Indigenous Academic and Institutional Capacity Building to tackle Public Health Emergencies in Africa

THE EBOLA EXPERIENCE, BIOSECURITY AND CAPACITY.

Akin Abayomi

BWC UNOG 18th December 2015

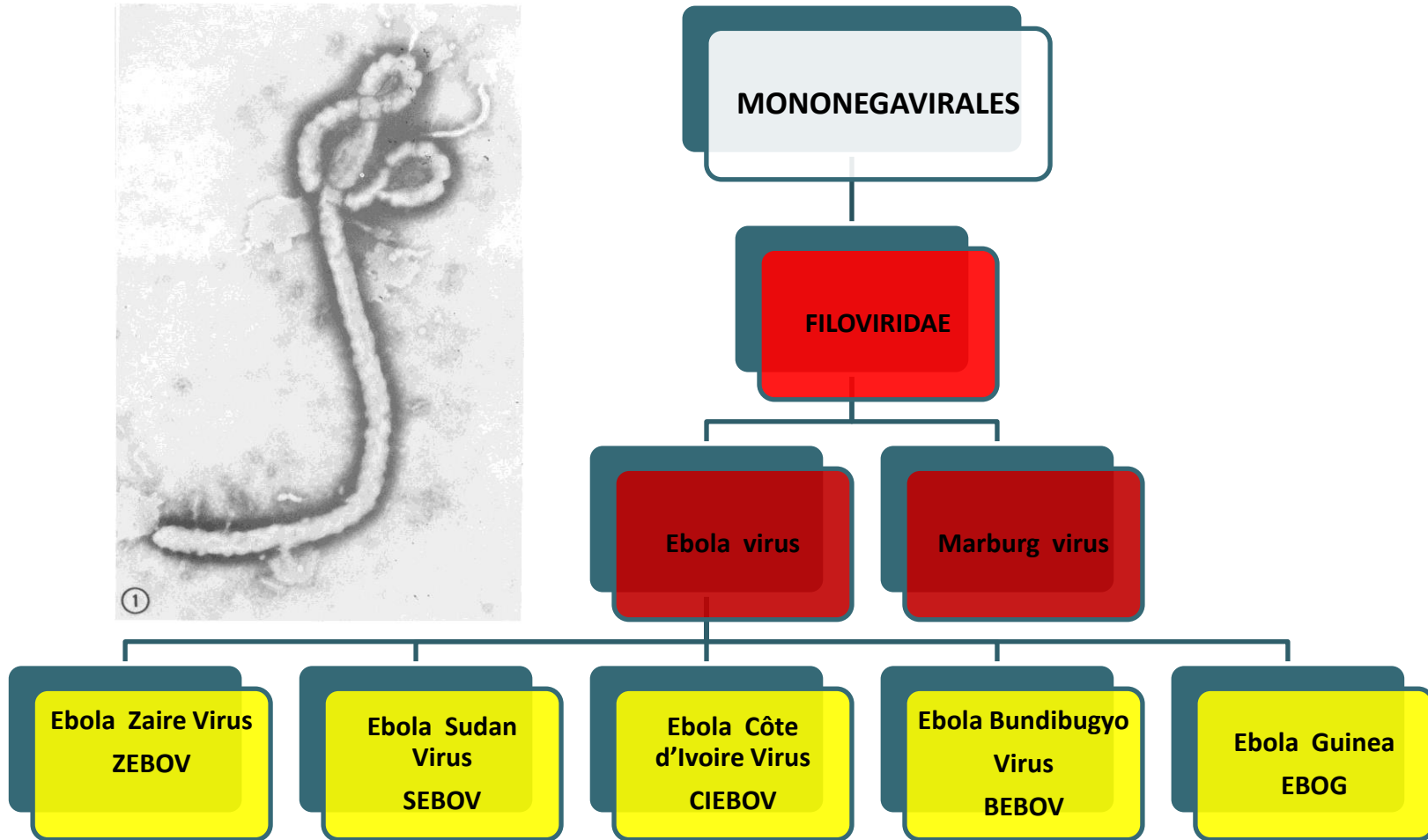# Cape Town

Tygerberg : 1,400 bed multi-disciplinary teaching hospital

So what is Ebola?

FILOVIRUSES ARE THE MOST VIRULENT AGENTS OF African Viral Haemorrhagic Fever (AVHF).

Ebola virus

MONONEGAVIRALES

FILOVIRIDAE

Ebola virus

Marburg virus

Ebola Zaire Virus ZEBOV

Ebola Sudan Virus SEBOV

Ebola Côte d'Ivoire Virus CIEBOV

Ebola Bundibugyo Virus BEBOV

Ebola Guinea EBOG
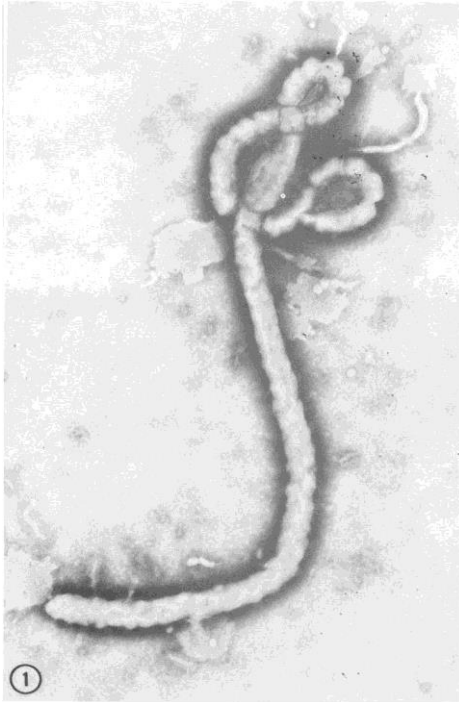
Haemorrhage vs GI features → Multi-organ Failure

Gingival bleeding

PHOTOS TAKEN IN CONGO 2003 ON EBOLA PATIENTS
(Courtesy Prof Jean-Jacques Muyembe)

"Ebola" a Category A pathogen

Category A pathogens are those organisms/biological agents that pose the highest risk to national security and public health because they can:

- be easily disseminated or transmitted from person to person

- Result in high mortality rates and have the potential for major public health impact

- **Cause public panic and social disruption**

- Require special action for public health preparedness and response

Category "A" pathogen

Lassa

Rift Valley

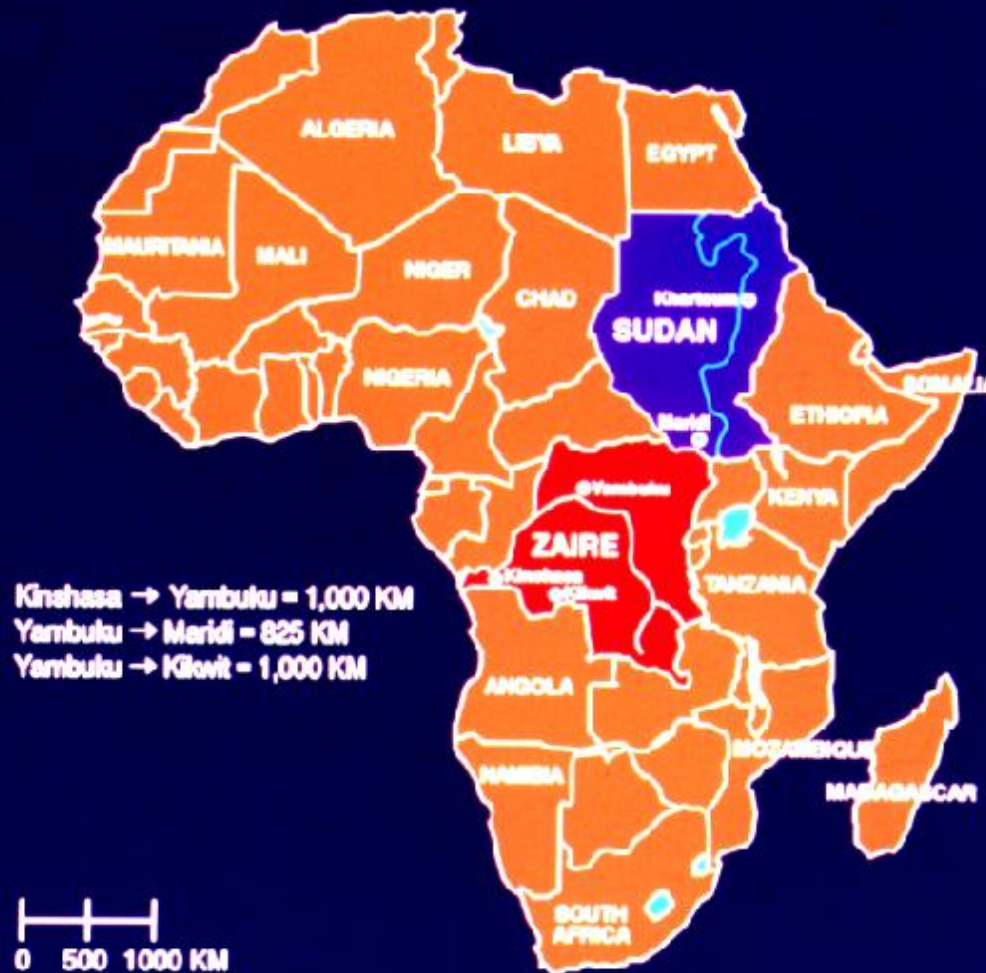Ebola

Marburg

Small pox

Anthrax

Pandemic Flu

Civil Unrest

Historical Distribution since 1976

Locations of Outbreaks of Ebola Hemorrhagic Fever, Sudan and DR Congo (Zaire), 1976
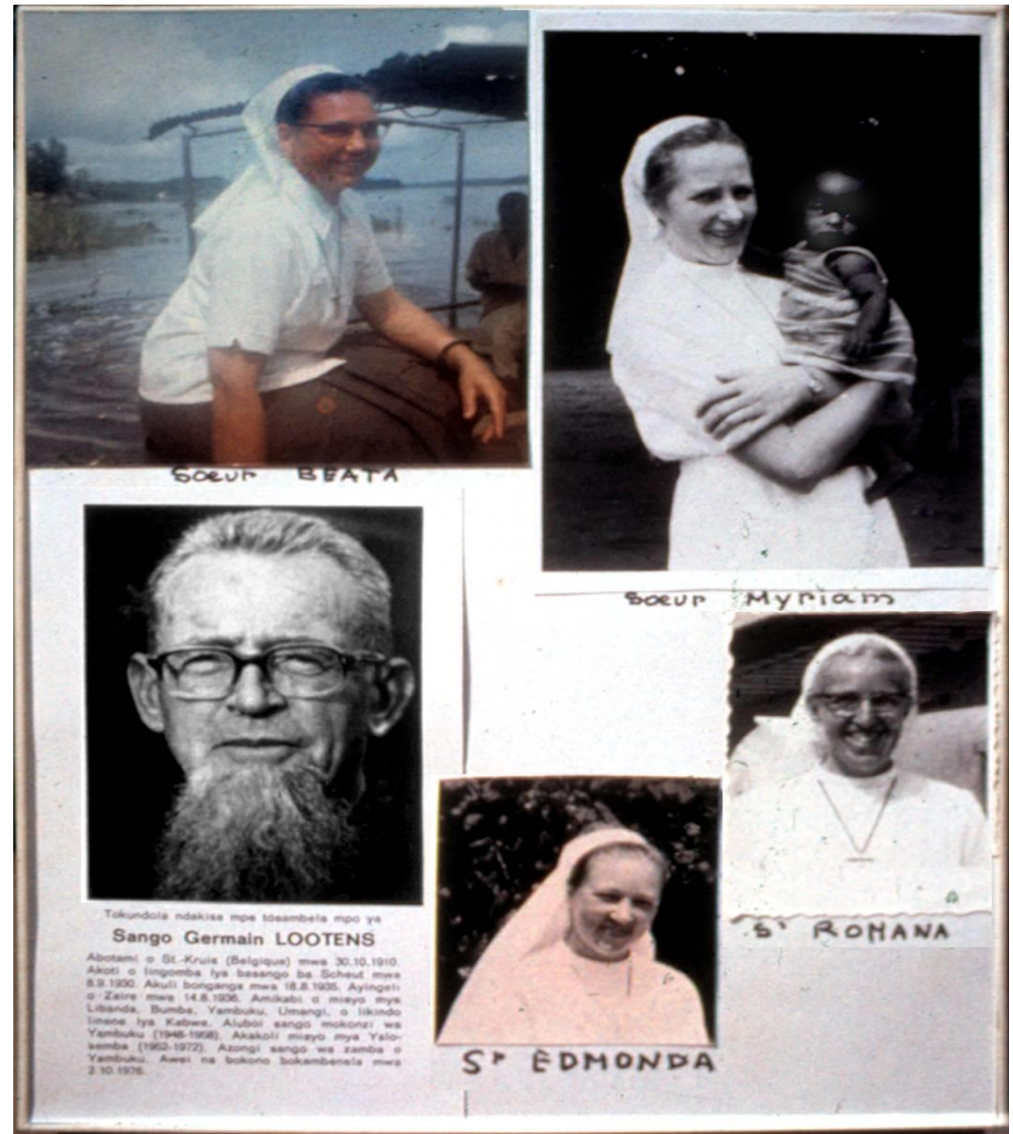
Ebola River Near Yambuku Hosp, Zaire 1976

