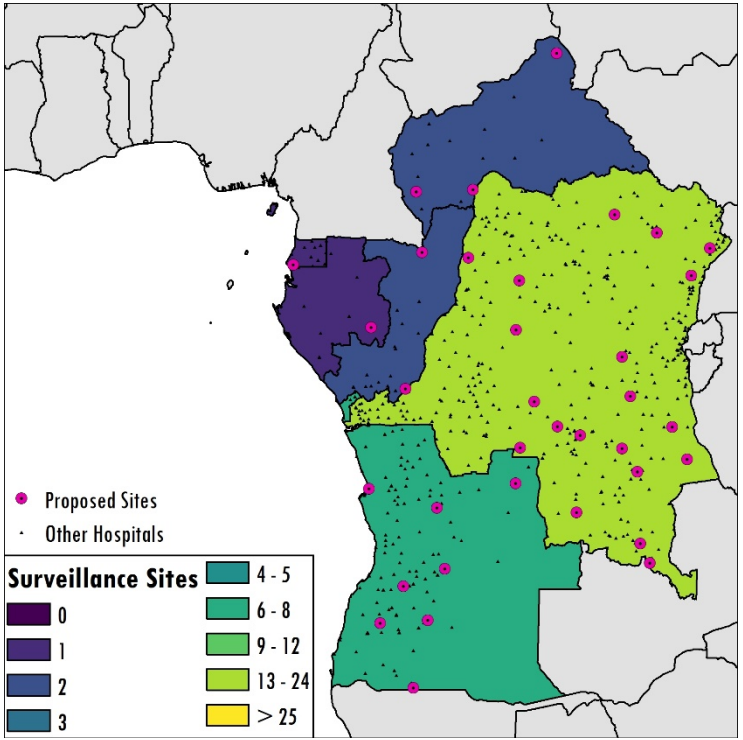
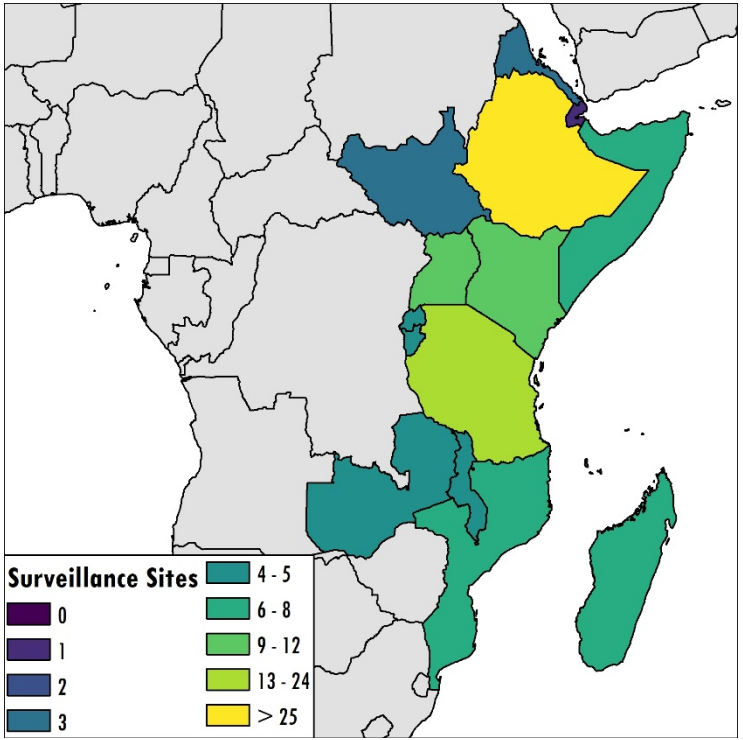


Eastern Sub-Saharan Africa

Country	Sites
Ethiopia	25
Tanzania	14
Kenya	12
Uganda	10
Mozambique	8
Madagascar	7
Somalia	6
Malawi	5
Zambia	5

