Globalization of Emerging Pathogens

Anticipating and Responding to Epidemics of International Concern

Kamran Khan MD, MPH, FRCPC

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Division of Infectious Diseases
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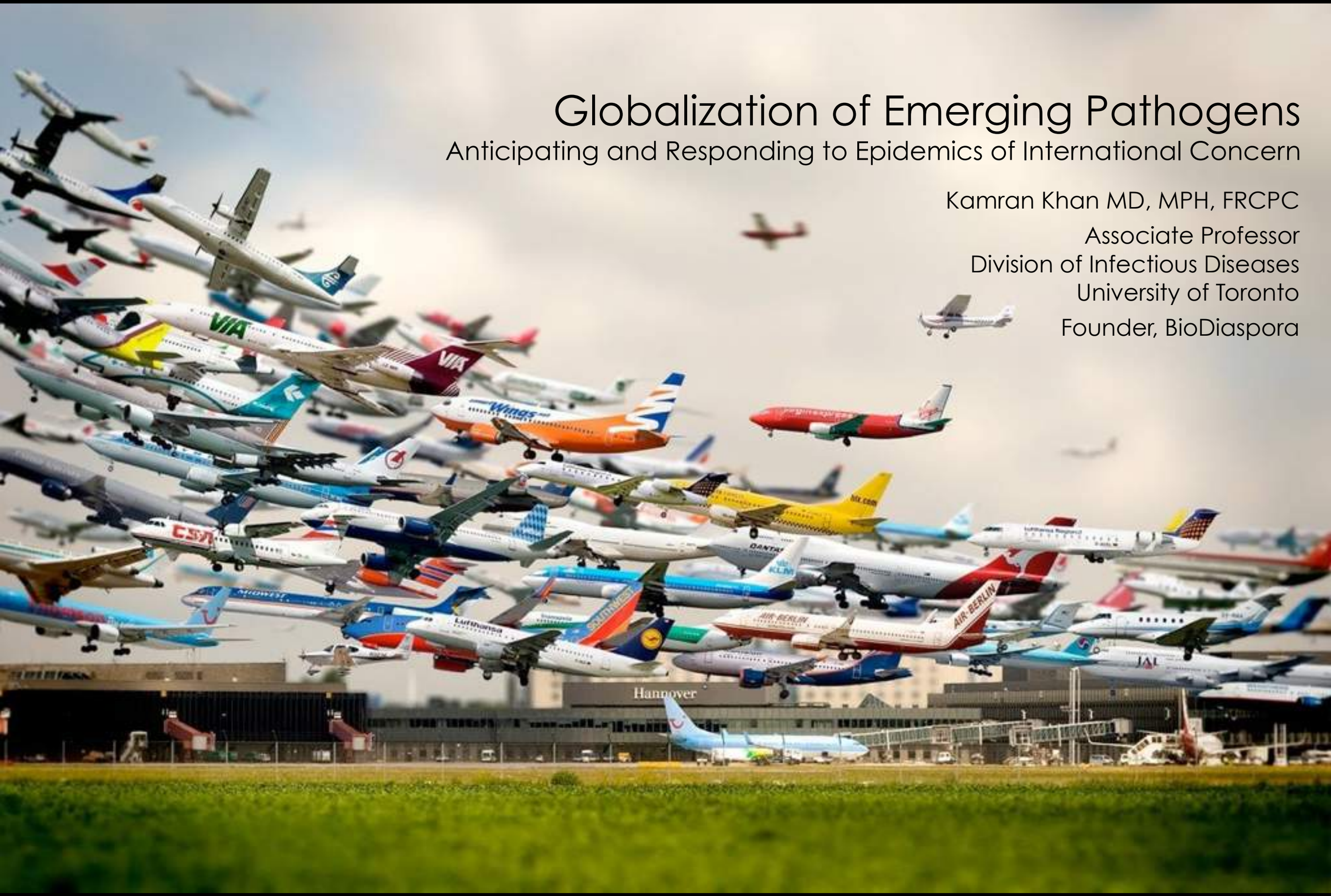


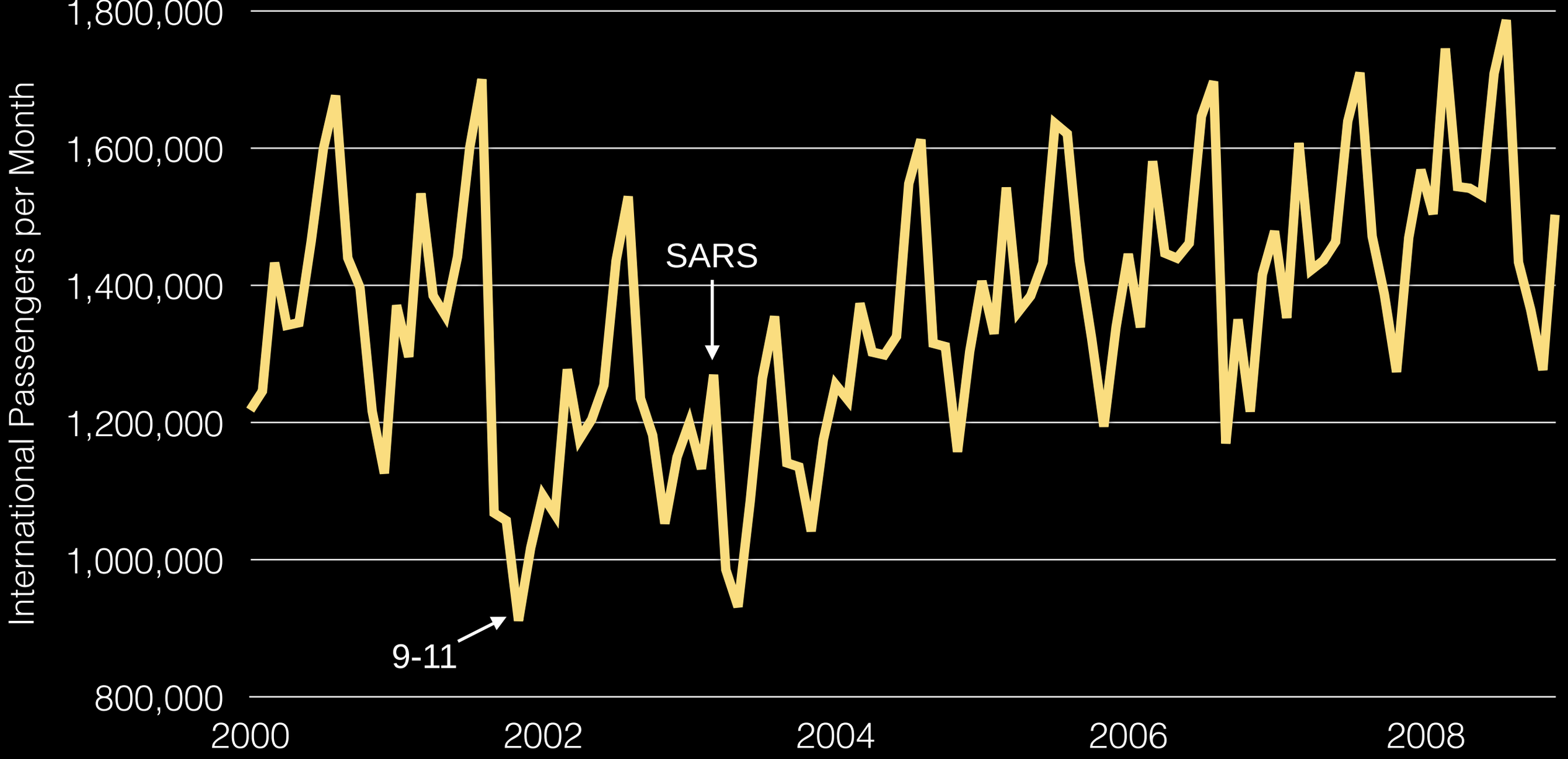
1999


RS CLINIC PATIENTS
ASE USE ENTRANCE DOOR TO LEFT
except
• Expectant fathers/partners
• Mothers & Fathers of High Risk Babies
All Scheduled Clinics NCELLED

