Mathematical modelling of the 25/26 influenza season

Summary

We find that the reproduction number, calculated from the fraction of Influenza tests that are positive, in the week the outbreak is declared was 1.18 (95% CI 1.17 - 1.2). This is somewhat larger than the 24/25 and 22/23 seasons and significantly higher than the 23/24 season. The 25/26 season also saw the highest reproduction numbers of the last four seasons in most of the counties in Norway. We also calibrate a metapopulation model to weekly hospital admissions and report on projections for the rest of the Influenza season. These scenarios indicate that we could have 6000-6500 total hospitalisations during the season and up to 750 weekly admissions at the peak which is likely to occur before the new year. Modelling scenarios should always be interpreted with caution as they rest on various assumptions, one of which is that there are no new variants, i.e H1N1 or Influenza B, that starts spreading after the current H3N2 outbreak.

Methods:

We first estimate exponential growth rates and corresponding reproduction number in the week when the outbreak starts (fraction of positive influenza tests reaches 10%) by fitting a Poisson regression model with the number of tests as an offset. We use 6 weeks prior to reaching the outbreak threshold and one week after as input and we allow one potential changepoint in the slope if that gives a lower BIC value[1]. Using a gamma distributed generation time with shape=2.6 and scale = 0.96[2] we then estimate the reproduction number following Wallinga and Lipsitch 2007[3]. We estimate reproduction numbers both nationally and in each county. It is important to note that estimating growth rates and reproduction numbers are quite sensitive to choices of threshold, amount of smoothing and data uncertainty.

We further fit an age-stratified meta-population model to hospital incidence data to produce possible scenarios for the development of the influenza outbreak. This model

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[1] Muggeo, V.M.R. (2003), Estimating regression models with unknown break-points. Statist. Med., 22: 3055-3071. https://doi.org/10.1002/sim.1545

[2] Ghani A, Baguelin M, Griffin J, Flasche S, van Hoek A, Cauchemez S, Donnelly C, Robertson C, White M, Truscott J, Fraser C, Garske T, White P, Leach S, Hall I, Jenkins H, Ferguson N, Cooper B (2009). “The Early Transmission Dynamics of H1N1pdm Influenza in the United Kingdom.”

[3] Wallinga J, Lipsitch M. How generation intervals shape the relationship between growth rates and reproductive numbers. Proc Biol Sci. 2007 Feb 22;274(1609):599-604. doi: 10.1098/rspb.2006.3754. PMID: 17476782; PMCID: PMC1766383.

is similar to the model used for various scenario modelling tasks during the COVID-19 pandemic in Norway. In the model, we use vaccination data from SYSVAK to move people to a vaccinated compartment with a 20% vaccination protection against infection. An influenza hospitalisation is defined as an admission from Norwegian Patient Registry with a respiratory ICD10 code or no registered ICD10 code both combined with a positive influenza test from the MSIS lab database.

We calibrate the model by estimating the beta-parameter, the initial number of infected and the amplitude of seasonal variation[4]. Two other key parameters are needed to make scenario projections, the infection hospitalisation rate (IHR) and the reduction in transmission during holidays. These parameters are not identifiable in the 25/26 season, but by fitting the model to previous seasons we find that a 10-20% reduction of transmission during the Christmas holiday week and an age-stratified IHR which corresponds to an overall IHR of around 0.55% provides a reasonable fit. It is also important to note that we only model one strain or variant of Influenza, so the model does consider the possibility of a second wave of a different strain.

We use a Poisson likelihood and fit the model using a grid search algorithm.

Results:

Estimated national reproduction numbers in the week when the percent positive indicator passes 10%, a predefined outbreak threshold, are shown in Figure 1. The growth rate in the current season when the 10% threshold was crossed is likely somewhat higher than in the 22/23 and 24/25 season and significantly higher than the 23/24 season. In Figure 2, we see estimated reproduction numbers by county. In most cases the 25/26 season is among the highest growth rates in each. Initial reproduction numbers will correlate with height of the epidemic peak, but the results from the 24/25 season need to be interpreted with caution since the 10% threshold was reached close to the Christmas holiday which led to a reduction in transmission with the main peak taking place in late February.

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[4] Seasonality is modelled as a function of the average temperature in Norway with the amplitude being the difference in transmission between the warmest and coldest day.

