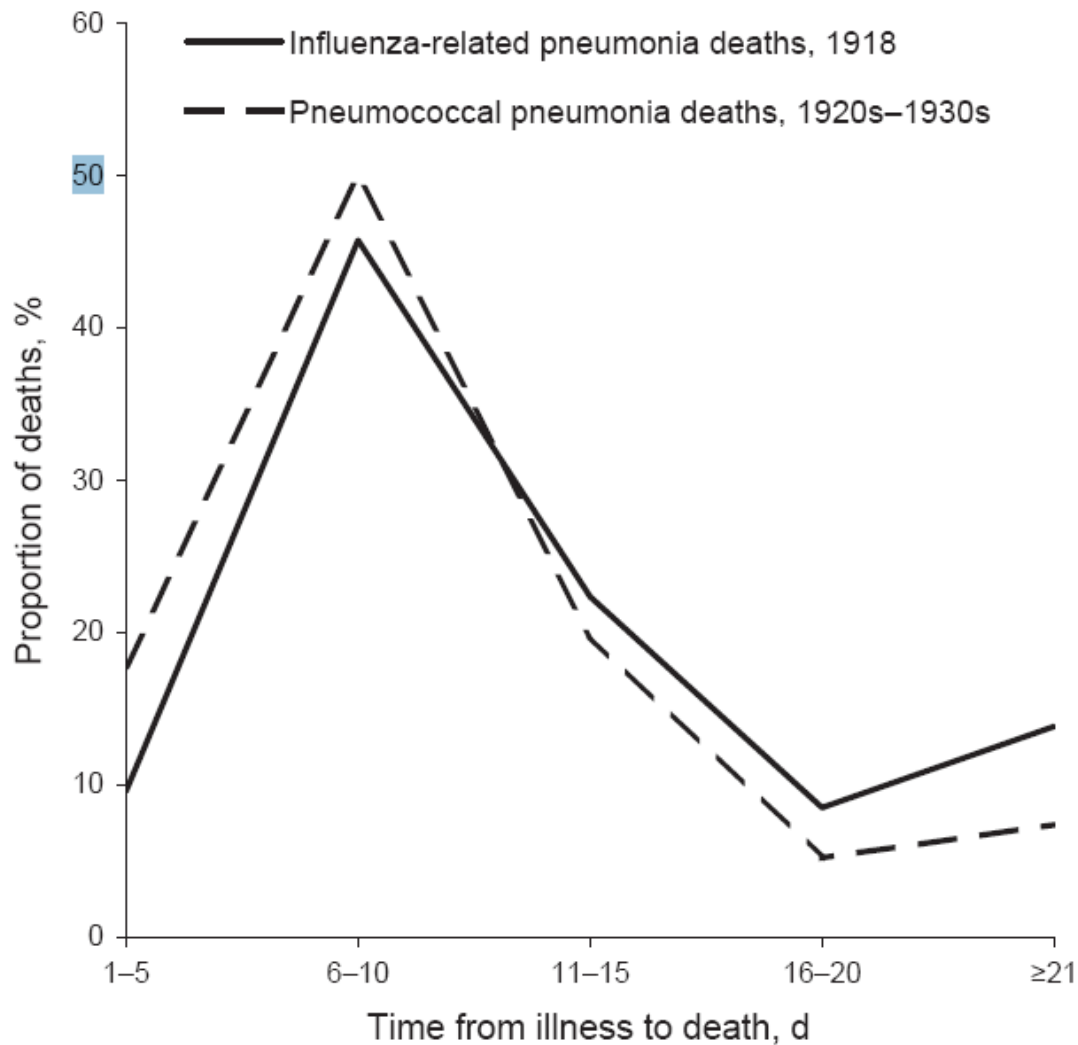


# Role of *S. pneumoniae* in post-flu pneumonia

Doo Ryeon Chung, MD, PhD

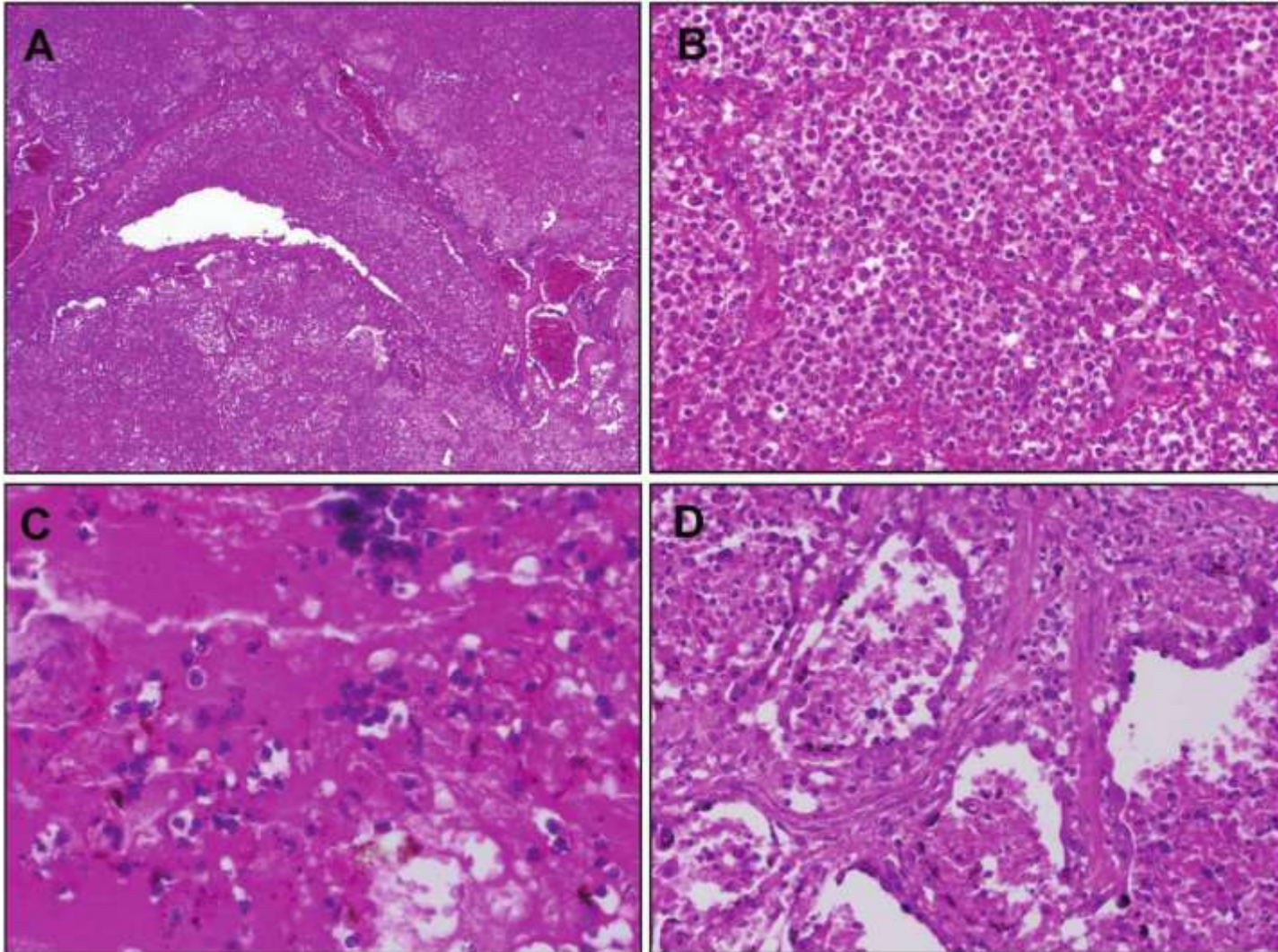
Samsung Medical Center, Seoul, Korea

# Role of *S. pneumoniae* in post-flu pneumonia



# Role of *S. pneumoniae* in post-flu pneumonia

Recut tissue specimens obtained during autopsy from 58 influenza victims in 1918-1919



# Role of *S. pneumoniae* in post-flu pneumonia

## Bacterial culture results in autopsy series involving 96 postmortem cultures of lung tissue from victims of the 1918 –1919 influenza pandemic

