Estimation of Reproductive number for influenza in the literature

Part of lecture on infectious disease modelling, Homayoun Bagheri, 2011

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Transmission dynamics of the great influenza pandemic of 1918 in Geneva, Switzerland: Assessing the effects of hypothetical interventions

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Société des nations. M. Paul Lachenal a exposé les problèmes qui résultent pour nous de la situation actuelle.

L'épidémie de grippe

Le Service d'hygiène nous communique :

Cas de grippe signalés le 12 février : 34, dont 25 antérieurs au 8 et 9 se répartissant sur les journées du 8 au 11 janvier.

Et voici la statistique de janvier:

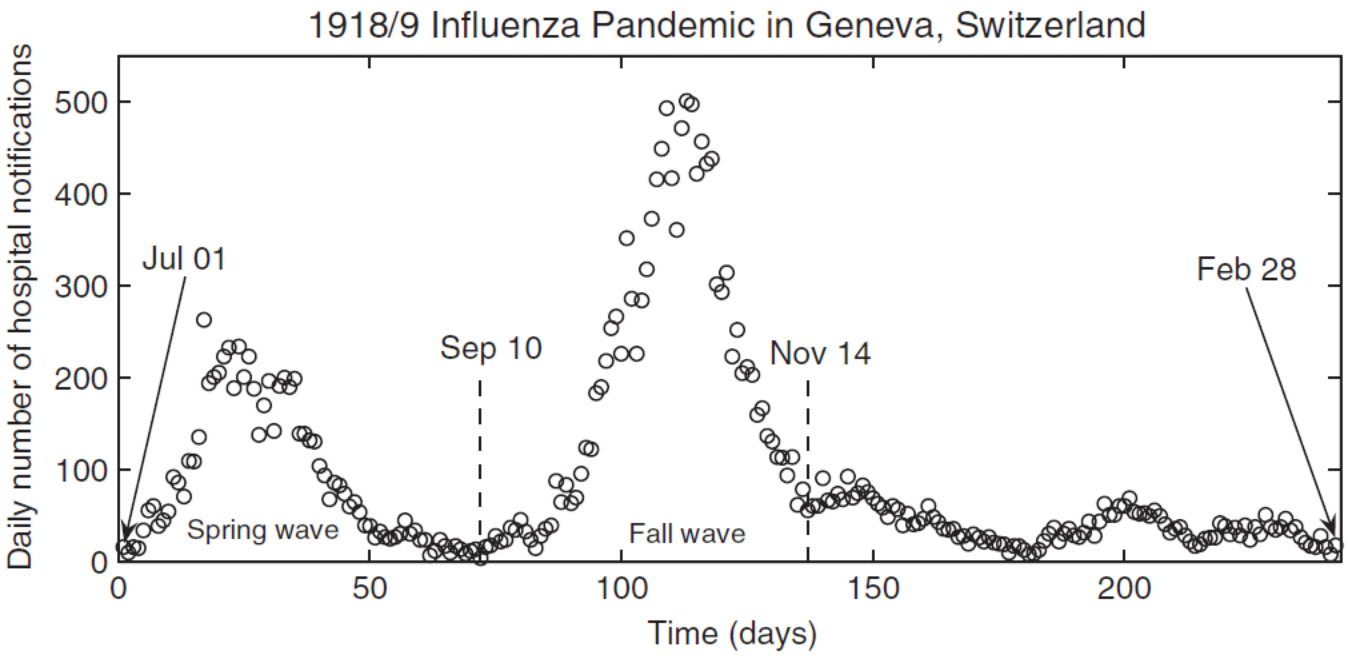
1er janvier, 23 cas; 2 janvier, 31 cas; 3 janvier, 37 cas; 4 janvier, 22 cas; 5 janvier, 31 cas; 6 janvier, 36 cas; 7 janvier, 29 cas; 8 janvier, 27 cas; 9 janvier, 32 cas; 10 janvier, 44 cas; 11 janvier, 28 cas; 12 janvier, 44 cas; 13 janvier, 63 cas; 14 janvier, 51 cas; 15 janvier, 51 cas; 16 janvier, 61 cas; 17 janvier, 61 cas; 18 janvier, 69 cas; 19 janvier, 54 cas; 20 janvier, 52 cas; 21 janvier, 53 cas; 22 janvier, 50 cas; 23 janvier, 56 cas; 24 janvier, 50 cas; 25 janvier, 41 cas; 26 janvier, 32 cas; 27 janvier, 36 cas; 28 janvier, 38 cas; 29 janvier, 29 cas; 30 janvier, 22 cas; et 31 janvier, 17 cas.

