Assessing the potential impact of emergent infectious diseases: Lessons from the 2009 H1N1 influenza pandemic

Mathematics in Emerging Infectious Disease Management

Centro Internacional de Ciencias, UNAM

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A TALE OF TWO CITIES

Mexico 2009

- April 23 , 8 pm– President Calderon announces to the country and the world that an unidentified strain of influenza has been detected by the Mexico surveillance systems
- Samples sent to Canada for analysis (Winnipeg)
- But the story obviously started earlier
  - Apr 17 – Surveillance is increased due to the suspicion of a severe respiratory disease circulating in Mexico City

Mr. X

- April 24 – Someone (let's call it Mr. X) shares w/ me (unofficially) the *epidemiological information* of the first 160 suspected cases (by Apr 18) in the Mexico City hospital network

- Due to fear of confidentiality, privacy issues, etc, we summarized the data as an epidemic curve of suspected cases and the distribution of times between symptoms onset and hosp/detection

- Using this data we start estimating the basic reproduction number (using Davoudi et al's new method among others)

- First preliminary estimates ~ Apr 28 (Tuesday)
- ~1.5-1.7 (agree w/ Brauer's Thm)
- Preliminary results shared with British Columbia and Canadian authorities first and later w/ others
- Public health work done !!! ☺
- But what about the scientific part?

- Mr. X had no power and no way to grant “official” access to the preliminary data
- Approached some Mexican authorities to see if we can get access (or permission to use) to the data
- Apr 28 – “Miraculously” obtained updated data from a new source (Mr. Y)
  - Still unofficially
- New data gave similar results

- Finally got official access to Mexico City's daily counts of confirmed cases from the SSDF
- Results were submitted to a "High Impact Journal" (May 9)
- Fraser et al appeared (May 11)
- Our paper was rejected
- Submitted to other journal
- Accepted and published ☺ (July)
- Formalized collaboration w/ SSDF (Visit)

Initial Human Transmission Dynamics of the Pandemic (H1N1) 2009 Virus in North America

Babak Pourbohloul, Armando Ahued, Bahman Davoudi, Rafael Meza, Lauren A. Meyers,
Danuta M. Skowronski, Ignacio Villaseñor, Fernando Galván, et al.

Influenza Other Respi Viruses. 2009;3:215-222.

