The Effect of Face Masks on Covid Transmission: A Meta-Analysis

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September 2024

Contents

Importance

- The true unbiased effect of face masks on Covid-19 transmission influences the corresponding measures to slow down the spread of the pandemic.
- Major decline in economic activity.
- The trade-off between costs and prevented Covid-19 cases (Bagepally et al. 2021)
- Sensitivity to the effectiveness of face masks in preventing Covid-19.

Problem Formulation I

The estimates of the effect vary not only in the primary studies but also the results of other meta-analyses differ.

- The meta-analysis by Chu et al. 2020 reports huge protective abilities of face masks. Face mask usage decreased the potential odds of infection by 85%.
- Jefferson et al. 2023 found little to no difference in wearing a mask compared to not wearing one.

Problem Formulation II

Other meta-analyses:

- use a low number of primary studies
- do not evaluate publication bias rigorously
- do not examine the heterogeneity of the estimates

Data I

The following search query was used to search the studies in the Google Scholar database.

("SARS-CoV-2" OR "2019-nCoV" OR "coronavirus" OR "COVID-19") respirator transmission (observational OR descriptive OR case-control) face mask respirator epidemiological -meta

Data II

Estimate types:

- Risk ratio
- Odds ratio
- Hazard ratio
- Percentage Increase
- Change

Data III

We collected 258 estimates of the effect from 44 studies together with corresponding variables on

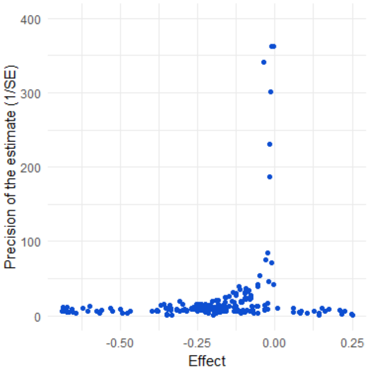
- methodology and effect type
- study set-up
- data used
- country and individual
- publication characteristics

Together more than 9,300 data points were collected.

Publication Bias I

Graphical method: Funnel plot as presented by Egger et al. 1997

Figure: Funnel plot



Publication Bias II

Linear Methods

	OLS	**FE**	**BE**	**Study**	**Precision**
Publication bias	0.074*	−0.436***	−0.306	0.040	−0.436
(Standard error)	(0.038)	(0.068)	(0.222)	(0.038)	(2.104)
Effect beyond bias	−0.282***	−0.187***	−0.243***	−0.197***	−0.187
(Constant)	(0.018)	(0.001)	(0.027)	(0.008)	(0.158)
Observations	256	256	256	256	256

Publication Bias III

Non-linear Methods

	Stem	WAAP	Top10	AK	Kink	Bayes
Publication bias					-0.436	0.180
(Standard error)					(1.315)	(0.304)
Effect beyond bias	-0.092	-0.223***	-0.094*	-0.240***	-0.187***	-0.440***
(Constant)	(0.110)	(0.030)	(0.035)	(0.032)	(0.024)	(0.097)
Observations	256	256	256	256	256	256

Publication Bias IV

Methods allowing for endogeneity

	IV	**p-uniform***
Publication bias	0.249	0.148***
(Standard error)	(0.191)	(0.068)
Effect beyond bias	-0.221***	-0.422***
(Constant)	(0.028)	(0.111)
Observations	256	256

Publication Bias V

Caliper test

	Threshold = -1.96	n	Threshold = 0	n
Caliper width = 0.2	0.778*	9		
	(0.147)			
Caliper width = 0.3	0.632	19		
	(0.114)			
Caliper width = 0.4	0.583	24		
	(0.103)			
Caliper width = 0.5	0.684**	38		
	(0.076)			
Caliper width = 0.6	0.745***	51	0.615	13
	(0.062)		(0.140)	
Caliper width = 0.7	0.724***	58	0.556	18
	(0.059)		(0.121)	
Caliper width = 0.8	0.730***	63	0.579	19
	(0.056)		(0.116)	

Heterogeneity I

Variables were selected based on their VIF scores and correlation coefficients among the variables. To estimate the effect of selected variables on the risk of Covid-19 transmission we could utilise the following equation.

$$\hat{risk}_{ij} = \beta_0 + \sum_{l=1}^{18} \beta_l X_{l,ij} + \gamma SE(\hat{risk}_{ij}) + \mu_{ij} \tag{1}$$

Heterogeneity II

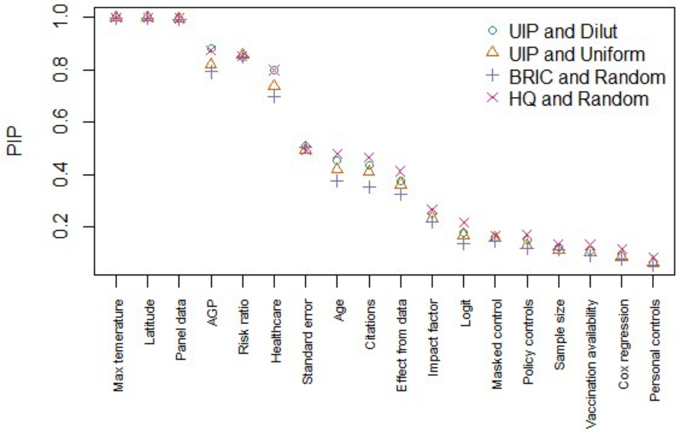
	Bayesian model averaging			Frequentist check		
	post.	SD	PIP	coefficient	SE	p-value
standard error	0.043	0.051	0.492	0.039	0.042	0.355
intercept	-2.797	NA	1.000	-3.466	0.444	0.000
Methodology and effect type						
RR	0.119	0.065	0.850	0.115	0.066	0.082
effect from data	0.069	0.106	0.365	0.150	0.093	0.106
logit	0.012	0.033	0.164	0.074	0.061	0.228
cox	-0.003	0.019	0.080	-0.004	0.053	0.942
Study set-up						
personal controls	-0.000	0.008	0.058	-0.014	0.031	0.648
policy controls	-0.008	0.029	0.136	-0.032	0.051	0.531
healthcare	0.110	0.076	0.747	0.127	0.060	0.034
AGP	-0.152	0.087	0.832	-0.170	0.056	0.002
vaccination available	-0.005	0.024	0.099	-0.026	0.052	0.620
control masked	0.012	0.037	0.149	0.026	0.060	0.660