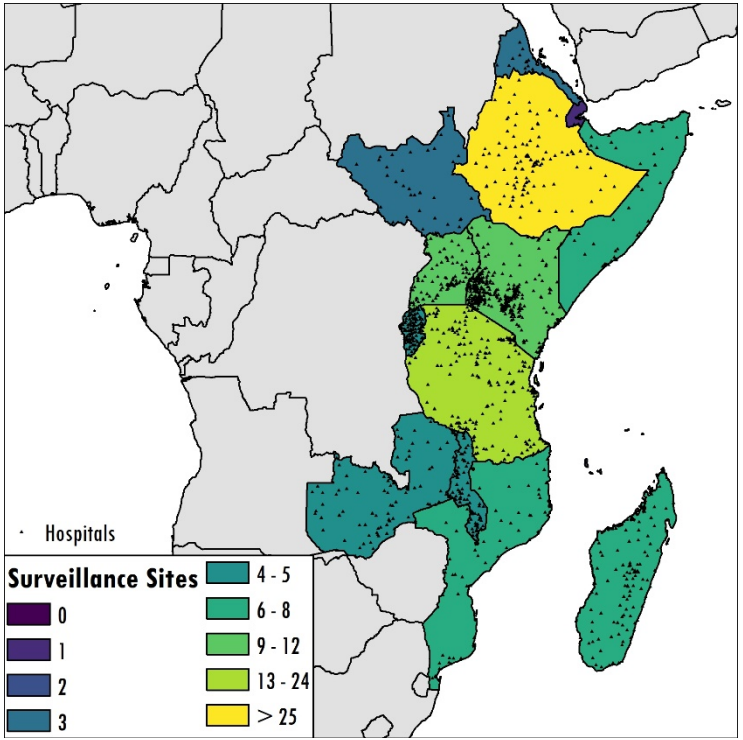
Country	Sites
Burundi	4
Rwanda	4
South Sudan	3
Eritrea	3
Djibouti	1



Eastern Sub-Saharan Africa

Country	Hospitals
Ethiopia	161
Tanzania	223
Kenya	403
Uganda	121
Mozambique	61
Madagascar	125
Somalia	79
Malawi	80
Zambia	91

