Supplemental Table 1. Reference model

Step	Variable label	Variable name*	Equation/source
1	Incident vaccinations on that day	vac_d	Input data
2	Vaccine effectiveness	ve_d	Input data
3	Incident cases on that day without vaccination	$casen_d$	Input data
4	Infection rate	r_d	$casen_d/popn_{d-1}$
5	Incident cases on that day with vaccination	$case_d$	$r_d \cdot (A_{d-1} + C_{d-1} + B_{d-1})$
6	Non-cases if no vaccination	$popn_d$	Initial value: starting population Subsequent values: $popn_{d-1} - casen_d$
7	Averted cases	$avert_d$	$casen_d - case_d$
8	Vaccination rate	v_d	$vac_d/(A_{d-1} + E_{d-1})$
9	Vaccinated non-cases incident	b_d	$A_{d-1} \cdot v_d$
10	Non-vaccinated non-cases	A_d	Initial value: starting population Subsequent values: $A_{d-1} \cdot (1 - r_d) – b_d$
11	Vaccinated non-cases from prior 14 days	b_{d-1} … b_{d-14}	$b_{d-1} \cdot (1 - r_d)$ … $b_{d-14} \cdot (1 - r_d)$
12	Vaccinated non-cases prevalent	B_d	$B_{d-1} \cdot (1 - r_d) + b_d – b_{d-14}$
13	Vaccinated non-cases susceptible	C_d	$C_{d-1} \cdot (1 - r_d) + b_{d-14} \cdot (1 - ve_d)$
14	Vaccinated non-cases immune	D_d	$D_{d-1} + b_{d-14} \cdot ve_d$
15	Non-vaccinated cases	E_d	$E_{d-1} + A_{d-1} \cdot r_d - E_{d-1} \cdot v_d$
16	Vaccinated cases	F_d	$F_{d-1} + (C_{d-1} + B_{d-1}) \cdot r_d + E_{d-1} \cdot v_d$

* Single letter variable names correspond to Figure 1 compartments.
Notes:
Subscripts indicate day, i.e., “d” indicates current day, “d-1” indicates prior day, and “d-14” indicates 14 days before.
These equations are for a 14-day immune lag, but lags of different durations were also tested (Table 3).

Supplemental Table 2. Test methods. Note that variable names and concepts are defined separately for each method and apply only to that method.

Method 1. (Current method)

Step	Variable label	Variable name	Equation or value
1	Incident cases during the month	$case_m$	Input data
2	Incident proportion of the starting population vaccinated during the month	vc_m	Input data
3	Vaccine effectiveness	ve_m	Input data
4	Vaccine coverage lagged	vc_lag_m	$(vc_m + vc_{m-1})/2$
5	Susceptible population	$pops_m$	Initial value: starting population Subsequent values: $(pops_{m-1}-case_{m-1})\cdot(1-vc\_lag_m\cdot ve_m)$
6	Infection risk	r_m	$case_m/pops_m$
7	Non-cases if no vaccination	$popn_m$	Initial value: starting population Subsequent values: $popn_{m-1}-casen_{m-1}$
8	Cases if no vaccination	$casen_m$	r_m*popn_m
9	Averted cases	$avert_m$	$casen_m-case_m$
Note: Subscripts indicate month, i.e., “m” indicates current month, “m-1” indicates prior month			

Method 2.

Step	Variable label	Variable name	Equation
1	Incident cases during the month	$case_m$	Input data
2	Incident proportion of the starting population vaccinated during the month	vc_m	Input data
3	Vaccine effectiveness	ve_m	Input data
4	No. effectively vaccinated during the month	vef_m	$pop_{m-1} \cdot vc_m \cdot ve_m$
5	Non-cases with vaccination	pop_m	Initial value: starting population Subsequent values: pop_{m-1} - $case_m$
6	Susceptible population	$pops_m$	Initial value: starting population Subsequent values: $pops_{m-1}$ - $case_m$ – vef_m
7	Infection risk	r_m	$case_m/pops_{m-1}$
8	Non-cases if no vaccination	$popn_m$	Initial value: starting population Subsequent values: $popn_{m-1}$ - $casen_{m-1}$
9	Cases if no vaccination	$casen_m$	$r_m \cdot popn_m$
10	Averted cases	$avert_m$	$casen_m$ - $case_m$

Note: subscripts indicate month, i.e., "m" indicates current month, "m-1" indicates prior month
Method 1 applies vaccine coverage (vc) and vaccine effectiveness (ve) to the susceptible population (i.e., non-cases who have not yet been effectively vaccinated), whereas method 2 applies vc and ve to all non-cases. The latter approach is appropriate since vc data is received as a proportion of the total population, including both cases and non-cases. Cases are assumed to be immune, and so the number effectively immunized equals the total population minus cases multiplied by vc and ve.