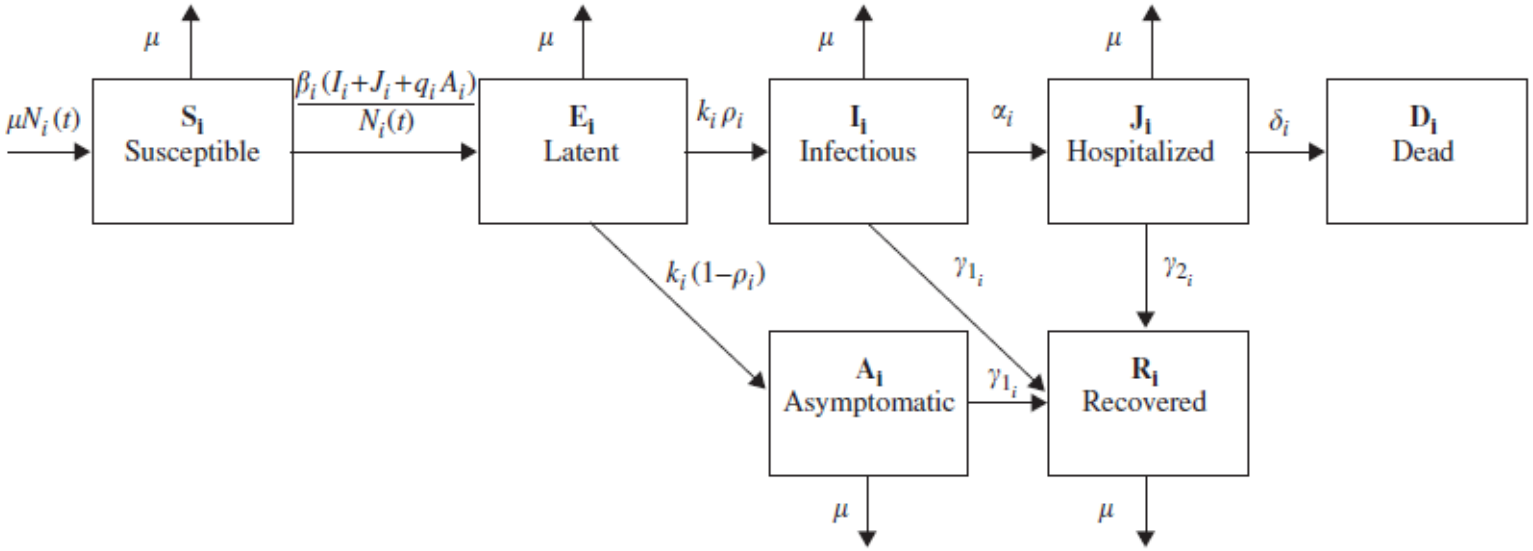
Au total, 1270 cas, contre 976 en décembre.

Une recrudescence

Nous avons reçu le communiqué suivant :

Sur le vu d'un nouveau préavis du Service d'hygiène, disant qu'une vague de recrudescence de l'épidémie de grippe, consécutive aux réunions nombreuses et variées qu'ont entraînées les fêtes de Noël et de Nouvel-An a été constatée, le Conseil d'Etat a décidé de maintenir jusqu'à nouvel avis l'interdiction des bals au « Bâtiment électoral », ainsi que dans les établissements désignés dans l'arrêté du Département de justice et police du 19 novembre 1917.


1918/9 Influenza Pandemic in Geneva, Switzerland
Daily number of hospital notifications
0
100
200
300
400
500
0
50
100
150
200
Time (days)
Jul 01
Sep 10
Nov 14
Feb 28
Spring wave
Fall wave



$$\dot{S}_i(t) = \mu N_i(t) - \beta_i S_i(t)(I_i(t) + J_i(t) + q_i A_i(t))/N_i(t) - \mu S_i(t),$$

$$\dot{E}_i(t) = \beta_i S_i(t)(I_i(t) + J_i(t) + q_i A_i(t))/N_i(t) - (k_i + \mu)E_i(t),$$

