Real-time mortality monitoring in England and Wales

Pia Hardelid

Statistics Unit, HPA Centre for Infections

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Outline

Background

Mortality data flow

Rapid system for monitoring weekly mortality

Results from mortality monitoring

Retrospective attribution of weekly deaths to various causes

Background

- Mortality is a key indicator of the severity of important health threats such as pandemic influenza, or extreme cold or heat
- Timely monitoring of mortality is therefore important to rapidly assess public health impact
- In response to H1N1 pandemic, HPA developed new system of age-specific mortality monitoring system using weekly data received directly from General Registry Office (GRO).

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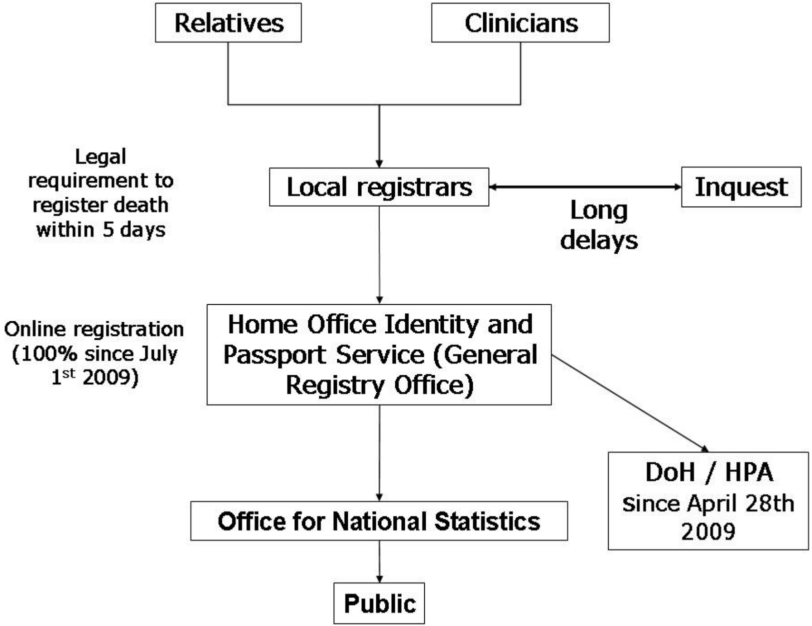
Reporting structure for deaths



Mortality data provision 2009-2010

- Prior arrival of pandemic influenza H1N1, only all-cause, all-age mortality data by date of registration was available, with a two week delay.
- From April 2009, all deaths reported from registry offices to Home Office IPS using an online system (RON) sent to HPA daily with one day's delay
- At end of April 2009 60% of deaths registered in RON, by 1st July 2009 100% of deaths on RON
- Receive counts of death registered by age, registration district and day of death

Rapid system for monitoring weekly mortality

- Data monitored weekly on Wednesday (i.e. all registrations by the Tuesday).
- This allows deaths occurring during the weekend (and bank holiday Mondays) to be registered.
- Daily deaths collated by ISO week and age group ($<$1, 1-4, 5-14, 15-24, 25-44, 45-64, 65+), corrected for reporting delay and compared against baseline
- Weekly report produced
- Procedure largely automated using STATA, R and LaTeX

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Estimating baseline mortality

- Deaths registered between 1999 and 2008 by age and date of death used to estimate baseline
- Poisson regression models with cyclical terms (similar to method suggested by Serfling, 1960) fitted:

$$\ln(y_i) = \beta_0 + \beta_1(week_i) + \beta_2(\sin \frac{2\pi(week_i)}{52}) + \beta_3(\cos \frac{2\pi(week_i)}{52}) + \epsilon_i$$

Options for excluding previous periods of high mortality

- Exclude years with influenza epidemics (suggested by Serfling)
- Exclude deaths during summers and winters
- Exclude weeks with high influenza activity (previous HPA method)
- Downweight observations according to size of Anscombe residuals (suggested by Farrington et al, 1996):

$$weight_i = \begin{cases} r_{Ai}^{-2} & \text{if } \mid r_{Ai} \mid > 1 \\ 1 & \text{otherwise} \end{cases}$$

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Calculation of baseline and predicition intervals

- Downweighting of residuals and model refitting was carried out twice
- Standard errors were rescaled if overdispersion present
- 99% prediction intervals estimated (Farrington et al, 1996):

