Passenger and Flight Crew Behaviors and Movements: Contributions to Respiratory-Disease Transmission on Transcontinental Airplane Flights

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Disclosures

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Outline

- **Modes of transmission of upper respiratory infectious diseases in transportation**
- **Documented instances of upper respiratory infectious disease transmission in air travel**
- **FlyHealthy Study**
  - **Behaviors and movements: risk of becoming infected**
  - **Airplane cabin microbiome**
- **Knowns**
  - **Findings**
  - **Known unknowns**

Modes of transmission of disease

- **Large droplets**
- **Aerosols**
- **Fomites**

Photo courtesy of CDC/Brian Judd

Modes of transmission: large droplets

- **Definitions vary, some say > 5 μm, others say > 60 μm in diameter**
- **Droplets contain**
  - **Cells (epithelial cells that line the airways; immune cells)**
  - **Physiological electrolytes such as those in mucus and saliva (e.g., K+, Na+, Cl-)**
  - **Infectious agents (e.g., bacteria, fungi, viruses)**

Modes of transmission: large droplets

- **Quickly fall to the ground (within ~ 1m) (gravity – it's more than a theory, it's a law)**
- **Expelled from mouth and nose by multiple modes**
  - **Sneezing**
  - **Coughing**
  - **Talking**
  - **Breathing**
  - **Singing**

Modes of transmission: aerosols

- **Smaller than a large droplet**
- **Generated in the same manner as large droplets**
- **Same content as large droplets**
- **Can remain suspended in air for long periods of time, and therefore**
- **Can travel distances > 1m**

Modes of transmission: fomites

- **Droplets and aerosols can become deposited on surfaces**
- **The microbes present can survive for hours or days, depending on the microbe, the environment, and the type of surface**
- **Indirect transmission from person to person**
- **Doorknob example**

Transmission of infectious diseases on airlines

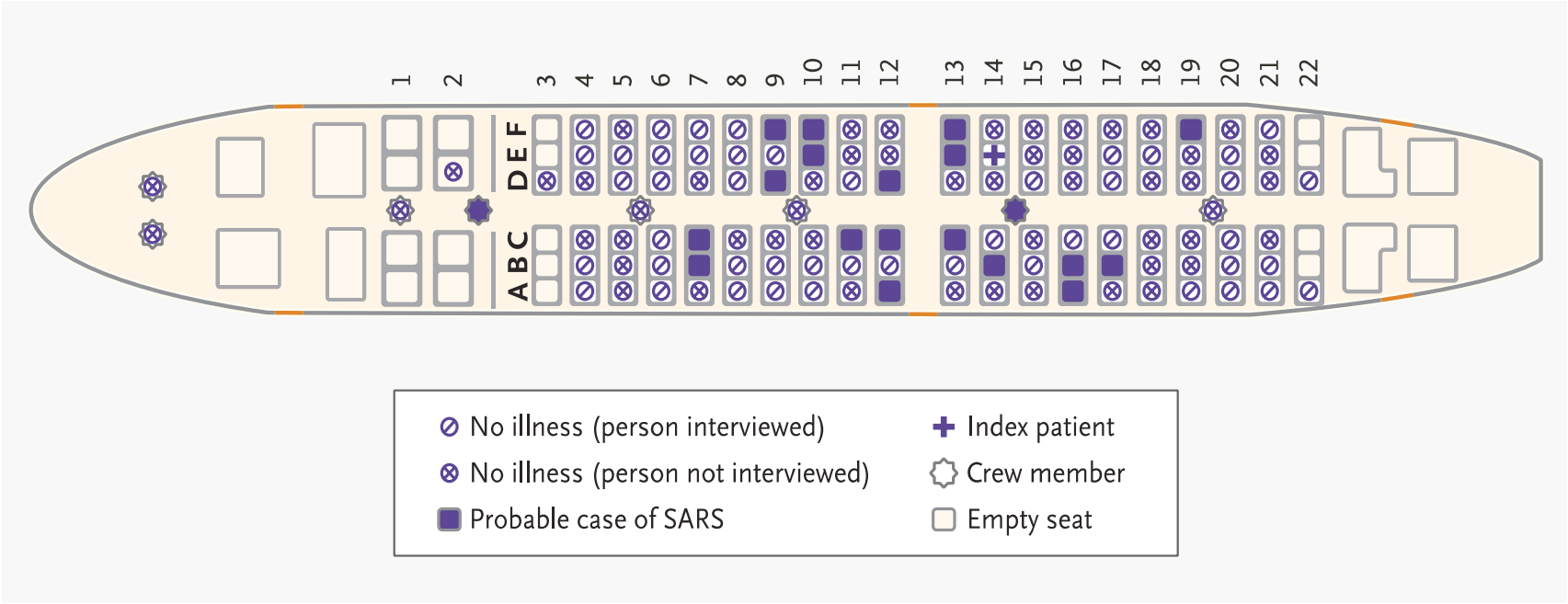
There were an estimated 4.5e9 flights taken in 2019. Spread of disease by air travel is a significant global health concern.

