Risks to business and the economy from future pandemics

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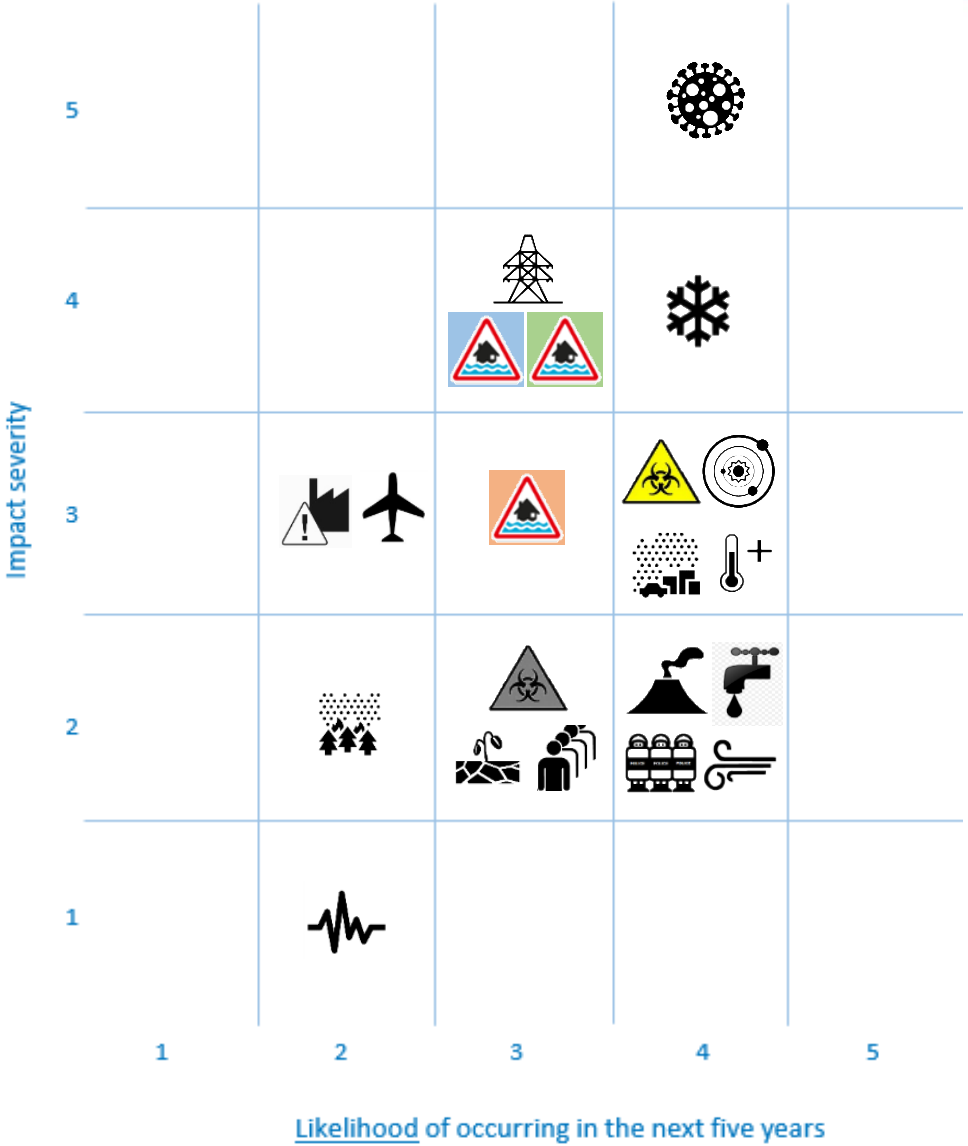
National Risk Register of Civil Emergencies, 2017



KEY

Natural hazards

- Coastal flooding
- River flooding
- Surface water flooding
- Storms and gales
- Cold and snow
- Heatwave
- Drought
- Space weather
- Volcanic eruptions
- Poor air quality
- Earthquakes
- Wildfires

Diseases

- Pandemic influenza
- Emerging infectious disease
- Animal disease

Major accidents

- Widespread electricity failure
- Transport accidents
- Industrial and urban accidents
- System failures

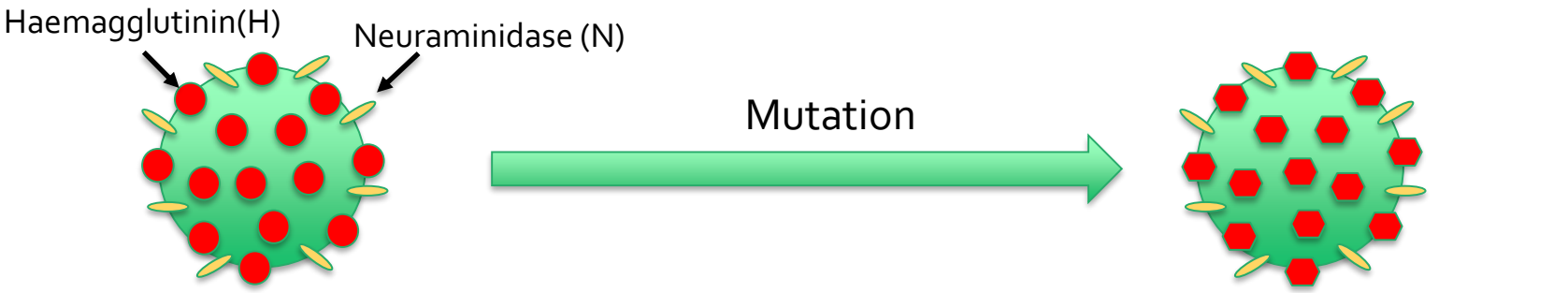
Societal risks

- Industrial action
- Public disorder

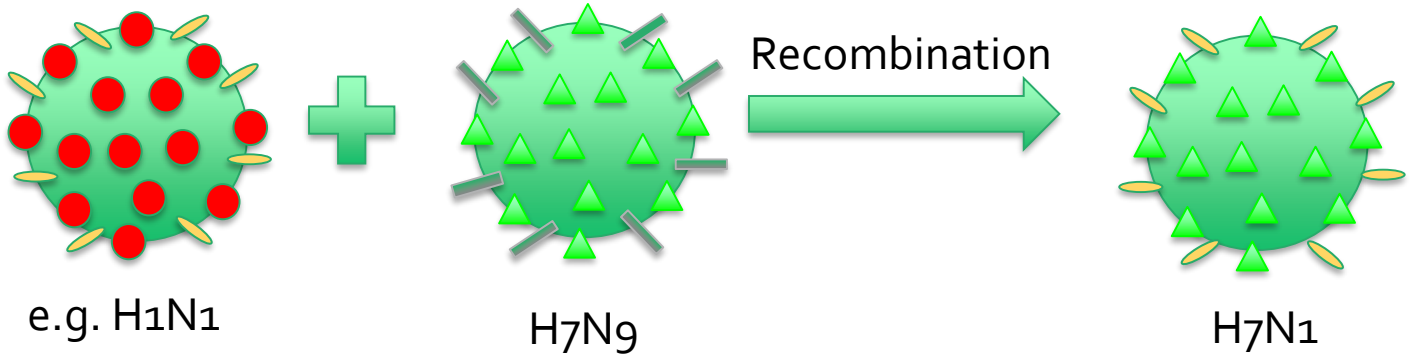
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644968/UK_National_Risk_Register_2017.pdf

What are pandemics, and how do they arise?

Antigenic Drift (seasonal flu)



Antigenic Shift (pandemic flu)



Pandemics can also occur when a strain jumps species (perhaps via an intermediate host)

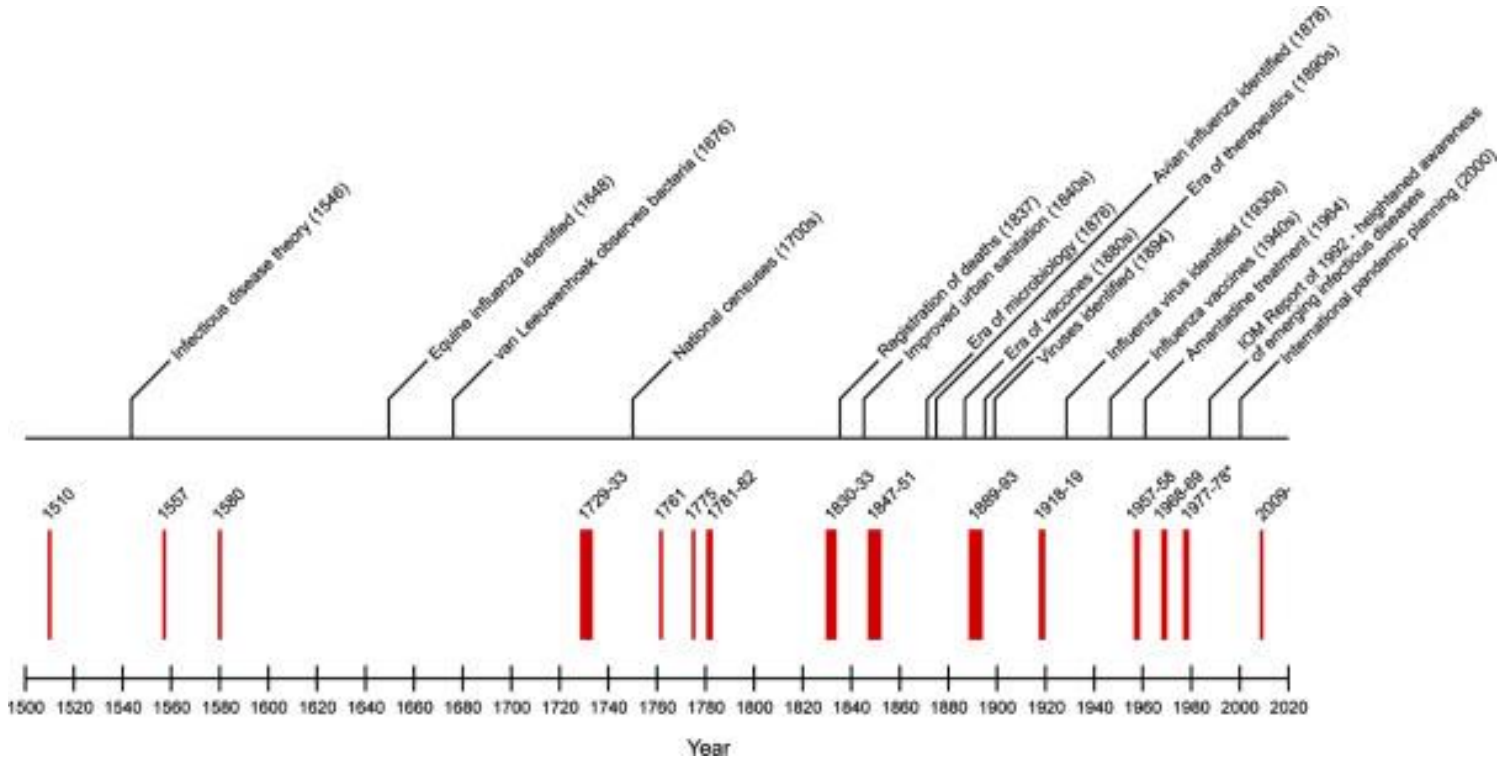
Jumping the “species barrier”