Method 3.

Step	Variable name	Variable*	Equation
1	Incident cases during the month	$case_m$	Input data
2	Incident vaccinations during the month	vac_m	Input data
3	Vaccine effectiveness	ve_m	Input data
4	Infection rate	r_m	$case_m/(A_{m-1} + C_{m-1})$
5	Vaccination rate	v_m	$vac_m/(A_{m-1} + E_{m-1})$
6	Vaccinated non-cases incident	b_m	$A_{m-1} \cdot v_m$
7	Non-vaccinated non-cases	A_m	Initial value: starting population Subsequent values: $A_{m-1} \cdot (1-r_m) - b_m$
8	Vaccinated non-cases susceptible	C_m	$C_{m-1} \cdot (1-r_m) + b_m \cdot (1-ve_m)$
9	Vaccinated non-cases immune	D_m	$D_{m-1} + b_m \cdot ve_m$
10	Non-vaccinated cases	E_m	$E_{m-1} \cdot (1-v_m) + A_{m-1} \cdot r_m$
11	Vaccinated cases	F_m	$F_{m-1} + (C_{m-1} + E_{m-1}) \cdot v_m$
12	Cases if no vaccination	$casen_m$	$popn_{m-1} \cdot r_m$
13	Non-cases if no vaccination	$popn_m$	Initial value: starting population Subsequent values: $popn_{m-1} - casen_m$
14	Averted cases	$avert_m$	$casen_m - case_m$

* Single letter variable names correspond to Figure 1 compartments
Notes: subscripts indicate month, e.g., “m” indicates current month, “m-1” indicates prior month
Includes all features of the reference model, including possible vaccination of unvaccinated cases, except does not track persons during the 14-day immune lag period (Figure 1, oval B).

Method 4.

Step	Variable name	Variable*	Equation
1	Incident cases during the month	$case_m$	Input data
2	Incident vaccinations during the month	vac_m	Input data
3	Vaccine effectiveness	ve_m	Input data
4	Infection rate	r_m	$case_m/(A_{ave} + C_{ave})$
5	Vaccination rate	v_m	$vac_m/(A_{ave} + E_{ave})$
6	Vaccinated non-cases incident	b_m	$A_{ave} \cdot v_m$
7	Non-vaccinated non-cases	A_m	Initial value: starting population Subsequent values: $A_{m-1} - A_{ave} \cdot r_m - b_m$
8	Vaccinated non-cases susceptible	C_m	$C_{m-1} - C_{ave} \cdot r_m + b_m \cdot (1-ve_m)$
9	Vaccinated non-cases immune	D_m	$D_{m-1} + b_m \cdot ve_m$
10	Non-vaccinated cases	E_m	$E_{m-1} - E_{ave} \cdot v_m + A_{ave} \cdot r_m$
11	Vaccinated cases	F_m	$F_{m-1} + (C_{ave} + E_{ave}) \cdot v_m$
12	Cases if no vaccination	$casen_m$	$popn_{ave} \cdot r_m$
13	Non-cases if no vaccination	$popn_m$	Initial value: starting population Subsequent values: $popn_{ave} - casen_m$
14	Averted cases	$avert_m$	$casen_m - case_m$

* Single letter variable names correspond to Figure 1 compartments
Notes: subscript “m” indicates current month, “ave” indicates the average of current and prior months

Method 5.

Step	Variable name	Variable	Equation
1	Vaccine effectiveness	ve_m	Input data
2	Cumulative proportion of population vaccinated by the end of the month	vc_cum_m	Input data
3	The number of cases that month	$case_m$	Input data
4	Cases without vaccination	$casen_m$	$case_m/(1-ve_m*vc\_cum_m)$
5	Averted cases	$avert_m$	$casen_m-case_m$
Note: Subscript "m" indicates current month, "m-1" indicates prior month			

Method 6.

