WINTER SEASON 2016/17 MORTALITY SUMMARY REPORT FROM THE EUROMOMO NETWORK

Pooled analysis of all-cause and influenza-attributable mortality from 21 European countries participating in the EuroMOMO network showed a marked excess mortality in most countries during the winter season of 2016/17.

Both all-cause and influenza-attributable mortality peaked in January-February 2017 and affected older individuals in particular. This mortality pattern coincided with the circulation of influenza A(H3N2) this season throughout Europe.

The total excess mortality seen in the 2016/17 winter season did not, however, reach a level quite as high as the excess mortality observed during the 2014/15 winter season.

BACKGROUND

Mortality in temperate and subtropical regions has a regular seasonal pattern, with higher mortality during winter compared to summer. This seasonality in mortality is driven predominately by deaths among the elderly. The pattern can be ascribed to various factors including seasonal transmission of influenza and other respiratory virus infections, as well as increased deaths from bacterial infections including bacterial pneumonia, and cardiovascular diseases. During particularly cold winter season, an increase in mortality may also be explained by a direct effect of "cold snaps" on the risk of death, especially among elderly and vulnerable groups in the population.

The EuroMOMO network monitors weekly all-cause mortality across participating European countries to detect, in a timely manner, any excess mortality compared to the expected (baseline) levels. EuroMOMO has been monitoring weekly excess all-cause mortality continuously since the H1N1 pandemic in 2009. The number of participating countries (or regions of countries) has gradually increased over the past six years, currently 21, thus covering large geographical parts of the European region.

In addition to the weekly detection of excess mortality, annual pooled estimates of the total excess winter mortality are provided to assess the severity of seasonal epidemics compared to previous seasons.

Recently, the network has also started to estimate excess mortality attributable to influenza, using a statistical algorithms including the effect of reported national influenza activity and temperature as explanatory variables

This preliminary report provides the estimates of excess all-cause mortality and influenza-attributable mortality for the 2016/17 winter season as compared to previous seasons.

METHODOLOGY

Estimation of all-cause mortality

Countries in the EuroMOMO network collected weekly data on the number of deaths from all causes, and excess (deviation from baseline) all-cause number of deaths was estimated using the EuroMOMO statistical algorithm. The algorithm is a time-series Poisson regression model with the number of weekly deaths as dependent variable and adjusted for trend and seasonal variation. The algorithm also corrects for the delay in registration of occurred deaths. The EuroMOMO hub at Statens Serum Institut, Denmark, compiled the weekly data from individual countries and conducted pooled analysis stratified by country. Z-scores were used to standardise outputs, enabling comparisons of mortality patterns between countries and between different time-periods. Estimates are calculated as totals (all age groups) and by age groups (< 5, 5–14, 15–64 and ≥ 65 years).

Data from 21 European countries or regions were included in the 2016/17 end-of-season analysis: Belgium, Berlin (Germany), Denmark, England (United Kingdom (UK)), Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Malta, the Netherlands, Northern Ireland (UK), Norway, Portugal, Scotland (UK), Spain, Sweden, Switzerland and Wales (UK).
The estimates for 2016/17 were based on data received in week 26, 2017, thus minimising delay in registration.

We calculated the cumulative excess all-cause mortality for the 2016/17 winter season and compared it with the previous winter seasons of 2013/14, 2014/15 and 2015/16.

Estimation of influenza-attributable mortality

The number of influenza-attributable deaths in the EuroMOMO network countries was estimated using the FluMOMO algorithm, based on weekly Influenza Activity (IA) data (ILI, ARI or intensity data, as available) from the participating 21 EuroMOMO countries, retrieved from the TESSy database at the European Centre for Disease Prevention and Control (ECDC). The model is a multiplicative Poisson regression time-series model with over-dispersion and ISO week as time unit. As in the EuroMOMO model, the multiplicative residual variance is post-regression corrected for skewness by applying a 2/3-power correction. As the dominant type/subtype of influenza viruses circulating varies from season to season, a separate effect of IA for each season is used. To adjust for a possible

confounding effect of excess temperatures, an explanatory variable reflecting the deviation of ambient temperature from expected normal temperature is included in the model, obtained for each of the countries from National Oceanic and Atmospheric Administration (NOAA). Further, two weeks delayed effects of the explanatory variables are also included in the model. The model estimates both baseline, and the effects of IA and excess temperatures simultaneously, i.e. controlled for one another.

