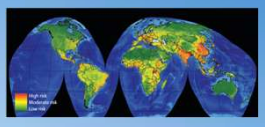
Emerging and Re-Emerging Infectious Disease Bio-Threats:
Where, How, and Why Now?









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David Alain Wohl, MD
Institute of Global Health and Infectious Diseases

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Overview

- Outbreaks, epidemics, pandemics are increasing in frequency and severity
- Looking out for current emerging and re-emerging threats (mpox, measles, H5N1)
- Introduction to UNC SPARC and role it plays in care, training and community awareness

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Thank You!

Acknowledgement

The vast majority of practice-changing and life-enhancing data to be presented was generated or supported by the US Federal government through the NIH, the CDC and other agencies staffed by people dedicated to our health and well-being.

Thank you, Federal Workers, for your passionate commitment and for creating what has been the **greatest** engine of research in the world.

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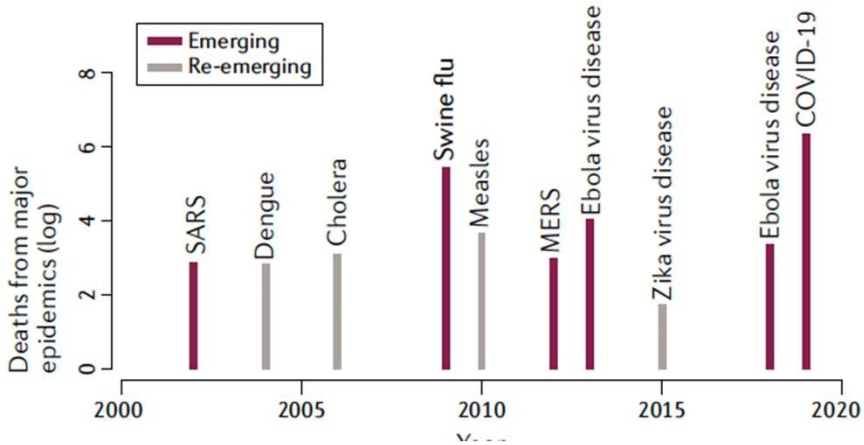
https://www.who.int/docs/default-source/epi-win/timeline-of-major-infectious-threats-in-21st-century-collabobration-machanism.pdf?sfvrsn=73d42d60_6

4

nature reviews microbiology

Infectious disease in an era of global change

Rachel E. Baker[1,2]✉, Ayesha S. Mahmud[3], Ian F. Miller[4,5], Malavika Rajeev[1], Fidisoa Rasambainarivo[1,6,7], Benjamin L. Rice[1,8], Saki Takahashi[1], Andrew J. Tatem[9], Caroline E. Wagner[4], Lin-Fa Wang[10,11], Amy Wesolowski[1,2] and C. Jessica E. Metcalf[1,12]✉



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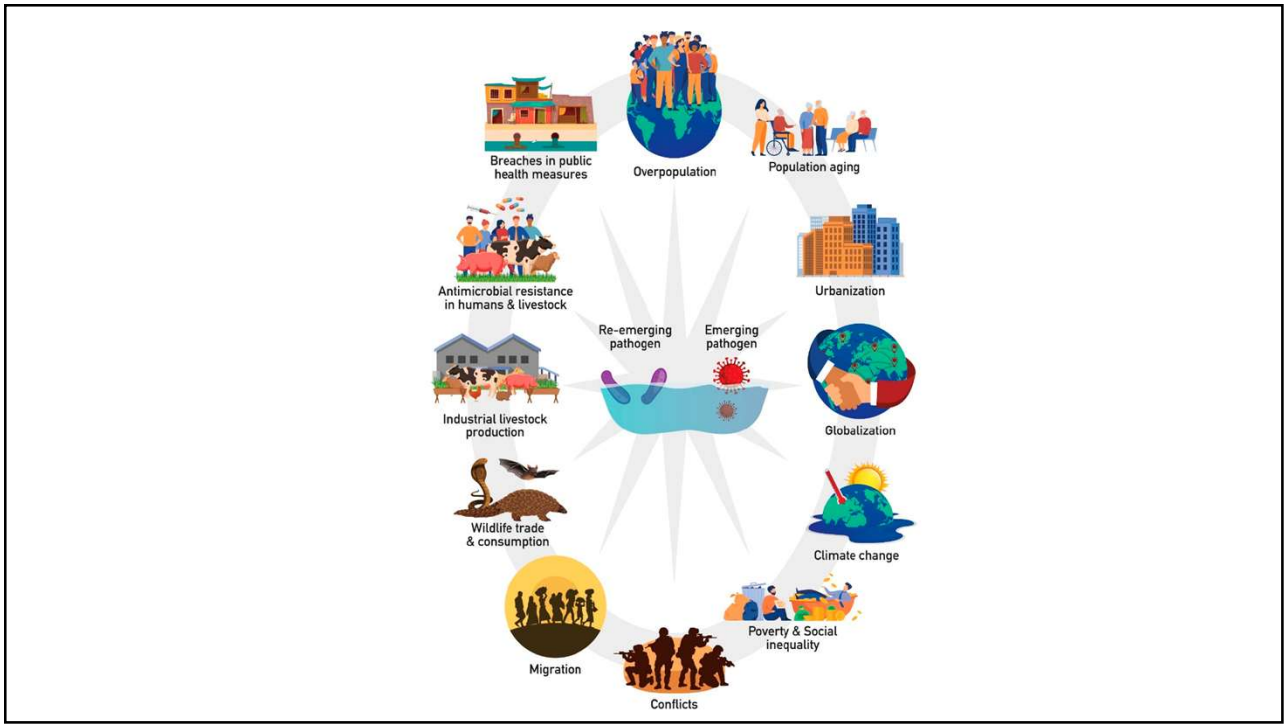
Breaches in public health measures
Overpopulation
Population aging
Antimicrobial resistance in humans & livestock
Urbanization
Re-emerging pathogen
Emerging pathogen
Industrial livestock production
Globalization
Wildlife trade & consumption
Climate change
Migration
Poverty & Social inequality
Conflicts

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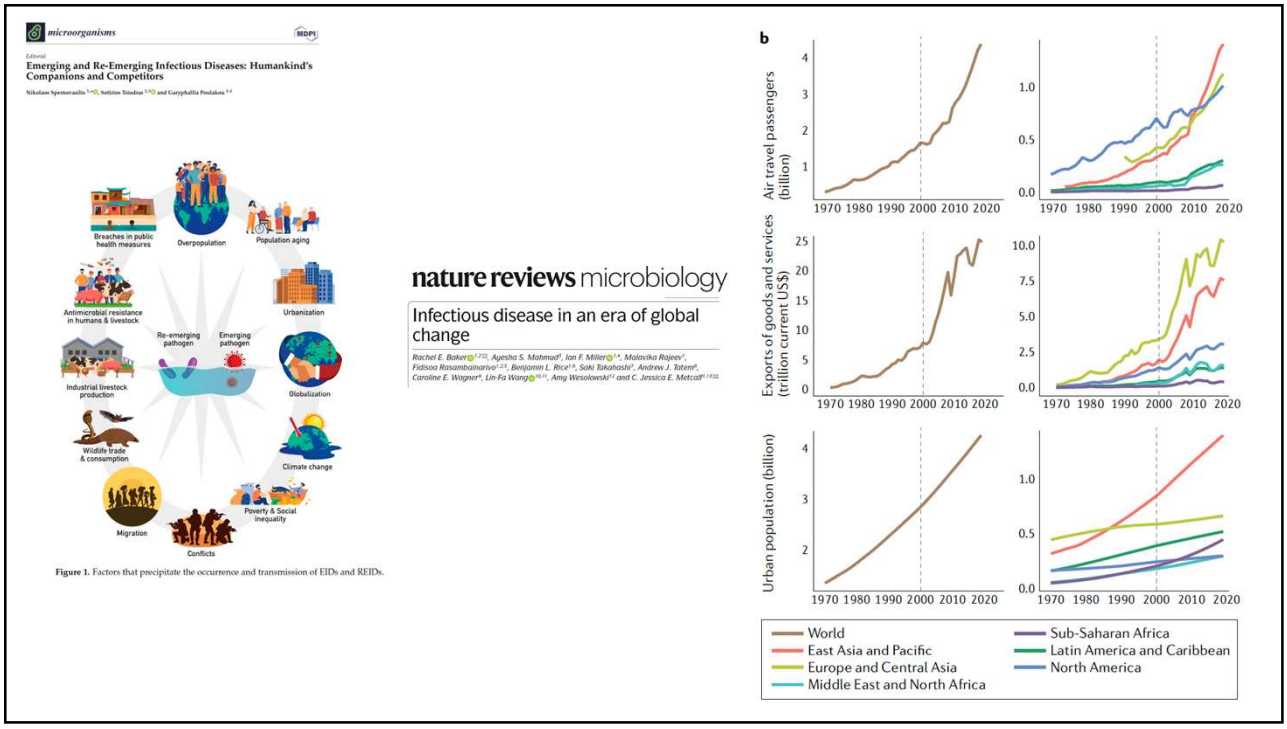
microorganisms
MDPI
Editorial
Emerging and Re-Emerging Infectious Diseases: Humankind's Companions and Competitors
Nikolaos Spernovasilis, Sotirios Tsiodras and Garyphallia Poulakou
Breaches in public health measures
Overpopulation
Population aging
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Antimicrobial resistance in humans & livestock
Re-emerging pathogen
Emerging pathogen
Industrial livestock production
Globalization
Wildlife trade & consumption
Climate change
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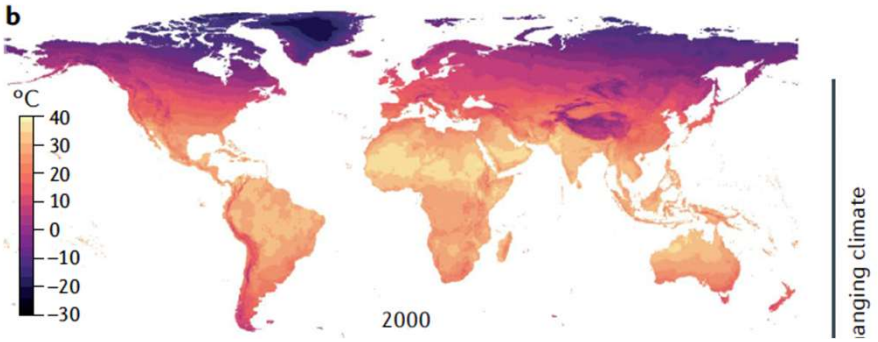
Migration
Conflicts
Figure 1. Factors that precipitate the occurrence and transmission of EIDs and REIDs.
nature reviews microbiology
Infectious disease in an era of global change
Rachel E. Baker, Ayesha S. Mahmud, Ian F. Miller, Malavika Rajeev, Fidisoa Rasambainarivo, Benjamin L. Rice, Saki Takahashi, Andrew J. Tatem, Caroline E. Wagner, Lin-Fa Wang, Amy Wesolowski and C. Jessica E. Metcalf
b
Air travel passengers (billion)
Exports of goods and services (trillion current US$)
Urban population (billion)
1970 1980 1990 2000 2010 2020
World
East Asia and Pacific
Europe and Central Asia
Middle East and North Africa
Sub-Saharan Africa
Latin America and Caribbean
North America