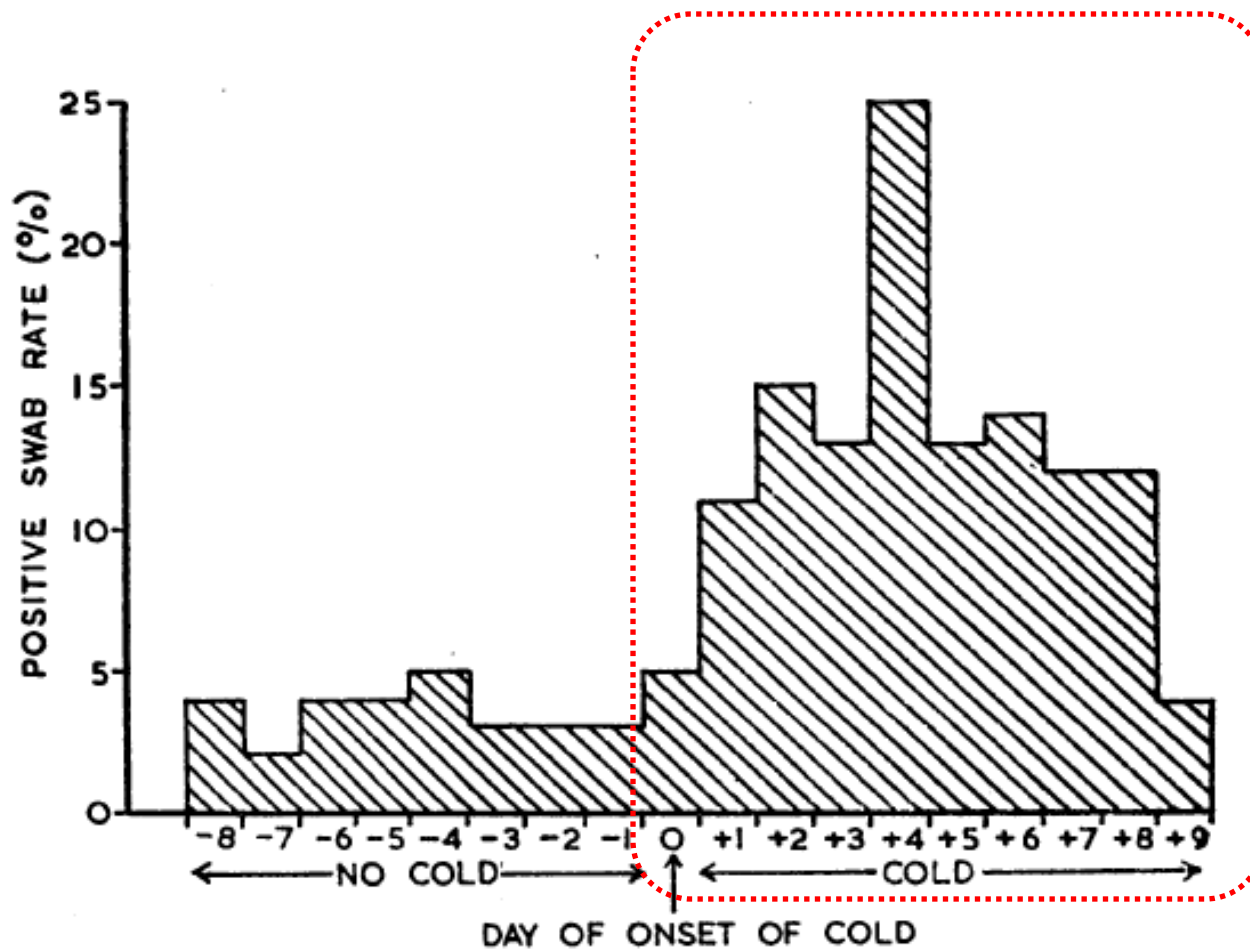
No. (%) of cultures from which organism was recovered, by organism

Type of autopsy series	No. of results	<i>Streptococcus pneumoniae</i>	<i>Streptococcus hemolyticus</i>	<i>Staphylococcus aureus</i>	<i>Diplococcus intracellulare meningitidis</i>	Mixed pneumopathogens	<i>Bacillus influenzae</i>	Other bacteria	No growth
All military (n = 60)	3515	<b>855 (24.3)</b>	615 (17.5)	263 (7.5)	40 (1.1)	707 (20.1)	387 (11.0)	484 (13.8)	164 (4.7)
All civilian (n = 36)	1751	380 (21.7)	281 (16.0)	164 (9.4)	1 (<0.1)	<b>398 (22.7)</b>	132 (7.5)	339 (19.4)	56 (3.2)
All military and civilian (n = 96)	5266	<b>1235 (23.5)</b>	896 (17.0)	427 (8.1)	41 (0.8)	1105 (21.0)	519 (9.9)	823 (15.6)	220 (4.2)
All higher- quality military and civilian <sup>a</sup> (n = 68)	3074	712 (23.2)	553 (18.0)	238 (7.7)	21 (0.7)	<b>828 (26.9)</b>	144 (4.7)	353 (11.5)	225 (7.3)
Predominance of pneumopathogens not confirmed (n = 14)	1115	209 (18.7)	132 (11.8)	52 (4.7)	0 (0.0)	24 (2.2)	210 (18.8)	<b>402 (36.1)</b>	86 (7.7)

In the 68 higher-quality autopsy series, in which the possibility of unreported negative cultures could be excluded, 92.7% of autopsy lung cultures were positive for 1 bacterium

