Exposure at work place and excess mortality in Sweden during the 1918 influenza pandemic

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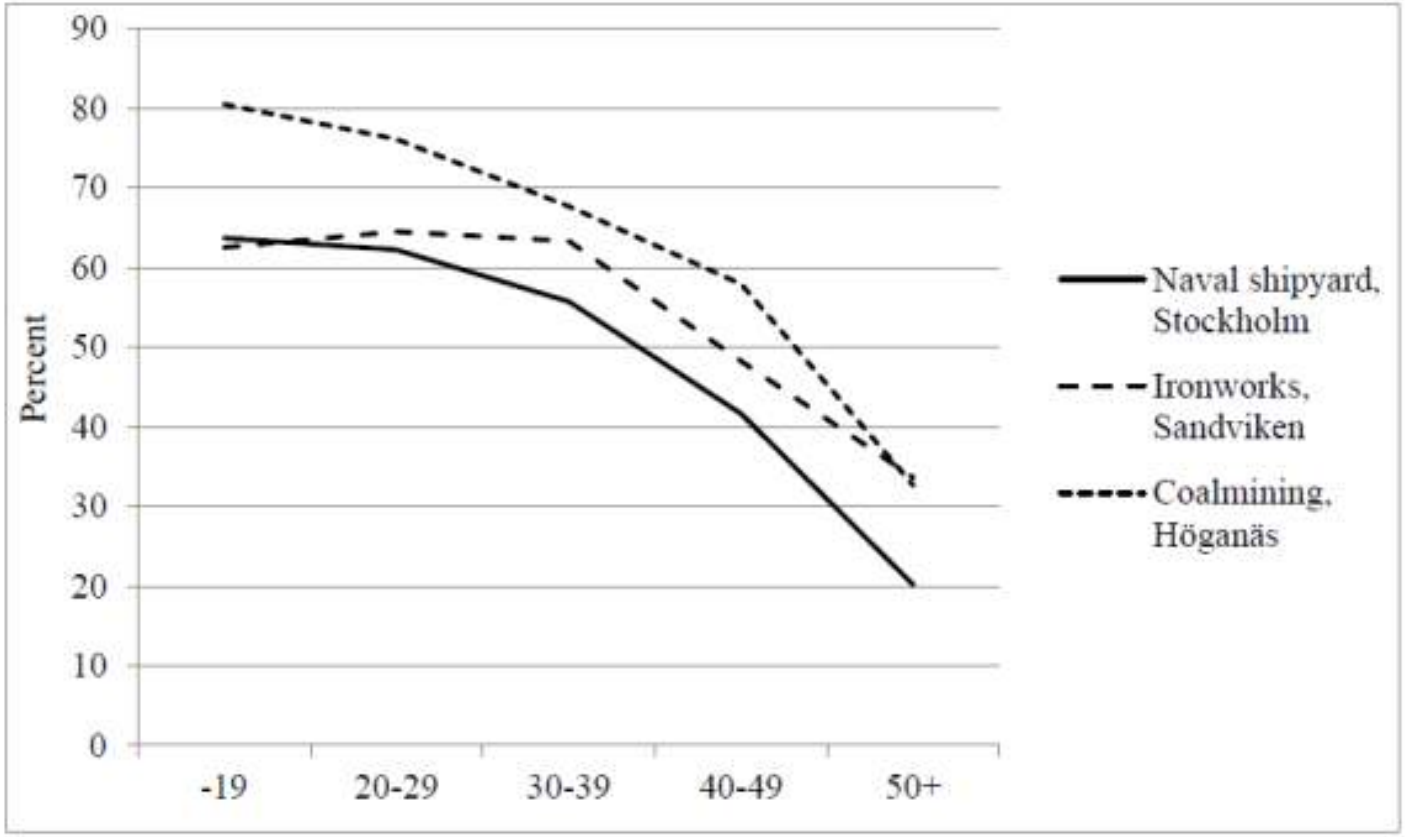
A social gradient in influenza mortality? If so, why?

- Many contemporary scientists claimed that the influenza during the pandemic did **not** have a social gradient (see Crosby 1976; Åman 1990)
- Others found socioeconomic differences in mortality during the pandemic (Sydenstricker 1931; Britten 1932; Collins 1931)
- More recently, an analysis of two socially contrasting parishes in Oslo showed that the working classes and those living in small apartments had the highest mortality (Mamelund 2006)
- In Chicago, social factors at the local level, such as literacy, homeownership, and unemployment were associated with influenza and pneumonia mortality in 1918 (Grantz el al 2016)
- Thus, we are faced with two contrasting views!