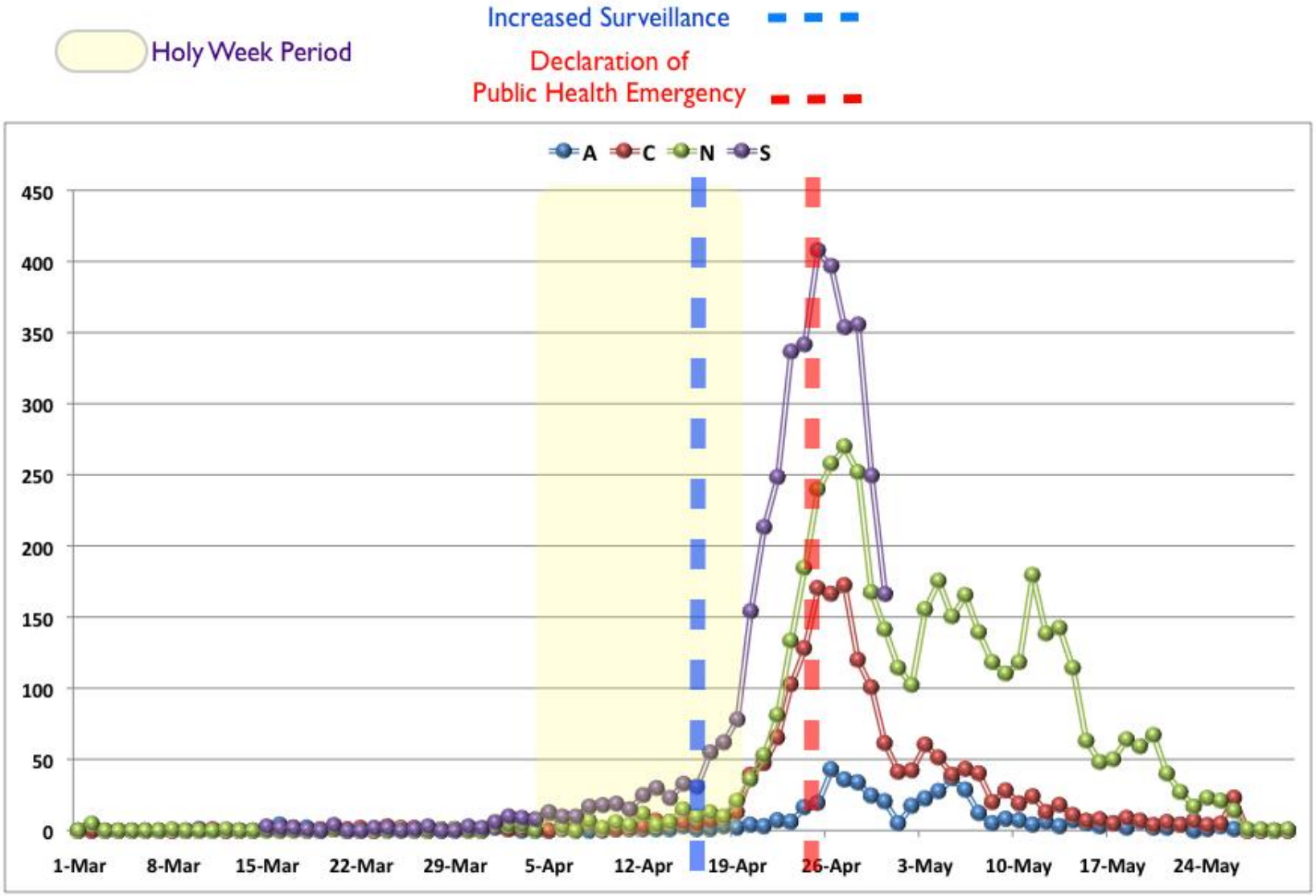


Figure 1

Pourbohloul *et al.*

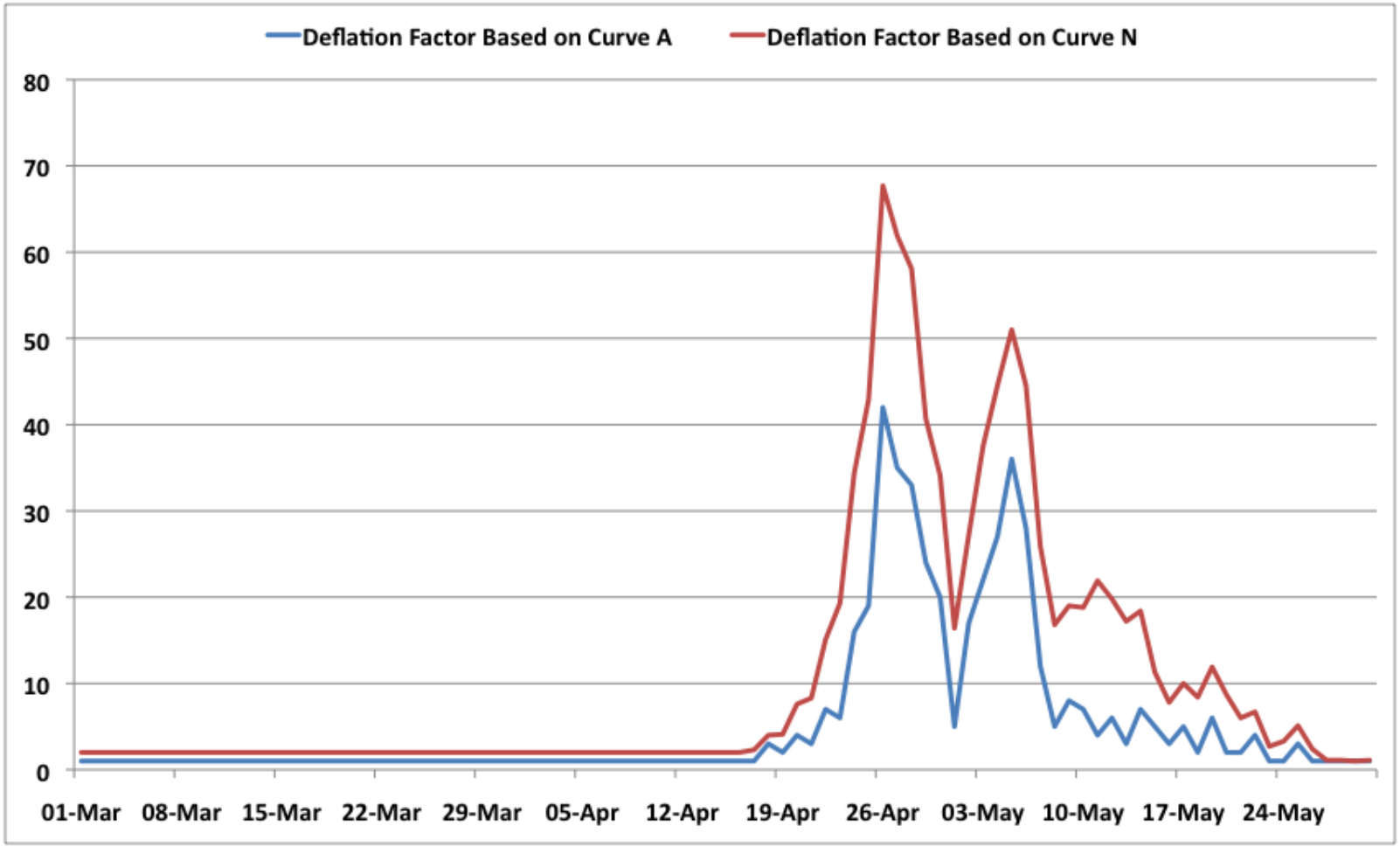


Figure 2a

Pourbohloul *et al.*

