Innovating to Protect Health Workers on the Frontline
Responding to the Ebola Epidemic

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• Ebola epidemic response, 2014-2016
• President’s Ebola Task Force
• USAID: Ebola Grand Challenge for Development
• WHO: Guidance for PPE to Protect Health Workers at the Frontline
• Zoonotic disease, natural reservoir unknown (bats?)
• Incubation period, 2-21 days
• Case fatality, 24-89%
• Supportive treatment reduces mortality
• Well-documented locations where transmission occurs
  • Hospitals: health workers, patients, visitors
  • Communities: family, friends, gathering places and funerals
• On-going clinical trials of vaccines and anti-viral treatment
• Post-Ebola: deafness, vision loss, neurological impairment and PTSD; Ebola virus in semen for >300 days
• Handling specimens requires biosafety level 4 practices

Cultured virus recovered from 1976 Zaire patient blood by PA Webb (CDC).

Electronmicrograph courtesy of FA Murphy (CDC).
Health Security

- **Humanitarian**
  - High mortality
  - Collapse of health systems
  - Other diseases untreated
  - Measles outbreak
  - Unsafe deliveries...

- **Economic**
  - Corporations pulling out
  - Airlines refusing to fly
  - No trading or deliveries

- **Political**
  - Lack of faith in governance
  - Years of post-conflict resolution unraveling

- **Security**
  - Civil unrest
  - Health teams murdered
  - Peacekeeping missions jeopardized

Source: Dr. Matthew Lim
WHO Ebola Response

DISEASE DETECTION
Deployed nearly 950 epidemiologists
And improved disease detection from an average of 4 contacts per patient to 69 contacts per patient

TRAINING
Pre-deployment training for 6,900+ medical and public health responders
And provided more than 250 types of training materials

PREPAREDNESS
Supporting more than 110 countries worldwide to ensure they are ready to respond to potential Ebola introduction

RESEARCH AND DEVELOPMENT
Expediting vaccine trials from 10+ years to 18 months

Ebola Response in Action

World Health Organization
Countering Ebola At Home and Abroad:
A Whole-of-Government Approach
CIVILIAN-LED, COMPREHENSIVE RESPONSE

The United States has been engaged in this effort since March, when the first cases were reported. In September, the President announced a massive scale-up of the response by calling upon the unique capabilities of the U.S. military to support the USAID-led effort.

- Deployment of key medical and expert personnel
  - The United States has deployed more than 170 civilian medical, healthcare, and disaster response experts from multiple U.S. government departments and agencies, some of whom are part of the USAID-led Disaster Assistance Response Team.

- Scaling-up the DoD presence
  - DoD has announced the planned deployment of 3,200 troops as part of Operation United Assistance; more than 1100 are already in the region.

- New hospital for infected workers
  - DOD is finishing construction of a hospital for infected medical workers, which will be operational and staffed by U.S. Public Health Service officers starting in November.

- Progress on Ebola Treatment Units
  - The U.S. military is overseeing the construction of up to 17 100-bed ETUs in Liberia.

- Community Outreach and Safe Burials:
  - Our support has helped Liberia increase the number of safe burial teams working across every county to safely and respectfully dispose of bodies, largely reducing a primary vehicle of transmission of the disease.
### Structure

**Base:** $4.6 Billion (Domestic & International)

**Contingency:** $1.5 Billion

**Transfer Language and General Provisions**

### Activities

- Domestic Preparedness
- International Ebola Efforts
- Global Health Security Agenda

<table>
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<tr>
<th>$ in billions</th>
<th>Department of Health and Human Services</th>
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<tr>
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<td><strong>Base</strong></td>
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<td><strong>Contingency</strong></td>
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<td>State/United States Agency for International Development</td>
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<td><strong>Contingency</strong></td>
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<td>Department of Defense</td>
<td>$0.1</td>
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<td>TOTAL, Ebola Emergency Request</td>
<td>$6.18</td>
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^ Sums do not equal totals due to rounding
UK: Over $320 million, 700 ETU beds, medical unit, medical ship, 750 soldiers, health care workers, helicopters, vehicles
European Commission: Over $225 million pledged, mobile laboratories, personnel, transport, coordination of medical evacuation for staff
China: Over $18 million, laboratory assistance, personnel, and at least 100 ETUs
France: Up to $89.7 million, including 7 ETUs and a medical unit
Canada: Over $57 million in financial assistance
Norway: Nearly $50 million, transport planes, medical evacuation treatment beds, and 160 health care workers
Japan: Over $40 million in direct assistance, in addition to 500,000 PPE items
Israel: Pledged $10 million, three medical units, and staff for ETUs

More than $1 billion pledged by the international community
**West Africa Ebola epidemic:**

- HCW were 21 to 32 times more likely to be infected with Ebola than the general population
- 815 probable and confirmed cases amongst HCW were identified
- Difficult to attribute Ebola infection to PPE but....
- Lack of PPE, serious gaps in IPC practices, poor employment conditions and anti-social determinants were contributory factors that confused HCW

**Key lesson learned:**

HCW protection is key to the capability of health systems to respond to health emergencies and provide critical health services.