Based on the estimated number of deaths, mortality rates were calculated using national population data downloaded from EuroStat, as at 1 January 2017, and linearly interpolated.

Definitions:

- **Winter season** is defined as the period from week 40 to week 20 the following year
- **Expected number of deaths (baseline)** for each winter season is estimated based on data from the 5 previous years. Pooled estimates are based on data received in week 26 after the last season
- **Excess deaths** are defined as observed deaths minus baseline deaths (EuroMOMO)
- **Deaths attributable to influenza** are the estimated number of deaths based on IA (FluMOMO)

FINDINGS

Excess all-cause mortality

Figure 1 shows the seasonal variation in pooled estimates of all-cause mortality over the four winter seasons 2013/14, 2014/15, 2015/16 and 2016/17. Deaths in total and deaths by age group are shown.

Figure 2 shows the cumulated pooled excess all-cause mortality for the participating EuroMOMO countries for the winter seasons 2013/14, 2014/15, 2015/16 and 2016/17.

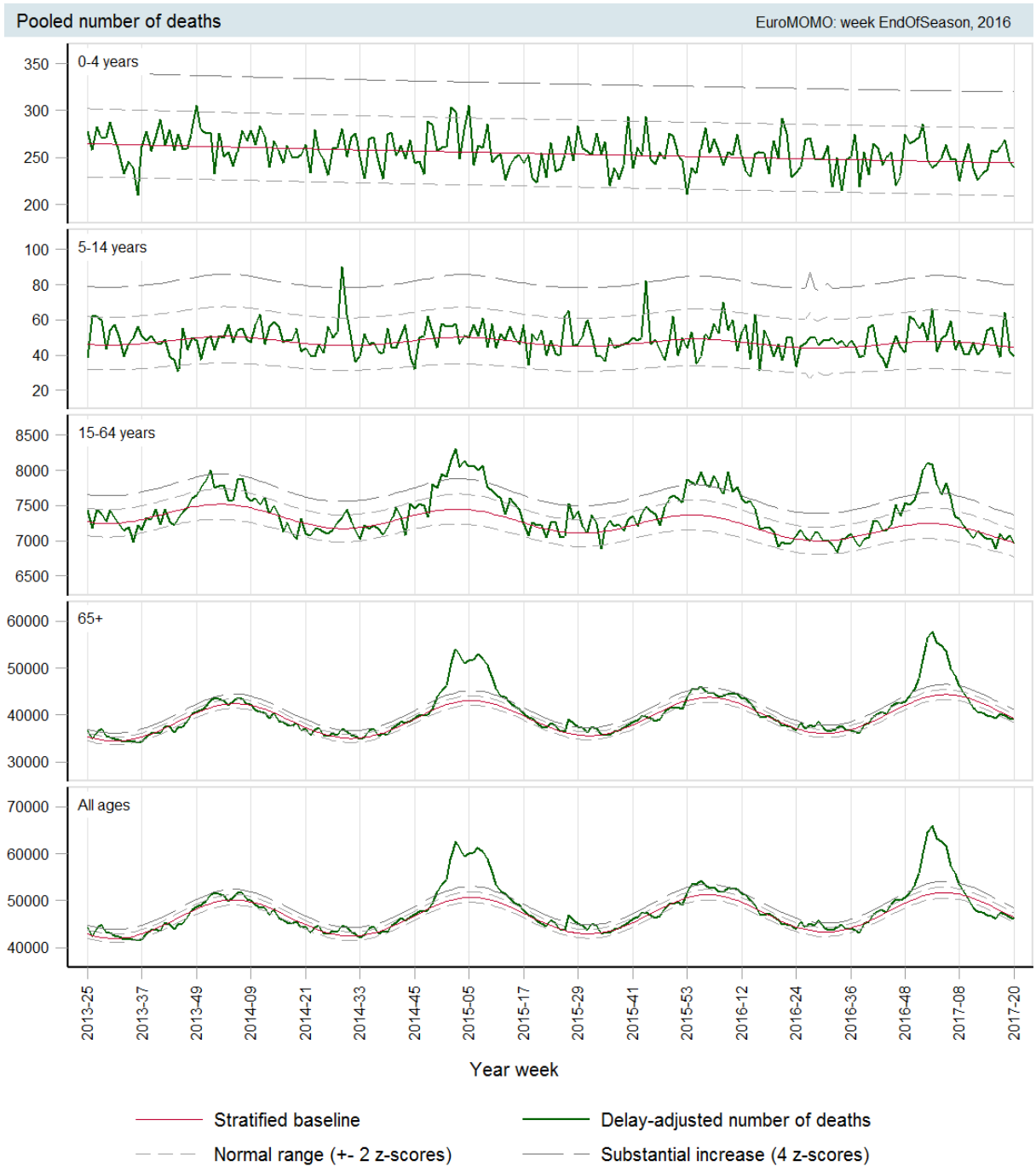
Table 1 shows estimated excess all-cause mortality rates in total and by age groups for the seven winter seasons from 2009/10 to 2016/17, and the number of participating countries by season. The number of reporting countries increased over the period from 8 to 21. Some countries only provided limited data (only z-scores, but without numbers) and thus cannot be included in the pooled analyses. It is important to note that the estimates in Table 1 may be different from the visual deviations from the baseline as seen in Figure 1, and different from graphs shown at the EuroMOMO website. This is due to the methods applied for the results in Table 1, i.e. all estimates are calculated on the previous five years without any conditioning on the future.