Image from www.ktis.fm/blogs/lisa/wp-content/swine-flu.bmp

Frequency of pandemics

- Difficult to determine from historical record
  - Flu not consistently reported as a disease
  - Small pandemics?
  - Large seasonal flu epidemics?
- 4 during the 20th century

"Influenza pandemics from 1510-2010." Morens, Taubenberger, Folker, & Fauci (2010)



Speed of spread and duration of pandemic:

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APRIL 2009

23 April:
Cases of H1N1 virus are confirmed in Mexico and the USA

24 April:
WHO announces an outbreak of human cases of H1N1 confirmed in Mexico and the USA

27 April:
The first two UK cases of H1N1 are confirmed in a couple from Scotland

WHO raises its alert level to Phase 4

FCO advises against all but essential travel to Mexico

28 April:
Michael McGimpsey makes a statement about the outbreak to the Northern Ireland Assembly

WHO raises alert level from 4 to 5

29 April:
Gordon Brown announces that the stockpile of antivirals will be increased from 33.5m to 50m

Alan Johnson informs the House of Commons of five confirmed cases in the UK and promises an advisory booklet drop

Edwina Hart provides an update on the situation to the Welsh Assembly Government

Nicola Sturgeon updates the Scottish Parliament on the outbreak and the two confirmed cases in Scotland

First case confirmed in England; first UK school closure

30 April:
H1N1 information campaign is rolled out on TV, radio and in print media and a booklet is prepared for household delivery

MAY 2009

1 May:
First case of human-to-human transmission in the UK is confirmed

14 May:
First laboratory-confirmed case reported in Northern Ireland

15 May:
Press release confirms agreements to secure up to 90m doses of pre-pandemic vaccine

FCO ceases to advise against all but essential travel to Mexico

29 May:
First laboratory-confirmed case reported in Wales. Cases now confirmed across the UK

JUNE 2009

11 June:
WHO raises its pandemic alert level to 6, the highest level

13 June:
Total number of UK cases reaches 1,000

15 June:
First UK death attributed to H1N1

JULY 2009

2 July:
Treatment phase begins

6 July:
Total UK deaths: 10

23 July:
National Pandemic Flu Service goes live in England

AUGUST 2009

13 August:
Andy Burnham announces the identification of priority groups: pregnant women, front-line health and social care workers, and everyone in at-risk groups (those who are at higher risk of serious illness or death should they develop influenza) aged over 6 months

21 August:
Total UK deaths: 60

SEPTEMBER 2009

10 September:
The four health departments release critical care strategies to cope with the expected increases in demand during the second wave of the pandemic

OCTOBER 2009

21 October:
Vaccination programme begins: front-line healthcare workers and their patients who fall into at-risk categories

29 October:
Total UK deaths: 137

NOVEMBER 2009

19 November:
Phase two of vaccination programme begins: children over 6 months and under 5 years

DECEMBER 2009

10 December:
Total UK deaths: 283

JANUARY 2010

7 January:
Total UK deaths: 308

FEBRUARY 2010

4 February:
Total UK deaths: 411

11 February:
National Pandemic Flu Service is stood down

MARCH 2010

18 March:
Total UK deaths: 457

342 in England

69 in Scotland

28 in Wales

18 in Northern Ireland

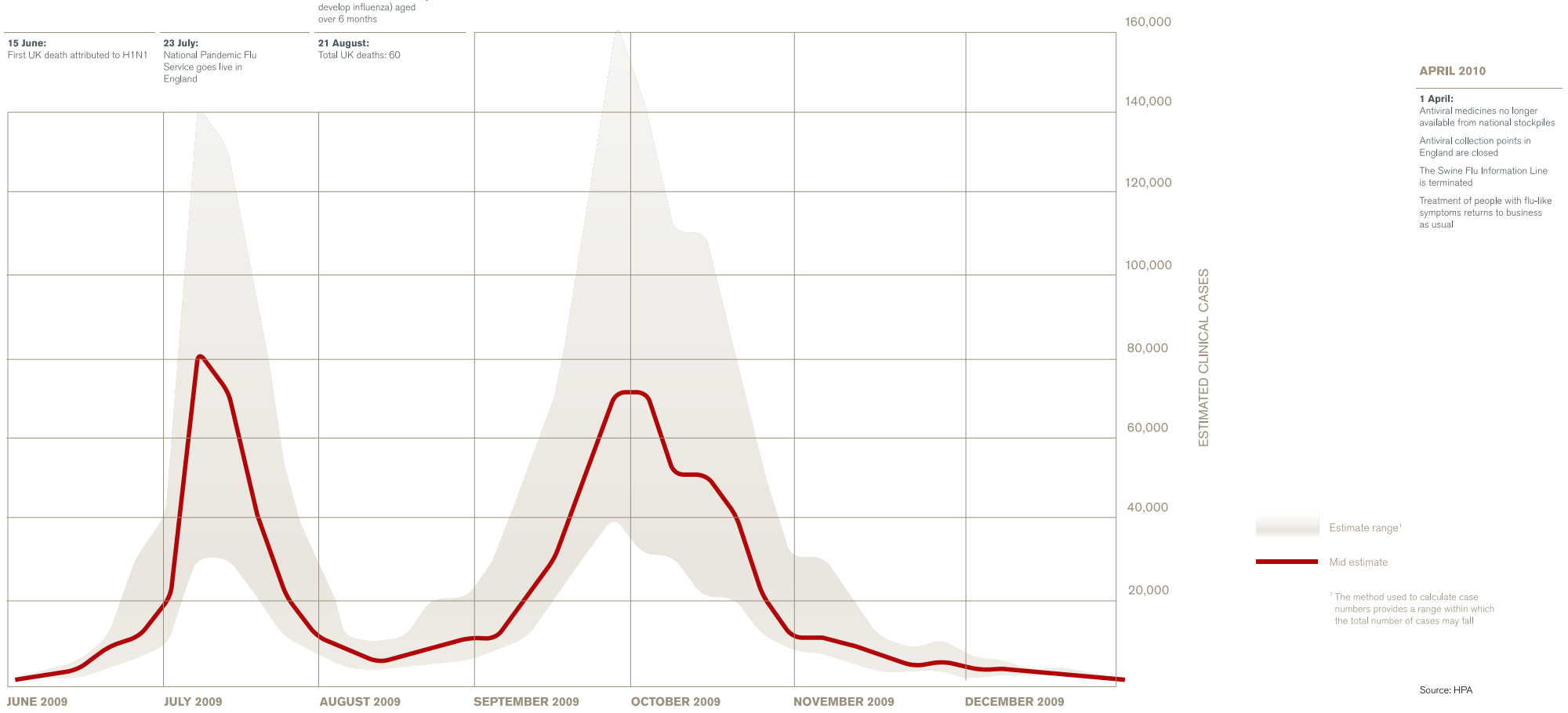
APRIL 2010

1 April:
Antiviral medicines no longer available from national stockpiles

Antiviral collection points in England are closed

The Swine Flu Information Line is terminated

Treatment of people with flu-like symptoms returns to business as usual

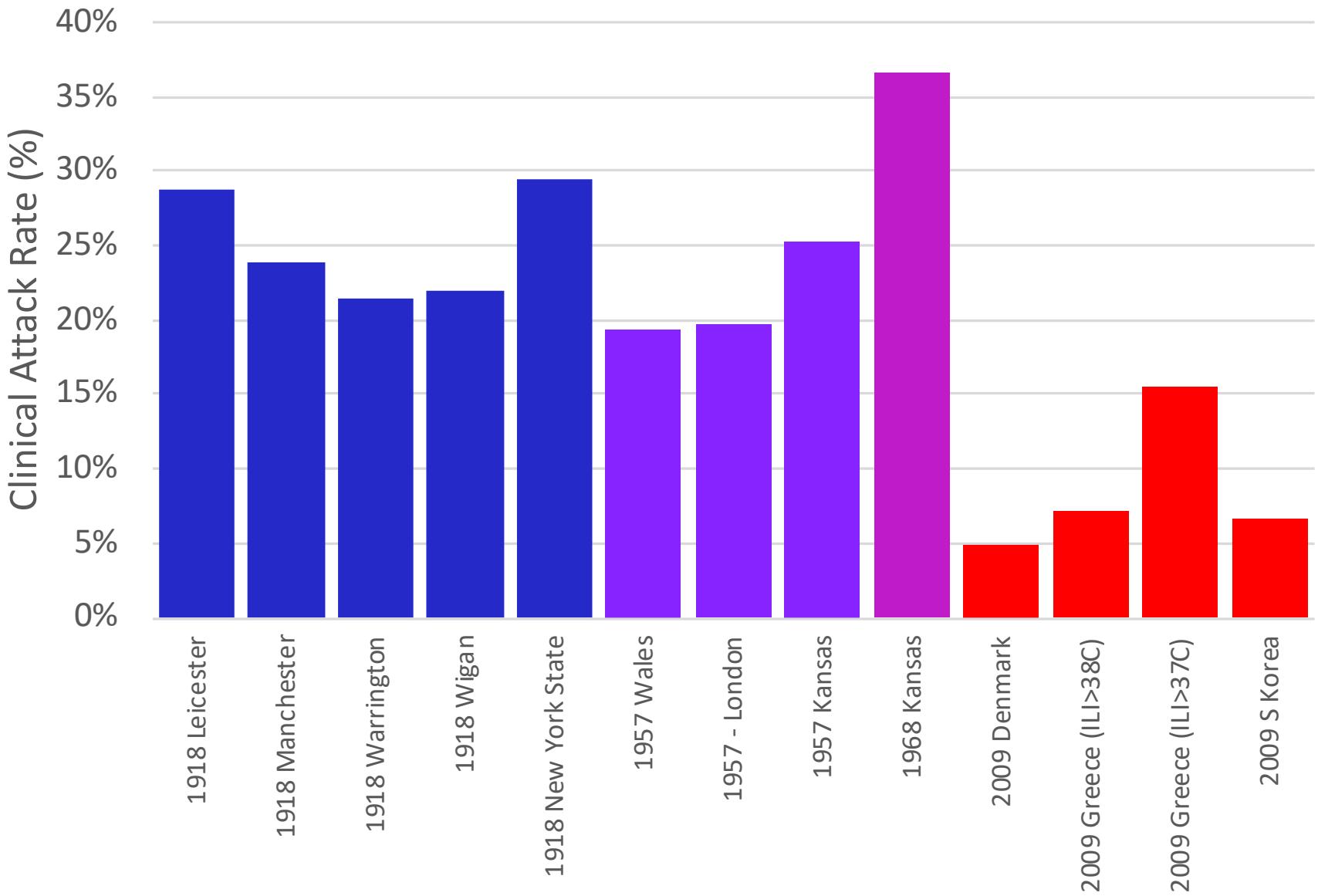


[1] The method used to calculate case numbers provides a range within which the total number of cases may fall