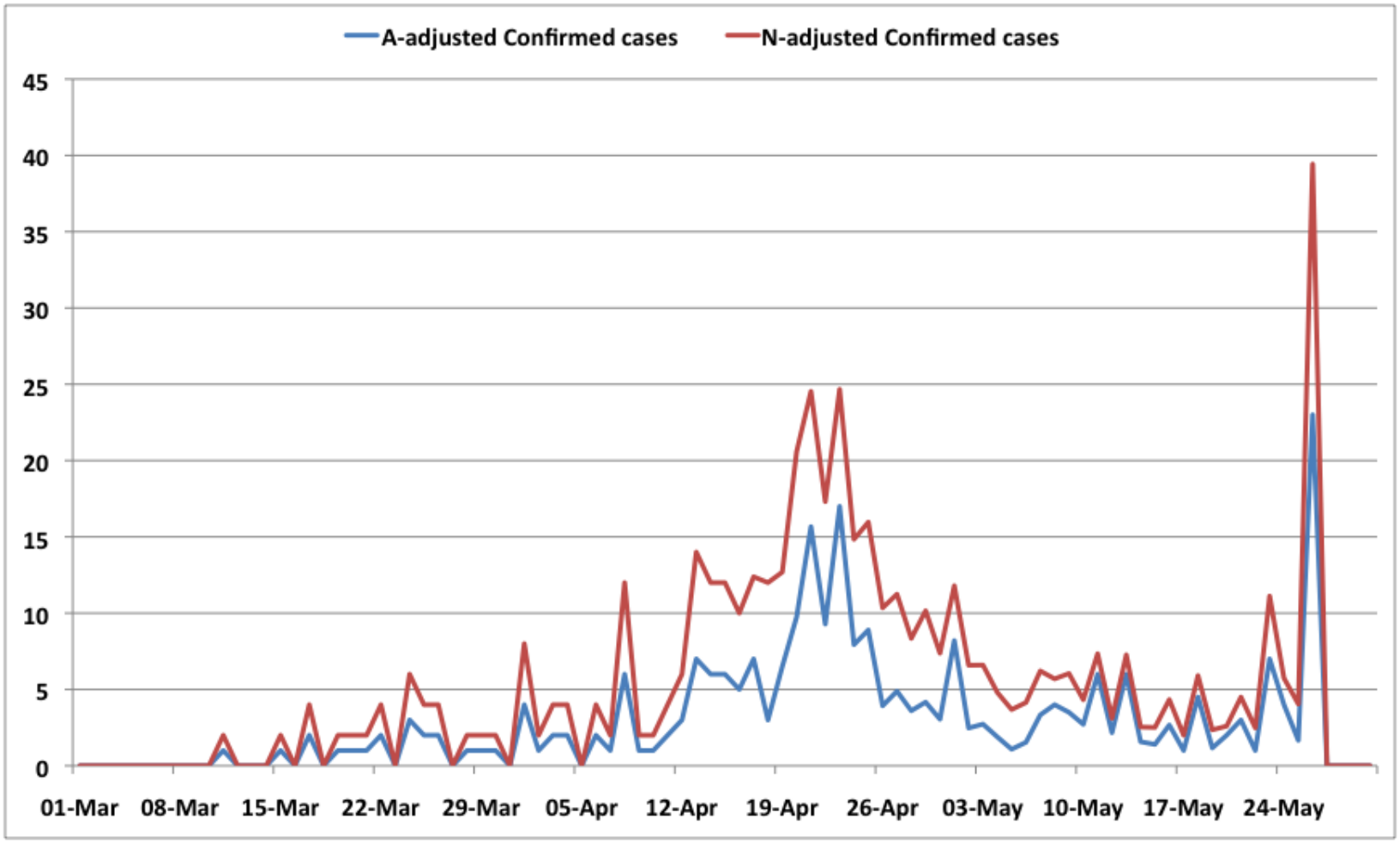


Figure 2b

Pourbohloul *et al.*

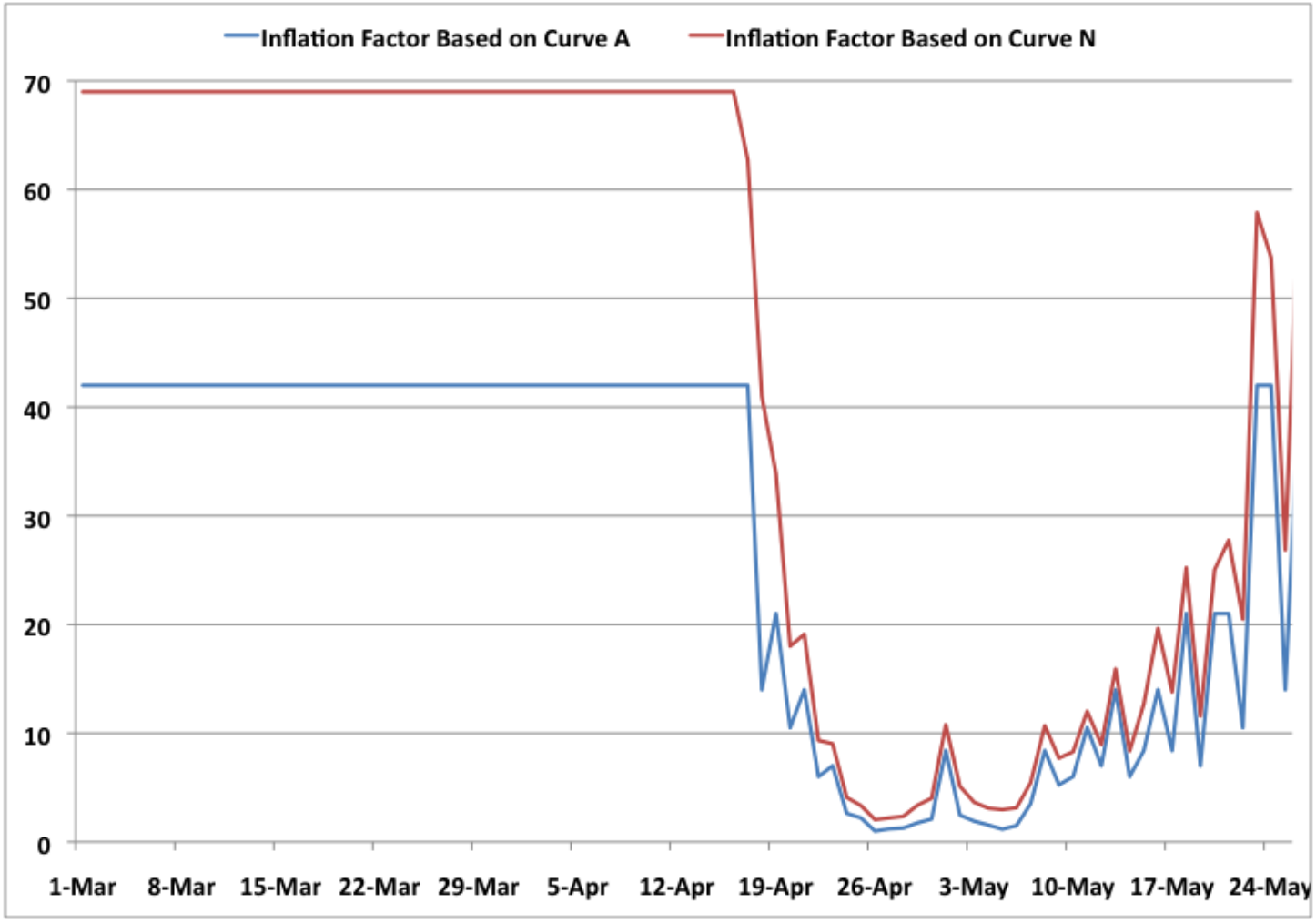


Figure 3a