Hospital Staff: 17
- EHF 13
- Died 11

SOEUR BEATA

Soeur Myriam

Tokundola ndakisa mpe tosambela mpo ya
Sango Germain LOOTENS

Abotami o St.-Kruis (Belgique) mwa 30.10.1910. Akoti o lingomba lya basango ba Scheut mwa 8.9.1930. Akufi bonganga mwa 18.8.1935. Ayingeli o Zaire mwa 14.8.1936. Amikabi o miayo mya Libanda, Bumba, Yambuku, Limangi, o likindo limone lya Kabwe. Aluboi sango mokonzi wa Yambuku (1948-1958). Akakoli miayo mya Yalosemba (1952-1972). Azongi sango wa zamba o Yambuku. Awei na bokono bokambenela mwa 2.10.1976.

Sr ROMANA

Sr EDMONDA

The Belgian Missionary Hospital Staff

Map of Ebola outbreaks in Africa.

Alexander KA, Sanderson CE, Marathe M, Lewis BL, Rivers CM, et al. (2015) What Factors Might Have Led to the Emergence of Ebola in West Africa?. PLoS Negl Trop Dis 9(6): e0003652. doi:10.1371/journal.pntd.0003652
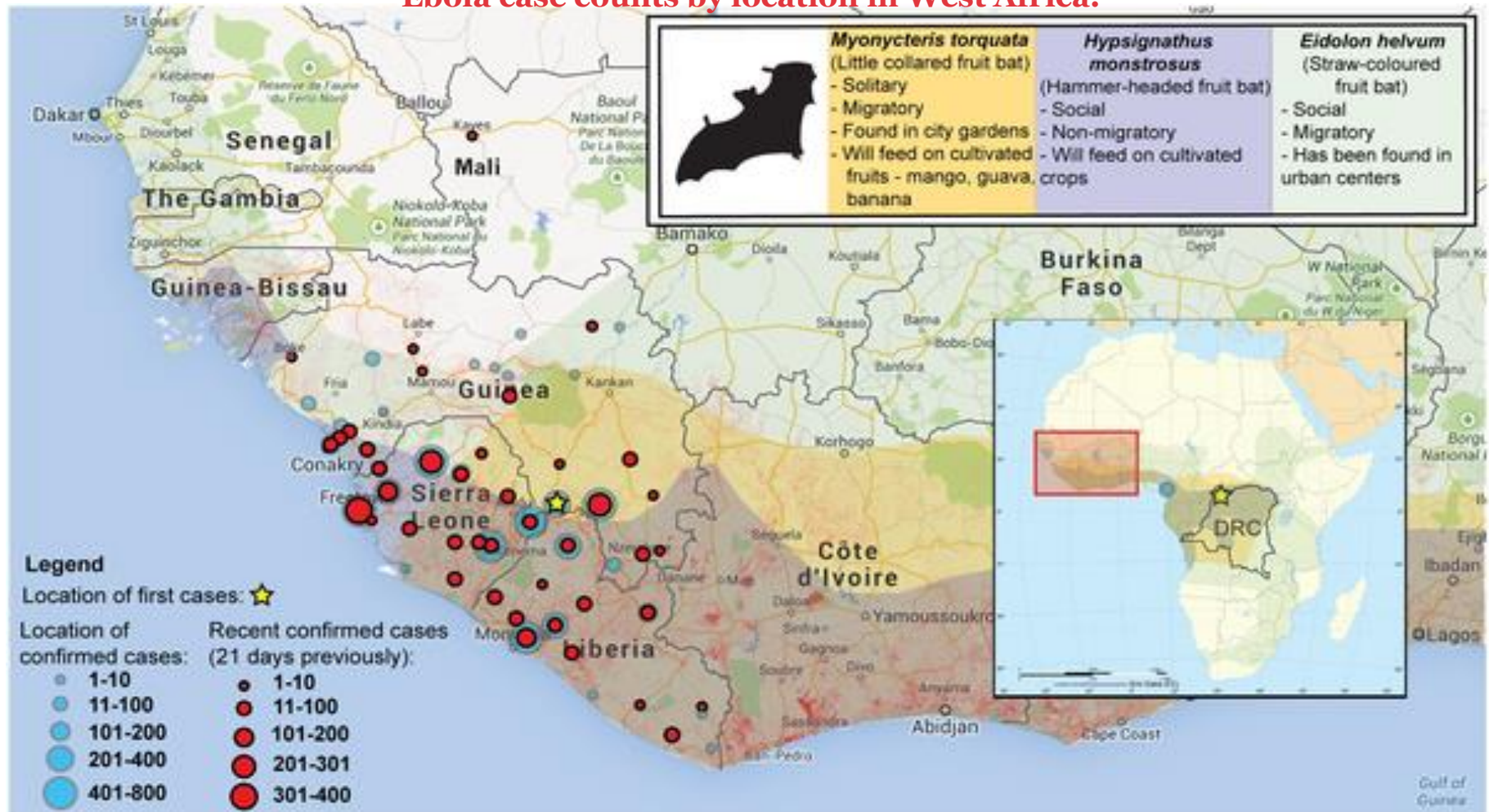
ECOLGY of EBOLA

Animal source of Ebola outbreak eludes scientists

CARRIED AWAY Straw-colored fruit bats, *Eidolon helvum* (shown), and other bat species may have carried Ebola virus from Central Africa to West Africa, where the virus is now causing the largest-ever epidemic of the disease.

Range of bat species suspected of being reservoirs of Ebola, human population density, and Ebola case counts by location in West Africa.

Myonycteris torquata (Little collared fruit bat)	Hypsignathus monstrosus (Hammer-headed fruit bat)	Eidolon helvum (Straw-coloured fruit bat)
- Solitary - Migratory - Found in city gardens - Will feed on cultivated fruits - mango, guava, banana	- Social - Non-migratory - Will feed on cultivated crops	- Social - Migratory - Has been found in urban centers

Legend

Location of first cases: ☆

Location of confirmed cases:
- ○ 1-10
- ○ 11-100
- ○ 101-200
- ○ 201-400
- ○ 401-800

Recent confirmed cases (21 days previously):
- ● 1-10
- ● 11-100
- ● 101-200
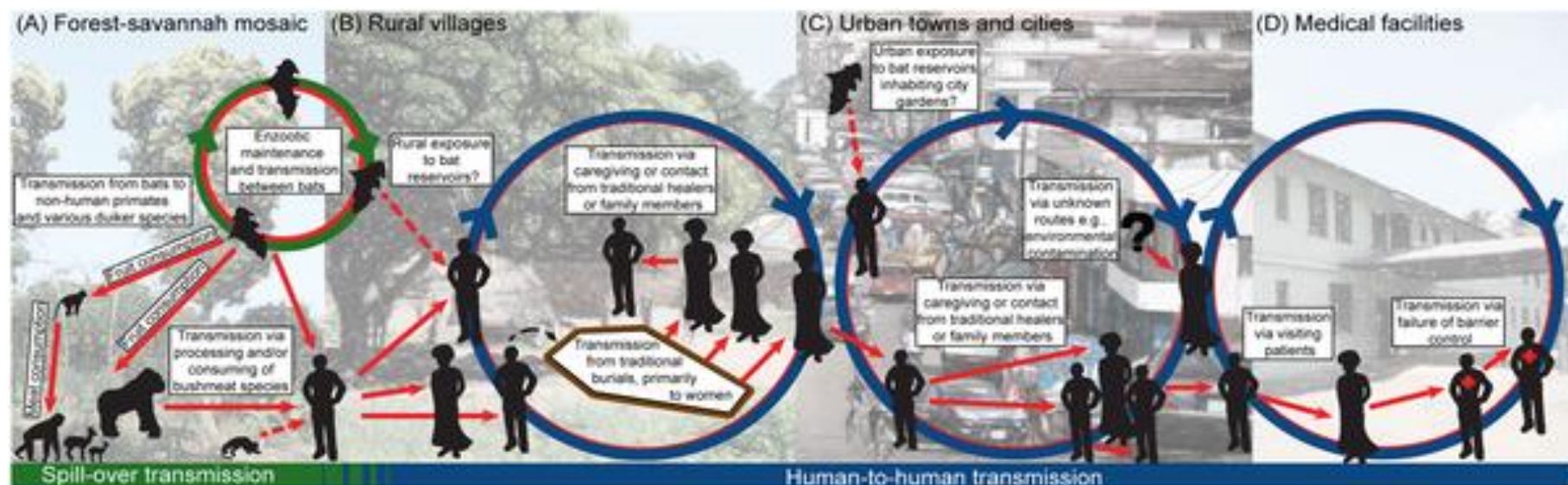- ● 201-301
- ● 301-400

PLOS | NEGLECTED TROPICAL DISEASES

Ebola virus has killed thousands of great apes in the last few years. Outbreaks in the Congo have occurred over large areas, often centering on gorilla and chimpanzee habitat. (World Conservation Union)

Schematic of virus spillover from wildlife and human-to-human transmission.

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The West African Outbreak

December 2013

June 2014.
Mapping origin and the movement
(Courtesy of PHE)

Epidemiological characteristics of the 2014 West African Ebola outbreak.