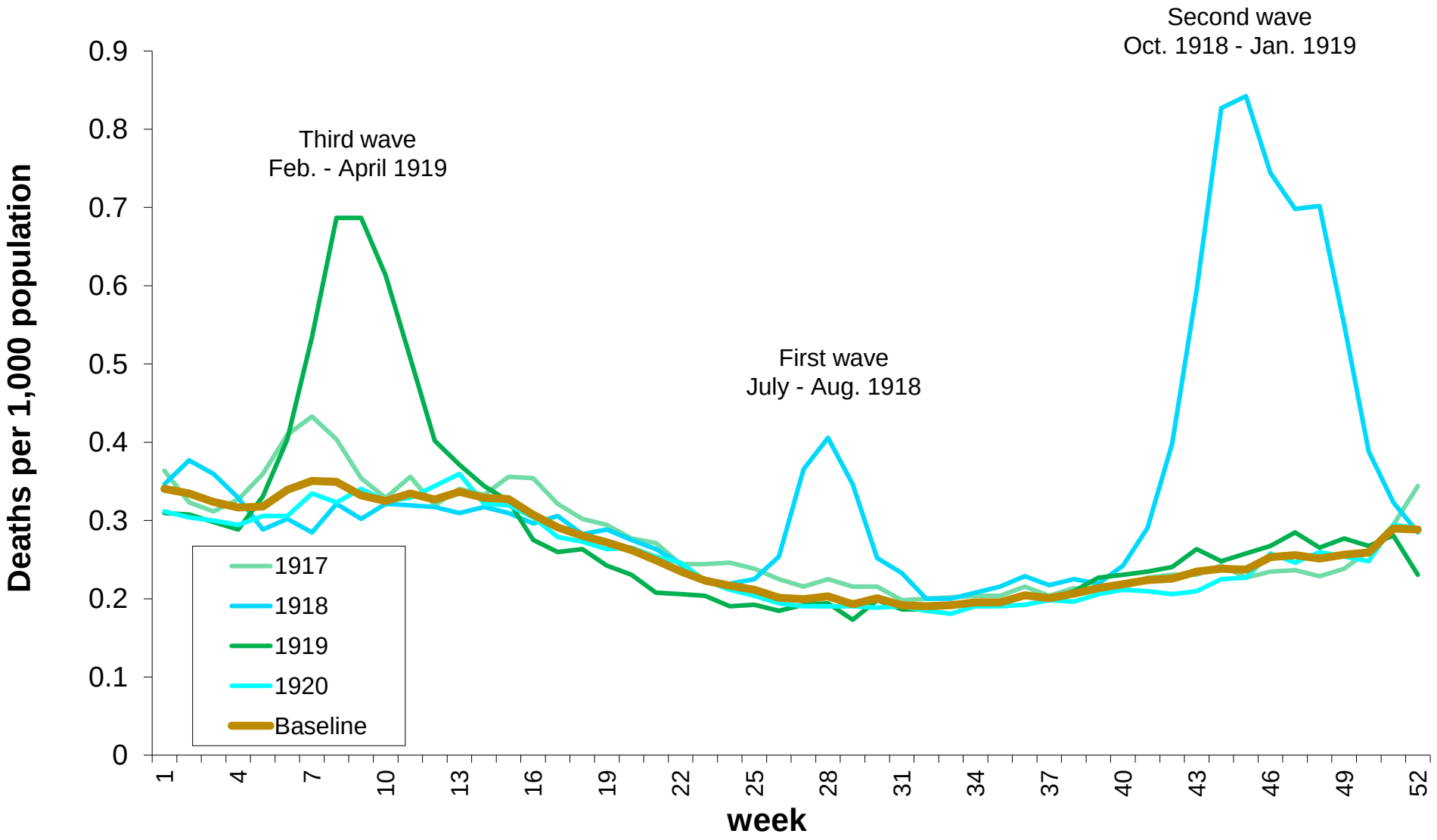
Source: HPA

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/61252/the2009influenzapandemic-review.pdf

Cumulative % of population that report being ill



“Excess” deaths



“Excess” deaths

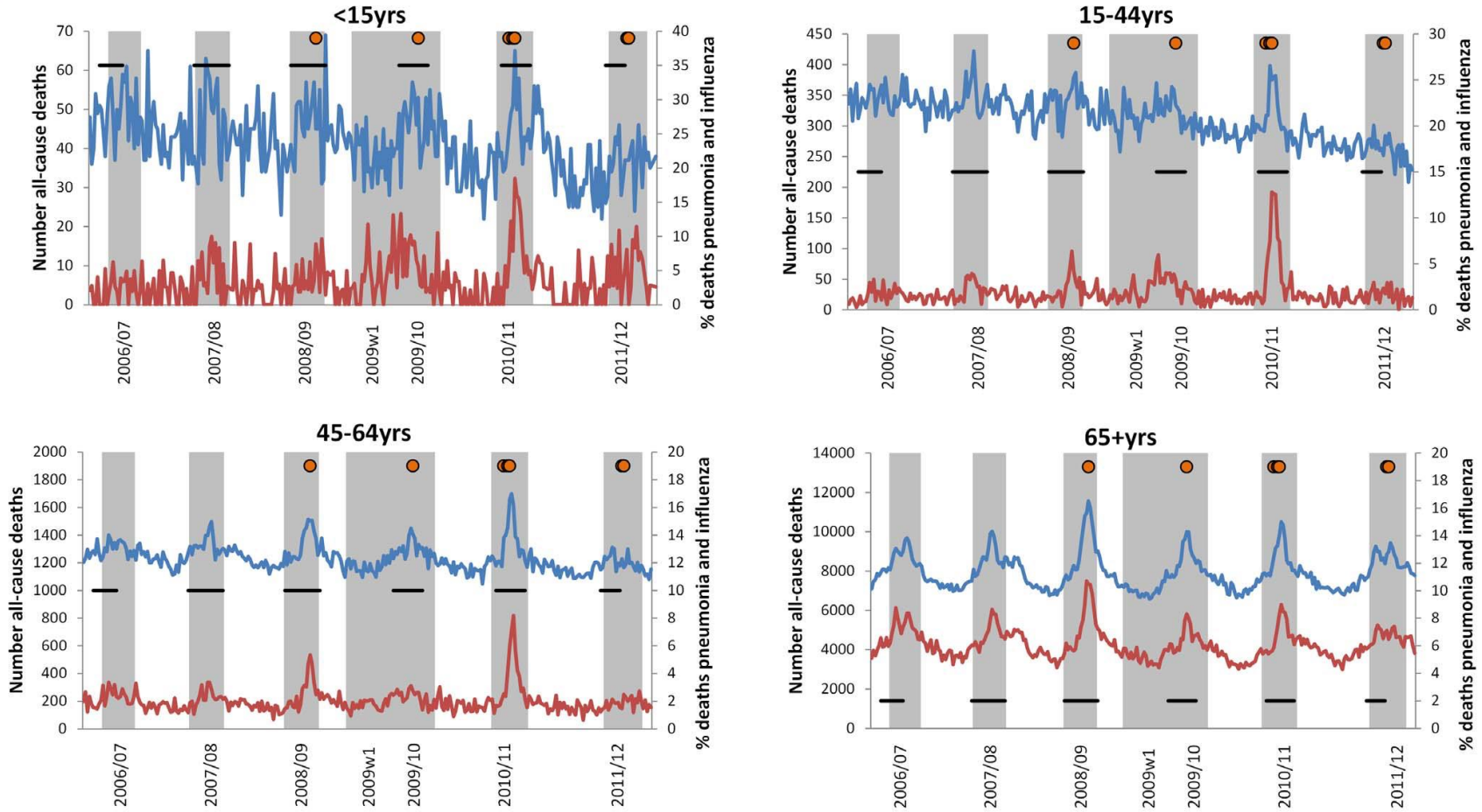
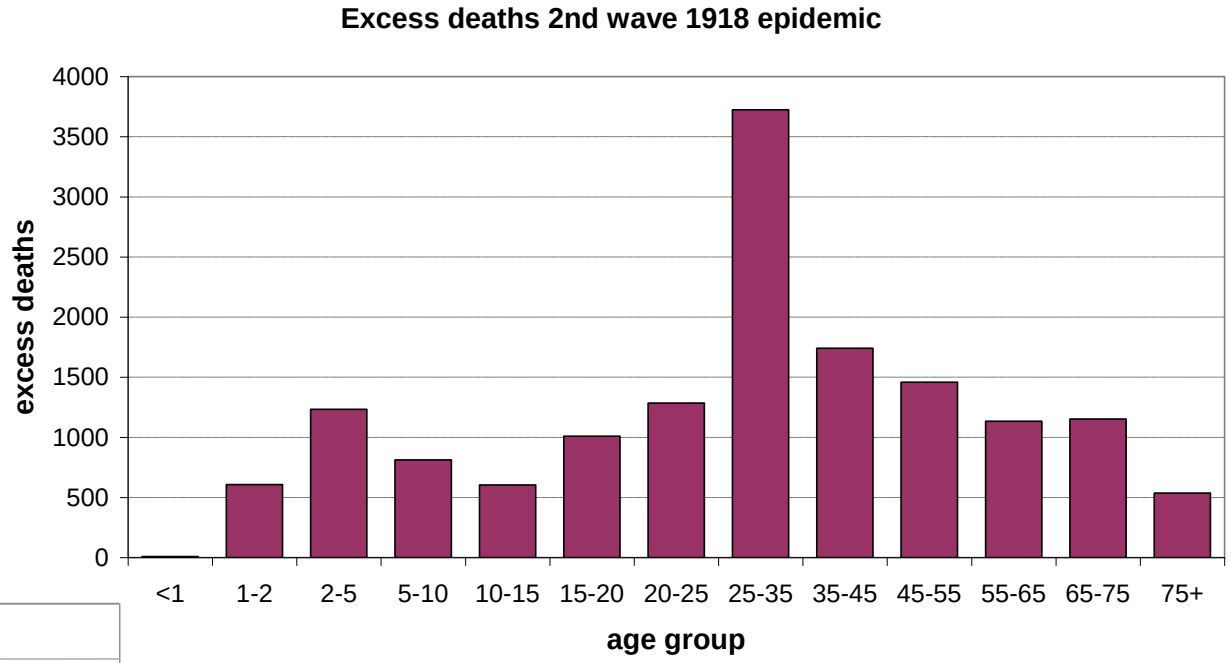