# The role of upper respiratory viral infections in pneumococcal transmission

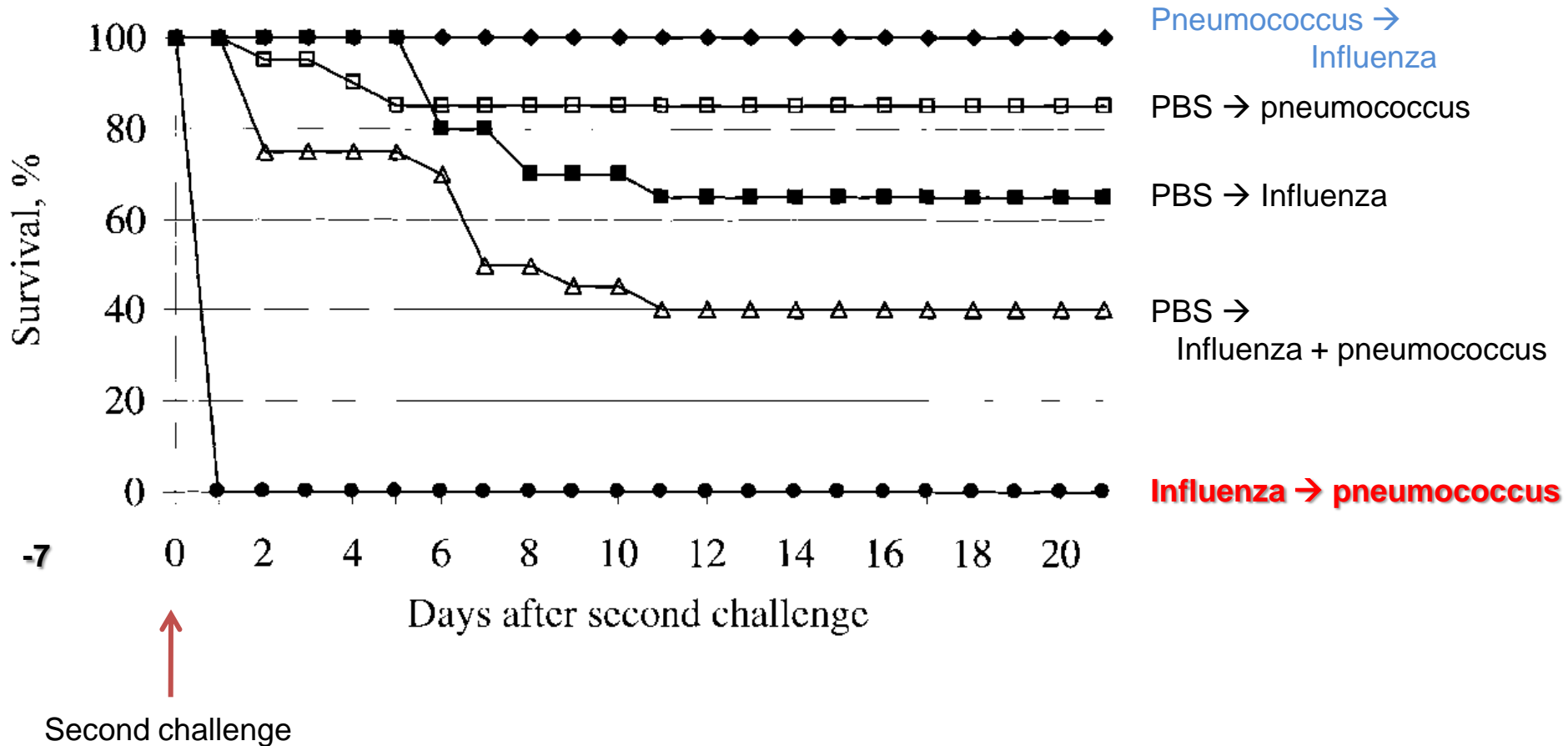
Relationship between pneumococcal colonization and onset of acute coryza