The Spanish flu in Sweden

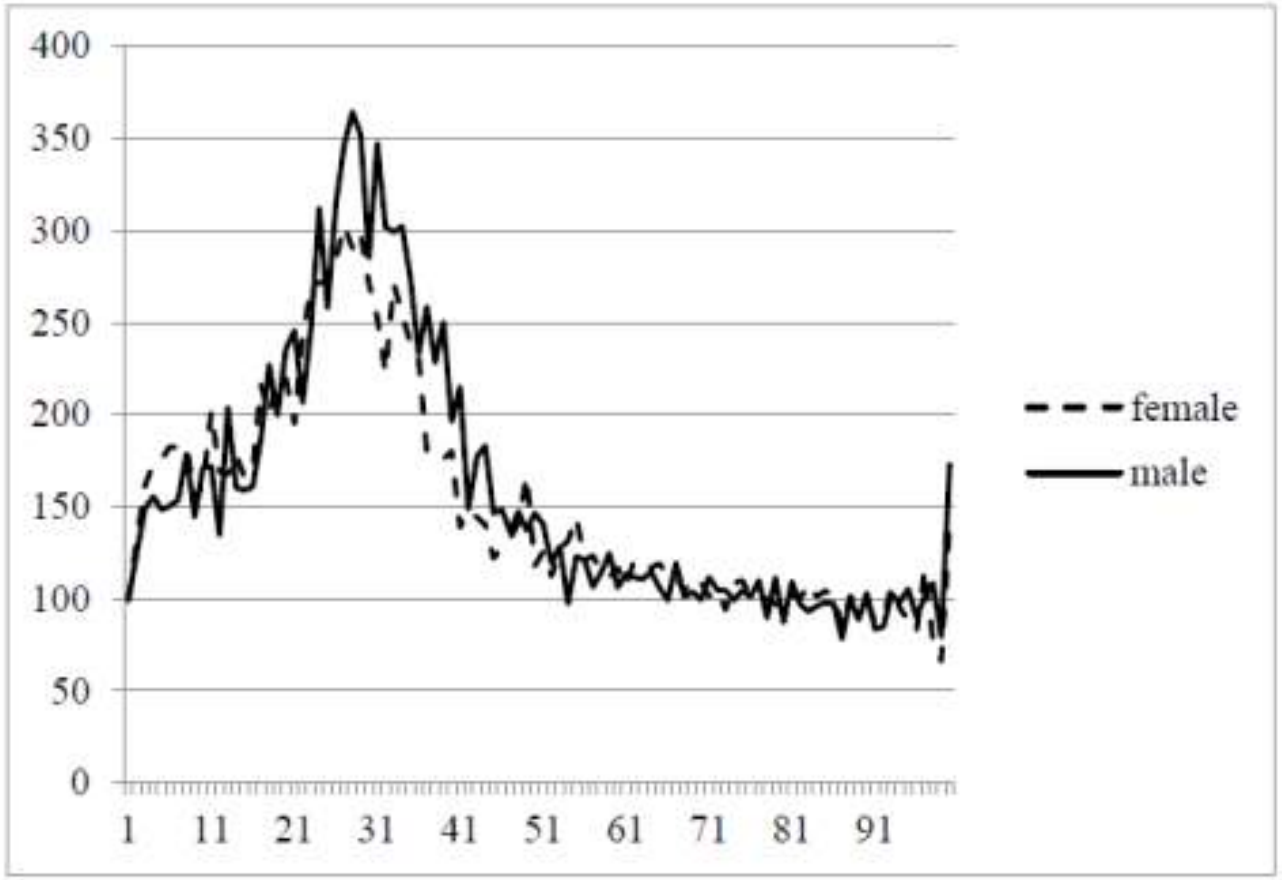
- Close to 35,000 people, out of a population of 5.8 million, died from influenza and pneumonia during the three waves of the pandemic
- Started at the end of June 1918
- First wave came in July and killed 52 persons
- Second wave came in September and peaked in October/November
- Third and milder wave came in April1919
- Morbidity officially 9 %, in Stockholm 1.4 %

Morbidity rate among males in 1918



Sources: Alling 1919, Gibson 1919, Widstrand 1918.

Mortality in 1918 relative to 1917



Source: Sveriges Officiella Statistik: Befolkningsrörelsen 1917, 1918.