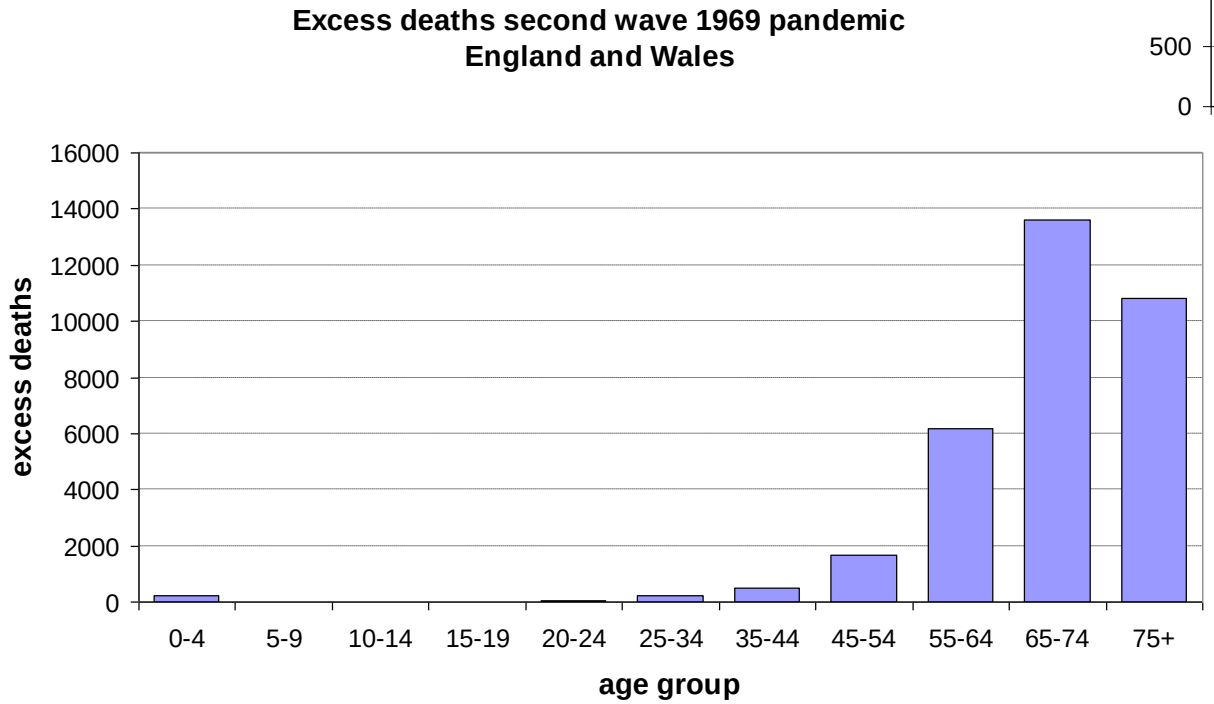
Figure 1. Weekly number of all-cause deaths by age group. The weekly numbers of all-cause deaths are blue and the proportion of those deaths classified as pneumonia and influenza (ICD-10 J9-J18) are red. Weeks shaded grey correspond to significant influenza activity, defined as an influenza incidence proxy (influenza-like illness consultation rates multiplied by proportion of samples positive for influenza) greater than 0 for three consecutive weeks. Horizontal black lines correspond to weeks with significant RSV activity, defined as a RSV incidence proxy (acute bronchitis consultation rates multiplied by proportion of samples positive for RSV) greater than 0 for three consecutive weeks. Orange circles correspond to weeks in which mean CET was below 0°C.
doi:10.1371/journal.pone.0079360.g001

~800 deaths in total associated with 2009 Pandemic (CI 0-2275)

Green et al.
PLoS One (2013)

Age-specific “excess” deaths





Estimated impact on the economy

Computable General Equilibrium Model, UK
Smith et al. Soc Sci Med (2011)

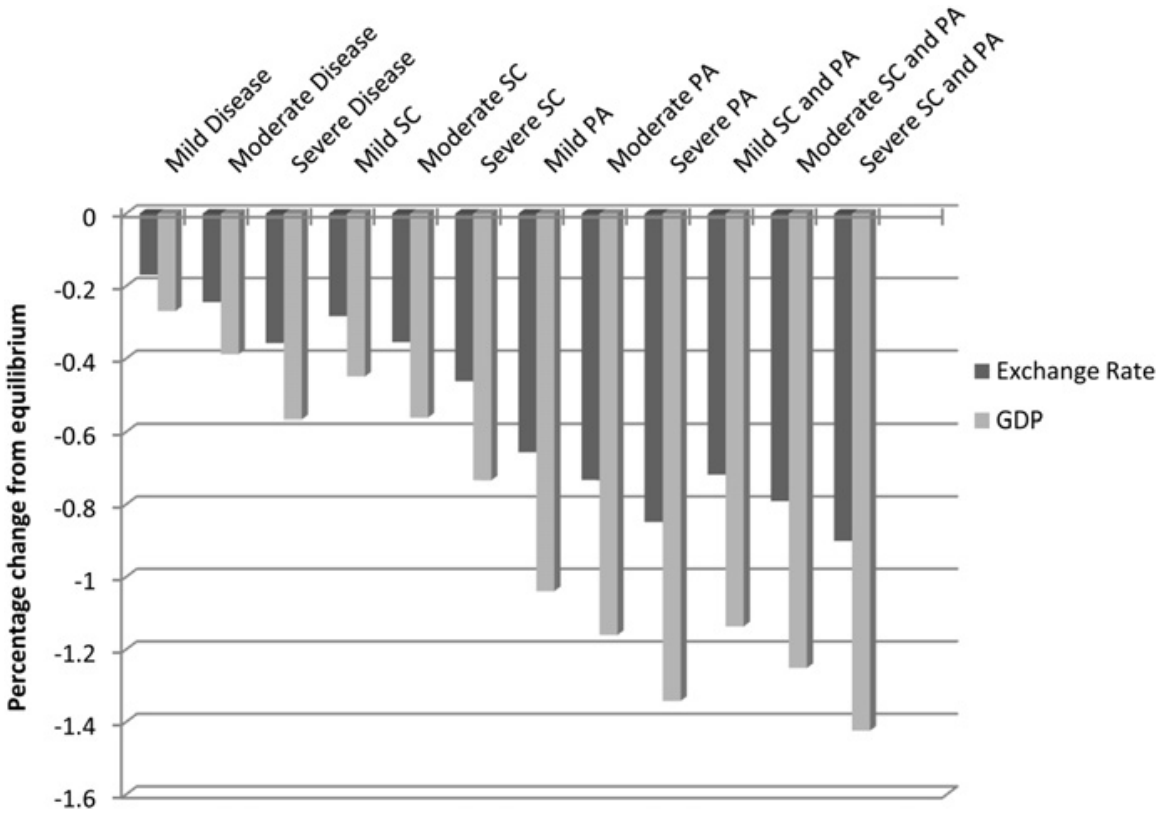
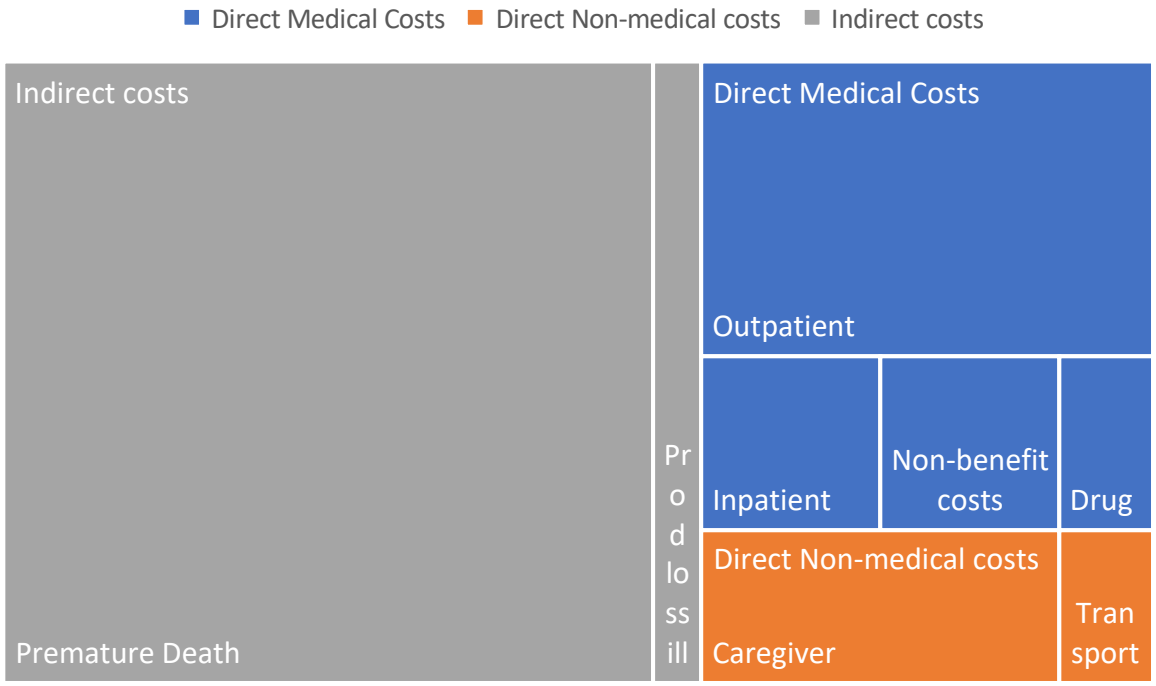


Fig. 1. Impact on GDP and exchange rate.

Universal Health Insurance Claims, Korea 2009
Kim et al. Scan J Inf Dis (2013)

Total estimated cost US$ 1091 million



Total = 0.14% of GDP
Overall CAR = 6.6%

Possible impact of mitigation strategies

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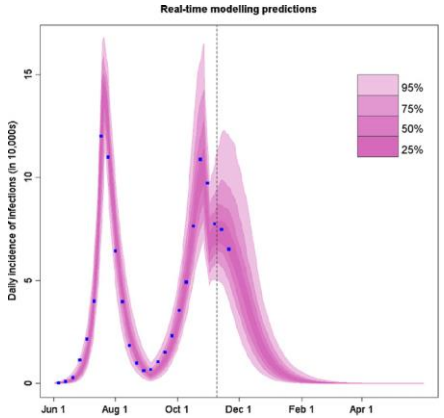
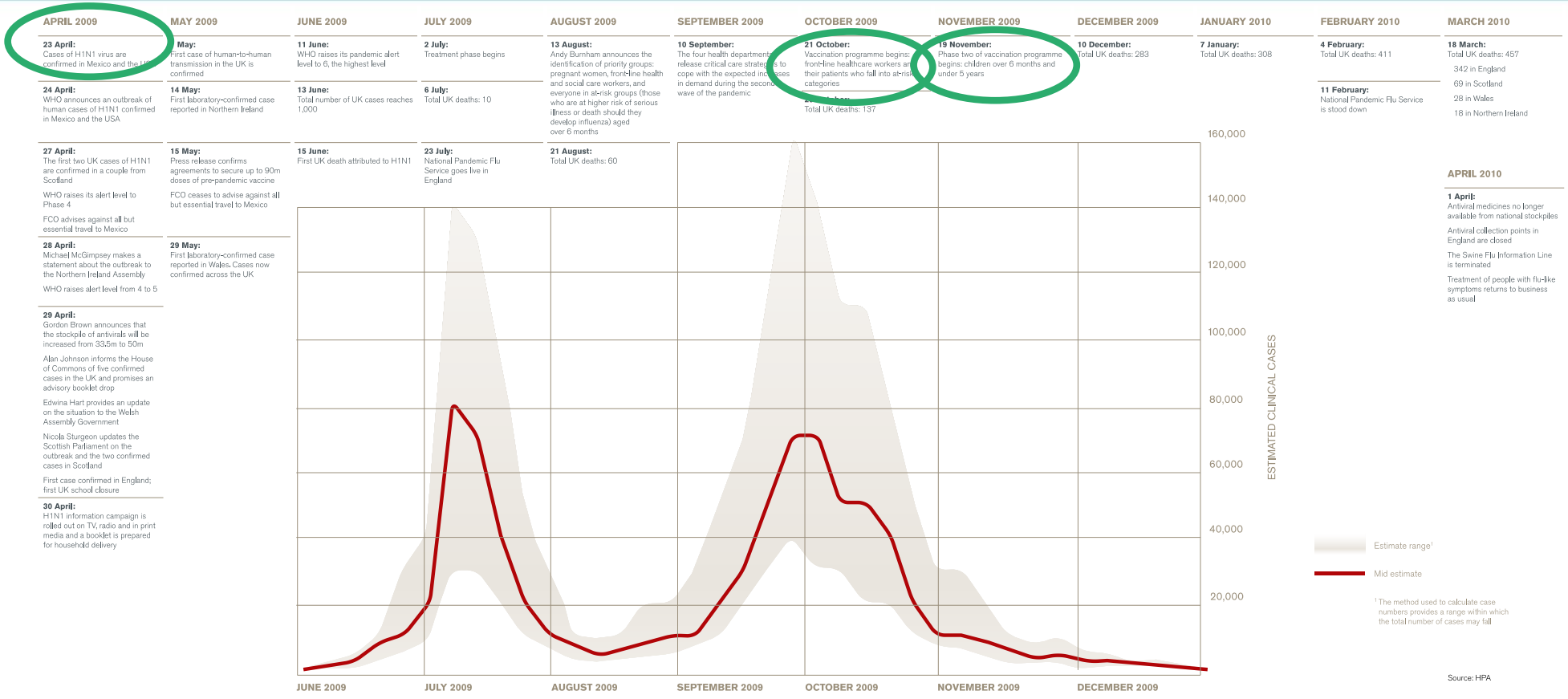
Vaccines: pandemic specific vaccine