Heterogeneity III

	Bayesian model averaging			Frequentist check		
		post. SD	PIP	coefficient	SE	p-value
Data characteristics						
panel data	0.196	0.047	0.997	0.209	0.053	0.000
sample size	0.001	0.006	0.109	0.006	0.011	0.564
Country and individual characteristics						
max temperature	0.372	0.079	1.000	0.431	0.074	0.000
latitude	0.236	0.049	1.000	0.265	0.050	0.000
age	0.058	0.079	0.419	0.126	0.067	0.060
Publication characteristics						
impact	0.004	0.009	0.229	0.008	0.011	0.446
citations	0.011	0.016	0.410	0.024	0.014	0.073

Heterogeneity IV

Comparison of Posterior Inclusion Probability for performed BMA models



Heterogeneity V

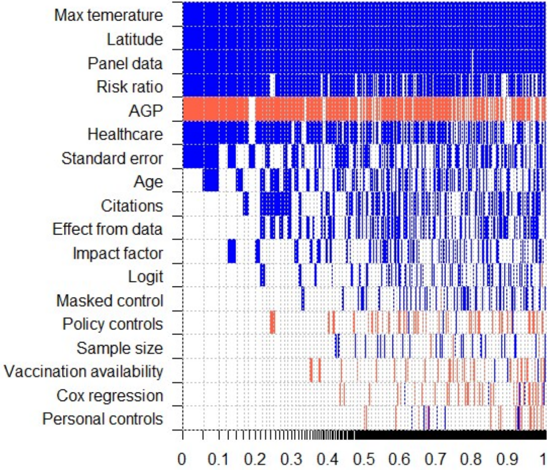
- **maximum average temperature:** positive effect (With increasing maximum temperature the protection provided by masks is lower.)
- **geographical latitude**: positive effect (with increasing latitude, the masks are less effective)
- **panel data**: positive effect (correlation with a random trial, decrease the probability of estimating the effect at a non-representative point in the time)
- **healthcare**: positive effect (lower protection, because healthcare professionals are in contact with infected individuals)
- **AGP**: negative effect (using a face mask during procedures that generate aerosols is essential for decreasing the risk of infection.)

Implied Estimate

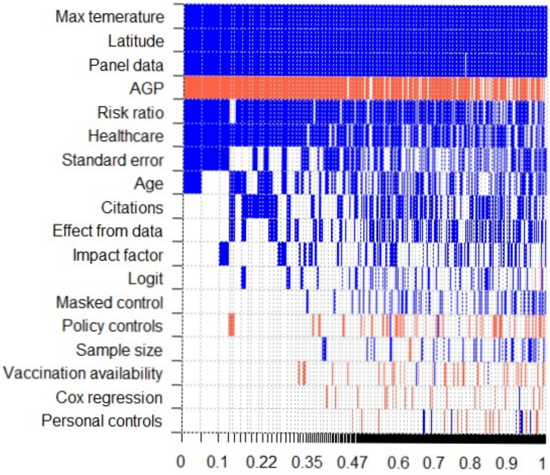
The implied estimate represents the effect of prominent studies after correcting for publication bias and misspecifications. The derived best practice estimates ranges from -0.129 to -0.157. This means that the masks reduce the risk of transmission by 12.9% to 15.7% for the set-ups of these studies.

Study	Implied estimate	95%CI
Karaivanov *et al.* (2021)	-0.136	(-0.161, -0.111)
Bundgaard *et al.* (2021)	-0.129	(-0.229, -0.030)
Nguyen *et al.* (2020)	-0.157	(-0.288, -0.025)

BMA figures I - dilution prior



BMA figures II - uniform prior



Recalculation of the effects

$$risk = RR - 1 \tag{2}$$

$$risk = \frac{OR}{1 - p_0 + p_0 * OR} - 1 \tag{3}$$

$$risk = \frac{percentage\_increase}{100} \tag{4}$$

$$risk = \frac{risk_{change}}{risk_{base}} \tag{5}$$

$$risk = exp(estimate) - 1 \tag{6}$$

$$\begin{aligned} se(risk) &= var\left(\frac{risk_{change}}{risk_{base}}\right)^{\frac{1}{2}} = \\ &= \left(\left(\frac{1}{risk_{base}}\right)^2 var(risk_{change})\right)^{\frac{1}{2}} = \frac{se(risk_{change})}{risk_{base}} \end{aligned} \tag{7}$$

$$se(risk) = \frac{(CI_{upper} - CI_{lower})}{3.92} \tag{8}$$