Summary of Ebola outbreak characteristics in West Africa

December–September 2014 [26]

Term	Definition	Current estimates
Reproductive number (R_0):	Number of healthy people one sick individual infects over the course of his/her illness.	Guinea: 1.71
		Liberia: 1.83
		Sierra Leone: 2.02
Serial interval:	Time between consecutive people falling ill in a chain of transmission.	15.3 days
Incubation period:	Amount of time passed between a person becoming exposed to Ebola and when they start to show symptoms of the disease.	11.4 days
Doubling time:	Time taken for the number of sick individuals to double.	Guinea: 15.7 days
		Liberia: 23.6 days
		Sierra Leone: 30.2 days
Confirmed case fatality rate:	Number of people who die of confirmed Ebola infection.	Guinea: 70.7%
		Liberia: 72.3%
		Sierra Leone 69.0%
Unconfirmed case fatality rate:	Number of people who die with suspected but not confirmed Ebola infection.	Guinea: 13%
		Liberia: 58%
		Sierra Leone: 35%

doi:10.1371/journal.pntd.0003652.t002

PLOS | NEGLECTED TROPICAL DISEASES

Ebola outbreak expected to accelerate in October

Projected cases assuming current level of control effort

REAL CASES ■   PROJECTED CASES ■

14,000

10,000

6,000

2,000

DEC. 6

SEPT. 22   OCT. 26
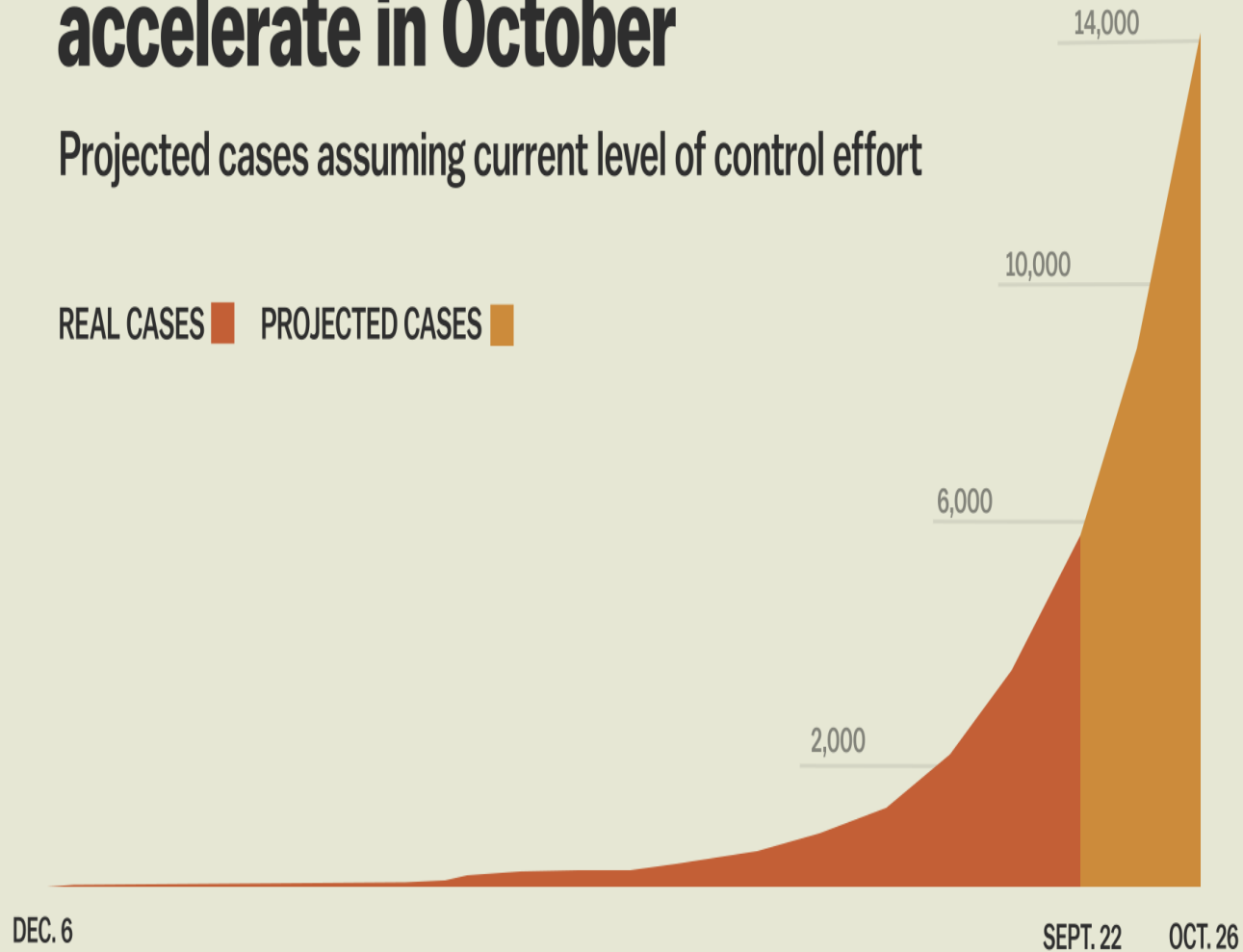
Source: HealthMap.org/Boston Children's Hospital

Total number of cases

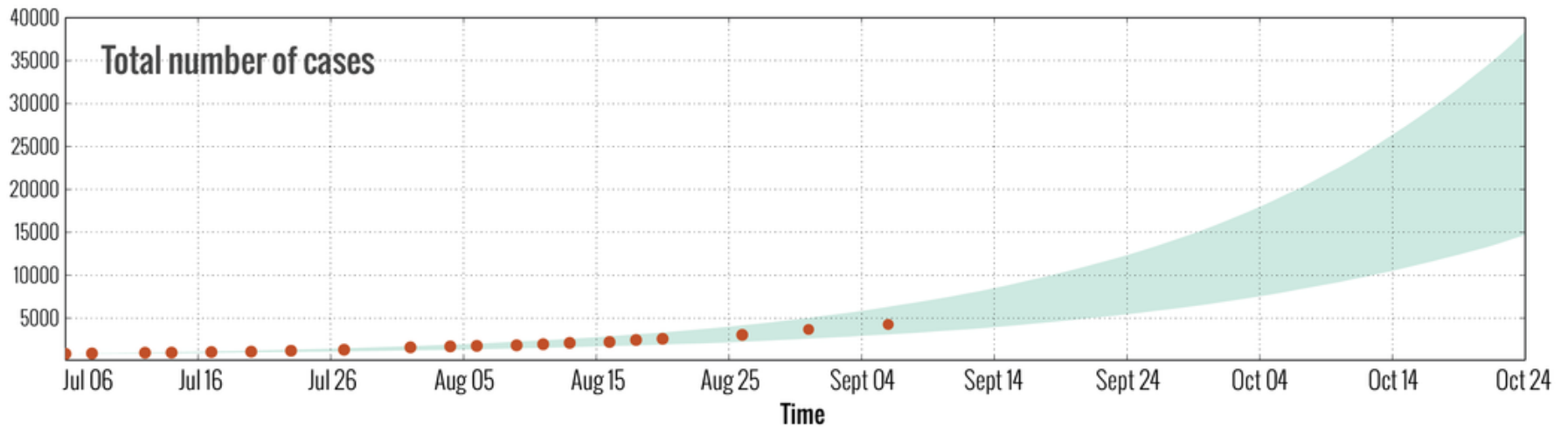| Date	Total Number of Cases
Sept 14 2014	[4000 - 8500]
Sept 24 2014	[5500 - 12300]
Oct 04 2014	[7500 - 17900]
Oct 14 2014	[10500 - 26300]
Oct 24 2014	[14800 - 38500]

Projections for the number of cases in Guinea, Liberia, and Sierra Leone.

The shaded areas correspond to the fluctuations cone provided by the stochastic microsimulations of the models selected by the calibration to data. WHO offical data are reported as red circles. The projected values consider that the epidemic continues to follow the current growth rate, thus assuming a worst-case scenario in which containment measures are not successful at curtailing the outbreak.

MOBS LAB

Effect of Air travel Restriction
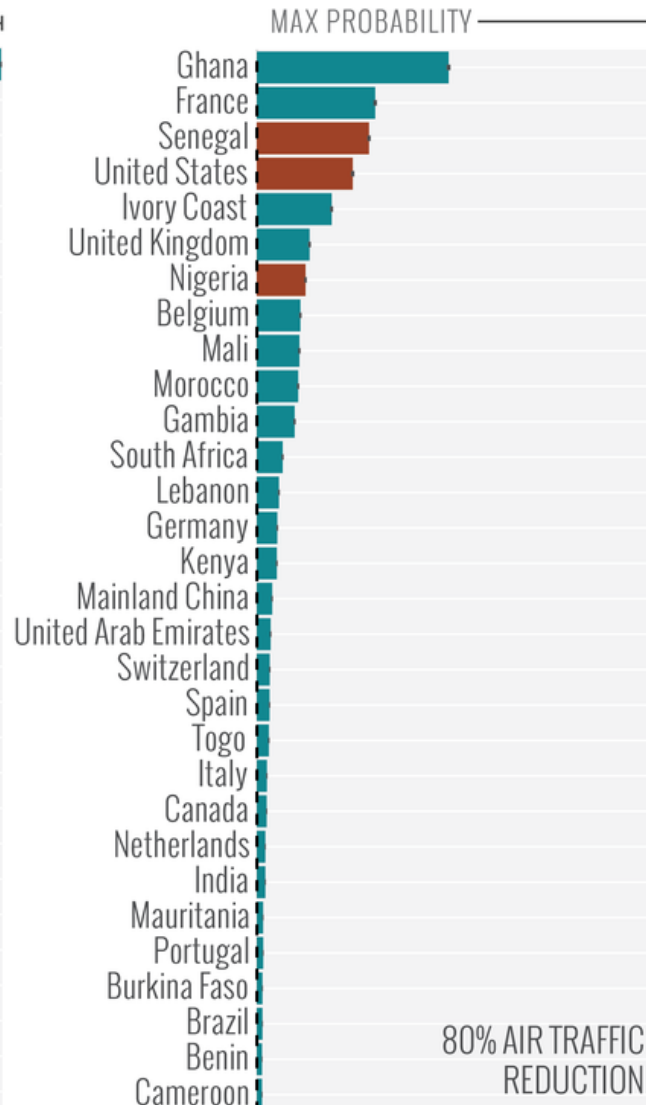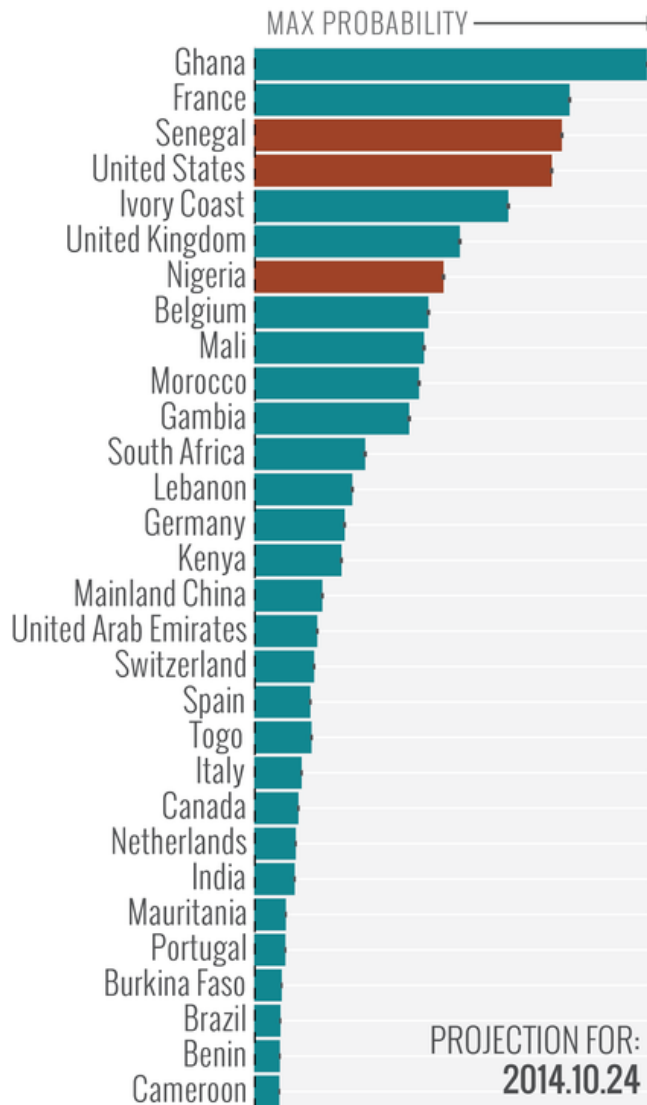
Top 30 countries ranked according to EVD importation risk.

The plot shows the top 30 countries ranked according to the relative probability of importation of EVD cases. Nigeria, Senegal, and US have already experienced case importation. We compare the results for the baseline case and a scenario with 80% traffic reduction to and from the EVD affected countries. The maximum probability projected for 24 October is about 96% and 46% in the baseline and traffic reduction scenarios, respectively.

Traffic reduction achieves only a 3-4 weeks delay in the growth of the case importation probability.