2003

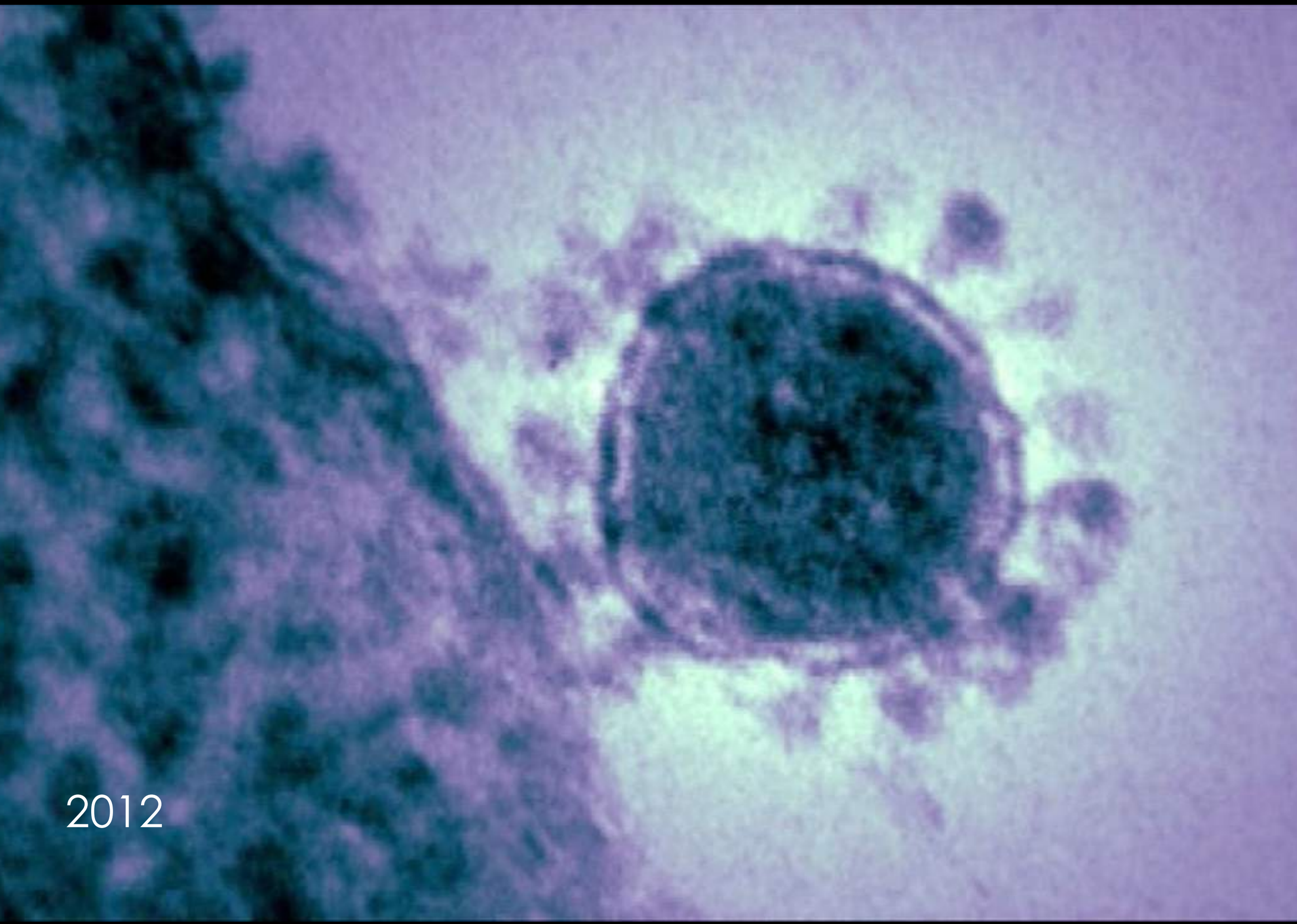
International Travel Volumes

Per Month via Toronto Pearson International Airport



2009

2010



2012

2013

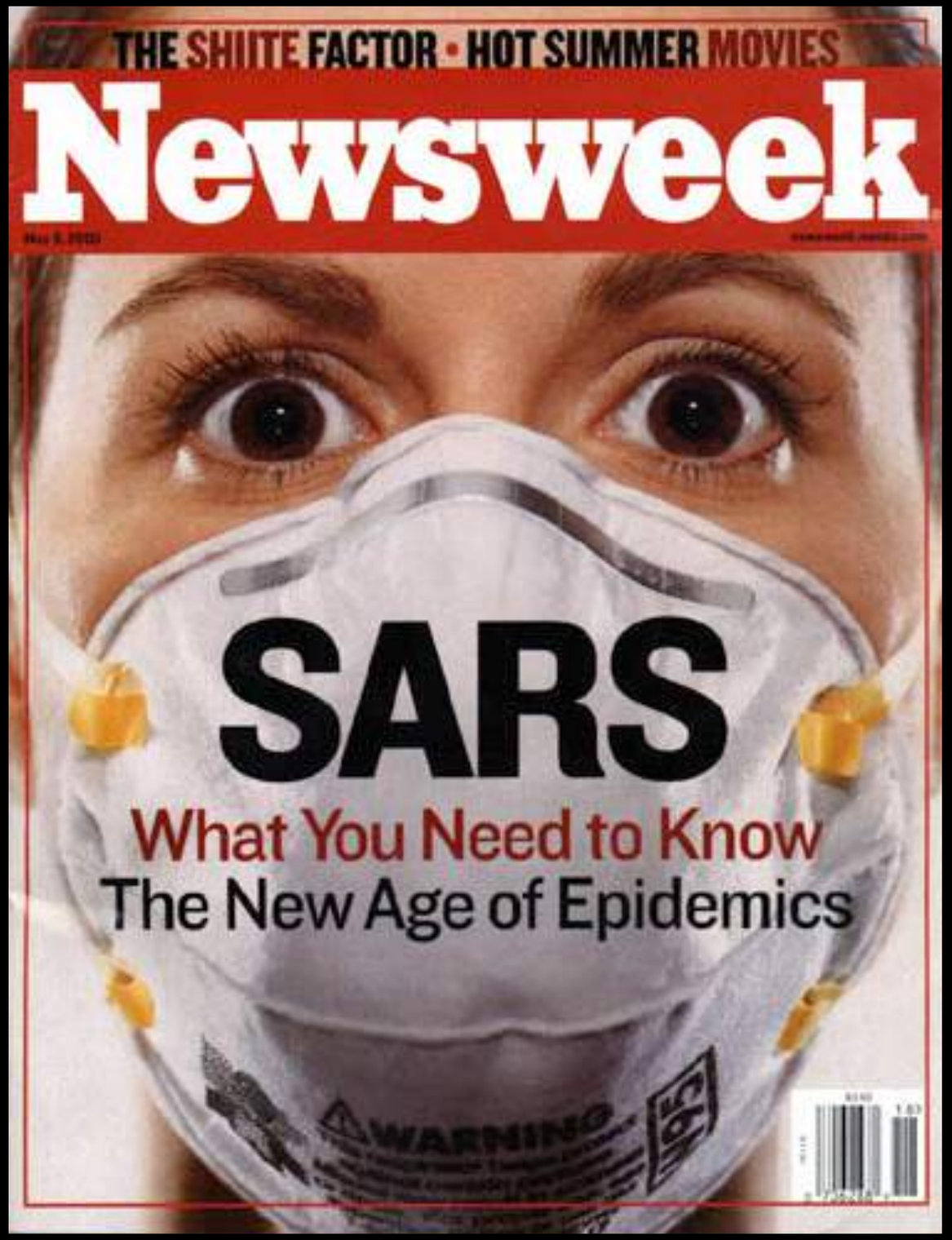
2013


STOP
NO ENTRANCE
WITHOUT PERMISSION
PE IDONY KANY
LABONGO TWE

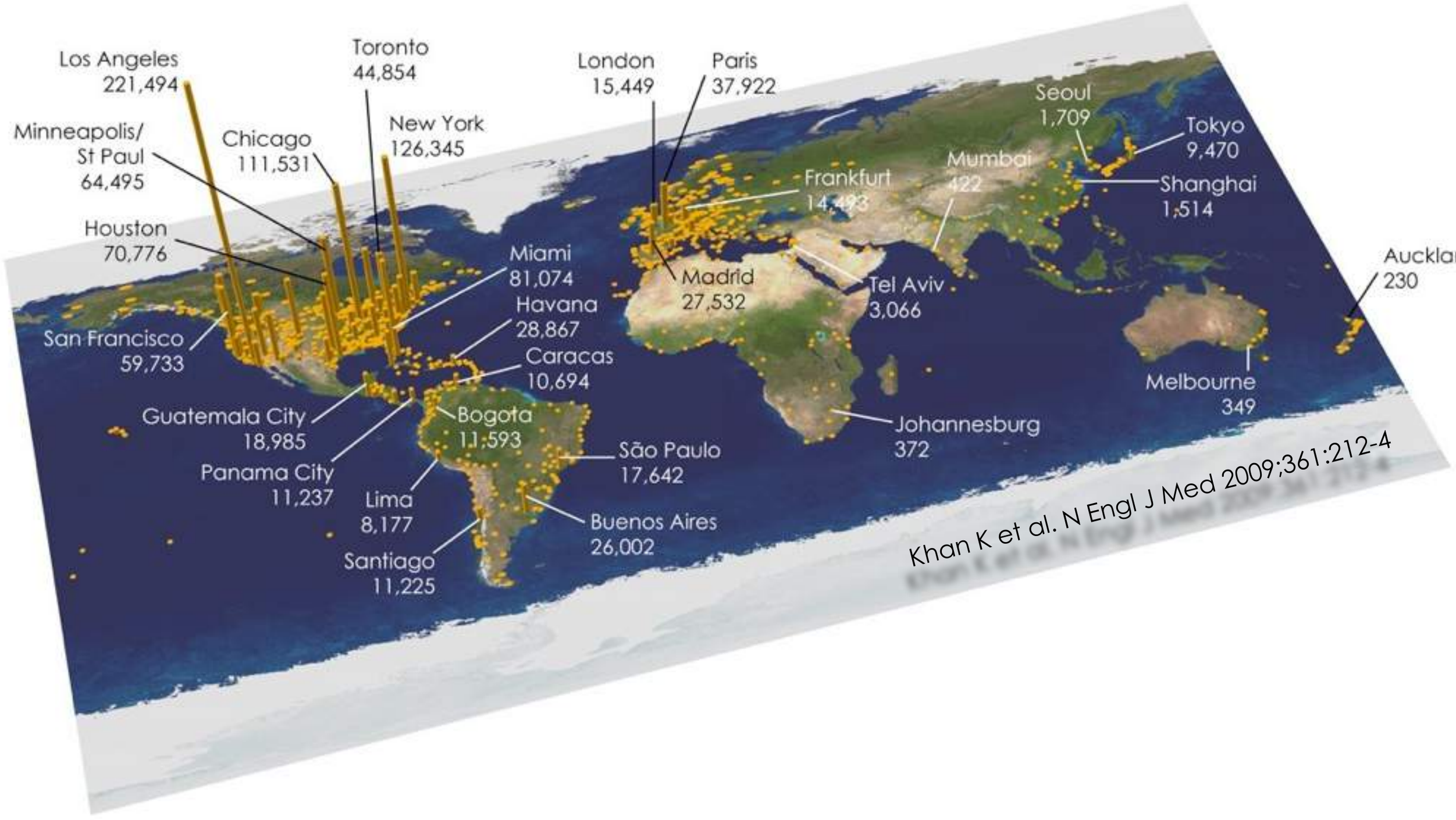
2014

Globalization

- Population growth
- Urbanization
- Animal pathogens
- Climate change
- Antimicrobial resistance
- Bioterrorism
- Mass gatherings

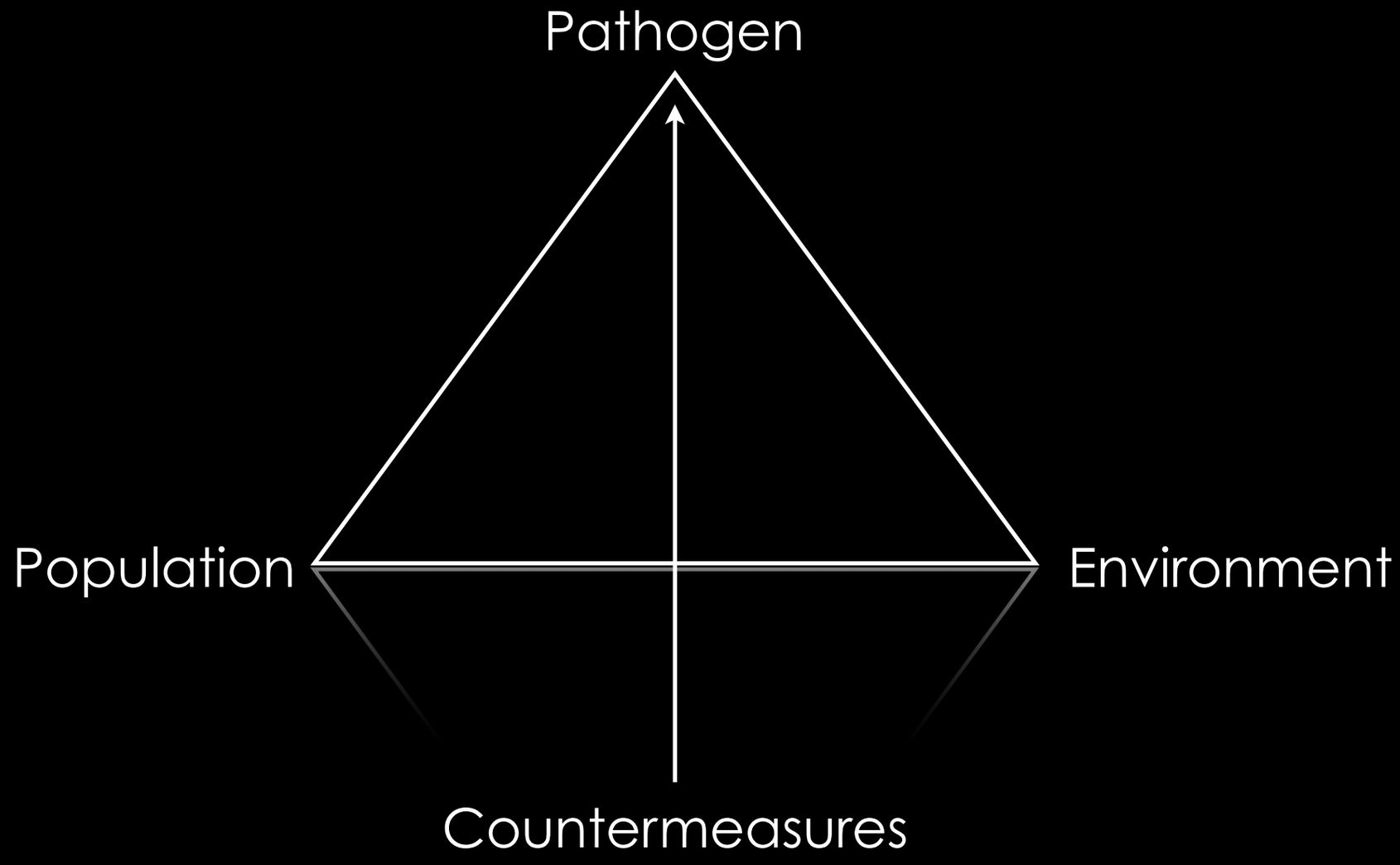