Pourbohloul *et al.*

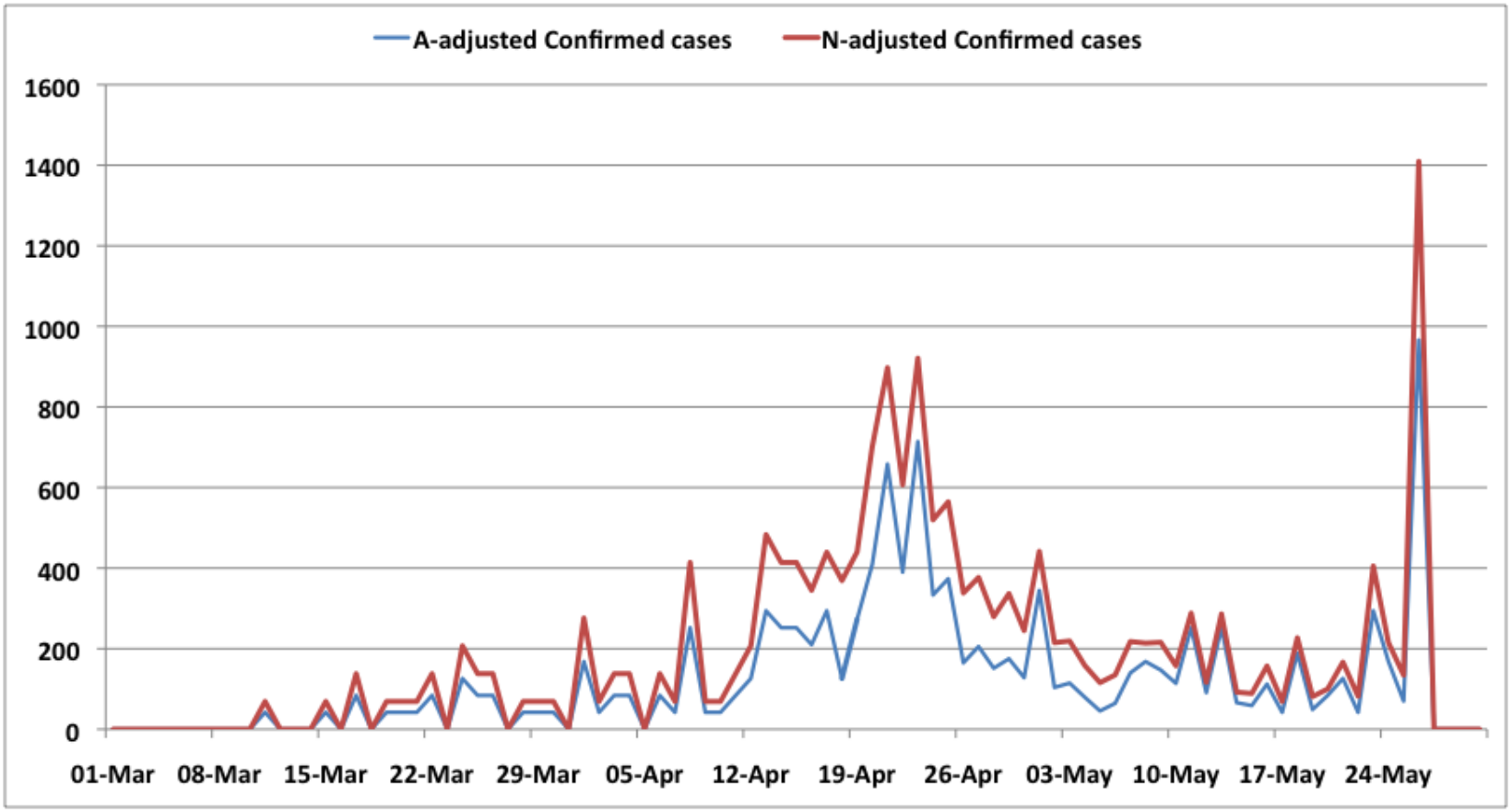
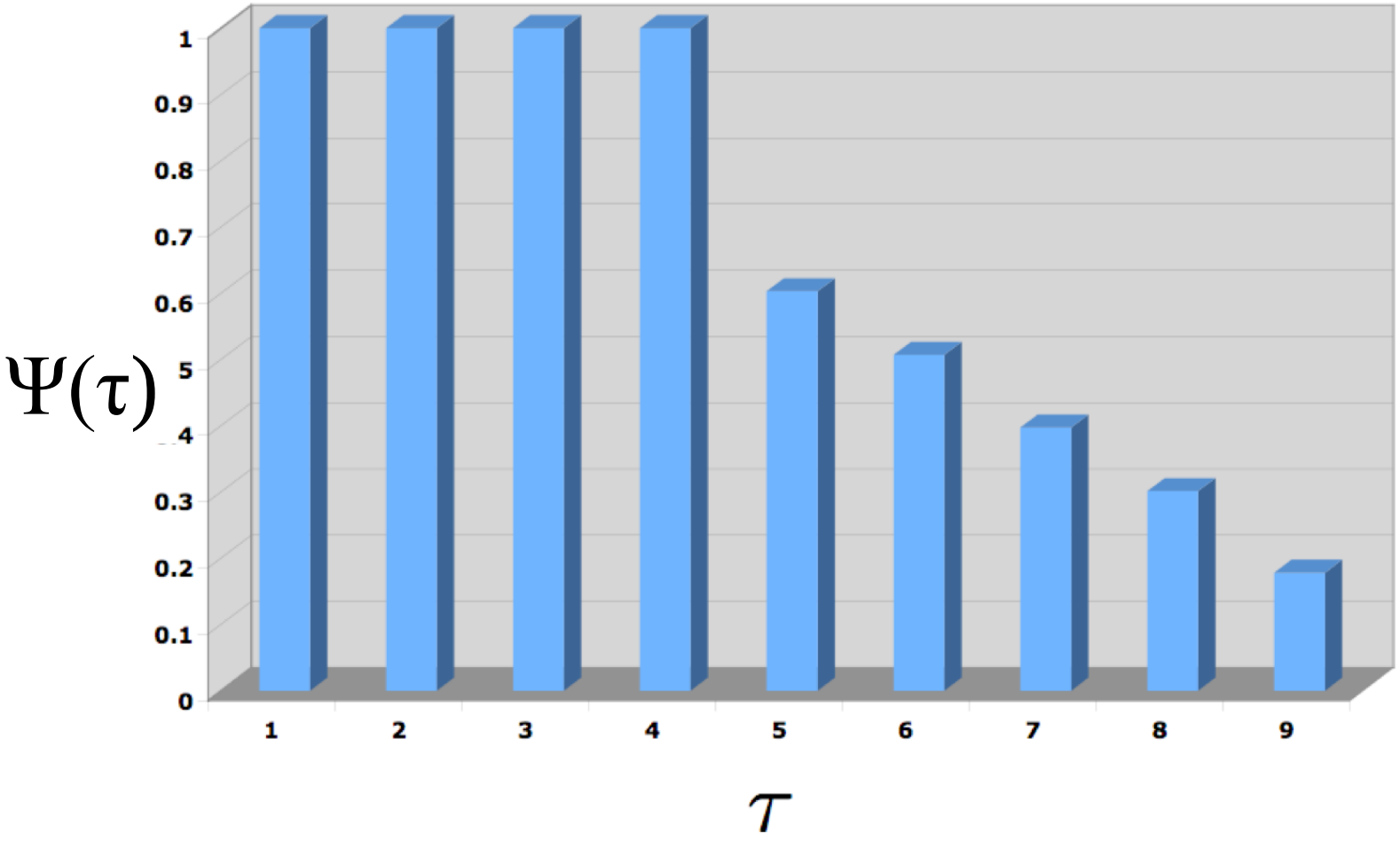
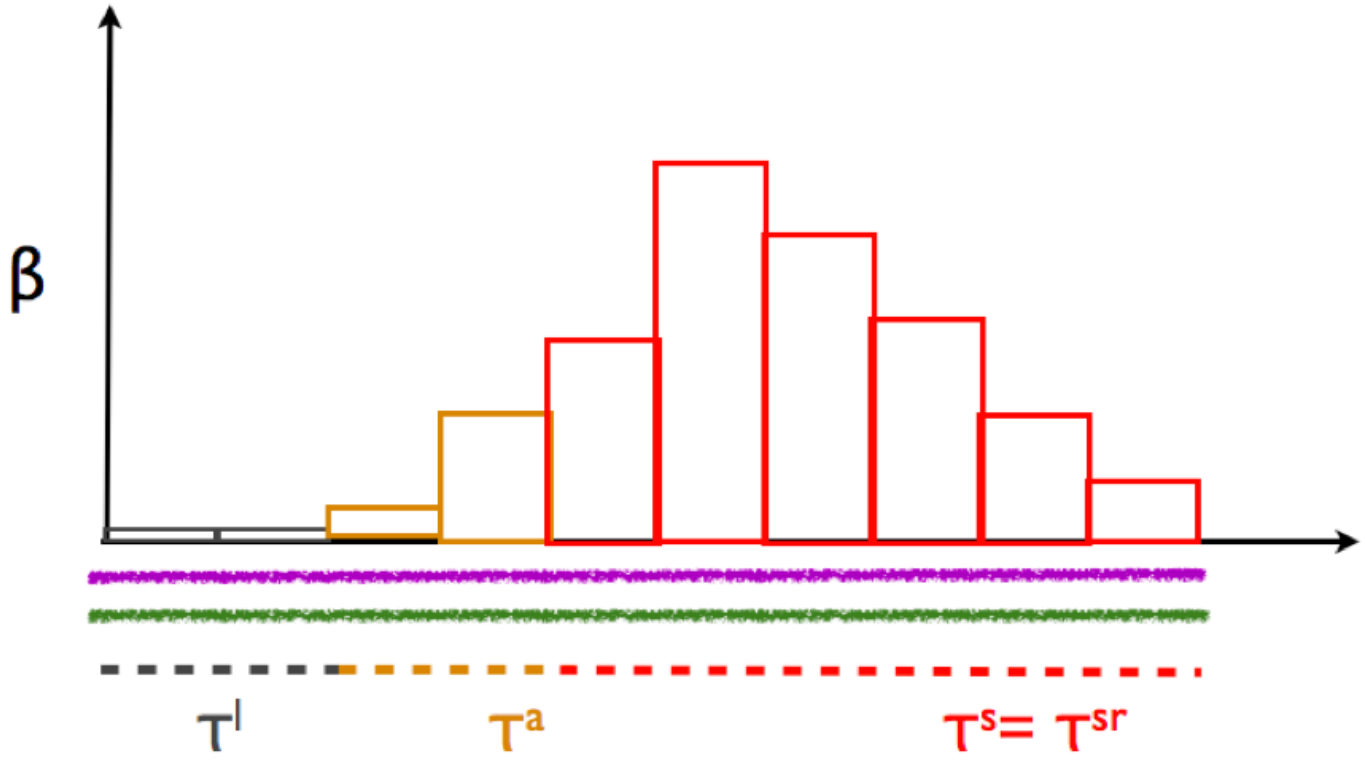