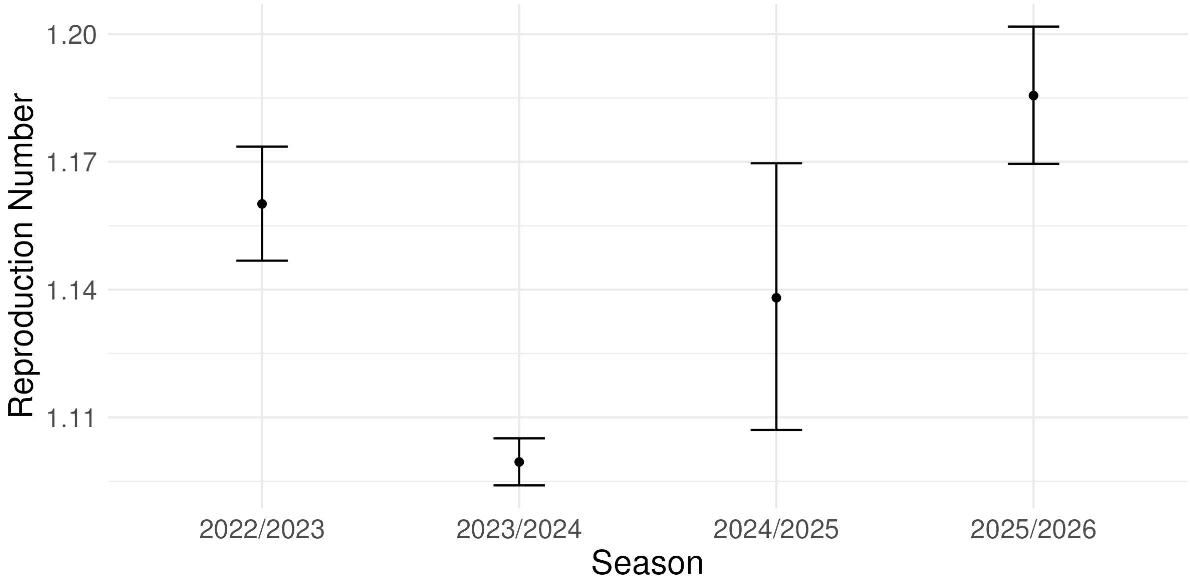

Figure 1: Estimated reproduction numbers in the week the outbreak is declared (percent positive reaches over 10%) base on the fraction of Influenza tests that are positive.

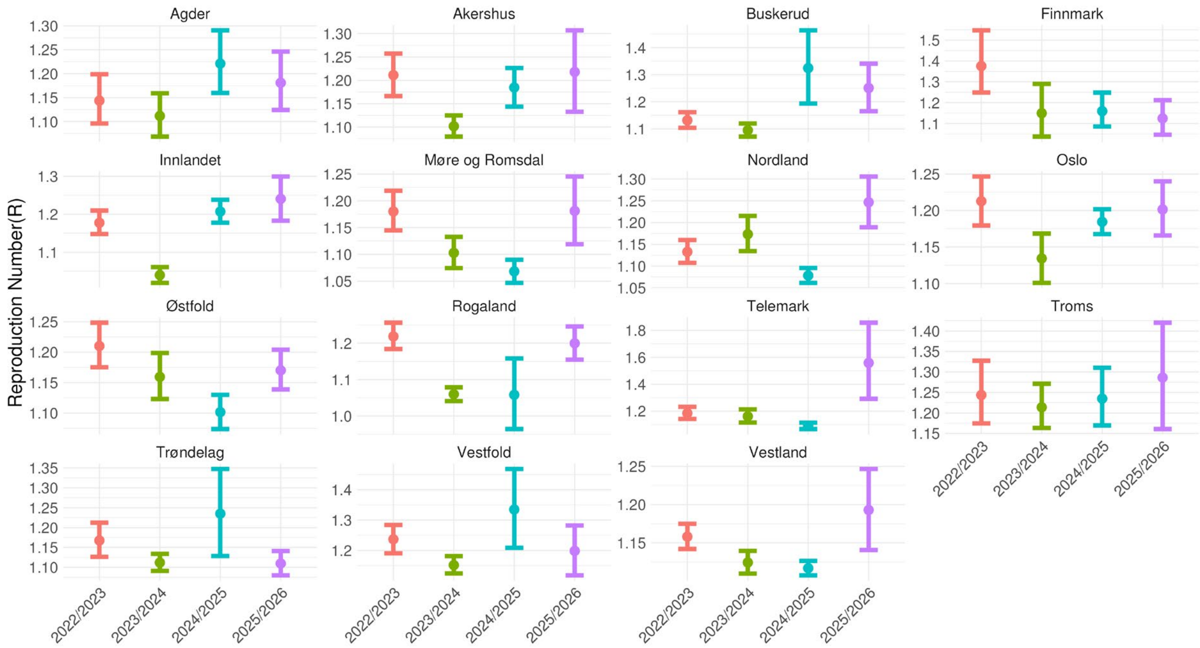

Figure 2: Estimated reproduction numbers in the week the outbreak is declared (percent positive reaches over 10%) in each county. The outbreak week will be different between different counties in the same season.