# Aspects of innate immunity that mediate the interaction between influenza and pneumococcus

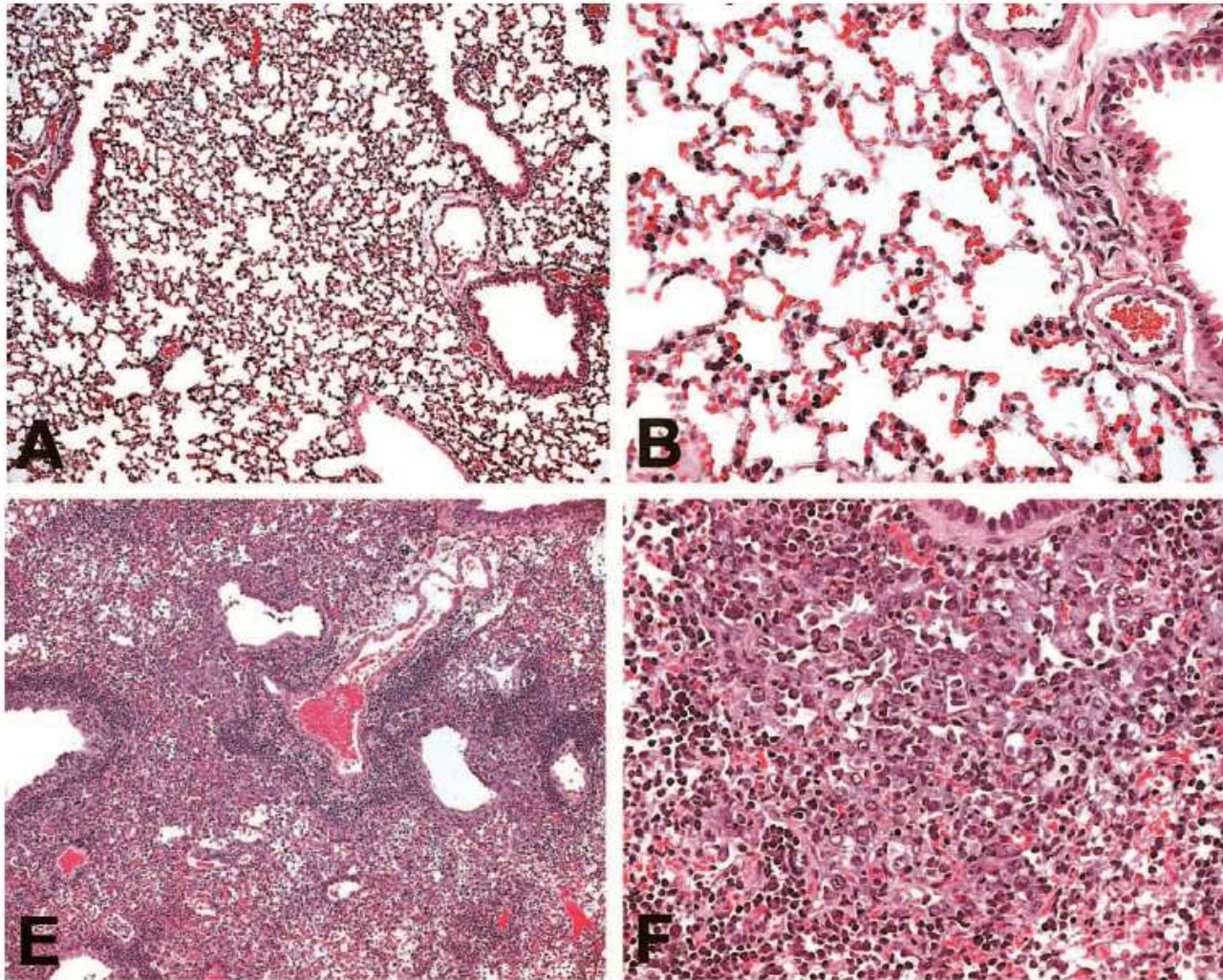
## Synergistic mortality in mice

*Mount Sinai strain of mouse-adapted influenza virus A/Puerto Rico/8/34(H1N1)*



# Aspects of innate immunity that mediate the interaction between influenza and pneumococcus

## Synergistic mortality in mice

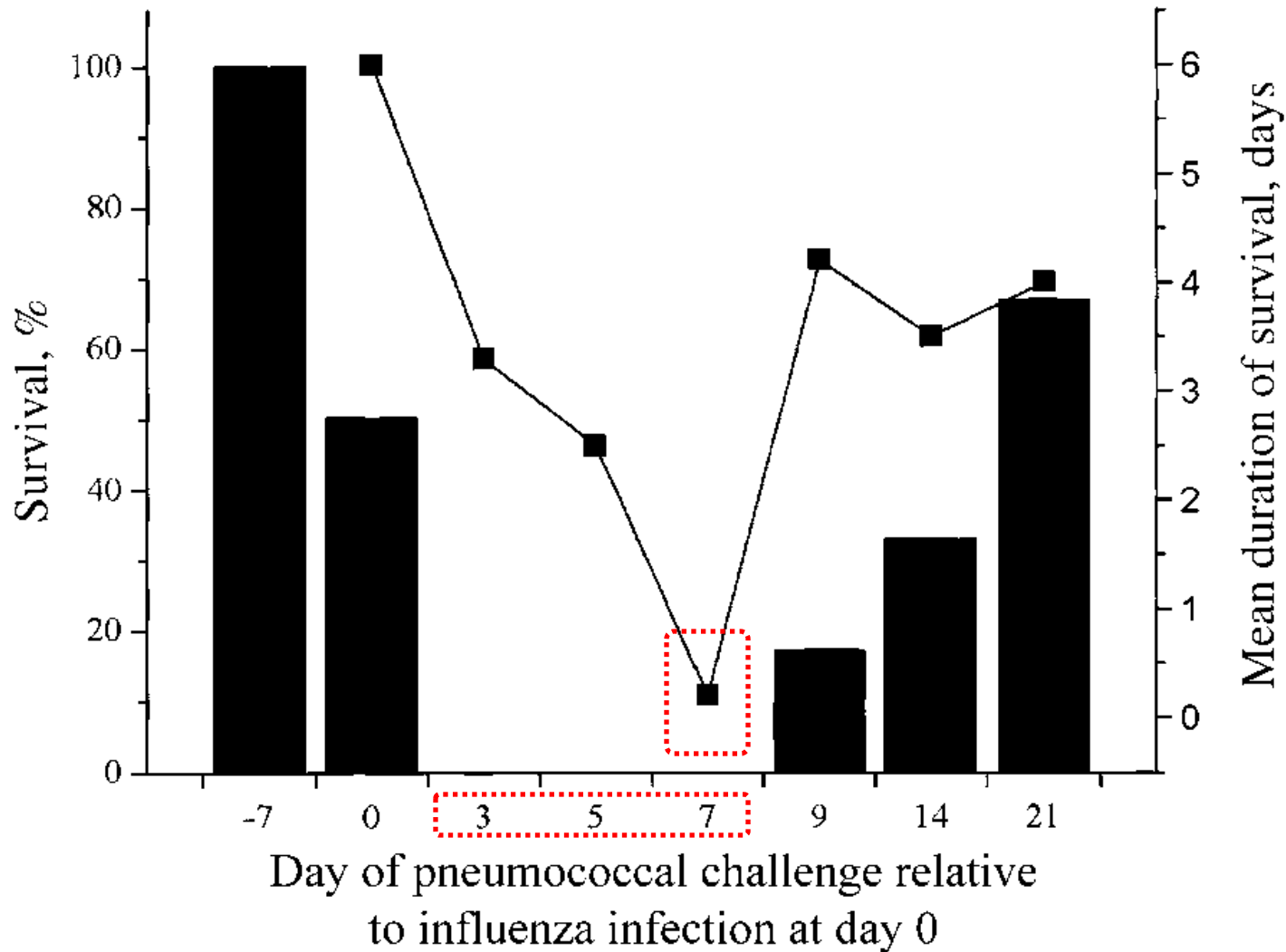


PBS  
→ Pneumococcus  