The estimated total excess all-cause mortality in the 2016/17 winter season for all age groups in the participating countries was 29.21 (95% CI 27.97-30.45) deaths per 100,000. The estimated excess mortality in the elderly (+65 years) alone was 152.79 (95% CI 146.43-159.16) per 100,000.

As shown in Table 1, the excess all-cause mortality observed during the 2016/17 winter season 2016/17 was markedly elevated compared to all the previous seasons except for the 2014/15 season. Thus, a high peak in mortality was experienced in many countries during January and February 2017 (Figure 1), affecting older individuals in particular. This excess mortality pattern is remarkably similar to the situation experienced in the 2014/15 season. Both seasons saw a widespread circulation of influenza A (H3N2) throughout Europe, which is well known to affect elderly people in particular.

Table 2 shows the estimated cumulated influenza-attributable mortality in the participating European countries in the winter seasons 2013/14, 2014/15, 2015/16 and 2016/17, respectively. The estimated influenza-attributable mortality in the 2016/17 winter season was 32.90 (min 9.51; max 118.71)0.45) per 100,000 population for all age groups, and 181.15 (min 54.26; max 1016.13) per 100,000 in individuals aged 65 years and above. These mortality rates are very similar to the influenza-attributable mortality rates in the 2014/15 winter season, which saw an estimated influenza-attributable mortality of 32.90 (min 0.51; max 80.09) per 100,000 for all age groups and 190.72 (min 0.00; max 570.68) per 100,000 in individuals aged 65 years and older. These mortality patterns are further illustrated in **Figure 3**.

Figure 1. Seasonal variation in pooled estimates of all-cause mortality over the four winter seasons 2013/14, 2014/15, 2015/16 and 2016/17 (until week 20/2017). Deaths in total and death by age group are shown.



Participating countries:
Belgium, Denmark, Estonia, Finland, France, Germany (Berlin), Greece, Hungary, Ireland, Italy, Malta
Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK (England), UK (Northern Ireland), UK (Scotland), UK (Wales)

Figure 2. Cumulated pooled excess all-cause mortality in the participating EuroMOMO countries/regions in the winter seasons 2013/14, 2014/15, 2015/16 and 2016/17 (until week 20/2017).