Climate Change



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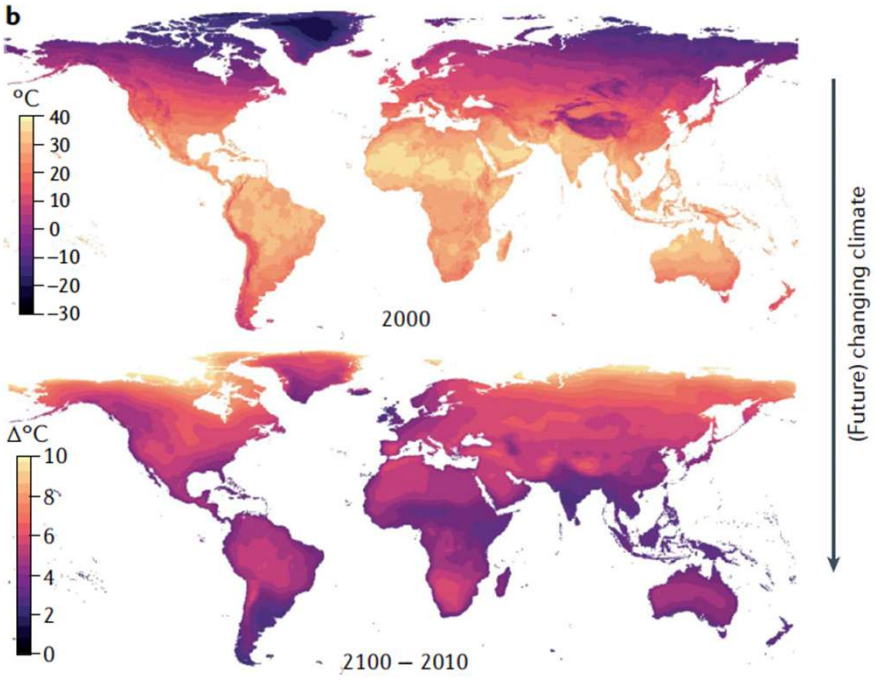
Climate Change



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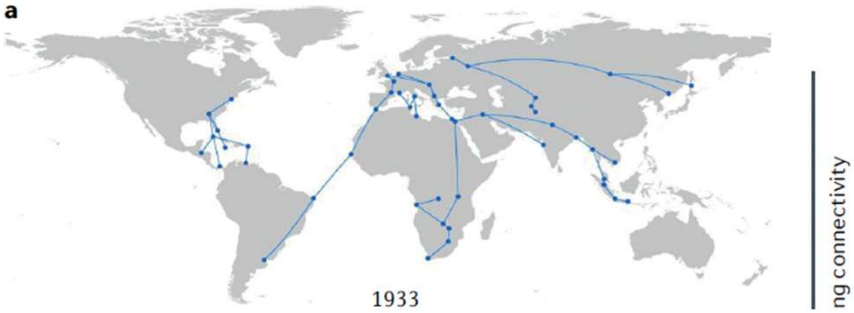
Connectivity



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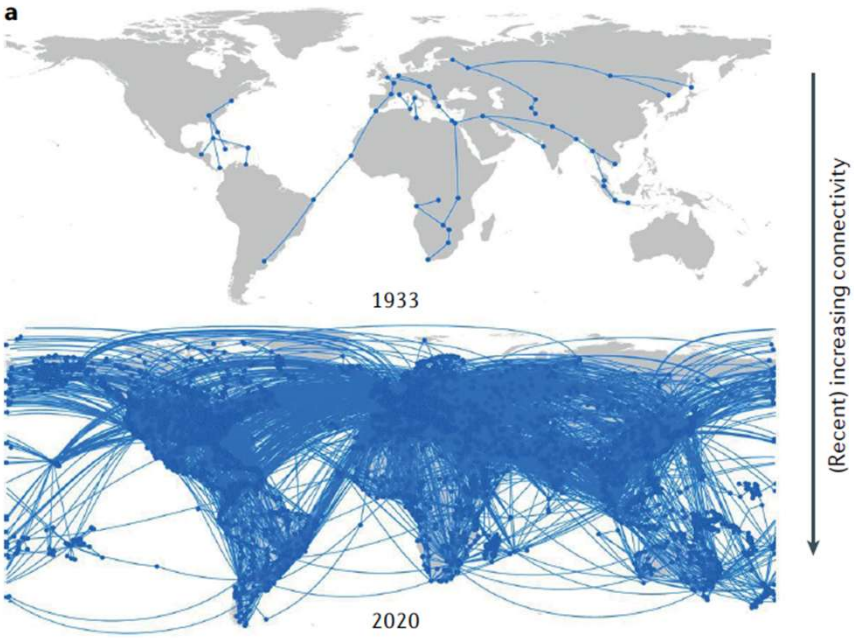
Connectivity

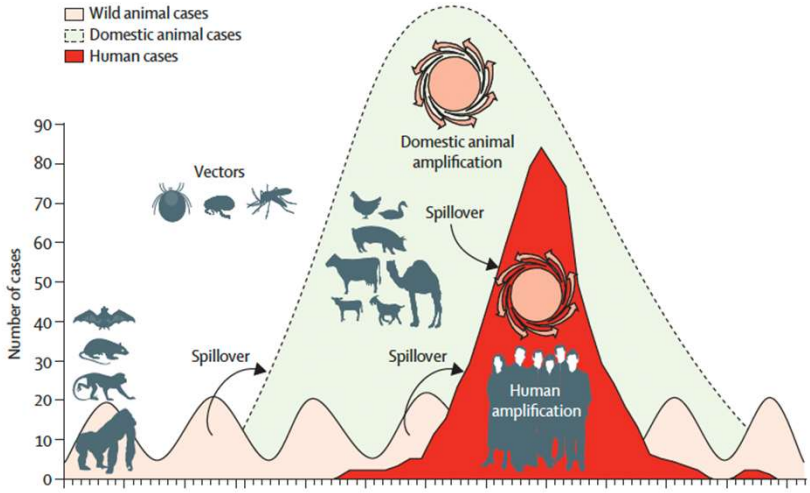


11

Ecology of zoonoses: natural and unnatural histories

William B Karesh, Andy Dobson, James O Lloyd-Smith, Juan Lubroth, Matthew A Dixon, Malcolm Bennett, Stephen Aldrich, Todd Harrington, Pierre Formenty, Elizabeth H Loh, Catherine C Machalaba, Mathew Jason Thomas, David L Heymann

THE LANCET



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nature communications

Article

Predicting the evolution of the Lassa virus endemic area and population at risk over the next decades

Received: 30 September 2021

Accepted: 2 September 2022

Published online: 27 September 2022

Check for updates

Raphaëlle Klitting, Liana E. Kafetzopoulou, Wim Thiery, Gytis Dudas, Sophie Gryseels, Anjali Kotamarthi, Bram Vrancken, Karthik Gangavarapu, Mambu Momoh, John Dambu Sandi, Augustine Goba, Foday Alhasan, Donald S. Grant, Sylvanus Okogbenin, Ephraim Ogbaini-Emovo, Robert F. Garry, Allison R. Smither, Mark Zeller, Matthias G. Pauthner, Michelle McGrew, Laura D. Hughes, Sophie Duraffour, Stephan Günther, Marc A. Suchard, Philippe Lemey, Kristian G. Andersen & Simon Dellicour

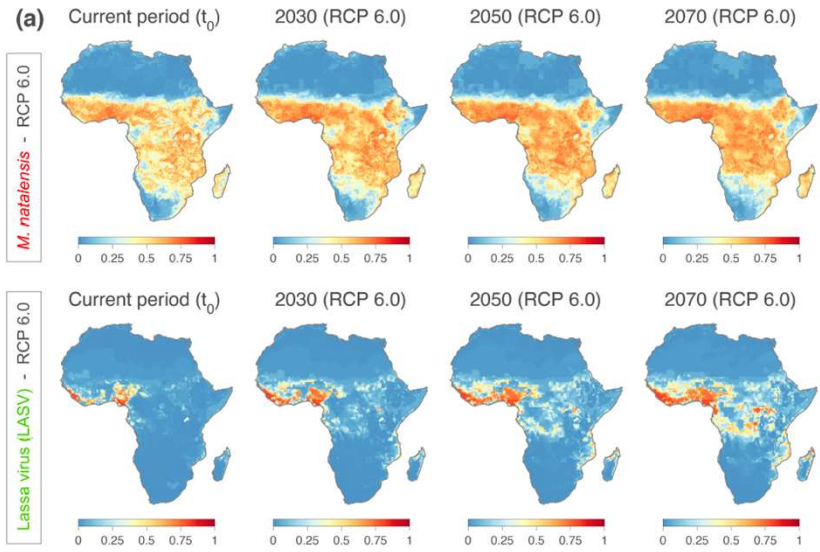

Fig. 2 | Projected ecological niche suitability of *Mastomys natalensis* and Lassa virus, as well as human population at risk of exposure to Lassa virus. a Pro- projections). F averaged over

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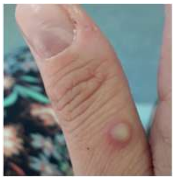
Look out 👀

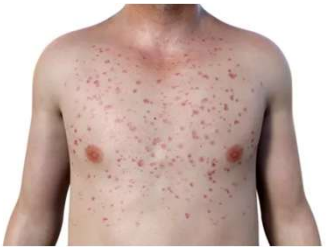
Mpox



H5N1

Measles

Viral Hemorrhagic Fevers Marburg, Ebola



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MPOX

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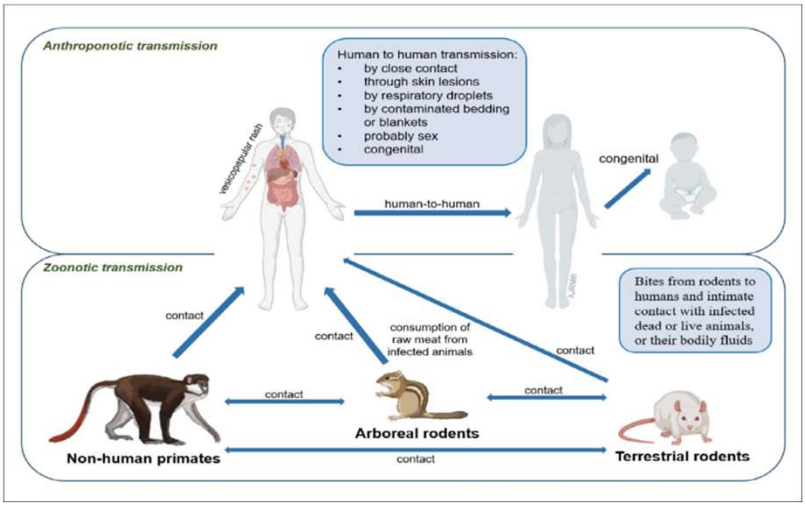
MPOX VIRUS: REVIEW



Monkeypox virus (MPXV) is a double-stranded DNA virus belonging to the Poxviridae family of the genus Orthopoxvirus with two different clades. The endemic disease status of MPX was updated to an outbreak worldwide in 2022.

Mpox is now endemic in US.

Antiviral treatment is available. The JYNNEOS vaccine is effective for pre-exposure prophylaxis.

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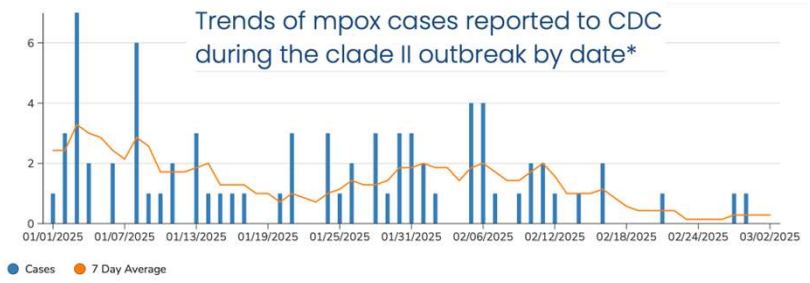
MPOX

- Mpox, a viral infection continues to be diagnosed in the US. During an outbreak of the virus that started in 2022 and has involved 121 countries, over 32,000 cases of Mpox were confirmed in the US with 785 in NC.
- To date, cases of Mpox detected in the US have all been **Clade II** of the virus. Since early 2023, the Democratic Republic of the Congo (DRC), has reported more than 27,000 cases of infection with the more severe **Clade I** viruses.



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MPOX UPDATE

The New York Times

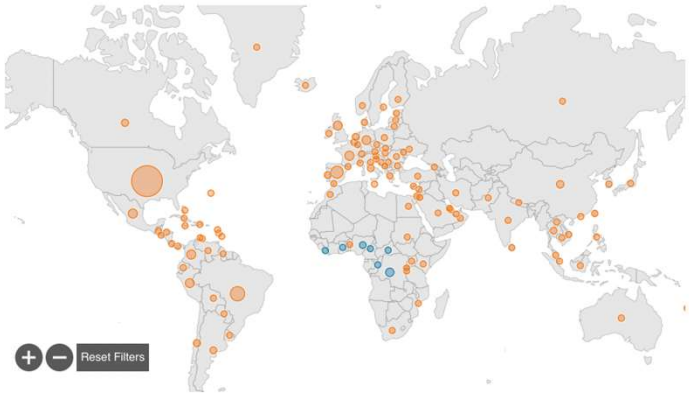
W.H.O. Declares Global Emergency Over New Mpox Outbreak

The epidemic is concentrated in the Democratic Republic of Congo, but the virus has now appeared in a dozen other African countries.