Projection provided on
1 October 2014

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Total as of October 2015

- **28,000 reported cases**

- **11,000 reported deaths**

- **14,000 survivors**

The Nigerian Factor

In July 2014 Ebola spreads to Lagos!!!!

Ebola virus epidemic in West Africa
Total cases: 17,145 Total deaths: 6,070

Mauritania

Senegal
Cases: 1
Deaths: 0

Gambia

Mali
Cases: 8
Deaths: 6

Niger

Burkina
Faso

Guinea-
Bissau

Guinea
Cases: 2,164
Deaths: 1,327

Nigeria
Cases: 20
Deaths: 8

Benin

Sierra Leone
Cases: 7,312
Deaths: 1,583

Togo

Côte d'Ivoire   Ghana

Liberia
Cases: 7,635
Deaths: 3,145

30 November 2014

Cameroon
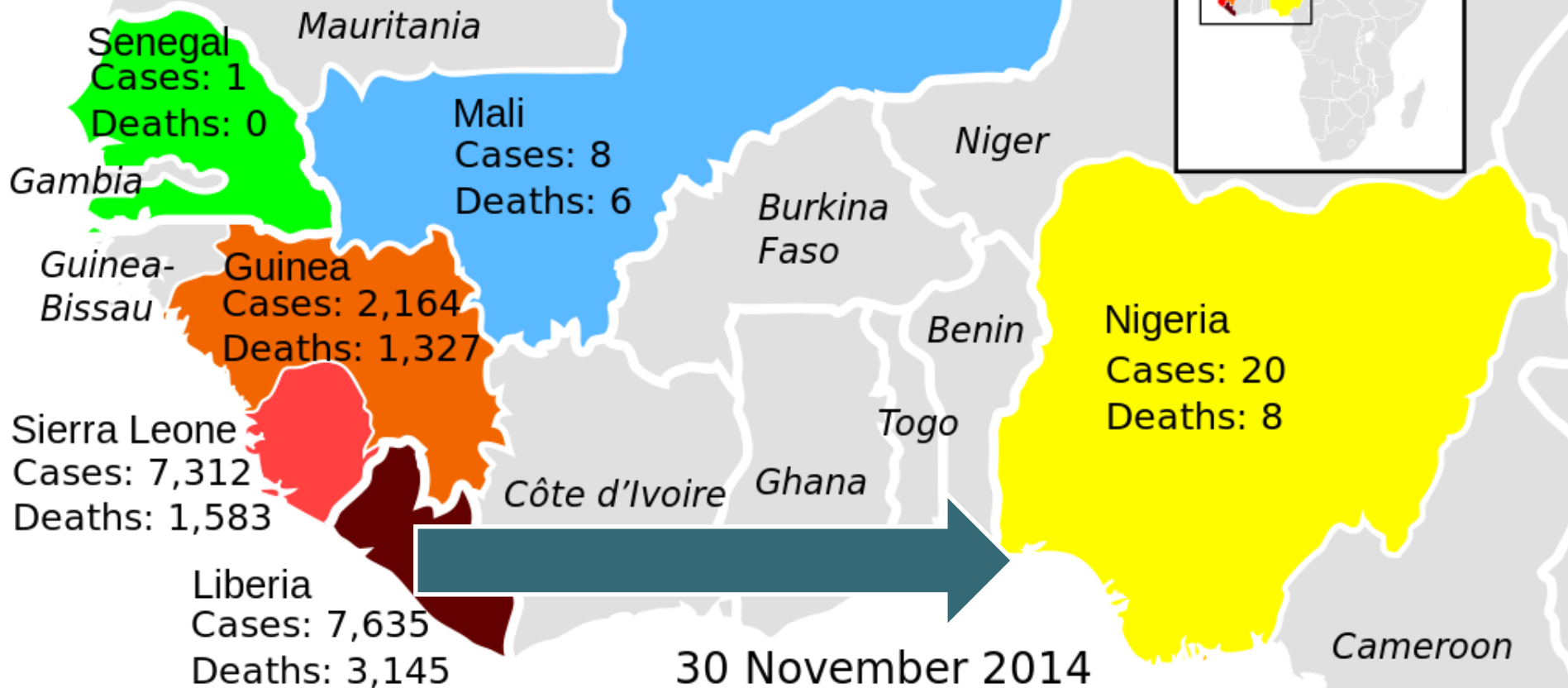
Lagos City

Lagos Metropolis or Megacity

- **Financial, Industrial and commercial nerve center of Nigeria**

- **Gate way into Nigeria : 1 international and 2 domestic airports. 2 sea ports**

- **Population is 23 million**

- **20 Local governments.**

- **6 of which have a density of >50,000/km2**

- **3 have a density in excess of 100,000/km2**

- **3rd fastest growing city in the world**

Lagos City Metropolis 23 Million inhabitants.

Ebola entry into Lagos

- **Index case entered Lagos on the 20th of July 2014 from Monrovia**

- **On 24th of July case confirmed to be Ebola**

- **Incident management center (IMS) and emergency operations Centre (EOC) set up**

- **Index case demised on the 25th July and same day cremation was conducted.**

Nigeria: 1 n 4 Africans is Nigerian. Population approaching 200 Million

About 12,000 people fly out of Nigeria daily to different corners of the globe, it could have had a devastating effect on the world if not rapidly contained.

TOP PASSENGER FLOWS:
Number of passengers (weekly)

6000+

3000-6000

1500-3000

300-1500

UK
GERMANY
FRANCE
ITALY
SPAIN

CANADA
USA

MOROCCO

TURKEY

LEBANON

EGYPT

UNITED ARAB
EMIRATES

SAUDI ARABIA

CHINA

INDIA

NIGER

SENEGAL
GAMBIA
GUINEA
SIERRA LEONE
LIBERIA
COTE
D'IVOIRE
GHANA
NIGERIA
CAMEROON

KENYA

SOUTH AFRICA
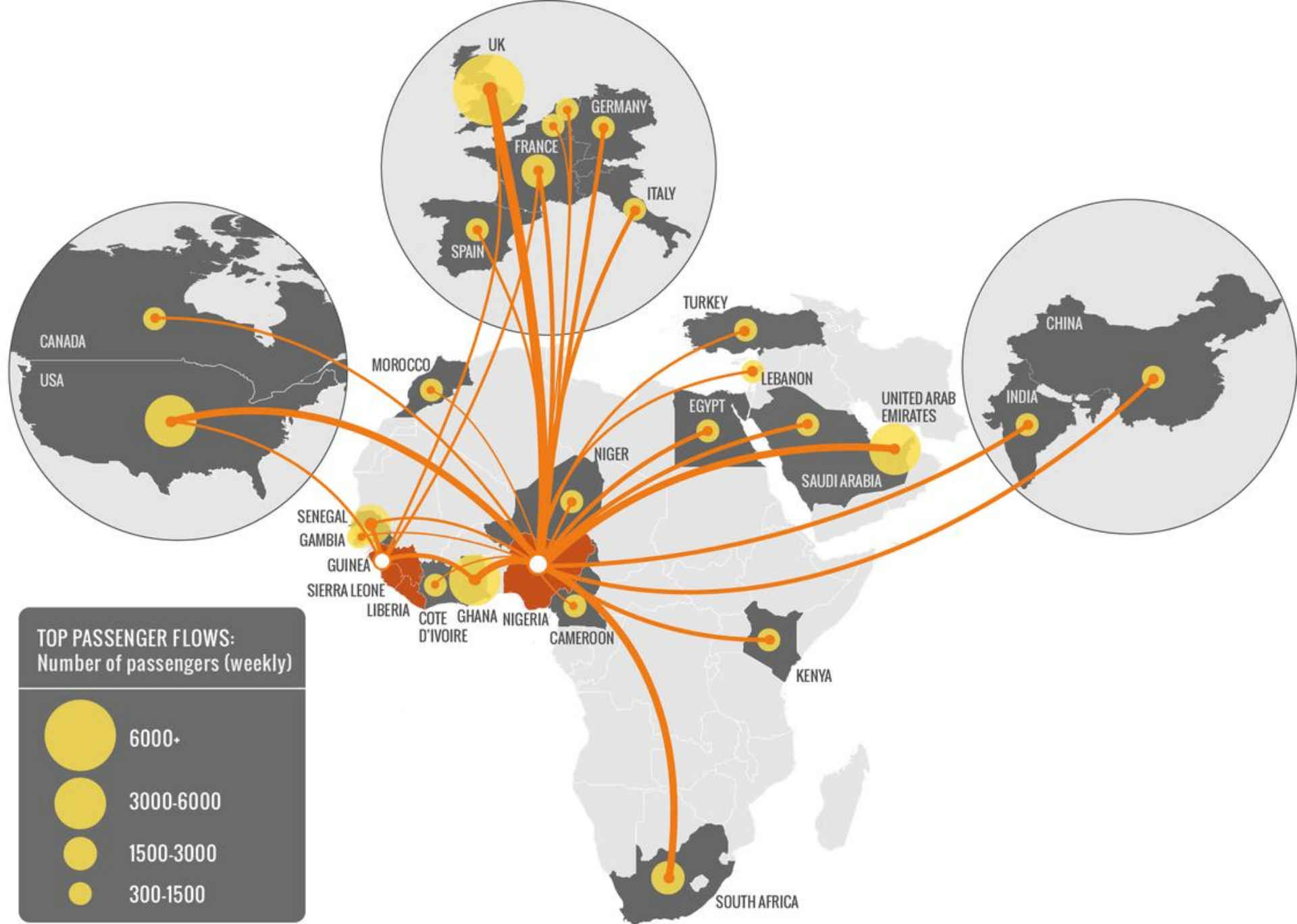
Commissioner of Health, Lagos State, Nigeria. Dr. Jide Idris. Mastermind of containing the Lagos outbreak and co- founder of GET Consortium.
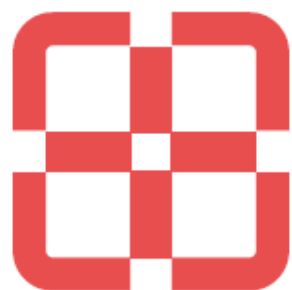
GET

Global Emerging Pathogens Treatment Consortium

GET

Help
Logistics
Infrastructure
Mobilised
Experts
Support
Samples
Healthy

Strategic planning, high level advocacy, research, networking and priority initiatives.