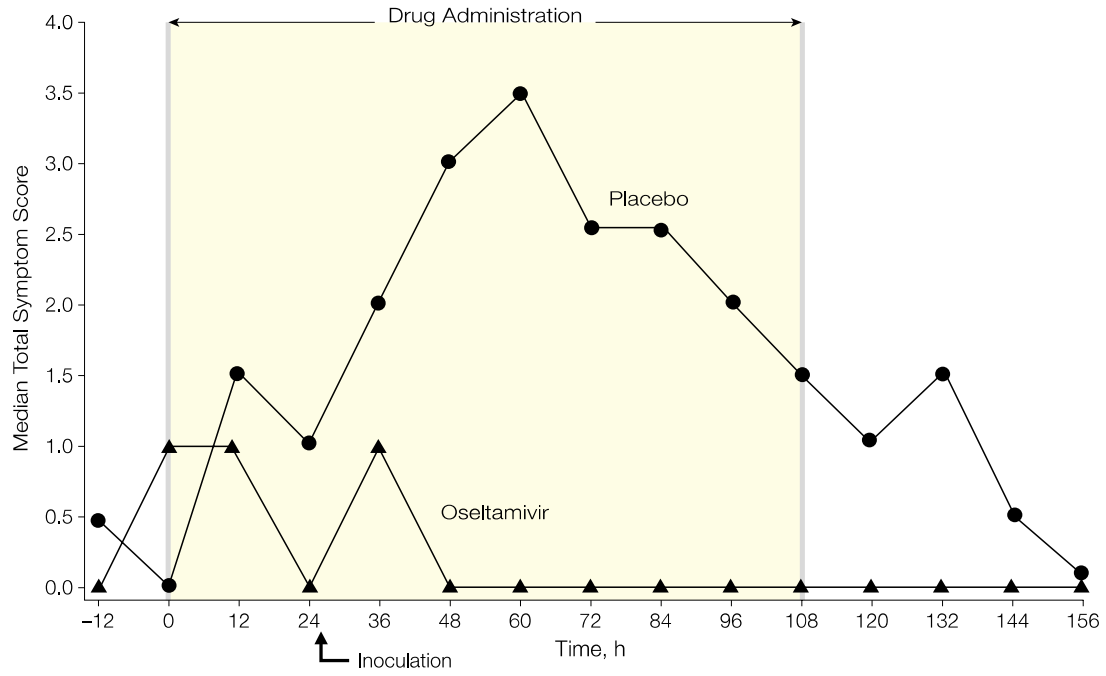
Groups to vaccinate	Only risk groups	Risk groups and 0–4 year olds	Risk groups and 5–14 year olds	Risk groups and 65+ year olds	Risk groups and 0–14 year olds	Risk groups and 0–14 and 65+ year olds
Number of cases prevented						
Mean	452,990	486,532	558,168	458,954	573,355	576,503
Median	422,175	448,900	511,930	427,119	524,127	526,817
10th centile	234,274	243,375	267,800	236,046	272,628	273,636
90th centile	710,252	777,693	908,364	721,682	938,357	944,056
Number of deaths prevented						
Mean	45	46	48	45	48	49
Median	43	44	46	43	46	46
10th centile	26	26	27	26	27	27
90th centile	67	68	72	67	73	73

Baguelin et al. Vaccine (2010)

Antivirals (neurominidase inhibitors): alleviation of symptoms

Hayden et al. JAMA (1999)

Figure 2. Effect of Oral Oseltamivir Prophylaxis on Illness Following Experimental Influenza A/Texas/36/91(H1N1) Inoculation



The total symptom score area under the curve value was lower in the combined oseltamivir groups (n = 21) compared with placebo (n = 12); *P* = .02. Fourteen symptoms related to influenza were included in the score.

Dobson et al. Lancet (2015)

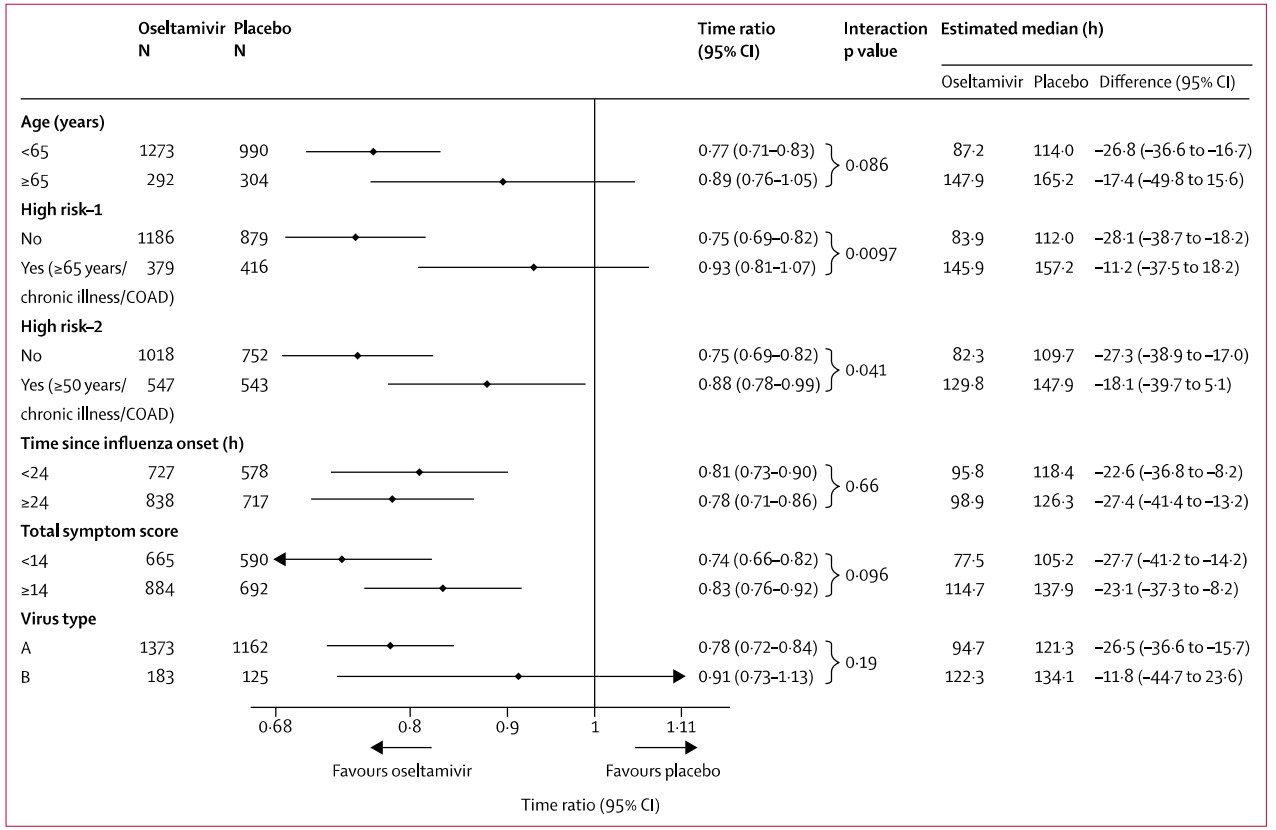


Figure 3: **Subgroup analyses for time to alleviation of all symptoms in the intention-to-treat infected population**
COAD=chronic obstructive airways disease. Estimated median (h)=estimated median time to alleviation of all symptoms from accelerated failure time model adjusted for trial. Diff (95% CI)=the difference in the estimated medians with bootstrap 95% CI.

ITT analysis: median times to alleviation = 97·5 h for oseltamivir and 122·7 h for placebo

Antivirals (neurominidase inhibitors): complications and hospitalisations

Dobson et al. Lancet (2015)

9 RCTs included in individual-level meta-analysis

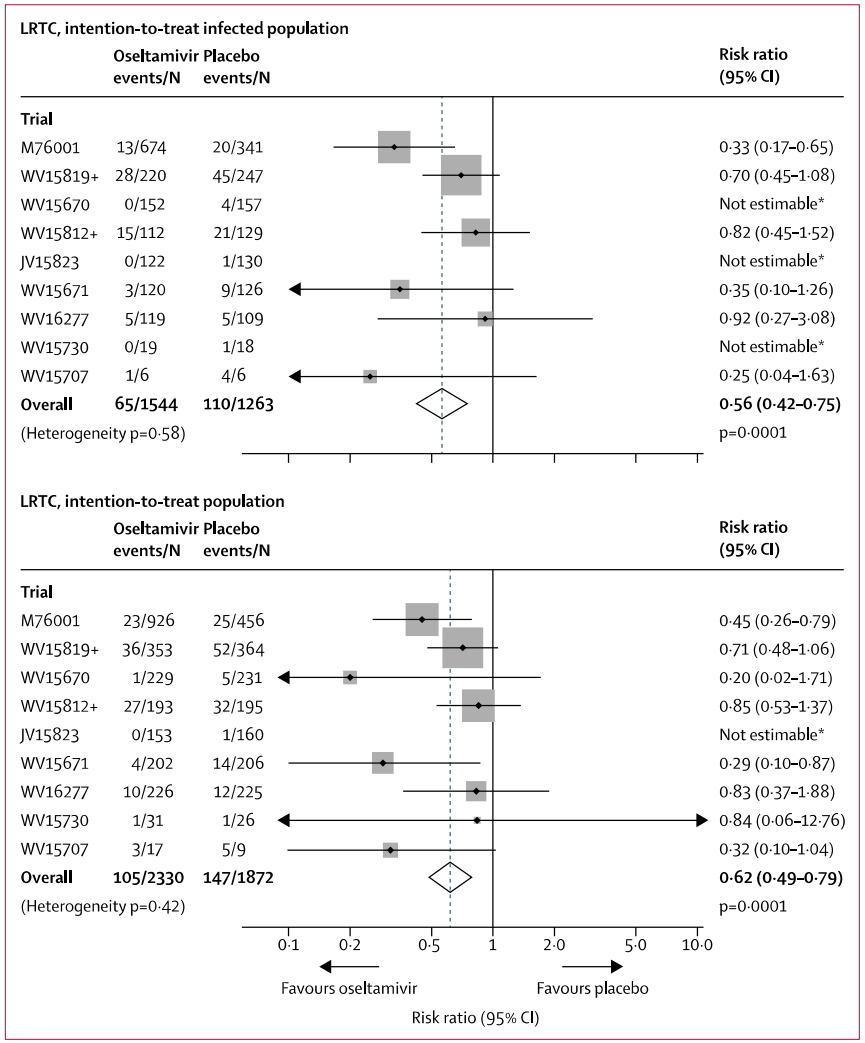


Figure 4: **LRTC, intention-to-treat infected, and intention-to-treat population**
LRTC=lower respiratory tract complications. Events=number of participants who had one or more events. *No events in oseltamivir group. The trial still contributes to the overall estimates.