Share full article 136

A laboratory nurse, with samples taken from a patient with a suspected case of mpox near Goma, Democratic Republic of Congo. Arlette Bashizi/Reuters

U.S. Cases	U.S. Deaths	Global Cases
Total Cases	Total Deaths	Total Cases
32,063	58	99,518



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MPOX

Daily Mail

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Latest Headlines | Flu | RSV | Dementia | Cancer | Weight Loss | Diet | CDC | WHO

California records more local cases of new deadlier mpox strain as expert warns virus could spread to more states

- **READ MORE:** Everything you need to know about the deadly mpox variant

By LUKE ANDREWS, US SENIOR HEALTH REPORTER
PUBLISHED: 15:42 EDT, 22 October 2025 | UPDATED: 15:56 EDT, 22 October 2025

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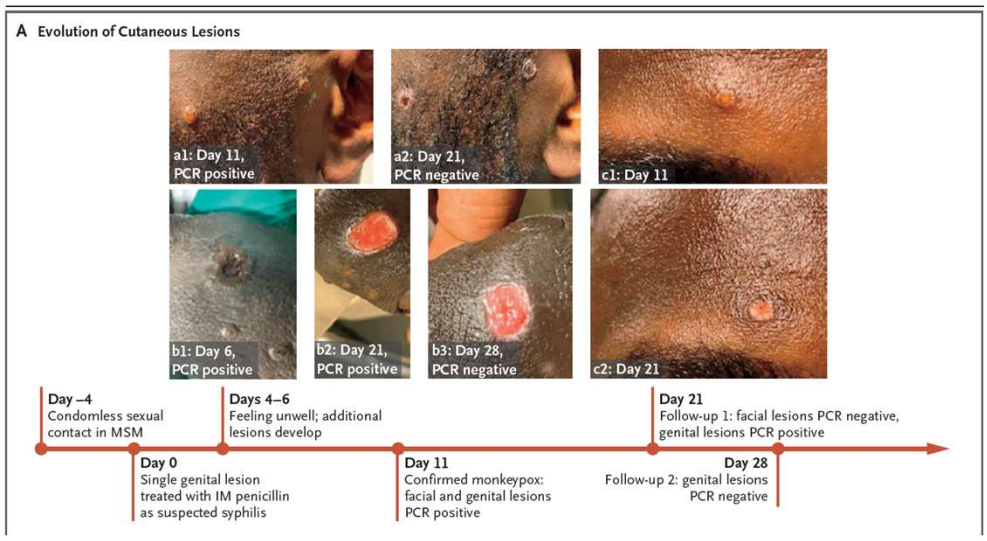
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Monkeypox Virus Infection in Humans
across 16 Countries — April–June 2022



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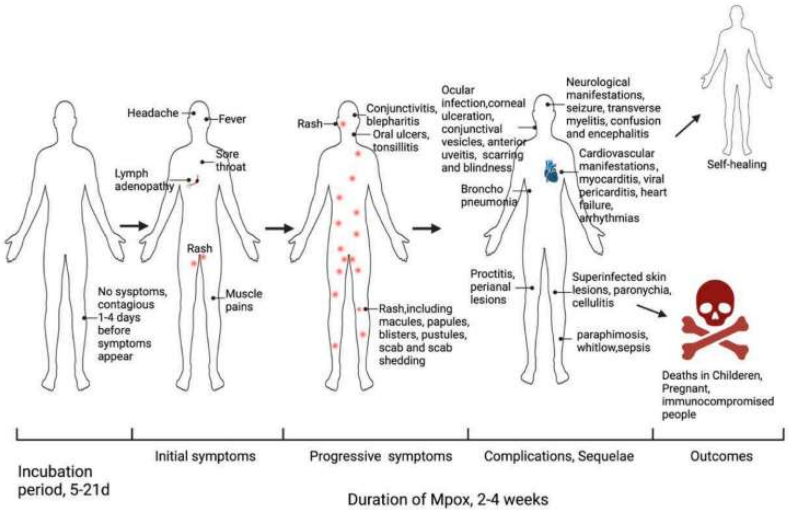
PROGRESSION OF MPOX



Sun Y, et al. J Clin Virol 2024;171:105662

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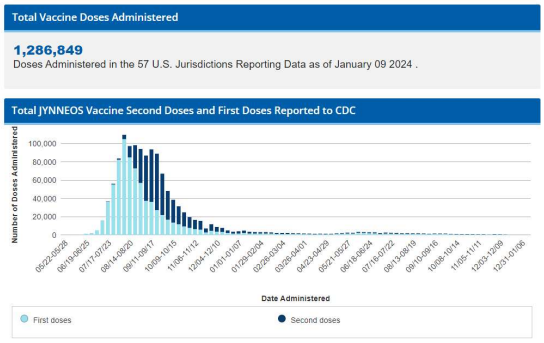
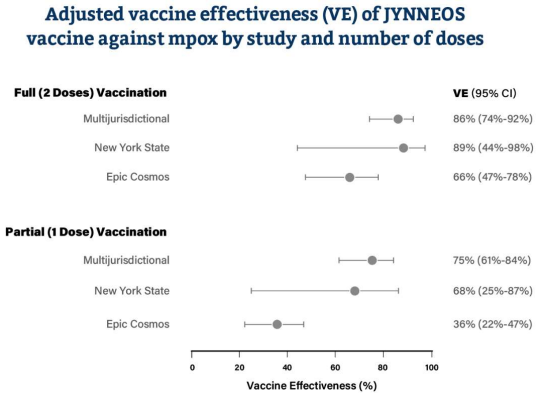
JYNNEOS VACCINE, US, CDC

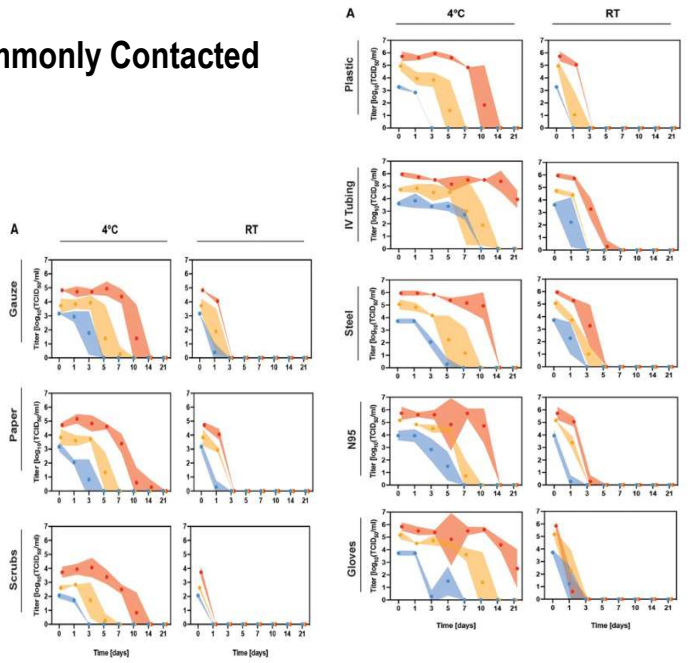




JYNNEOS vaccine (the vaccine used in the current mpox outbreak) is effective at preventing mpox among people at risk of mpox. Although ~1.2 million vaccine doses have been administered, **only 23%** of the population at risk has been fully vaccinated nationally. Vaccine coverage varies widely between jurisdictions. Reasons for coverage variability could include lower vaccine accessibility and awareness, fewer vaccine providers, lower vaccine confidence and demand, and concern about stigma; https://www.cdc.gov/poxvirus/mpox/cases-data/mpx-jynneos-vaccine-coverage.html

Stability of Monkeypox Virus on Commonly Contacted Surfaces in Clinical Settings

The persistence of viable MPXV and viral DNA was evaluated using porous (gauze, cotton, and scrubs), and nonporous (stainless steel, polypropylene plastic, intravenous tubing, N95 masks, and nitrile gloves) materials. Surfaces were inoculated with 10^5, 10^6, and 10^7 $TCID_{50}$ (50% Tissue Culture Infectious Dose) MPXV and incubated at room temperature (22 °C) and 4 °C for up to 21 days to determine the effect of temperature and inoculum titer on virus viability. We show that MPXV stability is influenced by both surface type and temperature, with nonporous surfaces and lower temperatures supporting longer virus viability. Infectious MPXV was detected for up to 21 days on intravenous tubing and nitrile gloves at 4 °C, whereas porous materials like cotton showed rapid loss of infectivity, especially at room temperature. Notably, we found that viral DNA did not correlate with the presence of infectious virus, suggesting that molecular assays may overestimate fomite-mediated transmission risks.



Stability of infectious monkeypox virus (MPXV) on nonporous surfaces at room temperature and 4 °C. Inocula of 50 µL containing 10^5, 10^6, or 10^7 $TCID^{50}$ of MPXV were evenly applied to the circular pieces of porous materials

Benete A, et al. Open Forum ID 2025;12:ofaf225

Efficient Inactivation of Monkeypox Virus by WHO Recommended Hand Rub Formulations and Alcohols

Increasing nonzoonotic human monkeypox virus (MPXV) infections urge reevaluation of inactivation strategies. We demonstrate efficient inactivation of MPXV by 2 World Health Organization–recommended alcohol-based hand rub solutions. When compared with other (re)emerging enveloped viruses, MPXV displayed the greatest stability. Our results support rigorous adherence to use of alcohol-based disinfectants.

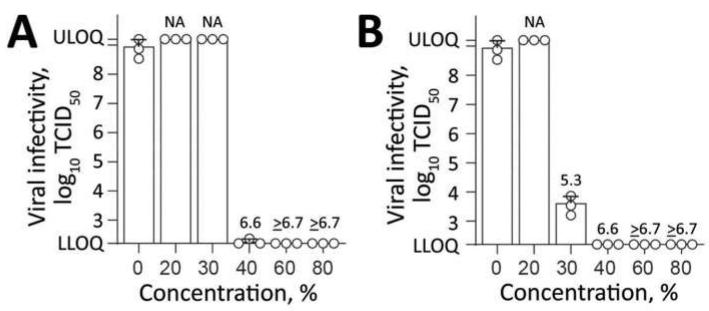


Figure 2. Effect of commercially available alcohols in inactivating monkeypox virus. A) Results for ethanol. B) Results for 2-propanol. Means of 3 independent experiments with SDs (error bars) are shown. Reduction factors are included above the bars. Biocide concentrations ranged from 0% to 80% with an exposure time of 30 s. Viral titers are displayed as $TCID_{50}$/mL values. LLOQ, lower limit of quantification (1.58×10^2 $TCID_{50}$/mL); NA, not applicable; $TCID_{50}$, 50% tissue culture infectious dose; ULOQ, upper limit of quantification (1.58×10^9 $TCID_{50}$/mL).