Documented cases of diseases transmitted on airplanes:

- **TB (4 reports)**
- **Measles (2 reports)**
- **Influenza (5 reports, including H1N1p)**
- **SARS (2 reports)**
- **Meningococcal infection**
- **Norovirus (3 reports)**
- **Cholera**
- **Shigellosis**

*****COVID-19*****

SARS transmission on CA 221 from HKG-PEK



Olsen, Sonja J., et al. "Transmission of the severe acute respiratory syndrome on aircraft." *New England Journal of Medicine* 349.25 (2003): 2416-2422.

Fly Healthy Study Goals

1)Characterize the airplane cabin microbiome

2)Quantify transmission opportunities

3)Create seat map of risk of transmission of ID from infected individual

FlyHealthy Research Study

- Flew a team of graduate students and postdocs between Atlanta and the West Coast
  - 5 round trips = 10 flights
  - 4 round trips = 8 flights during “flu season”
- Recorded behaviors and movements of passengers and flight attendants while above 10,000 feet – reconstructed all movements
- Took environmental samples (air, touch surfaces) before and after each flight – airplane cabin microbiome

FlyHealthy Research Study: Results of Environmental Sampling

1. **Bacterial communities were largely derived from human skin and oral commensals, as well as environmental generalists**

2. **Identified “core” airplane cabin microbiome**

3. **Very large flight-to-flight variations and no systematic pattern of change from pre- to post-flight**