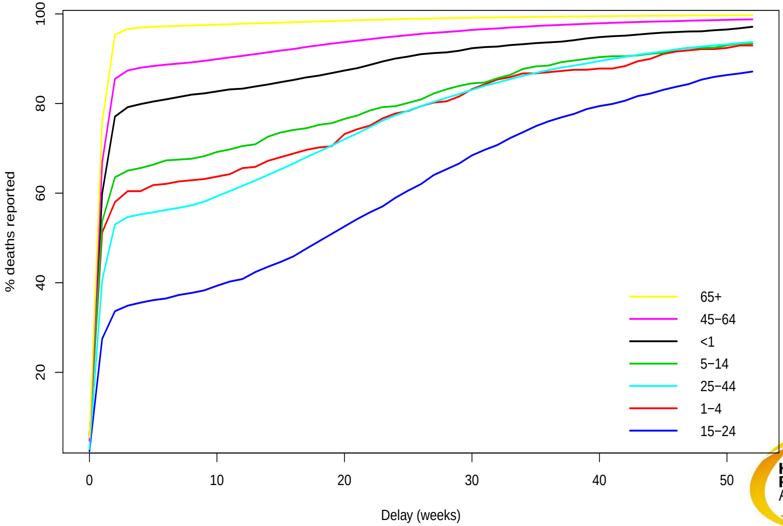
$$p_{99i} = (y_i^{2/3} + 2.58 * (\frac{4\,y_i^{1/3}}{9} * (\vartheta + y_i \epsilon_i^2))^{1/2})^{3/2}$$

- Any observed death count > prediction interval is in exceedance

Reporting delays

- Delays vary greatly by age
- In the short term they also depend on the day of the week of death (weekend effect) and holidays.
- Deaths either get reported within about 10 days or they fall into a group that can take many months (coroners' inquests).

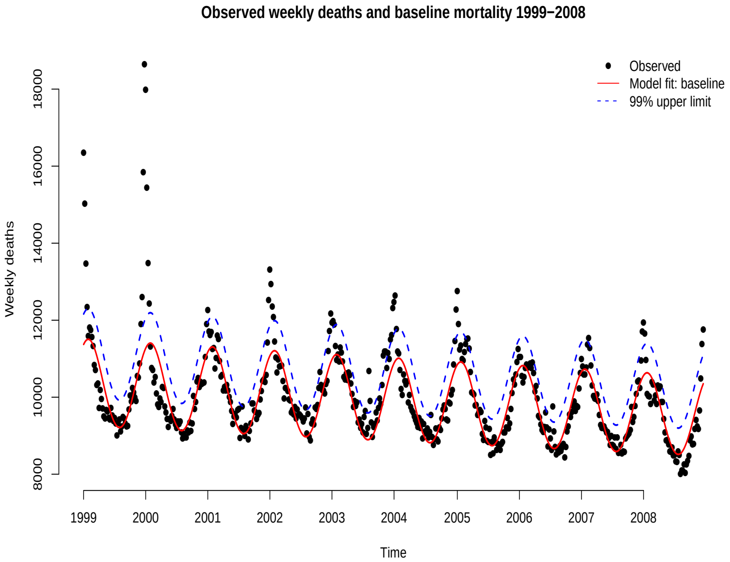
Reporting delay distribution



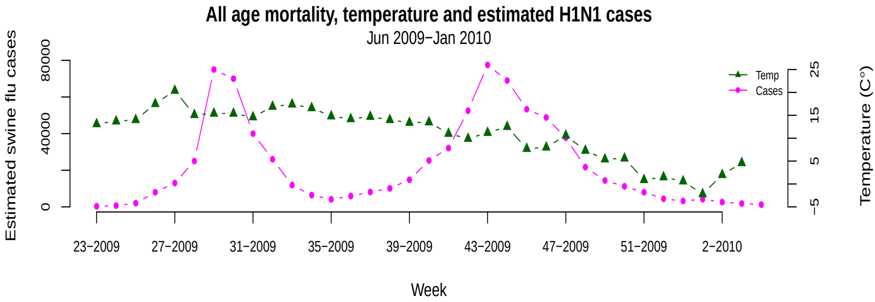
Dealing with reporting delay in observed weekly mortality data

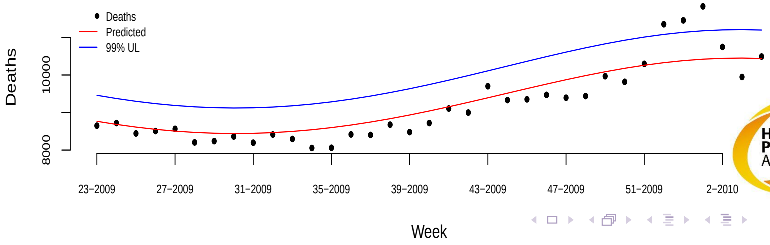
- Observed delay distribution by age group is calculated weekly every Wednesday with reference to deaths occurring in week 1 being reported by Tuesday week 2. All deaths assumed to have been reported by 2 years
- Adjust observed deaths using observed delay distribution
- Upper prediction limit of baseline also adjusted for uncertainty due to reporting delay