Figure 3b

Pourbohloul *et al.*

From Mexico hospitalization data




β
τ^l
τ^a
τ^s= τ^sr

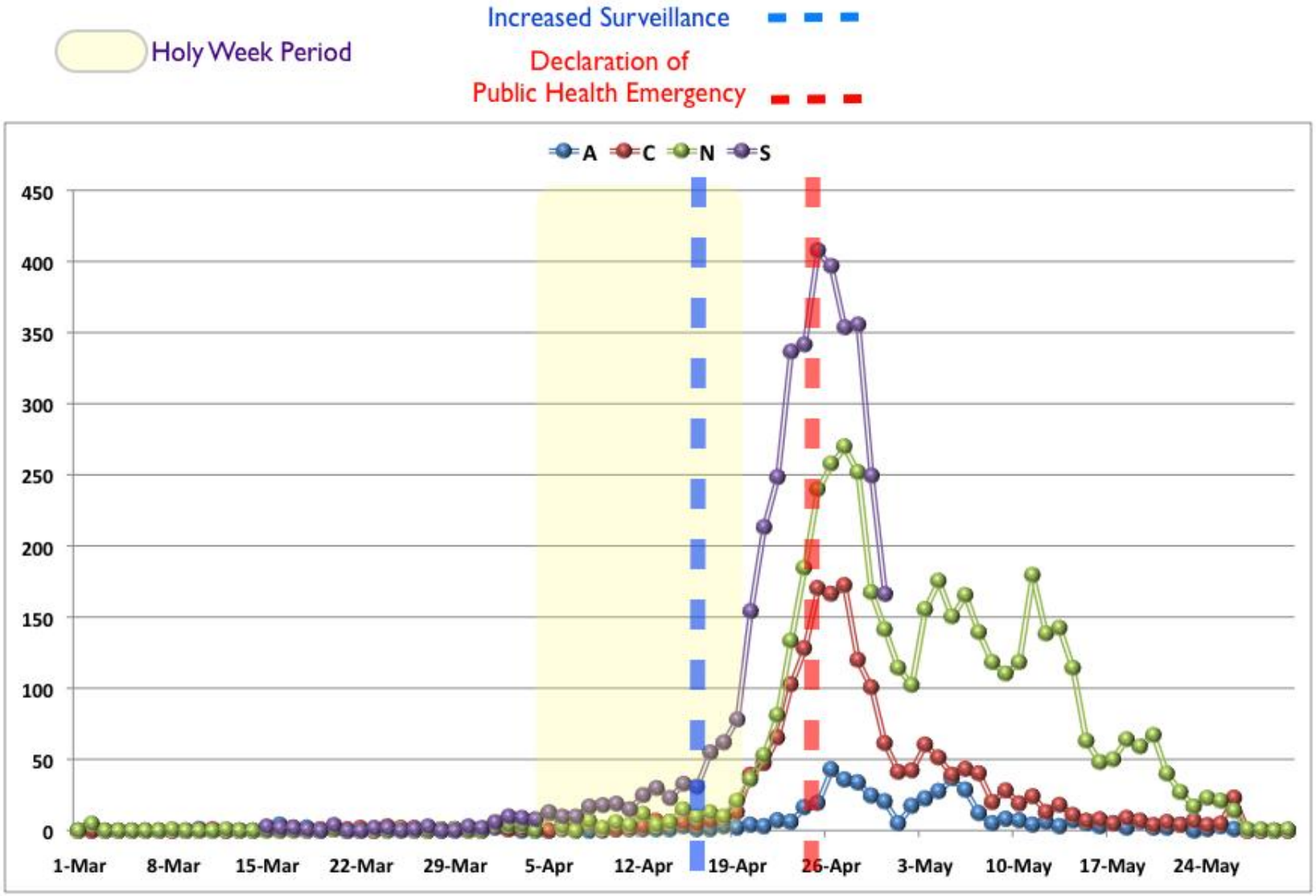
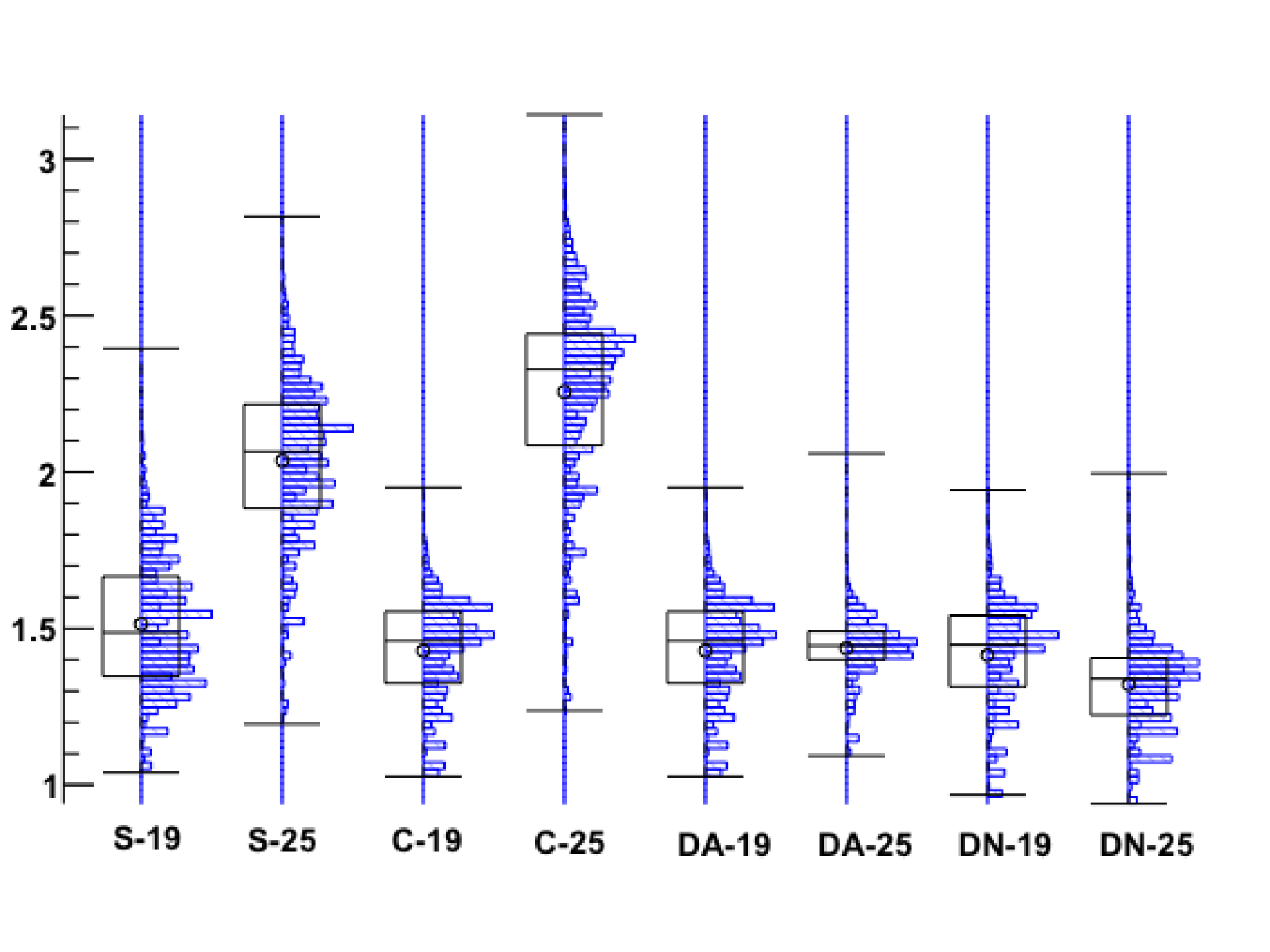