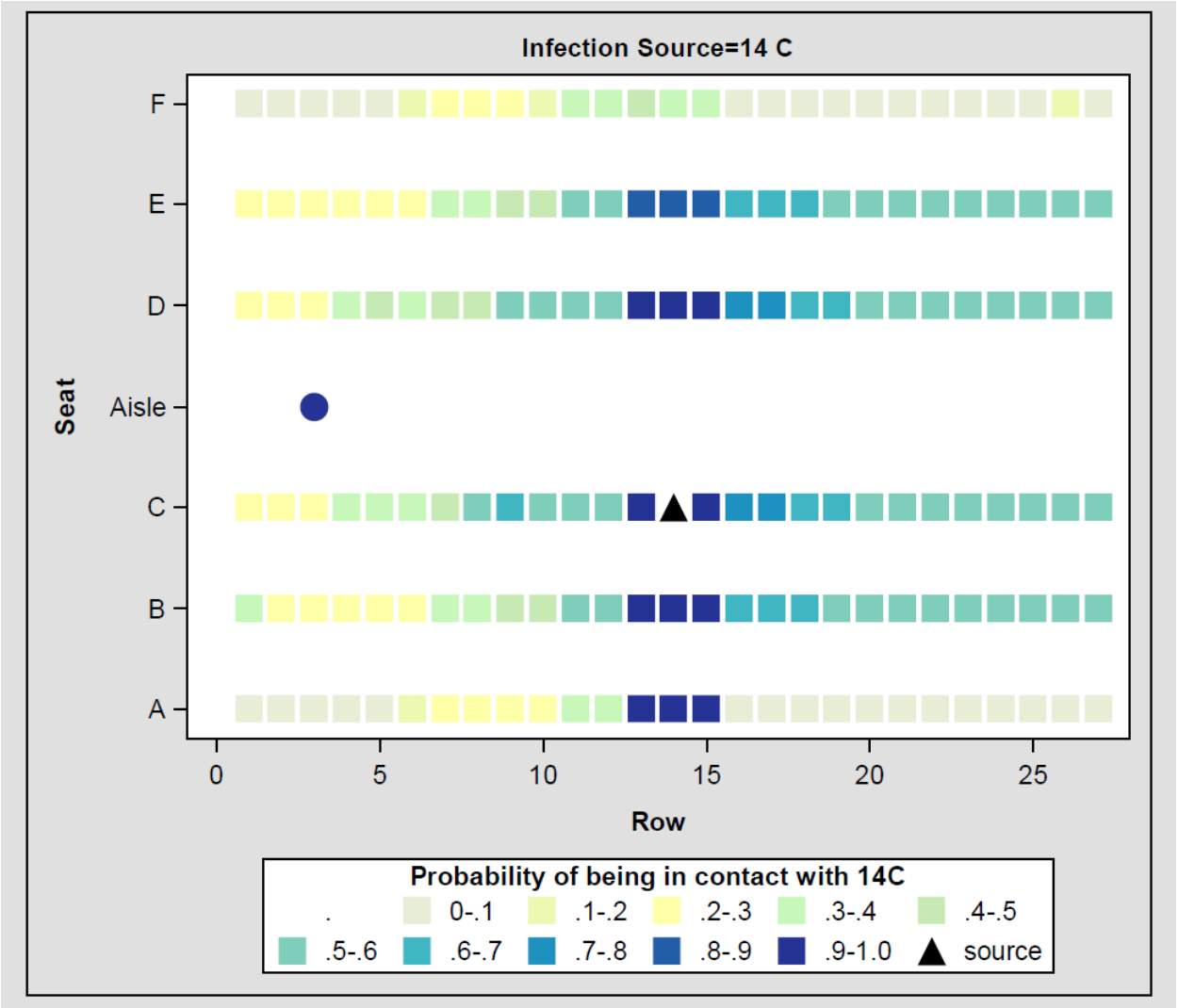
4. **Although different primers and sequencing techniques were used, the core microbiome from Boston subway system study has significant overlap with airplane cabins**

FlyHealthy Research Study: Results of Analysis of Behaviors and Movements

Using networks of close proximity contacts from 10 flights, generate many hundreds of thousands of 4 hour “fantasy flights”