Figure 3 shows the fit and projections for various indicators for the 25/26 season. With up-to-date data from week 50, the uncertainty in the projections has narrowed significantly over the last 2 weeks and the model currently predicts a peak of 700-800 hospitalisations per week and between 6000 and 7000 hospitalisations in total. For reference, the 22/23 season had 5800, the 23/24 season had 4600 and the 24/25 season had 8200. With the anticipated reduction in transmission during the holidays, the scenarios indicate that the peak of the epidemic wave and of hospitalisations will be before the end of the year, with the potential of lingering transmission at the current level afterwards.

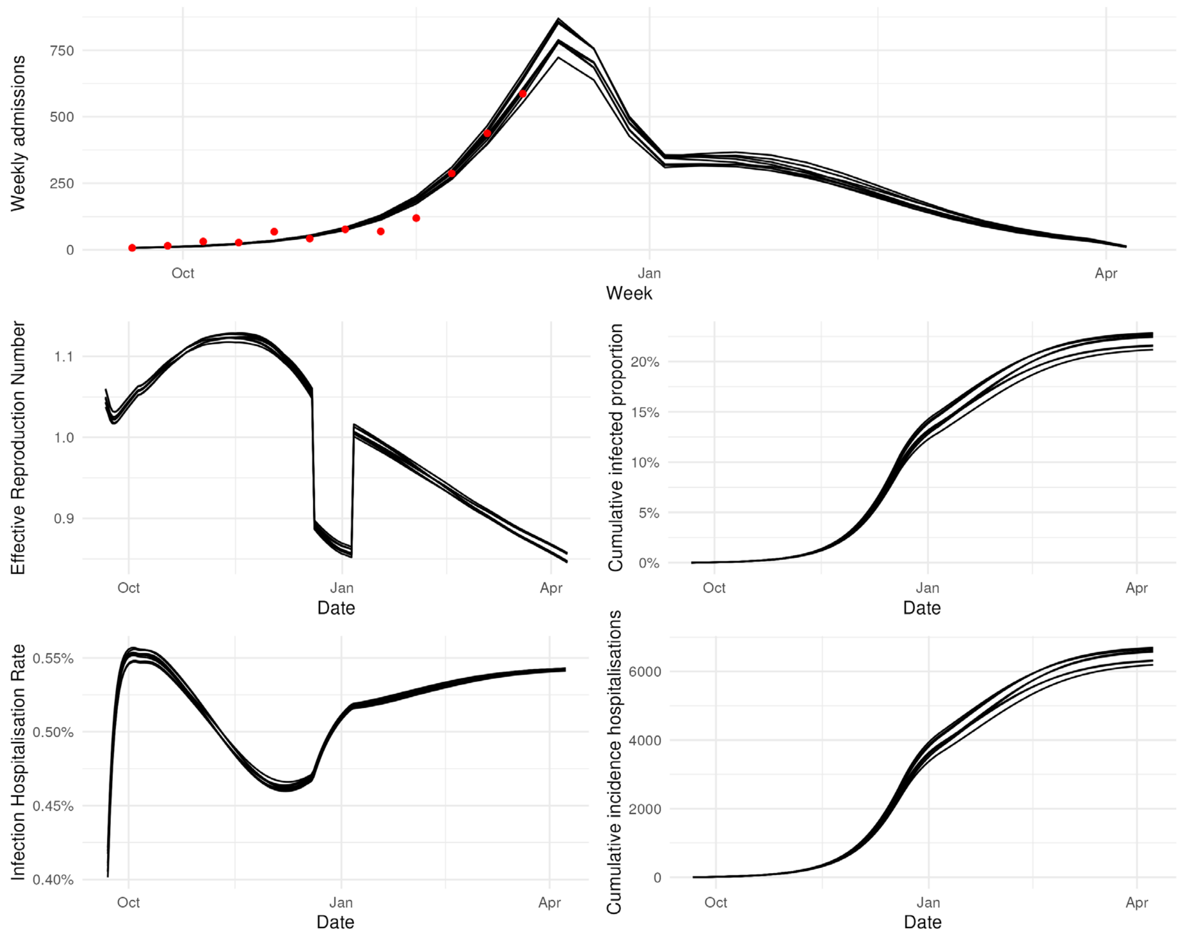

Figure 3: Weekly admissions, effective reproduction number, cumulative proportion infected, infection hospitalisation rate and cumulative incidence of hospitalisations for the best fitting parameters for the 25/26 season.