Figure 1

Pourbohloul *et al.*


3
2.5
2
1.5
1
S-19
S-25
C-19
C-25
DA-19
DA-25
DN-19
DN-25

Our conclusions

- pH1N1 “R” in Mexico City about 1.5 (consistent w/ Brauer’s Thm)
- Crucial to adjust for changes in “reporting fraction” and other effects (pears vs apples)
  - True incidence ≈ observed cases / prob. of detection
- Data on other “simultaneous” respiratory diseases (and negatives) used to adjust data for these
- New methodology (Davoudi et al) performed “well”
  - Estimations consistent with existing methods.
  - Allows estimation of R_0 during the early (stochastic) phase of an epidemic

2009, 84, 341–352

World Health Organization
Organisation mondiale de la Santé

Weekly epidem
Relevé épidémio

21 AUGUST 2009, 84rd YEAR / 21 AOÛT 200
No. 34, 2009, 84, 341–352
http://www.who.int/wer

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Mathematical modelling of the pandemic H1N1 200

Background and objectives of an

Rapid communications

Transmission potential of the new influenza A(H1N1) virus and its age-specificity in Japan

H Nishiura (h.nishiura@uu.nl)[1], C Castillo-Chavez[2], M Safan[3], G Chowell[2]
1. University of Utrecht, Utrecht, the Netherlands

DOI:10.1111/j.1750-2659.2009.00100.x
www.blackwellpublishing.com/influenza
Original Article

Initial human transmission dynamics of the pandemic (H1N1) 2009 virus in North America

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The Transmissibility and Pandemic Influenza A (H

Babak F
Danuta
Jonatha
Jesús Tr
Robert
Yang Yang,[1] Jonathan D. Sugimoto,[1,2] M. Elizabeth Hallora
Dennis L. Chao,[1] Laura Matrajt,[4] Gail Potter,[5] Eben Kenah,[1]

Pandemic influenza A (H1N1) 2009 (pandemic H1N1) is spreadi
become the dominant strain in the Southern Hemisphere, where the influenza
Here, on the basis of reported case clusters in the United States, we estimated
attack rate for pandemic H1N1 to be 27.3% [95% confidence interval (CI) fr
From a school outbreak, we estimated that a typical schoolchild infects 2.4 (9
other children within the school. We estimated the basic reproductive numbe
1.3 to 1.7 and the generation interval to range from 2.6 to 3.2 days. We use
evaluate the effectiveness of vaccination strategies in the United States for fall
available soon enough, vaccination of children, followed by adults, reaching 70% overall coverage,
in addition to high-risk and essential workforce groups, could mitigate a severe epidemic

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Rapid communications

Modelling of the influenza A(H1N1)v outbreak in Mexico City, April-May 2009, with control sanitary measures

G Cruz-Pacheco (cruz@mym.iimas.unam.mx)[1], L Duran[2], L Esteva[3], A A Minzoni[1], M López-Cervantes[2], P Panayotaros[1], A Ahued Ortega[4], I Villaseñor Ruíz[4]
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2. Faculty of Medicine, Universidad Nacional Autónoma de México, Mexico
3. Faculty of Sciences-FENOMEC, Universidad Nacional Autónoma de México, Mexico
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Influenza A (H1N1): Early Findings

,[1]* Christl A. Donnelly,[1]* Simon Cauchemez,[1] William P. Hanage,[1]
ove,[1] T. Déirdre Hollingsworth,[1] Jamie Griffin,[1] Rebecca F. Baggaley,[1]
nily J. Lyons,[1] Thibaut Jombart,[1] Wes R. Hinsley,[1] Nicholas C. Grassly,[1]
ıncois Balloux,[1] Azra C. Ghani,[1] Neil M. Ferguson[1]†;

Andrew Rambaut,[2] Oliver G. Pybus[3];

elia M. Alpuche-Aranda,[5] Ietza Bojorquez Chapela,[4] Ethel Palacios Zavala[4];

Dulce Ma. Espejo Guevara[6];

o Checchi,[7] Erika Garcia,[7] Stephane Hugonnet,[7] Cathy Roth[7]

he WHO Rapid Pandemic Assessment Collaboration‡

Estimation of the reproductive number and the serial interval in early phase of the 2009 influenza A/H1N1 pandemic in the USA

Laura Forsberg White,[a] Jacco Wallinga,[b,c] Lyn Finelli,[d] Carrie Reed,[d] Steven Riley,[e] Marc Lipsitch,[f] Marcello Pagano[g]

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Accepted 19 August 2009. Published 22 September 2009.