(non-lethal dose)

Influenza  
→ pneumococcus

# Aspects of innate immunity that mediate the interaction between influenza and pneumococcus

## Synergistic mortality in mice





# *Evidence for an interaction between various viral respiratory infections and the pneumococcus during seasonal pneumonia*

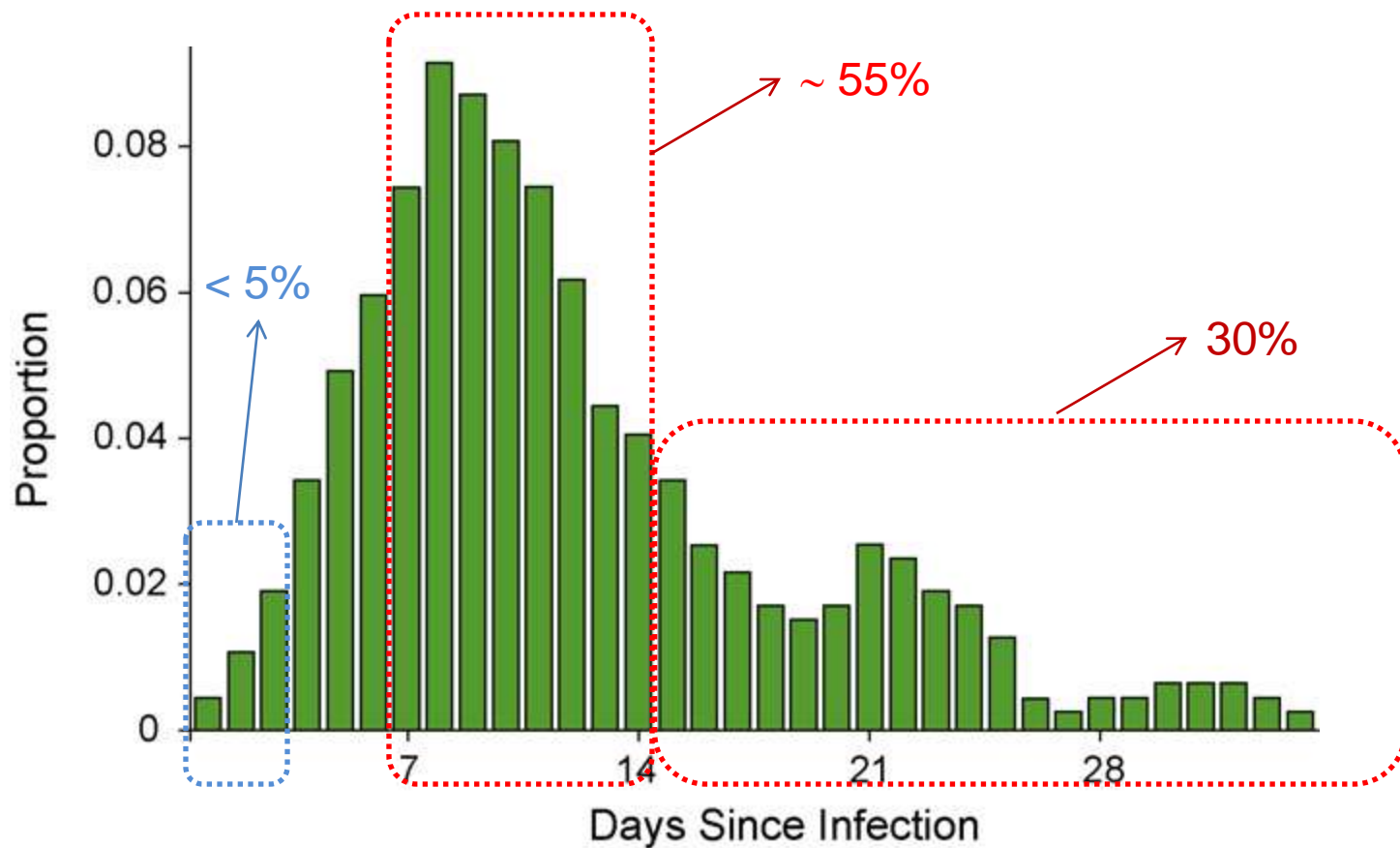
Case-control study, an outbreak of severe pneumococcal pneumonia among children in Iowa from 1995 to 1996