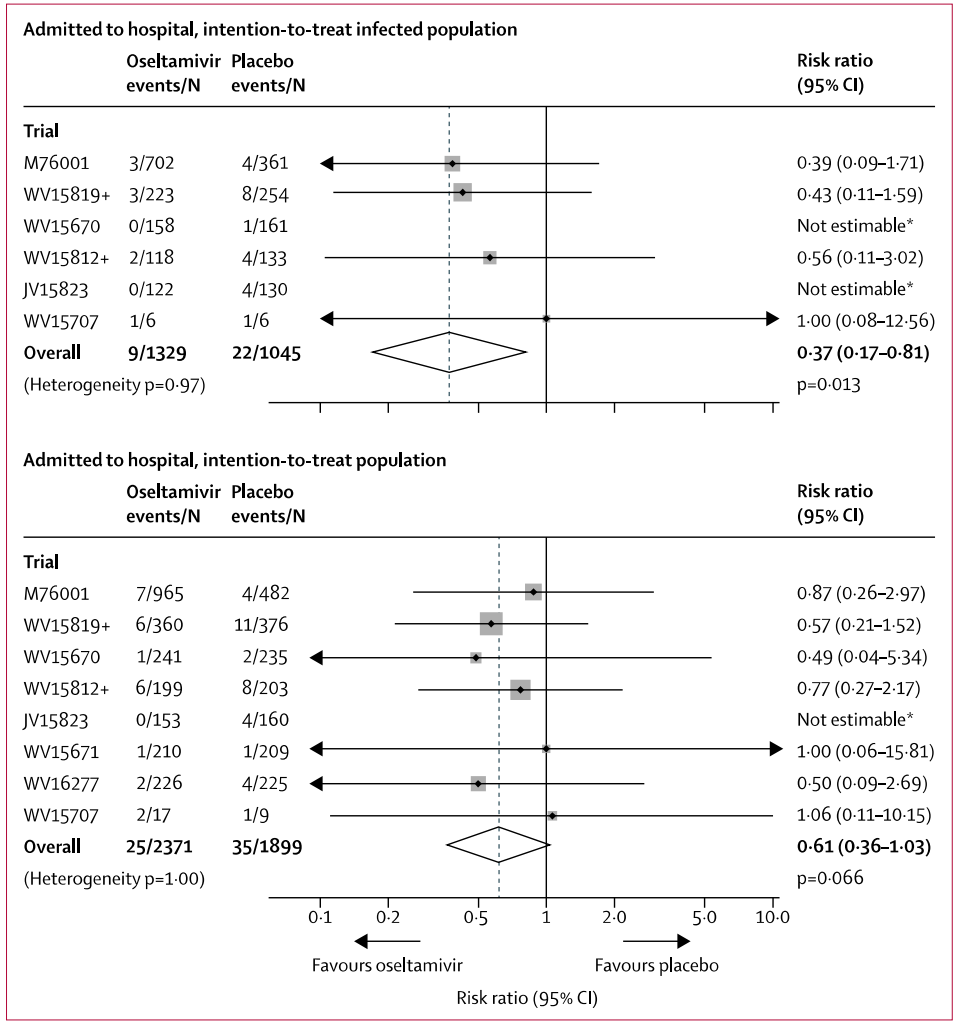
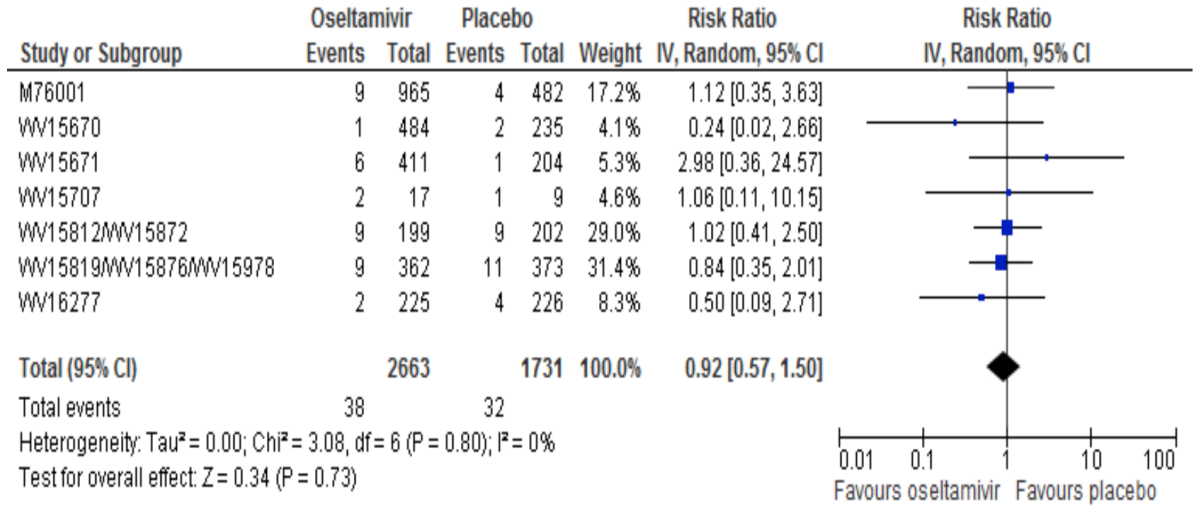


Figure 5: **Admittance to hospital, intention-to-treat infected, and intention-to-treat population**
Events=number of participants who had one or more events. *No events in oseltamivir group. The trial still contributes to the overall estimates.

Antivirals (neurominidase inhibitors): hospitalisations

Adults

Figure 5: Oseltamivir versus placebo for treatment. Hospital admission in adult treatment (safety population).

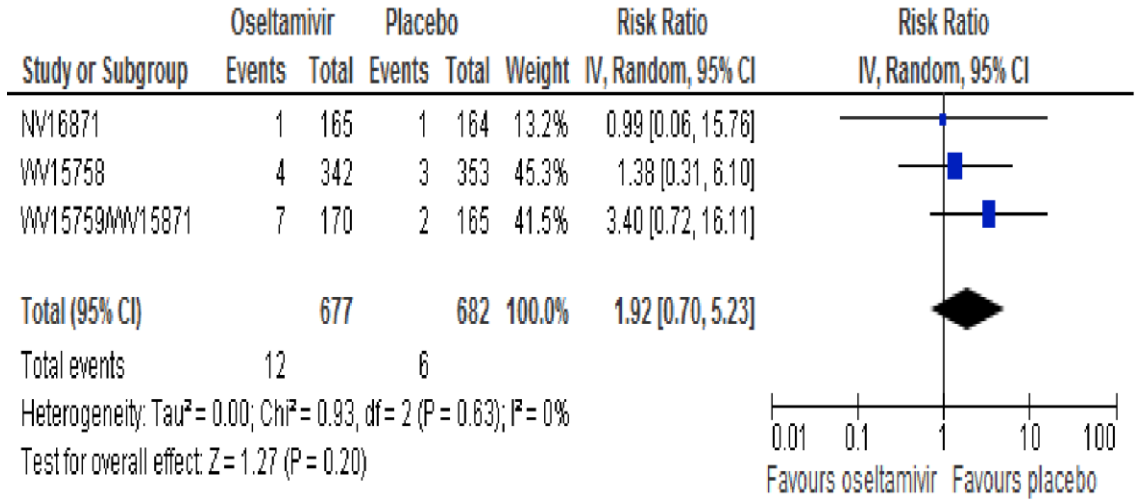


Jefferson et al. BMJ (2014)

20 RCTs included in individual-level meta-analysis

Children

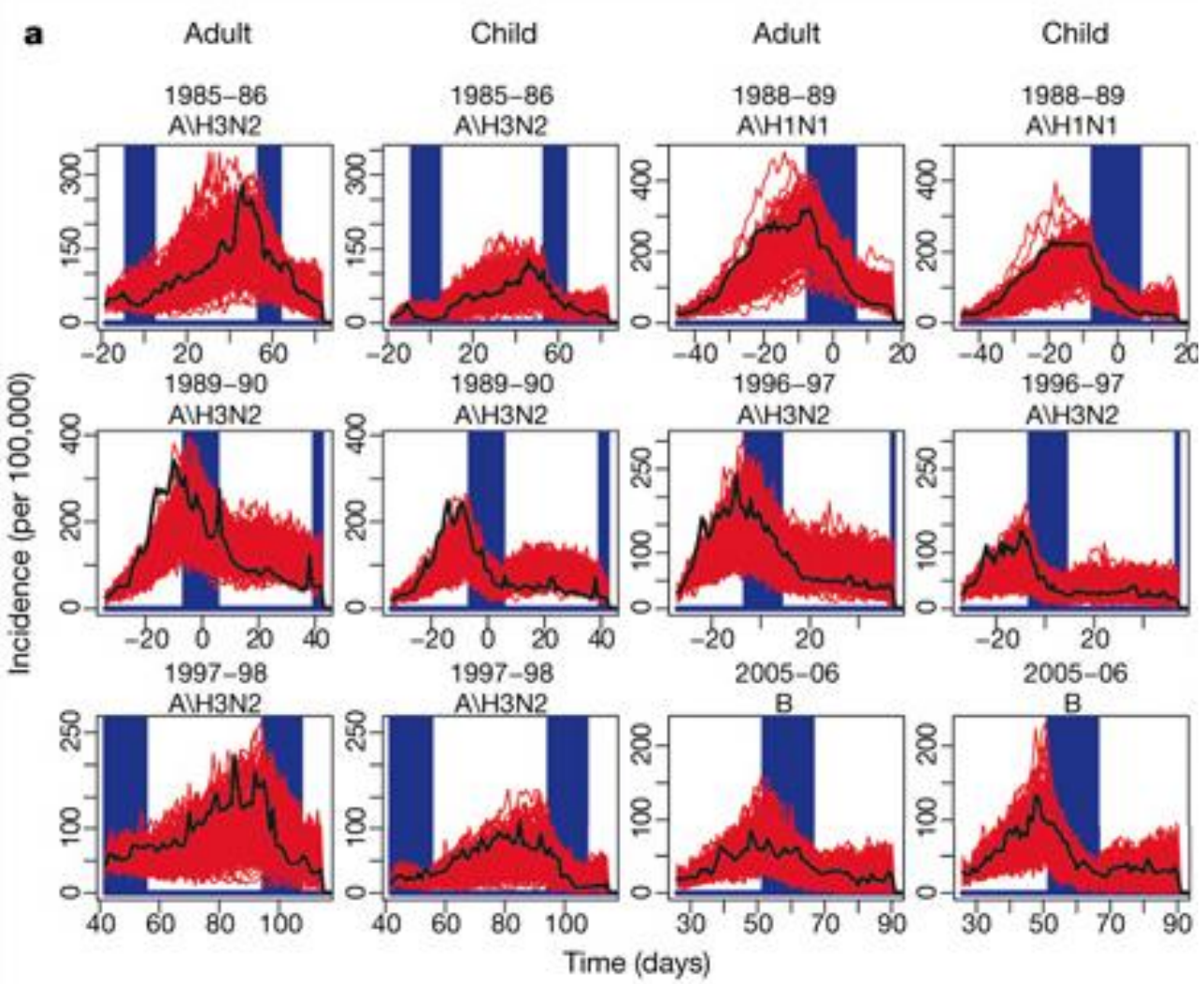
Figure 6: Oseltamivir versus placebo for treatment. Hospital admission in child treatment (safety population).