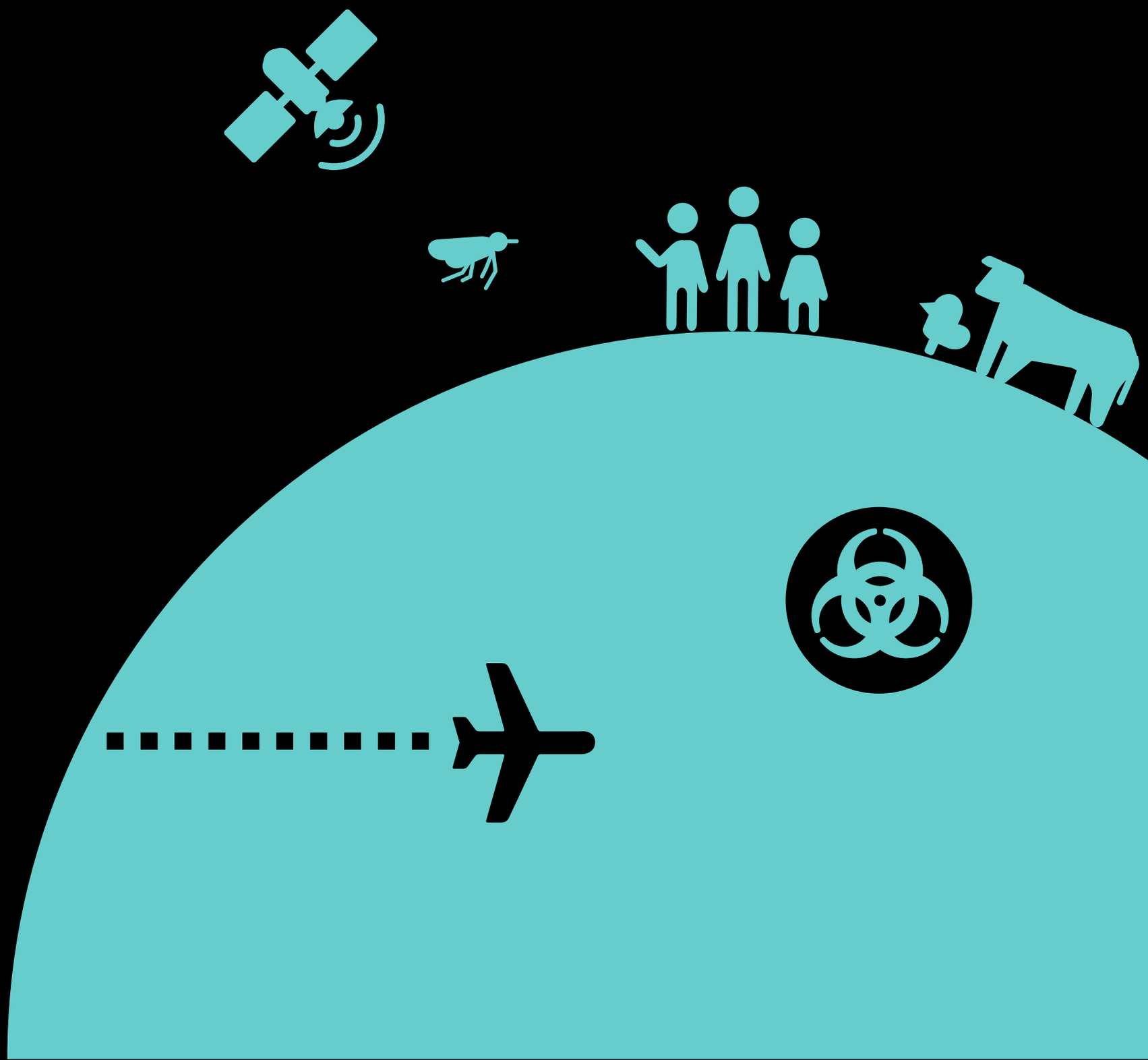
Predicting the Wave of a Pandemic



Khan K et al. N Engl J Med 2009;361:212-4

Anticipating Impact





The New York Times

"All the News That's Fit to Print" THURSDAY, JUNE 20, 2013 Reprinted With Permission

Business Day

Bits The Business of Technology

In New Tools to Combat Epidemics, the Key Is Context

By AMY O'LEARY

Not long ago, Google Flu seemed like magic — a smart, cheap way to sift digital data for the public good.