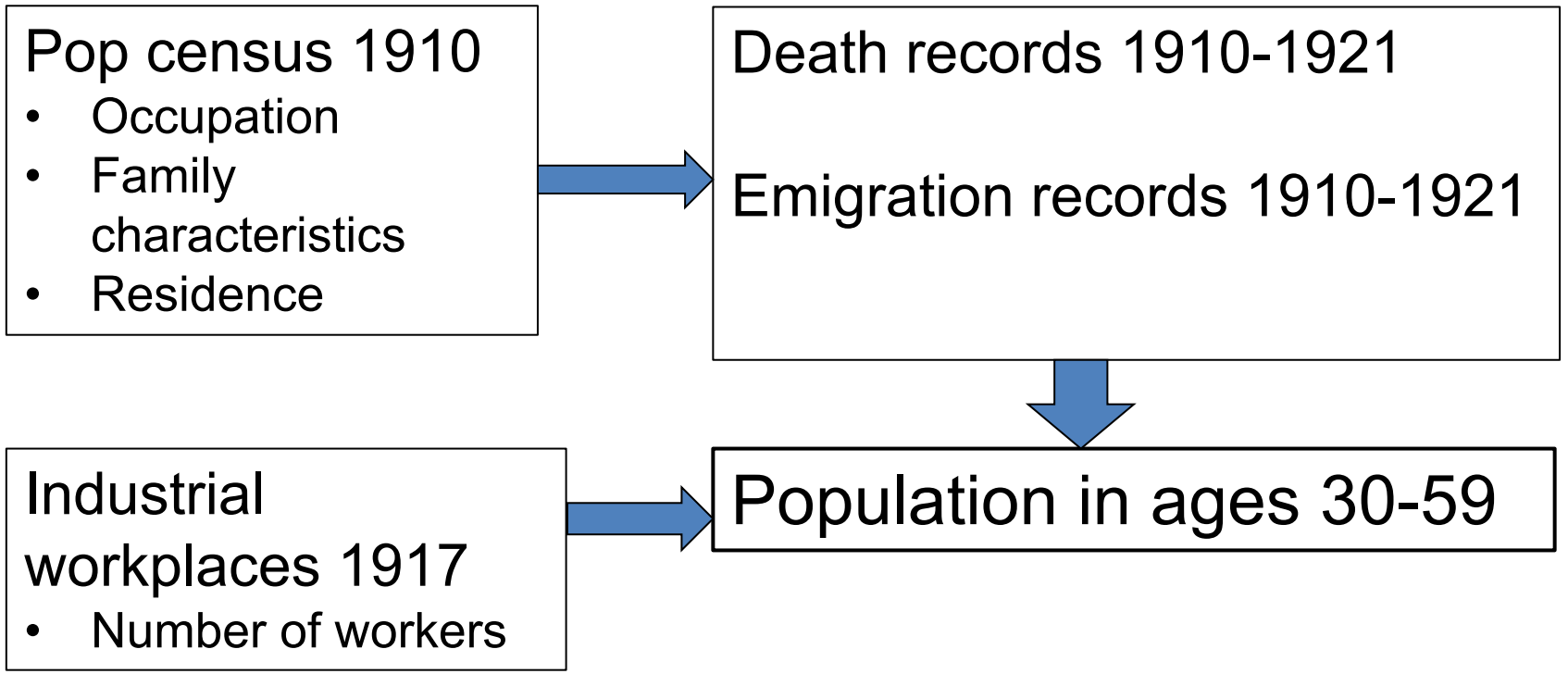
RESEARCH QUESTION 1

Was there a social gradient in the mortality in the flu?

DATA

- Individual-level data for the entire population of Sweden aged 30-59
- Information from the death records for the period 1915 to 1921 is linked with data on occupation, family characteristics, and residence from the population census of 1910
- Linking rate is 72 % for men, 68 % for women.
- 81,867 linked deaths in the period 1915 to 1921, of which 18,691 occurred between July 1, 1918 and June 30, 1919
- Men with certain occupations are linked to certain industries where we have information on number of workers. In all 78 different types of industries in 101 towns.