Step	Variable name	Variable	Equation
1	Vaccine effectiveness	ve_s	Input data
2	Cumulative proportion of population vaccinated by the end of the season	vc_cum_s	Input data
3	Total number of cases during the season	case	Input data
4	Total number of cases without vaccination during the season	$casen_s$	$cases/(1-ve_s*ve_s)$
5	Total averted cases for the season	$avert_s$	$casen_s$-case
Note: Subscript "s" indicates data for the entire influenza season			

Method 7.

Uses the reference model (Appendix 1) with steps 3-5 changed as follows:

Step	Variable name	variable	Equation
3	Number of cases on that day with vaccination	$case_d$	Input data
4	Infection rate	r_d	$case_d / (A_{d-1} + C_{d-1} + B_{d-1})$
5	Number of cases on that day without vaccination	$casen_d$	$popn_{d-1} \cdot r_d$

Supplemental Table 3. Simulated data used to test methods for determining numbers of influenza cases averted by vaccination

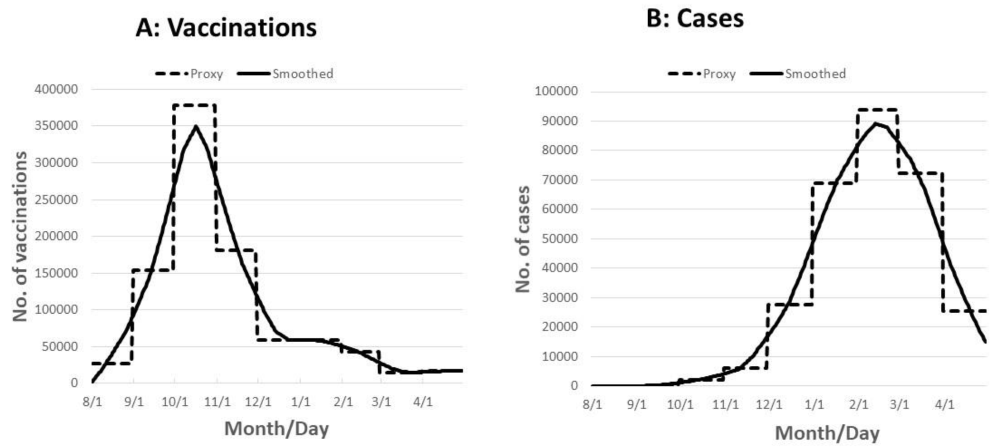
Month	Vaccine coverage	Cases without vaccination	Number Vaccinated	Cases with vaccination	Averted cases
Aug	0.0413	1.0	41,339.7	1.0	0.0
Sep	0.0899	31.6	89,867.8	30.6	0.9
Oct	0.1389	531.4	138,913.2	490.4	41.0
Nov	0.1341	4,102.8	134,121.1	3,526.9	575.9
Dec	0.0919	17,341.9	91,932.0	13,873.2	3,468.7
Jan	0.0400	36,026.0	39,981.1	27,412.6	8,613.4
Feb	0.0109	34,312.4	10,925.0	25,508.9	8,803.4
Mar	0.0026	21,097.1	2,564.3	15,562.6	5,534.6
Apr	0.0003	5,710.8	325.7	4,204.3	1,506.5
May	0.0000	845.0	30.0	621.9	223.1
Total	0.5500	120,000.0	550,000.0	91,232.5	28,767.5

Starting population=1,000,000; vaccine effectiveness=0.48. Values for vaccine coverage, cases without vaccination, and number vaccinated were generated in a normal distribution (Table 2). Cases with vaccination and averted cases were calculated using the Reference Model on day-level data and aggregated by month

Supplemental Table 4. Evaluation of test methods with data simulated based on real data

1. Start with real data (counts of influenza cases and vaccinations) aggregated by month and stratified by season and age group
2. Divide counts by the number of days per month to create a proxy for daily values (dotted lines in Figure S1).
3. Smooth using Loess procedure (solid lines in Figure S1).
4. Use reference model on smoothed daily data to calculate "true" averted cases.
5. Aggregate daily data by month to simulate the format that real data would be available in.
6. Use test methods 1-7 on monthly-aggregated data to estimate averted cases
7. Calculate error, i.e., percent difference between averted cases calculated by the reference model on daily data vs. test methods on monthly-aggregated data.
8. Test methods with smallest error are considered most accurate

Figure S1



Supplemental Table 5. Effect of modifying specific steps in methods 1 and 2.