DONNING PPE = 13 steps

DOFFING = 16 steps
Addressing unmet public health needs in midst of epidemic

• Ethical issue of research during an epidemic
• Gaps and needs occur everyday during a crisis
• Can innovation and ingenuity be made scientifically valid to solve some of the gaps?
  • Speed up vaccine and treatment trials
  • Provide more than supportive care
  • Solve supply chain challenges
  • Healthcare workers at greatest risk

White House/USAID hosted Hackethon for Innovative PPE October 2014
GROUNDBREAKING INNOVATIONS
for the largest Ebola epidemic in history

U.S. Agency for International Development
Center for Accelerating Innovation and Impact
GROUNDBREAKING INNOVATIONS for the largest Ebola epidemic in history

1,500

- Limited communications capacity across the community, government and health care workers
- Uncomfortable and difficult to use health care worker protective gear
- Void of rapidly deployable Ebola treatment units that provide comfortable working conditions for health care workers
- Simplification and safeguarding of patient care and health care worker safety
- Community education and mobilization
Drip Assist: monitors and controls IV fluids for patient (FDA approved)

Left: Photo from ETU

Right: Drip Assist unit runs with AAA battery
Color-fading chlorine

USAID FIGHTING EBOLA GRAND CHALLENGE
Ebola Treatment Units in settings without electricity

Social mobilization: health messaging through skits, songs, raps (uneducated, local dialects, cultural habits)
Current decontamination practice is using hand pump spray, which can spread infective fluids.

Field deployable walk-through decontamination shower-mist unit.
PPE worn by health workers allowed for average of 45 minutes of work in the ETU under hot, humid conditions.

Disposable sensor alarms that measured skin temperature and moisture to be worn by the health worker.
Containers turned into Ebola treatment units
Current Personal Protective Equipment (PPE)

- Face mask fogs within minutes, obscuring vision and communication (often work in 95°F and 95% humidity)
- Assistant may be required to remove PPE
- Sleeves ride up on the arm, risking potential exposure

5 piece PPE

28 potential points of contamination

PPE is so hot that healthcare workers lose up to 1.5 liters of sweat per hour

New Prototype Ebola Protective Suit

- 1 fully integrated suit
- Less than 10 potential points of contamination
- Wicking base layer and personal cooling system manage heat exposure
- Fingerless glove liner between inner and outer gloves keeps sleeves securely in place

10 minute removal process

8 step continuous doffing process

Integrated vents and large face shield reduce fog, improve communication, and reduce patients' fear when interacting with healthcare workers

Single person removal process

31 step doffing process

Up to 20 minute removal process

Johns Hopkins Center for Bioengineering Innovation and Design, Jhpiego, and Clinvue
Innovation in Personal Protective Equipment to Protect the Health Worker

Challenge:

• The off-the-shelf PPE pieces (gowns, suits, gloves, eye protection, gloves, masks) that health workers depend on for protection can be hot, stifling and socially inappropriate in tropical settings where likely the most transmissible and infectious pathogens emerge.
• There is little evidence-based research on the protective effects of PPE against Ebola.
• Each piece of PPE meets its product specifications (but not against Ebola), so there is no consistent approach to test a PPE ensemble for its protective effects against highly transmissible pathogens.
WHO Advisory Committees for Innovative Personal Protective Equipment

- Committees addressed: (1) Ebola virus and transmission, (2) Infection prevention and control/Occupational safety and health, (3) Technical specifications, procurement and logistics, and (4) PPE users and trainers

- Reviewed scientific evidence on the protective effects of PPE for highly transmissible diseases

- Reviewed and analyzed the application of global, regional and national technological, normative regulations and standards for PPE elements

- Synthesized the information to define 10 preferred features for a PPE system that is safer and more comfortable
Preferred Product Characteristics (Guidance) for Personal Protective Equipment for the Health Worker at the Frontline Responding to Viral Hemorrhagic Fevers* in Tropical Climates

Table. 10 Preferred Product Characteristics for new PPE system

<table>
<thead>
<tr>
<th>Group</th>
<th>Characteristic</th>
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<tr>
<td>Design feature</td>
<td>1. Protect mucous membranes</td>
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<td></td>
<td>2. Minimize the number of PPE element junctions</td>
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<td>3. Provide unobstructed range of vision</td>
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<td>4. Enable communication capability</td>
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<td>5. Use human factors design for size and comfort</td>
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<td>Material performance</td>
<td>6. Able to protect for the duration of work period</td>
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<td></td>
<td>7. Able to withstand repeated disinfection</td>
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<td></td>
<td>8. Manufacture packaging to withstand tropical climate exposure</td>
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<tr>
<td>Use desirability</td>
<td>9. Standardize donning and doffing protocol with minimum steps</td>
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<td></td>
<td>10. Dispose PPE in non-toxic and environment-friendly manner</td>
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*Ebola, Marburg, Lassa and other VHF that share the same transmission characteristics but does not include arboviral hemorrhagic fevers
• Protect mucous membranes: eye covering has to be doffed last.