Meister TL, et al. Emerg Infect Dis 2023;29:189

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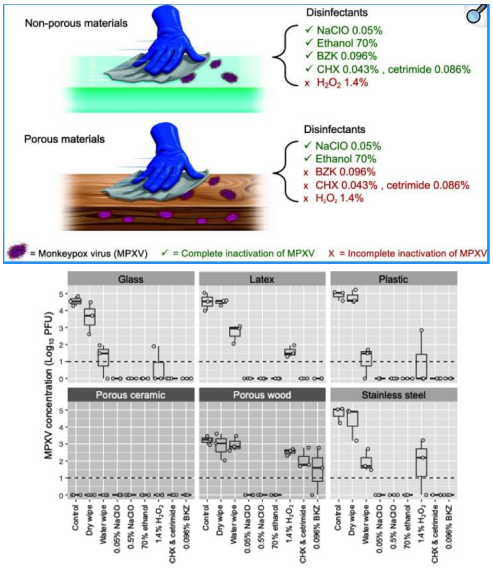
Efficacy of Disinfectants for Monkeypox Virus Inactivation on High Touch Surface Materials in Low-Resource Settings

Disinfection efficacy tests were conducted on surface carriers inoculated with the monkeypox virus(MPXV) by applying six disinfectant solutions (and three controls) on six surfaces common in low-resource settings: four nonporous surfaces (stainless steel, glass, plastic, and latex) and two porous surfaces (ceramic and wood). Disinfectants were wiped on carriers in triplicate, with a 1min contact time: 0.05 and 0.5% sodium hypochlorite, 70% ethanol, two quaternary ammonium compound (QAC)-based disinfectants, and1.4% hydrogen peroxide. MPXV was then quantified, and log10 removal values were calculated. Sodium hypochlorite (0.05and0.5%) and ethanol(70%) removed MPXV to below detection level, ≥ 99.97% reduction for nonporous surfaces, and ≥99.40% for wood, QAC-based disinfectants were efficacious on nonporous surfaces (≥99.97% inactivation) but had diminished efficacy on wood, a porous surface, and 1.4% H2O2 had limited efficacy across all tested surfaces. Results varied by disinfectant type and surface type. Based on our results, were commend using 0.05% sodium hypochlorite or 70% ethanol with 1 min contact time to inactive MPXV on clean nonporous and porous surfaces. As MPXV is evolving, future research with additional disinfectants, application methods, and environmental conditions and research to understand adsorption, disinfection efficacy, and transmission risk on porous surfaces are needed to develop practical disinfection recommendations.



Pitol AK, et al. Environ Sci Techhol 2024;31:19981

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MPOX: INFECTION PREVENTION AND CONCLUSIONS

Infection prevention

- Manage patient in a private room; special air handling is not required. If the patient is transported outside of their room, they should use well-fitting source control (e.g., medical mask) and have any exposed skin lesions covered with a sheet or gown.
- PPE: Gown, gloves, eye protection, N95 respirator or higher
- Waste is considered Category B except when they contain or are contaminated with lab cultures of clade 1 MPXV
- Standard cleaning and disinfection procedures should be performed using an EPA-registered hospital-grade disinfectant with an emerging viral pathogen claim (i.e., EPA, list Q)*
- Soiled laundry (e.g., bedding, towels, personal clothing) should be handled in accordance with recommended standard practices, avoiding contact with lesion material that may be present on the laundry. Soiled laundry should be gently and promptly contained in an appropriate laundry bag and never be shaken or handled in manner that may disperse infectious material.
- Activities such as dry dusting, sweeping, or vacuuming should be avoided. Wet cleaning methods are preferred.
- Those with confirmed MPXV infection should have recommended isolation precautions for mpox maintained until all lesions have crusted, those crusts have separated, and a fresh layer of healthy skin has formed underneath.

Conclusions: MPOX is now endemic in the US. Outbreaks continue in Africa. HCP should consider Mpox in patients with compatible symptoms

*https://www.epa.gov/pesticide-registration/disinfectants-emerging-viral-pathogens-evps-list-q; https://www.cdc.gov/mpox/hcp/infection-control/healthcare-settings.html

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H5N1

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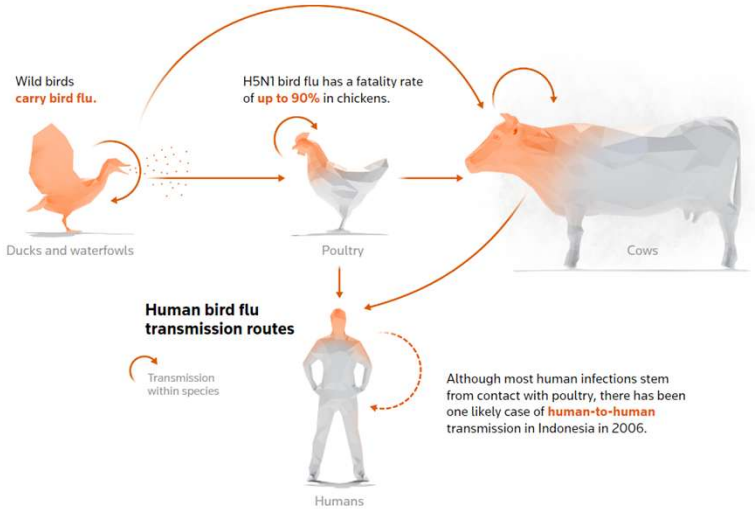
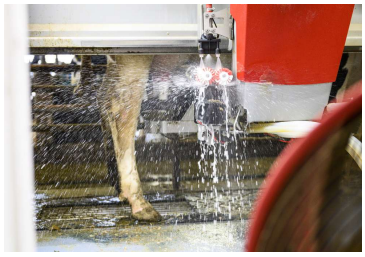
The Global H5N1 Influenza Panzootic In Mammals



Source: U.S. Centers for Disease Control and Prevention (CDC)



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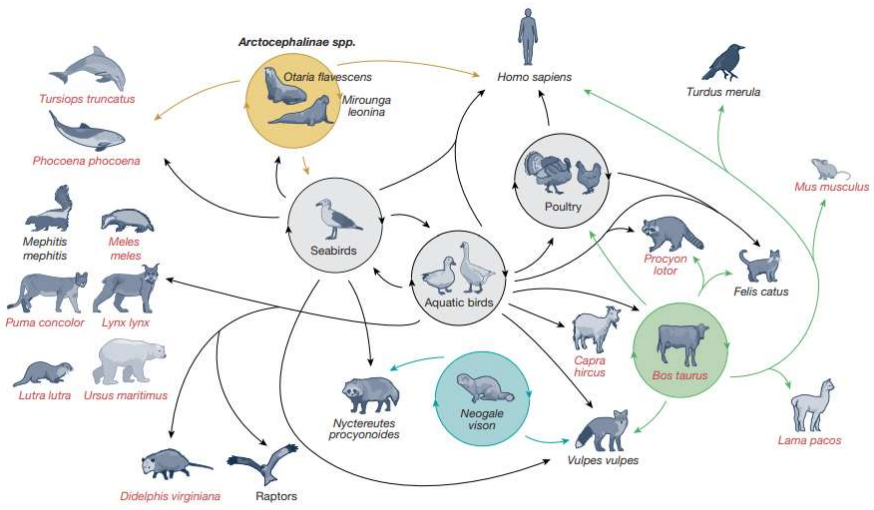

Fig. 2 | Multi-host ecology of H5N1 clade 2.3.4.4b since 2020. Wild aquatic birds (such as ducks, geese and swans) are the natural reservoir hosts for H5N1. Arrows indicate spillover into other host species. Cyclic arrows indicate sustained H5N1 transmission in that host species. New mammalian H5N1 hosts with sustained transmission are highlighted in yellow (South American marine mammals), green (US dairy cattle) and blue (European mink), with arrows in the same colours depicting spillovers from those mammalian outbreaks into additional species, possibly via unsampled intermediaries. Animals labelled in red are host species in which IAV has been detected for the first time during this outbreak (based on genetic sequence data, not serology).

2020:
H5N1 detected in wild birds in Europe, Asia, and Africa

2021:
WHO detects H5N1 in migratory birds in N America

2023:
Die offs of marine birds in S America. Detection of H5N1 these and in marine mammals, then >500 other species.

2024:
Unusual illness of cows in TX.
H5N1 detected.
Dairy workers with illness +H5N1

Peacock T, et al. Nature 2025;637:304

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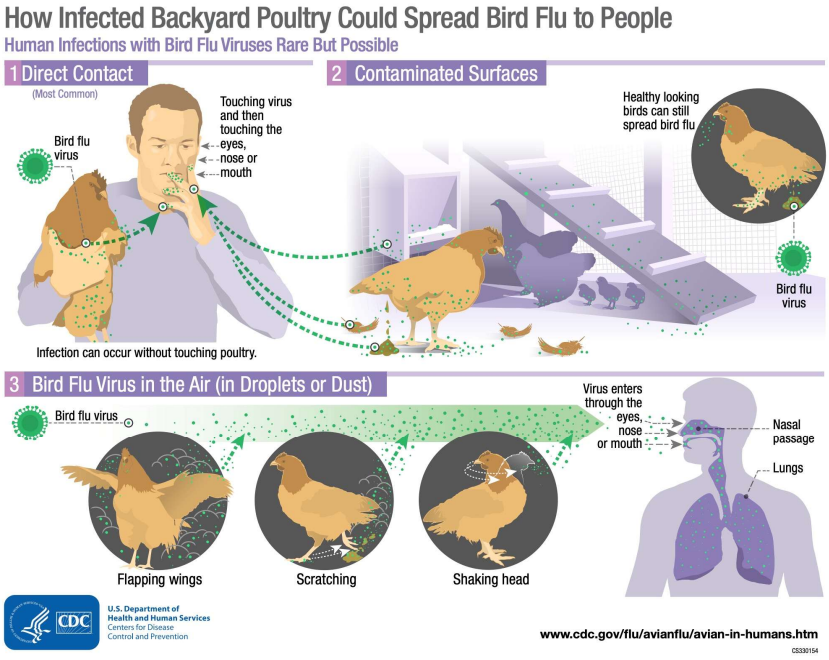
How Infected Backyard Poultry Could Spread Bird Flu to People
Human Infections with Bird Flu Viruses Rare But Possible
1 Direct Contact
(Most Common)
Bird flu virus
Touching virus and then touching the eyes, nose or mouth
Infection can occur without touching poultry.
2 Contaminated Surfaces
Healthy looking birds can still spread bird flu
Bird flu virus
3 Bird Flu Virus in the Air (in Droplets or Dust)
Bird flu virus
Flapping wings
Scratching
Shaking head
Virus enters through the eyes, nose or mouth
Nasal passage
Lungs
U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
www.cdc.gov/flu/avianflu/avian-in-humans.htm
CS330154
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The Global H5N1 Influenza Panzootic In People

Cumulative number of confirmed human cases† for avian influenza A(H5N1) reported to WHO, 2003-2024

Country	2003-2009*		2010-2014*		2015-2019*		2020		2021		2022		2023		2024		Total	
	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths
Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Azerbaijan	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	5
Bangladesh	1	0	6	1	1	0	0	0	0	0	0	0	0	0	0	0	8	1
Cambodia	9	7	47	30	0	0	0	0	0	0	0	0	6	4	10	2	72	43
Canada	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1
Chile	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
China	38	25	9										1	0	1	0	56	32
Djibouti	1	0	0										0	0	0	0	1	0
Ecuador	0	0	0										0	0	0	0	1	0
Egypt	90	27	120	5									0	0	0	0	359	120
India	0	0	0										0	0	0	0	1	1
Indonesia	162	134	35	3									0	0	0	0	200	168
Iraq	3	2	0										0	0	0	0	3	2
Lao People's Democratic Republic	2	2	0										0	0	0	0	3	2
Myanmar	1	0	0										0	0	0	0	1	0
Nepal	0	0	0										0	0	0	0	1	1
Nigeria	1	1	0										0	0	0	0	1	1
Pakistan	3	1	0										0	0	0	0	3	1
Spain	0	0	0										0	0	0	0	2	0
Thailand	25	17	0										0	0	0	0	25	17
Turkey	12	4	0										0	0	0	0	12	4
United Kingdom	0	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	5	0
United States of America**	0	0	0	0	0	0	0	0	0	0	1	0	0	0	58	0	59	0
Viet Nam	112	57	15	7	0	0	0	0	0	0	1	0	0	0	1	1	129	65
Total	**468**	**282**	**233**	**125**	**160**	**48**	**1**	**0**	**2**	**1**	**6**	**1**	**12**	**4**	**72**	**3**	**954**	**464**

Total

cases 954 deaths 464

*2003-2009, 2010-2014 and 2015-2019 total figures. Breakdowns by year available on subsequent tables.
** For the United States of America, in 2024, cases reported as A(H5) are included here.
†This count includes reported detections in asymptomatic individuals. In some cases, the confirmation of infection versus transient contamination of the nasopharynx/oropharynx with virus particles after exposure to infected birds or contaminated environment remains inconclusive. Total number of cases includes number of deaths. Counts are according to reporting country which may differ from country where exposure may have occurred.
WHO reports only laboratory-confirmed cases. All dates refer to onset of illness.
Source: WHO/GIP, data in HQ as of 12 Dec 2024.