$$A_i(t) = k_i(1 - \rho_i)E_i - (\gamma_{1_i} + \mu)A_i(t),$$

$$\dot{I}_i(t) = k_i\rho_i E_i(t) - (\alpha_i + \gamma_{1_i} + \mu)I_i(t),$$

$$\dot{J}_i(t) = \alpha_i I_i(t) - (\gamma_{2_i} + \delta_i + \mu)J_i(t),$$

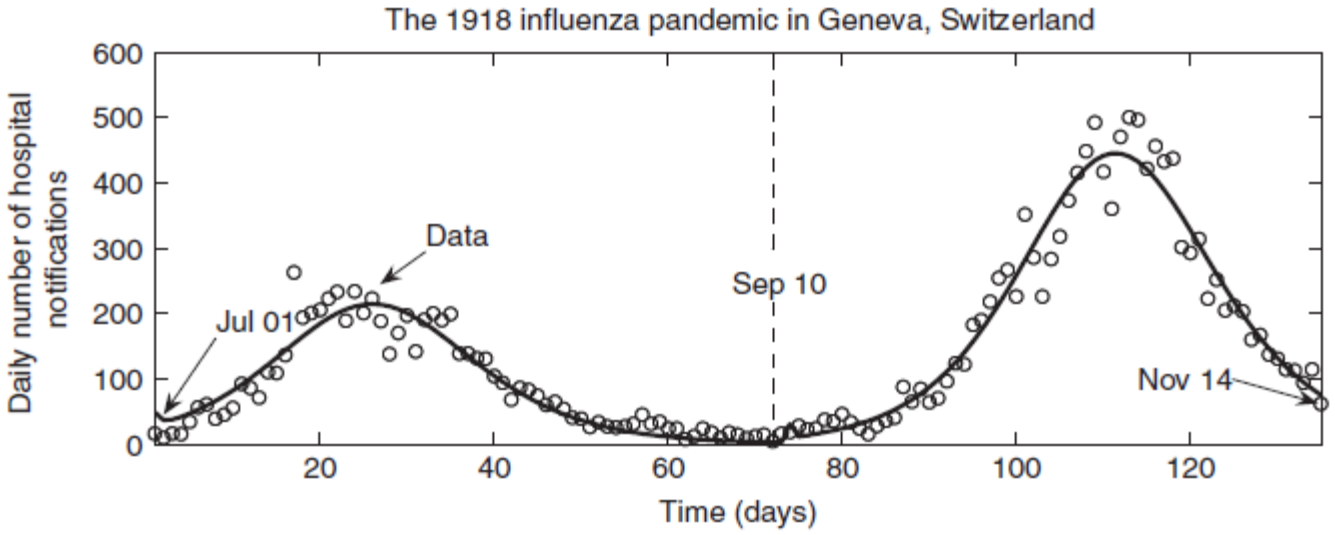
$$\dot{R}_i(t) = \gamma_{1_i}(A_i(t) + I_i(t)) + \gamma_{2_i} J_i(t) - \mu R_i(t),$$

$$\dot{D}_i(t) = \delta_i J_i(t),$$

$$\dot{C}_i(t) = \alpha_i I_i(t),$$

Table 1
Parameter definitions and baseline estimates for the spring and fall waves of the 1918/9 influenza pandemic in Geneva, Switzerland (Fig. 4)

Parameter	Definition	Source	Spring wave		Fall wave	
			Estimate	S.D.	Estimate	S.D.
β	Transmission rate ($days^{-1}$)	LS	8.00	0.13	5.75	0.24
γ_1	Recovery rate ($days^{-1}$)	LS	0.34	0.01	0.45	0.04
α	Diagnostic rate ($days^{-1}$)	LS	0.51	0.04	2.14	0.11
q	Relative infectiousness of the asymptomatic class	LS	0.003	0.004	0.014	0.01
ρ	Proportion of clinical infections ([0, 1])	LS	0.10	0.01	0.36	0.02
γ_2	Recovery rate for hospitalized class ($days^{-1}$)	—	1.10	0.26	0.58	0.07
δ	Mortality rate ($days^{-1}$)	Gani et al. (2005)	0.01	0.002	0.02	0.002
k	Rate of progression to infectious ($days^{-1}$)	Mills et al. (2004)	0.53	—	0.53	—
μ	Birth and natural death rate ($days^{-1}$)	Robine and Paccaud (2005)	$1/(60 * 365)$	—	$1/(60 * 365)$	—
$E(0)$	Initial number of exposed individuals	LS	207	7	9	11
$I(0)$	Initial number of infectious individuals	LS	132	4	34	4