• The different styles of PPE worn translate into different don/doff steps

• Human factor design for comfort and fit
Protect mucous membranes, reduce fogging and increase visibility
PROBLEMS WITH CURRENT DISINFECTION USING HYPOCHLORIDE

Chlorine-based decontamination is corrosive, need constant fresh stock to be effective. Its fumes are toxic when inhaled and caustic to eyes, skin, rubber, metal and other surfaces. Chlorine-saturated waste turns into toxic gases when disposed by burning and is environmentally harmful to plants/soil/drinking water. Chlorine can be purchased cheaply locally but its concentrate powder has to be shipped as dangerous goods requiring explosion-proof containers and special transport and storage.
GOAL: To bring to market an innovative personal protective equipment system to protect healthcare workers at the frontline by 2019.

- What is critical now is to map a strategy to implement the PPC guidance and to bring together public, private and civil society partners to innovate, standardize and create an effective PPE system using the best of technology, scientific methodology and human use design.
- The partners will include intergovernmental agencies, public health professionals, clinical infectious disease experts, industry manufacturers, bioengineers, designers, marketing specialists, logistics and procurement specialists, health investors, International aid agencies, foundations and PPE end-users, plus many others.
Health Security and Environment

CHALLENGES AHEAD

• More than 10,000 Ebola survivors suffer from sequelae from neurological, ocular, optical, psychological and systemic impairment

• Long-term sequestering of live virus in semen, (over 16 months) reinfection has been documented

• Community shunning of Ebola survivors

• More than 4,200 orphans in the Ebola affected countries requiring long-term care

• Weak health delivering systems at all levels, what has been put in place for Ebola needs nurturing and sustaining

• Access to costly vaccines and treatments

• Ebola could return anytime, what will the response be next time?
In Memoriam

Aniru Conteh
1942–2004

On the Front Lines of Lassa Fever

Aniru Conteh spent 25 years in his native Sierra Leone dedicated to treating patients with Lassa fever, a rodentborne viral disease, to which he ultimately succumbed on April 4, 2004. Dr. Conteh’s life is a model of the dedicated healthcare worker. His colleagues hope that his death can galvanize support for healthcare workers and scientists working on the front lines with Lassa fever virus and other emerging pathogens.

The son of the local chief, Aniru Sahib Sahib Conteh was born in the

Source: Dr. Robert Garry
Questions?
A GLOBAL HEALTH RISK FRAMEWORK

The role of the WHO
• Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
• The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.
• The health of all peoples is fundamental to the attainment of peace and security and is dependent upon the fullest co-operation of individuals and States . . . .
• . . . Governments have a responsibility for the health of their peoples which can be fulfilled only by the provision of adequate health and social measures.

principles declared in the World Health Organization constitution (1948)
The International Health Regulations (IHR, adopted in 1969 and revised in 2005) considers public health in the context of international traffic and trade.

**Purpose of IHR**

- “to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade” *(Article 2)*

194 member states signed to adopt the revised IHR as international law
1990-2015: new coordination role
40 bilaterals, 26 UN agencies, 20 global funds, >100 global health initiatives...

100+ health partners
challenges ahead

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CDC’S DOMESTIC RESPONSE

Since the diagnosis of the index patient in Dallas, CDC has surged personnel and resources and adapted its policies and procedures to be able to respond more effectively.

- **Contact Tracing**
  - CDC teams deployed to Dallas, Ohio, and NYC to assist in finding, assessing, and assisting those who came into contact with Ebola patients

- **New Guidelines for Use of PPE**
  - Focuses on specific PPE that HCWs should use and provides detailed step-by-step instructions

- **CDC Ebola Response Team**
  - Flexible and immediate deployment of expert staff based on local needs

- **Rapid Ebola Preparedness Teams**
  - Assess and support hospitals to safely care for Ebola patients

- **Post-Arrival Monitoring**
  - Asymptomatic travelers monitored by state/local health departments for 21 days

- **Revised Movement & Monitoring Guidance**
  - Prescribed public health actions based on the type of potential exposure
  - Specific guidance for monitoring healthcare workers who provide care to Ebola patients