Mortality baseline



Findings from mortality monitoring 2009/2010





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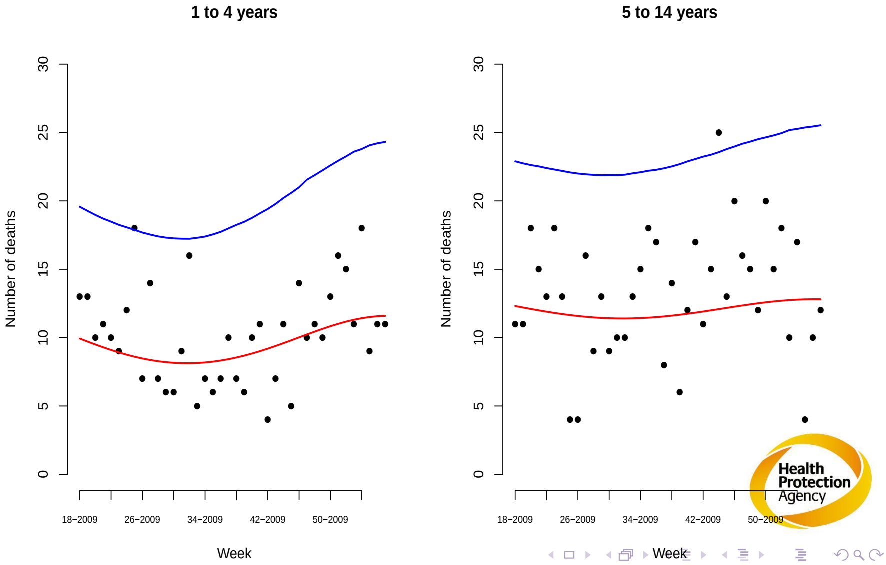
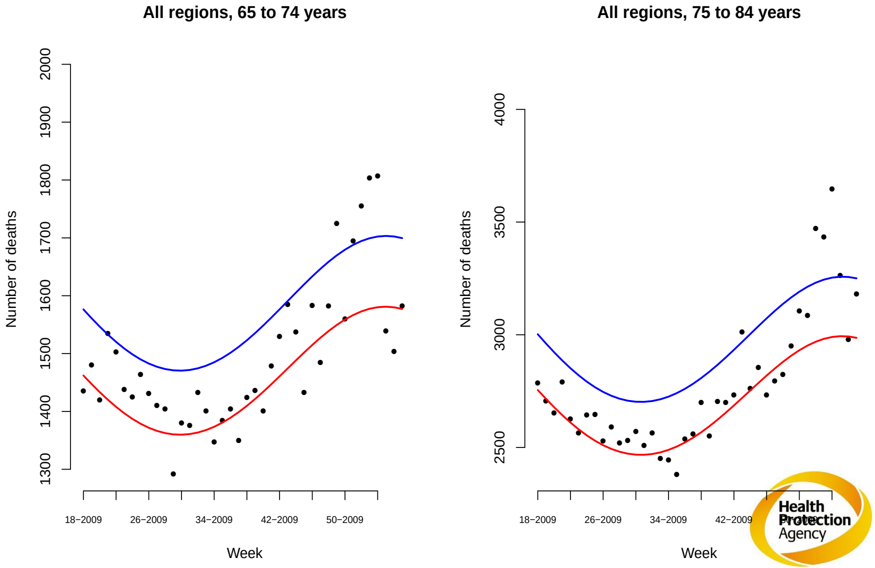
Observed mortality by age group: children 1-14 years (highest H1N1v incidence)



Mortality by age group: 65-74 years



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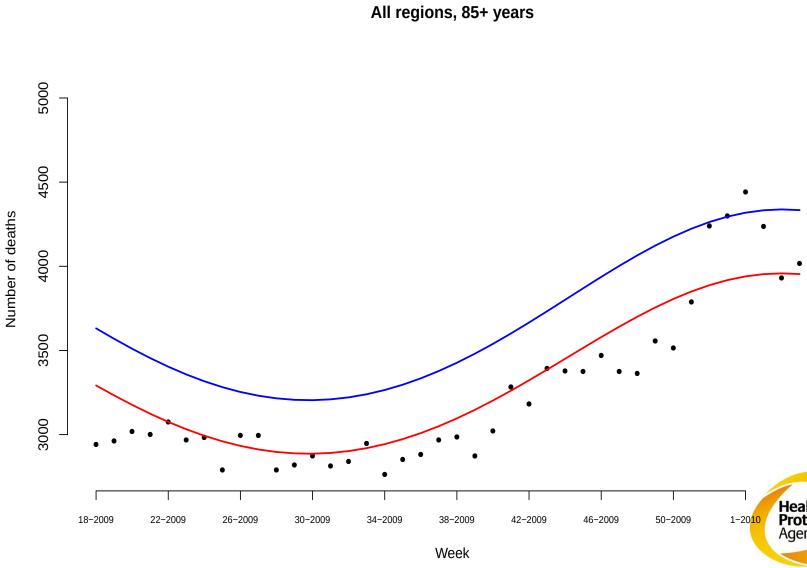
Mortality by age group: 85+ years