Step	Variable	Method 1	Method 1a	Method 1b	Method 1c	Method 2
1	vc_lag_m	$(vc_m+vc_{m-1})/2$		$\mathbf{(vc_m+vc_{m-1})/2}$		
2	$pops_m$	$pops_{m-1}-case_{m-1}$	$pops_{m-1}-case_{m-1}$	$pops_{m-1}-case_{m-1}$	$pops_{m-1}-case_{m-1}$	$\mathbf{pops_{m-1}-case_m}$
3				$\mathbf{pop_{m-1}-case_{m-1}}$	$pop_{m-1}-case_{m-1}$	$\mathbf{pop_{m-1}-case_m}$
4	vef_m	$pops_m \cdot vc\_lag_m \cdot ve_m$	$\mathbf{pops_m \cdot vc_m \cdot ve_m}$	$\mathbf{pop_m \cdot vc\_lag_m \cdot ve_m}$	$\mathbf{pop_m \cdot vc_m \cdot ve_m}$	$\mathbf{pop_{m-1} \cdot vc_m \cdot ve_m}$
5	$pops_m$	$pops_m-vef_m$	$pops_m-vef_m$	$pops_m-vef_m$	$pops_m-vef_m$	$pops_m-vef_m$
6	r_m	$case_m/pops_m$	$case_m/pops_m$	$case_m/pops_m$	$case_m/pops_m$	$\mathbf{case_m/pops_{m-1}}$
7	$popn_m$	$popn_{m-1}-case_{m-1}$	$popn_{m-1}-case_{m-1}$	$popn_{m-1}-case_{m-1}$	$popn_{m-1}-case_{m-1}$	$popn_{m-1}-case_{m-1}$
8	$casen_m$	$r_m \cdot popn_m$	$r_m \cdot popn_m$	$r_m \cdot popn_m$	$r_m \cdot popn_m$	$r_m \cdot popn_m$
9	$avert_m$	$casen_m-case_m$	$casen_m-case_m$	$casen_m-case_m$	$casen_m-case_m$	$casen_m-case_m$
Averted cases (number)		26,175.90	27,216.30	29,883.80	31,182.60	28,810.70
Error compared with reference model, %		-9.01	-5.39	3.88	8.39	0.15

Input data described in Table 2 and Supplemental Table 3. True averted cases per reference model = 28,767.5. Variable names: vc, incident proportion of the starting population vaccinated during the month; case, incident cases during the month; vc_lag, vaccine coverage lagged; pops, susceptible population; pop, non-cases with vaccination; vef, number effectively vaccinated during the month; r, infection risk; popn, non-cases if no vaccination; casen, number of cases if no vaccination; avert, cases averted by vaccination.

Bold type indicates a change from method in prior column

Method 1 (current method) and method 2 are described in Methods section and Supplemental Table 2. For method 1, step 5 in Supplemental Table 2 has been expanded to steps 2, 4 and 5 in this table to facilitate comparisons with other methods.

Method 1a: method 1 modified, no immune lag

Method 1b: method 1 modified, includes vaccine lag, vaccine coverage applied to all non-cases. Method 1 applies vaccine coverage (vc) and vaccine effectiveness (ve) to the susceptible population (i.e., non-cases who have not yet been effectively vaccinated), whereas method 2 applies vc and ve to all non-cases. The latter approach is appropriate since vc data is received as a proportion of the total population, including both cases and non-cases. Cases are assumed to be immune, and so the number effectively immunized equals the total population minus cases multiplied by vc and ve.

Method 1c: method 1 modified, no immune lag, vaccine coverage applied to all non-cases

Method 1d: (not shown above), same as method 2 except for step 4 (=$pop_m \cdot vc_m \cdot ve_m$): 28,635.50 averted cases, -0.46% error

Method 2: no vaccine lag, vaccine coverage applied to all non-cases, and incorporating additional edits