Country	Hospitals
Burundi	49
Rwanda	47
South Sudan	40
Eritrea	22
Djibouti	13



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Country	Sites	Hosp.
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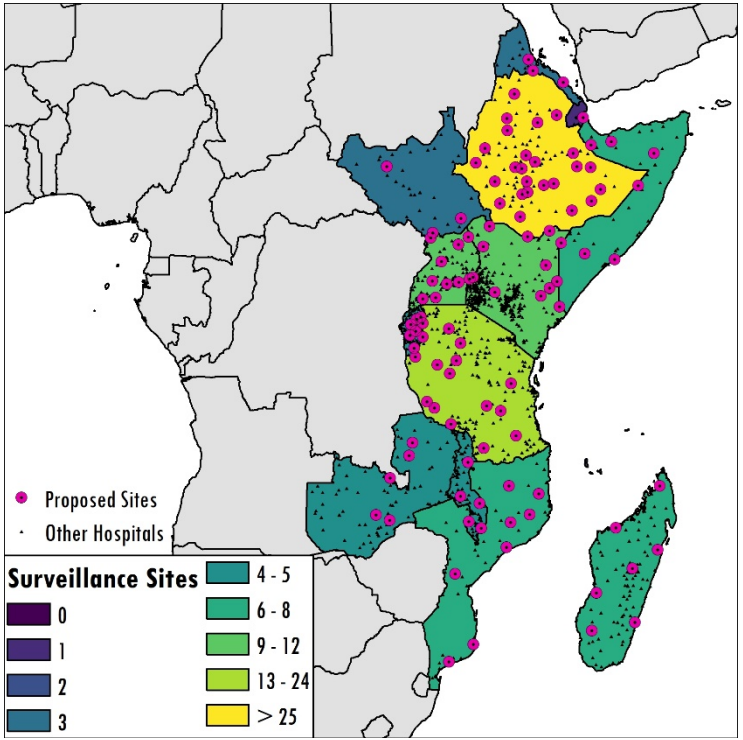
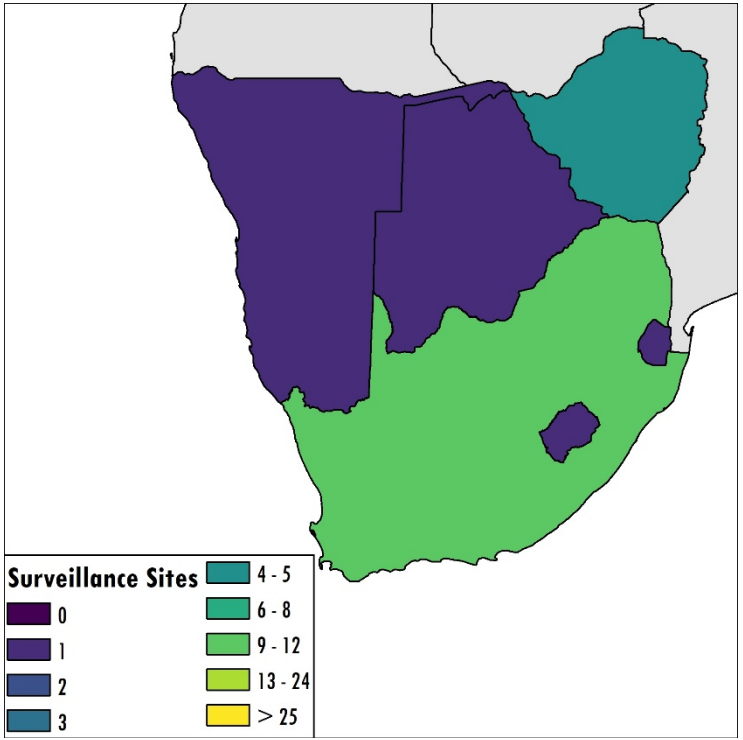
Eritrea	3	22
Djibouti	1	13



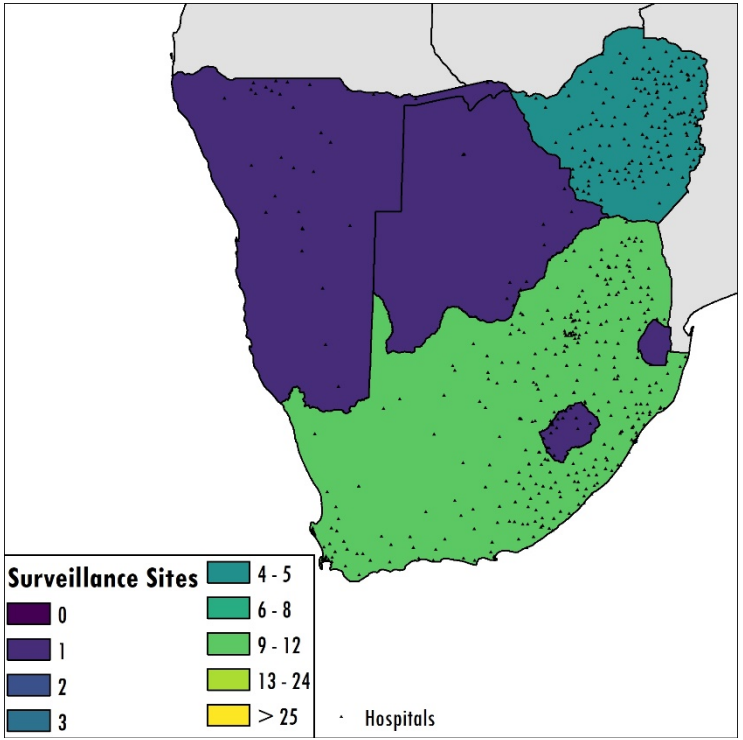
Southern Sub-Saharan Africa

Country	Sites
South Africa	12
Zimbabwe	4
Namibia	1
Botswana	1
Lesotho	1



Southern Sub-Saharan Africa

Country	Hospitals
South Africa	327
Zimbabwe	169
Namibia	36
Botswana	12
Lesotho	20