Children with evidence of influenza-like illness in the preceding 7–28 days

→ 12.4-fold greater risk of developing serious IPD compared with children without influenza-like illness.

# *Evidence that the pneumococcus was responsible for a considerable fraction of the influenza-associated mortality in 1918*

## Timeline post-infection of influenza deaths—1918 epidemic



# ***Evidence that the pneumococcus was responsible for a considerable fraction of the influenza-associated mortality in 1918***

Blood cultures of living influenza pneumonia patients in the 1918 camp pandemic

Camp	Number of blood cultures taken	Number (%) of positive blood cultures	Number positive for pneumococci	Number positive for haemolytic streptococci	Number positive for other bacteria
Camp Grant [54]	90	45 (50.0%)	45	0	0
Camp Beauregard [55]	111	54 (48.6%)	50	3	1
Puget Sound Navy Yard [56]	52	24 (46.2%)	0	23	1
Flanders and France [57]	33	13 (39.4%)	13	0	0
Fort Riley [58]	17	6 (35.3%)	3	3	0
Scottish Hospital [59]	15	5 (33.3%)	5	0	0
DC Navy Hospital [60]	40	10 (25.0%)	8	0	2
Camp Devens [61]	118	28 (23.7%)	27	1	0
Camp Travis [52]	178	21 (11.8%)	21	0	0
American Troops in England [53]	126	14 (11.1%)	12	2	0
Camp Sherman [47]	100	6 (6.0%)	6	0	0
Camp Lee and Camp Dix [62]	136	5 (3.7%)	5	0	0
Camp Custer [63]	510	11 (2.2%)	1	10	0
Camp Cody [51]	248	4 (1.6%)	3	1	0
Total	1774	246 (13.9%)	199	43	4

81% of bacteremia  
11% of cases of influenza pneumonia

***Evidence that the pneumococcus was responsible for a considerable fraction of the influenza-associated mortality in 1918***

Camp Jackson, South Carolina

312 post-mortem lung cultures (percutaneous needle aspiration)

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No. (%)

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*S. aureus*

153 (49)

*S. pneumoniae*

139 (45)