GERM Research and Humanitarian Agenda 10 working groups

- **Clinical Trials**
- **Biomarkers of prediction, high risk contact study**
- **Plasmapheresis and fractionating**
- **Ethics and Community Engagement**
- **Survivor program longitudinal studies**
- **Biobanking, biodata and bio security upgrade and design**
- **Environmental surveillance**
- **Grants and Publications**
- **Anthropology, social science and economic**

GET GOVERNANCE

Organizational Structure
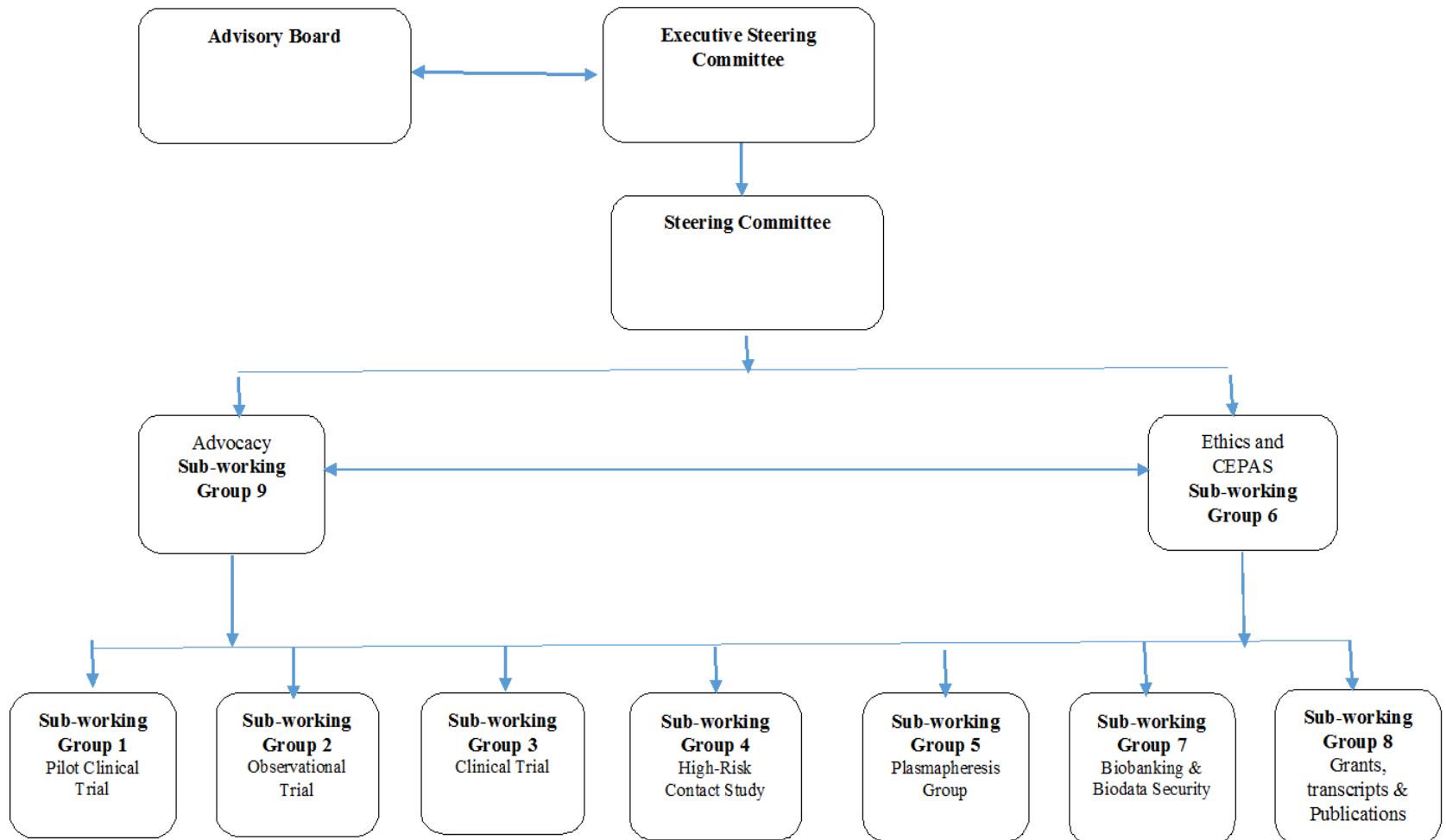
The Lagos Operation and Command response

FIGURE 2. Organizational structure of the Ebola Response Incident Management Center — Nigeria, July–September 2014

```
                            Minister of Health
                                   │
                            Program Director
                                 NCDC
                                   │
                            Incident Manager
        ┌──────────────────────────┼──────────────────────────┐
  Deputy Incident                                            Media
     Manager
        │
  ┌──────────────┬──────────────┬──────────────┬──────────────┬──────────────┐
Epidemiology/   Case Management/  Social      Lab Services   Point of Entry  Management/
Surveillance    Infection Control Mobilization                                Coordination

Alert, Investigation,  Evacuation Team   House to House   Diagnostics    International    Planning and
and Response                             Social Mobilization               Airports        Budgeting

Contact Tracing        Rumors /Alert     Social Media     Sample Movement  Land Borders    Private Sector
and Monitoring         Investigation                      & Coordination    (States)       Engagement

Logistics/Admin/       Infection &       Training and     Clinical Support  Training       Human Resources
Coordination           Prevention Control Communication

Data Management        Clinical Care     Advocacy                          Administration  Logistics

Operational            Decontamination                                                     Finance
Research
                       Psychosocial                                                        Secretariat
                       Support

                       Burial Team                                                         IT Support
```
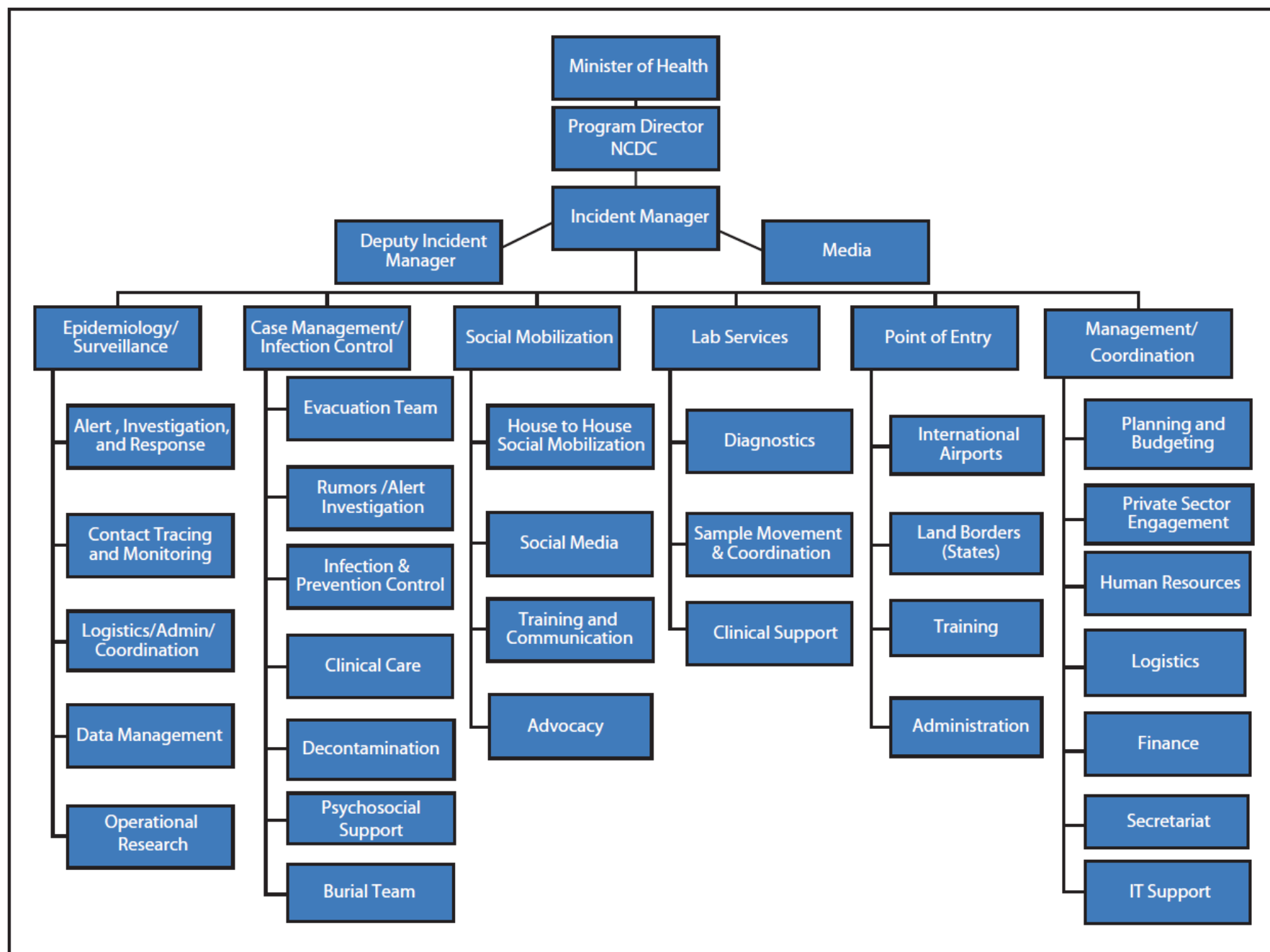
Emergency Operations Centre (EOC)

- By 24th Sept, 20 confirmed cases contracted the disease and 9 died

- 11 Survivors mostly health professional

- 150 contact tracers monitored 900 contacts

- 19,000 face to face visits assessing for symptoms, apart from phone calls

- House to house visits within 2km radius of a known contact. 26,000 households visited.

- Out break was under control in 2 months.

Nigeria

- **GET created the advise and support for:**
  - **Ebola Core Research Group**
  - **Biosafety Infrastructure upgrade**
  - **Training on modern technology**
  - **Long term infrastructure refurbishment**

Three of GET's Priority actions

- **Africa Regional Conference**

- **Convalescent blood strategy**

- **The escalating biosecurity threat of Ebola biological material**

Immediate steps

- **First task was to organize the first African Scientific Ebola conference.**

- **Aim was to: Rapidly understand the magnitude of the problem, promote awareness and promote capacity to conceptualize research and ethics in public health emergencies.**

First African Voices conference on Ebola. Dakar Jan 2015

Dakar Declaration on Ebola

Full text and conference report:

www.getafrica.org

AFRICAN VOICE AND LEADERSHIP MEETING TO ACCELERATE THE EVALUATION OF POTENTIAL TREATMENTS AND VACCINES FOR EBOLA IN WEST AFRICA

Dakar, Senegal, January 19-20, 2014

Africa

- **Has a severe shortage of health care personnel**

- **Lacks significant preparedness for biosecurity threats**

- **Ebola exposed the complete inadequacy of our capacity to deal with pandemic events**

- **Relies heavily on international support like MSF, RC or Oxfam to handle most health crises on the continent**

- **Has not fully adopted the international conventions governing biosecurity, like the BWC and GHSA**

Human Capacity Deficit

Using the example of African pathologists and scientists workforce.

Number of Persons Served Per Pathologist in sub-Saharan Africa

Legend:
- No Active Pathologist
- >5.0 million
- 2.5-5.0 million
- 1.0-2.5 million
- 500,000-1 million
- 200,000-500,000
- Data Not Available

Number of Persons Per Pathologist:
UK: 15,108
US: 19,232
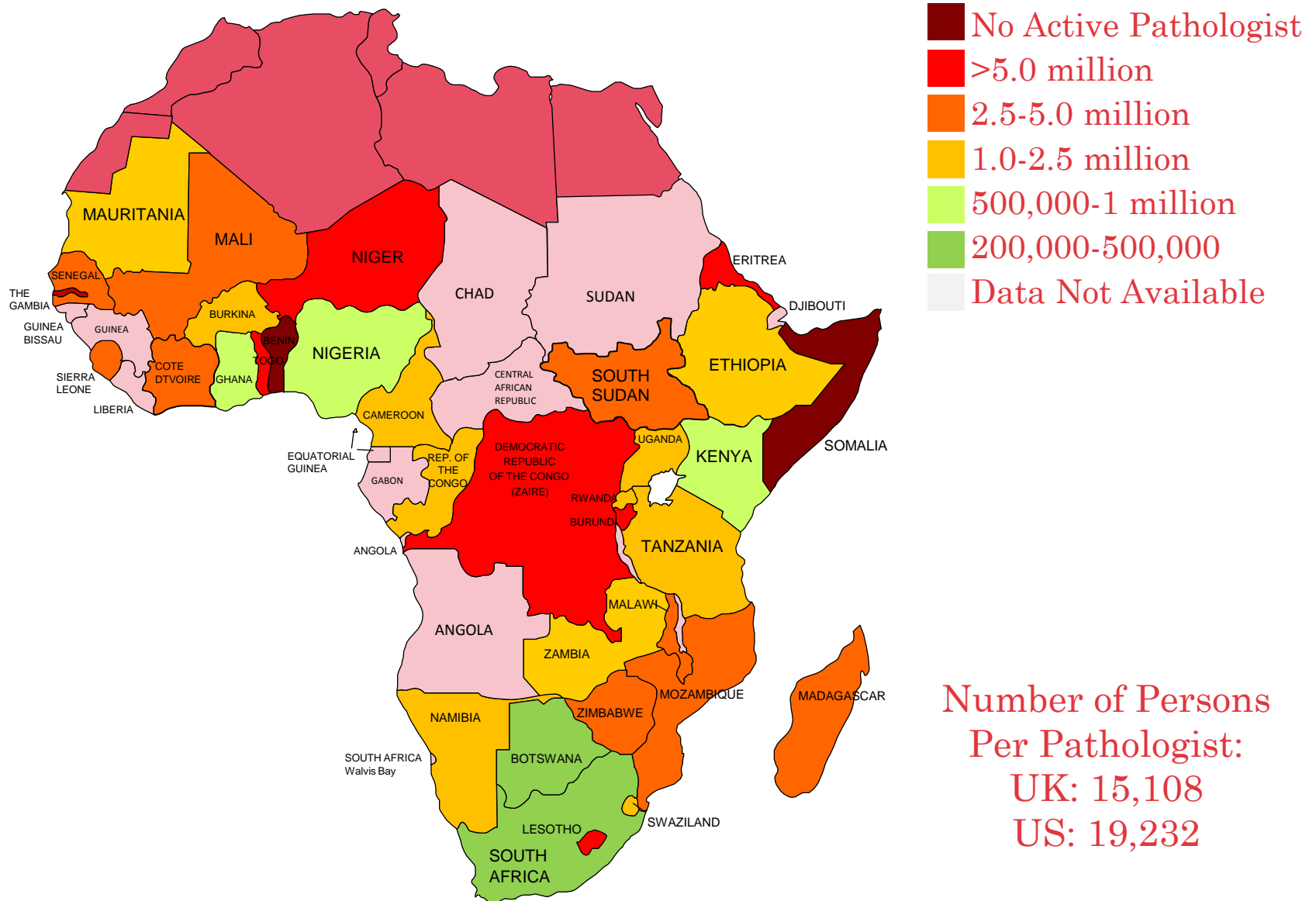
Socioeconomic and environmental factors may have influenced Ebola emergence in Guinea, Liberia, and Sierra Leone [64].