Southern Sub-Saharan Africa

Country	Sites	Hospitals
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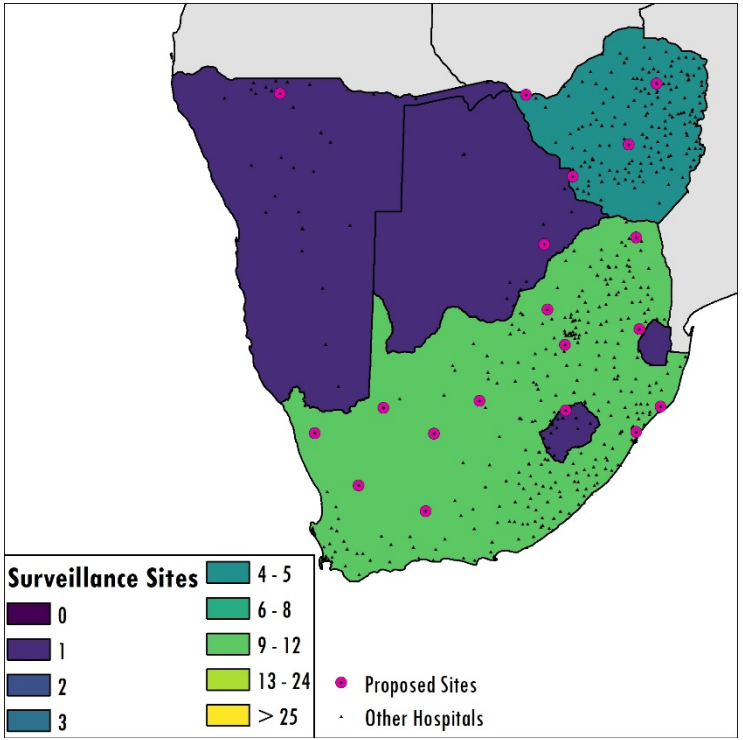
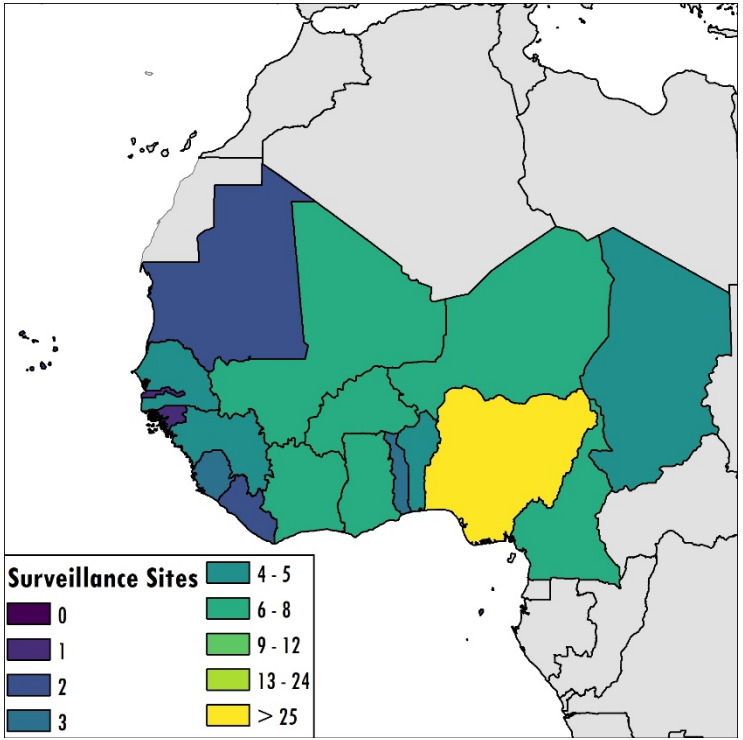
Zimbabwe	4	169
Namibia	1	36
Botswana	1	12
Lesotho	1	20