But Google Flu, which tries to track flu outbreaks faster than the government, has shown its limitations. Not only did it grossly overestimate the flu this year, but its methods did little to track new, deadly diseases that could emerge anywhere, in places as random as a mass religious gathering on the banks of the Ganges or a poultry market in Shanghai.

Now a new project called BioMosaic is building a more comprehensive picture of foreign-borne disease threats in the United States, by merging three separate data tools into a single app for guiding decisions at the time of an outbreak.

"A global event in Haiti becomes a local event in five counties in Florida and five counties in New York," Dr. Cetron said. "When you see it, you get these aha! moments of appreciation."

One of the doctors in the field who can benefit from these types of insights is Dr. Kamran Khan, an infectious disease specialist and researcher at St. Michael's Hospital in Toronto.

Dr. Khan, who said he had a "bad habit of being around emerging diseases," has worked on the front lines of the 1999 West Nile virus outbreak and the H1N1 pandemic of 2009. But the event that hit closest to home was when his own hospital was affected by a deadly outbreak of severe acute respiratory syndrome, or SARS, which hit Toronto in 2003.

That spring, the city had received an infected passenger from Hong Kong

ments and airlines to amass a database of human movement around the globe, encompassing 4,000 airports and 30 million flights a year, carrying 2.5 billion passengers.

With that information, he can better predict the likelihood of where a single case of bird flu in Asia, for instance, might eventually surface on other continents.

It is powerful data, but made even more so when placed in BioMosaic alongside a mapping tool that tracks on-the-ground disease reports. That part of the puzzle is HealthMap, which was created by a team at Boston Children's Hospital under the direction of John Brownstein, a professor at Harvard Medical School.

His staff monitors everything from Arabic news reports on cholera to a local television story about a ra-

ProMED mail

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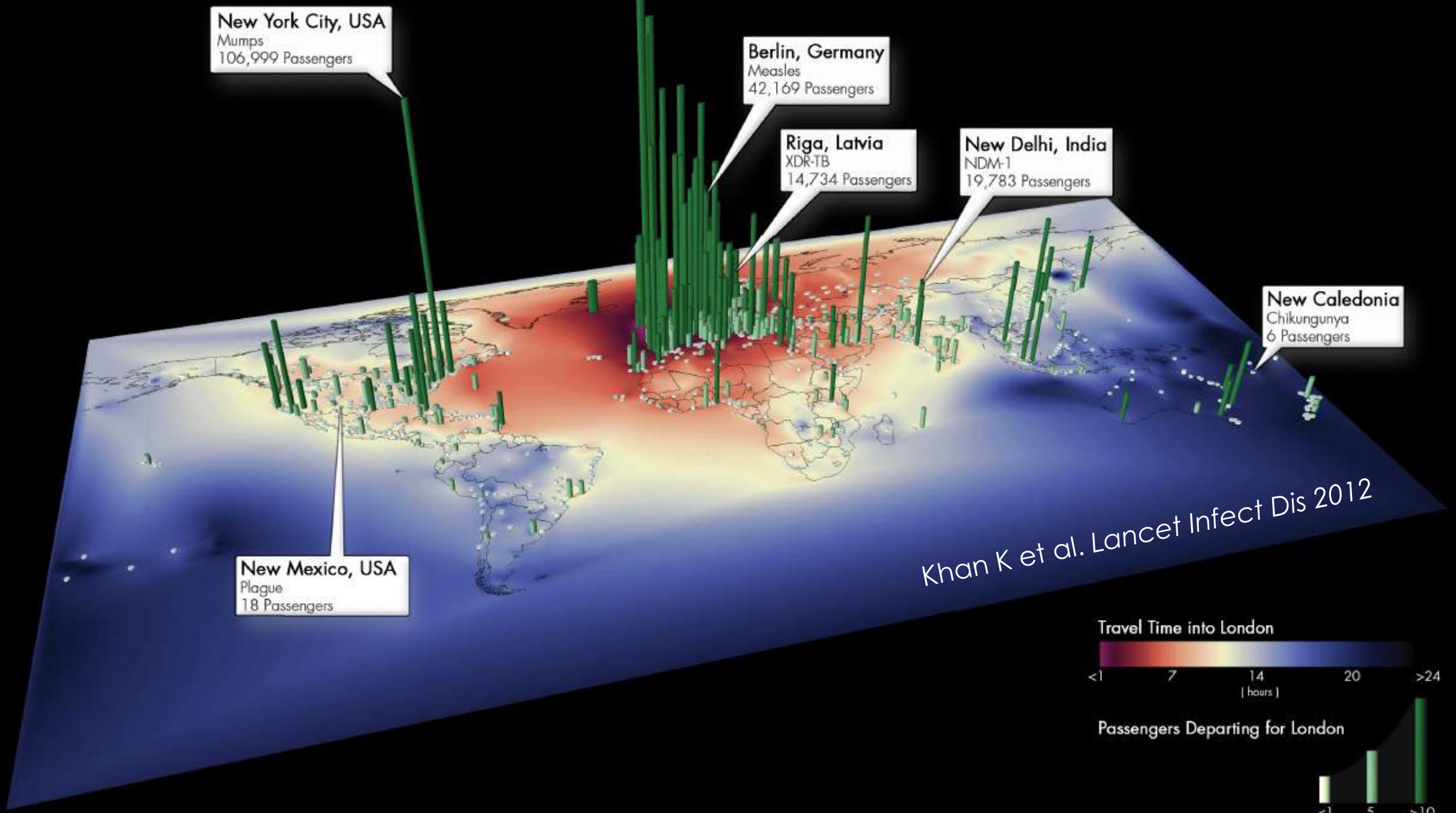
Global Public Health Intelligence Network (GPHIN)

HealthMap

Global Health, Local Information

London Olympics 2012

Integrated Global Epidemic Surveillance & Transportation Modelling



PLOS | CURRENTS OUTBREAKS

Assessing the Origin of and Potential for International Spread of Chikungunya Virus from the Caribbean

JUNE 6, 2014 · RESEARCH

AUTHORS

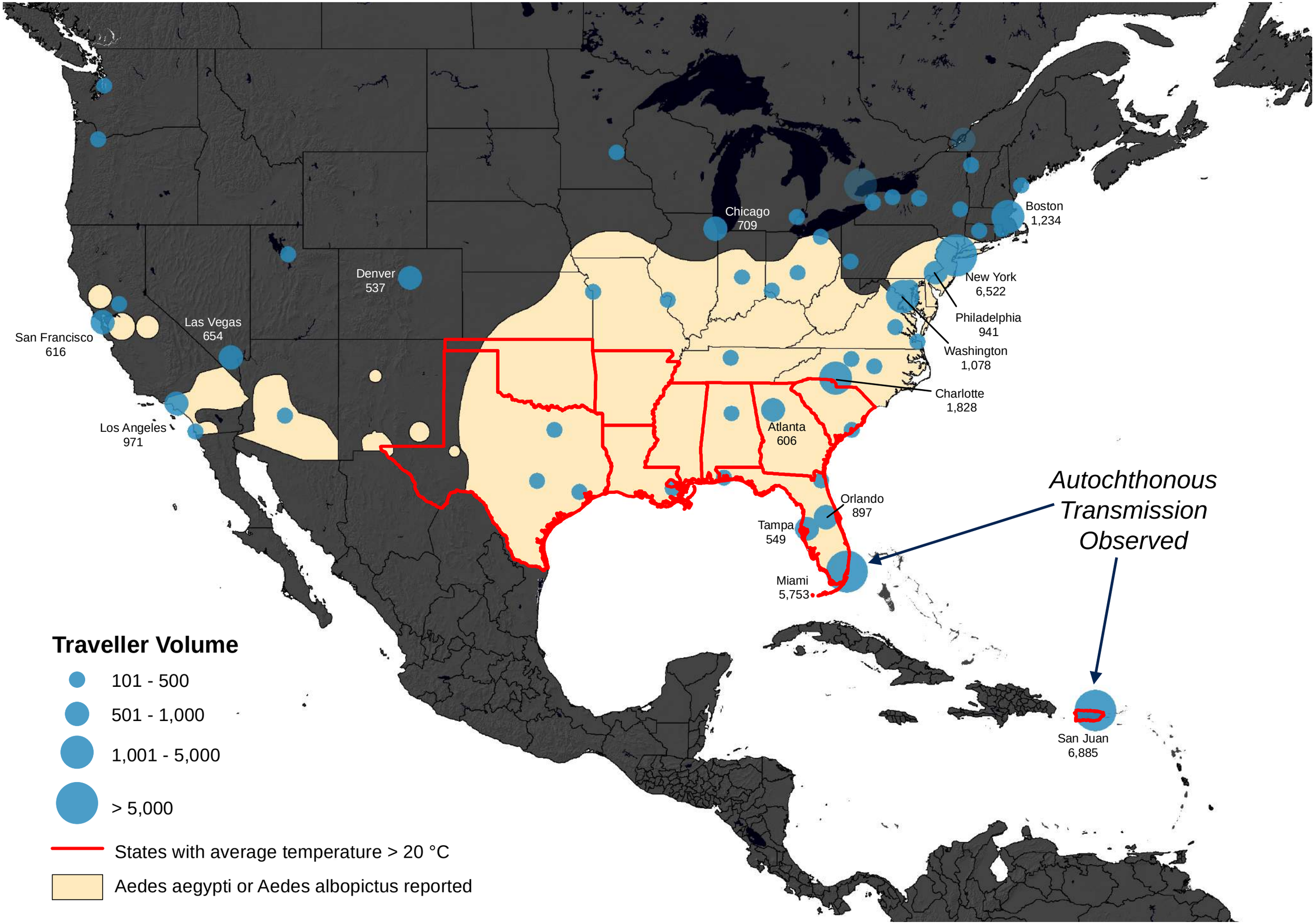
Kamran Khan Isaac Bogoch John S. Brownstein Jennifer Miniota Adrian Nicolucci Wei Hu
Elaine O. Nsoesie Martin Cetron Maria Isabella Creatore Matthew German Annelies Wilder-Smith