World Health Organization

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H5N1 INFLUENZA, CDC

Human Cases During 2024 - US

Cases in the U.S.	Deaths in U.S.
69 cases	1 cases

- Most but not all cases of H5N1 have exposure to animals:
  - 41 of the 69 bird flu cases in US so far were linked to dairy farms.
- Most US cases of symptomatic H5N1 in the US have been mild but 4 hospitalized and 1 death (65 yo man with comorbidities and backyard flock)

Exposure Source

State	Exposure Associated with Commercial Agriculture and Related Operations		Other Animal Exposure†	Exposure Source Unknown†	State Total
	Dairy Herds (Cattle)	Poultry Farms and Culling Operations			
California	36	0	0	2	38
Colorado	1	9	0	0	10
Iowa	0	1	0	0	1
Louisiana	0	0	1	0	1
Michigan	2	0	0	0	2
Missouri	0	0	0	1	1
Oregon	0	1	0	0	1
Texas	1	0	0	0	1
Washington	0	11	0	0	11
Wisconsin	0	1	0	0	1
Source Total	40	23	1	3	67

https://www.cdc.gov/bird-flu/situation-summary/index.html

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Signs and Symptoms of HPAI A(H5N1) Virus Infection

Figure 1. Conjunctivitis with Subconjunctival Hemorrhage in Both Eyes.

Uyeki NEJM 2024

Clinical findings in mild illness:

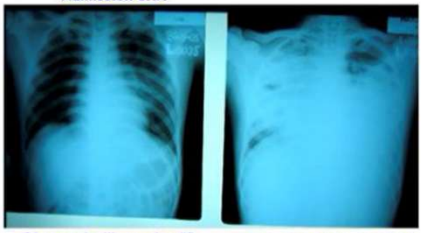
- Fever or feverishness, nonproductive cough, muscle aches, malaise, headache, sore throat, myalgia
  - Abdominal pain; vomiting and diarrhea can occur
  - Eye discomfort/redness/eye discharge (conjunctivitis) alone is uncommon but can occur

Progression to lower respiratory tract disease (5-7 days after symptom onset): difficulty breathing, shortness of breath, chest pain, tachypnea

- Hospital admission findings:
  - Clinical: hypoxia, signs of pneumonia
  - Laboratory: leukopenia, lymphopenia, mild-to-moderate thrombocytopenia
  - Radiographic findings: patchy, interstitial, lobar, and/or diffuse infiltrates and opacities, consolidation

37-yo woman, illness day #7 Admission CXR

Illness day #10; died day #11



21-yo male, illness day #5 Admission CXR

Illness day #12; survived (not ventilated)

T Uyeki, CDC September 2005

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Infection Prevention & Control: Identify-Isolate-Inform

Identify

Identify: consider possibility of H5N1 virus infection in persons with acute respiratory illness with relevant exposure history in the 10 days prior to symptom onset

Symptoms: remember conjunctivitis

Exposure: contact with potentially infected sick/dead birds, livestock, or other animals (e.g., handling, slaughtering, defeathering, butchering, culling, preparing for consumption or consuming uncooked/undercooked food or related uncooked food products, including unpasteurized/raw milk/dairy products), direct contact with water or surfaces contaminated with feces, unpasteurized/raw milk/dairy products, or parts (carcasses, internal organs, etc.) of potentially infected animals; prolonged exposure to potentially infected birds/other animals in a confined space

https://www.cdc.gov/bird-flu/prevention/hpai-interim-recommendations.html#cdc_generic_section_8-recommendations-for-infection-prevention-and-control; https://www.cdc.gov/bird-flu/hcp/novel-flu-infection-control/?CDC_AAref_Val=https://www.cdc.gov/flu/avianflu/novel-flu-infection-control.htm, accessed 8/11/2024

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Serologic Evidence of Recent Infection with Highly Pathogenic Avian Influenza A(H5) Virus Among Dairy Workers, MI & CO, June–August 2024

A convenience sample of persons who work in dairies was interviewed, and blood specimens were collected. Among 115 persons, 8 (7%; 95% CI=3.6%–13.1%) had serologic evidence of recent infection with A(H5) virus; all reported milking cows or cleaning the milking parlor

Summary

What is already known about this topic?

Infections with highly pathogenic avian influenza (HPAI) A(H5) viruses have been detected sporadically in dairy farm workers in the United States since April 2024. Public health response efforts include active monitoring of workers exposed to HPAI A(H5) virus for illness.

What is added by this report?

Health officials conducted surveys and serologic testing to identify recent HPAI A(H5) infections among dairy workers in two states. Serologic testing indicated that 7% of participating dairy workers had evidence of recent infection with HPAI A(H5) virus.

What are the implications for public health practice?

The findings support the need for active monitoring of exposed workers and testing to detect and treat HPAI A(H5) infections, including those in persons with very mild symptoms. These efforts should be coupled with farmworker education about infection risks and prevention measures.

TABLE 3. Characteristics of illnesses reported by dairy workers, by seropositivity to highly pathogenic avian influenza A(H5) (N = 115) — Colorado and Michigan, 2024

Reported signs and symptoms*	Serologic test result, no. (%) Negative n = 107	Positive n = 8
Any self-reported illness	42 (39)	4 (50)
No. of days from exposure† to onset, median (IQR)	15 (4 to 27)	−5 (−11 to 1)
Cough	13 (31)	0 (—)
Diarrhea	6 (15)	1 (25)
Difficulty breathing	7 (17)	0 (—)
Fatigue	21 (50)	0 (—)
Fever (≥100.4°F [≥38°C])	7 (17)	0 (—)
Feverishness or chills	15 (37)	1 (25)
Headache	19 (45)	1 (25)
Muscle aches	19 (45)	0 (—)
Nausea or vomiting	4 (9.5)	0 (—)
Rash	4 (9.5)	0 (—)
Red, draining, or itching eyes	26 (62)	3 (75)
Runny nose or nasal congestion	20 (48)	1 (25)
Seizure	0 (—)	0 (—)
Sneezing	13 (31)	1 (25)
Sore throat	24 (57)	1 (25)

Mellis AM, et al. MMWR 2024;44:1004

Seroprevalence of Highly Pathogenic Avian Influenza A(H5) Virus Infections Among Bovine Veterinary Practitioners, US, Sept. 2024

Summary

What is already known about this topic?

Highly pathogenic avian influenza (HPAI) A(H5) virus infections have been detected in humans exposed to infected dairy cattle.

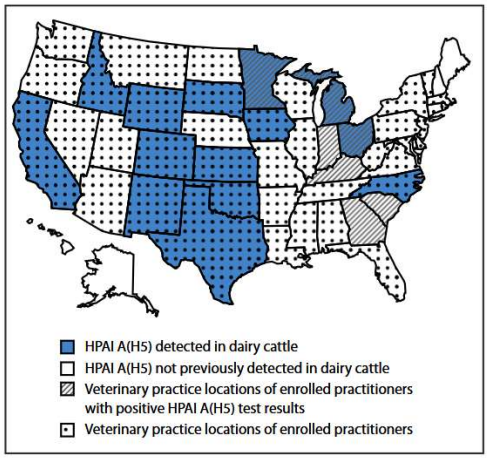
What is added by this report?

Public health officials conducted a serosurvey among 150 bovine veterinary practitioners. Three practitioners had evidence of recent infection with HPAI A(H5) virus, including two without exposures to animals with known or suspected HPAI A(H5) virus infections and one who did not practice in a U.S. state with known HPAI A(H5) virus–infected cattle.

What are the implications for public health practice?

These findings suggest the possible benefit of systematic surveillance for rapid identification of HPAI A(H5) virus in dairy cattle, milk, and humans who are exposed to cattle to ensure appropriate hazard assessments.

FIGURE. States with serosurvey-enrolled bovine veterinary practitioners* and states reporting highly pathogenic avian influenza A(H5) infections in dairy cattle — United States, September 2024



Abbreviation: HPAI = highly pathogenic avian influenza.
* Two practitioners with a positive serologic HPAI A(H5) test result indicating recent infection practiced in multiple states.

Leonard J, et al. MMWR 2025;74:50

Table 3 | Comparison of studies of influenza virus pasteurisation in milk

Study	Virus	Milk type	Addition to milk	Pasteurisation method	Inactivation[a]	Detection method
This Study	2.3.4.4b + IAVs + IDV	Commercial and raw	Spiked in	Laboratory model (63 °C and 72 °C)	Total	Plaque assay; EFE inoculation
Alkie et al.[36]	2.3.4.4b	Raw milk	Spiked in	Laboratory model (63 °C and 72 °C)	Near-total	EFE inoculation (EID_{50})
Caceres et al.[38]	B3.13 + 2.3.4.4b + IAVs	Commercial, raw milk and colostrum	Spiked in	Laboratory model (63 °C, 72 °C, 91 °C)	Near-total	$TCID_{50}$
Cui et al.[34]	2.3.4.4b + IAVs	Raw milk	Spiked in	Laboratory model (multiple temperatures)	Total	EFE inoculation
Guan et al.[33]	B3.13	Raw milk	Shed naturally	Laboratory model (63 °C and 72 °C)	Near-total	$TCID_{50}$; EFE inoculation
Kaiser et al.[39]	2.3.4.4b	Raw milk	Spiked in	Laboratory model (63 °C and 72 °C)	Near-total	$TCID_{50}$
Kwon et al.[37]	2.3.4.4b	Lactose at a 1:10 dilution	Spiked in	Laboratory model (63 °C, 66 °C and 99 °C)	Total	$TCID_{50}$
Palme et al.[29]	Multiple AIVs	Commercial milk; semi-skimmed and whole	Spiked in	Laboratory model (56 °C and 75 °C; relatively long incubation times)	Near-total	Plaque assay
Spackman et al.[35]	B3.13	Raw milk	Shed naturally	Actual equipment (72.5 °C)	Total	EFE inoculation (EID_{50})

[a]Inactivation: total = infectivity below limit of detection of assay; near-total = infectivity unquantified or near to limit of detection of assay.
EFE Embryonated Fowl's Egg, EID_{50} 50% Egg infectious dose, $TCID_{50}$ 50% tissue culture infectious dose.

Literature Review – Effectiveness of pasteurization to eliminate H5N1

In every case, it was found that pasteurization temperatures rapidly reduced the infectivity of influenza viruses. However, it is clear that the effects of pasteurization are not instantaneous, and the point at which infectivity became undetectable varied somewhat between studies. It was consistently shown that heating to 63 °C (LTLT method) fully inactivated influenza viruses long before reaching the minimum pasteurization time of 30 min (Table 3). Heating to 72 °C (HTST method) also consistently caused very rapid inactivation of the virus, but the times needed for virus titers to drop to the limit of detection were close to the minimum recommended inactivation time of 15 s. As a result, while several studies, including our own, found that all detectable virus was inactivated by heating for pasteurizing times and temperatures, other studies reported low but detectable levels of residual infectivity after heating for times very close to the minimum required for pasteurization.

We conclude that pasteurization conditions should effectively inactivate H5N1 HPAIV in cows' milk, but that *unpasteurized milk could carry infectious influenza viruses*.

Schfers J, et al. Nature Communications 2025;16:173

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H5N1 Therapeutics

- At present, H5N1 is susceptible to osteltamivir, baloxavir, and amantadine
- Mutations that can reduce effectiveness of antivirals being reported
- Early treatment with oseltamivir is recommended in suspect cases (i.e., those with acute respiratory symptoms and concerning exposure) **even** before confirmation of H5N1 and **even** if >48 hours since symptoms onset.
- Combination antiviral therapy (osteltamivir + baloxavir) has been used in hospitalized patients with H5N1 and should be considered.

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Why we are concerned about H5N1

- Massive spread in animal species including poultry and dairy cows
- Limited testing of farm animals and no animal vaccination
- Limited testing of farm workers
- Humans have no pre-existing immunity
- Variable disease severity including serious and lethal illness
- Evolution of H5N1 that may increase transmission potential to humans and by humans plus recombination with seasonal flu in a co-infected individual can lead to variant more efficiently spread from person to person.