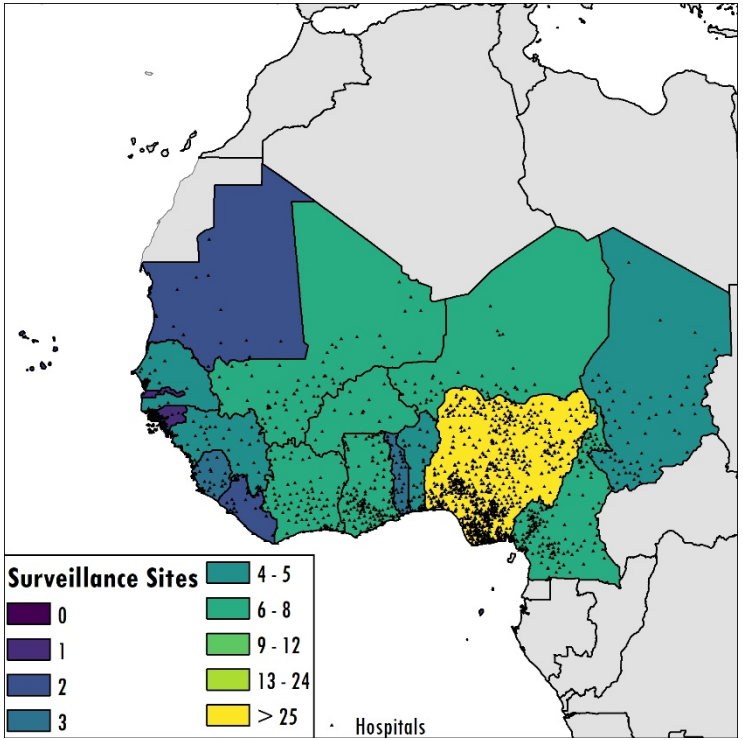
Western Sub-Saharan Africa

Country	Sites	Country	Sites
Nigeria	48	Benin	4
Ghana	8	Guinea	4
Cameroon	8	Sierra Leone	3
Cote d'Ivoire	7	Togo	3
Niger	6	Liberia	2
Burkina Faso	6	Mauritania	2
Mali	6	The Gambia	1
Senegal	5	Guinea-Bissau	1
Chad	5		



Western Sub-Saharan Africa

Country	Hospitals	Country	Hospitals
Nigeria	899	Benin	48
Ghana	178	Guinea	35
Cameroon	184	Sierra Leone	32
Cote d'Ivoire	100	Togo	38
Niger	41	Liberia	38
Burkina Faso	13	Mauritania	18
Mali	79	The Gambia	6
Senegal	29	Guinea-Bissau	8
Chad	78		