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Further work

- Daily model (more useful during heatwaves)
- Use of CUSUM, to detect smaller but sustained shifts from baseline
- Evaluate differences between using date of death vs. date of registration in models
- Attribution of excess at end of season

Retrospective attribution of weekly deaths to various causes

- Not possible to specify cause of excess mortality using current monitoring system
- Parliamentary questions and queries from Chief Medical Officer following high mortality observed during 2008/9 winter

Data sources

- Weekly mortality data by date of death from Office for National Statistics 1999-2008
- Central England Temperature data (daily mean, minimum, maximum) converted to weekly time series
- Counts of positive isolates from laboratory surveillance for influenza A, B and RSV (note: no denominators)

Suggested method

- Negative binomial GLMs with identity link function fitted with all-cause, all-age mortality by week of death for whole country as dependent variable
- Year (as categorical variable) temporal trend
- Temperature fitted as linear spline, with 4 d.f (pre-specified knots to indicate temperature above and below which mortality increases)
- Counts of positive flu A, flu B and RSV specimens fitted as linear terms with lags up to three weeks and interaction terms with year
- Week number fitted as cubic spline with 9 d.f. (unexplained seasonality)

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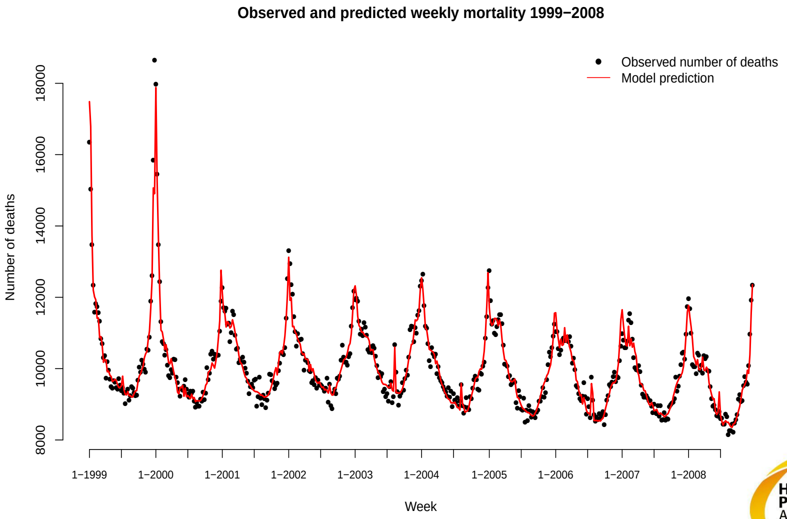
Results - model fit



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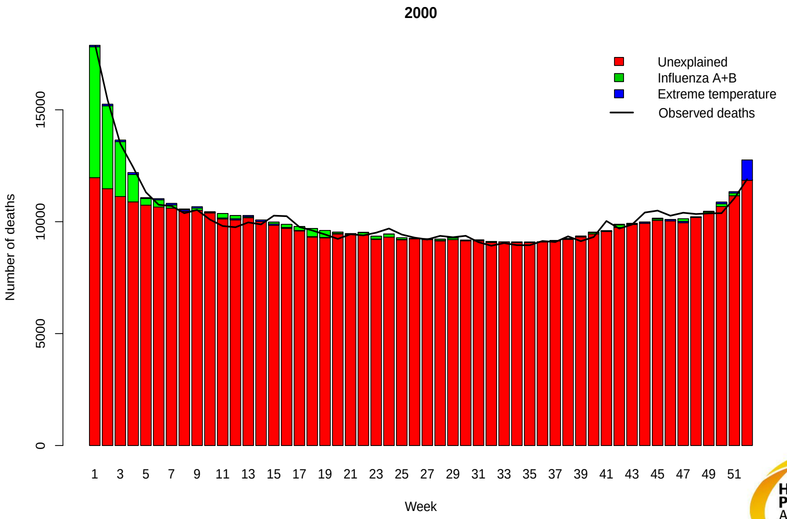
Deaths due to influenza/extreme temperature 2000



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Comments

- Work in progress!
- Useful in attributing deaths at end of season, not real-time
- Currently no mortality data available between December 2008 and April 2009
- Not age-specific

Selected references

- Farrington CP, Andrews NJ, Beale AD, Catchpole MA: A statistical algorithm for the early detection of outbreaks of infectious disease. *J Roy Stat Soc Stat Soc*. 1996. **159**. 547–563
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