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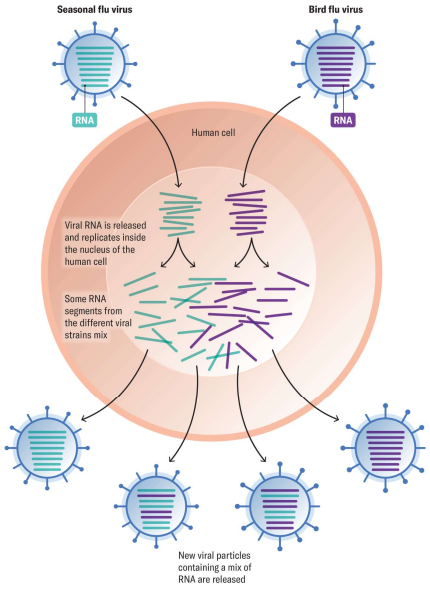
Seasonal flu + H5N1 = asking for trouble



https://www.scientificamerican.com/article/h5n1-detected-in-pig-highlights-the-risk-of-bird-flu-mixing-with-seasonal/

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MEASLES

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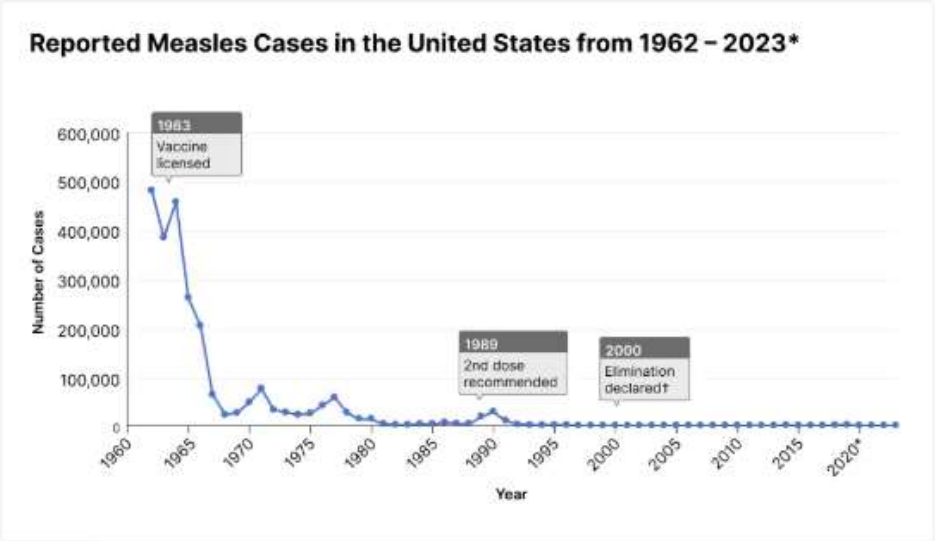
MEASLES CASES, US, CDC



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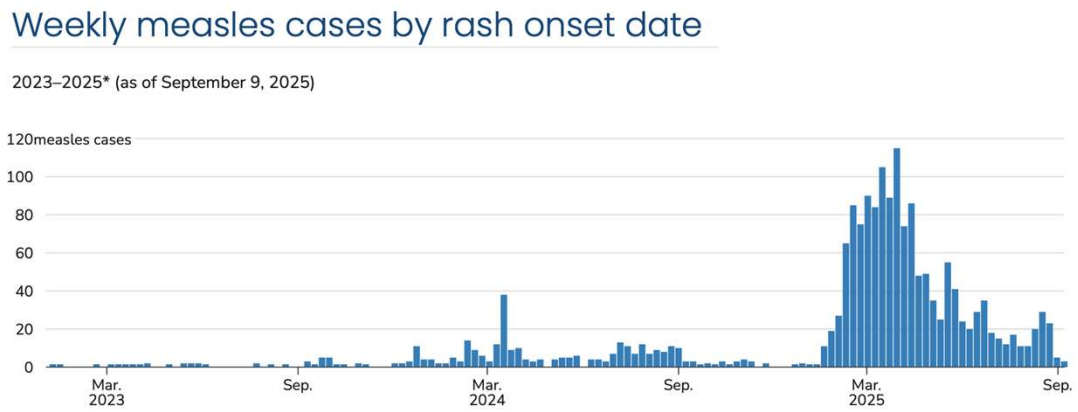
MEASLES CASES, US, CDC



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MEASLES, US, CDC

U.S. Cases in 2025

Total cases

1454

Age
Under 5 years: **404 (28%)**
5-19 years: **554 (38%)**
20+ years: **489 (34%)**
Age unknown: **7 (0%)**

Vaccination Status
Unvaccinated or Unknown: **92%**
One MMR dose: **4%**
Two MMR doses: **4%**

U.S. Hospitalizations in 2025

12%

12% of cases hospitalized (180 of 1454).

Percent of Age Group Hospitalized
Under 5 years: **21% (86 of 404)**
5-19 years: **7% (41 of 554)**
20+ years: **11% (53 of 489)**
Age unknown: **0% (0 of 7)**

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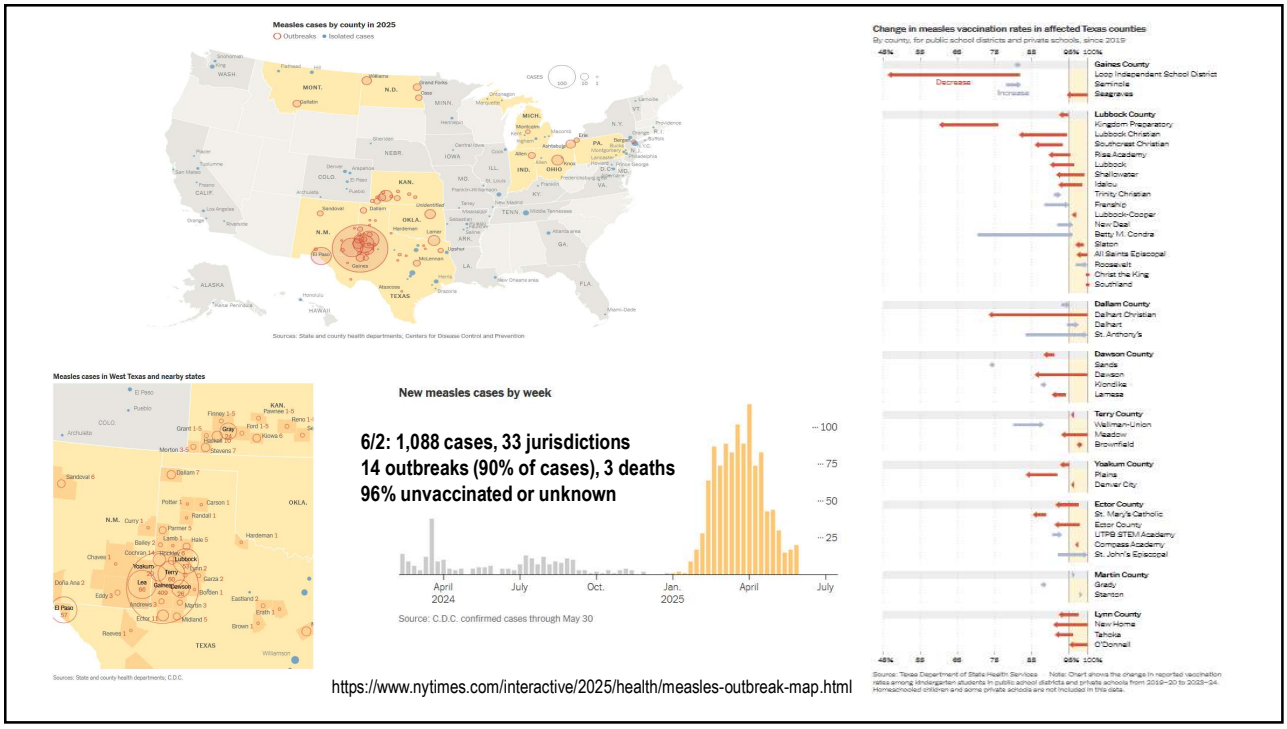

https://www.nytimes.com/interactive/2025/health/measles-outbreak-map.html

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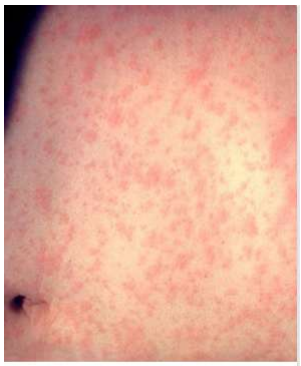
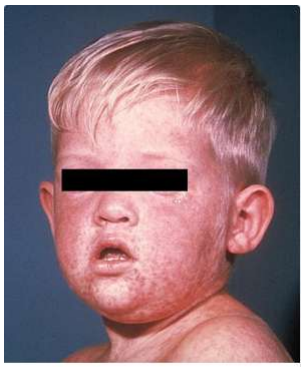
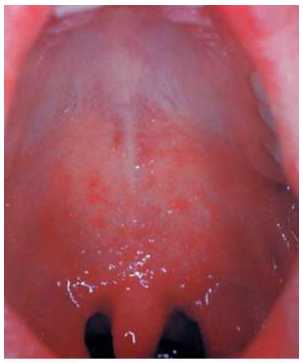
MEASLES ASSOCIATED SKIN FINDINGS



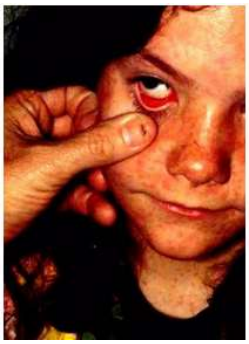
Skin of a patient after three days with measles rash.
Source: CDC/PHIL



Face of boy after three days with measles rash.
Source: CDC/PHIL



This was a patient who presented with Koplik's spots on palate due to pre-eruptive measles on day three of the illness.
Source: CDC/PHIL



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MEASLES: TIME COURSE & COMPLICATIONS

- 1st symptoms (7-10 days after exposure): High fever (may spike to >104°) Cough; Runny nose (coryza); Conjunctivitis) {the three C's}
- 2–3 days after symptoms begin**: Koplik spots which are pathognomonic** (may be absent)
- 3–5 days after symptoms begin: **measles rash**
- **Complications (common**): Otitis (10%), diarrhea (10%)
- **Complications (severe):** Hospitalization (20%, unvaccinated); pneumonia (5%, usually children); encephalitis (0.1%, usually children); death (1-3 per 1,000 children); pregnancy (premature birth or low-birth weight baby)
- **Long-term (SSPE):** Generally, develops 7-10 years after infection (person may have recovered fully). Risk (1989-1991) = 7-11 per 100,000 measles cases. Risk higher if infected <2 years of age.

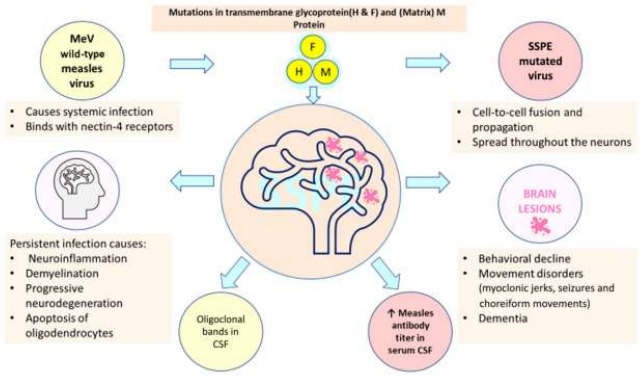

FIGURE 1 | Pathogenesis of subacute sclerosing panencephalitis.

https://www.cdc.gov/measles/signs-symptoms/index.html; Mubbashir Z, et al. Brain and Behavior 2025;15:e70292

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MEASLES: KEY FACTS

- **Prevention:**
  - Immunization is the only effective preventive measure against acquiring measles.
    - Two doses of MMR vaccine are ~97% effective.
    - Primary vaccine failure of the first dose at 12 months of age or older occurs in up to 5% of people, but 95% of first dose failures will seroconvert from a second dose.
    - Preventing outbreaks (i.e., reaching community protection levels) requires ≥95% of the population to be immune.
      - Combination vaccines have been shown to elicit the same immune response as individual vaccines. Vaccinating individuals who are already immune to one or more of the antigens in the combination vaccine, either from previous immunization or natural infection, are not associated with any increased risk of adverse events.

https://www.ecdc.europa.eu/en/measles/facts; https://www.cdc.gov/measles/hcp/index.html