	Country	Guinea	Liberia	Sierra Leone
Environmental features	Country size	94,926 sq miles (245,857 km²)	43,000 sq miles (111,370 km²)	27,699 sq miles (71,740 km²)
	Crop production index increase (2004–2006 = 100) (1961–2012)	246%	118%	388%
	Livestock production index increase (2004–2006 = 100) (1961–2012)	346%	305%	328%
Human resources and infrastructure	Number of physicians (per 1,000 people in 2010)	0.1	0.01	0.02
	Improved sanitation (Total, Rural, Urban)	19%, 11%, 33%	17%, 6%, 28%	13%, 7%, 23%
	Improved water source (% of population without access in 2012)	25%	25%	40%
Population features	Urban population increase (% of population (1960–2013)	223% increase (1960–2012)	275% increase (1961–2013)	178% increase (1961–2013)
	Historical civil unrest	Yes	Yes	Yes
	Literacy (% of people age 15 and above)	25% in 2010	43% in 2008	44% in 2012
Cultural and behavioral features	Use of traditional healers	High	High	High
	Use of traditional burial practices	High	High	High
	Bushmeat consumption	High	High	High

doi:10.1371/journal.pntd.0003652.t003

Alexander KA, Sanderson CE, Marathe M, Lewis BL, Rivers CM, et al. (2015) What Factors Might Have Led to the Emergence of Ebola in West Africa?. PLoS Negl Trop Dis 9(6): e0003652. doi:10.1371/journal.pntd.0003652
http://journals.plos.org/plosntds/article?id=info:doi/10.1371/journal.pntd.0003652

PLOS | NEGLECTED TROPICAL DISEASES

Ebola's Massive impact on Healthcare providers compounding an already depleted workforce

Table 5: Ebola virus disease infections in health-care workers in the three countries with intense transmission

Country	Cases	Deaths
Guinea	106	59
Liberia*	361	174
Sierra Leone	138	106
Total	605	339

Convalescent plasma in infectious epidemics

- **Possibly the only treatment that can be of value in a public health emergency with a pathogen for which there is no known treatment and which is spreading at alarming rates with high fatality**

Treatment of EHV with convalescent blood

Patient	Time Onset/date transfusion	CC of blood received	Outcome
1	7	400cc	alive
2	11	150cc	Alive
3	13	150cc	Alive
4	9	250cc	Alive
5	15	250cc	Alive
6	13	250cc	Alive
7	11	450cc	Alive
8	8	450cc	Dead

Treatment of Ebola haemorrhagic fever with blood transfusions from convalescent patients was carried out in Kikwit, 1995

Clinical Aspects of Ebola Virus Disease
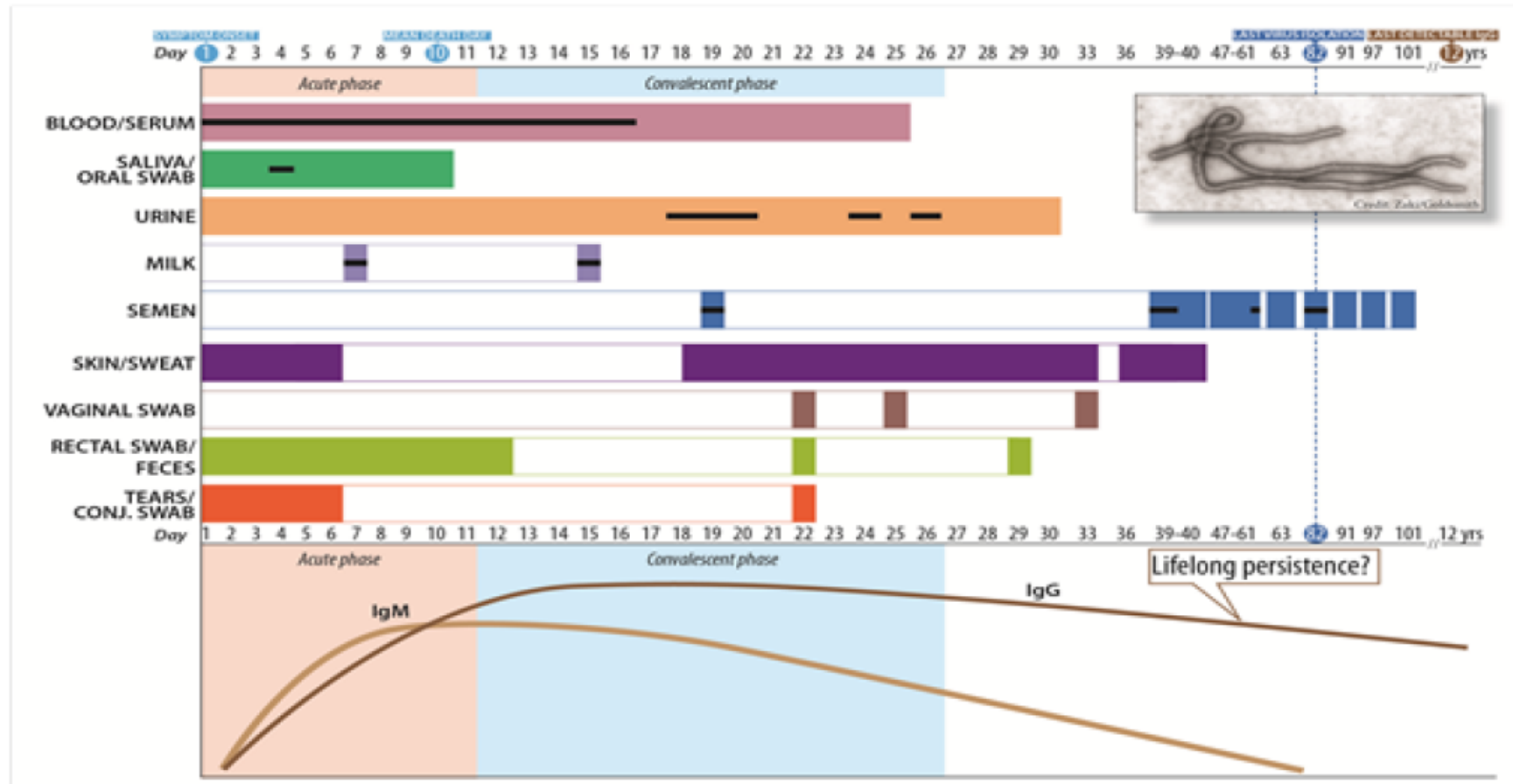
Figure 2. Ebola virus shedding in body fluids. Colors=PCR positive. Bars=culture positive.

Source: Pierre Rollin/CDC

Convalescent Plasma Technology

- **Extract plasma from a fully recovered patient**

- **Whole blood donation or plasmapheresis**

- **Standard screening for blood born pathogens**

- **Plasma viral reduction step**

- **Freezing at minus 30 degrees**

- **Administer to new cases of Ebola in clinical trial setting**

- **Fractionating to Ebola Hyper immune Globulin**
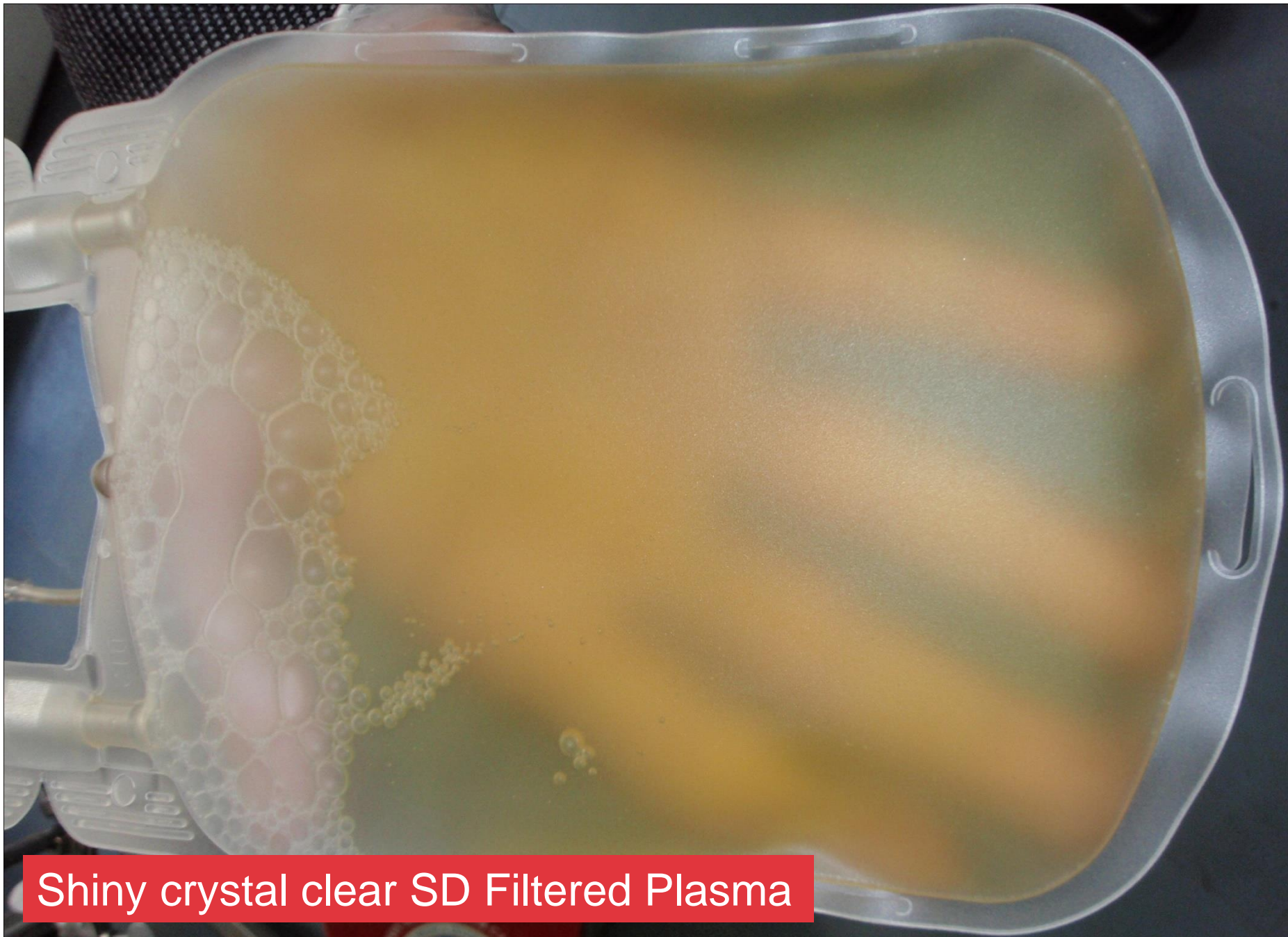
Shiny crystal clear SD Filtered Plasma