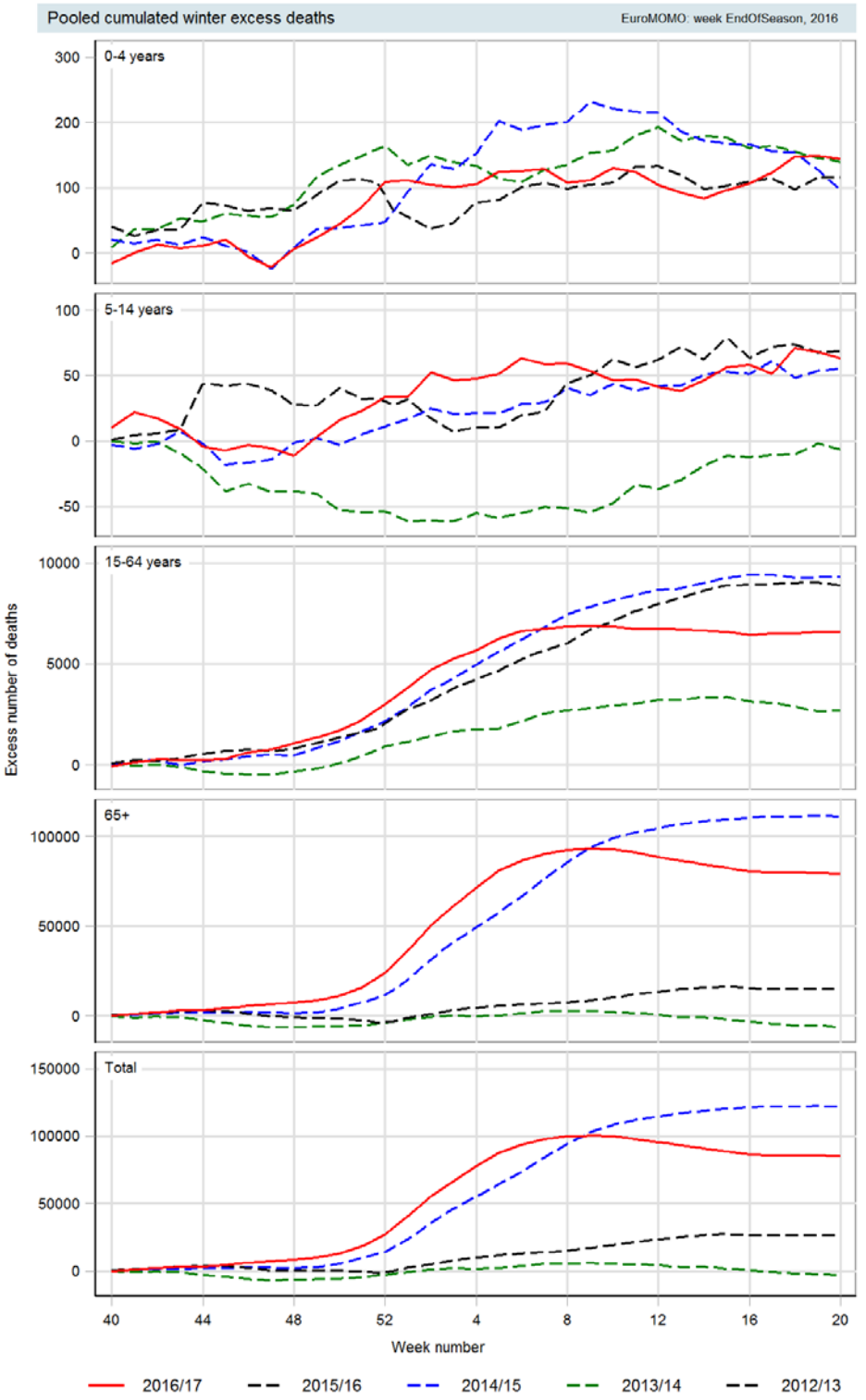


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Table 1. Pooled analysis of excess mortality (number of deaths per 100,000 population) during the winter season from week 40 to week 20 for the years 2009/10 until 2016/17; shown in total and by age group.