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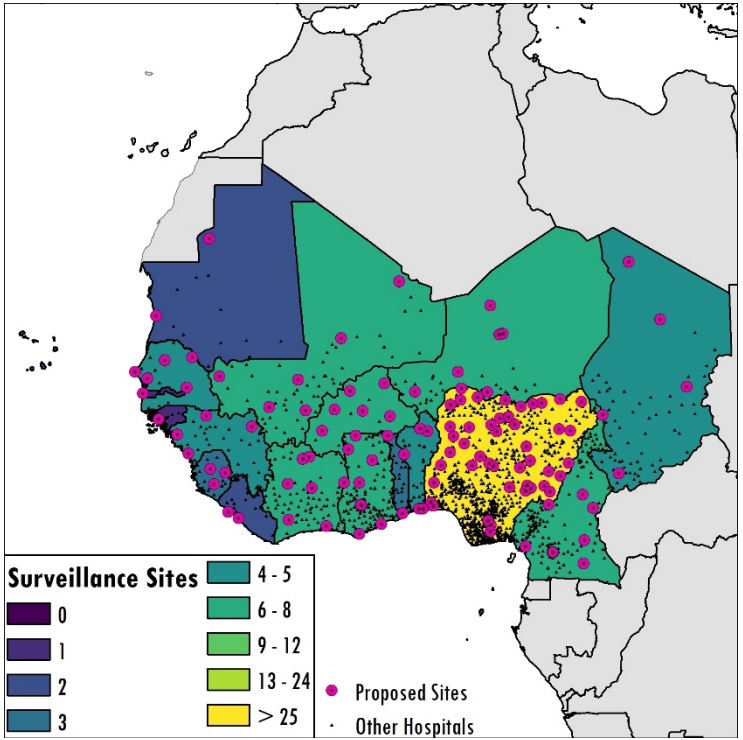
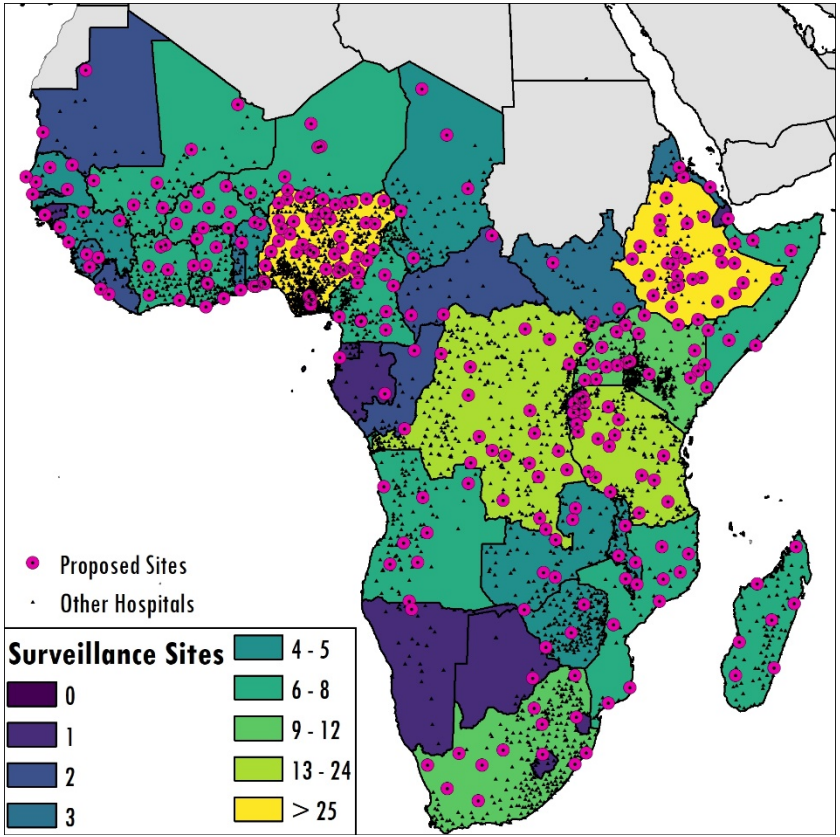
Ghana	8	178	Guinea	4	35
Cameroon	8	184	Sierra Leone	3	32
Cote d'Ivoire	7	100	Togo	3	38
Niger	6	41	Liberia	2	38
Burkina Faso	6	13	Mauritania	2	18
Mali	6	79	The Gambia	1	6
Senegal	5	29	Guinea-Bissau	1	8
Chad	5	78			



Sub-Saharan Africa



Facility-level metadata to inform planning and response

- Number of staff: stratified by type (e.g. technician, nurse, doctor)
- Number of total beds
- Number of intensive care units
- Average utilization of resources / baseline availability
- Diagnostics available in-facility / presence of pathogen-specific test equipment
- Availability of WHO Essential Medicines
- Availability of isolation wards
- Availability of Personal Protective Equipment (PPE)

How can we sample for future updates

- Daily, weekly, monthly
  - from surveillance viewpoint
  - feasibity and cost
  - Agility vs. mission creep?
- Is 2000 sentinels too ambitious or too cautious?

Thank you! Questions?