School closure

Prior to 2009 some data to suggest that mass school closure could interrupt transmission

- Teacher's strike
- Holiday periods
- etc



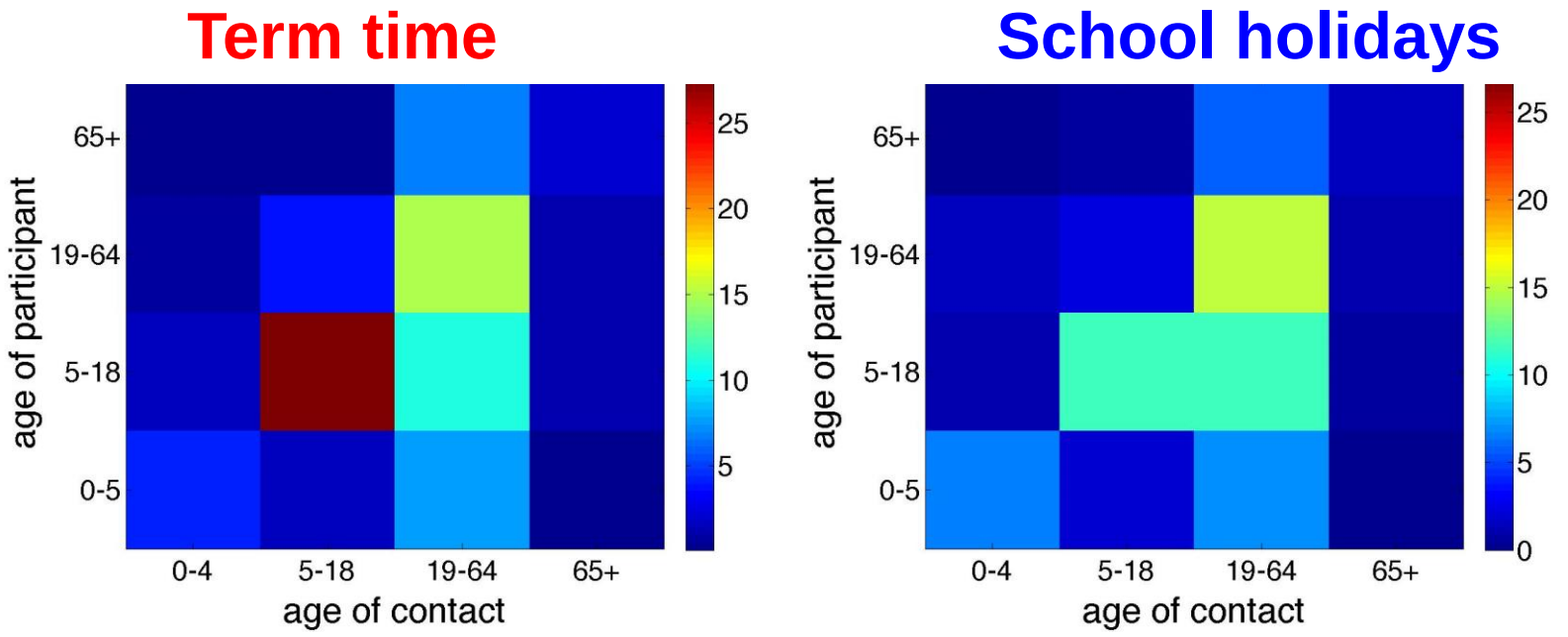
Cauchemez et al. (2008) Nature 452, 750-754

School closure & behaviour change: changes in contact patterns

Flusurvey is an online survey of influenza-like-illness, launched during 2009 pandemic

Participants asked to report # people met in previous day

Over 9000 reports during pandemic

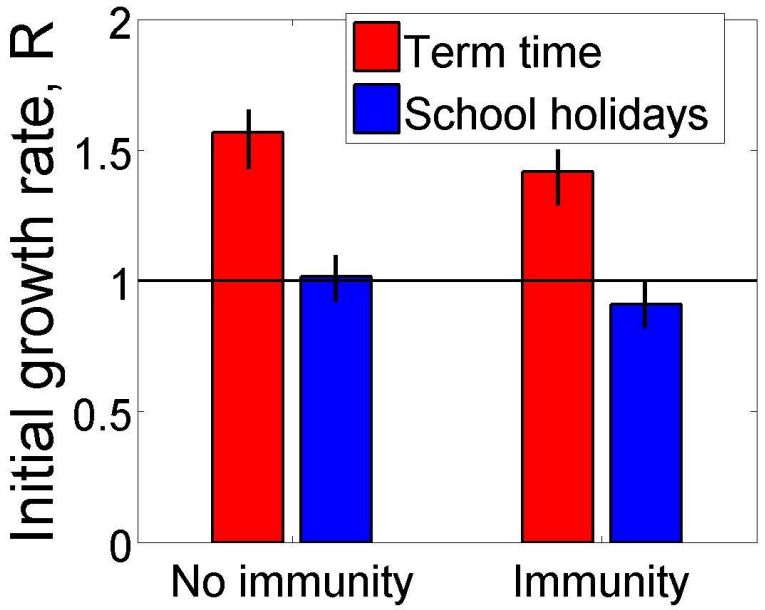


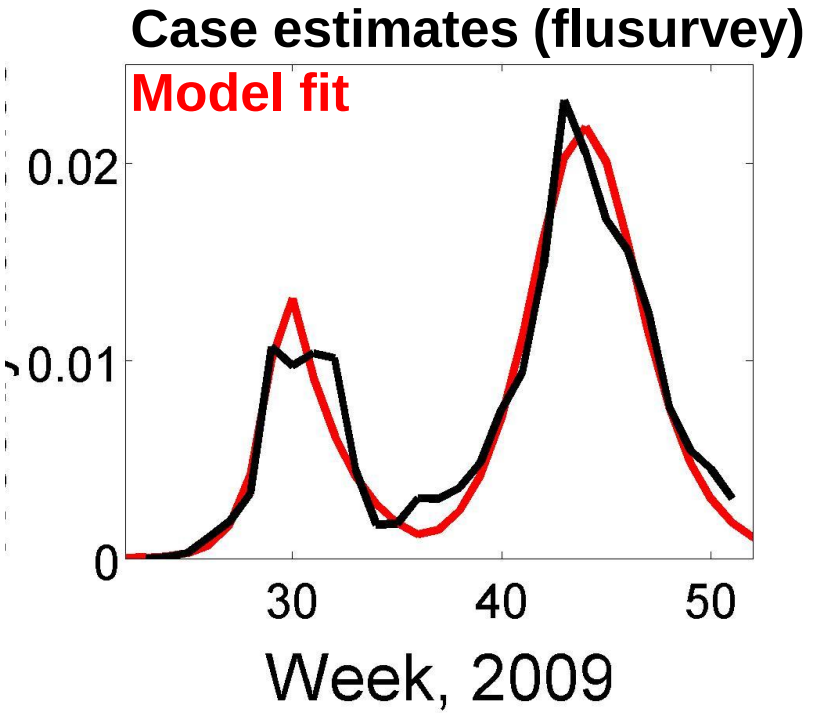
Eames et al. PLoS Comp Biol (2012)

School closure & behaviour change: changes in contact patterns

Fit age-structured model to incidence data

- transmission rate per encounter
- seeding of infection & holiday timing
- scaling factor for asymptomatic/mild





Eames et al. PLoS Comp Biol (2012)

Summary of interventions for pandemic flu

Vaccines

- Pandemic specific vaccines available too late to have major impact. APA in place.
- Pre-pandemic vaccines – need to guess the strain. Limited stockpile.
- Universal vaccines not available

Antivirals

- Probably effective at reducing illness and severe disease. Stockpiled.

School closure

- Probably effective at delaying an epidemic, but very disruptive and costly

Antibiotics

- Probably effective at preventing some mortality and morbidity. Buffer stocks.

Travel restrictions

- Probably ineffective and very disruptive.

Mask wearing by the public

- Probably limited or no impact.

Other pandemic threats

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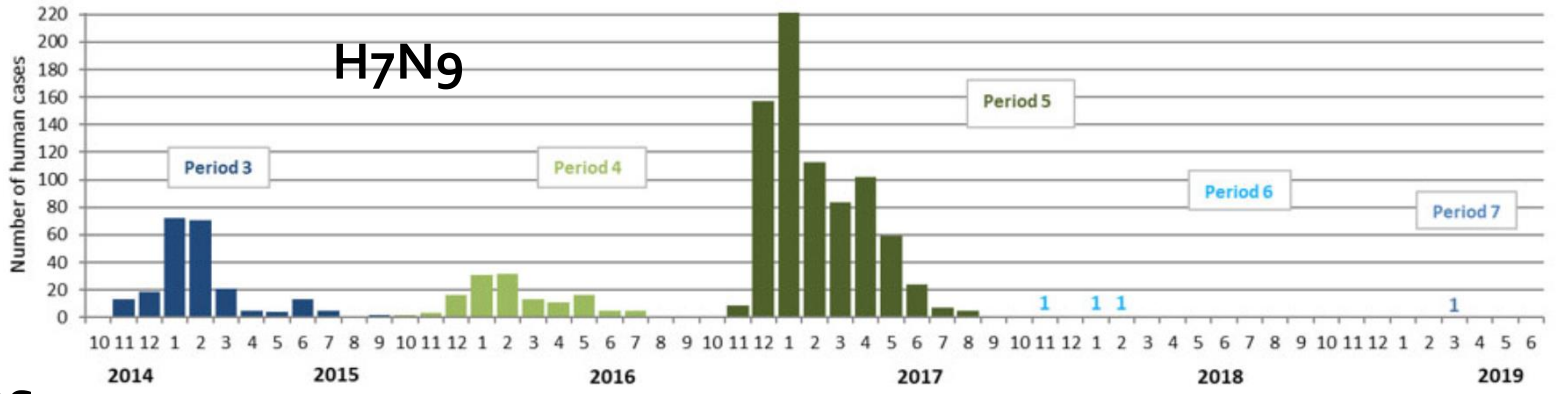
Other pandemic threats: respiratory and close contact

Avian and swine influenzas

- Significant risk
- Monitored



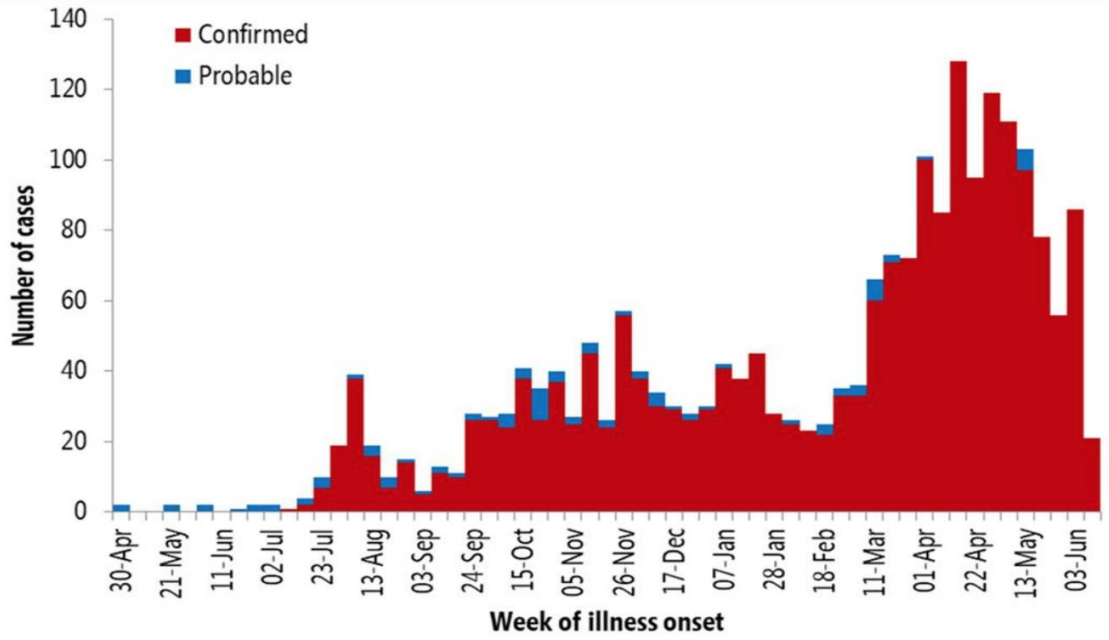
http://www.fao.org/ag/againfo/programmes/en/empres/h7n9/img/wave_7/fig5_2019_06_05.jpg

Other respiratory viruses, such as coronaviruses e.g. SARS and MERS, adenoviruses, enteroviruses, etc

- Significant risk

Other close contact, highly pathogenic viruses, e.g. Ebola, Nipah etc.