Hope Mobiles

The Inside of a Hope Mobile
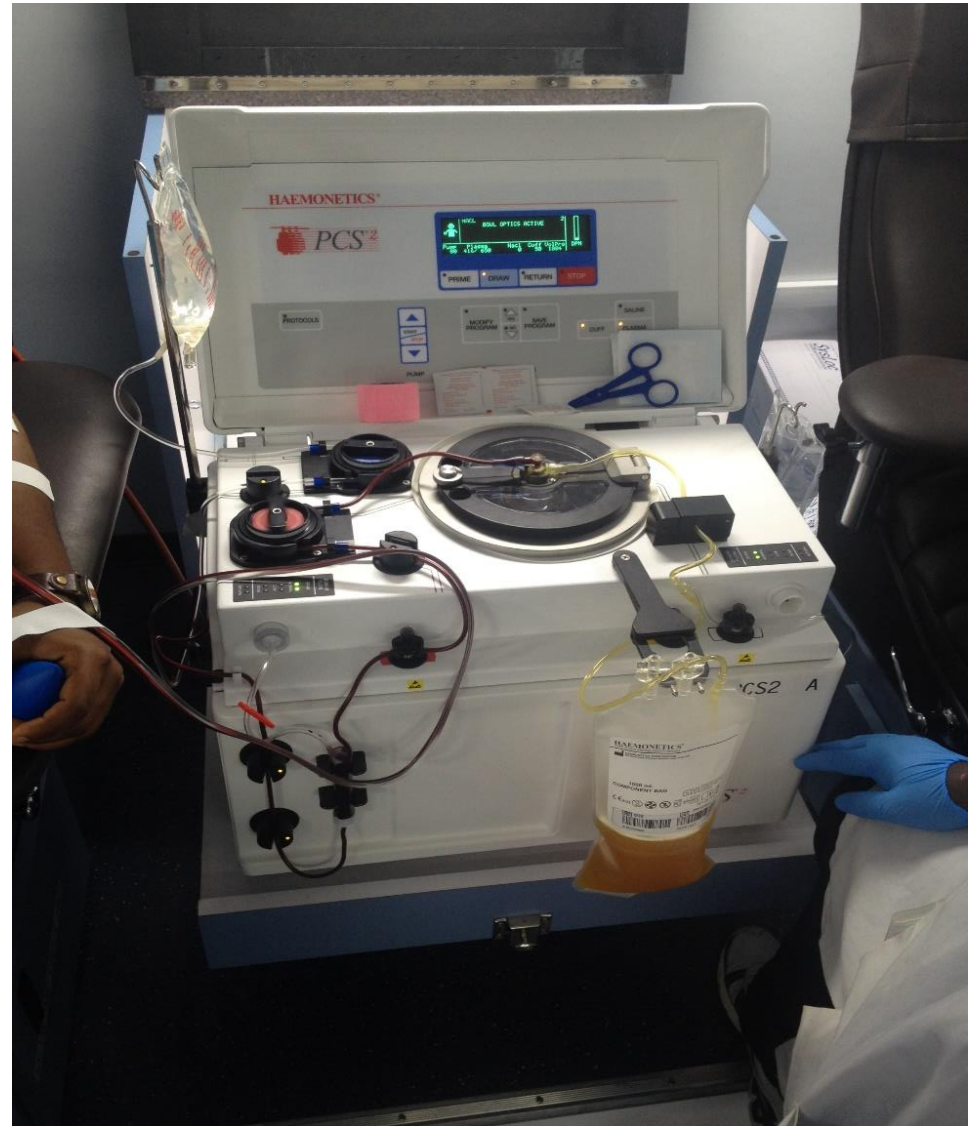
Antanov Airline carrier, took the Cargo to West Africa.

Mobile unit to Monrovia, Conakry and Lagos.

Infrastructure to Sierra Leone.

Sierra Leone

Liberia ELWA2 Hospital site of the first ECP pilot study. (CRO ClinicalRm)

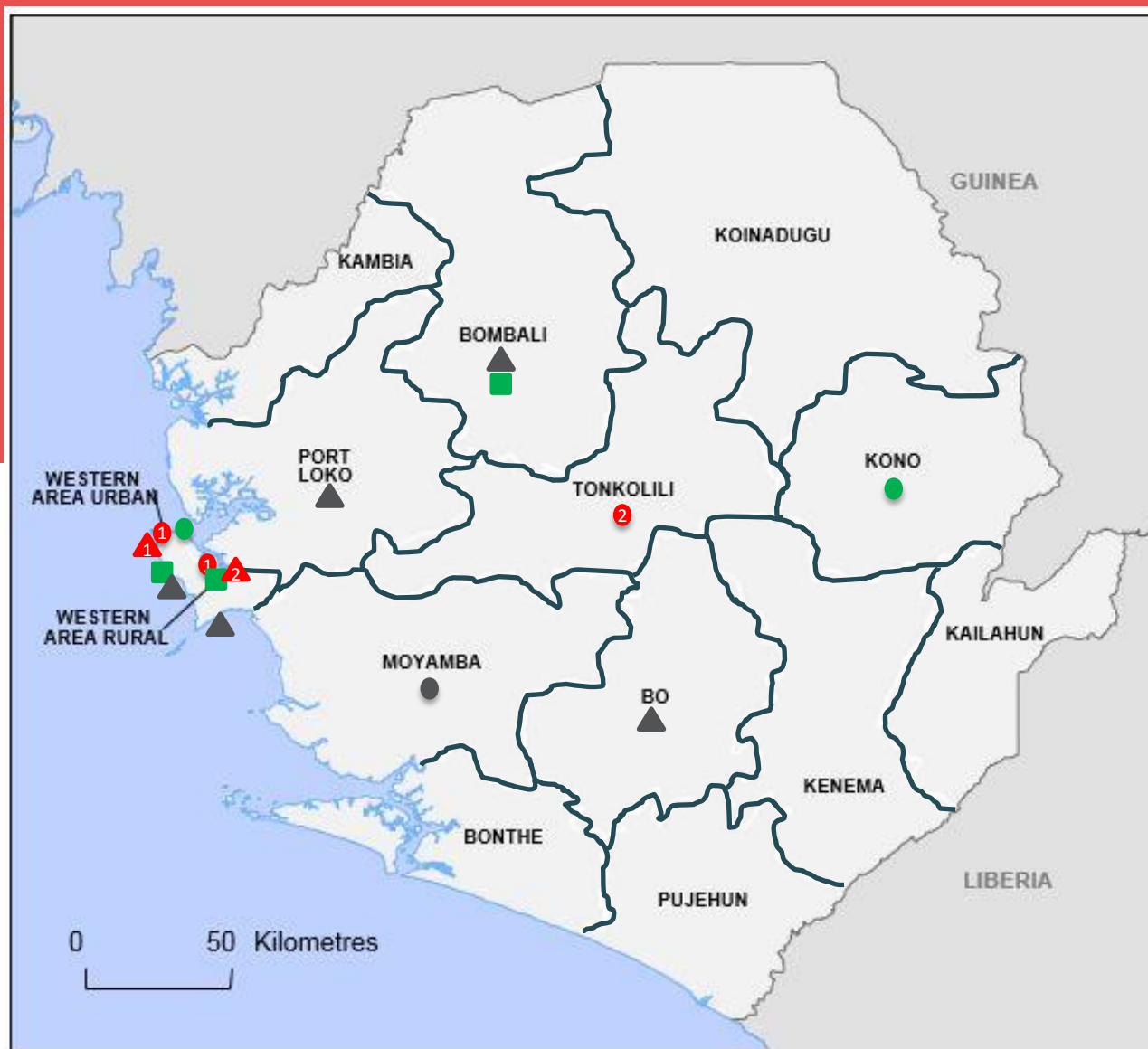# Banking highly infectious Pathogens in Public Health Emergency scenarios

- **The current outbreak of Ebola in West Africa is unprecedented in scale as an EID, and has generated a great number and variety of biological samples. Such samples constitute a precious, non-renewable resource, but also pose a biosecurity threat.**

The Sierra Leone Model

Coverage

Legend:
- **Fixed / Stay** (green square)
- **Mobile / TBC** (gray circle)
- **Field / Close** (red triangle)

Left side labels:
- Dutch
- Goderich
- Jui
- Chinese P3
- Kingtom - Nigerian
- Kingtom - Canadian
- Lakka
- PHE Kerry Town
- Hastings

Right side labels:
- PHE P.L.
- PHE Makeni
- Holy Spirit Bombali
- Magburaka Tonkolil
- Dutch Kono
- CDC Bo
- Medac Moyamba

Outbreak response 2014-2015 (May)

- **16 international labs**
    - **Western area = 9 labs**
    - **East = 1 lab**
    - **North = 4 labs**
    - **South =2 labs**
- **10 countries**
    - **South Africa - 1**
    - **USA -2**
    - **Canada -2**
    - **Italy -2**
    - **Germany - 1**
    - **China - 2**
    - **Netherlands - 2**
    - **Nigeria-1**
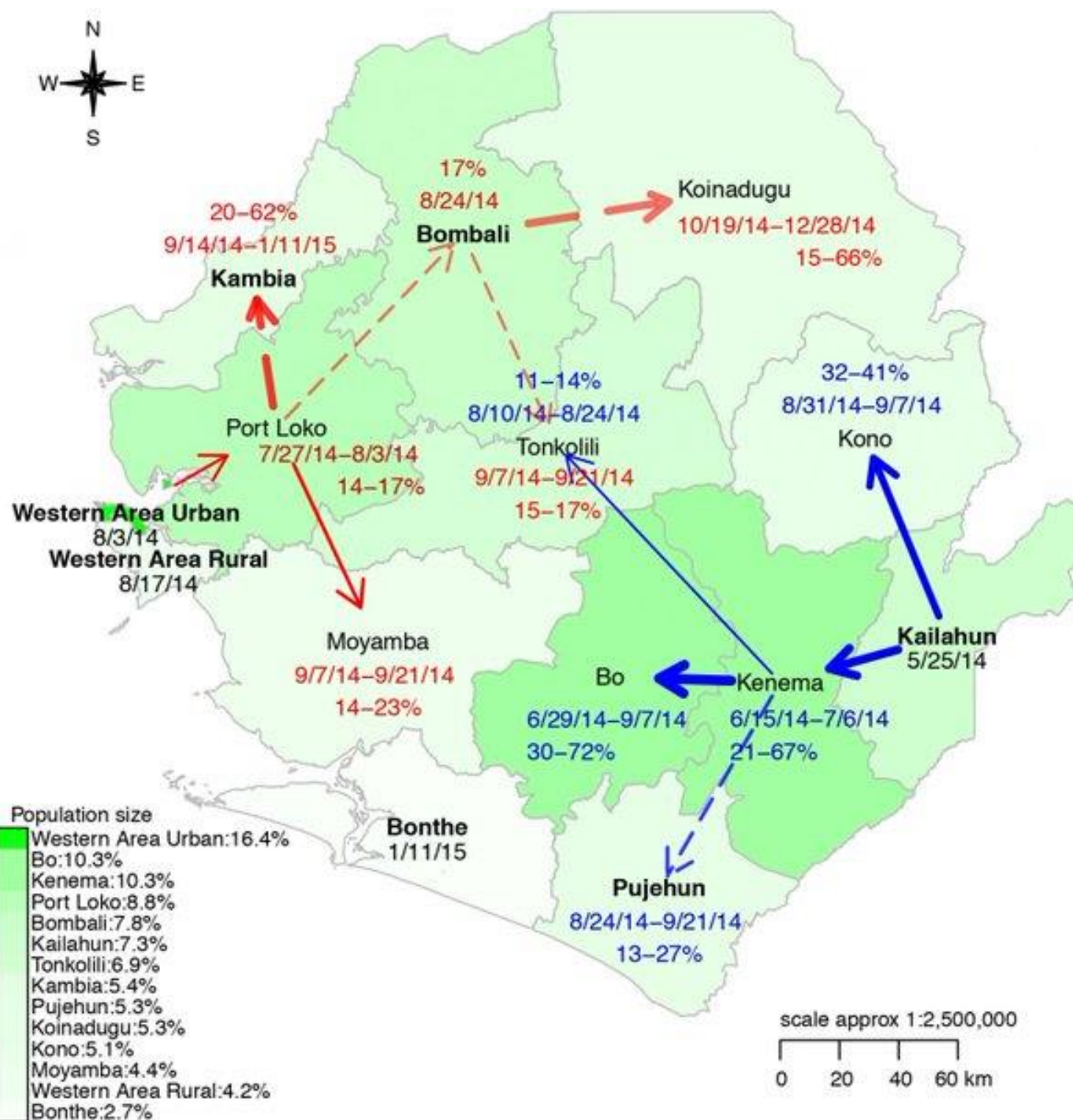   - **United Kingdom - 3**