Probability of transmission: 0.018 (2x0.009) for one minute of close contact

Moser MR*, et al.* (1979) Outbreak of influenza aboard a commercial airliner. *American Journal of Epidemiology* 110(1):1-6.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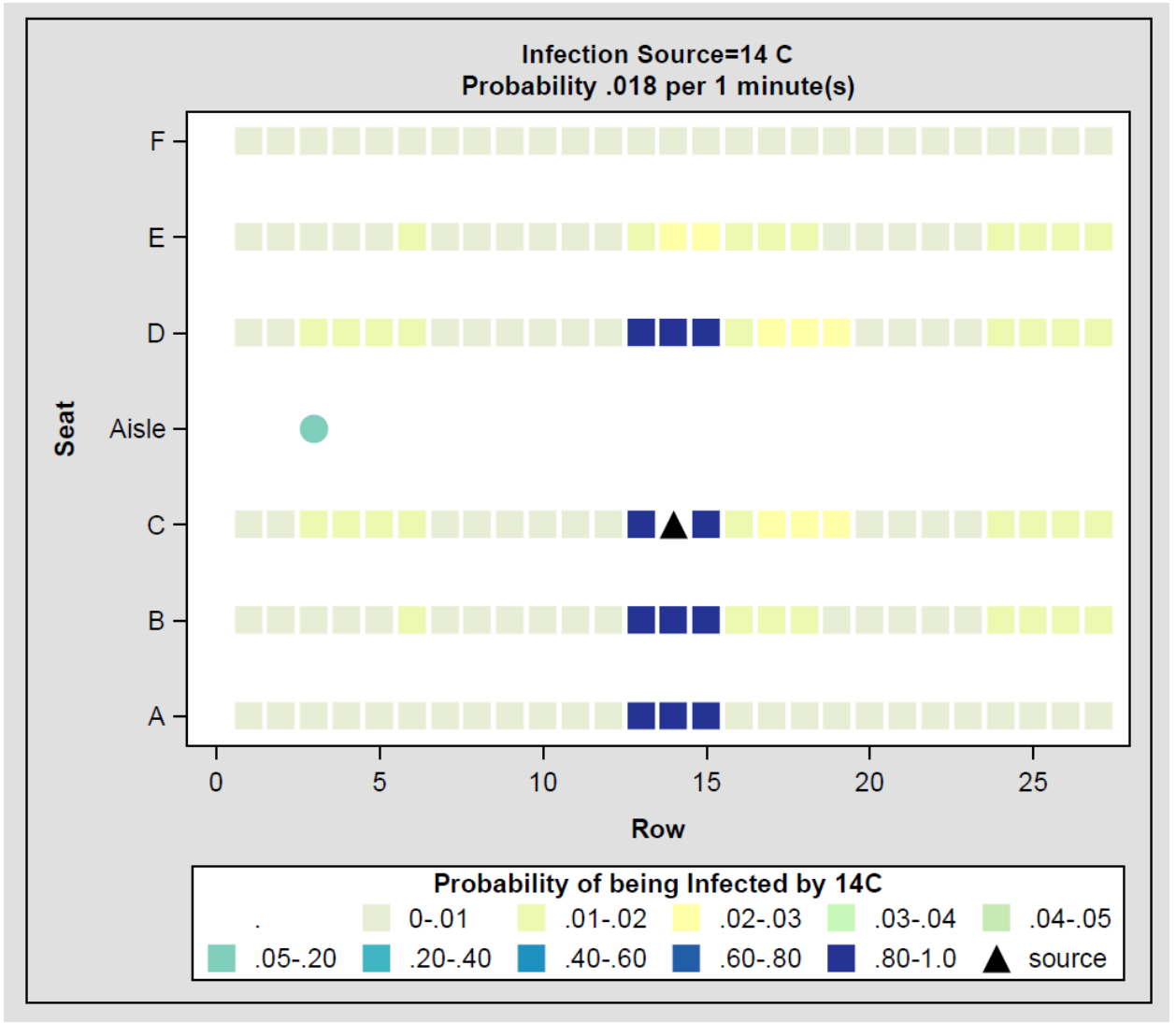
F
E
D
Aisle
C
B
A
Seat
0
5
10
15
20
25
Row
Probability of being in contact with 14C
.
0-.1
.1-.2
.2-.3
.3-.4
.4-.5
.5-.6
.6-.7
.7-.8
.8-.9
.9-1.0
source


Infection Source=14 C
Probability .018 per 1 minute(s)
Seat
F
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Aisle
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5
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20
25
Row
Probability of being Infected by 14C
.
0-.01
.01-.02
.02-.03
.03-.04
.04-.05
.05-.20
.20-.40
.40-.60
.60-.80
.80-1.0
source

The FlyHealthy Study

What we know

Without masking and without movement restrictions:

- **Lots of movement**
- **Core microbiome consisting of commensals and mutualists**
- **At least one person infected beyond those seated immediately around the index case.**

What we don’t know

Results applicable only to flights on single aisle planes of about 5-6 hours duration

- **Long haul flights**
- **Double aisle planes**
- **Contributions of aerosol exposures**
- **Contributions of fomites**
- **Identification of infection source**

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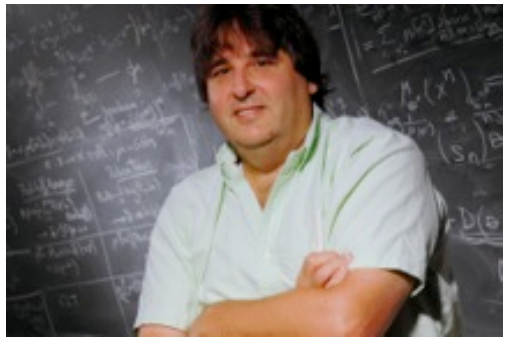

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FlyHealthy Research Team