- Heightened awareness & surveillance
- New vaccines, antivirals being developed
- **Instability increases risk**

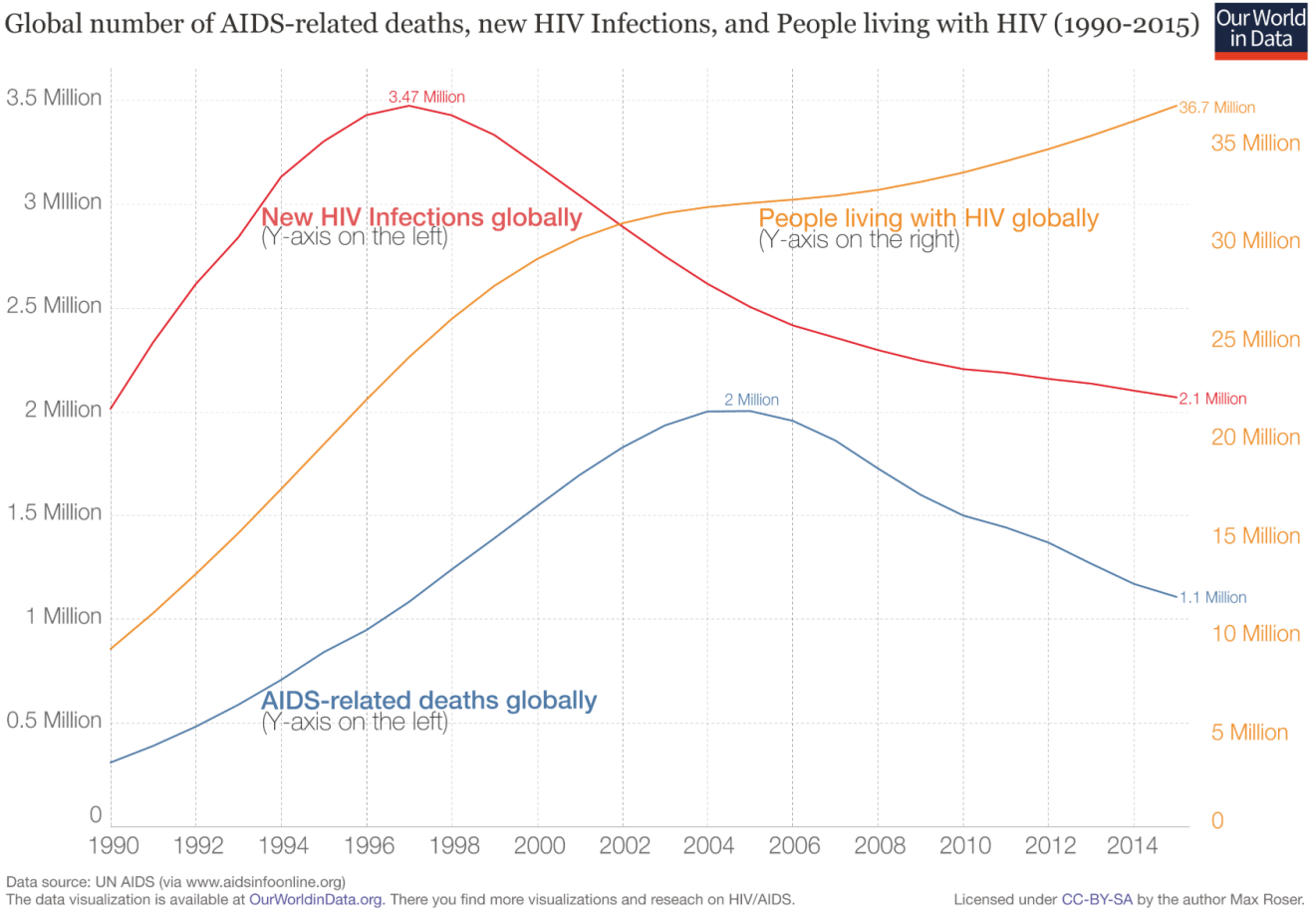


https://apps.who.int/iris/bitstream/handle/10665/325242/SITREP_EVD_DRC_UGA_20190612-eng.pdf?ua=1

Other pandemic threats: sexual and blood-borne

Virus

- HIV-like?

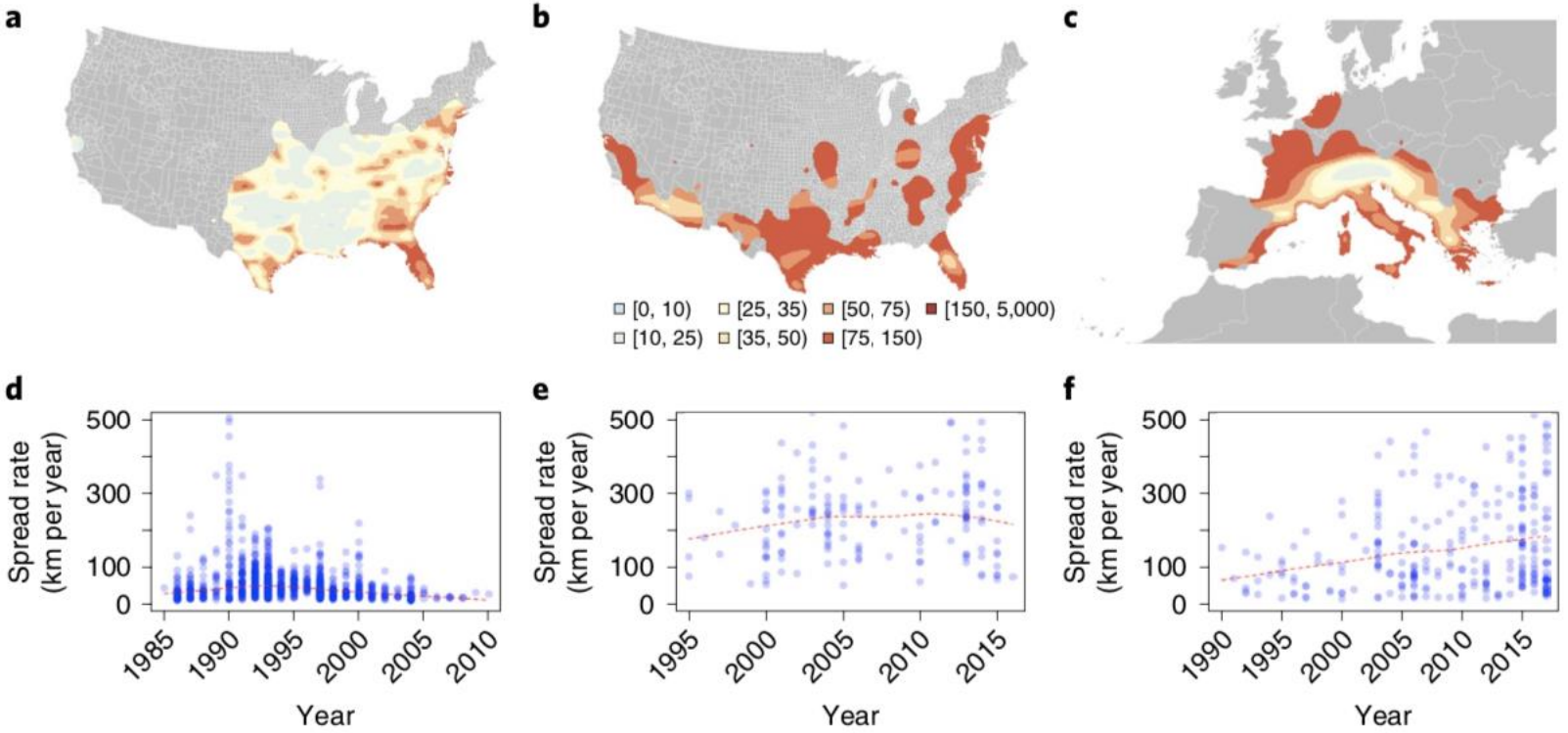


https://ourworldindata.org/uploads/2013/11/HIV-AIDS.png

Bacteria

- Antibiotic resistant gonorrhea

Other pandemic threats: vector-borne diseases



Cases of dengue have doubled every decade since 1990, with 58·4 million in 2013.

Lancet Countdown (2018)

Fig. 1 | Reconstruction of *Ae. albopictus* and *Ae. aegypti* spread. a–c, Spread of *Ae. albopictus* (**a**) and *Ae. aegypti* (**b**) in the United States, and spread of *Ae. albopictus* in Europe (**c**). Estimates of speed of spread in km per year are based on thin spline regression on mosquito observations since their earliest detection in each continent. Red indicates fast dispersal whereas yellow and white indicate slower spread velocity measured in km per year (see legend below **b**). Areas highlighted in grey have no reported mosquito presence. **d–f**, Summaries of the speed of dispersal of *Ae. albopictus* (**d**) and *Ae. aegypti* (**e**) spread in the United States and of *Ae. albopictus* spread in Europe (**f**) starting from their date of first detection until 2017. The red line indicates the average velocity per year across all districts using the thin spline regression model.

Kraemer et al. Nature Microbiology (2019)

Pandemics: changing risks?

- **Influenza**
  - Risk of pandemic largely unchanged
  - No significant new technologies over last 10 years, no new technologies on horizon
- **Other respiratory / close contact viruses**
  - Highly likely to lead to future pandemics: risk increasing due to interconnectedness
  - Fewer countermeasures
- **Other highly-pathogenic direct-contact viruses, e.g. Ebola**
  - Heightened awareness and new countermeasures being developed
  - Health system failures are the greatest risk
- **HIV**
  - Huge gains over the last 10-20 years. Sustainable?
- **Vector-borne diseases**
  - **Arboviruses**: pandemics occurring at the moment (zika, chikungunya) and others expanding range (dengue, yellow fever?)
    - Difficult to control, vaccines being developed for some
  - **Malaria**: huge gains over recent years, stalled partly due to increasing resistance