Brauer's Thm

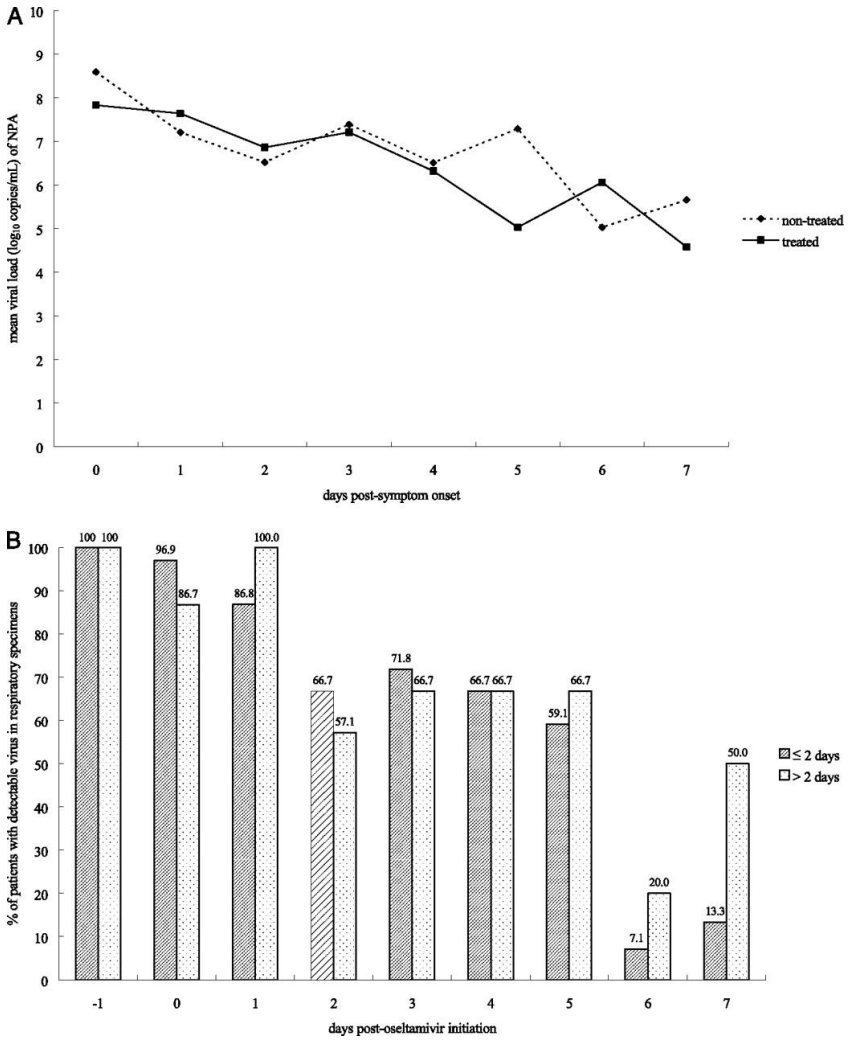
- R0 ≈ 1.5 independently of model used
- Apparently true for this pandemic
- Let's take a closer look

Article	R0	Mean Gen Interval / Inf period (days)
Fraser et al	1.4-1.6	1.3-2.71 (GI)
Yang et al	1.3-1.7	2.6-3.2 (GI)
Nishiura et al *	2.0-2.6 (Japan)	1.3-3.1 (GI)
Pourbohloul et al	1.29-1.57	3-1-7 (L-A-S)
Cruz-Pacheco et al	1.72	3 (Inf Per)
White et al	1.7-1.8 (US)	2.2-2.3
Nishiura et al **	1.21-1.35 (Japan)	2.1-3.3

Viral level measures

- 8-13 % of patients still shedding virus 8 days after detection (De Serres et al, EID 2010)
- 50% of a sample of Chinese patients still shedding virus at day 6 (De Serres et al, EID; Cao et al, NEJM 2009)
- Median duration of viral shedding, as assessed by RT-PCR, was 9 days in Korean study (Na et al, Medical Virology 2010)
- Age effects (longer infections for younger individuals)

(A) The mean ± SD viral load (log10 copies/mL) profile in NPA at different days post symptom onset in pandemic A(H1N1)-infected patients not treated and treated with oseltamivir.



Li I W et al. Chest 2010;137:759-768

Viral shedding/load vs GI

- How do they relate?
- GI dependent on
  - infectivity “profile”
  - contact patterns between pairs
  - Competition between my infected contacts
- GI hard to measure directly (need to identify case-pairs)

CANPan

Canadian Consortium for Pandemic Preparedness Modelling

Consortium Canadien de Modélisation pour la Preparation du Plan Pandémie

Estimation of the Reproductive Number of an Emergent Disease

Cindy Feng

Project Description

The emergence of infectious disease epidemics pose a significant threat to public health; thus, signifying the importance of developing statistical methods to

The purpose of this project was to investigate various methods of estimating R0 and to highlight the differences between each method by way of simulation studies. Our results were used to investigate differences in H1N1 transmission dynamics by geographic location, population

Cindy Feng (SFU Statistics) – CanPan Intern

- Project: compare different methodologies for estimating R0 using simulated and real epidemic data

- Two general class of methods
  - Based on GI: WP, WT, Cauchemez
  - "Mechanistic": SIR, Davoudi et al
    - Depend on infectious period and infectivity profile

Challenges for estimating R0

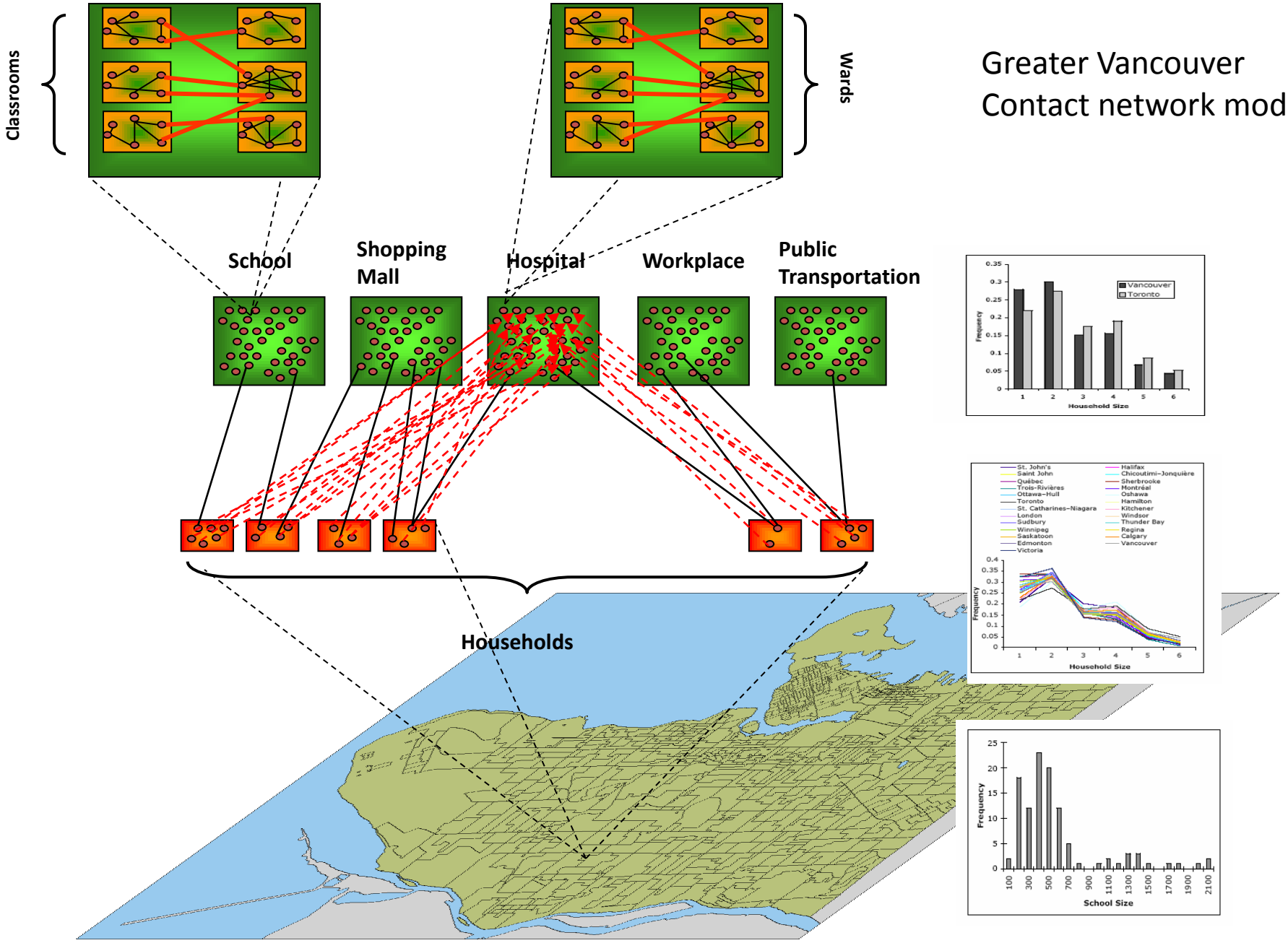
- Data:
  - Quality
  - Underreporting / asymptomatics
  - Trends of testing, surveillance, awareness, age-distribution
  - Data heterogeneity
    - A case in day x is likely not the same as a case in day y
- Most estimation methods require previous information about either the GI or the infectious/infected period