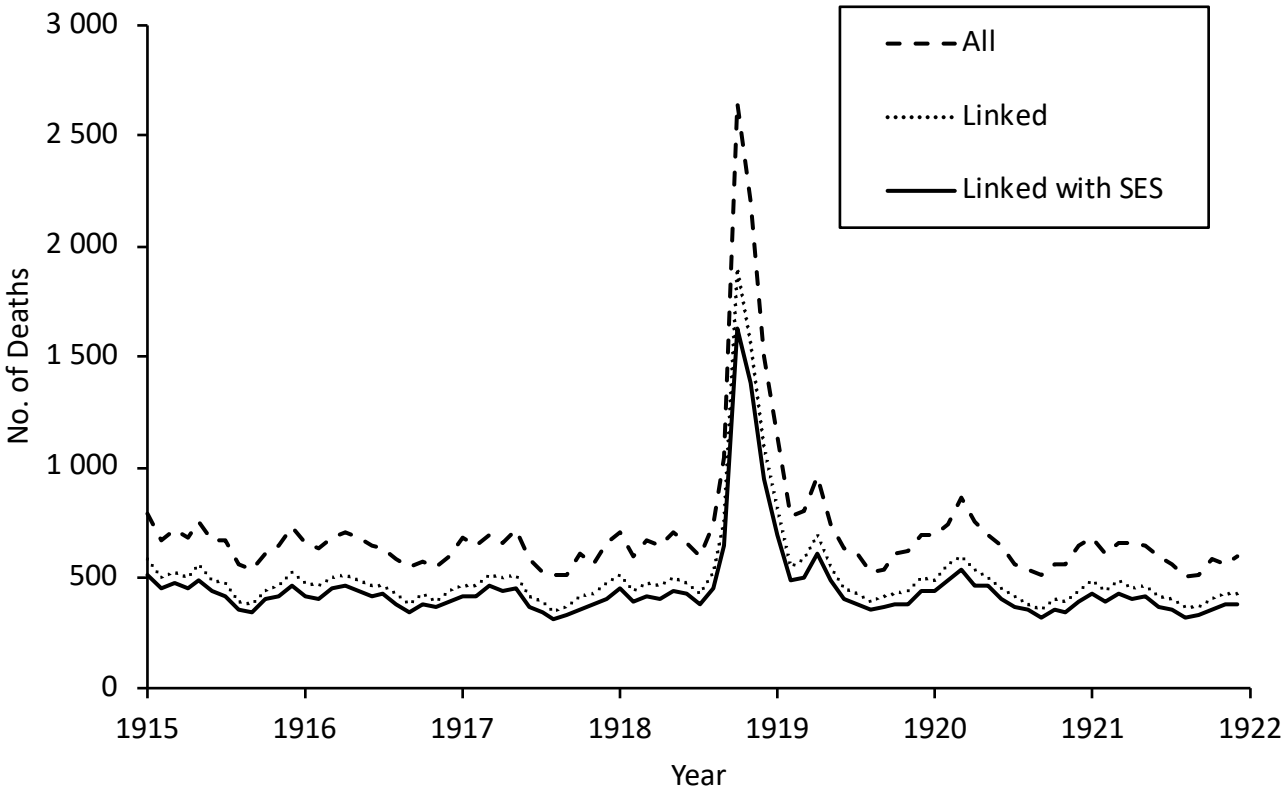
Data structure



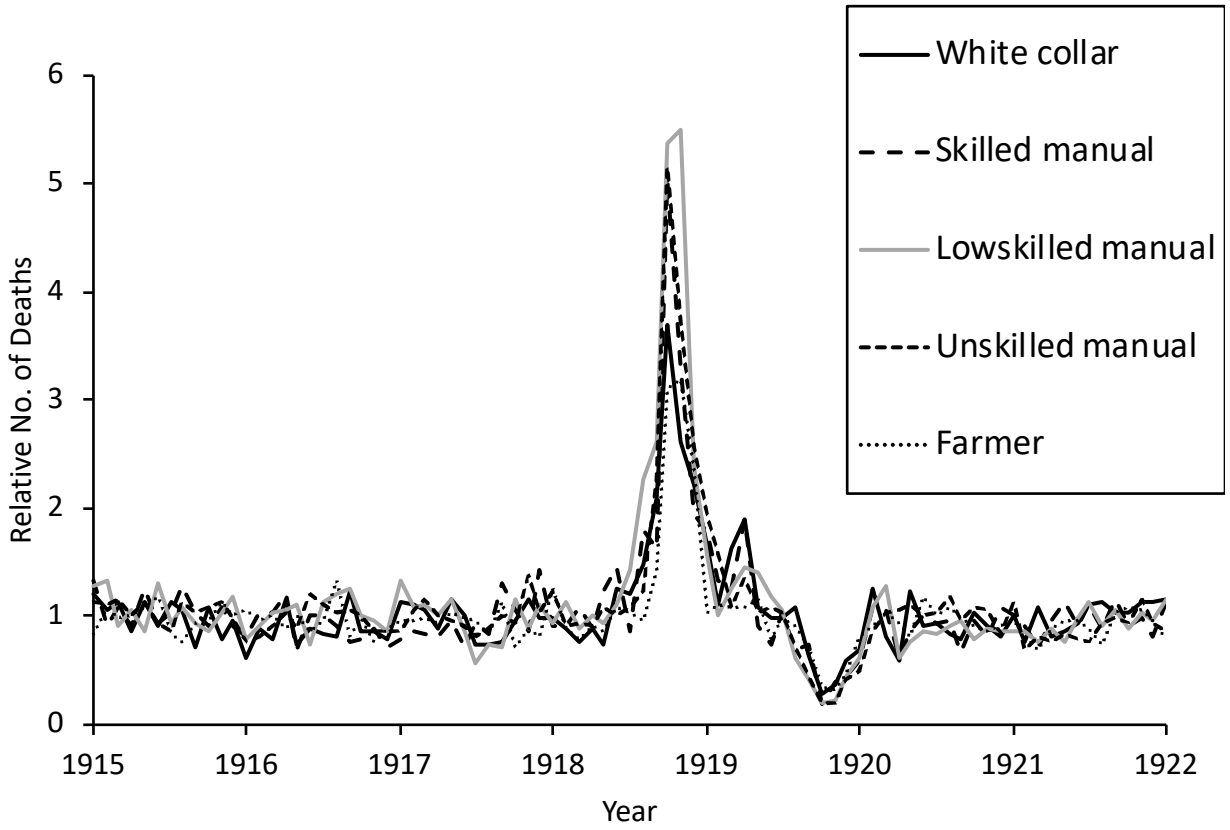
EXCESS MORTALITY

- Since the death registers did not provide information on the cause of death, we based the analysis on the estimation of excess mortality, using a method that eliminates the normal seasonality almost completely
- According to our estimates, there was a total of 42,454 excess deaths in the pandemic period
- The numbers of proven and likely influenza deaths in the same period, reported by Statistics Sweden, was 34,374