ABSTRACT

Background: For the first time, an outbreak of chikungunya has been reported in the Americas. Locally acquired infections have been confirmed in fourteen Caribbean countries and dependent territories, Guyana and French Guiana, in which a large number of North American travelers vacation. Should some travelers become infected with chikungunya virus, they could potentially introduce it into the United States, where there are competent Aedes mosquito vectors, with the possibility of local transmission.

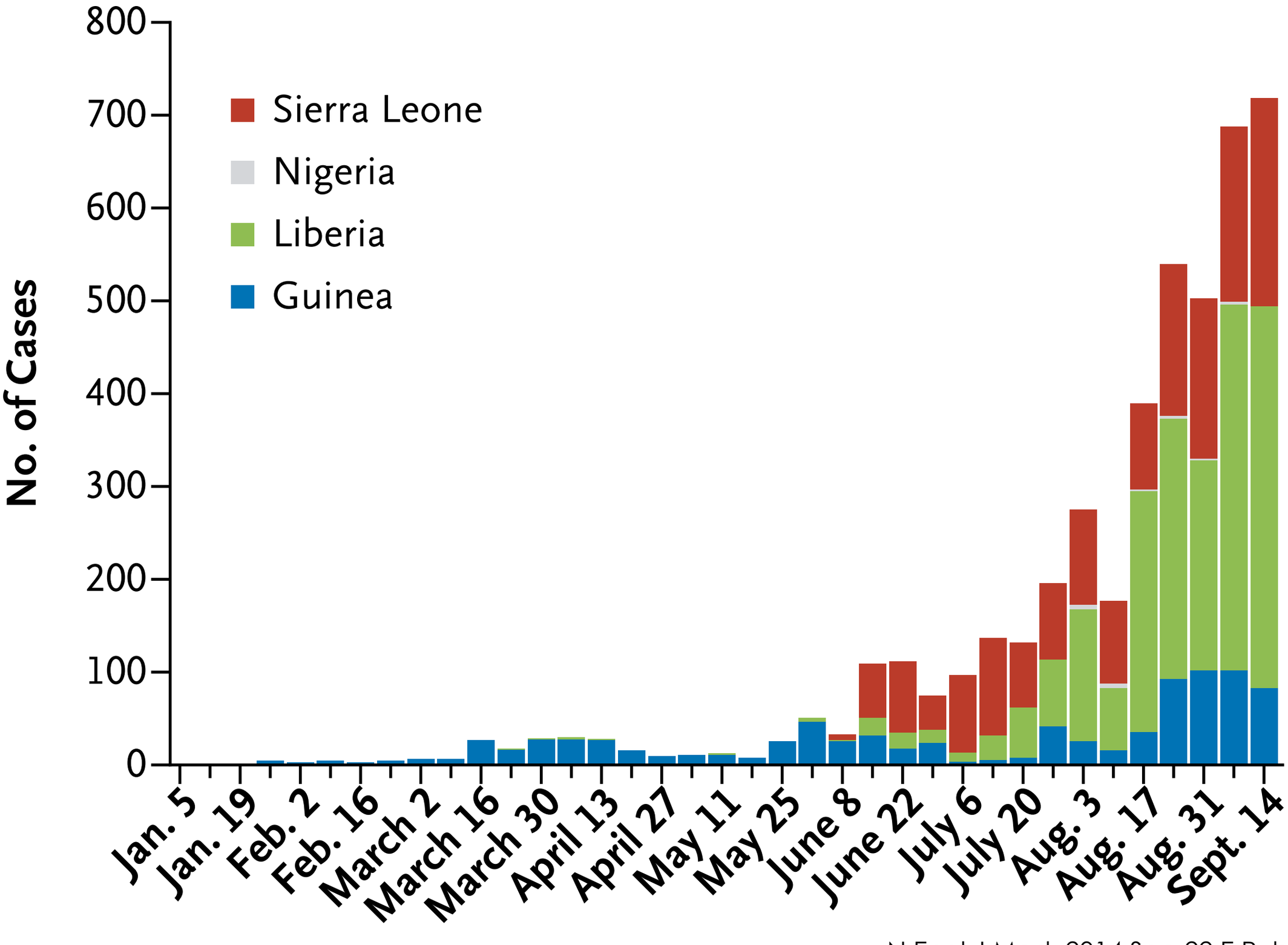
Methods: We analyzed historical data on airline travelers departing areas of the Caribbean and South America, where locally acquired cases of chikungunya have been confirmed as of May 12th, 2014. The final destinations of travelers departing these areas between May and July 2012 were determined and overlaid on maps of the reported distribution of Aedes aeygpti and albopictus mosquitoes in the United States, to identify potential areas at risk of autochthonous transmission.