Season	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Dominant type of influenza	A(H1N1)pdm09	A(H1N1)pdm09	A(H3N2)	Mixed + B	Mixed	A(H3N2)	A(H1N1)pdm09 + B	A(H3N2)
Age groups	**Excess mortality per 100,000 population (95% confidence interval)**							
0-4	1.24 (-0.07;2.56)	1.77 (0.74;2.81)	1.64 (0.73;2.55)	1.14 (0.36;1.92)	1.76 (1.00;2.52)	1.38 (0.62;2.14)	2.42 (1.70;3.14)	0.88 (0.15;1.60)
5-14	0.72 (0.43;1.01)	0.77 (0.52;1.02)	0.65 (0.44;0.86)	0.49 (0.31;0.67)	0.18 (0.02;0.35)	0.51 (0.35;0.67)	0.50 (0.34;0.66)	0.18 (0.03;0.34)
15-64	1.76 (1.10;2.42)	-0.13 (-0.67;0.41)	-3.49 (-3.98;-3.00)	2.09 (1.66;2.53)	1.67 (1.22;2.12)	5.94 (5.53;6.35)	4,85 (4.47;5.23)	3.49 (3.13;3.86)
65+	104.12 (93.95;114,30)	29,57 (21.26;37.89)	51.34 (43.47;59.21)	88.20 (81.42;94.99)	-12.46 (-20.11;-4.79)	214.17 (207.60;220.74)	14.71 (8.82;20.60)	152.79 (146.43;159.16)
Total	18.66 (16.82;20.49)	5.42 (3.89;6.96)	6.73 (5.26;8.21)	17.25 (15.96;18.55)	-1.39 (-2.96;0.18)	43.63 (42.30;44.96)	5.37 (4.15;6.58)	29.21 (27.97;30.45)
Number of countries included	8	11	12	14	18	18	19	21
Number of countries included	7	9	11	12	17	17	18	21

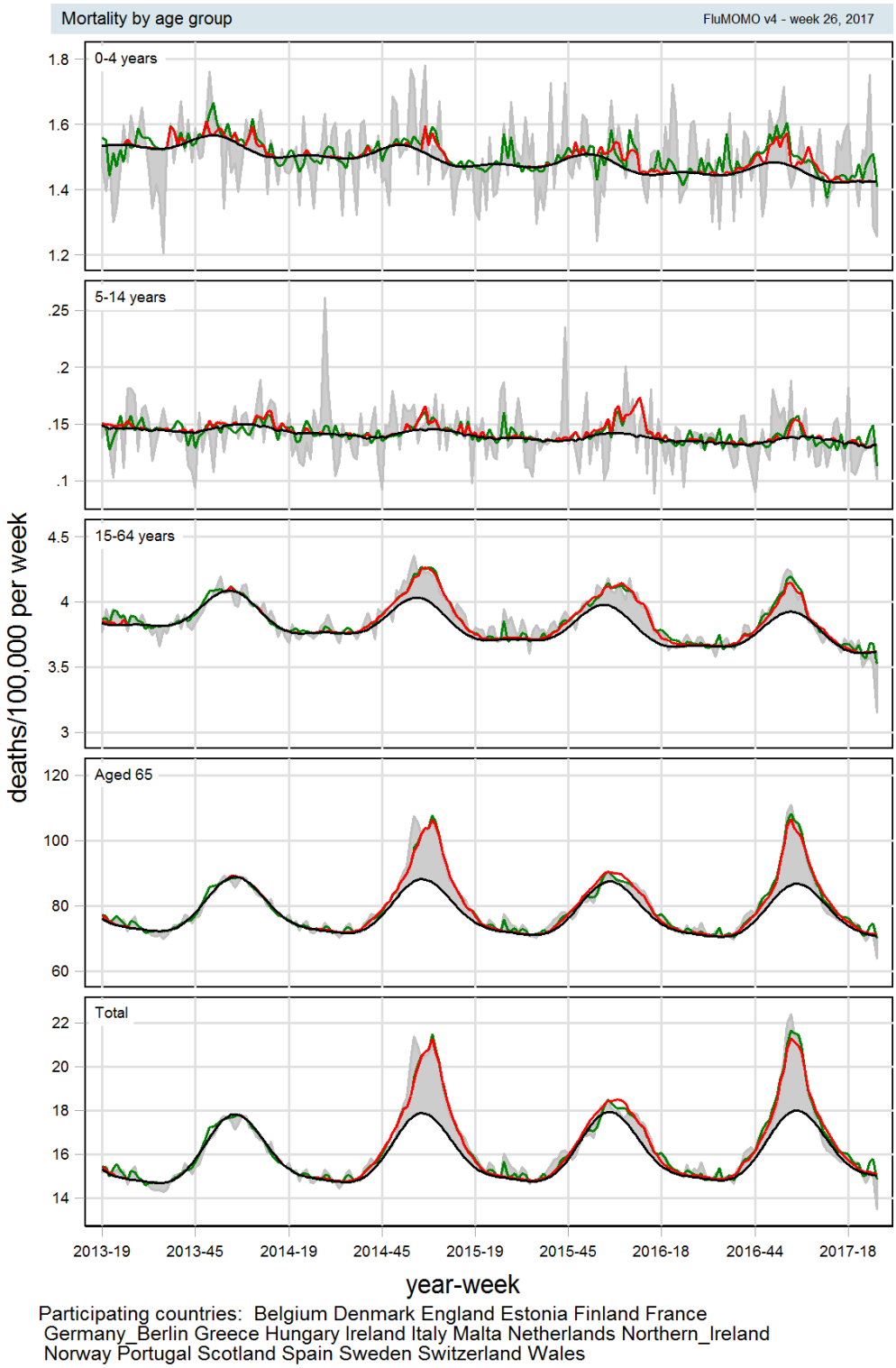
Note: Excess mortality is defined as the observed number of deaths minus baseline per 100,000 population.