- Thus, our estimations included about 8,000 deaths not diagnosed as influenza, of which almost 3,000 were deaths in pneumonia

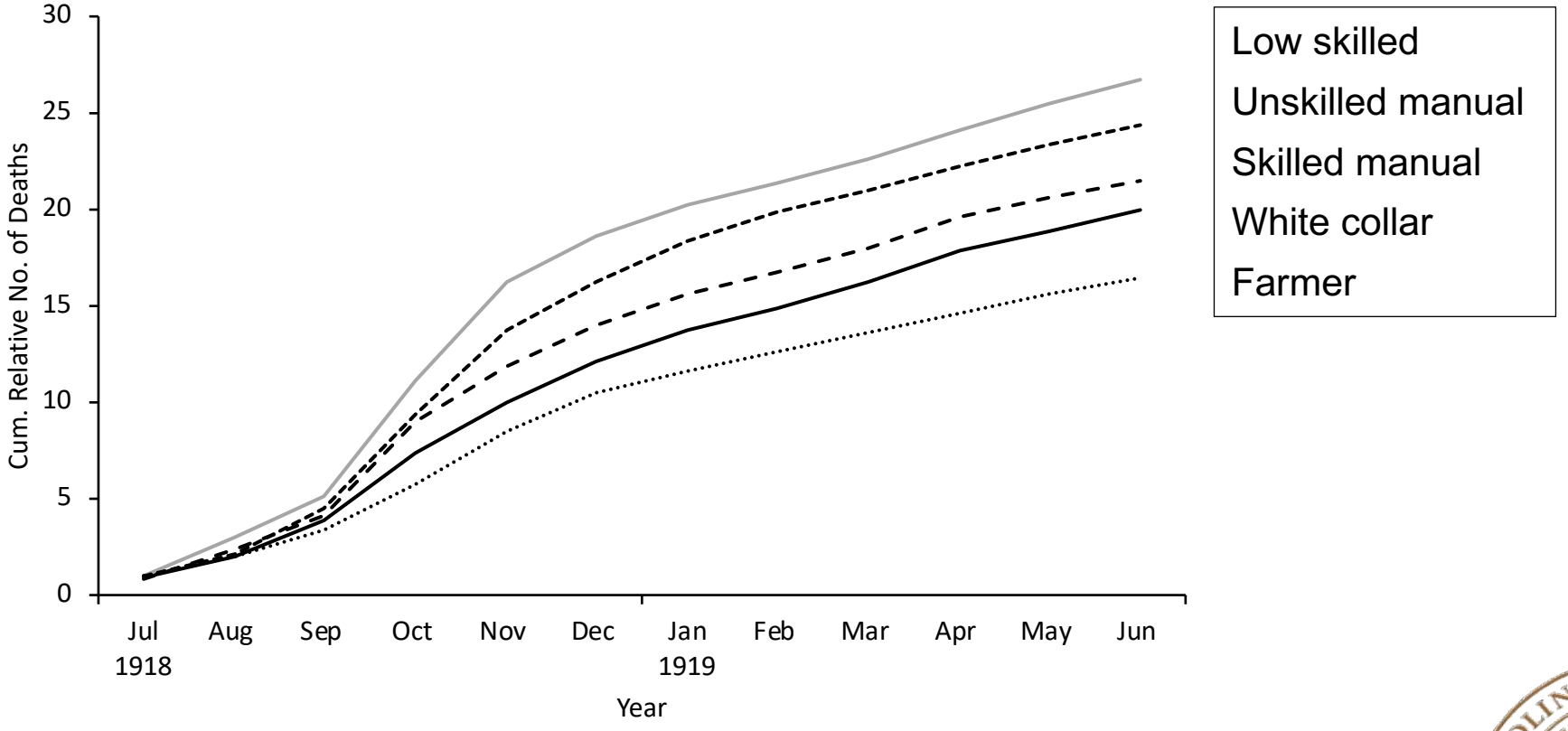
Deaths among all, linked, and linked with SES, men, 30-59 years



Excess mortality by social class, men, 30-59 years



Cumulative excess mortality by social class, men, 30-59 years



MODELLING

Mortality was modelled using a complementary log-log model (estimated using the cloglog command in STATA 14)