Challenges for estimating R0

- Past information helpful for influenza (although not necessarily relevant for an emergent strain)
- What about other diseases w/ no prior history?
- Period of infection “easier” to measure than GI
  - Individual vs pair information
- So methods that either directly estimate these quantities or that depend on individual outcomes may be preferable?

Other activities of DMM related to the pandemic

- CanPan internships
- Estimation of R0 for BC
- Evaluation of intervention strategies for the fall/winter wave
  - GVRD contact network model (Bahman)
  - ODE version of the GVRD (Jessica)



Greater Vancouver
Contact network model

Other activities of DMM related to the pandemic

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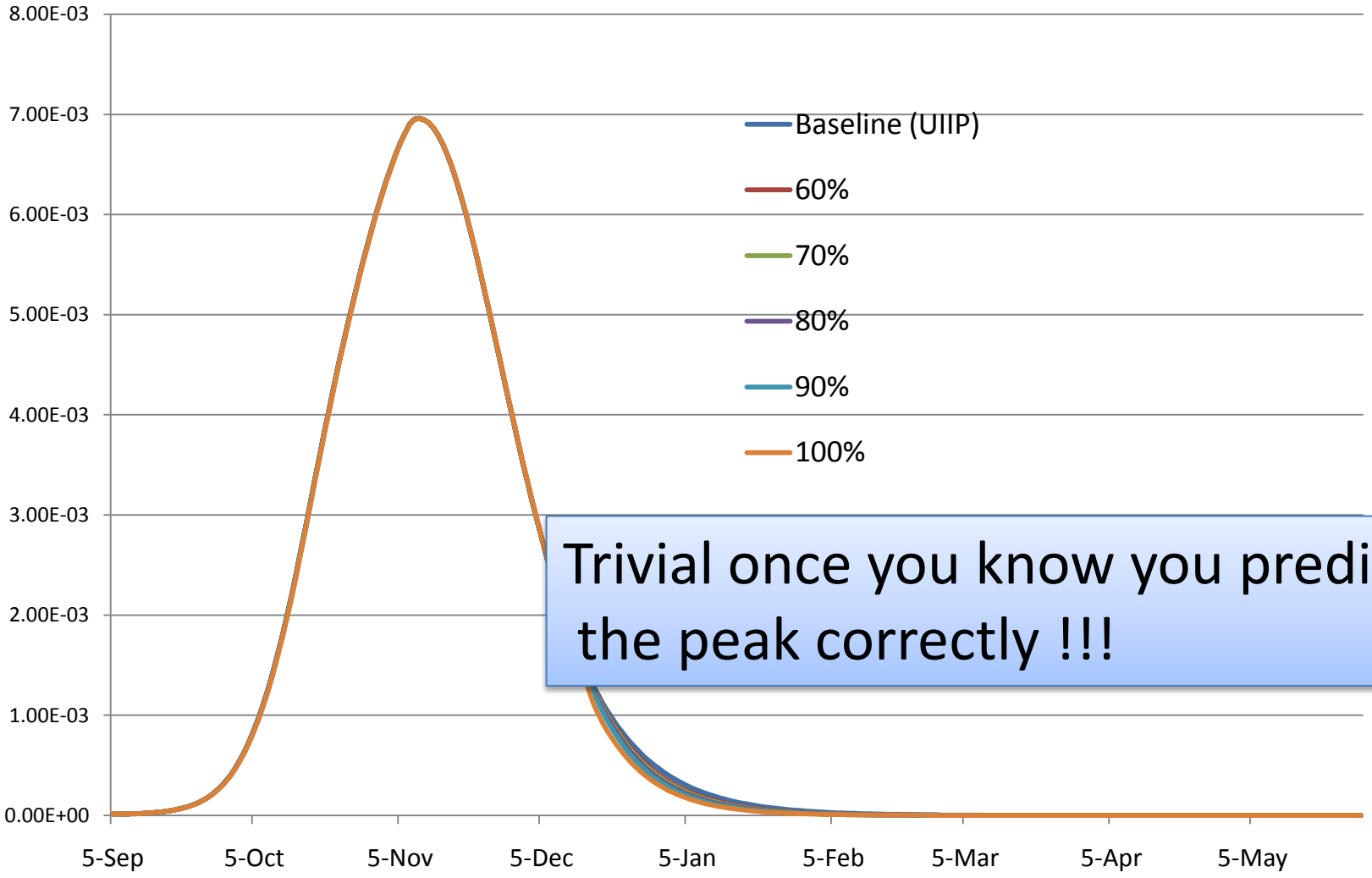
  - Use of antivirals for prophylaxis
  - Late vaccination of school children

Overall Attack Rates After Vaccinating School children Starting @ Dec 1st

Baseline: 32.8%; 60% Cov: 32.6%; 70% Cov: 32.5%; 80% Cov: 32.5%; 90% Cov: 32.4%; 100% Cov: 32.2%.



Trivial once you know you predicted the peak correctly !!!

Other activities

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  - Use of antivirals for prophylaxis
  - Late vaccination of school children
- BC Science and Health Expo (BC Year of Science)
  - Exposition: The Contact Network (or how Math helped save the world during the last pandemic and other cool stories !)


The Contact Network
What else?


You're Invited
FREE
Year of Science
SCIENCE AND HEALTH EXPO
Everything from Batman... to Vampires... to Zero Gravity.
Learn how Science is Cool!
Thursday, November 25
10:30 AM – 7:00 PM
- and -
Friday, November 26, 2010
9:30 AM – 3:00 PM

Los termometros térmicos son una tecnología que permite captar la temperatura de las personas en tiempo real que ya se usa en otros aeropuertos del muendo como una medida de control sanitario y que en México es nueva, al grado que en Cancún se instalarían los primeros

Acknowledgments

- Fernando Galvan - Secretaria de Salud Mexico
- Secretaria de Salud del Distrito Federal
- DMM-UBCCDC
- CanPan – CIHR
- Organizers – Marco Jose

BC Centre for Disease Control
An Agency of the Provincial Health Services Authority

UBC

CANPan
Canadian Consortium for Pandemic Preparedness Modelling
Consortium Canadien de Modélisation pour la Preparation du Plan Pandémie

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Mathematics in Emerging Infectious Disease Management

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