Khan K et al. PLoS Currents Outbreaks; 2014 June 6



Khan K et al. PLoS Currents Outbreaks; 2014 June 6

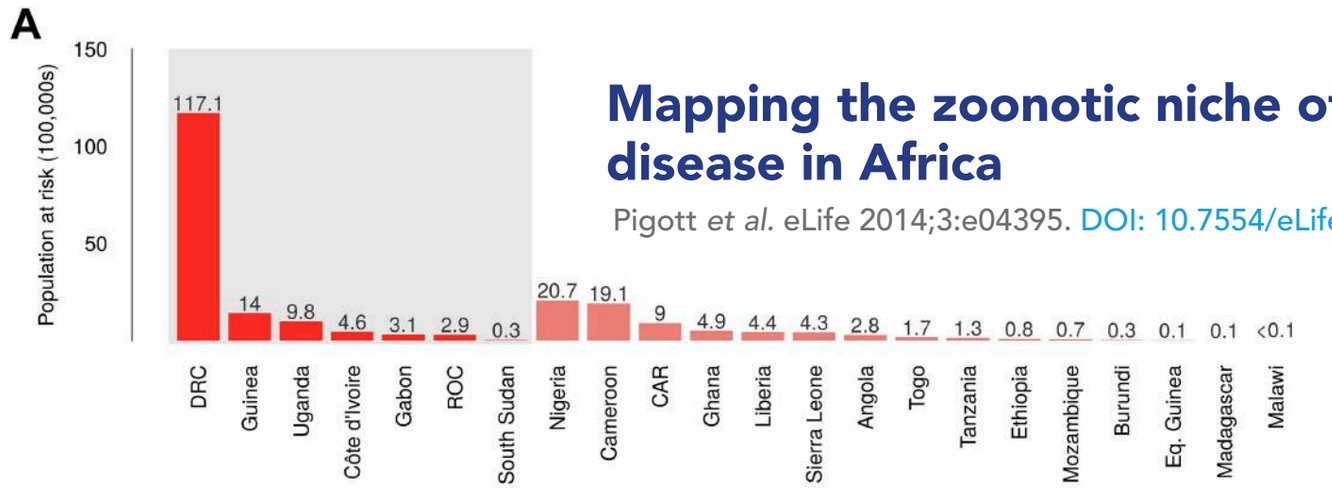
A West Africa

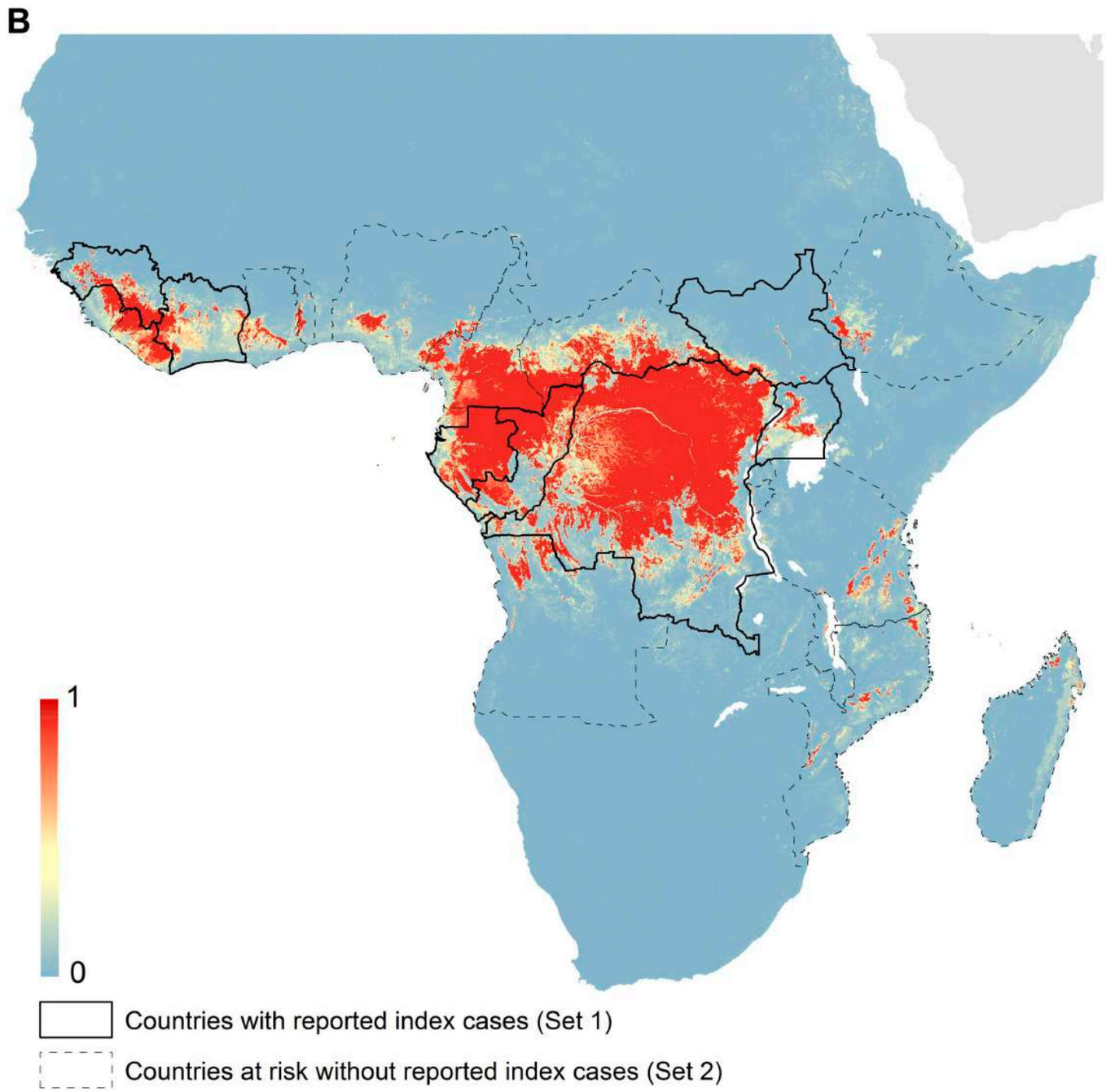


N Engl J Med. 2014 Sep 22 E Pub

Mapping the zoonotic niche of Ebola virus disease in Africa

Pigott *et al.* eLife 2014;3:e04395. DOI: 10.7554/eLife.04395





Assessment of the potential for international dissemination of Ebola virus via commercial air travel during the 2014 west African outbreak

Isaac I Bogoch, Maria I Creatore, Martin S Cetron, John S Brownstein, Nicki Pesik, Jennifer Miniota, Theresa Tam, Wei Hu, Adriano Nicolucci, Saad Ahmed, James W Yoon, Isha Berry, Simon Hay, Aranka Anema, Andrew J Tatem, Derek MacFadden, Matthew German, Kamran Khan

Summary

Background The WHO declared the 2014 west African Ebola epidemic a public health emergency of international concern in view of its potential for further international spread. Decision makers worldwide are in need of empirical data to inform and implement emergency response measures. Our aim was to assess the potential for Ebola virus to spread across international borders via commercial air travel and assess the relative efficiency of exit versus entry screening of travellers at commercial airports.

Methods We analysed International Air Transport Association data for worldwide flight schedules between Sept 1, 2014, and Dec 31, 2014, and historic traveller flight itinerary data from 2013 to describe expected global population movements via commercial air travel out of Guinea, Liberia, and Sierra Leone. Coupled with Ebola virus surveillance data, we modelled the expected number of internationally exported Ebola virus infections, the potential effect of air travel restrictions, and the efficiency of airport-based traveller screening at international ports of entry and exit. We deemed individuals initiating travel from any domestic or international airport within these three countries to have possible exposure to Ebola virus. We deemed all other travellers to have no significant risk of exposure to Ebola virus.

Findings Based on epidemic conditions and international flight restrictions to and from Guinea, Liberia, and Sierra Leone as of Sept 1, 2014 (reductions in passenger seats by 51% for Liberia, 66% for Guinea, and 85% for Sierra Leone), our model projects 2·8 travellers infected with Ebola virus departing the above three countries via commercial flights, on average, every month. 91 547 (64%) of all air travellers departing Guinea, Liberia, and Sierra Leone had expected destinations in low-income and lower-middle-income countries. Screening international travellers departing three airports would enable health assessments of all travellers at highest risk of exposure to Ebola virus infection.

Interpretation Decision makers must carefully balance the potential harms from travel restrictions imposed on countries that have Ebola virus activity against any potential reductions in risk from Ebola virus importations. Exit screening of travellers at airports in Guinea, Liberia, and Sierra Leone would be the most efficient frontier at which to assess the health status of travellers at risk of Ebola virus exposure, however, this intervention might require international support to implement effectively.

Funding Canadian Institutes of Health Research.

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International EVD Dispersion

Data and Methods

- Air travel data from Int'l Air Transport Association (IATA)
- Flight schedules from Sept-Dec 2014
- Assessment of flight cancellations & travel restrictions
- Passenger flight itineraries from Sept-Dec 2013

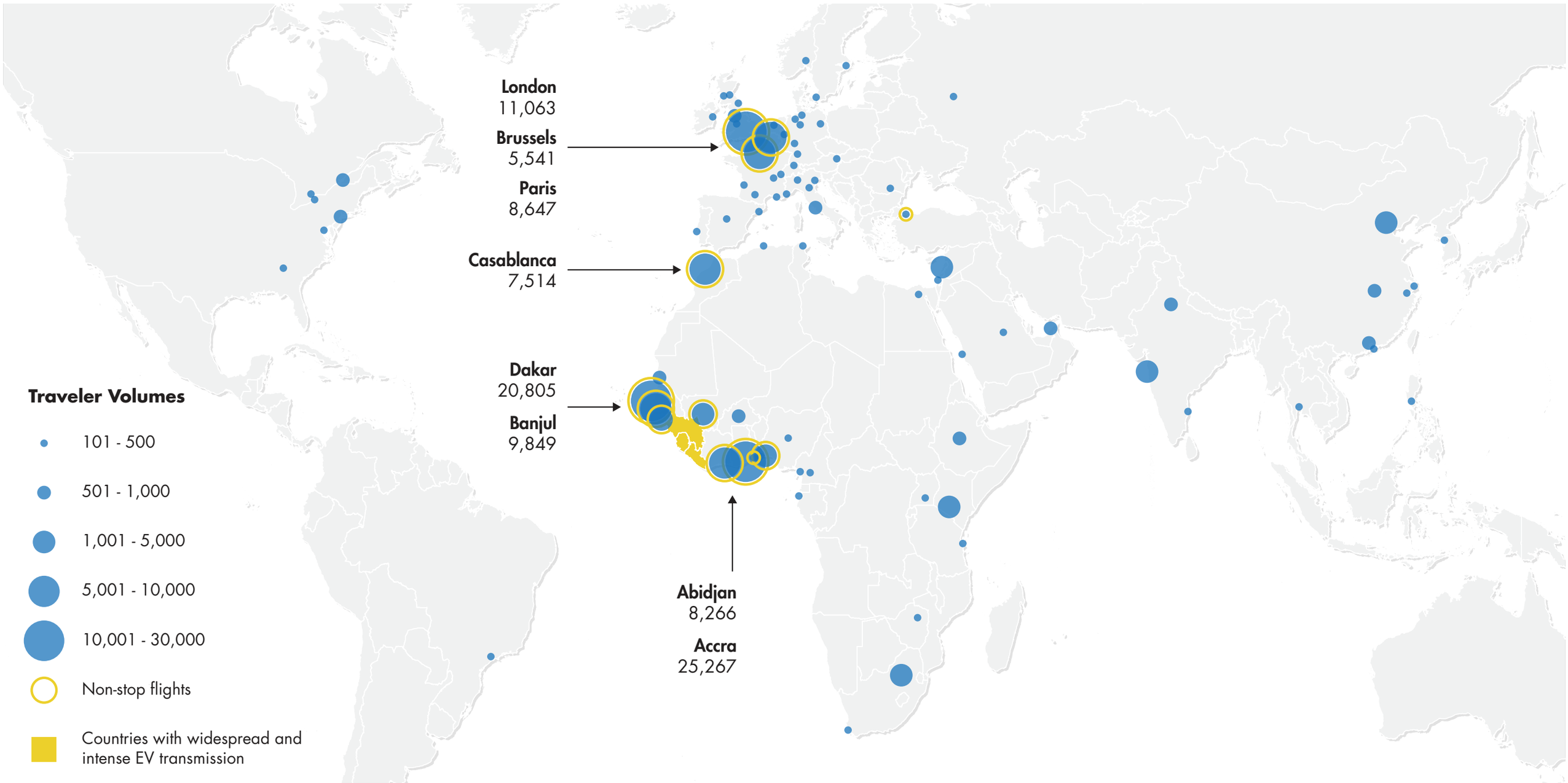
International EVD Dispersion

Model Assumptions

- Ebola virus infections are
  - Homogeneously distributed in Guinea, Liberia and Sierra Leone
  - Independent of probability of air travel
- Sensitivity analyses
  - Flat epidemic curve vs exponential growth
  - Pre-epidemic & reduced travel volume scenarios
  - Underreporting of EVD cases