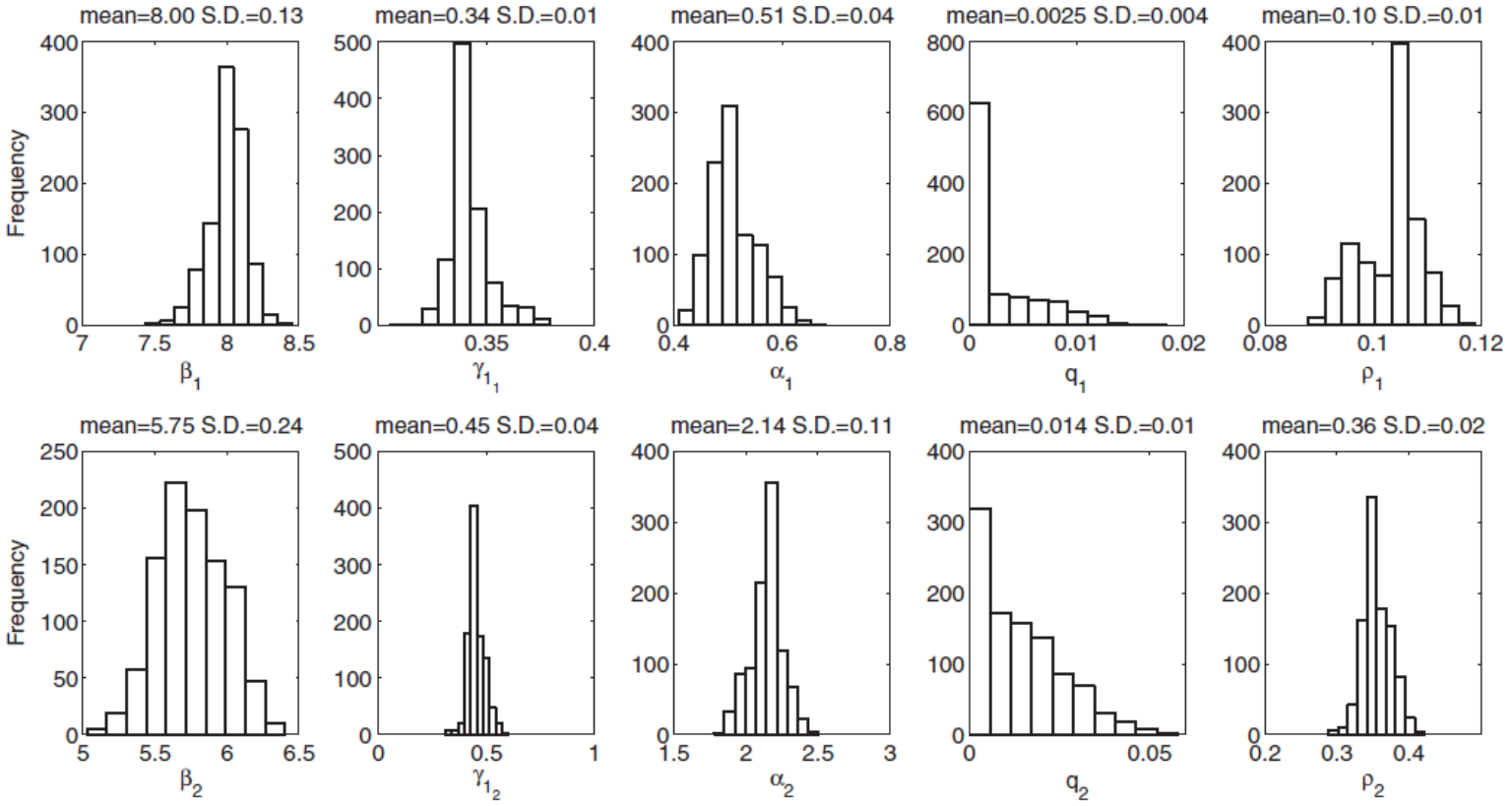


Table 2
Population parameters and estimated reproductive numbers and reporting rates for the spring and fall waves of the 1918/9 influenza pandemic in Geneva, Switzerland

Flu wave	Case fatality rate (%)	$\mathscr{R}$	S.D. $\mathscr{R}$	Reporting (%)	S.D. Reporting (%)
Spring	0.7 (Gani et al., 2005)	1.49	0.02	59.7	2.0
Fall	3.25 (Gani et al., 2005)	3.75	0.09	83.0	2.0

Estimates of the standard deviation (S.D.) for $\mathscr{R}_i$ and clinical reporting were obtained from our simulation study consisting of 1000 replicates (see Fig. 6).