The complementary log-log model takes the following form:

$$\Pr(y = 1|x) = 1\text{-}\exp\{\exp(-x'\beta)\}$$

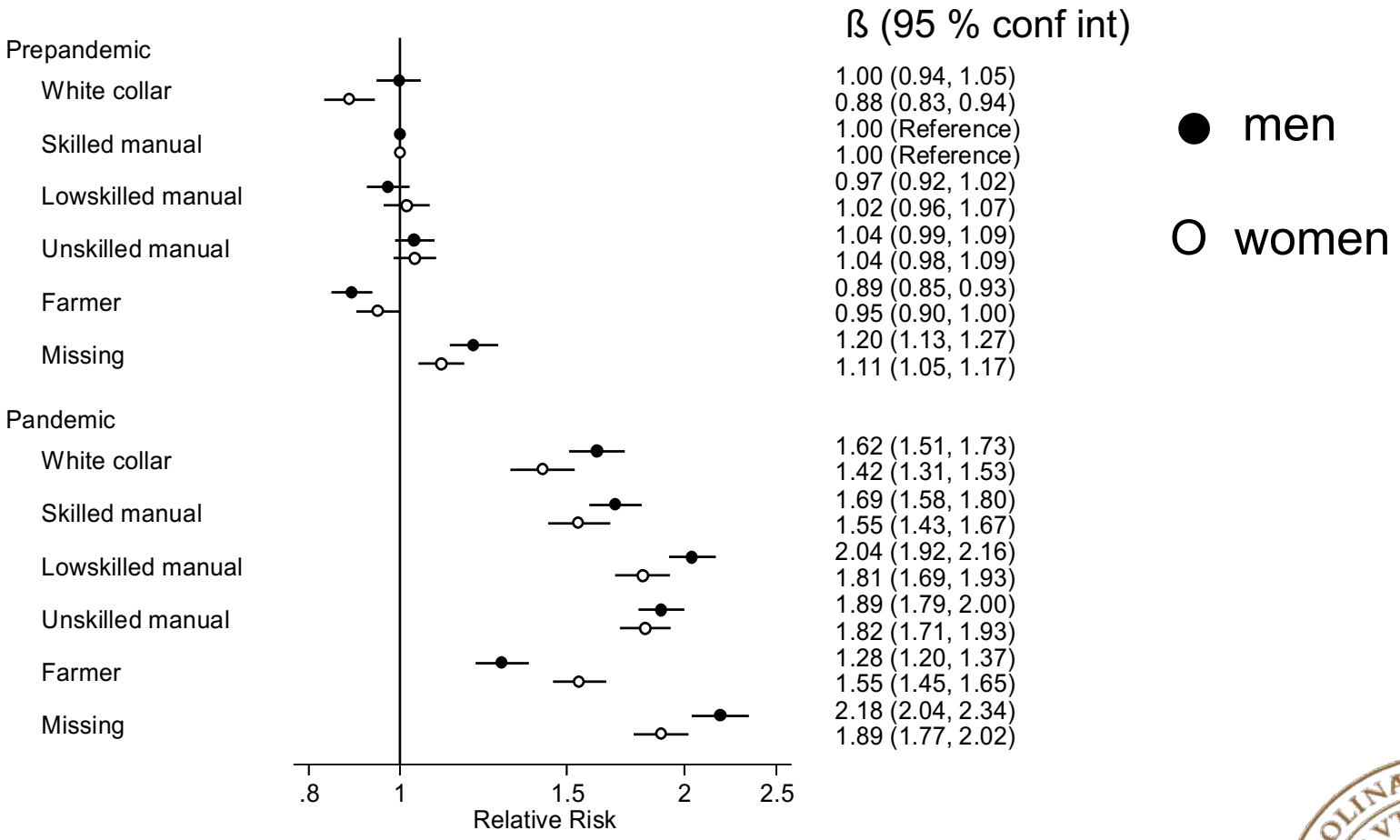
where y is an indicator variable with the value one if the individual died during the month, or zero otherwise,

x is a vector of covariates, and

β is the vector of parameters to be estimated

We used monthly data and adjusted for marital status, presence of children, migration history, and residency (urban/rural)

Relative risks for the interaction between social class and pandemic period*



* July 1918 to June 1919 relative to January 1915 to June 1918

Summary of Bengtsson, Dribe & Eriksson

Am J Epidemiol. 2018 Dec 1;187(12):2568-2576

- Differences between social classes, especially farmers versus others – and larger for men than women - but no social gradient

Theory:

- Not dependent on nutritional status but may interact with diseases that are dependent on nutrition (TB, malaria)
- No treatment
- Partial immunity due to previous exposure
- Genetic factors
- **Exposure**

Research question 2

Was mortality higher for workers in large than small factories?