Destinations of Air Travelers

Departing Guinea, Liberia, Sierra Leone via Direct & Indirect Flights, Sept-Dec 2013



	Traveller volume*	Proportion of total volume (%)	Health-system capacity measures (global rank out of 191 countries)			
			Health-care expenditure per head, US$†	Physicians per 1000 people†	Nurses and midwives per 1000 people†	Hospital beds per 1000 people†
Ghana	25 272	17·5%	83 (149)	0·1 (135)	0·9 (116)	0·9 (142)
Senegal	20 818	14·4%	51 (158)	0·1 (135)	0·4 (140)	0·3 (165)
UK	12 493	8·7%	3647 (20)	2·8 (42)	8·8 (23)	2·9 (69)
France	10 292	7·1%	4690 (14)	3·2 (31)	9·3 (19)	6·4 (15)
Gambia	9849	6·8%	26 (177)	0 (152)	0·6 (130)	1·1 (134)
Côte d'Ivoire	8266	5·7%	88 (147)	0·1 (135)	0·5 (136)	NA
Morocco	7574	5·2%	190 (119)	0·6 (104)	0·9 (116)	0·9 (142)
Belgium	5541	3·8%	4711 (13)	3 (34)	15·8 (4)	6·5 (13)
Nigeria	4182	2·9%	94 (144)	0·4 (110)	1·6 (100)	NA
China	4090	2·8%	322 (100)	1·9 (67)	1·9 (92)	3·8 (49)
Mali	3680	2·5%	42 (164)	0·1 (135)	0·4 (140)	0·1 (168)
USA	2927	2·0%	8895 (3)	2·5 (52)	9·8 (18)	2·9 (69)
India	2466	1·7%	61 (153)	0·7 (102)	1·7 (96)	0·7 (149)
Kenya	2392	1·7%	45 (162)	0·2 (122)	0·8 (121)	1·4 (123)
Germany	1825	1·3%	4683 (15)	3·8 (14)	11·5 (12)	8·2 (6)
Lebanon	1706	1·2%	675 (62)	3·2 (31)	2·7 (81)	3·5 (55)
South Africa	1558	1·1%	645 (64)	0·8 (99)	4·9 (55)	NA
Guinea-Bissau	1340	0·9%	30 (175)	0 (152)	0·6 (130)	1 (139)
Canada	1299	0·9%	5741 (8)	2·1 (61)	9·3 (19)	2·7 (75)
Italy	1293	0·9%	3032 (23)	4·1 (9)	0·3 (145)	3·4 (60)

NA=No data available. *From Sept 1, 2013, to Dec 31, 2013. †2007–12 estimates from World Bank.

Two Thirds of Air Traffic goes to Low and Lower-Middle Income Countries


STOP THE
FLIGHTS!
CDC

International Health Regulations

"...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".*

Purpose and Scope (Article 2)


TO GATES
LOOK FOR:
Ebola
CHAPPATTE
International New York Times

Entry and exit screening of airline travellers during the A(H1N1) 2009 pandemic: a retrospective evaluation

Kamran Khan,[a] Rose Eckhardt,[b] John S Brownstein,[c] Raza Naqvi,[d] Wei Hu,[b] David Kossowsky,[b] David Scales,[e] Julien Arino,[f] Michael MacDonald,[g] Jun Wang,[b] Jennifer Sears[b] & Martin S Cetron[h]

Objective To evaluate the screening measures that would have been required to assess all travellers at risk of transporting A(H1N1)pdm09 out of Mexico by air at the start of the 2009 pandemic.

Methods Data from flight itineraries for travellers who flew from Mexico were used to estimate the number of international airports where health screening measures would have been needed, and the number of travellers who would have had to be screened, to assess all air travellers who could have transported the H1N1 influenza virus out of Mexico during the initial stages of the 2009 A(H1N1) pandemic.

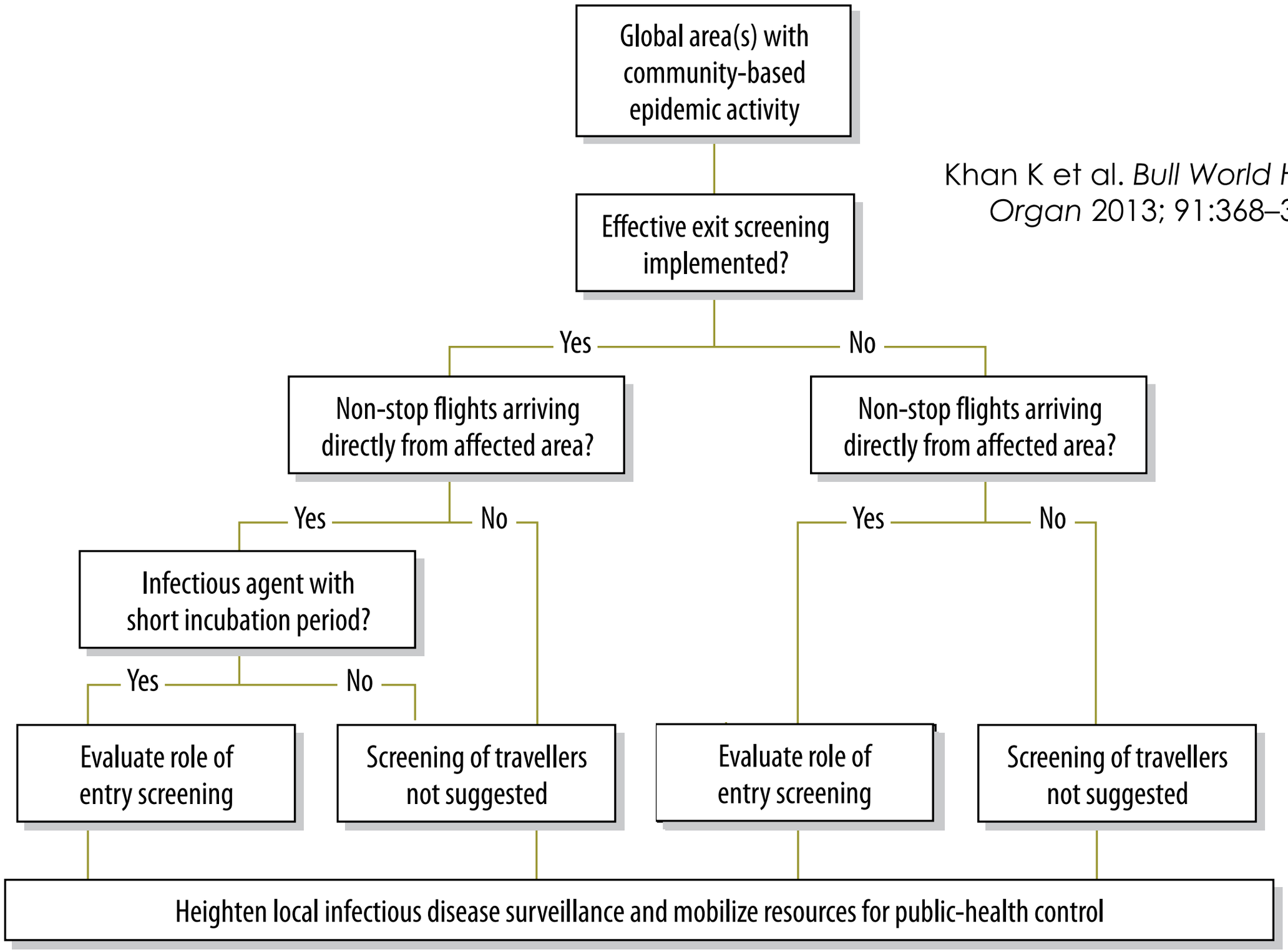
Findings Exit screening at 36 airports in Mexico, or entry screening of travellers arriving on direct flights from Mexico at 82 airports in 26 other countries, would have resulted in the assessment of all air travellers at risk of transporting A(H1N1)pdm09 out of Mexico at the start of the pandemic. Entry screening of 116 travellers arriving from Mexico by direct or connecting flights would have been necessary for every one traveller at risk of transporting A(H1N1)pdm09. Screening at just eight airports would have resulted in the assessment of 90% of all air travellers at risk of transporting A(H1N1)pdm09 out of Mexico in the early stages of the pandemic.

Conclusion During the earliest stages of the A(H1N1) pandemic, most public health benefits potentially attainable through the screening of air travellers could have been achieved by screening travellers at only eight airports.

Abstracts in عربي, 中文, Français, Русский and Español at the end of each article.