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Comparative estimation of the reproduction number for pandemic influenza from daily case notification data

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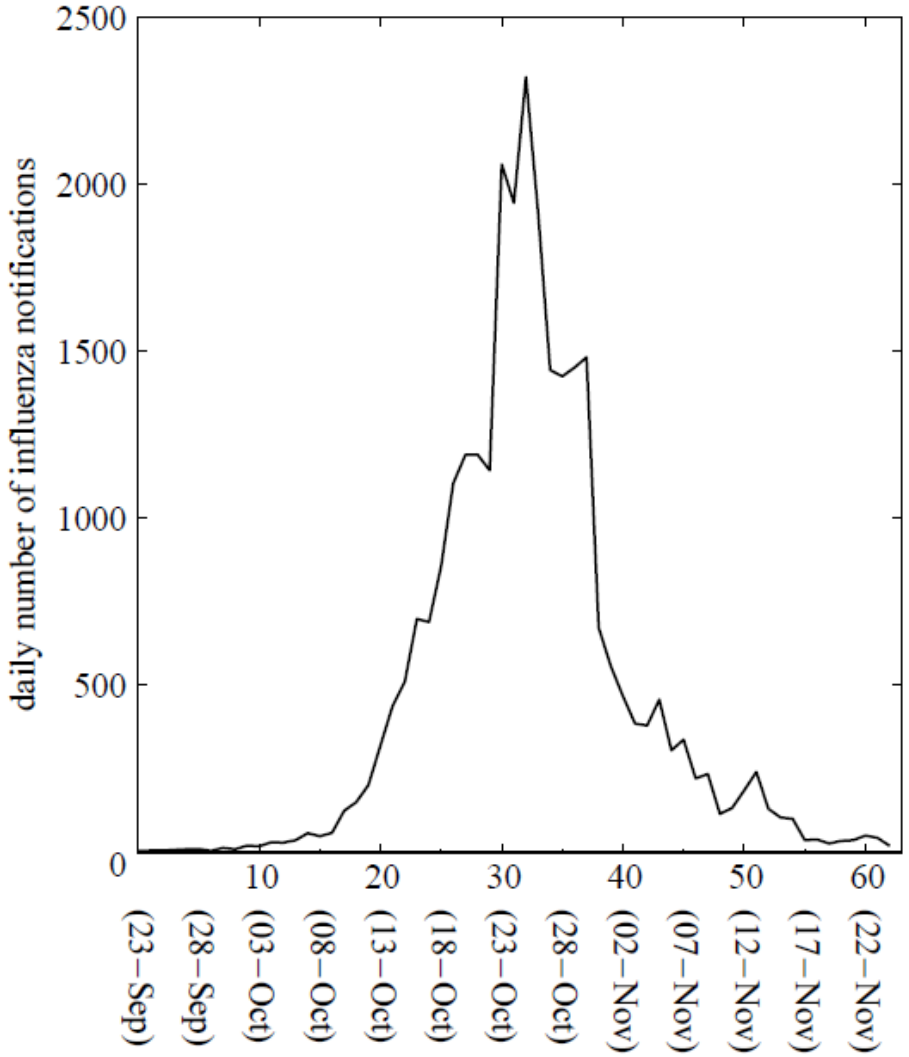

Figure 1. Daily number of influenza notifications in San Francisco, California during the 1918–1919 influenza pandemic (Department of Hygiene 1922).

Table 1. Estimates of the reproduction number for the autumn wave of the Spanish flu pandemic in San Francisco, California. n.a., not applicable. The number of data points is smaller than the number of parameters being estimated (seven parameters for the complex SEIR model). Note that the stochastic SIR method provides the effective reproduction number at time t, while the other methods estimate the reproduction number by fitting the models to a specified number of epidemic days of data. The number of degrees of freedom (d.f.) is different by method. Initial growth rate, simple SEIR and complex SEIR estimate 1, 2 and 7 parameters, respectively. d.f. was determined by the difference between the observed number of epidemic days, n, and the number of parameters to be estimated (e.g. for the complex SEIR, d.f. at 17 days was $n-7=10$).

	initial growth rate		simple SEIR		complex SEIR		stochastic SIR	
epidemic days	$\mathcal{R}$	$\mathcal{R}$ 95% CI	$\mathcal{R}$	$\mathcal{R}$ 95% CI	$\mathcal{R}$	$\mathcal{R}$ 95% CI	$\mathcal{R}_t$	$\mathcal{R}_t$ 95% CI
5	5.78	(3.80, 8.15)	3.72	(2.01, 5.44)	n.a.	n.a.	1.96	(0.83, 3.09)
17	2.98	(2.73, 3.25)	2.38	(2.16, 2.60)	2.20	(1.55, 2.84)	2.10	(1.21, 2.95)

Potential assignment:

Review of R0 estimates for influenza in the literature.

Why is there so much disparity?