Table 2. Estimates of cumulative combined influenza-attributable mortality (based on FluMOMO algorithm) in the participating EuroMOMO countries, for each of the winter seasons 2013/14, 2014/15, 2015/16 and 2016/17, respectively.

Season	2013/14	2014/15	2015/16	2016/17
Dominant type of influenza	Mixed	A(H3N2)	A(H1N1)pdm09 + B	A(H3N2)
Age groups	**Influenza-attributable mortality per 100,000 population [min-max]**			
0-4	3.56 [0.37-10.22]	1.10 [0.00-5.16]	1.72 [0.00-8.18]	0.72 [0.00-11.68]
5-14	0.32 [0.00-3.31}	0.16 [0.00-0.69]	0.04 [0.00-3.83]	0.26 [0.01-2.31]
15-64	1.56 [0.00-5.44]	3.17 [0.35-10.79]	3.25 [0.19-17.98]	2.39 [0.08-20.01]
65+	56.28 [0.00-339.95]	190.72 [0.00-570.68]	30.06 [0.00-207.09]	181.15 [54.26-1016.13]
Total	7,82 [0.00-45.01]	32.9 [0.51-80.09]	5.1 [0.12-42.86]	32.90 [9.51.118.71]
Number of countries included	17	17	19	21

Figure 3. Estimates of accumulative weekly influenza-attributable mortality rates (deaths per 100,000 people per week) in the 20 participating EuroMOMO countries, for the winter seasons

2013/14 to 2016/17. Estimates are calculated with the FluMOMO model (see main text for details).



Note: The shaded grey areas represent deviations in expected deaths from the estimated baseline. The red curves signify mortality attributable to influenza activity, and the green curve signify effect of extreme temperatures, on top of the red curve.

COMMENTARY

The 2016/17 influenza season in Europe was dominated by circulation of influenza A(H3N2) virus in most European countries. Similar to what we saw during the influenza season in 2014/15. This led to a marked excess mortality in the 2016/17 season, particularly among older individuals.

However, the total all-cause mortality recorded during the 2016/17 did not reach quite as high a level as seen in the 2014/15 winter season. The total excess mortality per 100,000 population across all age groups was 43.63 (95%CI 42.30-44.96) in 2014/15 compared to 29.21 (95%CI 27.97-30.45) in 2016/17 (Table 1). However, the rise in mortality started a bit earlier in the 2016/17 season as compared to 2014/15 (Figure 2).

In addition to estimating the all-cause mortality using the established EuroMOMO algorithm, we also this season estimated the influenza-attributable mortality using the FluMOMO algorithm, based on national influenza activity data retrieved directly from the TESSy database at ECDC. Further, we compared this to influenza-attributable mortality estimates for the previous three seasons (Table 2). These estimates show a similar influenza-attributable mortality in 2016/17 as compared to 2014/15. It should be noted, however, that the mortality rates obtained using the EuroMOMO method and the FluMOMO method, respectively, are not strictly comparable, since the baseline used in the calculations are derived differently. When calculating the baseline using the EuroMOMO method, other factors than influenza are also incorporated, which may affect the estimates of excess all-cause mortality.

Importantly, the application of the FluMOMO algorithm and the use of national influenza activity data retrieved directly from TESSy allowed us to provide some timely estimates of the influenza-attributable mortality burden during the influenza season. The EuroMOMO network aims to develop this estimation and reporting mechanism further in the coming seasons.

Acknowledgments

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