Grupp	Undergrupp	Industri
2	d	Finare stenförädlingsindustri
2	e	Kalk- och kritbruk
2	f	Cementfabriker
2	h	Tegelbruk
2	i	Porslins- och kakelfabriker
2	j	Glasindustri
3	e	Sågverk- och hyvlerier
3	i	Snickeri- och möbelfabriker
4	a	Pappersmassefabriker
4	b	Pappersbruk och pappfabriker
4	d	Tapetfabriker
4	f	Boktryckerier
5	d	Stärkelsefabriker
5	f	Bagerier
5	h	Sockerraffinaderier
5	i	Choklad- och karamellfabriker
5	m	Bryggerier och mälterier
5	o	Tobaksfabriker
5	p	Mejerier
5	q	Margarin- och flottfabriker samt talgrefinaderier
5	s	Fiskberedningsanstalter och konservfabriker
6	d	Trikåfabriker
6	f	Repslageri och bindgarnsfabriker
6	h	Hatt- och mössfabriker
7	a	Garverier
7	d	Gummivarufabriker
8	e	Krutbruk och andra sprängämnesfabriker
8	f	Tändsticksfabriker
9	a	Elektricitetsverk
9	b	Gasverk
9	c	Vattenledningsverk

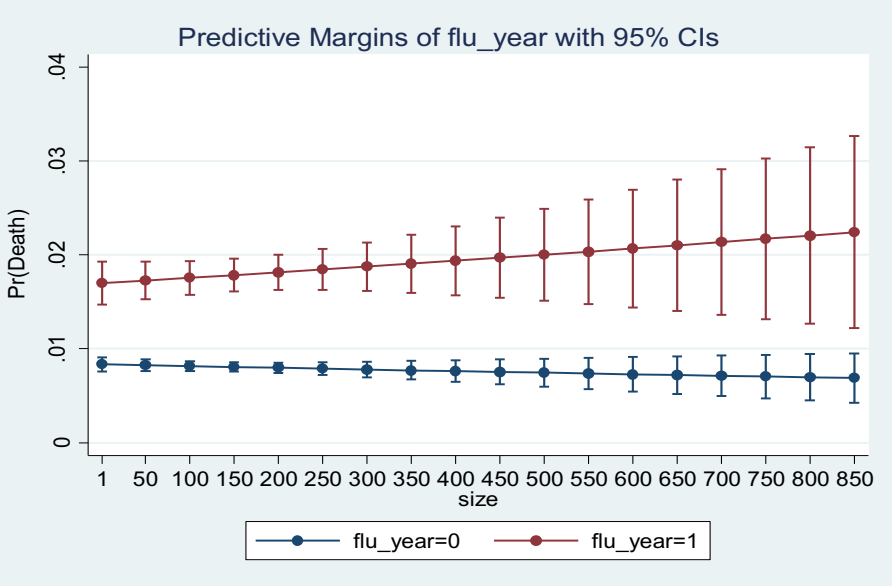
Occupations linked to 31 industries out 78 (so far…)

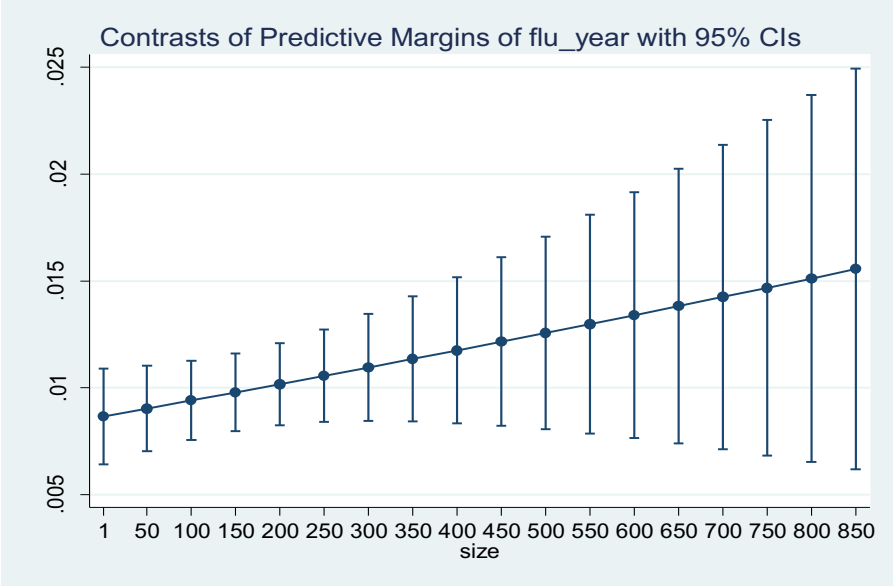
The largest towns excluded (so far …)