Khan K et al. *Bull World Health Organ* 2013; 91:368–376

Fig. 5. **Evidence-based decision-support tool for cities at risk of the importation of a pathogen causing infectious disease**



Khan K et al. *Bull World Health Organ* 2013; 91:368–376

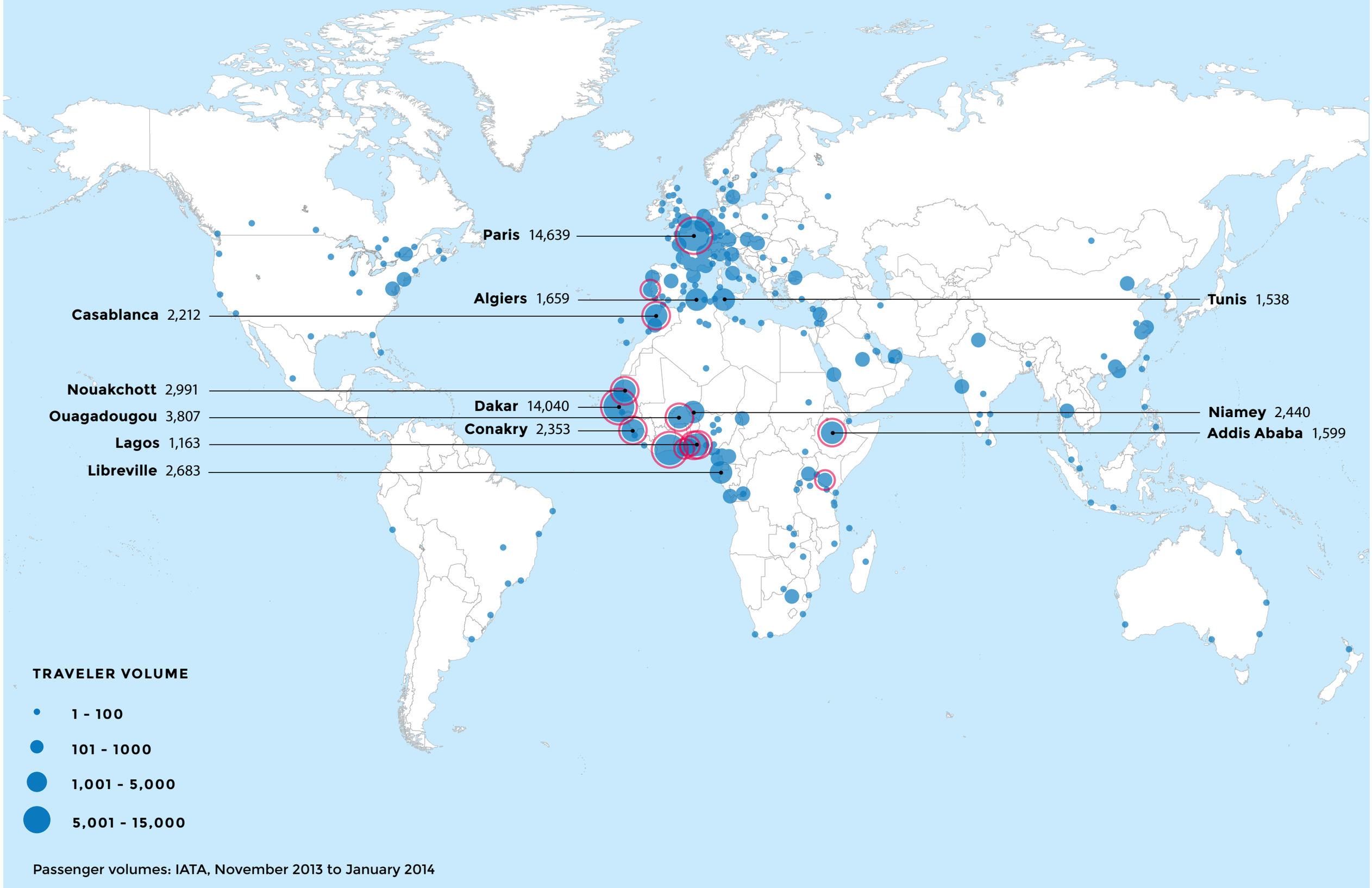
EVD Traveler Screening Strategies

	Exit screening	Entry screening of direct flights	Entry screening of indirect flights
Number of cities where screening would be required	3*	15†	1238
Estimated number of travellers who would be screened	144 798	144 798	362 855 926
Estimated number of low-risk‡ travellers who would be screened (%)	376 (0·1%)	376 (0·1%)	362 711 504 (99·9%)
Number of travellers needed to screen to assess one traveller with potential exposure to Ebola virus§	1	1	2512
Travel time until screening, h			
Median (IQR)	0	2·7 (2·0–6·1)	4·0 (2·0–7·6)¶
Mean (SD)	0	3·9 (2·6)	5·8 (4·9)

Bogoch I et al. Lancet 2014;Oct 21,2014

FINAL DESTINATIONS AND VOLUMES OF TRAVELERS FROM MALI

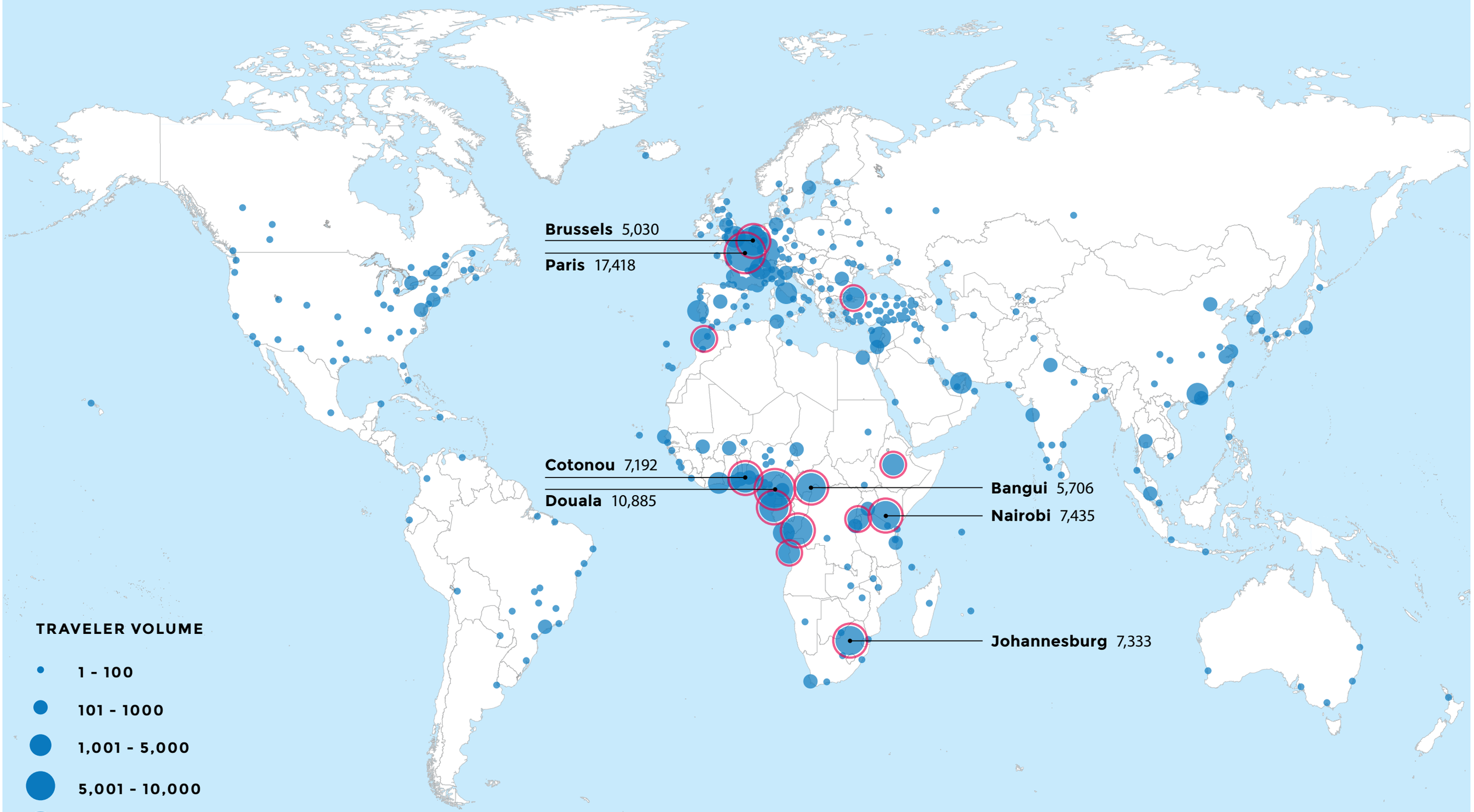
From November to January



Passenger volumes: IATA, November 2013 to January 2014

FINAL DESTINATIONS AND VOLUMES OF TRAVELERS FROM CONGO

From November to January



Passenger volumes: IATA, November 2013 to January 2014 | Scheduled non-stop flights: IATA, November 2014 to January 2015

Timeliness


60
55
5
50
10
45
15
40
20
35
30
25
30
25
5
20
10
TRANSAIR
PILOT SHOP
1/5 SEC


BRAZIL

Summary

- Globalization of emerging pathogens
- Multidisciplinary team in Toronto
- Curation & organization of diverse data
- Web-GIS app for analysis & data visualization
- Global partnerships including US CDC & WHO

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