EBOLA SAMPLES IN FREEZERS

Tracking the Data and the Samples

- **Patient presents to a holding Centre with features of Ebola**

- **Blood taken and sent to one of 16 labs**

- **If negative patient discharged**

- **If positive moved to a Ebola Isolation Unit anywhere in the country**

- **The created a complex matrix of data and sample**

Ebola Holding center and adjacent Treatment Unit in Freetown

N
W E
S

20–62%
9/14/14–1/11/15

Kambia

17%
8/24/14

Bombali

Koinadugu
10/19/14–12/28/14
15–66%

11–14%
8/10/14–8/24/14

32–41%
8/31/14–9/7/14

Kono

Port Loko
7/27/14–8/3/14
14–17%

Tonkolili
9/7/14–9/21/14
15–17%

Western Area Urban
8/3/14
Western Area Rural
8/17/14

Kailahun
5/25/14

Moyamba
9/7/14–9/21/14
14–23%

Bo
6/29/14–9/7/14
30–72%

Kenema
6/15/14–7/6/14
21–67%

Population size
Western Area Urban:16.4%
Bo:10.3%
Kenema:10.3%
Port Loko:8.8%
Bombali:7.8%
Kailahun:7.3%
Tonkolili:6.9%
Kambia:5.4%
Pujehun:5.3%
Koinadugu:5.3%
Kono:5.1%
Moyamba:4.4%
Western Area Rural:4.2%
Bonthe:2.7%

Bonthe
1/11/15

Pujehun
8/24/14–9/21/14
13–27%

scale approx 1:2,500,000

0   20   40   60 km

Biobanking and Biosecurity Strategy

- **Political and Public Awareness**

- **Develop draft policies on biobanking and biosecurity**

- **Data retrieval (MSF)**

- **Sample verification (GPP Canada)**

- **Infrastructure refurbishment (GPP Canada)**

- **Biological threat reduction (Biosecu-re)**

- **Legislation**

Biobanking and Biosecurity Workshop in Freetown. August 2015

Program covered over 3 days

- History of biobanking in Africa
- What can biobanks do and importance to the bio-economy
- Governance, Community Engagement and Ethics of biobanking
- Laboratory information management systems LIMS and BIMS
- What is a data base and how does it relate to a biobank.
- Sustainability of biobanking
- Biosafety and Biosecurity and EID. BWC, GHSA, IHR and PVS.
- Biobank infrastructure and outline of Biosafety Level Classifications
- Conceptualization of Country policy framework and strategy
- Finalize the Concept Document for biobanking, Biosecurity and managing the Ebola samples
- Commitment from Government and expression of Political will

Spectrum of Attendees

- Senior MOH representatives
- Members of the Mano River Union
- Directors of Biomedical research
- Senior Members of the Medical research community
- Senior scientists
- Ethics Committee
- Community members
- Dean of Medicine
- Dean of Veterinarian School
- Head of Botany
- Senior Anthropologists and social scientists
- Head of Public health

- Heads of Security (army and Police) and Intelligence agencies
- Representatives of Ministry of Finance
- Representatives of Foreign Affairs
- Ministry of Justice PS and Legal representatives responsible for MTA
- Leaders of response to the Ebola Outbreak
- Representatives of Ebola Survivors Association
- Blood Bank
- Directors of Laboratories handling Ebola testing
- WHO representatives

Sample Verification Exercise in Sierra Leone

What is a Biobank?

- **A facility that actively engages with Research projects and National Initiatives**
  - **To plan the receipt of samples for processing and storage**
  - **Has capacity to add value to biological samples**
  - **Disseminates material as required for multiple research purposes**
  - **Is on the cutting edge of analytical developments and enquiry**
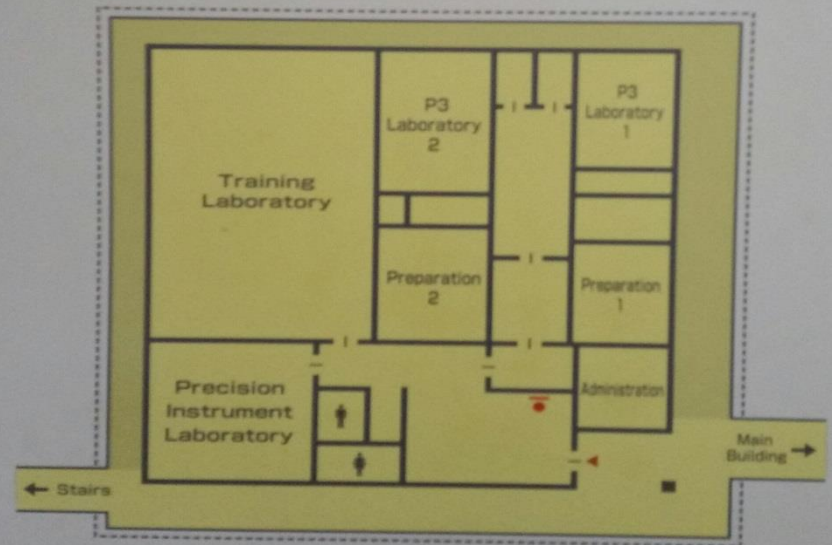
Space Requirements (Dedicated Facility)

LOBBY

14 sq m

RECEIPT

27 sq m

LABORATORY

39 sq m

DISPATCH

25 sq m

Office

46 sq m

IT

8 sq m

14M

22M
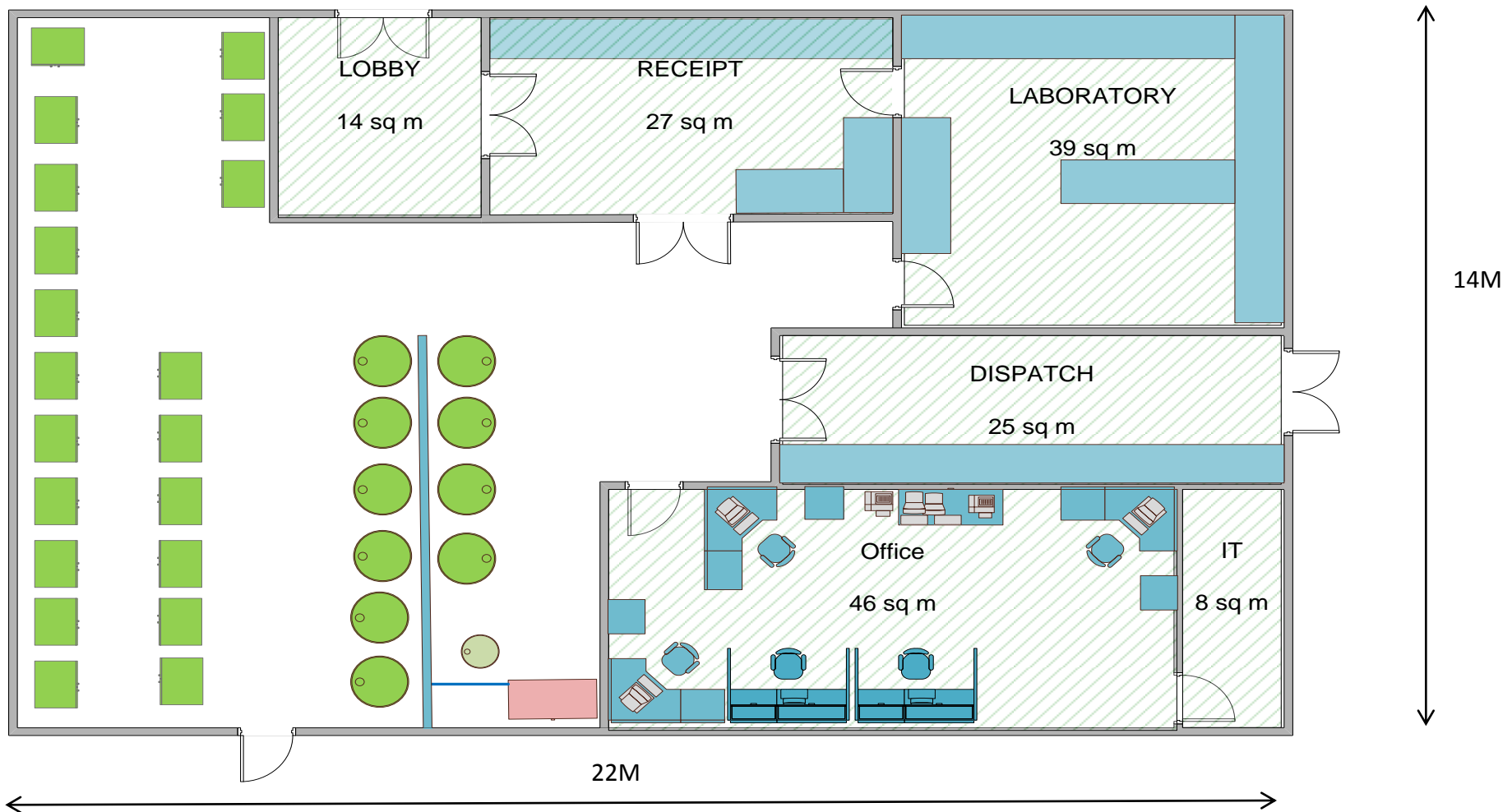
Total Area = 308M^2

Biosecurity Containment Facilities

Noguchi Memorial Institute
for Medical Research

P3 Laboratory Building

Training Laboratory

P3 Laboratory 2

P3 Laboratory 1

Preparation 2

Preparation 1

Precision Instrument Laboratory

Administration

← Stairs

Main Building →

1st Floor Plan

LAB. 1 SYSTEM CONTROL PANEL

A human side to science

Ebola Survivor Stigma Workshops

Fine Art Healing Therapy

Yusuf Koroma's story.

The GET Ebola Survivor Mentoring Program.

14,000 Survivor's

GET support Team on ground in Sierra Leone

Thank you.
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Acknowledgements

- **All the hard working volunteers of GET, now too many to mention**
- **GATES Foundation for initial seed funding to help launch the consortium**
- **Rebecca Katz for her wise counsel**
- **West African Task force for research into emerging infectious diseases**
- **WHO for the role in fast tracking meetings and developing guidelines**
- **MSF for supporting the biobanking workshops in the endemic zone, data retrieval project**
- **GPP Canada for Sample retrieval Project**
- **Outpouring to the Nations or generous philanthropic Support**
- **BWC ISU and Daniel Feakes for the Invitation**