Odds ratios of the interaction between work place size and pandemic period

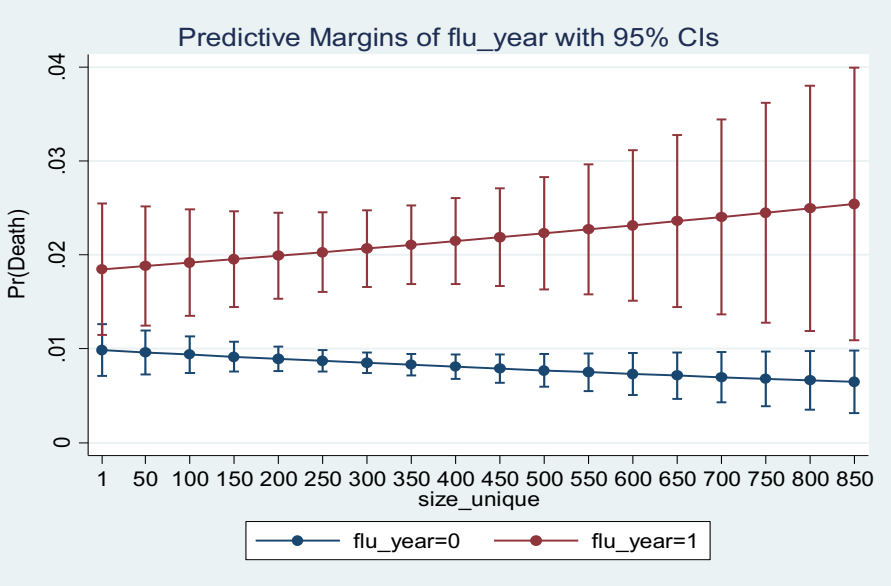
Model	1	2	3	4	5	6
Panel A. Average work place size (n=152870)						
Spanish flu	2.05243***	2.05673***	2.05935***	2.05873***	2.05889***	2.05884***
Work place size	0.99995	0.99995	1.00006	0.99995	0.99986	0.99977
Spanish flu * Work place size	1.00057*	1.00057*	1.00056*	1.00056*	1.00056*	1.00056*
χ^2	488.47320	513.06222	544.82369	552.69363	578.74351	616.54396
Panel B. Unique work place size (n=32305)						
Spanish flu	1.84668***	1.86123***	1.86469***	1.86489***	1.90531***	1.89862***
Work place size	0.99982	0.99977	0.99979	0.99979	0.99951	0.99950
Spanish flu * Work place size	1.00098**	1.00095**	1.00095**	1.00095**	1.00088**	1.00089**
χ^2	134.22656	170.06137	192.92416	193.06762	226.46356	277.41999
Controls						
Age	X	X	X	X	X	X
Marital status		X	X	X	X	X
Children		X	X	X	X	X
Migrant		X	X	X	X	X
Socioeconomic status			X	X	X	X
City				X	X	X
Fixed effects						
County					X	X
Industry						X

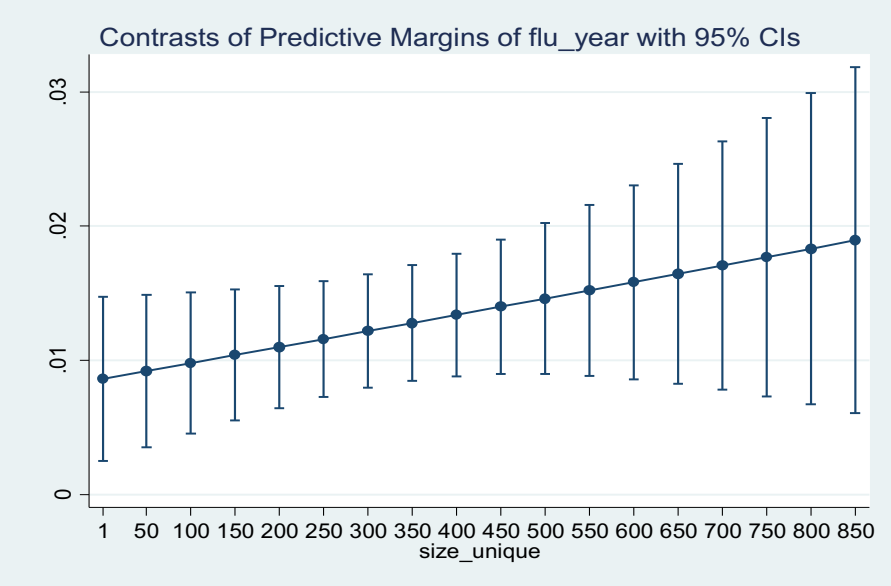
Predicted probabilities of death during the pandemic and the reference period (Panel A)





Predicted probabilities of death during the pandemic and the reference period, unique workplace (Panel B)





Summary of the two papers

- Differences between social classes, especially farmers versus others and larger for men than women - but no social gradient

Excess influenza mortality dependent on exposure:

- Twice as high excess mortality among men working in large factories (800-850 workers) comparative to those working in small factories (1-50 workers)
- In normal years workers at large factories had slightly lower risk of dying