Table 1. Summary of interventions and their timing across 17 cities

Intervention	Number of 17 cities implementing	Median (interquartile range) epidemic stage (CEPID) at time of implementation*
Making influenza a notifiable disease	15	5.6 (3.1, 25.9)
Emergency declarations	4	—
Isolation policies	14	15.7 (7.6, 30.8)
Quarantine of households where infection identified	5	—
School closures	14	30.8 (15.1, 96.3)
Church closures	15	29.9 (12.4, 130.6)
Theater closures	15	29.9 (10.3, 66.9)
Dance hall closures	11	44.7 (12.4, –)
Other closures	13	84.7 (29.9, 322.0)
Staggered business hours to reduce congestion in stores and on transit systems	8	—
Mask ordinances	2	—
Rules forbidding crowding on streetcars	6	—
Private funerals	11	92.1 (30.8, –)
Bans on door-to-door sales	1	—
Interventions designed to reduce transmission in the workplace	0	—
Protective sequestration of children	3	—
Bans on public gatherings	15	30.8 (12.4, 118.1)
No-crowding rules in locations other than transit systems	3	—
Community-wide business closures	1	—

*Shown only for interventions implemented in at least nine cities (>50%); 75th percentile not shown for interventions implemented in <13 cities.

tions are included in supporting information (SI) *Appendix*]. We then related this information to the observed outcomes of the peak weekly death rate and CEPID during the period September–December, 1918. Excess death rates were used as a proxy for case incidence because of the more accurate reporting of deaths than cases. We hypothesized that early implementation of multiple NPIs in an immunologically naïve population would slow the progression of the epidemic, resulting in a flatter epidemic curve, but that over time aggregate outcomes would approach those observed in cities not implementing such measures, until roughly comparable levels of herd immunity were achieved.

Results

Effect of Early Interventions on Epidemic Spread. We assessed the relationship between the timing of NPIs and three measures of epidemic outcome: (*i*) the peak weekly rate of excess P&I deaths per 100,000 population (peak death rate) during the study period; (*ii*) the "normalized" peak weekly excess P&I death rate (peak weekly death rate during the study period divided by the median weekly rate during the period); and (*iii*) the CEPID per 100,000 population during the study period. The stage of the epidemic at the time of each intervention was defined as the CEPID from the start of the study period until

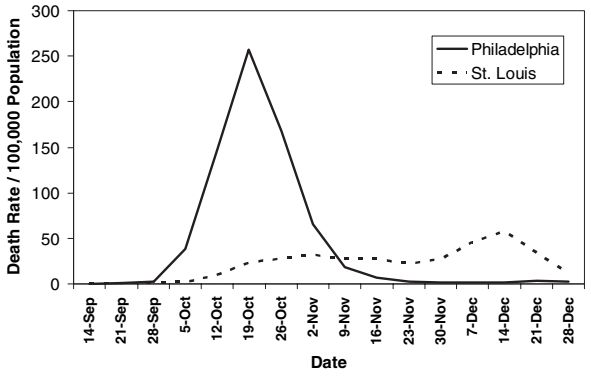

Fig. 1. Excess P&I mortality over 1913–1917 baseline in Philadelphia and St. Louis, September 8–December 28, 1918. Data are derived from ref. 10.

the date on which the intervention was announced. Thus, early interventions in a given city were those that were implemented when relatively few individuals had died, whereas later ones

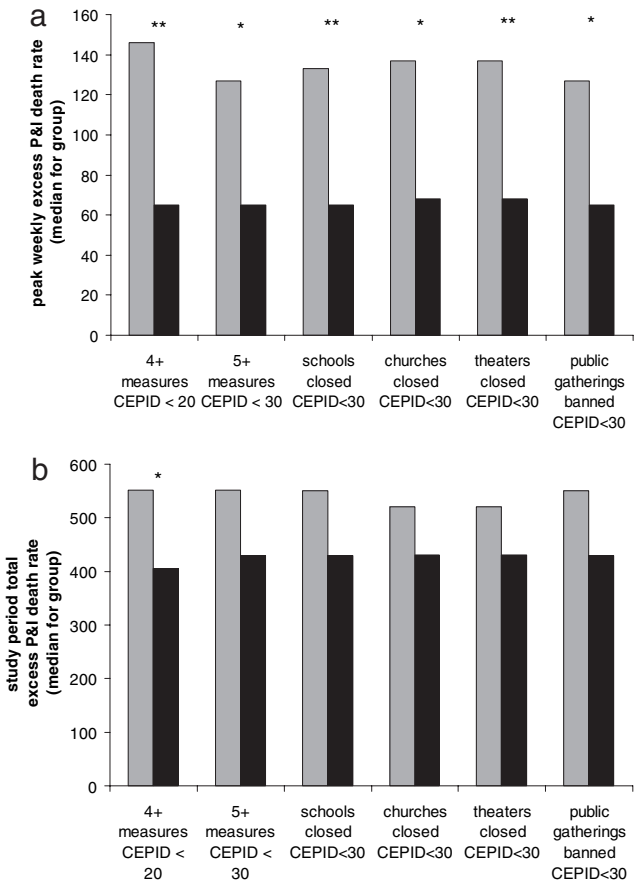

Fig. 2. Relationship of (*a*) peak weekly excess P&I death rate and (*b*) total excess P&I death rate during the study period to the timing of various NPIs. Cities were divided evenly into those intervening early (black bars) vs. late or not at all (gray bars), and the median outcome for the early and late groups was plotted. The first two groups of bars assess overall timing of intervention, comparing those cities that announced four or more NPIs before experiencing 20/100,000 CEPID with those with three or fewer and those that announced five or more NPIs before experiencing 30/100,000 CEPID with those with four or fewer. The remaining groups compare those cities that announced particular measures before experiencing 30/100,000 CEPID with those that did not. Significance by Mann–Whitney *U* test: *, $P < 0.05$; **, $P < 0.01$.