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\*Mixed cultures

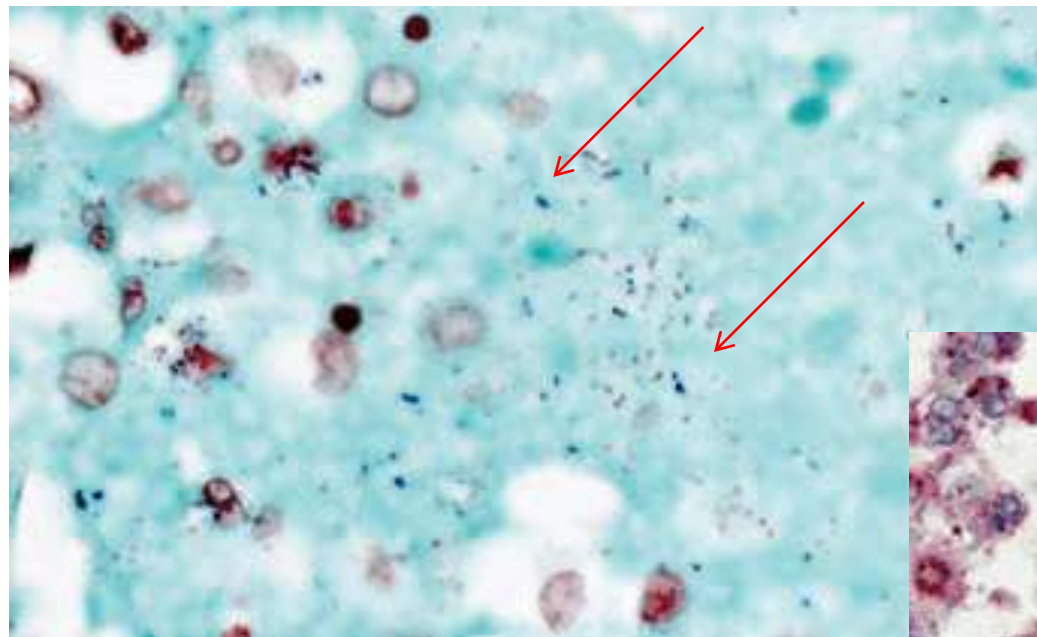
27%

*... suggesting the possibility of some skin contamination during autopsy or needle aspiration*

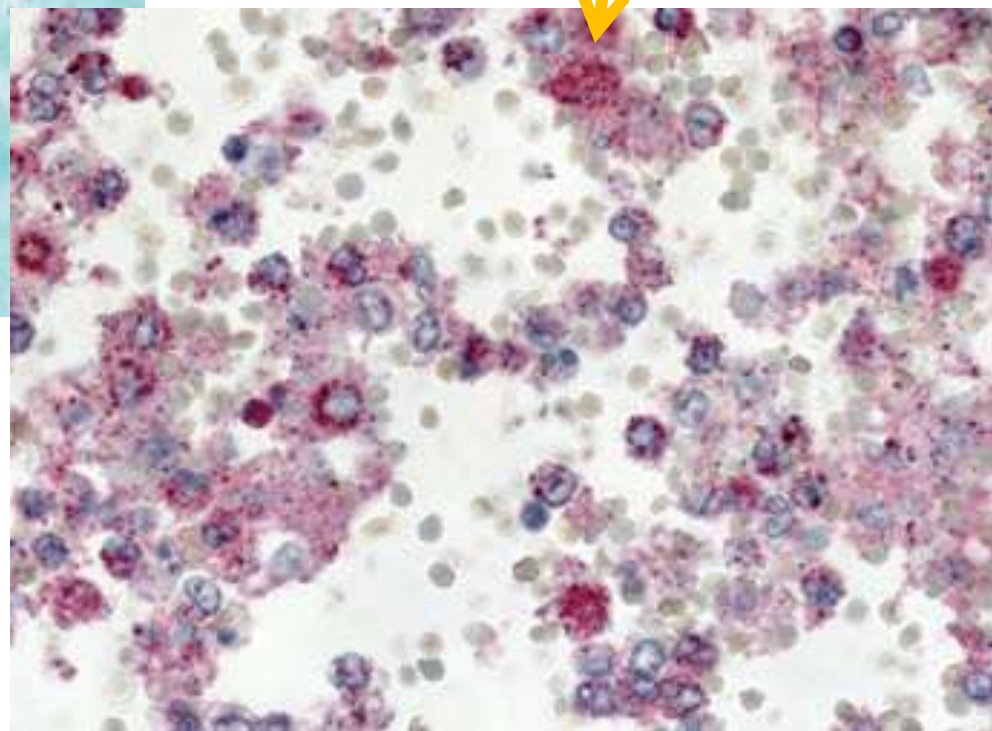
## Novel influenza A (H1N1)

- CDC , postmortem lung specimens from patients with fatal cases of 2009 pandemic influenza A (H1N1)
- May 1–August 20, 2009
- 77 U.S. patients with fatal cases
- Immunohistochemical assays/PCR (16S ribosomal DNA)
- Evidence of concurrent bacterial infection
  - 22 /77(28.6%)
    - including 10 (13.0%) caused by *S. pneumoniae*
    - 7 (9.1%) *S. aureus*
    - 6 (7.8%) *S. pyogenes*
    - 2 (2.6%) *S. mitis*
    - 1 (1.3%) *H. influenzae*

## Novel influenza A (H1N1)



*Immunohistochemical staining  
of multiple S. pneumoniae*



# Pathophysiological interactions between influenza and bacterial respiratory pathogens