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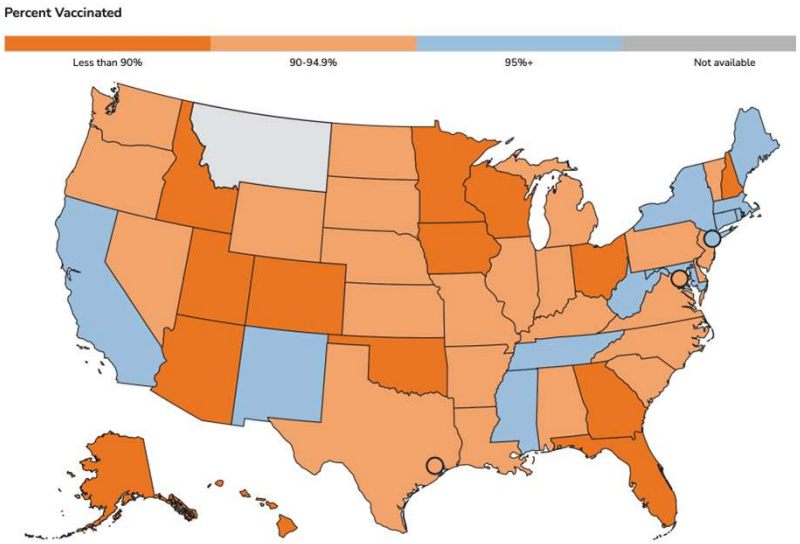
MEASLES VACCINATION KINDERGARDENERS, US, CDC



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R_0 OF SELECTED INFECTIOUS DISEASES AND NEEDED VACCINE COVERAGE TO PREVENT OUTBREAKS

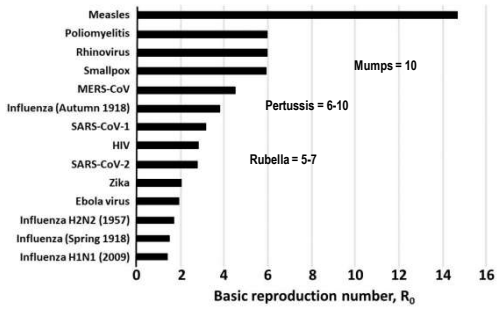

Figure 4. Estimated values of R_0 in different viral infections, culled from a variety of published sources

Aronson JK, et al. https://www.cebm.net/wp-content/uploads/2020/04/%E2%80%9CWhen-will-it-be-over_%E2%80%9D_-An-introduction-to-viral-reproduction-numbers-1.pdf

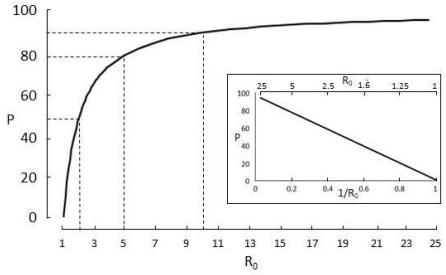

Figure 1. The relation between the basic reproduction number of a virus, R_0, and the proportion of the population that needs to be immunized to achieve herd immunity; note the steep rise of the curve at values of R_0 between 1 and 5; three examples are shown: R_0 =2, proportion = 50%, R_0 = 5, proportion = 80%; R_0 = 10, proportion = 90%; the inset shows a linearization of the main graph, generated by plotting P against $1/R_0$

R0 is affected by:

- the size of the population and the proportion of susceptible people at the start;
- the infectiousness of the organism;
- the rate of disappearance of cases by recovery or death, the first of which depends on the time for which an individual is infective;

Survival of Measles Virus in Air

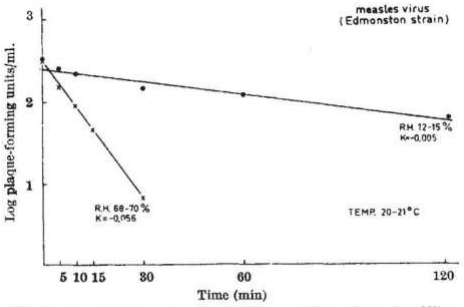

Fig. 1. Survival of measles virus at low and high relative humidity. Ordinates, log plaque-forming units/ml. collection fluid. 1 ml. collection fluid corresponds with 2·2 l. of air

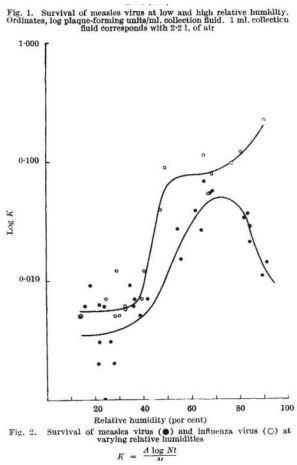

Fig. 2. Survival of measles virus (●) and influenza virus (○) at varying relative humidities

$$K = \frac{\Delta \log Nt}{\Delta t}$$

De Jong JG, Winkler KC. Nature 1964;201;1054

MEASLES OUTBREAK N A PEDIATRIC PRACTICE: AIRBORNE TRANSMISSION IN AN OFFICE SETTING

In February 1981, a measles outbreak occurred in a pediatric practice in DeKalb County, GA. The source case, a 12-year-old boy vaccinated against measles at 111/2 months of age, was in the office for one hour on the second day of rash, primarily in a single examining room. On examination, he was noted to be coughing vigorously. Seven secondary cases of measles occurred due to exposure in the office. Four children had transient contact with the source patient as he entered or exited through the waiting room; only one of the four had face-to-face contact within 1 m of the source patient. The three other children who contracted measles were never in the same room with the source patient; one of the three arrived at the office **one hour after the source patient had left**. The risk of measles for unvaccinated infants (attack rate 80%, 4/5) was 10.8 times the risk for vaccinated children (attack rate 7%, 2/27) (*P* = .022, Fisher exact test, two-tailed). Airflow studies demonstrated that droplet nuclei generated in the examining room used by the source patient were dispersed throughout the entire office suite. Airborne spread of measles from a vigorously coughing child was the most likely mode of transmission. The outbreak supports the fact that measles virus when it becomes airborne can survive at least one hour. The rarity of reports of similar outbreaks suggests that airborne spread is unusual. Modern office design with tight insulation and a substantial proportion of recirculated ventilation may predispose to airborne transmission.

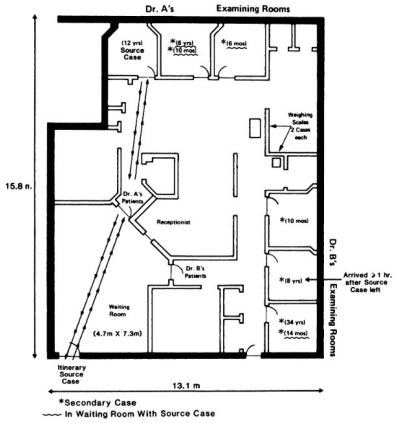

Fig 1. Pediatric office suite, DeKalb County, GA, in which there was a measles outbreak on Feb 6, 1981.

Bloch AB, et al. Pediatric 1985;75:676

AIRBORNE TRANSMISSION OF MEASLES IN A PHYSICIAN'S OFFICE

An unusual outbreak of measles occurred in 1982 in a pediatrician's office in Muskegon, Mich. Three children, who had arrived at the office 60 to 75 minutes after a child with measles had departed, developed measles. Using a model based on airborne transmission, it is estimated that the index patient was producing 144 units of infection (quanta) per minute while in the office. Characteristics such as coughing, increased warm air recirculation, and low relative humidity may have increased the likelihood of transmission. Adequate immunization of all patients and staff, respiratory isolation and prompt care of all suspected cases, and adequate fresh-air ventilation should decrease the risk of airborne transmission of measles in this setting. Airborne transmission may occur more often than previously suspected, a possibility that should be considered when evaluating current measles control strategies.

Measles virus can survive for 2 hours in the air and remain infectious

Remington PL, et al. 1985;253:1574

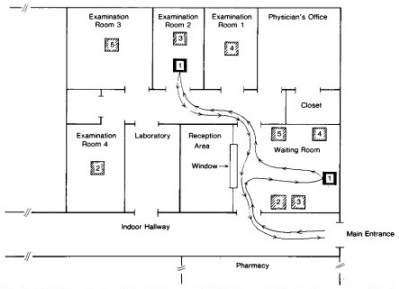

Fig 1.—Pediatric outpatient clinic, Muskegon, Mich. Solid square indicates index case; slashed squares, secondary cases.

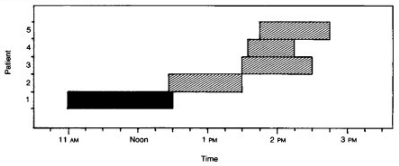

Fig 2.—Duration of pediatrician's office visit by index (solid bar) and secondary (slashed bars) measles cases.

Secondary Attack Rates by Age, Vaccination Status, and Time of Arrival in Pediatrician's Office, Michigan, 1982

Time in Office	Attack Rate, No. (%)			
	Age <15 mo and Unvaccinated	Ages 15 mo-18 yr		Age >18 yr
		Unvaccinated	Vaccinated	
Present *with* index patient (n=24)	0/3 (0)*	1/1 (100)	0/9 (0)	0/11 (0)
Arrived <90 min *after* index patient left (n=32)	2/7 (29)	1/1 (100)	0/8 (0)	0/16 (0)
Arrived ≥90 min *after* index patient left (n=28)	0/5 (0)	0/2 (0)	0/10 (0)	0/11 (0)

*Two of these three patients received immune human serum globulin eight days after exposure.

MEASLES: AIRBORNE PREVENTION AND SURFACE DISINFECTION

Prevention of airborne spread: UV-lights in classrooms

- NY, 510 cases of measles (2,368 students). Attack rates among the bus-riding and non-bus-riding susceptibles in unirradiated classrooms was essentially the same, 83% and 77% respectively. Attack rate of 90% bus-riding susceptibles of the same grades in irradiated classrooms was significantly greater than that of 69% among the irradiated non-bus riders.*
- NY, 1946: Cluster RCT (school in 1 village equipped with UV; another was the control). The Westchester Study has presented a contrast, not of spread of infection within two villages, one irradiated and one not, but of one village, Pleasantville, protected from dynamic spread within by irradiation of shared atmospheres but subject to bombardment of infection from surrounding villages with subthreshold ventilation, and another village.**
- However, multiple outbreaks of measles during flying suggest improved air handling not sufficient to prevent outbreaks.# 1946-2012, 9 reports, 13 index cases, 23 2nd cases, 10 flights, separation = same row to 17 rows (median, 6 rows) {Edelson}. Current outbreak in Denver.

Susceptibility to disinfectants

- Povidone iodine: Concentration = 0.1%, 0.5%, 10%; 99.90% inactivation in 0.5min^
- Povidone iodine: Concentration = 0.1%; Undetectable virus within 0.5min^^
- CHG: Concentration = 0.05%; Undetectable virus within 1min^^
- Benzalkonium chloride: 0.01%; <3-$\log_{10}$
- Presumed susceptibility to alcohol but no actual studies in literature

*Perkins JE, et al. Am J Public Nations Health 1947;37:529; **Wells MW, Holla WA. JAMA 1050;142:1337;#FR de Barros, et al. J Clin Virol 2006;36:235, Lim LL, et al. AJIC 2016;44:958, Edelson PJ. Travel Med Infect Dis 2012;10:230. ^Sauerbrei A. Microbiology Open 2020;9:e1097; ^^Kawana R, et al. Dermatology 1997;195 Suppl 2:29

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DEMONSTRATION PRESUMPTIVE MEASLES IMMUNITY

- Presumptive proof of immunity (written documentation required)
  - Birth before 1957
  - 2 doses of MMR (1st dose, 12-15 months; 2nd dose, 4-6 years of age but can be provided >28 days after dose 1) – children can also receive MMRV (licensed for children 12 months to 12 years of age)
  - Clinical disease diagnosed by a healthcare provider with lab confirmation
  - Positive serology (demonstration of immunity via receipt of 2 MMR doses preferred over serology)
- 2 doses of MMR 97% effective: However, if infected, likely to have a milder illness and reduced likelihood of transmission
- Adults who do not have presumptive evidence of immunity should get at least one dose of MMR vaccine. Adults at higher risk of exposure should receive 2 doses (separated by at least 28 days): Healthcare personnel, international travelers, and students at post-high school education institutions.
- Contraindications: Pregnancy, immunosuppression, active TB, recent receipt of blood products, live vaccine within past 4 weeks, moderately or severely ill, life--threatening allergies following a dose of MMR

https://www.cdc.gov/vaccines/vpd/mmr/public/index.html

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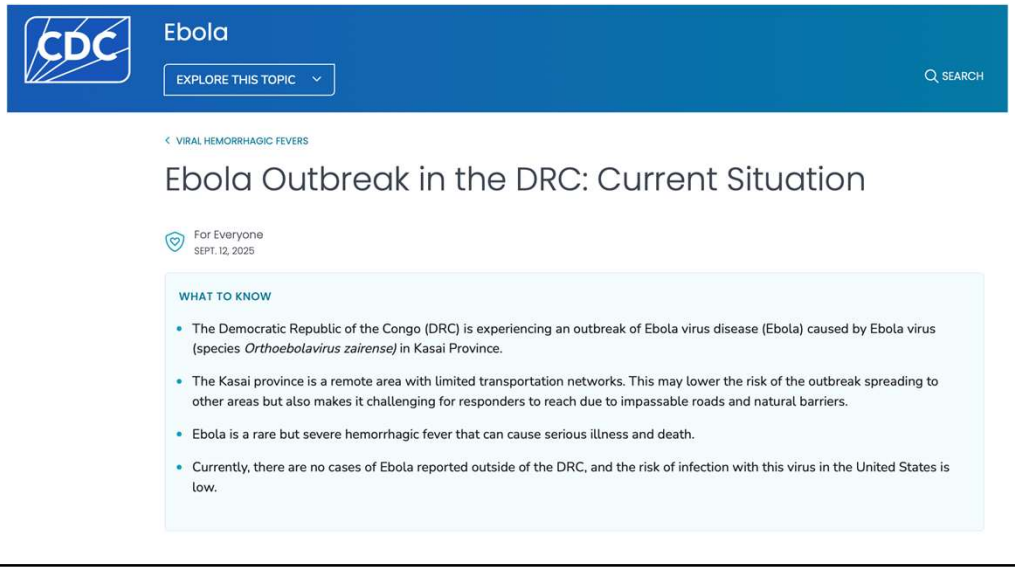
Ebola



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The Evolution and Future of Influenza Pandemic Preparedness

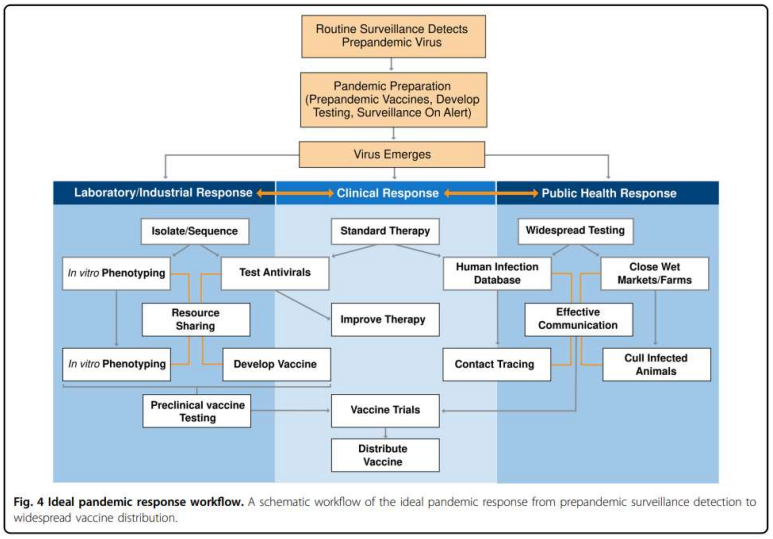

Fig. 4 Ideal pandemic response workflow. A schematic workflow of the ideal pandemic response from prepandemic surveillance detection to widespread vaccine distribution.

Harrington WN, et
Experiment & Molec
Med 2021;53:737

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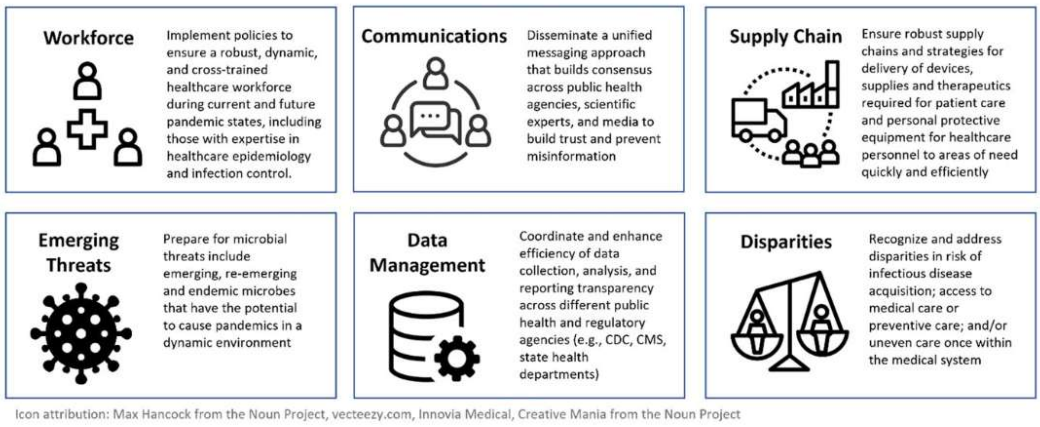
PANDEMIC PLANNING: SHEA RECOMMENDATIONS



Icon attribution: Max Hancock from the Noun Project, vecteezy.com, Innovia Medical, Creative Mania from the Noun Project

Figure 1. Topics selected by the SHEA Pandemic Preparedness workgroup for policymakers.

Hsu VP, et al. ICHE 2024:1-3

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THE COVID-19 PANDEMIC: LOOKING BACK AND LOOKING FORWARD, US RESPONSE

Missteps and Misinformation in US Pandemic Response

- Lack of a centralized, coordinated Federal response
- Executive Branch consistently minimized and trivialized risk of COVID-19
- US Public Health infrastructure woefully inadequate
- Slow development and scale-up of rapid, accurate, and widely available testing
- Inaccurate initial assumptions about transmission: Failure to focus on aerosol transmission; failure to recognize the importance of asymptomatic and pre-symptomatic spread
- Inadequate stockpiles of PPE and failure to rapidly ramp up production
- Initial failure to recommend masking by the public as a mitigation strategy
- Failure to initially focus on transmission in nursing homes

Major Remaining Pandemic Concerns

- Science denialism
- Politicization of pandemic response
- Vaccine hesitancy and resistance
- Vaccinations for children
- Evolution and spread of more highly transmissible and/or virulent variants
- Post-COVID-19 clinical issues
- Lack of public support for public health interventions (e.g., mask mandates) if /when another wave or new agent arrives
- Need for recurring boosters
- Unanticipated challenges
- Pandemic fatigue

Henderson D, Haessler S, Weber DJ. ICHE 2021;2 August

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CURRENT CHALLENGES IN PANDEMIC PREPAREDNESS

Public skepticism: Impact on public health

- Science denialist
- Vaccine hesitancy and misinformation
- Desire to "punish" public health agencies for disruption, economic loss and deaths resulting from COVID-19
- Loss of public health personnel

Governmental actions: States

- Pending state laws outlawing mandatory immunizations
- Pending state laws outlawing mRNA vaccines

Governmental actions: Federal

- Withdrawal from World Health Organization: CDC contact prohibited
- ~20% decrease in HHS workforce including FDA, CDC, and NIH
- Likely ~40% decrease in CDC funding
- Elimination of entire departments within HHS
- Removal of key senior personnel
- Vaccine denialism and misinformation (e.g., MMR causes autism)
- Recommendations for non-evidence-based interventions (e.g., cod liver oil to prevent measles)
- Elimination and reduction in infectious disease research grants
- Substantial reduction in funds for public health
- Federal withholding of research funding for selected universities
- Elimination of offices/agencies responsible for pandemic preparedness planning

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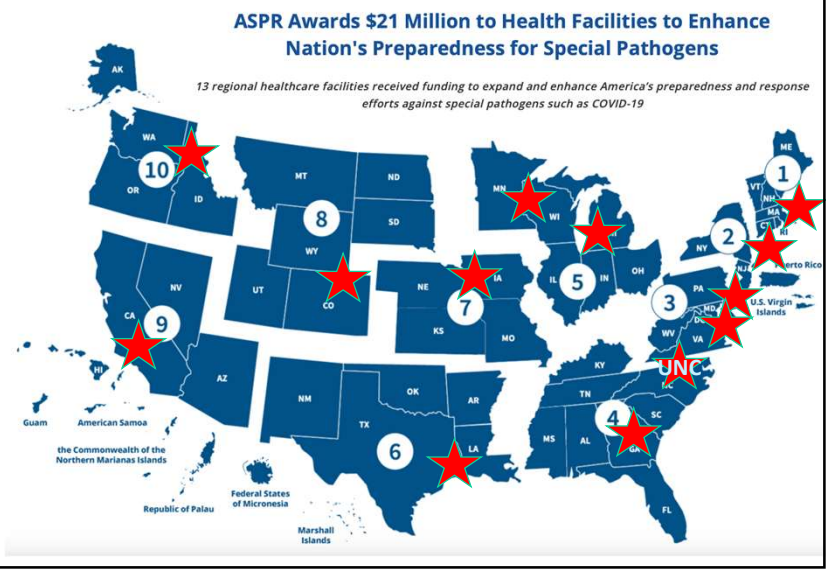
UNC Regional Emerging Special Pathogen Treatment Center (RESPTC) – SPECIAL PATHOGENS RESPONSE CENTER (SPARC)

- Hospitals with enhanced capability and capacity to care for highly infectious diseases
- Maintain a skilled and trained staff
- Improve regional healthcare system preparedness for emerging special pathogens
- Act as regional hubs for the National Special Pathogen System
- Build emerging special pathogen <u>research</u> capacity



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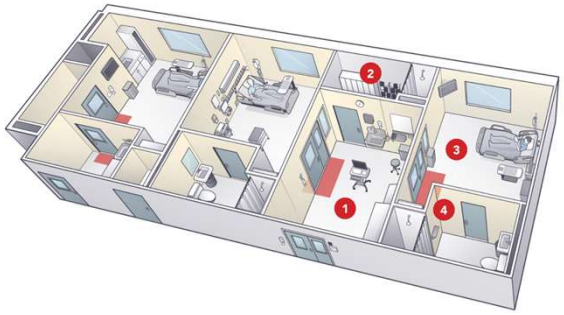
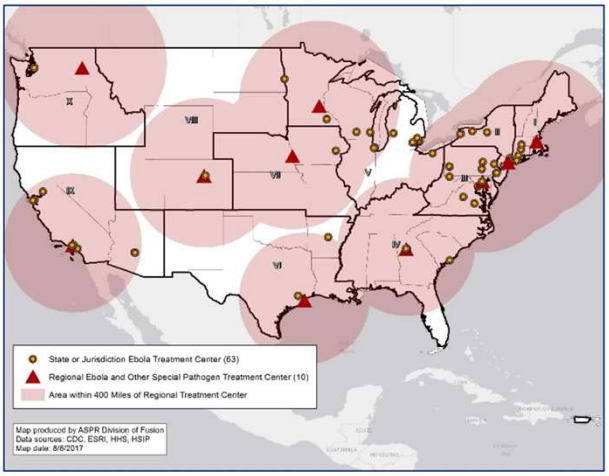
Limited U.S. Special Pathogen Treatment Capacity

Regional Emerging Special Pathogen Treatment Network

- National Ebola Training and Education Center
- 10 Regional Emerging Treatment Centers
- Assessment Centers





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UNC SPARC – Trainings and Exercises

Three level training

1. **Personal Protective Equipment**
2. **Clinical Skills in PPE**
   - **UNC Simulation Center**
   - **Mobile Lab**
   - **CAC training in Tri-Care Simulation Center**
3. **Full simulation exercise**

Annual Training

- **3 half-day sessions**
- **1 full day simulation**

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CONCLUSIONS

- Expect outbreaks, including of pathogens you skipped over in medical school
- Keep informed about what is happening
- Get vaccinated
- Be aware: UNC SPARC available for care of patients with special pathogens.

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